CAN-CBM-CLOCK

Real Time Clock with CAN Interface

Hardware-Manual

to Product C.2836.03

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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 module. 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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Changes in the Chapters

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

Version	Chapter	Changes versus previous version
1.2	-	First English version
1.3	-	Safety Instructions and warning and other messages inserted, Classification inserted
	1.2	Note on chapter “Quick Start” inserted
	2.1	Value of current consumption changed
	2.6	New chapter: “RTC”
	3.1.1	Figure modified
	4.	New chapter “Quick Start”
	5.	Description of CAN connector added
	5.1	New chapter: “Conductor Connection/ Conductor Cross Section”
	6, 7	Chapters revised
	8	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 CAN-CBM-Clock module follow the instructions below and read the manual carefully to protect yourself and the CAN-CBM-Clock module from damage.
- The permitted operating position is specified as shown (Fig. 7). Other operating positions are not allowed.
- Do not use damaged or defective cables to connect the CAN-CBM-Clock module 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 objects.
- 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-Clock module 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.

- Do not open the housing of the CAN-CBM-Clock module.
- The CAN-CBM-Clock module has to be securely installed before commissioning.
- Never let liquids get inside the CAN-CBM-Clock module. Otherwise, electric shocks or short circuits may result.
- Protect the CAN-CBM-Clock module from dust, moisture and steam.
- Protect the CAN-CBM-Clock module from shocks and vibrations.
- The CAN-CBM-Clock module may become warm during normal use. Always allow adequate ventilation around the CAN-CBM-Clock module and use care when handling.
- Do not operate the CAN-CBM-Clock module 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-Clock is to be integrated.

Qualified Personal
This documentation is directed exclusively towards qualified personal 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-CBM-Clock module is the operation as a real time clock with CAN interface. The esd guarantee 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-Clock module is intended for indoor installation only.
- The operation of the CAN-CBM-Clock module in hazardous areas, or areas exposed to potentially explosive materials is not permitted.
- The operation of the CAN-CBM-Clock module for medical purposes is prohibited.

Service Note
The CAN-CBM-Clock module does not contain any parts that require maintenance by the user except the battery. Unauthorized intervention to the device voids warranty claims. For a battery change the case has to be opened.

NOTICE
The battery change may only be carried out by qualified personal! It is recommended to send the CAN-CBM-Clock module to esd for the battery change after 5 years.

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

Typographical Conventions

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

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

Number Representation
All numbers in this document are base 10 unless designated otherwise. For hexadecimal numbers $_h$ is appended . For example, 42 is represented as $2A_h$ in hexadecimal format.

Content

1. Overview

1.1 Description of the Module

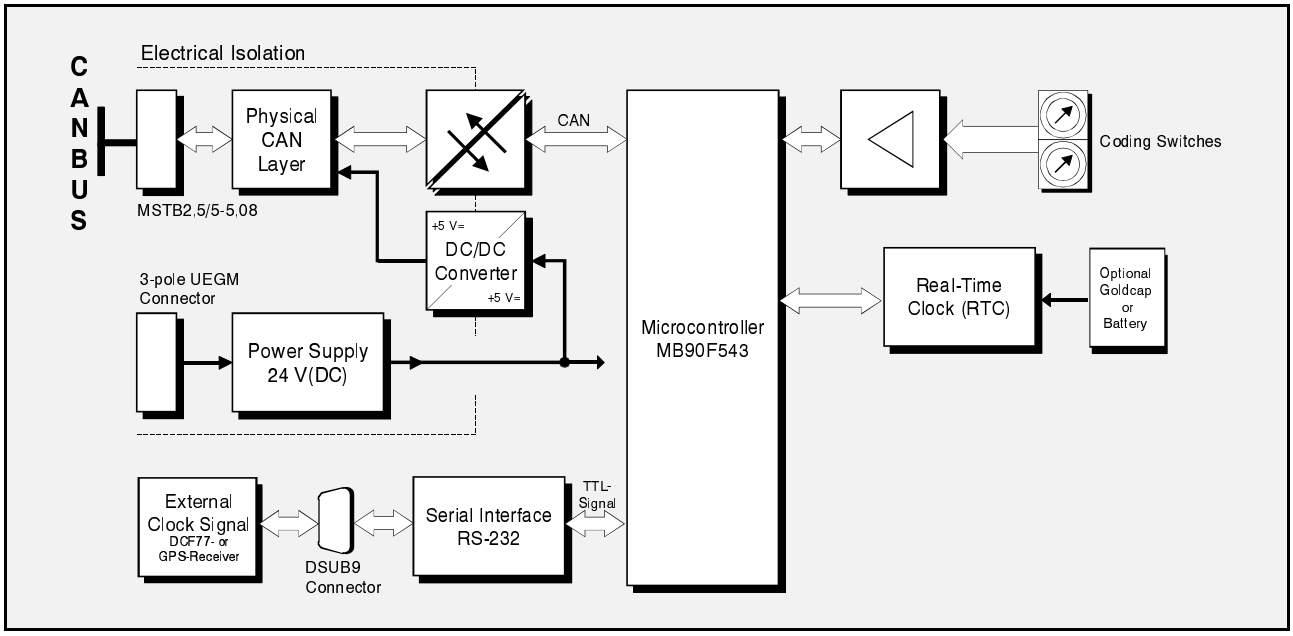


Figure 1: Block circuit diagram of the CAN-Clock module

The CAN-Clock module connects an external DCF77-receiver or an external GPS-receiver (NMEA protocol 0183-compatible) to the CAN bus. The time information is transmitted as time stamp. Furthermore the module is equipped with an internal real-time clock (RTC). The time information of the RTC can be transmitted as time stamp on the CAN bus, if the external clock signals fail to appear. The time data is given in CANopen format.

The module is operated by an MB90F543 microcontroller, which has built-in SRAM and CAN controller. The firmware is held in internal flash.

The ISO 11898-compliant CAN interface allows a maximum data transfer rate of 1 Mbit/s. The CAN-interface is electrically isolated via optocouplers and a DC/DC-converter. The CAN interface is connected via a 5-pin screw-/ plug connector in Combicon style.

The connection for the external time receiver is designed as serial RS232-interface with a DSUB9 connector.

1.2 View of the Module with Connectors and Coding Switches

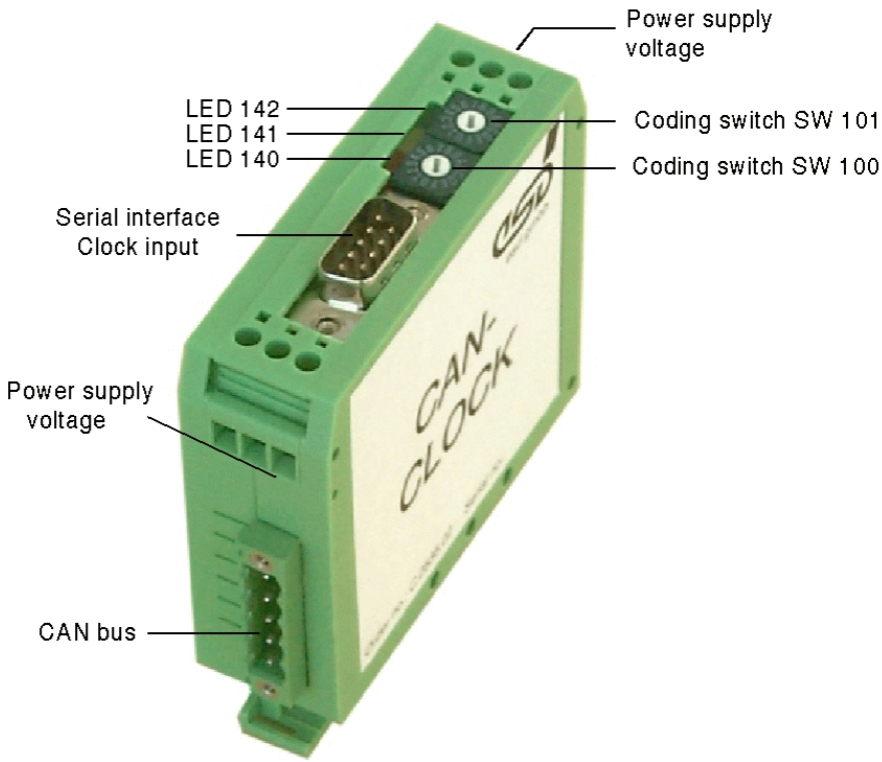
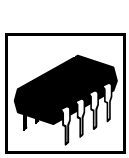


Figure 2: Position of the connectors and coding switches

NOTICE
Read chapter “Quick Start” on page 19, before you start with the installation of the hardware!



2. Technical Data

2.1 General Technical Data

Power supply voltage	nominal voltage 24 V/DC, input voltage range 12 V/DC ... 32 V/DC
current consumption	40 mA (at 24 V, 20 °C)
Connectors	X100 (DSUB9, male) - serial interface, external clock-signal X250 (Phoenix Contact, 5-pin MSTB2.5/5-5.08) - CAN net X300 (2x3-pin screw connector UEGM) - 24 V-power supply voltage
Temperature range	0 ... +50 °C ambient temperature
Humidity	max. 90 %, non-condensing
Dimensions	25 mm x 87 mm x 84 mm (W x H x D) (including mounting rail fitting and connector projection DSUB9, without CAN-connector)
Weight	approx. 120 g

Table 1: General technical data

2.2 Microcontroller Unit

Microcontroller	MB90F543
Memory	SRAM: integrated in MB90F543, 6 Kbyte Flash-EPROM: integrated in MB90F543, 128 Kbyte

Table 2: Microcontroller Unit

2.3 CAN Interface

Number of CAN interfaces	1x CAN
CAN controller	MB90F543, CAN 2.0A/B,
Electrical isolation of the CAN interfaces from other units	via optocoupler and DC/DC-converter reference voltage: 300 V_{DC}, 250 V_{AC}
Physical layer CAN	Physical Layer according to ISO 11898, transmission rate programmable from 10 Kbit/s up to 1 Mbit/s

Table 3: Data of the CAN interface

2.4 Serial Interface

Controller	MB90F543	
Interface	RS232, with auxiliary supply DCF77-receiver	
Connector	9-pin DSUB connector	
External receiver	GPS signal	NMEA Protocol, 0183 compatible (National Marine Electronics Association), worldwide available signal, bit rate: 4800 baud (constant), e.g.: eTrex of Gamin (NMEA 0183)
	DCF77 signal	radio signal of the time measurement standard of the Physikalisch-Technische Bundesanstalt, transmitter: Mainflingen, reach approx. 2000 km highly stable carrier frequency: 77.5 kHz e.g.: Expert mouseClock of Gude GmbH

Table 4: Data of the serial interface

2.5 RTC

The CAN-CBM-Clock module is equipped with an internal RTC (Real Time Clock). The RTC is powered by a lithium coin cell. For a battery change the case of the CAN-CBM-Clock module has to be opened.

NOTICE
The battery change may only be carried out by qualified personal! It is recommended to send the CAN-CBM-Clock module to esd for the battery change after 5 years.

Frequency tolerance of the RTC	maximum (at 25˚C): ±20ppm
Hold-up time	Minimum: 5 years, typical: 8 years
Battery	Type: Coin cell, 3 V, Lithium-battery (CR1220) Self-discharge: typical 1% per year at 23˚C Storage life: typical 10 years

Table 5: Data of the real time clock

2.6 Software

The CAN-Clock module operates with the CANopen-protocol according to CiA Draft-Standard 401.
Times are transmitted to the CAN bus in CANopen-format
coding of time: in milliseconds after midnight
coding of date: in days since January 1st, 1984
(please refer to the software manual of the CAN-Clock module)

3. Description of the Units

3.1 CAN Interface

3.1.1 Interface Circuit

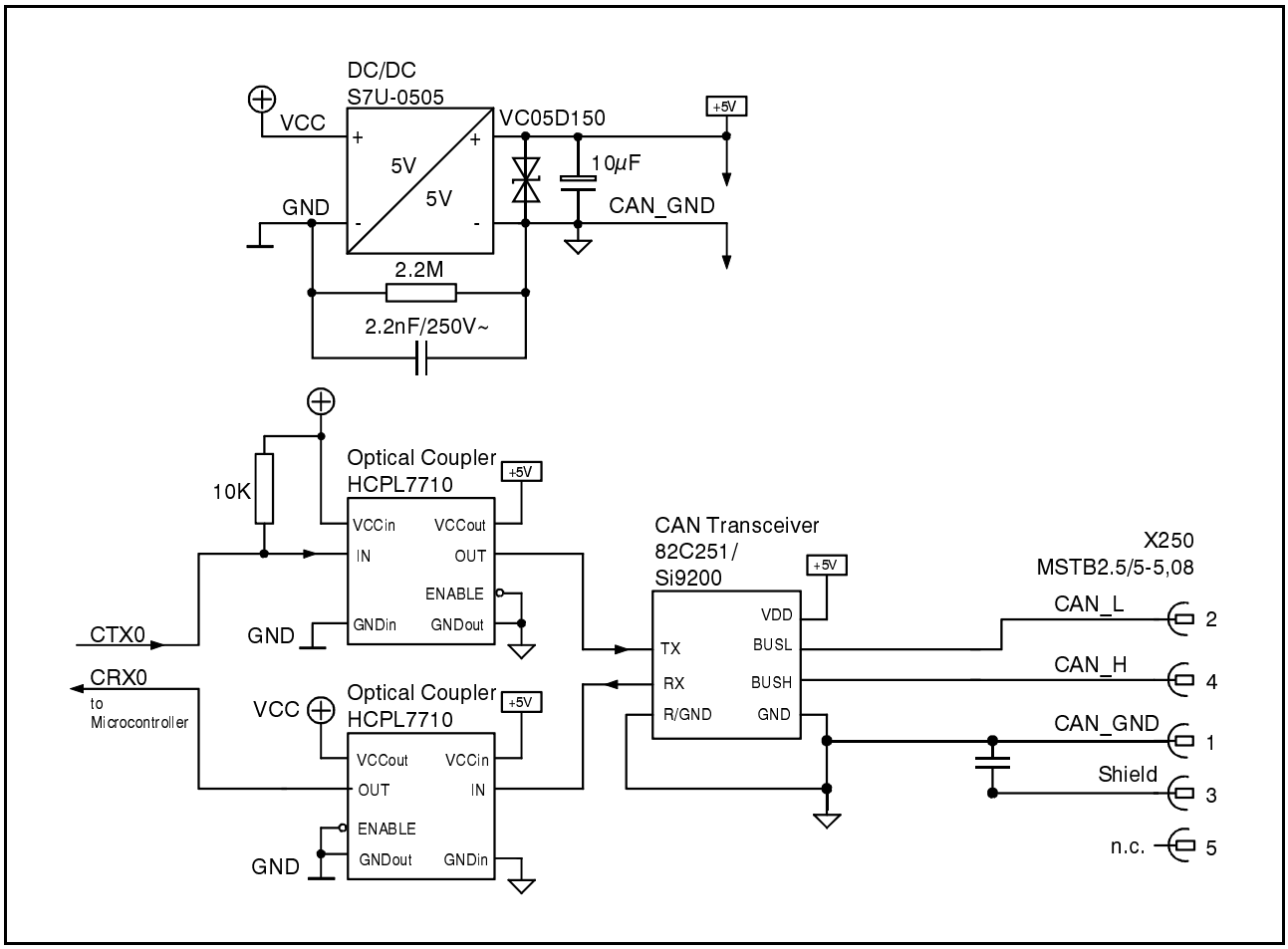
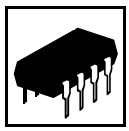


Figure 3: Circuit of the CAN interfaces



3.2 Serial Interface

3.2.1 Default Setting of the Module

Bit rate:	4800 baud
Data bits:	8
Parity:	no
Stop bits:	1
Handshake:	none

3.3 Setting Node Number and CAN Bit Rate via Coding Switch

With the coding switches the CANopen node number and the CAN bit rate can be set.

If the position of the coding switches is evaluated as bytes, the assignment is:
Coding switch SW101 (upper switch *): High-nibble
Coding switch SW100 (lower switch *): Low-nibble
* Module is mounted on the mounting rail with the LEDs up.

3.3.1 Overview of the Coding Switch Settings

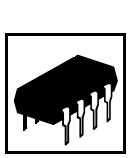
Coding switch position (when switching on)	Interpretation by the firmware
0	bit rate will be set
$01...7F_h$	setting of the CANopen node number (node-ID)
$80_h...FE_h$	reserved for future applications
FF_h	firmware update

Table 6: Index of the bit rate

3.3.2 Setting the CAN Bit Rate

To set the CAN bit rate the following steps have to be made:

1.	Switch the module off
2.	Position both coding switches to ‘0’
3.	Switch the module on; LED141 (yellow) and LED 142 (green) turn on
4.	Select the bit rate and position switch SW100 correspondingly (table of bit rates see below)
5.	To accept the new bit rate position the switch to ‘1’; LED141 turns off
6.	Switch off the module
7.	Set CANopen node number (see page 17)



3.3.3 Assignment of the Position of the Coding Switch to the CAN Bit Rates

Position of the Coding Switch SW100	Bit Rate [Kbit/s]
0	1000
1	666.6
2	500
3	333.3
4	250
5	166
6	125
7	100
8	66.6
9	50
A	33.3
B	20
C	12.5
D	10
E	reserved
F	reserved

Table 7: Index of the bit rates

3.3.4 Setting the CANopen Node Number

To set the CANopen node number (Node-ID) carry out the steps described below:

1.	Switch off the module
2.	Set the node number with the coding switches: Position 01_h...$7F_h$: CANopen node number (nibble assignment, see above)
3.	Switch on the module If the coding switches are positioned to a value between 01_h...$7F_h$, this value is interpreted as node number.

3.4 LED Display

Function	Name	Colour	Indicator State	Meaning
Power	LED142	green	off	Module is off
			on	Module is on
Bit rate mode	LED141	yellow	off	Module is off or bit rate setting mode is inactive
			blinking	DCF77 Operation: LED flashes in the clock pulse of the DCF77-signal - short blinking followed by a long off phase: incorrect signal - short turning off followed by a long on phase: correct signal
				GPS Operation: Reception of a valid time telegram ($GPRMC)
			on	Bit rate setting mode is active
Failure	LED140	rot	off	Module off or no failure
			on	Failure, no bit rate is set

Table 8: Meaning of the indicator states of the LEDs

4. Quick Start

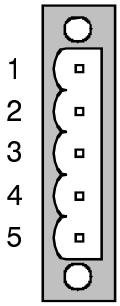
Step	Action	See page
	**Read the safety instructions at the beginning of this document carefully, before you start with the hardware installation!**	4
	**DANGER** Hazardous Voltage - Risk of electric shock. All current circuits which are connected to the device have to be sufficiently protected against hazardous voltage (SELV according to EN 60950-1).	
1	Mount the CAN-CBX-module and connect the interfaces (power supply voltage, CAN, serial interface).	-
2	Please note that the CAN bus has to be terminated at both ends! esd offers special T-connectors and termination connectors. Additionally the CAN_GND signal has to be connected to earth at exactly one point in the CAN network. A CAN node with electrical connection to earth potential acts as an earth potential.	24
	**NOTICE** **Please note the chapter "Correct Wiring of Electrically Isolated CAN Networks"!**	
3	Set the baud rate. The baud rate can be set via the coding switch SW100 as described in chapter: "Setting the CAN Bit Rate".	16
4	Set the module number (node-ID). The node ID can be set via the coding switches LOW and HIGH. It may be set to values between 1 and 127 (01-7F$_h$).	17
5	Apply the 24 V power supply voltage.	-

5. Connector Assignment

5.1 CAN Bus (X250, Combicon-Style)

Device connector: Phoenix Contact socket MSTB2,5/5-GF-5,08
Connector plug:: Phoenix Contact MSTB 2,5/5-STF-5,08 (screw connection, included in the scope of delivery). For conductor connection and conductor cross section see page 21.

Pin Position:



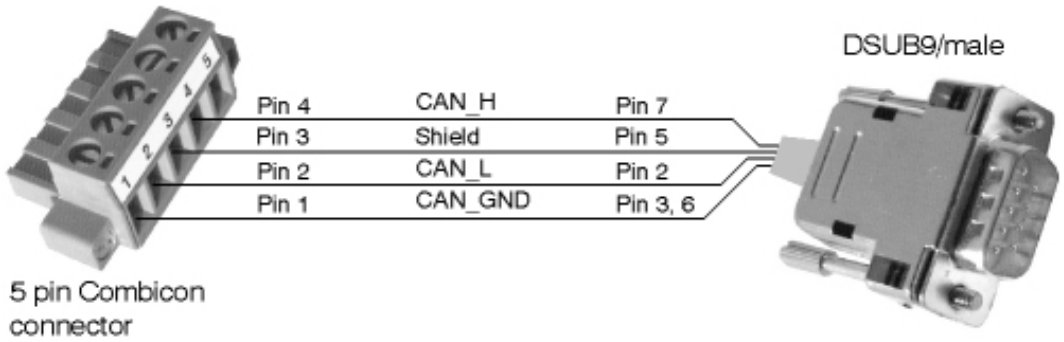
(view of socket)

Pin Assignment:

Pin	Signal
1	CAN_GND
2	CAN_L
3	Shield
4	CAN_H
5	n.c.

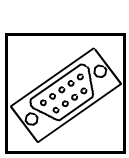
Signal description:

CAN_L, CAN_H... CAN signal lines
CAN_GND ... reference potential of the CAN physical layers
Shield... shielding



The 9-pin DSUB connector is assigned in accordance with CiA DS 102.

Figure 4: Adapter cable 5-pin connector plug to 9-pin DSUB



5.1.1 Conductor Connection/Conductor Cross Sections

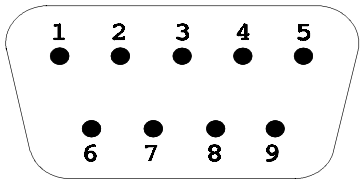
The following table contains an extract of the technical data of the connector plug.

Interface	CAN-Connector[1]
Connector type plug component (type series)	MSTB 2,5/5-STF-5,08
Connection method	screw connection
Stripping length	7 mm
Conductor cross section solid min. / max.	0.2 mm²/2.5 mm²
Conductor cross section stranded min. / max.	0.2 mm²/2.5 mm²
Conductor cross section stranded, with ferrule without plastic sleeve min. / max.	0.25 mm²/2.5 mm²
Conductor cross section stranded, with ferrule with plastic sleeve min. / max.	0.25 mm²/2.5 mm²
Conductor cross section AWG/kcmil min.	24/12
2 conductors with same cross section, solid min./ max.	0.2 mm²/1 mm²
2 conductors with same cross section, stranded min./max.	0.2 mm²/1.5 mm²
2 conductors with same cross section, stranded, ferrules without plastic sleeve, min./max.	0.25 mm²/1 mm²
2 conductors with same cross section, stranded, TWIN ferrules with plastic sleeve, min./max.	0.5 mm²/1.5 mm²
Minimum/Maximum AWG according to UL/CUL	30/12

[1] Technical Data from Phoenix Contact website, connector plug

5.2 Serial Interface (X100, 9 pin DSUB, male)

Pin Assignment:



Pin Position:

Signal	Pin		Signal
n.c	6	1	n.c
Vcc_help	7	2	RxD (Input)
n.c	8	3	TxD (Output)
Vcc_out	9	4	-Vcc_help
		5	GND

9-pin DSUB connector

n.c. ... not connected
Vcc_help... 9 V output voltage
auxiliary supply for DCF77-receiver (e.g.: Expert mouseClock of Gude)
-Vcc_help... -9 V output voltage
auxiliary supply for DCF77-receiver
Vcc_ out... 5 V output voltage
power supply voltage for other DCF77- or GPS-receiver

5.3 Power Supply (X101, UEGM)

Voltage is supplied by means of the screw connector UEGM, integrated in the case. It can be connected to lines with a cross-section of up to 2.5 mm².

Assignment of the screw connectors is the same on both sides of the case. They can be used alternatively. The center contact is for +24 V and the two outer contacts are for GND.

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

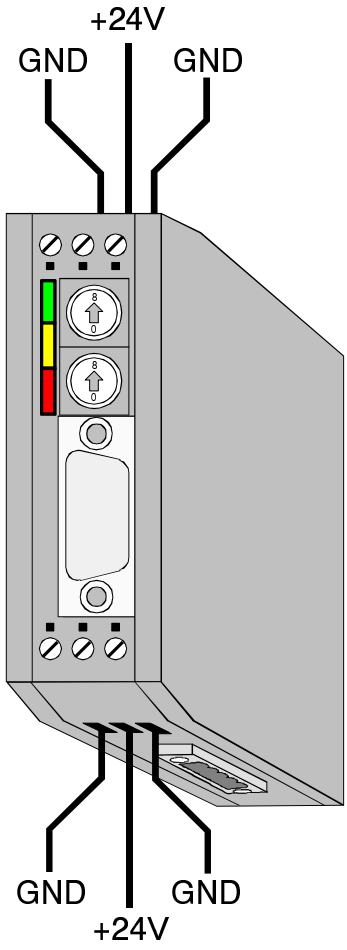


Figure 5: Voltage supply

6. Correct Wiring of Electrically Isolated CAN Networks

For the CAN wiring all applicable rules and regulations (EC, 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. Please note that using this flexibility requires a network designed in consideration of the interactions of all network parameters.

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 the special features of the derived standards CANopen, ARINC825, DeviceNet and NMEA2000 are not described in this wiring hints.

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

- Reliable 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 to the specifications of CANopen, ARINC825, DeviceNet and NMEA2000, **however it must be observed that it is strictly not recommended to mix the wiring guidelines of the various specifications!**

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 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.

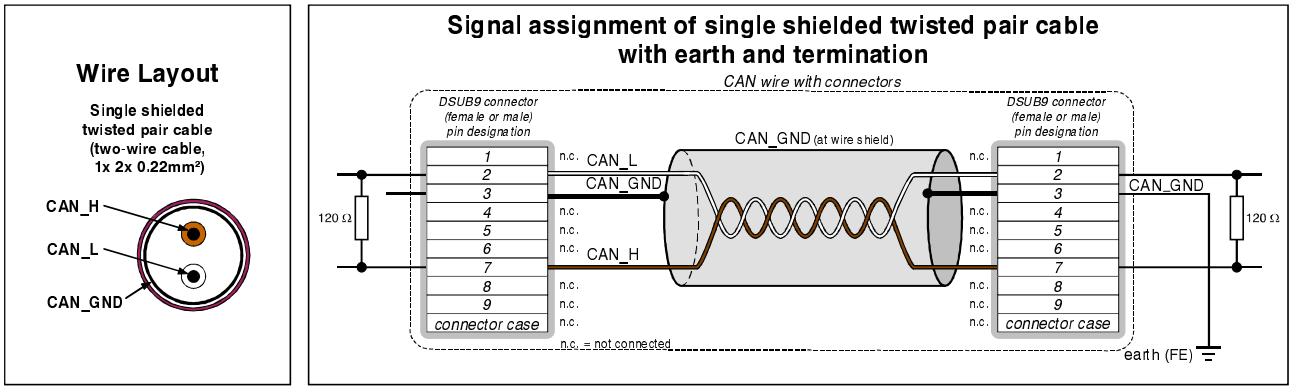


Figure. 6: CAN wiring for light industrial environment

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.

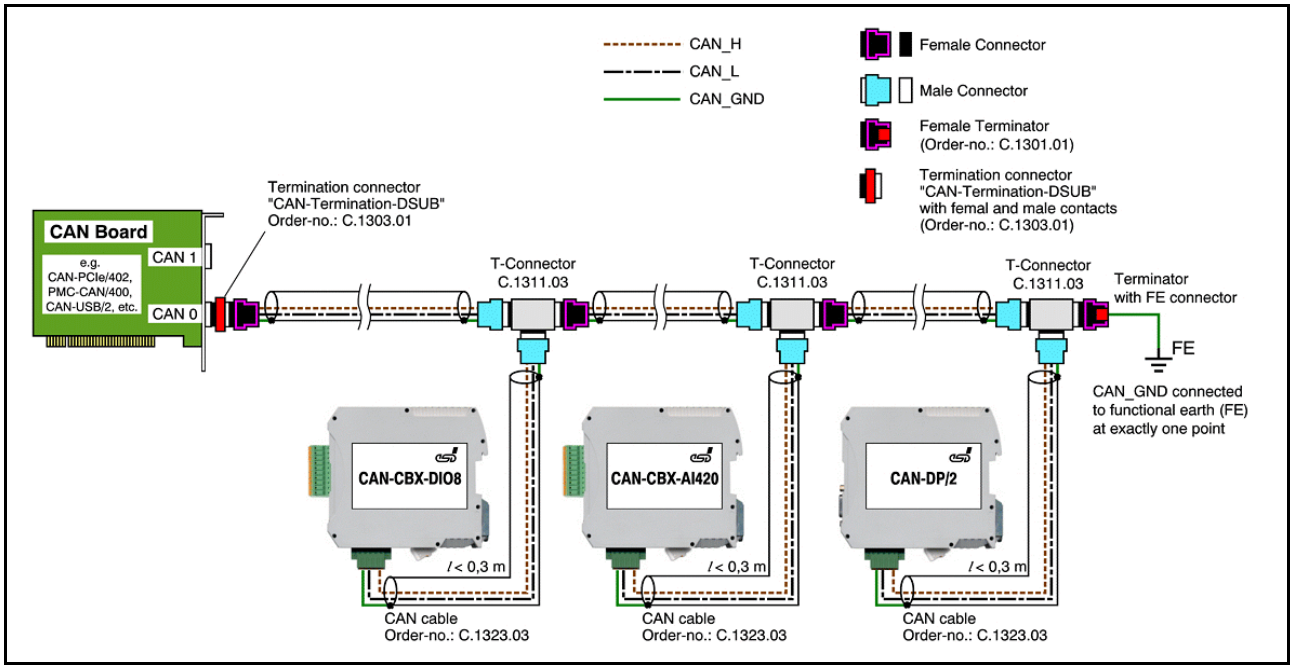


Figure. 7: Example for proper wiring with single shielded single twisted pair wires

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 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 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 cannot be avoided, double shielded cables are recommended.

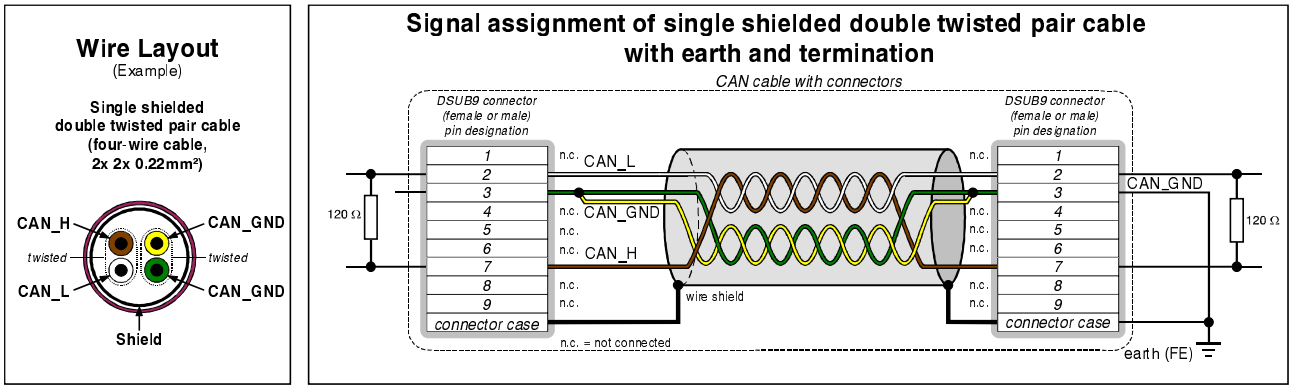


Fig. 8: CAN wiring for heavy industrial environment

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!

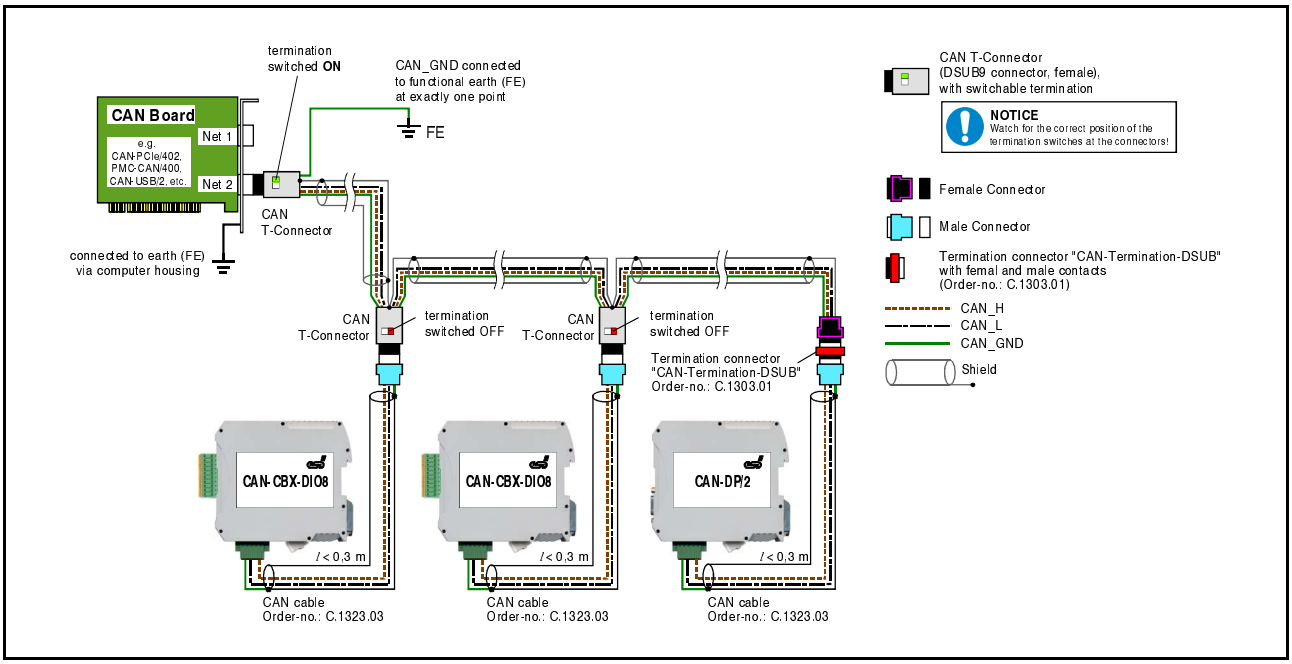
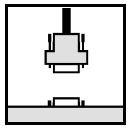


Fig. 9: Example for proper wiring with single shielded double twisted pair cables

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 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 an earthing 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

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 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.$\overline{6}$	80	-	
500	130	100	
333.$\overline{3}$	180	-	
250	270	250	
166	420	-	0.5 to 0.6
125	570	500	
100	710	650	0.75 to 0.8
83.$\overline{3}$	850	-	
66.$\overline{6}$	1000	-	
50	1400	1000	
33.$\overline{3}$	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.

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.de	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) Part No.: 93 022 016 (UL appr.) BUS-Schleppflex-PUR-C (1x 2x 0.25 mm²) Part 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.de	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) Part No.: 93 022 026 (UL appr.) BUS-Schleppflex-PUR-C (2x 2x 0.25 mm²) Part 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.

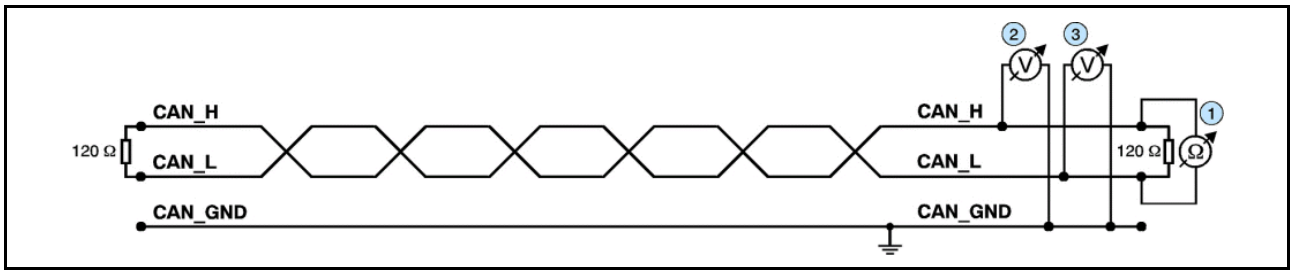


Figure. 10: Simplified diagram of a CAN network

7.1 Termination

The termination is used to match the 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

CAN_GND of the CAN network should be connected to 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.

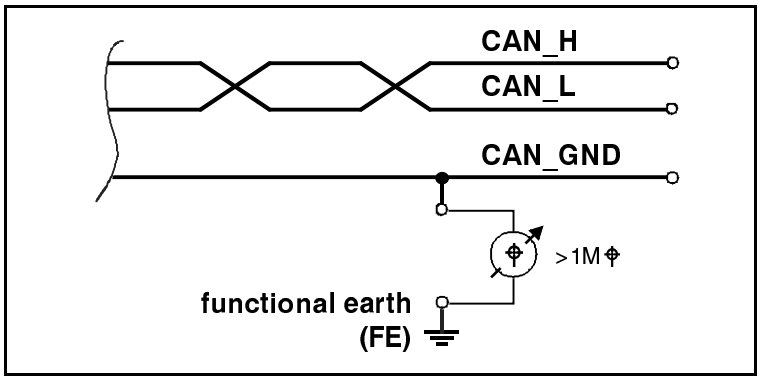


Fig. 11: Simplified schematic diagram of ground test measurement

The measured resistance should be higher than 1 M Ω. 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 is probably faulty. Another indication for a faulty transceiver is a very high deviation between the two measured input resistances (>> 200%).

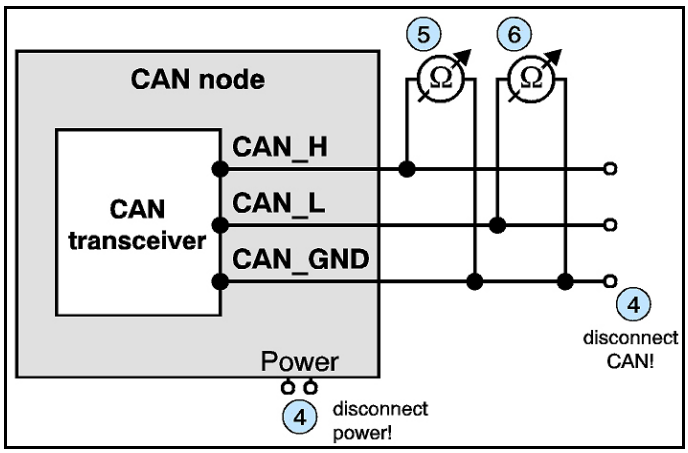


Figure 12: Simplified diagram of a CAN node

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	Features	Order No.
CAN-CBM-Clock-Battery	CAN-CBM-Clock - Battery CAN-CBM-Clock Clock-Distribution DCF/GPS CANbloc-Mini-Modul (CANopen) - for clock distribution on CAN-Bus - input signal via DCF (see list of supported receivers, RS232) or - input signal via GPS (NMEA, RS232) - backup by local RealTime-Clock (RTC) with battery - CAN interface ISO-11898 with galvanic isolation up to 1 MB/s	C.2836.03

Table 10: Order information

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

Manuals		Order No.
CAN-CBM-Clock-ME	Manual in English	C.2836.21
CAN-CBM-Clock-MD	Manual in German	C.2836.20

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.