CAN-CBM-Bridge/2

Intelligent CAN-Bridge

Hardware Manual

to Product C.2853.02

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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 CAN-CBM-Bridge/2. 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 Information and warning messages inserted, Classification inserted	2016-05-31
	2.	New chapter “Hardware Installation ”	
	3.	Chapter moved	
	4.2.1, 4.2.2	Values corrected	
	5.	Chapter moved, link for manual download updated	
	6.	Chapter moved	
	6.1	Name of connector revised	
	6.4	Notices inserted	
	6.5	New chapter “Conductor Connection/Conductor Cross Sections”	
	7., 8.	Chapters updated	
	9.	Declaration of Conformity inserted	
	10.	Order Information moved and revised	
1.4	5.	Note on terminal programs changed	2016-11-01
	5.1	Examples revised, description of commands 'Reset' and 'Help' and 'Show rotary switch state' inserted	

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 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 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-CBM-Bridge/2 follow the instructions below and read the manual carefully to protect yourself from injury and the CAN-CBM-Bridge/2 from damage.
- Do not use damaged or defective cables to connect the CAN-CBM-Bridge/2 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-CBM-Bridge/2 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.

- Do not open the housing of the CAN-CBM-Bridge/2.
- The CAN-CBM-Bridge/2 has to be securely installed before commissioning.
- The permitted operating position is specified as shown (Figure: 2). Other operating positions are not allowed.
- Never let liquids get inside the CAN-CBM-Bridge/2. Otherwise, electric shocks or short circuits may result.
- Protect the CAN-CBM-Bridge/2 from dust, moisture and steam.
- Protect the CAN-CBM-Bridge/2 from shocks and vibrations.
- The CAN-CBM-Bridge/2 may become warm during normal use. Always allow adequate ventilation around the CAN-CBM-Bridge/2 and use care when handling.
- Do not operate the CAN-CBM-Bridge/2 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-CBM-Bridge/2 is to be integrated.

→ All current circuits which are connected to the device have to be sufficiently protected against hazardous voltage (SELV according to EN 60950-1) before you start with the installation.
→ Ensure the absence of voltage before starting any electrical work

NOTICE
The CAN-CBM-Bridge/2 shall not be connected to a DC power supply network without protection against surge voltage.
→ Use an external overvoltage protection.

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 CAN-CBM-Bridge/2 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 CAN-CBM-Bridge/2 may cause radio interferences in which case the user may be required to take adequate measures.

Intended Use

The intended use of the CAN-CBM-Bridge/2 is the operation as intelligent CAN-Bridge, that links two independent CAN networks.
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-CBM-Bridge/2 is intended for indoor use only.
- The operation of the CAN-CBM-Bridge/2 in hazardous areas, or areas exposed to potentially explosive materials is not permitted.
- The operation of the CAN-CBM-Bridge/2 for medical purposes is prohibited.

Service Note

The CAN-CBM-Bridge/2 does not contain any parts that require maintenance by the user. The CAN-CBM-Bridge/2 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.

Abbreviations

API	Application Programming Interface
CAN	Controller Area Network
CPU	Central Processing Unit
CiA	CAN in Automation
SDK	Software Development Kit

Table of contents

1. Overview

1.1 Module Description

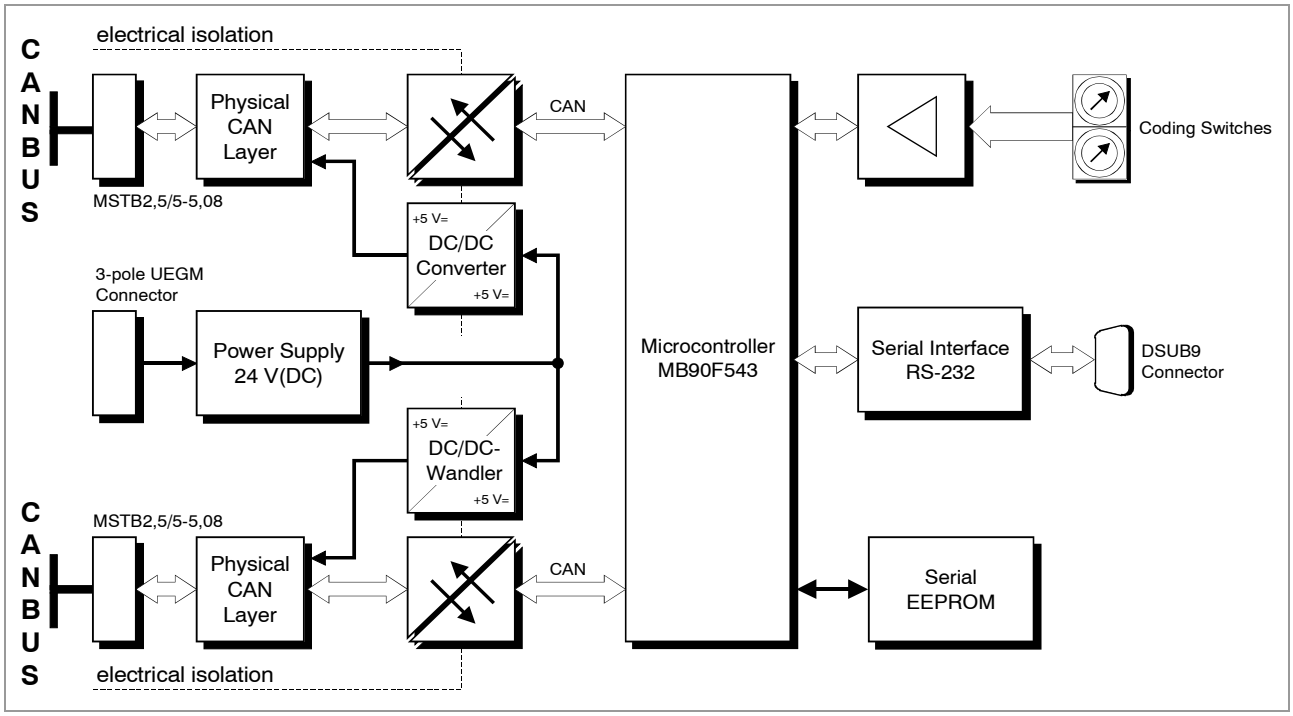


Figure 1: Block circuit diagram of CAN-CBM-Bridge/2

The module CAN-CBM-Bridge/2 can connect two independent CAN nets. The nets can be operated with different bit rates.

The module works with a MB90F453 microcontroller which buffers CAN data into a local SRAM. The firmware is contained in the flash. Parameters are stored in a serial EEPROM.

The ISO 11898-compliant CAN interfaces allow a maximum data transfer rate of 1 Mbit/s each. The CAN interfaces are electrically isolated by optical couplers and DC/DC converters. They are connected via 5-pin screw/plug connectors.

For matters of service and development the module features a serial interface. RS-232 is used as physical interface. It is connected via a DSUB9 connector.

1.2 Front View with Connectors and Coding Switches

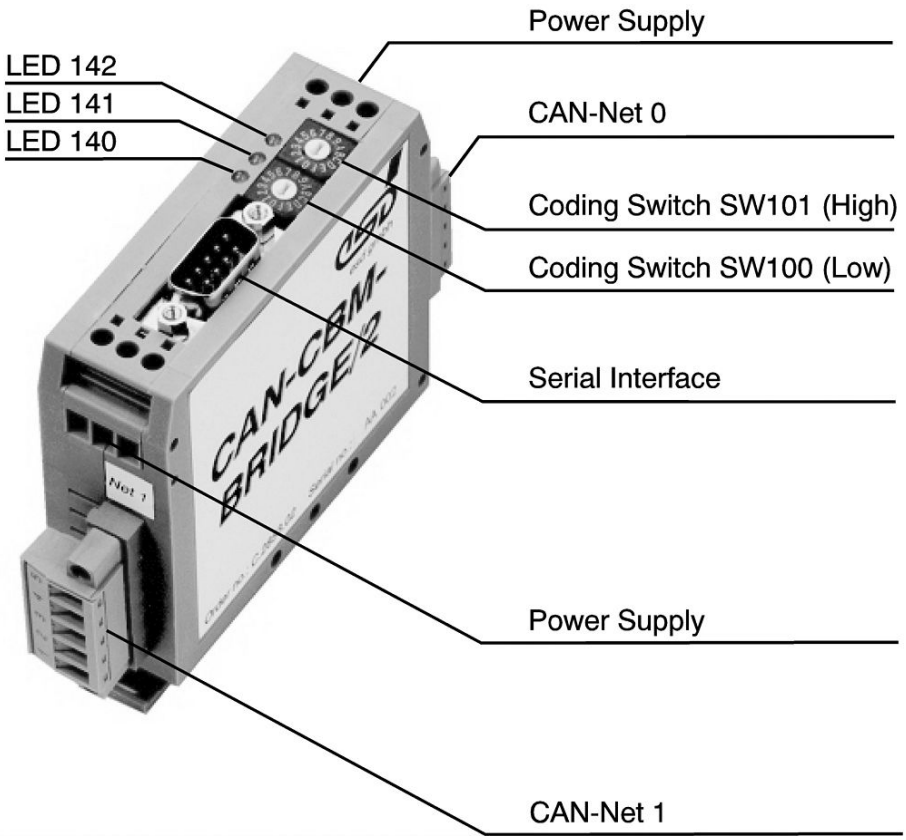


Figure 2: Position of connectors and control devices

See also page 25 for signal assignment of the connectors.
For conductor connection and conductor cross section see page 29.

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

2. Hardware Installation

To put the CAN-CBM-Bridge/2 into operation, please follow the installation notes.

Step	Procedure	see page
	**Read the safety instructions at the beginning of this document carefully, before you start with the hardware installation!**	5
	**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-CBM-Bridge/2 is to be integrated. → All current circuits which are connected to the device have to be sufficiently protected against hazardous voltage (SELV according to EN 60950-1) before you start with the installation. → Ensure the absence of voltage before starting any electrical work.	
	**NOTICE** The CAN-CBM-Bridge/2 shall not be connected to a DC power supply network without protection against surge voltage. → Use an external overvoltage protection.	
1.	Mount and connect the CAN-CBM-Bridge/2 gateway and connect the interfaces (Power supply, CAN bus, serial interface).	10
2.	Please note that the CAN bus has to be terminated at both ends! **esd** offers special T-connectors and termination connectors for external termination. Additionally the CAN_GND signal has to be connected to earth at **exactly one** point in the CAN network. All esd termination devices will provide a corresponding contact. For details please read chapter “Correct Wiring of Electrically Isolated CAN Networks”. Any CAN node that does not support a galvanic isolation represents the equivalent of a Ground (GND) connection.	30
3.	Turn on the 24 V-power supply voltage of the CAN-CBM-Bridge/2.	-

3. Technical Data

3.1 General Technical Data

Power supply	permitted voltage range: 12 VDC ... 32 VDC Nominal voltage 24 VDC, current (at 24 V, 20 °C): $I_{typical}$: 100 mA
Connectors	X100 (DSUB9, male) - serial interface X300 (2x3-pin screw connector UEGM) - 24 V power supply X200 (Phoenix contact, 5-pin MSTB2.5/5-5.08) - CAN net 0 X250 (Phoenix contact, 5-pin MSTB2.5/5-5.08) - CAN net 1
Temperature range	0...50 °C ambient temperature, (-20 °C ... +70 °C on request)
Humidity	max. 90%, non-condensing
Case dimensions (W x H x D)	Width: 20 mm, height: 85 mm, depth: 83 mm (including hatrail mounting and jutted out connector DSUB9, without CAN connector)
Weight	ca. 120 g

Table 1: General data of the module

3.2 Microcontroller Unit

Microcontroller	MB90F543	
Memory	SRAM: Flash-EPROM: EEPROM:	intern in MB90F543, 6 kbyte intern in MB90F543, 128 kbyte serial SPI-EEPROM

Table 2: Microcontroller Units

3.3 CAN Interface

Number of CAN interfaces	2x CAN
CAN controller	MB90F543, acc. to ISO 11898-1 (CAN 2.0 A/B), 11-bit and 29-bit CAN identifier
Status display	yellow LEDs
Electrical insulation of CAN interfaces from other units	via optocouplers and DC/DC converters reference voltages 300 VDC/250 VAC
Physical layer CAN	physical layer in accordance with ISO 11898-2, transfer rate programmable from 10 Kbit/s to 1 Mbit/s
Bus termination	terminating resistor has to be set externally, if required

Table 3: Data of the CAN interface

3.4 Serial Interface

Controller	MB90F543
Physical Interface	RS232 , only the signals RxD, TxD and GND are supported
Connector	9-pin DSUB

Table 4: Data of the serial interface

3.5 Software

Configuration	via terminal at serial interface
Update	update option via serial interface
CAN bit rate	adjustable in 14 steps or bit-timing register of the controller can be programmed directly
CAN identifier	11-bit and 29-bit-CAN identifiers (also in combination)
Number of CAN-identifier areas which can be masked to link the nets	2 masks per CAN net
Number of CAN-identifier links which can be set individually	13 in direction from net 0 to net 1 and 13 in direction from net 1 to net 0

Table 5: Performance features of the software

4. Description of the Units

4.1 CAN

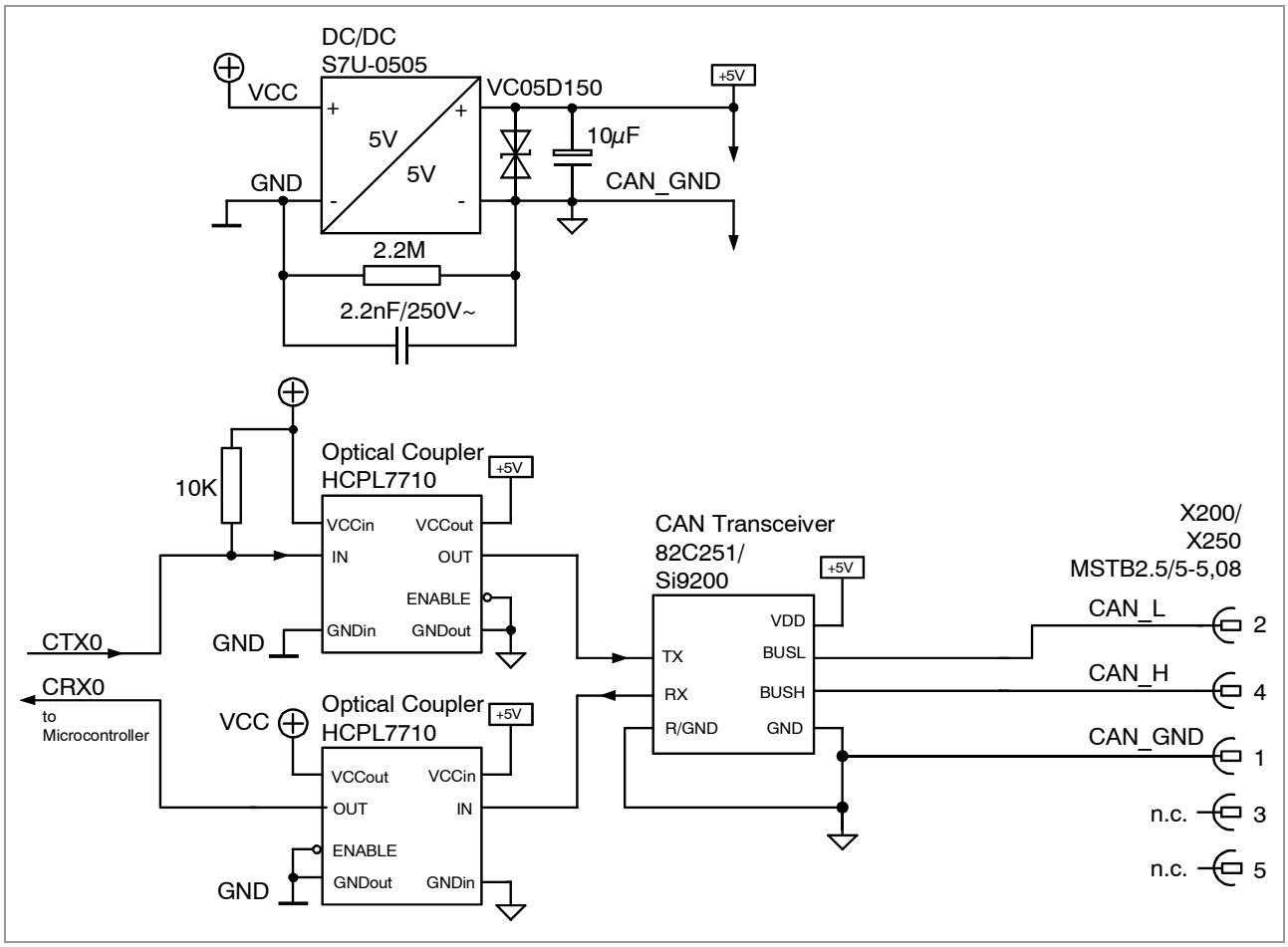


Figure 3: CAN interface

4.2 Serial Interface

4.2.1 Default Setting of CAN-CBM-Bridge/2 Module

Bitrate: 9600 Baud
Data bits: 8
Parity: no
Stop bit: 1
Handshake: NONE

4.2.2 Configuration

The serial interface is controlled by microcontroller MB90F543. The bitrate is 9600 Baud. Set the user's terminal / PC to this value. The bitrate can not be changed at the CAN-CBM-Bridge/2 module.

4.2.3 Connecting the Serial Interfaces

Below, the wiring of the serial interface is shown. The figure is used to explain the short terms of the signals as used in the chapter Connector Assignments. The signal description is given exemplary for the connection of the CAN-CBM-Bridge/2 to a PC.

INFORMATION
For the connection of the CAN-CBM-Bridge/2 module to the RS-232 interface of the PCs a nullmodem is necessary (if not already considered by the configuration of the serial lines).

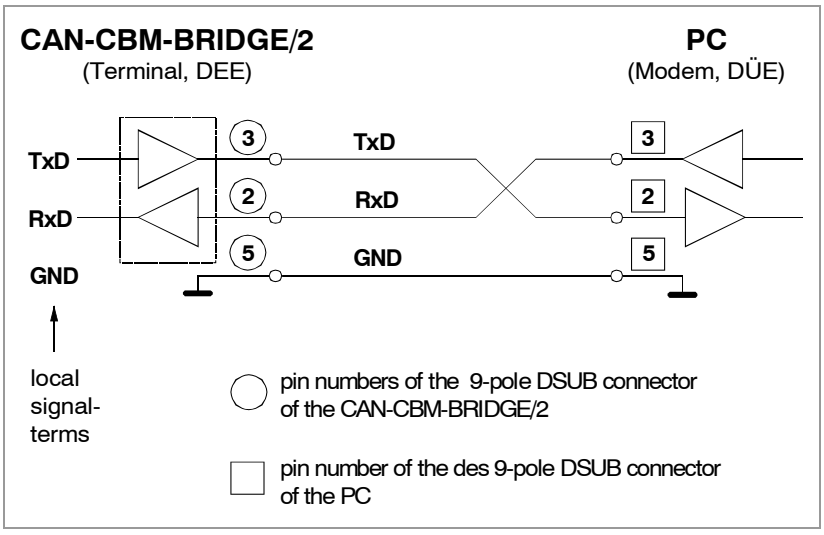


Figure 4: Connection diagram for RS-232 operation

4.3 Function of Coding Switches

The configuration of the module can be changed via the coding switches.

Standard operation: ‘Individual Configuration’:

Usually customers configure the CAN-CBM-Bridge/2 themselves (see chapter ‘Configuration of the CAN-CBM-Bridge/2’, from page 19). For this both coding switches have to be set to ‘0’ when the module is switched on (power on). During configuration and operation the coding switches are not evaluated, therefore it is recommendable to leave them set to ‘0’ at all times.

NOTICE
When switching on the power both coding switches must be set to ‘0’!
Settings unequal ‘0’ are only permissible to select customized configurations.

Special case ‘Customized Configuration’:

By means of the coding switches programmed configurations can be selected. These customized configurations are selected via coding switch positions unequal ‘0’. They can, for example, contain set assignments of CAN-identifiers of both networks. Should you require a lot of CAN-CBM-Bridge/2 modules with the same configuration for an application, feel free to contact our support team. We would be pleased to make you an offer for an individual solution.

Coding switch	Function	Default setting at delivery
SW101 (High)	Setting of customized configurations	‘0’
SW100 (Low)	Setting of customized configurations	‘0’

Table 6: Function of coding switches

4.4 LED Display

In fault-free status the green as well as both yellow LEDs shine continuously. In case of an error in one of the two CAN-networks the according LED starts flashing.
The upper LED 142 (see front view on page 10) shows errors in CAN-network 0 and the middle LED 141 errors in CAN-network 1.

LED	Colour	Function	Status	Meaning
LED 142	yellow	status CAN 0	off	no power supply or CPU is not working
			permanently shining	CAN-status OK
LED 141	yellow	status CAN 1	flashing	CAN-error (such as bus off)
LED 140	green	power	off	power supply ‘off’
			shining	power supply ‘on’

Table 7: LED status

5. Configuration of the CAN-CBM-Bridge/2

This chapter describes the procedure for the configuration of the CAN-CBM-Bridge/2, which can easily be done for example by means of the free terminal programs 'Tera Term' or 'PuTTY'.

5.1 Serial Interface and Coding Switches

The serial interface of the PC has to be configured with the values which are described in chapter “Default Setting of CAN-CBM-Bridge/2 Module”, (page 16).

NOTICE
At the module CAN-CBM-Bridge/2 both coding switches must be set to ‘0’ at power on!
Settings unequal ‘0’ are only permitted for ‘Customized Configuation’ (see page 17).

5.1.1 Commands

After the power supply has been switched on the CAN-CBM-module wakes up and puts out a message in the terminal program.

Now you can enter the commands directly and acknowledge with >Enter<.

COMMANDS:

R Command **R** shows the current configuration of the module. In the example below the module is still in default setting. The following message will be displayed:

Input:	**R** >Enter<
Output:	B0 : 6 B1 : 6

Both CAN nets have got a default bit rate of 125 kbit/s, this corresponds to a *HexIndex* of 6 (see Table 8 on page 20), when leaving the manufacturer.

Bn:HexIndex By means of the command **Bn:** you can configure the desired bit rate of the CAN net with net number **n**, with:

n= 0 for net 0
n= 1 for net 1

If values between 0 to 0xF are specified for *HexIndex*, the bit rate is configured according to the following table:

HexIndex	Bit rate [kbit/s]	*HexIndex*	Bit rate [kbit/s]
0	1000	8	66.6
1	666.6	9	50
2	500	0xA	33.3
3	333.3	0xB	20
4	250	0xC	12.5
5	166	0xD	10
6	125	0xE	reserved
7	100	0xF	reserved

Table 8: Index of bit rate

In the following example the bit rate of net 1 (*n*=1) is to be configured to 10 kbit/s. From Table 8 you get the *HexIndex* = 0xD. Your input therefore is as follows:

Input: **B1:D** >Enter<

Bn:8000yyzz Alternatively you can configure the bit-timing register of the MB90F543 component used, directly. In this case the register value for the bit-timing registers BTR0 and BTR1 is specified directly.
Here is:

n: 0 ,1... net number
yy: value for BTR0
zz: value for BTR1

Please refer to the manuals of the controller MB90F543 for the correct way to determine the bit timing and the bit rate from the register values.

The manual can e.g. be downloaded from the Cypress homepage:
http://www.cypress.com/

Search for 'MB90540 Series' Hardware Manual.

I0:ID net 0 I1:ID net 1

This command assigns an identifier of CAN net **1** to an identifier of CAN net **0**. The identifier *ID net 0*, which is received by CAN net **0** is assigned to identifier *ID net 1* of CAN net **1**.

NOTICE
If you want to configure 29-bit CAN identifier (value range bit 28...bit 0), bit 29 has to be configured (0x20000000 corresponding to CANopen!).

In the example below the 29-bit identifier 0x3456789 of net **0** is mapped to the 11-bit identifier 0x543 of net **1**.

Input: **I0:23456789 I1:543** >Enter<

In the following example the 11-bit identifier *ID net 0* = 0x200 is mapped to the 11-bit identifier *ID net 1* = 0x300.

Input: **I0:200 I1:300** >Enter<

I1:ID Net 1 I0:ID Net 0

This command assigns an identifier of CAN net **0** to an identifier of CAN net **1**. The identifier *ID net 1*, which was received by CAN net **1** is transmitted to identifier *ID net 0* of CAN net **0**.

In the following example the 29-bit identifier *ID net 1* = 0x4567893 is to be transmitted to the identifier *ID net 0* = 0x205.

Input: **I1:24567893 I0:205** >Enter<

If you configure an identifier which is not between 0x0 and 0x7FF or within the 29-bit range, the assignment is not accepted.
At the moment a total of 13 ID assignments are possible for both directions.

Mm:n:zzzzzzzzzzzzzzzzzzzzzzzzzzzzzz

This command defines masks for identifiers.
This way all identifiers or particular areas of identifiers can be assigned.
Here is:

m:	0,1...	net in which the identifiers are to be received
n:	0,1...	net in which the filtered CAN frames are to be transmitted
z...z:	0, 1, x...	mask 0: the according bit has to be logically 0 1: the according bit has to be logically 1 x: the status of the according bit does not matter

NOTICE
Please note that the bits are numbered from right to left.
The first bit from the left is therefore bit 30!

The mask must always have the full length of 30 bits (29 bits + 30th bit to distinguish between 11-bit and 29-bit identifiers).
The first bit is the distinction bit, the following bit is the MSB of the CAN identifier, etc.

Bit 30	Meaning
0	11-bit identifier
1	29-bit identifier

In the following examples **all** identifiers are let through from net 0 to net 1:
- 11-bit Identifier

Input: **M0:1:0xxxxxxxxxxxxxxxxxxxxxxxxxxxx**
>Enter<

- 29-bit Identifier:

Input: **M0:1:1xxxxxxxxxxxxxxxxxxxxxxxxxxxx**
>Enter<

In the following examples only the **odd 11-bit or 29-bit identifiers between 0x0 and 0xFF** are let through from net 0 to net 1:
- 11-bit Identifier:

Input: **M0:1:00000000000000000000xxxxxxx1**
>Enter<

- 29-bit Identifier:

Input: **M0:1:10000000000000000000xxxxxxx1**
>Enter<

It is not possible to define two 11-bit or two 29-bit masks at the same time. Only one 11-bit mask and one 29-bit mask can be set.

The current configuration of the CAN-CBM-Bridge/2 module from the previous examples can be displayed by means of command **R**.

Input:	**R** >Enter<
Output:	B0:6 I0:200 I1:300 I0:23456789 I1:543 M0:1:00000000000000000000000xxxxxxx1 B1:D I1:24567893 I0:205

E

After the configuration has been successfully completed, the configured data is stored in the configuration memory by means of command **E**. Only after the data has been stored the changes become effective.
The CAN-CBM-Bridge/2 module is now in RUN status and meets the desired bridge function.

Input: **E** >Enter<

C

You can delete a configuration again by means of the command **C**. The command deletes **all** identifier assignments and resets the CAN bit rates to the default value of *HexIndex* 6, that is a bit rate of 125 kbit/s.
The configuration memory is also deleted.

Input: **C** >Enter<

Q

The command **Q** resets the CAN-CBM-Bridge/2. This command only restarts the module. The configured settings will not be changed.

Input: **Q** >Enter<

D

The command **D** shows the state of the coding switches SW101 (High) and SW100 (Low) in hexadecimal format (S: 0 … FF).
In the following example coding switch SW101 is set to 0xA and coding switch SW100 is set to 0x7:

Input:	**D** >Enter<
Output:	S: A7

H or **?** With the commands **H** or **?** a help text can be shown, which contains a list of the available commands.

Input:	**H** >Enter<
Output:	C - Clear all settings and deactivate bridge E - Store all settings to EEPROM and activate them R - Read/Show all settings B<net>:<baud> - Set baud rate M<net-from>:<net-to>:<mask> - Set mask (max: 2 per net) I<net-from>:<id-from> i<net-to>:<id-to> - Set single id forwarding (max: 13 per net) D - Read/Show rotary switches state Q - Reset

5.1.2 Change Existing Configurations

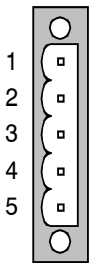
It is not possible to modify single parameters of an existing configuration. You have to call the command **C** (see page 23) to clear all parameters. After that you have to configure the CAN-CBM-Bridge/2 again with the correct parameters. Do not forget to call the command **E** to store the configured data to the configuration memory.

6. Connector Assignments

6.1 CAN Bus (X200/X250)

Device connector : Phoenix Contact base strip
Plug component: Phoenix Contact MSTB 2,5/5-STF-5,08, screw connection
Phoenix Contact Order No.: 1937143 (included in delivery)
For conductor connection and conductor cross section see page 29.

Pin Position:



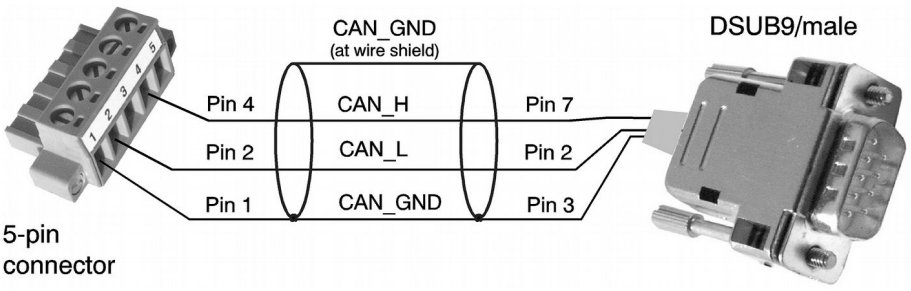
Pin Assignment:

Signal	Pin
CAN_GNDx	1
CAN_Lx	2
Shield	3
CAN_Hx	4
n.c.	5

Signal description:

CAN_Lx, CAN_Hx ... CAN signals of CAN net x (x … 1, 2)
CAN_GNDx ... reference potential of the local CAN physical layer
Shield ... shielding
(the shield lines of both CAN channels are linked directly)
n.c. ... not connected

Recommendation of an adapter cable from 5-pin plug component (here connector with screw-connection) to 9-pin DSUB:



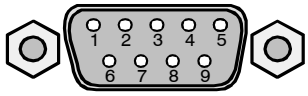
The assignment of the 9-pin DSUB-connector and the cable plug is designed according to CiA 303 part 1.

Figure 5: Adapter cable 5-pole plug component to 9-pole DSUB

6.2 RS-232 Interface (X100)

Device connector: 9-pin DSUB connector, male

Pin Position:



Pin Assignment:

Signal	Pin		Signal
n.c.	6	1	n.c.
		2	RxD (input)
n.c.	7	3	TxD (output)
n.c.	8	4	n.c.
n.c.	9	5	GND

n.c. ... not connected

6.3 Access line for the serial Interface

Below the access line of the serial interface (RS-232) of the CAN-CBM-Bridge/2 to a PC is shown.

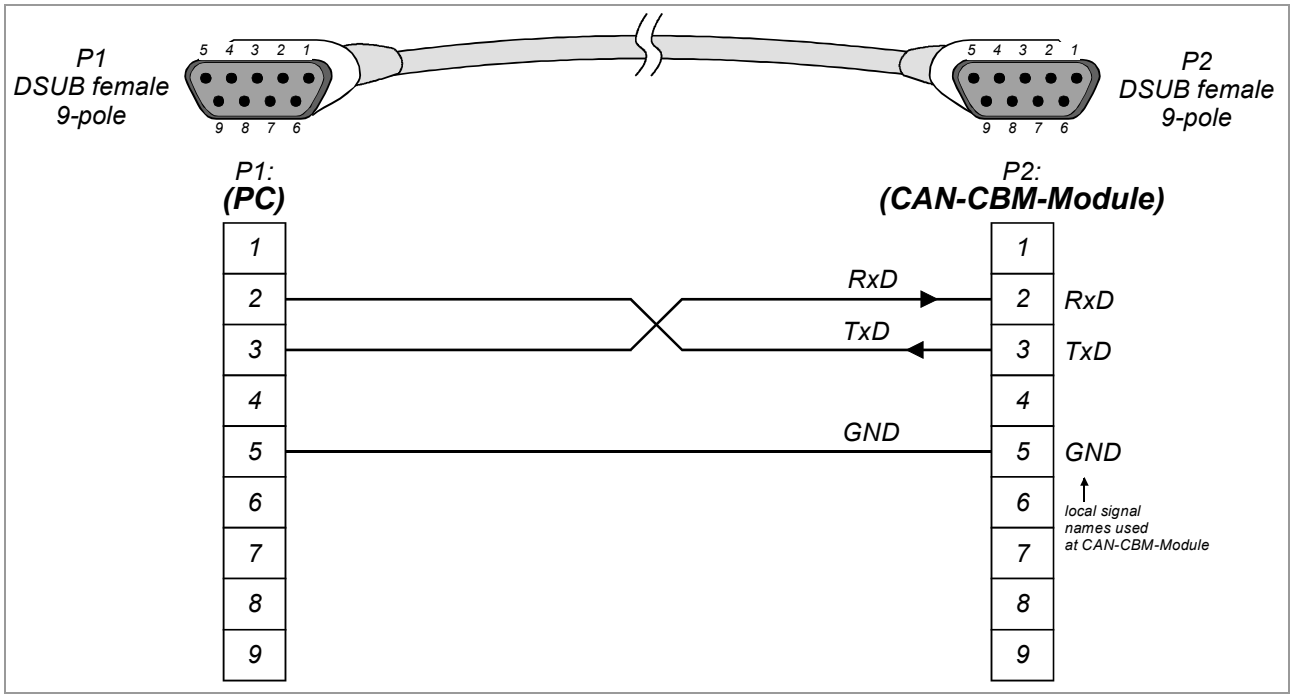


Figure 6: Assignment of Access line

6.4 Power Supply (X101, UEGM)

DANGER
The CAN-CBM-Bridge/2 may only be driven by power supply current circuits, that are contact protected. A power supply, that provides a safety extra-low voltage (SELV or PELV) according to EN 60950-1, complies with this conditions.

NOTICE
The CAN-CBM-Bridge/2 shall not be connected to a DC power supply network without protection against surge voltage.
→ Use an external overvoltage protection.

The power is supplied by means of the UEGM screw connectors integrated in the case. They are suitable for lines with a cross section of up to 2.5 mm².

The connector assignment is the same on both sides of the case. They can be used alternatively. The middle contact has been designed for +24 V and the two outer contacts for GND.

The permitted voltage range is +12 VDC ... +32 VDC

NOTICE
It is not permissible to ‚feed through' the 24 V power supply, i.e. to use one side as 24 V input and the other side as 24 V output in order to supply further devices!

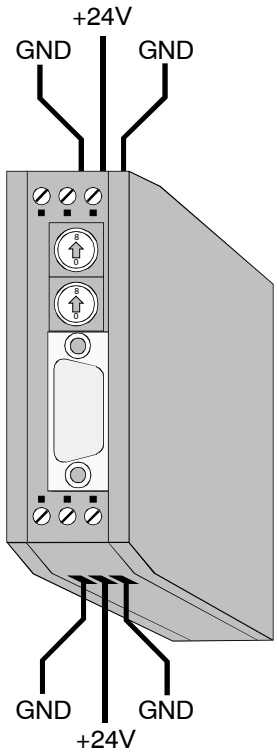


Figure 7: Power supply

6.5 Conductor Connection/Conductor Cross Sections

The following table contains an extract of the technical data of the cable plugs.

Characteristics	Connector Type[1]
	CAN Connector
Connector type plug component (Range of articles)	MSTB 2,5/..-STF-5,08
Connection method	screw connection
Conductor cross section solid min. / max.	0.2 / 2.5 mm²
Conductor cross section flexible min. / max.	0.2 / 2.5 mm²
Conductor cross section flexible, with ferrule without plastic sleeve min. / max.	0.25 / 2.5 mm²
Conductor cross section flexible, with ferrule with plastic sleeve min. / max.	0.25 / 2.5 mm²
Conductor cross section AWG/kcmil min. / max.	24 / 12
2 conductors with same cross section, solid min. / max.	0.2 / 1 mm²
2 conductors with same cross section, stranded min. / max.	0.2 / 1.5 mm²
2 conductors with same cross section, stranded, ferrules without plastic sleeve, min. / max.	0.25 / 1 mm²
2 conductors with same cross section, stranded, TWIN ferrules with plastic sleeve, min./ max.	0.5 / 1.5 mm²
Minimum AWG according to UL/cUL	30
Maximum AWG according to UL/cUL	12

1 Technical Data from Phoenix Contact website, printed circuit board connector, plug component

7. 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.

7.1 Standards concerning CAN Wiring

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

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

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

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

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

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

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

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

7.2.1 General Rules

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

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

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

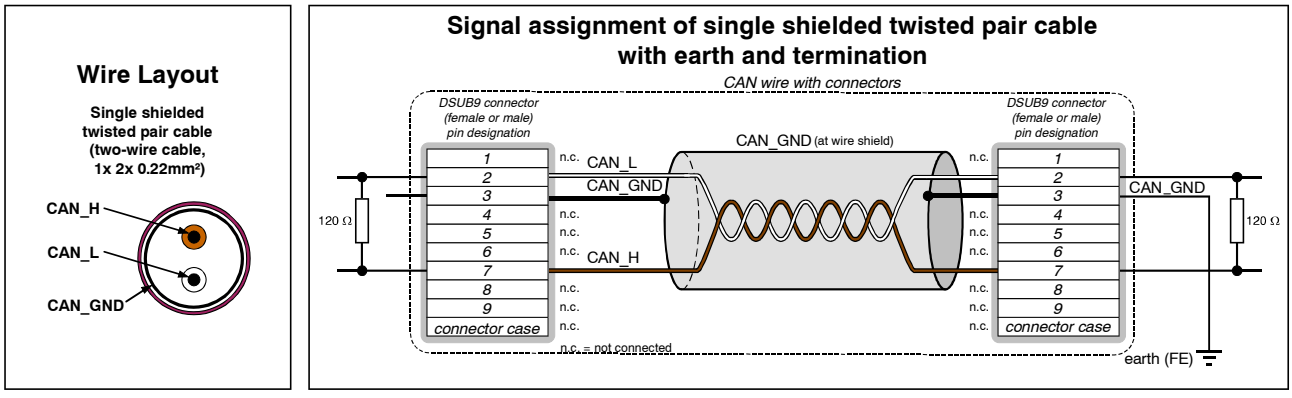


Figure 8: CAN wiring for light industrial environment

7.2.2 Cabling

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

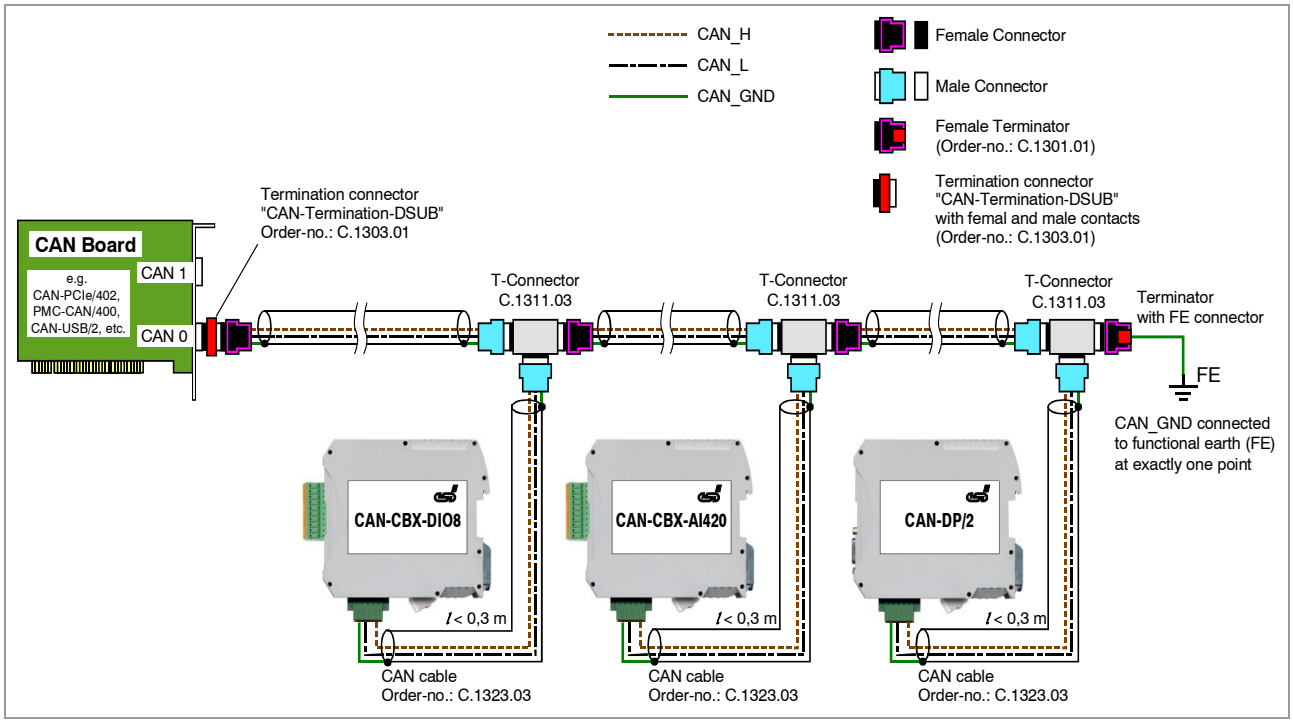


Figure 9: Example for proper wiring with single shielded single twisted pair wires

7.2.3 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 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.

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

7.3.1 General Rules

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

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

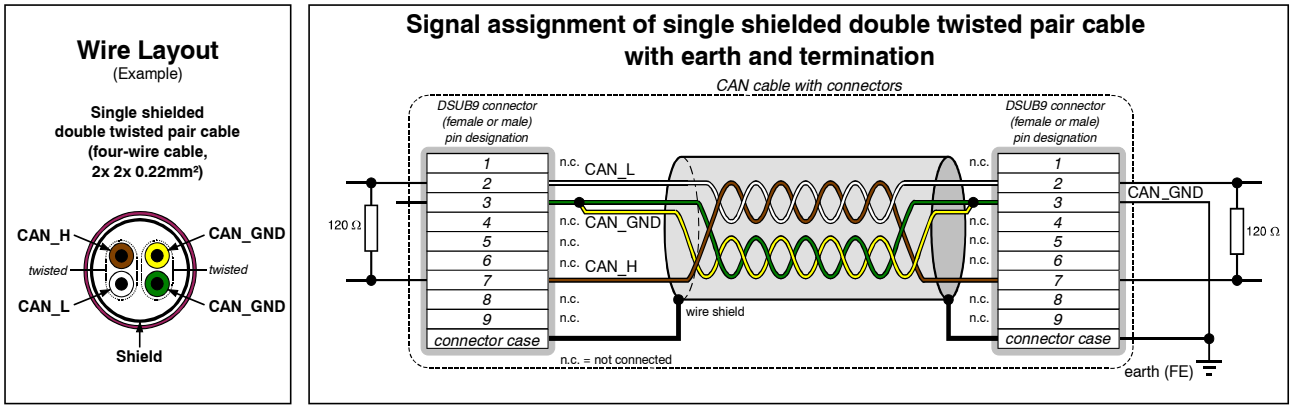


Figure 10: CAN wiring for heavy industrial environment

7.3.2 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!

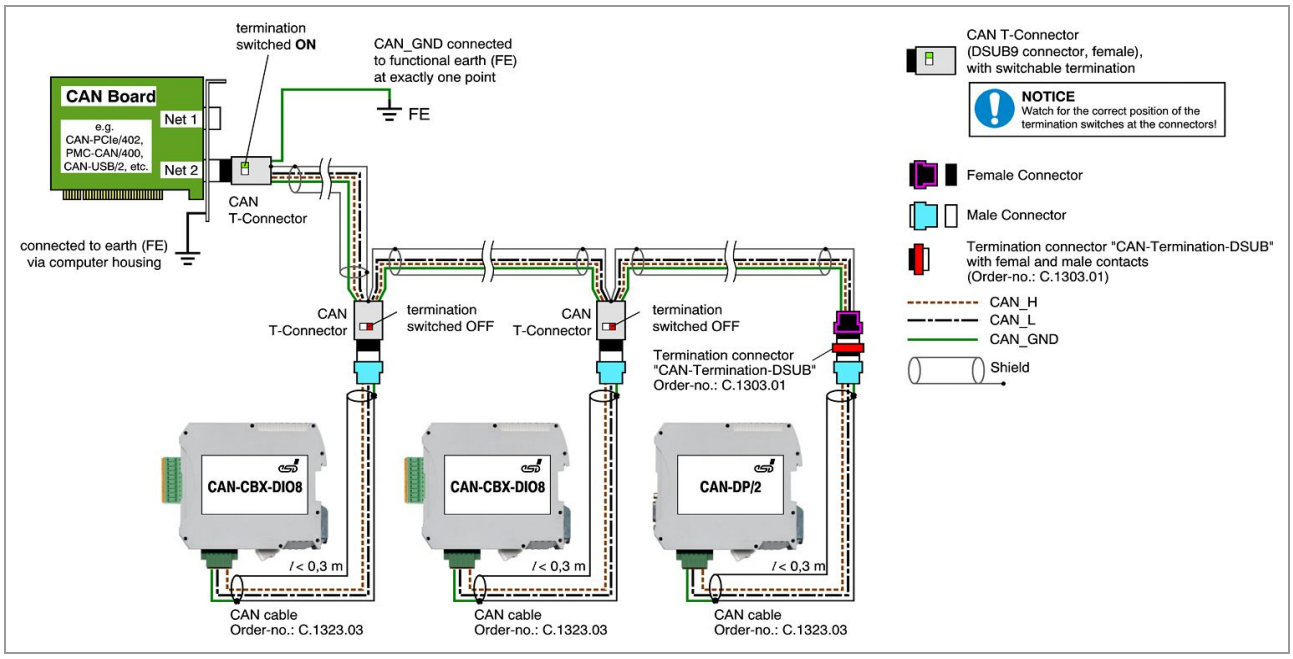


Figure 11: Example of proper wiring with single shielded double twisted pair cables

7.3.3 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 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).

7.4 Electrical Grounding

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

7.5 Bus Length

NOTICE
Please note that the cables, connectors and termination resistors used in CANopen networks shall meet the requirements defined in ISO11898-2.
In addition, further recommendations of the CiA, like standard values of the cross section, depending on the cable length, are described in the CiA recommendation CiA 303-1 (see CiA 303 CANopen Recommendation - Part 1: „Cabling and connector pin assignment“, Version 1.8.0, Table 2).

Bit-Rate [kbit/s]	Theoretical values of reachable wire length **with esd interface** l_{max} [m]	**CiA recommendations** (07/95) for reachable wire lengths l_{min} [m]	Standard values of the cross-section according to CiA 303-1 [mm²]
1000	37	25	0,25 to 0,34
800	59	50	0,34 to 0,6
666,6̄	80	-	
500	130	100	
333,3̄	180	-	
250	270	250	
166	420	-	0,5 to 0,6
125	570	500	
100	710	650	0,75 to 0,8
83,3̄	850	-	
66,6̄	1000	-	
50	1400	1000	
33,3̄	2000	-	not defined in CiA 303-1
20	3600	2500	
12,5	5400	-	
10	7300	5000	

Table 9: Recommended cable lengths at typical bit rates (with esd-CAN interfaces)

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

7.6 Examples for CAN Cables

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

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

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

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

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

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

8. CAN Troubleshooting Guide

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

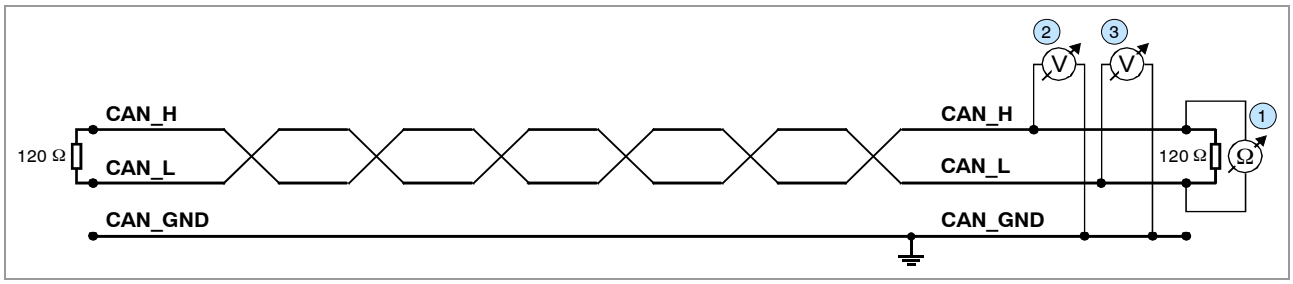


Figure 12: Simplified diagram of a CAN network

8.1 Termination

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

To test it ,please

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

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

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

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

8.2 Electrical Grounding

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

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

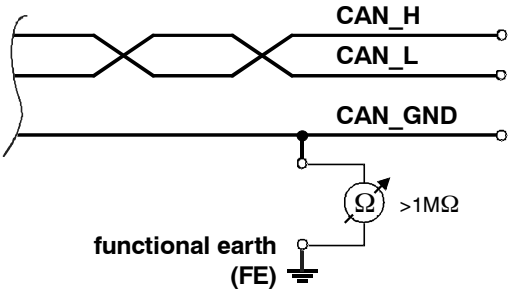


Figure 13: Simplified schematic diagram of ground test measurement

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

8.3 Short Circuit in CAN Wiring

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

8.4 CAN_H/CAN_L-Voltage

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

To test for faulty transceivers, please

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

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

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

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

8.5 CAN Transceiver Resistance Test

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

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

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

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

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

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

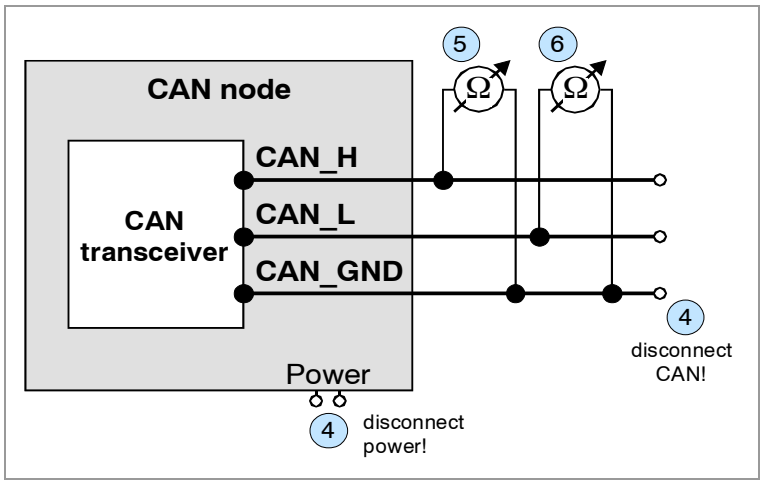


Figure 14: Measuring the internal resistance of CAN transceivers

8.6 Support by esd

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

9. 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
CAN-CBM-Bridge/2

Typ, Modell, Artikel-Nr.
Type, Model, Article No.
C.2853.02

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.
2145.1005.01,
H-Z00-0596-16

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, 2016-05-24

Rechtsgültige Unterschrift / *authorized signature*

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10. Order Information

Type	Properties	Order No.
CAN-CBM-Bridge/2	CAN-CBM-Bridge/2 Compact module-DIN rail mountable, - 2 CAN interfaces, physical layer according to ISO 11898, electrically isolated, up to 1 MBit/s, - firmware with Bridge functionality, - baudrate adjustable via software for each CAN Interface, - additional RS-232 is used for configuration	C.2853.02

Table 10: Order information

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-CBM-Bridge/2-ME	Hardware manual in English	C.2853.21

Table 11: 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.