CAN-CBX-AO412

4 Analog Outputs, 12-Bit

Manual

to Product C.3040.02

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Firmware version:	Rev. 2.04

Changes in the chapters

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

Version	Chapter	Changes versus previous version
1.2	-	Note to Safety Instructions , conformity etc. and Typographical Conventions inserted
	2.	Technical data changed
	3.1	Note to Conductor Connection /Conductor Cross Section inserted
	3.2	Description of the LEDs updated
	3.3	Figure updated, description of the coding switches and baud rates revised
	4.	Former chaper “Description of the Units”moved to sub-section of chapter “Connector Assignment”. Connector Assignments revised, note to “Conductor Connection /Conductor Cross Section” inserted
	5.	Chapter moved and updated
	6.	Chapter moved and updated
	7.	Chapter “Software” renamed to “CANopen-Firmware”, general part (chapter 7.1 - 7.4) updated and restructured
	7.6	Parameter description inserted
	7.8	Chapter to “Definition of Terms” inserted
	7.9.1	Product-specific Properties CAN-CBX-AO412 inserted in table, new objects 1005_h, 1006_h, $100E_h$, 1019_h, 1029_h, $1F80_h$, $1F91_h$
	7.9.2-7.9.21	Chapter revised, description of the product-specific properties only contained in the table in “Overview of Communication Profile Objects with Product-Specific Values” (chapter 7.9.1)
	7.9.22	New chapter “NMT Startup ($1F80_h$)”
	7.9.23	New Chapter “Self Starting Nodes Timing Parameters ($1F91_h$)”
	7.10	“Overview of the implemented Objects” inserted, , description of objects 6443_h and 6444_h inserted
	7.11	Description of objects $2404_h$and 2405_h inserted, description of object 2000_h is transferred to object 2404_h
	8.	Chapter revised
	9.	EU Declaration of Conformity inserted
	10.	“Order Information” moved

Technical details are subject to change without further notice.

Safety Instructions

- When working with CAN-CBX modules follow the instructions below and read the manual carefully to protect yourself and the CAN-CBX module from damage.
- The permitted operating position is specified as shown (Fig. 7). Other operating positions are not allowed.
- Do not open the housing of the CAN-CBX module
- Never let liquids get inside the CAN-CBX module. Otherwise, electric shocks or short circuits may result.
- Protect the CAN-CBX module from dust, moisture and steam.
- Protect the CAN-CBX module from shocks and vibrations.
- The CAN-CBX module may become warm during normal use. Always allow adequate ventilation around the CAN-CBX module and use care when handling.
- Do not operate the CAN-CBX module adjacent to heat sources and do not expose it to unnecessary thermal radiation. Ensure an ambient temperature as specified in the technical data.
- Do not use damaged or defective cables to connect the CAN-CBX 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 domestic animals, or 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-CBX 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.

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.

Conformity

The CAN-CBX module 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 CBX-module may cause radio interferences in which case the user may be required to take adequate measures.
Note:	To ensure EU Conformity a cable with a maximum wire length of 3 m has to be used for the analog outputs

Intended Use

The intended use of the CAN-CBX module is the operation as a CANopen module with analog outputs.
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-CBX module is intended for indoor installation only.
- The operation of the CAN-CBX module in hazardous areas, or areas exposed to potentially explosive materials is not permitted.
- The operation of the CAN-CBX module for medical purposes is prohibited.

Service Note

The CAN-CBX module does not contain any parts that require maintenance by the user. The CAN-CBX module 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.

Contents

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*

The following indicators are used to highlight noticeable descriptions.

Attention:
Warnings or cautions to tell you about operations which might have unwanted side effects.

Note:
Notes pointing out something important or useful.

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.

1. Overview

1.1 Description of the Module

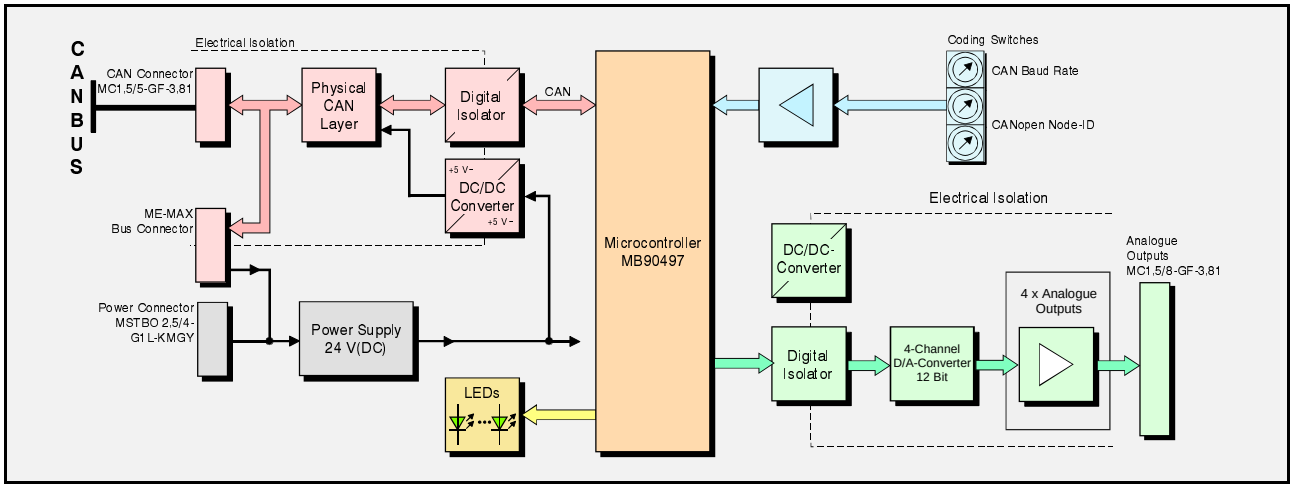


Fig. 1: Block circuit diagram of the CAN-CBX-AO412 module

The CAN-CBX-AO412 module is equipped with a MB90F497 microcontroller, which buffers the CAN data into a local SRAM. The firmware is stored in the Flash. Parameters are stored in a serial EEPROM.

The four analog outputs are converted via a LTC2620 12-bit-D/A-converter.
The outputs are connected via an 8-pin screw-/plug connector. The analog outputs are electrically isolated by digital isolators for the protection of the other components.

The power supply voltage and the CAN-bus-connection can either be fed via the InRailBus connector, integrated in the top-hat-rail or via separate plugs.

The ISO 11898-compliant CAN interface allows a maximum data transfer rate of 1 Mbit/s. The CAN-interface is electrically isolated by a digital isolator and a DC/DC-converter.

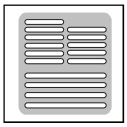
The CANopen node number and the CAN-bit rate can be configured via three coding switches.

2. Technical Data

2.1 General technical Data

Power supply voltage	Nominal voltage: 24 V/DC Input voltage range: 24 V ±20% Current consumption (load-free, typically, 24 V, 20 ˚C): 42 mA
Connectors	24 V (4-pin printed circuit board connector with spring-cage connection, X100) - 24 V-power supply voltage InRailBus (5-pin ME-MAX-TBUS connector, Phoenix Contact X101) - CAN interface and power supply voltage via InRailBus 1G... 4O (8-pin printed circuit board connector with spring-cage connection, X500) - analog outputs CAN (5-pin printed circuit board connector with spring-cage connection, X400) - CAN interface Only for test- and programming purposes: X200 (6-pin SMD socket strip) the connector is placed inside the case
Temperature range	-20 ˚C ... +60 ˚C ambient temperature
Humidity	max. 90%, non-condensing
Protection class	IP20
Pollution degree	maximum permissible according to DIN EN 61131-2: Pollution Degree 2
Housing	Plastic housing for carrier rail mounting NS35/7,5 DIN EN 60715
Dimensions	width: 22.5 mm, height: 99 mm, depth: 114.5 mm (including mounting rail fitting and connector projection, without mating plug)
Weight	approx. 130 g

Table 1: General data of the module



2.2 CPU-Unit

CPU	16 bit µC MB90F497
RAM	2 Kbyte integrated
Flash	64 Kbyte integrated
EEPROM	minimum 256 byte

Table 2: Microcontroller

2.3 CAN-Interface

Number	1
Connector	5-pin line connector with spring-cage connections or via Phoenix Contact TBUS-connector (InRailBus)
CAN-Controller	MB90F497, ISO 11898-1, (CANopen-software only 11-bit CAN-identifiers are supported)
Electrical isolation of the CAN interface against other units	via dual-channel digital isolator and DC/DC-converter
Physical CAN Layer	Physical Layer according to ISO 11898-2, transfer rate programmable from 10 Kbit/s up to 1 Mbit/s
Bustermination	has to be set externally if required

Table 3: Data of the CAN-interface

2.4 Analog Outputs

Number	4 D/A-converter channels
Converter type	LTC2620
Resolution	12 bit + VZ
Output voltage range	± 10 V
Output current	maximum: 10 mA
Minimum load resistor	> 1 kΩ/channel
Electrical isolation of the interface against other units	via four-channel digital isolator (IL717-3)

Table 4: Data of the analog outputs

2.5 Software Support

The firmware of the module supports CANopen® according to CiA ® CANopen specifications CiA 301 [1] and CiA DS-401 [2].

The CAN-CBX-AO412 EDS file can be downloaded from the esd website www.esd.eu.

3. Hardware Installation

3.1 Connecting Diagram

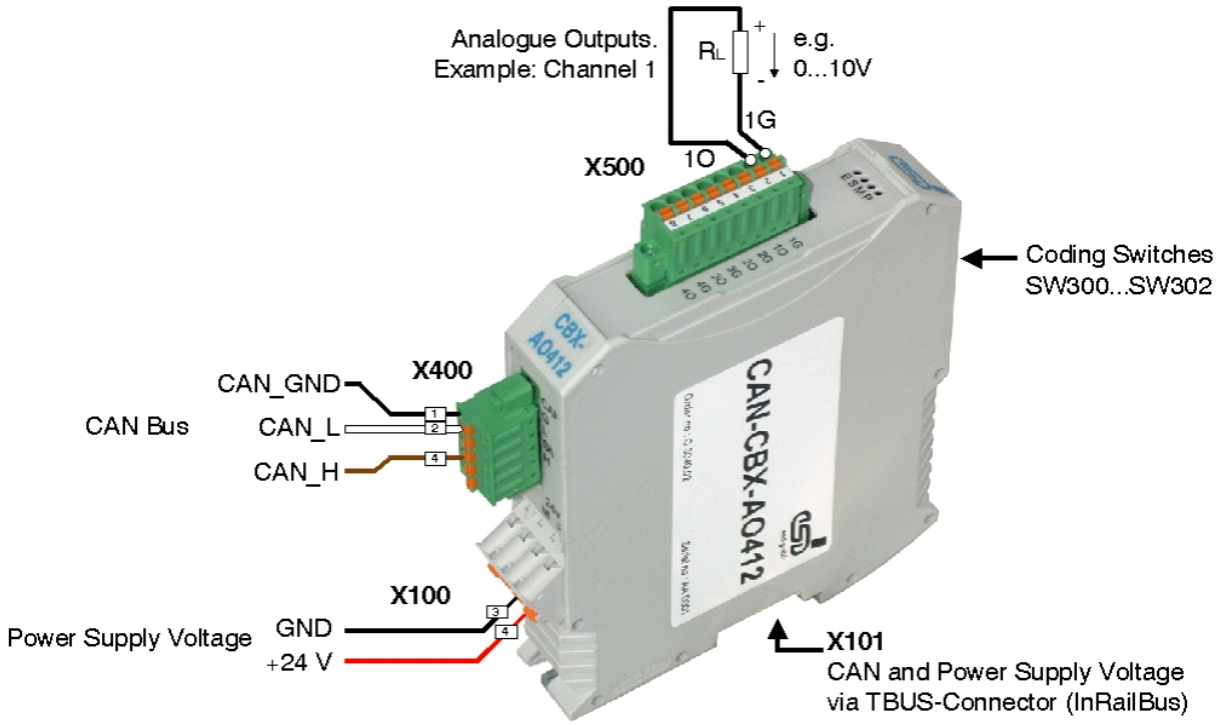


Fig. 2: Connection of the CAN-CBX-AO412 module

Note:
The connector pin assignment can be found on page 24 and following.
For conductor connection and conductor cross section see page 30.

3.2 LED Display

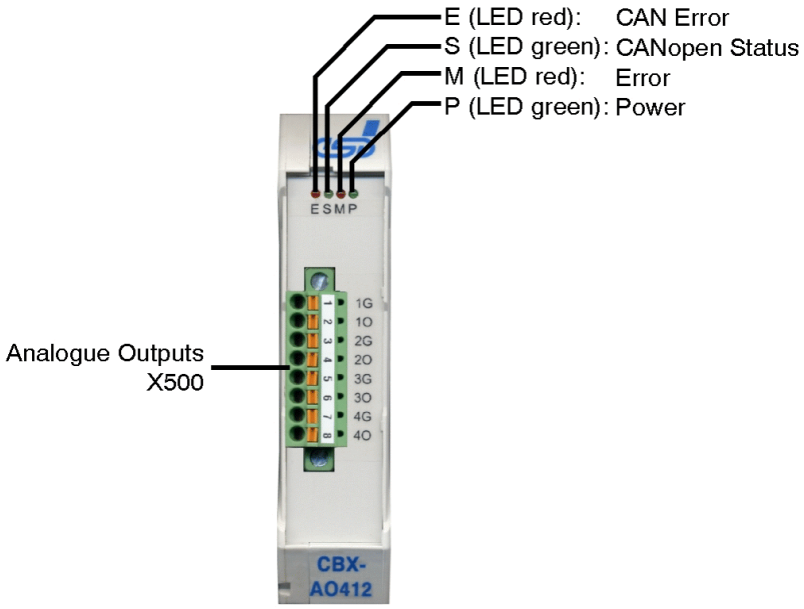


Fig. 3: Position of the LEDs in the front panel

The CAN-CBX-AO412 module is equipped with four Status-LEDs. The terms of the indicator states of the LEDs are chosen in accordance the terms recommended by the CiA [3]. The indicator states are described in the following chapters.

3.2.1 Indicator States

In principle the are 8 indicator states distinguished:

Indicator state	Display
on	LED on
off	LED off
blinking	LED blinking with a frequency of approx. 2.5 Hz
flickering	LED flickering with 10 Hz
1 flash	LED 200 ms on, 1400 ms off
2 flashes	LED 200 ms on, 200 ms off, 200 ms on, 1000 ms off
3 flashes	LED 2x (200 ms on, 200 ms off) + 1x (200 ms on, 1000 ms off)
4 flashes	LED 3x (200 ms on, 200 ms off) + 1x (200 ms on, 1000 ms off)

Table 5: Indicator states of the LEDs

Note:
Red and green LEDs are strictly switched in phase opposition according to the CANopen Specification [3].
For certain indicator states viewing all LEDs together might lead to a misinterpretation of the indicator states of adjacent LEDs. It is therefore recommended to look at the indicator state of an LED individually, in covering the adjacent LEDs.

3.2.2 Operation of the CAN-Error LED

LED indication			Display function	
Label	Name	Colour	Indicator state	Description
E	CAN Error	red	off	no error
			1 flash	CAN controller is in *Error Active* state
			on	CAN controller state is *Bus Off* (or coding switch position ID-node > $7F_h$ when switching on; see 'Special Indicator States'on page 16)
			2 flashes	Heartbeat or Nodeguard error occurred. The LED automatically turns off, if Nodeguard/Heartbeat-messages are received again.

Table 6: Indicator states of the red CAN Error-LED

3.2.3 Operation of the CANopen-Status LED

LED indication			Display function	
Label	Name	Colour	Indicator state	Description
S	CANopen Status	green	blinking	*Pre-operational*
			on	*Operational*
			1 flash	*Stopped*
			3 flashes	Module is in bootloader mode, the power LED is off, (or coding switch position ID-node > $7F_h$ when switching on; see page 16)

Table 7: Indicator states of the CANopen Status-LED

3.2.4 Operation of the Error-LED

LED indication			Display function	
Label	Name	Colour	Indicator state	Description
M	Error	red	off	no error
			on	CAN Overrun Error The sample rate is set so high, that the firmware is not able to transmit all data on the CAN bus.
			2 flashes	Internal software error e.g.: - stored data have an invalid checksum therefore default values are loaded - internal watchdog has triggered - indicator state is continued until the module resets or an error occurs at the outputs.

Table 8: Indicator state of the Error-LED

3.2.5 Operation of the Power-LED

LED indication			Display function	
Label	Name	Colour	Indicator state	Description
P	Power	green	off	no power supply voltage; or the module is in Bootloader-Mode, this state is indicated by the CANopen status-LED (3 Flashes)
			on	power supply voltage is on and application software is running

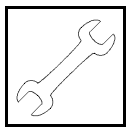
Table 9: Indicator state of the Power-LED

3.2.6 Special Indicator States

The special indicator state described in the following table is indicated by the CANopen-Status-LED and the CAN-Error-LED together:

LED indication	Description
CANopen-Status LED: 3 flashes and CAN-Error LED: on	The coding switches for the Node-ID are set to an invalid ID-value, when switching on. The firmware application will be stopped.

Table 10: Special Indicator States



3.2.7 Assignment of LED Labelling to Name in Schematic Diagram

Labelling on CAN-CBX-AO412	Name of the LED in Schematic Diagram*[1]
E	LED200A
S	LED200B
M	LED200C
P	LED200D

*[1] The Schematic Diagram is not part of this manual.

3.3 Coding Switches

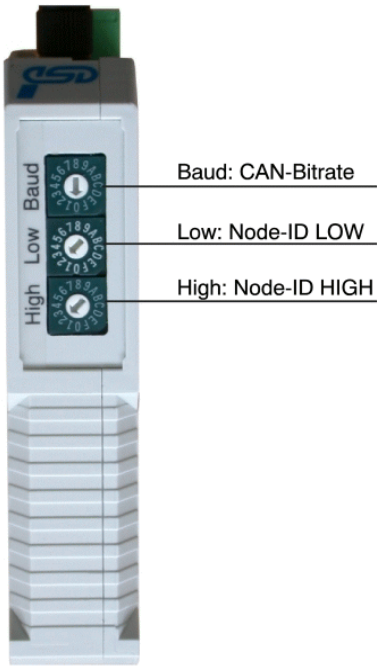


Fig. 4: Position of the coding switches

Attention:
At the moment the module is switched ‘on’, the state of the coding switches is determined. Changes of the settings therefore have to be made **before switching on** the module, because changes of the settings are not determined during operation.

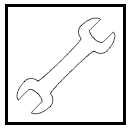
After a reset (e.g. NMT reset) the settings are read again.

3.3.1 Setting the Node-ID via Coding Switch

The address range of the CAN-CBX-module can be set *decimal* from 1 to 127 or *hexadecimal* from 01_h to $7F_h$.

The three higher-order bits (higher-order nibble) can be set with coding switch **HIGH**, the four lower-order bits can be set with coding switch **LOW**.

Note:
Avoid the following settings:
Setting the address range of the coding switches to values higher than $7F_h$ causes error messages, the red CAN-Error LED is on.
If the coding switches are set to 00_h, the CAN-CBX-module changes into Bootloader mode.



3.3.2 Setting the Baud Rate

The baud rate can be set with the coding switch **Baud**.

Values from 0_h to F_h can be set via the coding switch. The values of the baud rate can be taken from the following table:

Setting [Hex]	Bit rate [Kbit/s]
0	1000
1	$666.\overline{6}$
2	500
3	$333.\overline{3}$
4	250
5	166
6	125
7	100
8	$66.\overline{6}$
9	50
A	$33.\overline{3}$
B	20
C	12.5
D	10
E	800
F	$83.\overline{3}$ *2

*2) implemented from firmware version 2.06 on

Table 11: Index of the baud rate

3.3.3 Assignment of Coding-Switch Labelling to Name in Schematic Diagram

Labelling on the CAN-CBX-AO412	Name in the Schematic Diagram *1)
Baud	SW301
Low	SW300
High	SW302

*1) The Schematic Diagram is not part of this manual.

3.4 Installation of the Module Using InRailBus Connector

If the CAN bus signals and the power supply voltage shall be fed via the InRailBus, please proceed as follows:

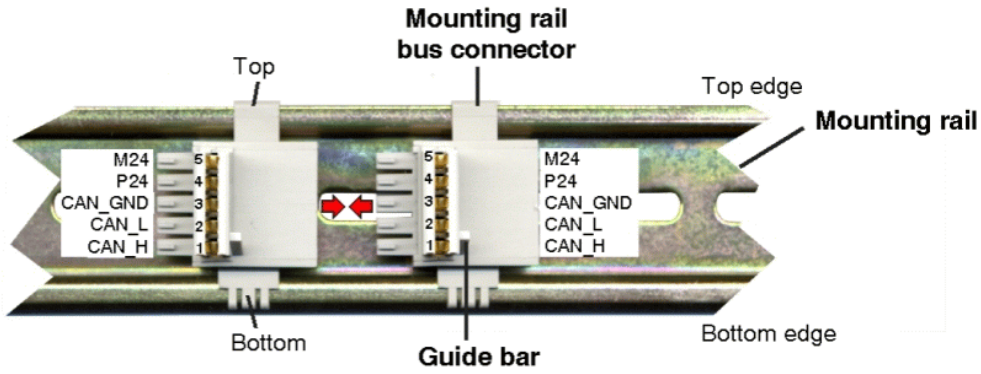


Figure 5: Mounting rail with bus connector

1. Position the InRailBus connector on the mounting rail and snap it onto the mounting rail using slight pressure. Plug the bus connectors together to contact the communication and power signals (in parallel with one). The bus connectors can be plugged together before or after mounting the CAN-CBX modules.

2. Place the CAN-CBX module with the DIN rail guideway on the top edge of the mounting rail.

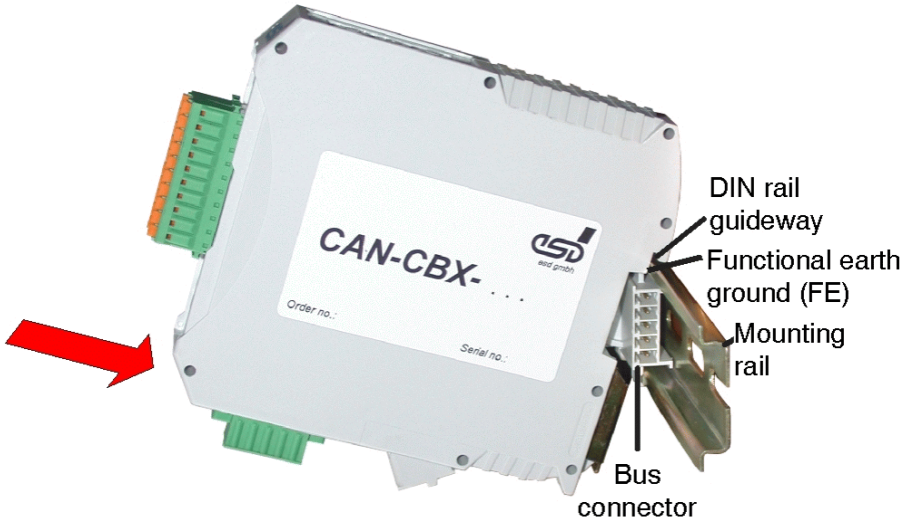


Figure 6 : Mounting CAN-CBX modules

3. Swivel the CAN-CBX module onto the mounting rail in pressing the module downwards according to the arrow as shown in figure 6. The housing is mechanically guided by the DIN rail bus connector.

4. When mounting the CAN-CBX module the metal foot catch snaps on the bottom edge of the mounting rail. Now the module is mounted on the mounting rail and connected to the InRailBus via the bus connector. Connect the bus connectors and the InRailBus if not already done.

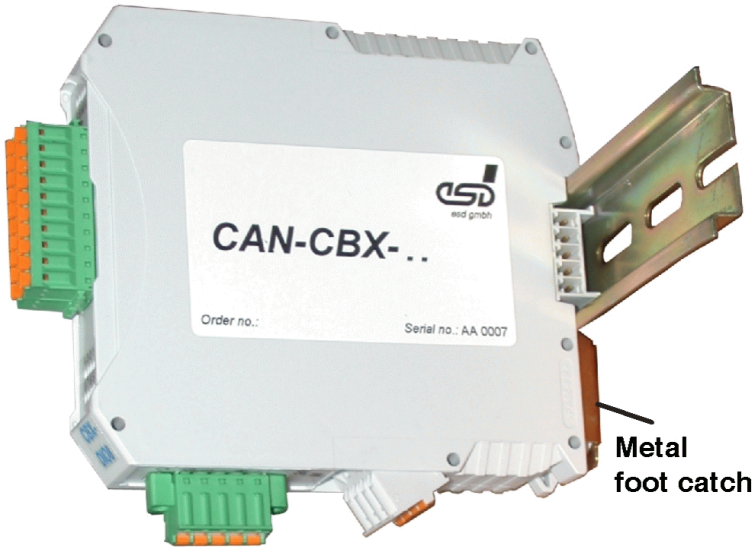


Figure 7: Mounted CAN-CBX module

3.4.1 Connecting Power Supply and CAN-Signals to CBX-InRailBus

To connect the power supply and the CAN-signals via the InRailBus, a terminal plug is needed. The terminal plug is not included in delivery and must be ordered separately (order no.: C.3000.02, see order information).

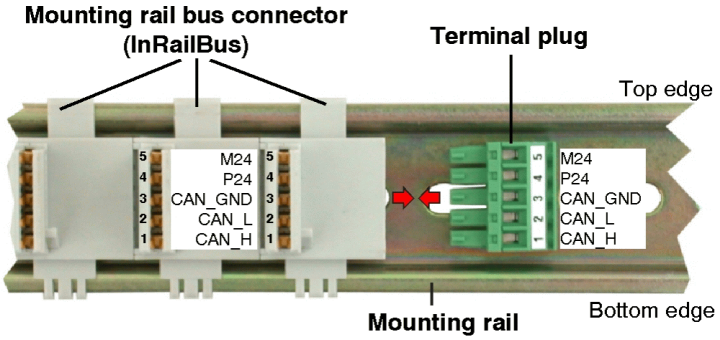


Fig. 8: Mounting rail with InRailBus and terminal plug

Plug the terminal plug into the socket on the right of the mounting-rail bus connector of the InRailBus, as described in Fig. 8. Then connect the CAN interface and the power supply voltage via the terminal plug.

3.4.2 Connection of the Power Supply Voltage

The power supply voltage can be supplied via the 24V connector or via the InRailBus.

Attention!
Please note the safety instructions containing the requirements on power supply current circuits (see page 4)!

Attention!
The connections for the 24 V power supply are internally connected and must **not** be supplied by two independent power sources at the same time!

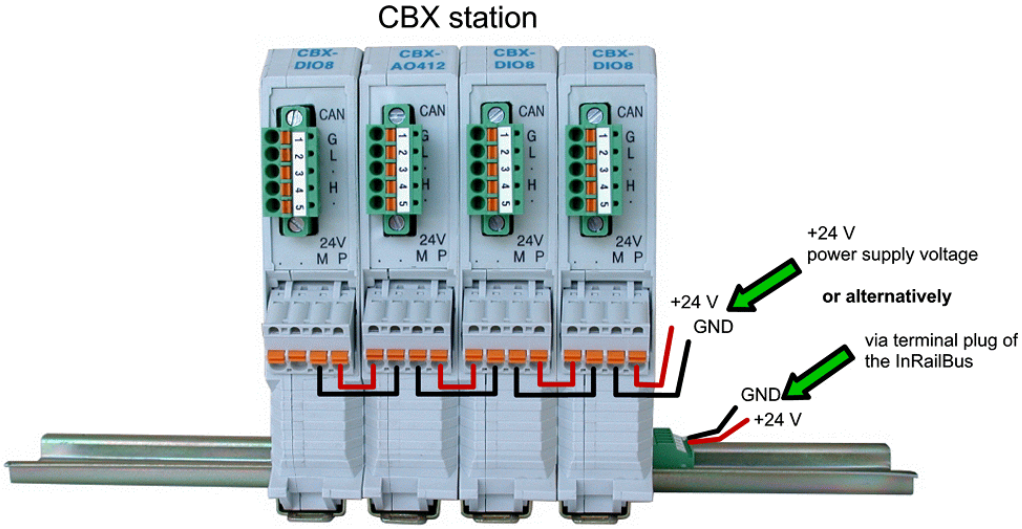


Fig. 9: Connecting the power supply voltage to the CAN-CBX station

Earthing of the Mounting Rail

Note:
The module is connected with the mounting rail via its functional earth contact.
This improves the stability against electromagnetic disturbances.
Thus the mounting rail shall be connected to an appropriate functional earth contact in the environment or in the installation.
Please note, that the impedance of the connection has to be kept low.
The functional earth contact of the module does not ensure electrical safety.

3.4.3 Connection of CAN

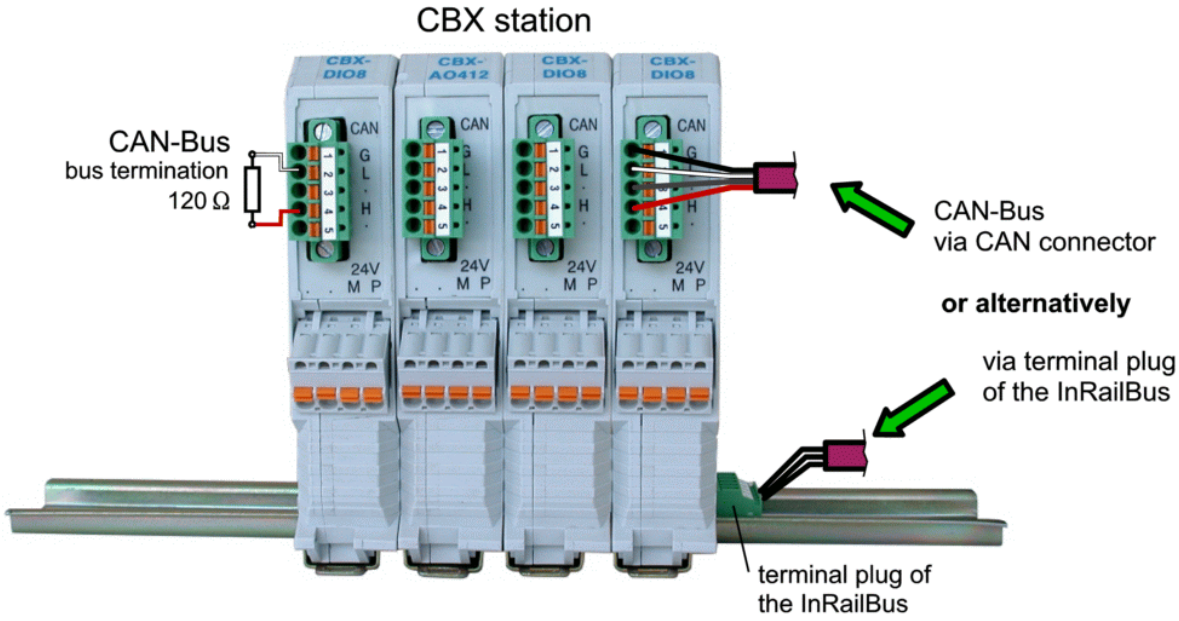


Fig. 10: Connecting the CAN signals to the CAN-CBX station

Generally the CAN signals can be fed via the CAN connector of the first CAN-CBX module of the CBX station. The signals are then connected through the CAN-CBX station via the InRailBus. To loop the CAN signals through the CBX station the CAN bus connector of the last CAN-CBX module of the CAN-CBX station has to be used. The CAN connectors of the CAN-CBX modules which are not at the ends of the CAN-CBX station must not be connected to the CAN bus, because this would cause incorrect branching.
A bus termination must be connected to the CAN connector of the CAN-CBX module at the end of the CBX-InRailBus (see Fig. 10), if the CAN bus ends there.

3.5 Remove the CAN-CBX Module from the InRailBus

If the CAN-CBX module is connected to the InRailBus please proceed as follows:

Release the module from the mounting rail in moving the foot catch (see Fig. 7) downwards (e.g. with a screwdriver). Now the module is detached from the bottom edge of the mounting rail and can be removed.

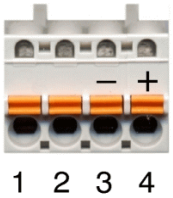
Note:
It is possible to remove individual devices from the CBX station without interrupting the InRailBus connection, because the contact chain will not be disrupted.

4. Connector Assignments

4.1 Power Supply Voltage 24 V (X100)

Device connector: Phoenix-Contact MSTBO 2,5/4-G1L-KMGY
Line connector: Phoenix-Contact FKCT 2,5/4-ST, 5.0 mm pitch, spring-cage connection,
Phoenix-Contact order no.: 19 21 90 0 (included in the scope of delivery)
For conductor connection and conductor cross section see page 30.

Pin Position:



Pin Assignment:

Labelling on Housing	24V			
	•	•	M	P
Labelling on connector	(free)	(free)	-	+

Pin No.	1	2	3	4
Signal	P24 (+ 24 V)	M24 (GND)	M24 (GND)	P24 (+ 24 V)

Please refer also to the connecting diagram on page 13.

Note:
The pins 1 and 4 are connected internally.
The pins 2 and 3 are connected internally.

Signal Description:

P24... power supply voltage +24 V
M24... reference potential

4.2 CAN

4.2.1 CAN Interface

The physical layer is designed according to ISO 11898-2. The CAN bus signals are electrically isolated from the other signals via a digital isolator and a DC/DC converter.

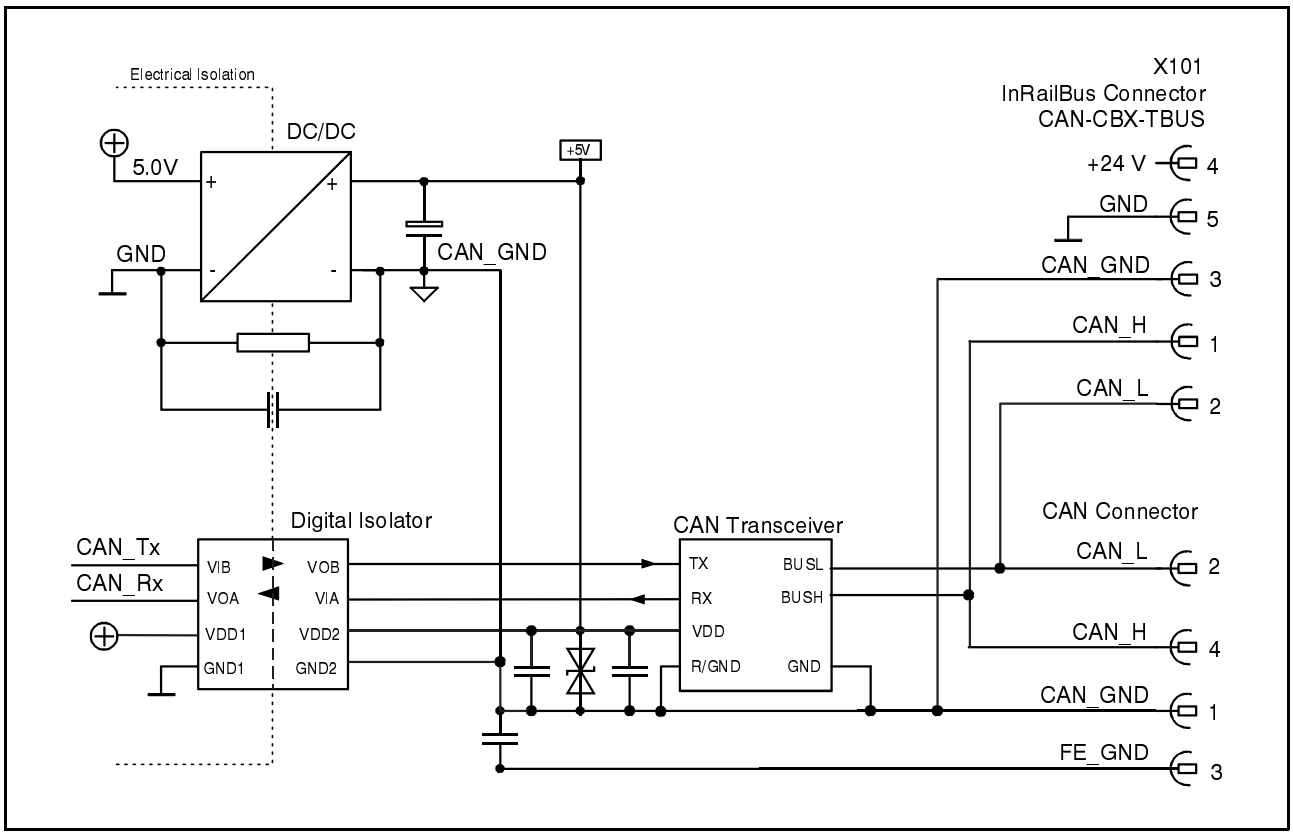


Fig. 11: CAN Interface

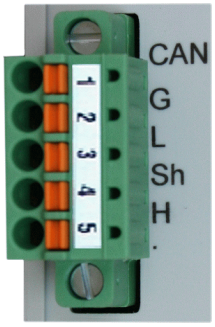
The CAN interface can be connected via the CAN connector or optionally via the InRailBus. Use the mounting-rail bus connector of the CBX-InRailBus (CAN-CBX-TBUS), see order information (page ?).

4.2.2 CAN Connector

Device Connector: Phoenix-Contact MC 1,5/5-GF-3,81
Line Connector: Phoenix-Contact FK-MCP 1,5/5-STF-3,81, spring-cage connection,
Phoenix-Contact order no.:1851261 (included in the scope of delivery)
For conductor connection and conductor cross section see page 30.

Pin Position:

(line connector with labelling)



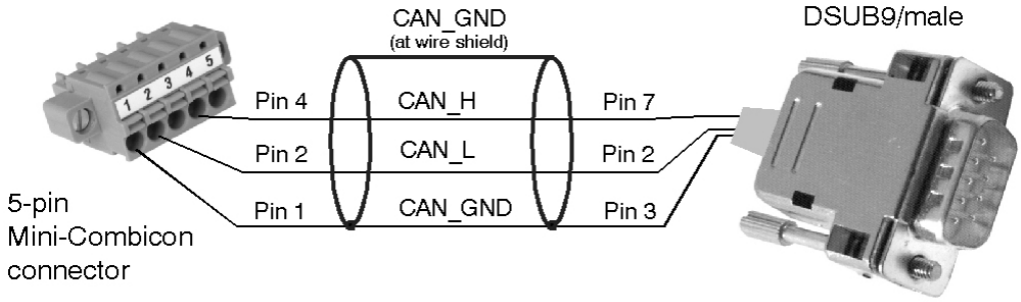
Pin-Assignment:

Labelling	Signal	Pin
G	CAN_GND	1
L	CAN_L	2
Sh	Shield	3
H	CAN_H	4
•	-	5

Signal description:

CAN_L, CAN_H ...	CAN signals
CAN_GND ...	reference potential of the local CAN physical layer
Shield ...	pin for line shield connection (using hat rail mounting direct contact to the mounting rail potential)
- ...	not connected

Recommendation of an adapter cable from 5-pin Phoenix Contact connector (here line connector FK-MCP1,5/5-STF-3,81 with spring-cage-connection) to 9-pin DSUB:

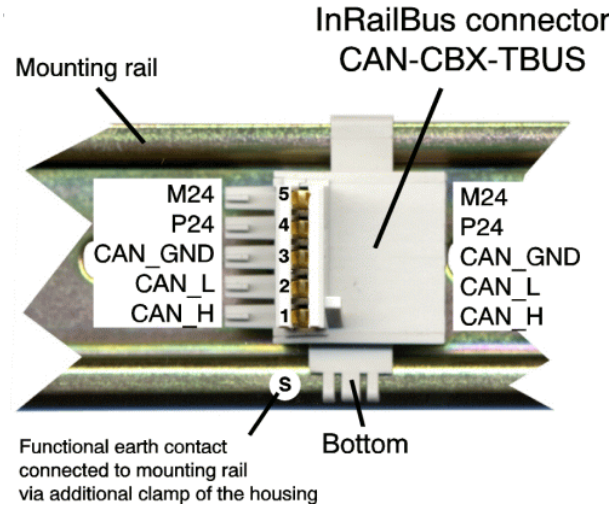


The 9-pin DSUB connector is assigned according to CiA 102

4.2.3 CAN and Power Supply Voltage via InRailBus Connector

Connector type: Mounting rail bus connector CAN-CBX-TBUS
(Phoenix-Contact ME 22,5 TBUS 1,5/5-ST-3,81 KMGY)

Pin Position:



Pin Assignment:

Pin	Signal
5	M24 (GND)
4	P24 (+24 V)
3	CAN_GND
2	CAN_L
1	CAN_H
S	FE (PE_GND)

Signal Description:

CAN_L,
CAN_H ... CAN signals
CAN_GND ... reference potential of the local CAN-Physical layers
P24... power supply voltage +24 V
M24... reference potential
FE... functional earth contact (EMC)(connected to mounting rail potential)

4.3 Analog Outputs

4.3.1 Analog Output Circuits

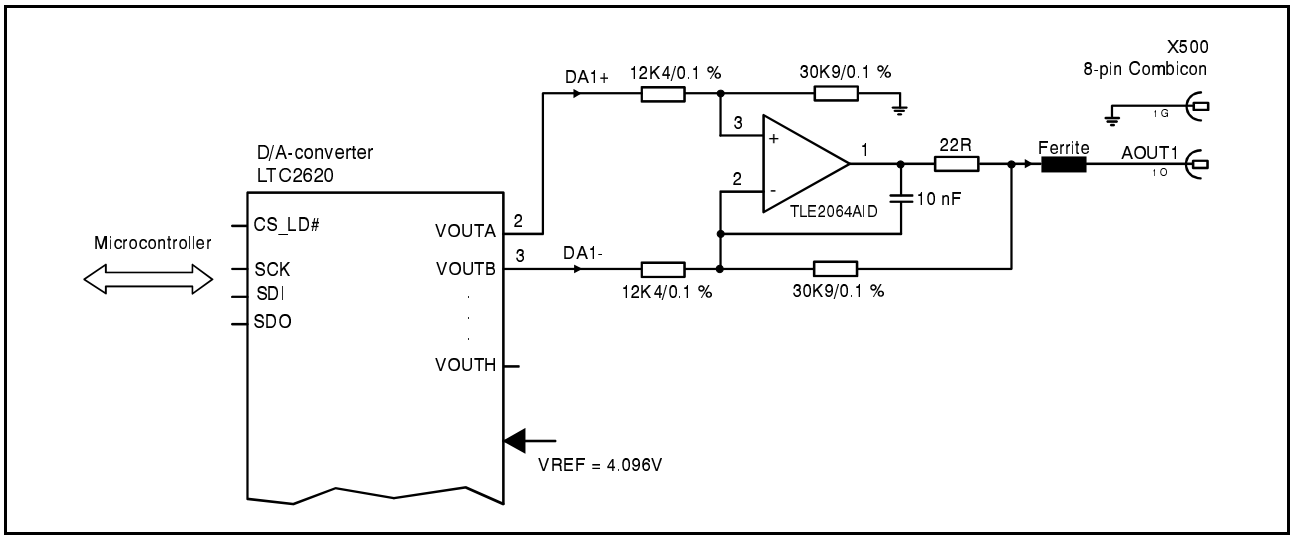


Fig. 12: Analog output circuit (example: channel 1)

Special features of the circuit
The voltage at the output of the CAN-CBX-AO412 module is generated by two outputs of the internal digital/analog-converter LTC®2620 of Linear Technology and a post-connected differential amplifier TLE2064AID of Texas Instruments.

Calculation of the measurement range
For the internal D/A-converter the voltage value of the LSB ($V_{LSB\_D/A}$) is determined by the reference voltage V_{REF} = 4.096 V and its resolution n = 12.

$$V_{LSB\_D/A} = \frac{V_{REF}}{2^n} = \frac{4.096\ V}{2^{12}} = 1\ mV \quad [6]$$

The amplification K of the post-connected differential amplifier is: $K = \frac{30.9\ k\Omega}{12.4\ k\Omega} \approx 2.492$

The resolution of the output voltage of the module results as: $V_{LSB} = V_{LSB\_D/A} \cdot K \approx 2.492\ mV$

The voltage range of the module is determined by the maximum output voltage of the D/A-converter and the gain of the differential amplifier. The maximum output voltage of the D/A-converter is the reference voltage V_{REF} = 4,096 V minus the voltage of a bit ($V_{LSB\_D/A}$).

$$V_{max} = \left(V_{REF} - V_{LSB\_D/A}\right) \cdot K = \left(4.096\ V - \frac{4.069\ V}{2^{12}}\right) \cdot \frac{30.9\ k\Omega}{12.4\ k\Omega} \approx 10.205\ V$$

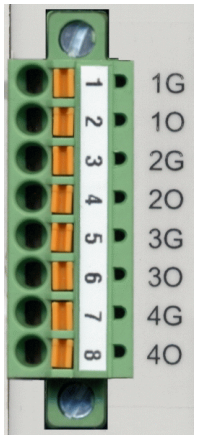
As a result the voltage range of the module is V_{MIN} = -10.205 V to V_{MAX} = +10.205 V (rounded). See also object 6411_h on page 80.

4.3.2 Analog Outputs X500

Device's socket: Phoenix MC 1,5/8-GF-3,81
Line connector: Phoenix FK-MCP 1,5/8-STF-3,81 (spring-cage connection)
Phoenix-Contact order no.:1851290 (included in the scope of delivery)
For conductor connection and conductor cross section see page 30.

Pin Position:

(view of line connector)



Pin Assignment

Pin:	Signal:
1	1G
2	1O
3	2G
4	2O
5	3G
6	3O
7	4G
8	4O

Signal description:

*x*O... Signal pin of the analog output x
*x*G ... Reference potential analog-ground

(*x* = 1, 2, 3, 4)

Note:
The *x*G-pins are electrically connected.

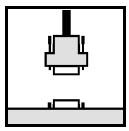
Note:
To ensure EMC properties a cable with a maximum wire length of 3 m has to be used.

4.4 Conductor Connection/Conductor Cross Sections

The following table contains an extract of the technical data of the line connectors.

Interface	**Power Supply Voltage 24 V** [7]	**Analog Inputs, CAN** [8]
Connector type plug component (Range of articles)	FKCT 2,5/..-ST KMGY	FK-MCP 1,5/..-STF-3,81
Connection method	spring-cage connection	spring-cage connection
Stripping length	10 mm	9 mm
Conductor cross section solid min.	0.2 mm²	0.14 mm²
Conductor cross section solid max.	2.5 mm²	1.5 mm²
Conductor cross section stranded min.	0.2 mm²	0.14 mm²
Conductor cross section stranded max.	2.5 mm²	1.5 mm²
Conductor cross section stranded, with ferrule without plastic sleeve min.	0.25 mm²	0.25 mm²
Conductor cross section stranded, with ferrule without plastic sleeve max.	2.5 mm²	1.5 mm²
Conductor cross section stranded, with ferrule with plastic sleeve min.	0.25 mm²	0.25 mm²
Conductor cross section stranded, with ferrule with plastic sleeve max.	2.5 mm²	0.5 mm²
Conductor cross section AWG/kcmil min.	24	26
Conductor cross section AWG/kcmil max	12	16
2 conductors with same cross section, solid min.	n.a.	n.a.
2 conductors with same cross section, solid max.	n.a.	n.a.
2 conductors with same cross section, stranded min.	n.a.	n.a.
2 conductors with same cross section, stranded max.	n.a.	n.a.
2 conductors with same cross section, stranded, ferrules without plastic sleeve, min.	n.a.	n.a.
2 conductors with same cross section, stranded, ferrules without plastic sleeve, max.	n.a.	n.a.
2 conductors with same cross section, stranded, TWIN ferrules with plastic sleeve, min.	0.5 mm²	n.a.
2 conductors with same cross section, stranded, TWIN ferrules with plastic sleeve, max.	1 mm²	n.a.
Minimum AWG according to UL/CUL	26	28
Maximum AWG according to UL/CUL	12	16

n.a. ... not allowed



5. 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.

5.1 Light Industrial Environment (Single Twisted Pair Cable)

5.1.1 General Rules

Note:
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 118982-2. Single shielded double twisted pair cable wiring as described in chapter 5.2 ensures the EU Conformity as well.

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

1	A cable type with a wave impedance of about 120 Ω ±10% with an adequate wire 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 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.

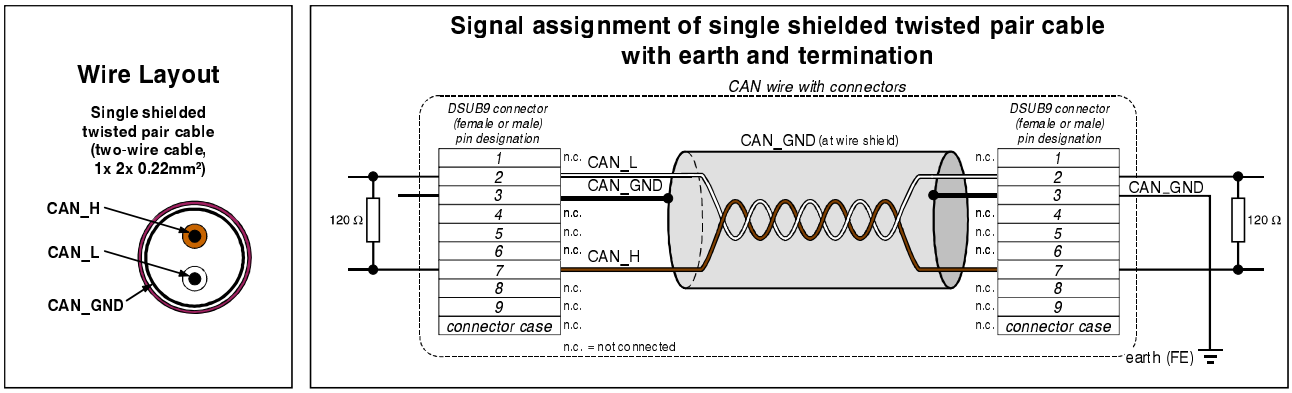


Figure. 13: CAN wiring for light industrial environment

5.1.2 Cabling

- for devices which have only one CAN connector per net use T-connectors and cable stubs (shorter than 0.3 m) (available as accessory)

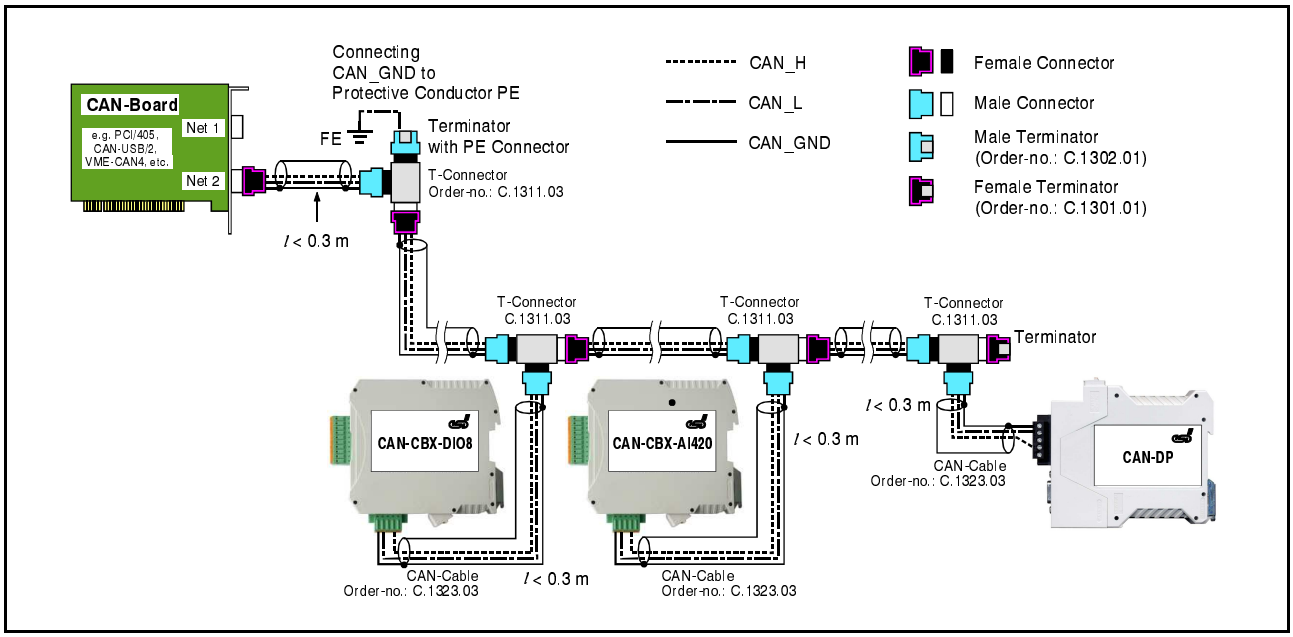


Figure. 14: Example for proper wiring with single shielded single twisted pair wires

5.1.3 Termination

- If the used CAN interface is not equipped with an integrated CAN termination and it is at an end of the bus, use external termination plugs.

- 9-pin DSUB-termination connectors with male and female contacts and earth terminal are available as accessories

5.2 Heavy Industrial Environment (Double Twisted Pair Cable)

5.2.1 General Rules

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

1	A cable type with a wave impedance of about 120 Ω ±10% with an adequate wire 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 ● the two twisted wires to the data signals (CAN_H, CAN_L) and ● the cable shield to the reference potential (CAN_GND)! ● 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 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 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.

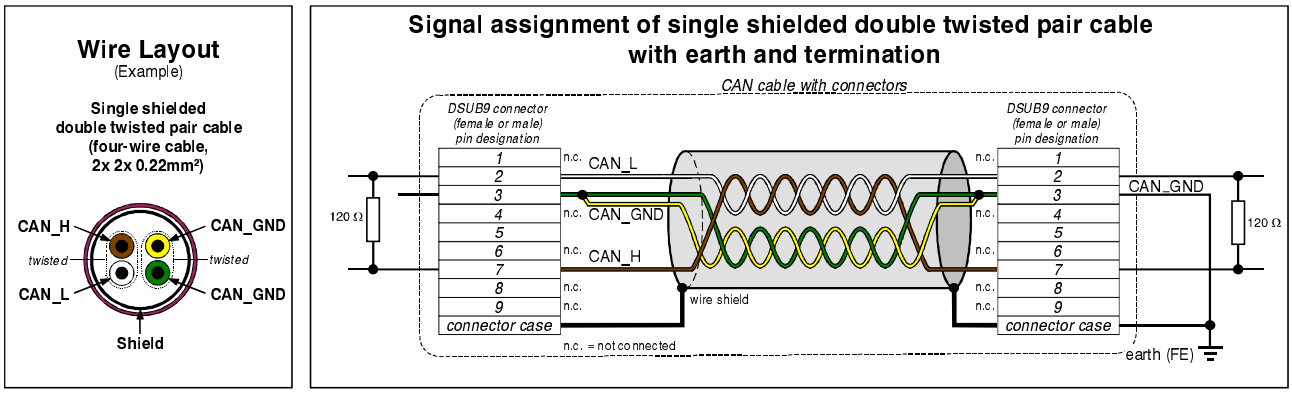


Fig. 15: CAN wiring for heavy industrial environment

5.2.2 Device Cabling

Attention:
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.

Furthermore, mixed use of single twisted and double twisted cables should be avoided!

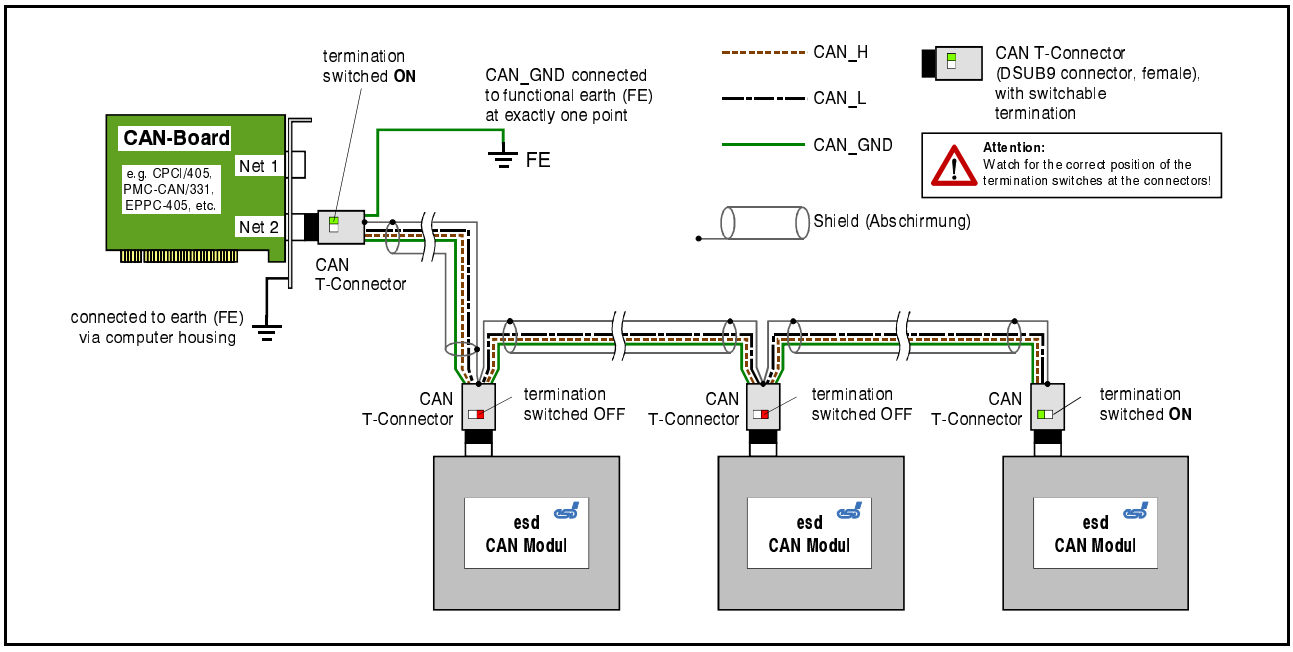
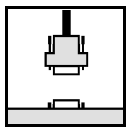


Fig. 16: Example for proper wiring with single shielded double twisted pair cables

5.2.3 Termination

- If the used CAN interface is not equipped with an integrated CAN termination and it is at an end of the bus, use external termination plugs.

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



5.3 Electrical Grounding

- For CAN devices with electrical isolation the CAN_GND must be connected between the CAN devices!
- CAN_GND has to be connected to the earth potential (FE) at **exactly one** point in the net!
- Each *CAN interface with electrical connection to earth potential* acts as an earthing point. For this reason do not connect more than one *CAN device with electrical connection to earth potential*!
- Earthing can e.g. be made at a connector

5.4 Bus Length

- Optical couplers are delaying the CAN signals. By using fast digital isolators and testing each board at 1 Mbit/s, esd modules typically reach a wire length of 37 m at 1 Mbit/s within a closed net without impedance disturbances like e.g. longer stub.

Bit-Rate [kBit/s]	Typical values of reachable wire length **with esd interface** l_{max} [m]	**CiA recommendations** (07/95) for reachable wire lengths l_{min} [m]
1000	37	25
800	59	50
666.$\overline{6}$	80	-
500	130	100
333.$\overline{3}$	180	-
250	270	250
166	420	-
125	570	500
100	710	650
83.$\overline{3}$	850	-
66.$\overline{6}$	1000	-
50	1400	1000
33.$\overline{3}$	2000	-
20	3600	2500
12.5	5400	-
10	7300	5000

Table 12: Reachable wire lengths depending on the bit rate when using esd-CAN interfaces

Note:
Please note the recommendations according to ISO 11898 for the selection of the cross section of the wire depending of the wire length.

5.5 Examples for CAN Cables

5.5.1 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.)

5.5.2 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.)

Note:
Completely configured CAN cables can be ordered from **esd**.

6. CAN-Bus Troubleshooting Guide

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

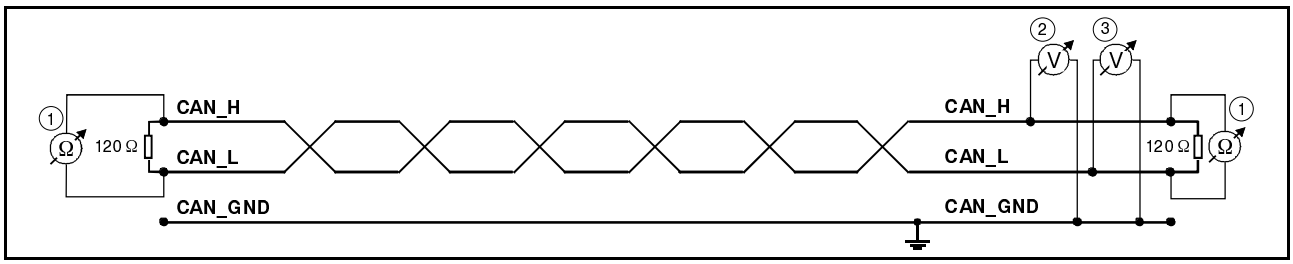


Figure. 17: Simplified diagram of a CAN network

6.1 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 eliminated. 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 the ends of the network (see figure above) and the middle (if the network cable consists of more than one line section). (1)

The measured value should be between 50 Ω and 70 Ω. The measured value should be nearly the same at each point of the network.

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.

6.2 Ground

CAN_GND of the CAN network has to be connected to Functional earth potential at only one location. This test will indicate if the shielding 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 picture on the right hand).
3. Connect CAN_GND to earth potential.

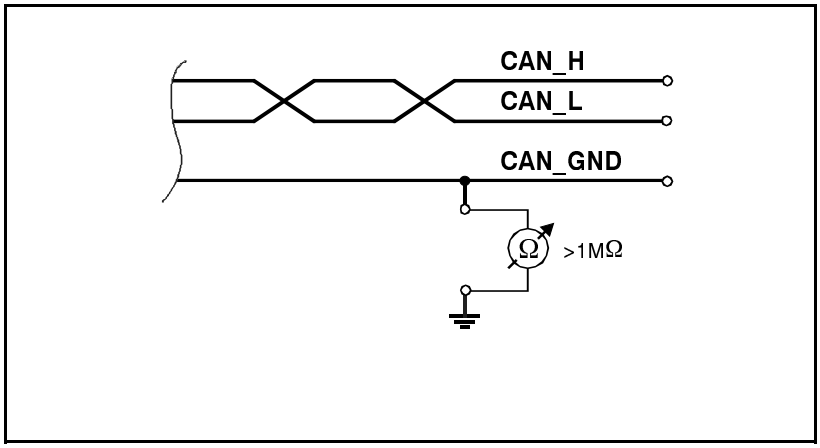


Fig. 18: Simplified schematic diagram of ground test measurement

The resistance should be higher than 1 M Ω. If it is lower, please search for additional grounding of the CAN-GND wires.

6.3 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 the error rate will increase strongly. Make sure that there is no short circuit between CAN_GND and CAN_L!

6.4 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 volts. 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 GND (2) (see figure above).
4. Measure the DC voltage between CAN_L and GND (3) (see figure above).

Normally the voltage should be between 2.0 V and 4.0 V.

If it is lower than 2.0 V or higher than 4.0 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. For a voltage higher than 4.0 V, please check for excessive voltage.

To find the node with a faulty transceiver please test the CAN transceiver resistance (see next page).

6.5 CAN Transceiver Resistance Test

CAN transceivers have one circuit that controls CAN_H and another circuit that controls CAN_L. Experience has shown that electrical damage to one or both of the circuits may increase the leakage current in these circuits.

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

1. Switch off the (4) node and disconnect it from the network (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).

Normally the resistance should be between 1 M Ω and 4 M Ω or higher. If it is lower than this range, the CAN transceiver is probably faulty.
Another sign for a faulty transceiver is a very high deviation between the two measured input resistance (>> 200%).

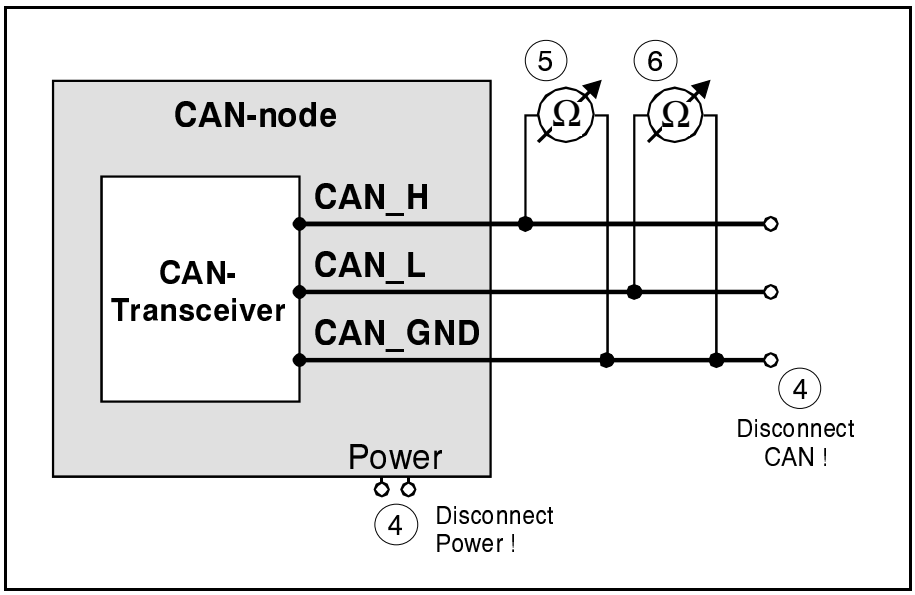


Figure 19: Simplified diagram of a CAN node

7. CANopen Firmware

Apart from basic descriptions of CANopen, this chapter contains the most significant information about the implemented functions.

A complete CANopen description is too extensive for the purpose of this manual.
Further information can therefore be taken from the CANopen documentation [1] and [4].

7.1 Definition of Terms

COB ...	Communication Object
Emergency-Id...	Emergency Data Object
NMT...	Network Management (Master)
SDO...	Service Data Object
Sync...	Sync(frame) Telegram

PDOs (Process Data Objects)
PDOs are used to transmit process data.
In the ‘Transmit’-PDO (TPDO) the CAN-CBX-module transmits data to the CANopen network.
In the ‘Receive’-PDO (RPDO) the CAN-CBX-module receives data from the CANopen network.

SDOs (Service Data Objects)
SDOs are used to transmit module internal configuration- and parameter data. In opposition to the PDOs SDO-messages are confirmed. A write or read request on a data object is always answered by a response telegram with an error index.

7.2 NMT-Boot-up

The CAN-CBX module can be initialized with the 'Minimum Capability Device' boot-up as described in [1].

Usually a telegram to switch from *Pre-Operational* status to *Operational* status after boot-up is sufficient. For this the 2-byte telegram '01_h', '00_h', for example, has to be transmitted with CAN-identifier '0000_h' (= Start Remote Node all Devices).

7.3 The CANopen-Object Directory

The object directory is basically a (sorted) group of objects which can be accessed via the CAN network. Each object in this directory is addressed with a 16-bit index. The index in the object directories is represented in hexadecimal format.
The index can be a 16-bit parameter in accordance with the CANopen specification [1] or a manufacturer-specific code. By means of the MSBs of the index the object class of the parameter is defined.

Part of the object directory are among others:

Index	Object
0001_h ... $009F_h$	definition of data types
1000_h ... $1FFF_h$	Communication Profile Area
2000_h ... $5FFF_h$	Manufacturer Specific Profile Area
6000_h ... $9FFF_h$	Standardized Device Profile Area
$A000_h$ ... $FFFF_h$	reserved

7.4 Communication Parameters of the PDOs

The communication parameters of the PDOs (according to [1]) are transmitted as SDO (Service Data Objects) on ID '**600_h + Node-ID**' (Request). The receiver acknowledges the parameters on ID '**580_h + Node-ID**' (Response).

The **Node-ID** (module No.) is configured via coding switches Low and High. Please refer to chapter "Coding Switches" (page 18) for a detailed description of possible configurations.

7.4.1 Access on the Object Directory

The SDOs (Service Data Objects) are used to access the object directory of a device.
An SDO is therefore a 'channel' to access the parameters of the device. Access via this channel is possible in *operational* and *pre-operational* status.

The SDOs (Service Data Objects) are transmitted on ID '**600_h + Node-ID**' (request).
The server acknowledges the parameters on ID '**580_h + Node-ID**' (response).

An SDO is structured as follows:

Identifier	Command code	Index		Sub-index	LSB	Data field		MSB
		(low)	(high)					

Example:

600_h+ Node-ID	23_h (write)	00_h	14_h (Index=1400_h) (Receive-PDO-Comm-Para)	01_h (COB-def.)	$7F_h$	04_h	00_h	00_h COB Node ID = 0000 $047F_h$

Identifier
The parameters are transmitted with ID '600_h + NodeID' (request).
The receiver acknowledges the parameters with ID '580_h + NodeID' (response).

Command code
The command code transmitted consists among other things of the Command Specifier and the length. Frequently required combinations are, for instance:

$40_h = 64_{dec}$: Read Request, i.e. a parameter is to be read
$23_h = 35_{dec}$: Write Request with 32-bit data, i.e. a parameter is to be set

The CAN-CBX-module responds to every received telegram with a response telegram. This can contain the following command codes:

$43_h = 67_{dec}$: Read Response with 32 bit data, this telegram contains the parameter requested
$60_h = 96_{dec}$: Write Response, i.e. a parameter has been set successfully
$80_h = 128_{dec}$: Error Response, i.e. the CAN-CBX-module reports a communication error

Frequently Used Command Codes
The following table summarizes frequently used command codes. The command frames must always contain 8 data bytes. Notes on the syntax and further command codes can be found in [1].

Command	Number of data bytes	Command code
Write Request (Initiate Domain Download)	1 2 3 4	$2F_h$ $2B_h$ 27_h 23_h
Write Response (Initiate Domain Download)	-	60_h
Read Request (Initiate Domain Upload)	-	40_h
Read Response (Initiate Domain Upload)	1 2 3 4	$4F_h$ $4B_h$ 47_h 43_h
Error Response (Abort Domain Transfer)	-	80_h

Index, Sub-Index
Index and sub-index will be described in the chapters “Device Profile Area” and “Manufacturer Specific Objects” of this manual.

Data Field
The data field has got a size of a maximum of 4 bytes and is always structured ‘LSB first, MSB last’. The least significant byte is always in ‘Data 1’. With 16-bit values the most significant byte (bits 8...15) is always in ‘Data 2’, and with 32-bit values the MSB (bits 24...31) is always in ‘Data 4’.

Error Codes of the SDO Domain Transfer

The following error codes might occur (according to [1]):

Abort code	Description
05040001_h	wrong command specifier
06010002_h	wrong write access
06020000_h	wrong index
06040041_h	object can not be mapped to PDO
06060000_h	access failed due to an hardware error
06070010_h	wrong number of data bytes
06070012_h	service parameter too long
06070013_h	service parameter too small
06090011_h	wrong sub-index
06090030_h	transmitted parameter is outside the accepted value range
08000000_h	undefined cause of error
08000020_h	data cannot be transferred or stored in the application
08000022_h	data cannot be transferred or stored in the application because of the present device state
08000024_h	access to flash failed

7.5 Overview of used CANopen-Identifiers

Function	Identifier [Hex]	Description
Network management	0	NMT
SYNC	80	Sync to all, (configurable via object 1005_h)
Emergency Message	80 + *NodeID*	configurable with object 1014_h
Client-SDO	580 + *Node-ID*	SDO from CAN-CBX-AO412
Server-SDO	600 + *Node-ID*	SDO to CAN-CBX-AO412
Node Guarding	700 + *NodeID*	configurable with object $100E_h$

NodeID: CANopen-address set [1_h...$7F_h$]

7.5.1 Setting the COB-ID

The COB-IDs which can be set (except the one of SYNC), are deduced initially from the setting of the Node-ID via the coding switches (see page 18). If the COB-IDs are set via SDO, this setting is valid even if the coding switches are set to another Node-ID after that.
To accept the Node-ID from the coding switches again, the *Comm defaults* or all defaults have to be restored (object 1011_h).

7.6 Default PDO-Assignment

PDOs (Process Data Objects) are used to transmit process data. The PDO mapping can be changed. The following tables show the default mapping at delivery of the module:

PDO	CAN identifier	Length	Transmission direction	Default assignment
RPDO1	n.a.	n.a.	n.a.	RPDO1 is not used
RPDO2	300_h + Node-ID	8 byte	to CAN-CBX-AO412 (Receive-PDO)	D/A-values channel 1 to 4 as 16-bit values
RPDO3	400_h + Node-ID	8 byte	to CAN-CBX-AO412 (Receive-PDO)	Dummy Mapping

Rx-PDO2 (-> CAN-CBX-AO412)

CAN-Identifier: 300_h + Node-ID

Byte	0	1	2	3	4	5	6	7
Parameter	*Analog_Output_16-Bit_1*		*Analog_Output_16-Bit_2*		*Analog_Output_16-Bit_3*		*Analog_Output_16-Bit_4*	

Rx-PDO3 (-> CAN-CBX-AO412)

CAN-Identifier: 400_h + Node-ID

Byte	0	1	2	3	4	5	6	7
Parameter	*Dummy_Mapping*		*Dummy_Mapping*		*Dummy_Mapping*		*Dummy_Mapping*	

Parameter description:

Name	Description	see page
Analog_Output_ 16-Bit_x	Read the analog output x (x = 1-4)	80
Dummy Mapping	Placeholder	-

7.7 Setting and Reading the Analog Values

7.7.1 Setting the Analog Outputs

The analog outputs are set, as soon as an object for setting the outputs of the CAN-CBX-AO412 is received.

7.7.2 Reading the Analog Outputs

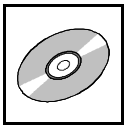
Differing from the CANopen Specification CiA 301 the values of the analog outputs can be read. If the CAN-CBX-AO412 module receives an RTR-frame on RPDO2, in response the D/A-values of the channels 1 to 4 will be transmitted on this PDO.

7.8 Communication Profile Area

7.8.1 Used Names and Abbreviations

The following names are used in the tables for the description of the communication parameters:

PDO-Mappable	PDO-Mapping is possible for this Sub-index of the PDO
Save to EEPROM	the value of this parameter is stored in the local EEPROM, if the command 'save' is called (see page 61)
Data type	data type (e.g. unsigned 8, unsigned 32)
Access mode	allowed access modes to this parameter ro... read_only This parameter can only be read. Write accesses will cause an error message. const.... constant This parameter can not be set by the user. It is readable. Write accesses will cause an error message. rw... read&write This parameter can be read or written.
Value range	value range of the parameter
Default value	default setting of the parameter
Name/Description	name and short description of the parameter

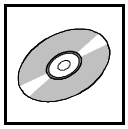


7.9 Implemented CANopen-Objects

A detailed description of the objects can be taken from CiA 301 [1].

7.9.1 Overview of Communication Profile Objects with Product-Specific Values

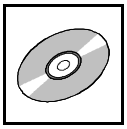
Index	Sub-index	Description	Data type	Access mode	Product-specific properties
1000_h	-	Device Type	unsigned 32	ro	00080191_h
1001_h	-	Error Register	unsigned 8	ro	Supported error: bits: 0: generic 1: current 2: voltage 4: communication error
1002_h	-	Manufacturer Status Register (internal use only!)	unsigned 32	ro	00_h
1003_h	A_h	Pre-Defined-Error-Field	unsigned 32	rw	00_h
1005_h	-	COB-ID Sync	unsigned 32	rw	80_h
1006_h	-	Communication Cycle Period	unsigned 32	rw	00_h
1008_h	-	Manufacturer Device Name	visible string	ro	"CAN-CBX-AO412"
1009_h	-	Manufacturer Hardware Version	visible string	ro	x.yy (depending on version)
$100A_h$	-	Manufacturer Software Version	visible string	ro	x.yy (depending on version)
$100C_h$	-	Guard Time	unsigned 16	rw	0000_h
$100D_h$	-	Life Time Factor	unsigned 8	rw	00_h
$100E_h$	-	Node Guarding Identifier	unsigned 32	rw	Node-ID + 700_h
1010_h	3	Store Parameter	unsigned 32	rw	Parameters which can be saved or loaded: 1005_h ...1029_h, 6411_h, 6443_h, 6444_h, 2000_h, 2404_h, 2405_h
1011_h	3	Restore Parameter	unsigned 32	rw	
1014_h	-	COB-ID Emergency Object	unsigned 32	rw	80_h + Node-ID
1015_h	-	Inhibit Time EMCY	unsigned 16	rw	00_h
1016_h	1	Consumer Heartbeat Time	unsigned 32	rw	00_h
1017_h	-	Producer Heartbeat Time	unsigned 16	rw	00_h
1018_h	4	Identity Object	unsigned 32	ro	Vendor Id: 00000017_h Prod. Code: 23040002_h
1019_h	-	Synchronous Counter Overflow	unsigned 8	rw	00_h
1020_h	0-2	Verify Configuration	unsigned 32	ro	n.a.
1029_h	3	Error Behaviour	unsigned 8	rw	00_h



Implemented CANopen Objects

Index	Sub-index	Description	Data type	Access mode
1401_h	2	2. Receive PDO-Parameter	PDO CommPar (20_h)	rw
1402_h	2	3. Receive PDO-Parameter	PDO CommPar (20_h)	rw
1601_h	0	2. Receive PDO-Mapping	PDO Mappping (21_h)	rw
1602_h	0	3. Receive PDO-Mapping	PDO Mappping (21_h)	rw

Index	Sub-index (max.)	Description	Data type	Access mode	Product-specific properties
$1F80_h$	-	NMT startup	unsigned 32	rw	default: 2 (autostart disabled)
$1F91_h$	1	Self starting nodes timing parameters	unsigned 16	rw	default: 64_h (= 100 ms)



7.9.2 Device Type (1000_h)

INDEX	**1000_h**
Name	*device type*
Data type	unsigned 32
Access mode	ro
Default value	see chapter 7.9.1 (page 49)

Example: Reading the Device Type

The CANopen master transmits the read request with identifier '603_h' (600_h + Node-ID) to the CAN-CBX module with the module no. 3 (Node-ID=3_h):

ID	RTR	LEN	DATA							
			1	2	3	4	5	6	7	8
603_h	0_h	8_h	40_h	00_h	10_h	00_h	00_h	00_h	00_h	00_h
			Read Request	Index=1000_h		Sub Index				

The CAN-CBX module no. 3 responds to the client by means of read response with identifier '583_h' (580_h + Node-ID) with the value of the device type:

ID	RTR	LEN	DATA							
			1	2	3	4	5	6	7	8
583_h	0_h	8_h	43_h	00_h	10_h	00_h	**94_h**	**01_h**	**02_h**	**00_h**
			Read Response	Index=1000_h		Sub Index	Example here: Device Profile Nr.0191_h		Example here: Input	

value of device type: 0002.0194_h.
The value of the device type of this CAN-CBX module is printed in chapter 7.9.1 (page 49)

The data field is always structured following the rule 'LSB first, MSB last' (see page 43, data field).

7.9.3 Error Register (1001_h)

The CAN-CBX module uses the error register to indicate error messages.

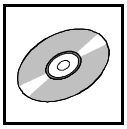
INDEX	**1001_h**
Name	*error register*
Data type	unsigned 8
Access type	ro
Default value	0

The following bits of the error register are being supported at present:

Bit	Meaning
0	*generic*
1	*current*
2	*voltage*
3	*temperature*
4	*communication error* (overrun, error state)
5	*device profile*
6	reserved
7	*manufacturer*

For a list of the error bits supported by this CAN-CBX module see chapter 7.9.1 (page 49).

Bits which are not supported are always returned as ‘0’.
If an error is active, the according bit is set to ‘1’.



7.9.4 Pre-defined Error Field (1003_h)

INDEX	**1003_h**
Name	*pre-defined error field*
Data type	unsigned 32
Access mode	ro
Default value	No

The *pre-defined error field* provides an error history of the errors that have occurred on the device and have been signalled via the Emergency Object.
Sub-index 0 contains the current number of errors stored in the list.
Under sub-index 1 the last error which occurred is stored. If a new error occurs, the previous error is stored under sub-index 2 and the new error under sub-index 1, etc. In this way a list of the error history is created.
The error buffer is structured like a ring buffer. If it is full, the oldest entry is deleted for the latest entry.

This module supports a maximum of 10 error entries. When the 11th error occurs the oldest error entry is deleted. In order to delete the entire error list, sub-index '0' has to be set to '0'. This is the only permissible write access to the object.

With every new entry to the list the module transmits an **Emergency Frame** to report the error.

Index	Sub-index	Description	Value range	Default	Data type	Access mode
1003_h	0	*no_of_errors_in_list*	0, 1...A_h	-	unsigned 8	rw
	1	*error-code n*	0...$FFFFFFFF_h$	-	unsigned 32	ro
	2	*error-code (n-1)*	0...$FFFFFFFF_h$	-	unsigned 32	ro
	:	*:*	:	:	:	ro
	A_h	*error-code (n-9)*	0...$FFFFFFFF_h$	-	unsigned 32	ro

Meaning of the variables:

no_of_errors_in_list - contains the number of error codes currently on the list
n = number of error which occurred last
- in order to delete the error list this variable has to be set to '0'
- if *no_of_errors_in_list* ≠0, the error register (Object 1001_h) is set

error-code x The 32-bit long error code consists of the CANopen-emergency error code described in [1] and the error code defined by esd (manufacturer-specific error field).

Bit:	31 16	15 0
Contents:	*manufacturer-specific error field*	*emergency-error-code*

manufacturer-specific error field: always '00', unless
emergency-error-code = 2300_h (see below)

emergency-error-code: The following error-codes are supported:

8110_h - CAN overrun error
- Sample rate is set too high, thus the firmware is not able to transmit all data to the CAN bus.

8120_h - CAN in error passive mode
8130_h - Lifeguard error / heartbeat error
8140_h - Recovered from "Bus Off"
8240_h - Unexpected SYNC data length
6000_h - Software error:
-EEPROM checksum error (no transmission of this error message as emergency message)
6110_h - Internal Software error
e.g.:
- saved data had invalid checksum and default data is loaded

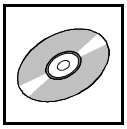
$FF10_h$ - Data loss (A/D data overflow)
5000_h - Hardware error (e.g. A/D-converter defective)
5030_h - Sensor error

Emergency Message

The data otf the emergency frame transmitted by the CAN-CBX-module have the following structure:

Byte:	0	1	2	3	4	5	6	7
Contents:	*emergency-error-code* (siehe oben)		*error-register* 1001_h	*no_of_errors _ in_list* $1003{,}00_h$	-			

An emergency message is transmitted, if an error occurs. If this error occurs again, no further emergency message is generated.
If the last error message is cancelled, again an emergency message is transmitted to indicate the error disappearance.



7.9.5 COB-ID of SYNC-Message (1005_h)

INDEX	**1005_h**
Name	*COB-ID SYNC message*
Data type	unsigned 32
Access mode	rw
Default value	see chapter 7.9.1 (page 49)

Structure of the parameter:

Bit-No.	Value	Meaning
31 (MSB)	-	do not care
30	0/1	0: Device does not generate SYNC message 1: Device generates SYNC message
29	0	always 0 (11-bit ID)
28...11	0	always 0 (29-bit IDs are not supported)
10...0 (LSB)	x	Bit 0...10 of the SYNC-COB-ID

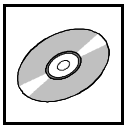
The identifier can take values between $0...7FF_h$.

7.9.6 Communication Cycle Period (1006_h)

INDEX	**1006_h**
Name	*Communication Cylcle Period*
Data type	unsigned 32
Access mode	rw
Default value	0 µs

Value range of the parameter:

Value	Meaning
0	No transmission of SYNC messages
1...$FFFFFFFF_h$	Cycle time in microseconds



7.9.7 Manufacturer Device Name (1008_h)

INDEX	**1008_h**
Name	*manufacturer device name*
Data type	visible string
Default value	see chapter 7.9.1 (page 49)

For detailed description of the SDO Uploads, please refer to [1].

7.9.8 Manufacturer Hardware Version (1009_h)

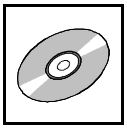
INDEX	**1009_h**
Name	*manufacturer hardware version*
Data type	visible string
Default value	string: e.g. ‘1.00’ (depending on version)

The hardware version is read similarly to reading the manufacturer’s device name via the domain upload protocol. Please refer to [1] for a detailed description of the upload.

7.9.9 Manufacturer Software Version ($100A_h$)

INDEX	**$100A_h$**
Name	*manufacturer software version*
Data type	visible string
Default value	string: e.g.: ‘1.2’ (depending on version)

Reading the software version is similar to reading the manufacturer’s device name via the domain upload protocol. Please refer to [1] for a detailed description of the upload.



7.9.10 Guard Time ($100C_h$) und Life Time Factor ($100D_h$)

The CAN-CBX module supports the node guarding or alternatively the heartbeat function (see page 69).

Note:
By the recommendation of the CiA, the heartbeat-function shall be used preferentially. Use the node-guarding only for existing systems and not for new developments!

Guard time and life time factors are evaluated together. Multiplying both values will give you the life time. The guard time is represented in milliseconds.

INDEX	**$100C_h$**
Name	*guard time*
Data type	unsigned 16
Access mode	rw
Default value	0 [ms]
Minimum value	0
Maximum value	$FFFF_h$ (65.535 s)

INDEX	**$100D_h$**
Name	*life time factor*
Data type	unsigned 8
Access mode	rw
Default value	0
Minimum value	0
Maximum value	FF_h

7.9.11 Node Guarding Identifier ($100E_h$)

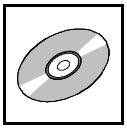
The module only supports 11-bit identifiers.

INDEX	**$100E_h$**
Name	*node guarding identifier*
Data type	unsigned 32
Access mode	rw
Default value	700_h + Node-ID

Structure of the parameter *node guarding identifier* :

Bit-No.	Meaning
31 (MSB) 30	reserved
29...11	always 0, because 29-bit-IDs are not supported
10...0 (LSB)	bit 0...10 of the node guarding identifier

The identifier can take values between $1...7FF_h$.



7.9.12 Store Parameters (1010_h)

INDEX	**1010_h**
Name	*store parameters*
Data type	unsigned 32

This object supports saving of parameters to a non-volatile memory, the EEPROM here.
Therefore the parameter groups shown below are distinguished. After they are transferred, the parameters are immediately active. The non-volatile storage of the parameters however is not carried out automatically. It must be initiated with a write access to object 1010_h and should only be carried out if the module is in the state *pre-operational*. In order to avoid storage of parameters by mistake, storage is only executed when the specific signature as shown below is transmitted.

Reading the index returns information about the implemented storage functionality (refer to [1] for more information).

Index	Sub-index	Description	Value range	Data type	Access mode
1010_h	0	*number_of_entries*	4	unsigned 8	ro
	1	*save_all_parameters* (objects 1000_h ... $9FFF_h$)	no default, write: 65 76 61 73_h (= ASCII: ‘e’ ‘v’ ‘a’ ‘s’)	unsigned 32	rw
	2	*save_communication_parameter* (objects 1000_h ... $1FFF_h$)		unsigned 32	rw
	3	*save_application_parameter* (objects 6000_h ... $9FFF_h$)		unsigned 32	rw
	4	*save_manufacturer_parameter* (objects 2000_h ... $5FFF_h$)		unsigned 32	rw

Assignment of the variables

save all parameters

saves the parameters of all objects (if available), which have a read/write (rw) right of access.

save_communication_parameter

saves all communication parameters of those objects (objects 1000_h ... $1FFF_h$, if available), which have a read/write (rw) right of access (here e.g. 1005_h ... 1029_h).

save_application_parameter

saves all application parameters of those objects (objekte 6000_h ... $9FFF_h$, if available), which have a read/write (rw) right of access (here e.g. $6xxx_h$).

save_manufacturer_parameter

saves all manufacturer parameters of those objects (objects 2000_h ... $5FFF_h$, if available), which have a read/write (rw) right of access (here e.g. $2xxx_h$).

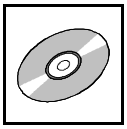
The storage mode is shown in the content of this object:
Bit 1 of object 1010_h, sub-index 1 is not set, i.e the CAN-CBX-module does not save the configuration automatically. The storage must be initiated by writing the character string 'save' (73_h 61_h 76_h 65_h, order from CAN telegram) to object 1010_h, sub-index 1-4.

On read access to the appropriate sub-index, the CAN-CBX module provides information about its storage functionality with the format described in the following:

Bit:	31 2	1	0
Inhalt:	reserved	auto	cmd
	0	0	1
	MSB		LSB

Bit	Value	Description
auto	0	CAN-CBX module does **not** save the parameters autonomously
	1	CAN-CBX module **saves** the parameters autonomously
cmd	0	CAN-CBX module does **not** save the parameters on command
	1	CAN-CBX module **saves** the parameters on command

Autonomous saving means that the CAN-CBX module stores the storable parameters non-volatile and without a user request.



7.9.13 Restore Default Parameters (1011_h)

INDEX	**1011_h**
Name	*restore default parameters*
Data Type	unsigned 32

Via this command the default parameters, valid when leaving the manufacturer, are restored.
Therefor the parameter groups described below are distinguished.
Every individual setting stored in the EEPROM will be lost.
After a reset the default parameters will be active. The reset of the parameters however must be initiated with a write access to object 1011_h. To write the index a specific signature as shown below has to be transmitted.
Reading the index provides information about its parameter restoring capability (refer to [1] for more information).

Index	Sub-index	Description	Value range	Data type	Access mode
1011_h	0	*number_of_entries*	4	unsigned 8	ro
	1	*restore_all_default_parameters* (objects 1000_h ... $9FFF_h$)	no default, write: 64 61 6F $6C_h$ (= ASCII: ‘d’ ‘a’ ‘o’ ‘l’)	unsigned 32	rw
	2	*restore_communication_parameter* (objects 1000_h ... $1FFF_h$)		unsigned 32	rw
	3	*restore_application_parameter* (objects 6000_h ... $9FFF_h$)		unsigned 32	rw
	4	*restore_manufacturer_parameter* (objects 2000_h ... $5FFF_h$)		unsigned 32	rw

Assignment of the variables

restore all parameters

restores the default parameters of all objects (if available), which have a read/write (rw) right of access.

restore_communication_parameter

restores all communication default parameters of those objects (objects 1000_h ... $1FFF_h$, if available, here e.g. 1005_h ... 1029_h).

restore_application_parameter

restoers all application default parameters of those objects (objekts 6000_h ... $9FFF_h$, if available, here e.g. $6xxx_h$).

restore_manufacturer_parameter

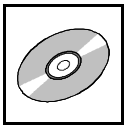
loads all manufacturer default parameters of those objects (objects 2000_h ... $5FFF_h$, if available, here e.g. $2xxx_h$).

Bit 0 of object 1011_h, sub-index 1 is set, i.e. the CAN-CBX module restores the default values initiated by writing the signature 'load' (64_h 61_h $6F_h$ $6C_h$, sequence in CAN telegram) in object 1011_h, sub-index 1-4.

On read access to the appropriate sub-index, the CANopen device provides information about its default parameter restoring capability with the following format:

Bit:	31 ... 1	0
Content:	reserved	cmd
	0	1
	MSB	LSB

Bit	Value	Description
cmd	0	the CAN-CBX-module does **not** restore default parameters
	1	the CAN-CBX-module **restores** the default parameters



7.9.14 COB_ID Emergency Message (1014_h)

INDEX	**1014_h**
Name	*COB-ID emergency object*
Data type	unsigned 32
Default value	80_h + Node-ID

This object defines the COB-ID of the emergency object (EMCY).

The structure of this object is shown in the following table:

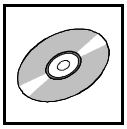
Bit-No.	Value	Meaning
31 (MSB)	0/1	0: EMCY exists / is valid 1: EMCY does not exist / EMCY is not valid
30	0	reserved (always 0)
29	0	always 0 (11-bit ID)
28...11	0	always 0 (29-bit IDs are not supported)
10...0 (LSB)	x	bits 0...10 of COB-ID

The identifier can take values between $0...7FF_h$.

7.9.15 Inhibit Time EMCY (1015_h)

INDEX	**1015_h**
Name	*inhibit_time_emergency*
Data type	unsigned 16
Access mode	rw
Value range	0...$FFFF_h$
Default value	0

The *Inhibit Time* for the EMCY message can be defined with this entry. The time is determined as a multiple of 100 µs.



7.9.16 Consumer Heartbeat Time (1016_h)

INDEX	**1016_h**
Name	*consumer heartbeat time*
Data type	unsigned 32
Default value	No

The heartbeat function can be used for mutual monitoring of the CANopen modules (especially to detect connection failures). Unlike node guarding/life guarding the heartbeat function does not require RTR-Frames.

Function:
A module, the so-called heartbeat producer, cyclically transmits a heartbeat message on the CAN-bus on the node-guarding identifier (see object $100E_h$). One or more heartbeat consumers receive the message. It has to be received within the heartbeat time stored on the heartbeat consumer, otherwise a heartbeat event is triggered on the heartbeat-consumer module. A heartbeat event generates a heartbeat error on the CAN-CBX module.

Each module can act as a heartbeat producer and a heartbeat consumer. The CAN-CBX module can represent at most one heartbeat consumer per CAN net.

Index	Sub-index	Description	Value range	Default	Data type	Access mode
1016_h	0	*number_of_entries*	1	1	unsigned 8	ro
	1	*consumer_heartbeat_time*	0...$007FFFFF_h$	0	unsigned 32	rw

Meaning of the variable *consumer-heartbeat_time_x*:

	consumer-heartbeat_time_x		
Bit	31 24	23 16	15 0
Assignment	reserved (always '0')	*Node-ID* (unsigned 8)	*heartbeat_time* (unsigned 16)

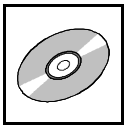
Node-ID Node-Id of the heartbeat producer to be monitored.

heartbeat_time Within this time [ms] the heartbeat producer has to transmit the heartbeat on the node-guarding ID, to avoid the transmission of a heartbeat event.
The consumer-heartbeat time of the monitoring module must always be higher than the producer-heartbeat time of the heartbeat-transmitting module.

Example:

consumer-heartbeat_time = 0031 $03E8_h$

=> *Node-ID* = 31_h = 49_d
=> *heartbeat time* = $3E8_h$ = 1000_d => 1 s



7.9.17 Producer Heartbeat Time (1017_h)

INDEX	**1017_h**
Name	*producer heartbeat time*
Data type	unsigned 16
Default value	0 ms

The producer heartbeat time defines the cycle time with which the CAN-CBX- module transmits a heartbeat-frame to the node-guarding ID.

If the value of the producer heartbeat time is higher than '0', it is active and stops the node-/ life-guarding (see page 59).
If the value of the producer-heartbeat-time is set to '0', transmitting heartbeats by this module is stopped.

Index	Sub-index	Description	Value range	Default	Data type	Access mode
1017_h	0	*producer-heartbeat_time*	0...$FFFF_h$	0 ms	unsigned 16	rw

producer-heartbeat_time Cycle time [ms] of heartbeat producer to transmit the heartbeat on the node-guarding ID (see object $100E_h$).
The consumer-heartbeat time of the monitoring module must always be higher than the producer-heartbeat time of the heartbeat-transmitting module.

7.9.18 Identity Object (1018_h)

INDEX	**1018_h**
Name	*identity object*
Data type	unsigned 32
Default value	No

This object contains general information to the CAN module.

Index	Sub-index	Description	Value range	Default	Data type	Access mode
1018_h	0	*no_of_entries*	4	4	unsigned 8	ro
	1	*vendor_id*	0...FFFFFFFF$_h$	0000 0017$_h$	unsigned 32	ro
	2	*product_code*	0...FFFFFFFF$_h$	see chapter 7.9.1 (page 49)	unsigned 32	ro
	3	*revision_number*	0...FFFFFFFF$_h$	0	unsigned 32	ro
	4	*serial_number*	0...FFFFFFFF$_h$	-	unsigned 32	ro

Description of the variables:

vendor_id This variable contains the esd-vendor-ID. This is always 0000 0017$_h$.

product_code Here the esd-article number of the product is stored.
The nibbles of the long words have the following meaning:

product_code = `abcd efgh`$_h$

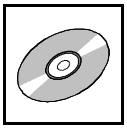
`a`: 1... article number beginning with character “K”
2....article number beginning with character “C”

`bcde`: 4-digit hex number, which is interpreted as the integer part of the decimal number (on the left of the decimal point).

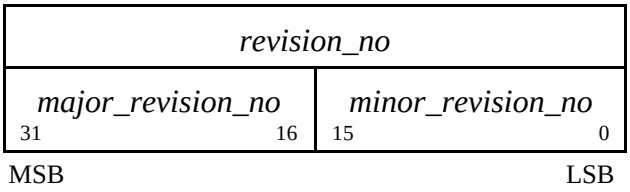
`f`: currently not evaluated

`gh`: 2-digit hex number, which is interpreted an fraction part of the decimal number (on the right of the decimal point).

Example: ‘2303 2002$_h$’ corresponds to article number ‘C.3020.02’.



revision_number Here the software version is stored. In accordance with [1] the two MSB represent the revision numbers of the major changes and the two LSB show the revision number of minor corrections or changes.



serial_number Here the serial number of the hardware is read. The first two characters of the serial number are letters which designate the manufacturing lot. The following characters represent the actual serial number.

In the two MSB of *serial_no* the letters of the manufacturing lot are coded. They each contain the ASCII-code of the letter with the MSB set '1' in order to be able to differentiate between letters and numbers:
(ASCII-Code) + 80_h = read_byte

The two last significant bytes contain the number of the module as BCD-value.

Example:
If the value 'C1C2 0105_h' is being read, this corresponds to the hardware-serial number code 'AB 0105'. This value has to correspond to the serial number of the module.

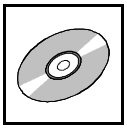
7.9.19 Synchronous Counter Overflow Value (1019_h)

INDEX	**1019_h**
Name	*Synchronous_Counter_Overflow*
Data type	unsigned 8
Default value	0

This object defines whether a counter is mapped into the SYNC message or not and further the highest value the counter can reach.

The value range of the object is described in the following table:

Value	Description
0	The SYNC message shall be transmitted as a CAN message of data length ‘0’.
1	reserved
2...240	The SYNC message shall be transmitted as a CAN message of data length ‘1’. The first data byte contains the counter.
241...255	reserved



7.9.20 Verify Configuration (1020_h)

INDEX	**1020_h**
Name	*verify configuration*
Data type	unsigned 32
Default value	No

In this object the date and the time of the last configuration can be stored to check later whether the configuration complies with the expected configuration or not.
The content of the parameters is not evaluated by the firmware.

Index	Sub-index	Description	Value range	Default	Data type	Access mode
1020_h	0	*no_of_entries*	2	2	unsigned 8	ro
	1	*configuration_date*	0...$FFFFFFFF_h$	0	unsigned 32	rw
	2	*configuration_time*	0...$FFFFFFFF_h$	0	unsigned 32	rw

Parameter Description:

configuration_date Date of the last configuration of the module. The value is defined in number of days since the 01.01.1984.

configuration_time Time in ms since midnight at the day of the last configuration.

7.9.21 Error Behaviour Object (1029_h)

INDEX	**1029_h**
Name	*error behaviour object*
Data type	unsigned 8
Default value	No

If an error event occurs (such as heartbeat error), the module changes into the status which has been defined in variable *communication_error* or *output_error*.

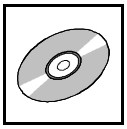
Index	Sub-index	Description	Value range	Default	Data type	Access mode
1029_h	0	*no_of_error_classes*	1	1	unsigned 8	ro
	1	*communication_error*	0...2	0	unsigned 8	rw

Meaning of the variables:

Variable	Meaning
no_of_error_classes	number of error-classes (here always ‘1’)
communication_error	heartbeat/lifeguard error and *Bus off*

The module can enter the following states if an error occurs.

Variable	Module state
0	pre-operational (only if the current state is operational)
1	no state change
2	stopped



7.9.22 NMT Startup ($1F80_h$)

INDEX	**$1F80_h$**
Name	*NMT startup*
Data type	unsigned 32
Default value	2

The NMT startup is implemented to be able to start CANopen nodes in environments without NMT-master.
Via NMT startup the auto startup of a CANopen node can be switched on or off.
Further features of the parameters *NMT startup* are currently not supported.

The value range of the object is described in the following table:

Value	Meaning
$0000\ 0002_h$	Auto startup disabled (default)
$0000\ 0008_h$	Auto startup enabled
all other values	reserved

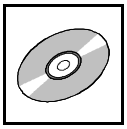
7.9.23 Self Starting Nodes Timing Parameters ($1F91_h$)

INDEX	**$1F91_h$**
Name	*Self starting nodes timing parameters*
Data type	unsigned 16

Index	Sub-index	Description	Value range	Default	Data type	Access mode
$1F91_h$	0	*number_of_entries*	1	1	unsigned 8	ro
	1	*NMT master detection timeout*	0...$FFFF_h$	64_h	unsigned 16	rw

Sub-index 1 of this object contains the timeout in [ms] between the change from “preoperational” > “operational”. In default it is 100 ms.

The sub-indices 2 and 3 of this object are not supported.



7.9.24 Receive PDO Communication Parameter 1401_h, 1402_h

The objects 'Receive PDO Communication Parameter $1401_{h,}$ 1402_h' contain the communication parameters for the PDOs the CAN-CBX-AO412 is able to receive.

INDEX	**1401_h**
Name	*2. receive PDO parameter*
Data Type	PDOCommPar

INDEX	**1402_h**
Name	*3. receive PDO parameter*
Data Type	PDOCommPar

Index	Sub-index	Description	Value range	Default	Data type	Access mode
1401_h	0	*no_of_entries*	2	2	unsigned 8	ro
	1	*COB_ID used by PDO2*	1...800007FF_h	300_h + Node-ID	unsigned 32	rw
	2	*transmission type*	0...FF_h	FF_h	unsigned 8	rw
1402_h	0	*no_of_entries*	2	2	unsigned 8	ro
	1	*COB_ID used by PDO3*	1...800007FF_h	400_h + Node-ID	unsigned 32	rw
	2	*transmission type*	0...FF_h	FF_h	unsigned 8	rw

All *transmission types* are supported.

7.9.25 Receive PDO Mapping Parameter 1601_h, 1601_h

This object contains the PDO mapping parameters for the PDOs the CAN-CBX-AO412 is able to receive.

INDEX	**1601_h**
Name	*2. receive PDO mapping*
Data Type	PDO Mapping

INDEX	**1602_h**
Name	*3. receive PDO mapping*
Data Type	PDO Mapping

The following table shows the assignment of the Receive PDO Mapping Parameter for the default-configuration:

Index	Sub-index	Description	Value range	Default	Data type	Access mode
1601_h	0	*no_of_mapped_application_objects_in_PDO_2*	4	4	unsigned 8	rw
	1	*1st_application_object*	6411 0110_h 6411 0210_h, 6411 0310_h, 6411 0410_h, 0003 0010_h	6411 0110_h	unsigned 32	rw
	2	*2nd_application_object*		6411 0210_h	unsigned 32	rw
	3	*3rd_application_object*		6411 0310_h	unsigned 32	rw
	4	*4th_application_object*		6411 0410_h	unsigned 32	rw
1602_h	0	*no_of_mapped_application_objects_in_PDO_3*	4	4	unsigned 8	rw
	1	*1st_application_object*	6411 0110_h 6411 0210_h, 6411 0310_h, 6411 0410_h, 0003 0010_h	0003 0010_h	unsigned 32	rw
	2	*2nd_application_object*		0003 0010_h	unsigned 32	rw
	3	*3rd_application_object*		0003 0010_h	unsigned 32	rw
	4	*4th_application_object*		0003 0010_h	unsigned 32	rw

7.10 Device Profile Area

7.10.1 Overview of the implemented Objects

Index	Name	Data Type
6411$_h$	*Write Analogue Outputs 16-Bit*	integer 16
6443$_h$	*Error Mode*	unsigned 8
6444$_h$	*Error Value*	integer 32

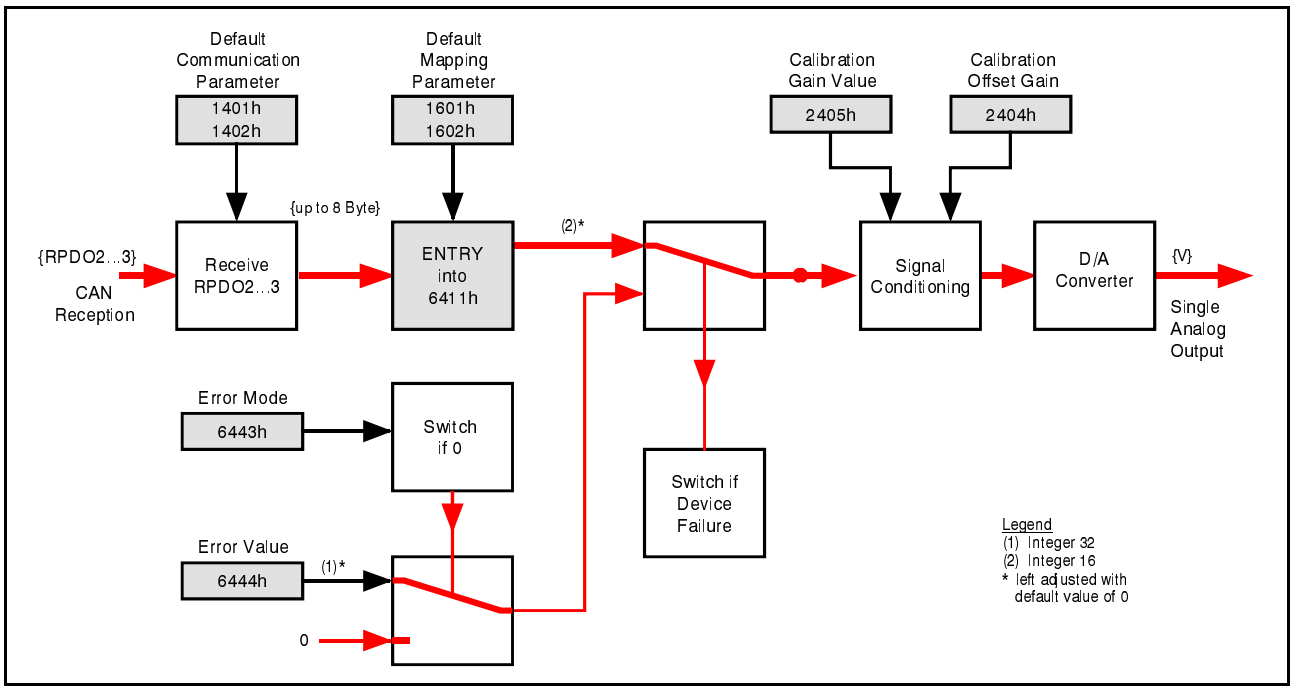


Fig. 20: Overview of implemented objects

7.10.2 Write Analog Output 16-Bit (6411_h)

7.10.2.1 Assignment of the Sub-Indices

Index	Sub-index	Description	Value range	Default	Data type	Access mode
6411_h	0	*Number of entries*	4	4	unsigned 8	ro
	1	*AOUT1_value*	8000_h...$7FFF_h$	0	integer 16	rw
	2	*AOUT2_value*	8000_h...$7FFF_h$	0	integer 16	rw
	3	*AOUT3_value*	8000_h...$7FFF_h$	0	integer 16	rw
	4	*AOUT4_value*	8000_h...$7FFF_h$	0	integer 16	rw

7.10.2.2 Assignment of the variables *AOUTx_value* (x = 1...4)

The number in the name of the variable indicates the number of the analog output channel.

With the variable *AOUTx_value* the output values of the channels can be specified individually. The analog value contains the voltage as 16-bit value. The value is represented as two's complement. The firmware rounds up or down to the 13 bit (12 bit + sign) of the two digital-analog-converters (see page 28).

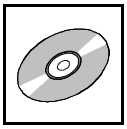
The bit value is calculated according to the following formula:

$$n_{Bit} \approx V_{OUT} \cdot \frac{2^{15}}{10.205\ V}$$

n_{Bit}... Bit value
V_{OUT}... Output voltage
U_{FS}... Voltage (full scale) = 10.205 V

The analog value is transmitted in two's complement representation.

Two's complement representation	Output voltage
8000_h	-10.205 V
:	:
$FFFB_h$	-2.492 mV
$FFFC_h$...0003_h	0.000V
0004_h	+2.492mV
:	:
$7FFF_h$	+10.205 V



7.10.2.3 Examples of CAN-Frames for the SDO-Transfer

For SDO transfer the 8-byte data section of the CAN telegram has the following structure:

Data byte	d1	d2	d3	d4	d5	d6	d7	d8
Content	$2B_h$	11_h	64_h	01h to 04h	$LSB_{OutputX}$	$MSB_{OutputX}$	various	various

Description of the data bytes:

d1: Command code (here $2B_h$ = „Write Request for 2 data bytes“)
d2 and d3: **Index** (here 6411_h = „Write_Analog_Outputs_16-Bit“)
d4: Subindex: Number of the output X (X = 1 to 4)
d5 and d6: Data field, containing the voltage value for output X.
d7 and d8: Not defined, entry optional

Telegram Example 1:
The output voltage of the output channel 1 shall be set to V_{OUT} = 5.0 V.
The bit value is calculated according to the following formula:

$$n_{Bit} \approx 5.0V \cdot \frac{2^{15}}{10.205V} \approx 16051_d = 3EB3_h$$

The following table shows the entries in the data section of the CAN telegram.
For output channel 1 the subindex has to be $d4 = 01_h$.

Data byte	d1	d2	d3	d4	d5	d6	d7	d8
Content	$2B_h$	11_h	64_h	**01h**	**$B3_h$**	**$3E_h$**	various	various

Telegram Example 2:
The output voltage of the output channel 2 shall be set to V_{OUT} = -5,0 V.
Under consideration of the representation in the two's complement, the bit value is calculated according to the following formula:

$$n_{Bit} \approx -5.0V \cdot \frac{2^{15}}{10.205V} \approx -16051_d = C14D_h$$

The following table shows the entries in the data section of the CAN telegram.
For output channel 2 the subindex has to be $d4 = 02_h$.

Data byte	d1	d2	d3	d4	d5	d6	d7	d8
Content	$2B_h$	11_h	64_h	**02h**	**$4D_h$**	**$C1_h$**	various	various

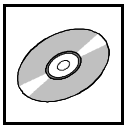
7.10.3 Analog Output Error Mode (6443_h)

Index	Sub-Index	Description	Value range	Default	Data type	Access mode
6443_h	0	*Number of entries*	4	4	unsigned 8	ro
	1	*Error_Mode_Analog_Output_1*	0, 1, 2	1	unsigned 8	rw
	2	*Error_Mode_Analog_Output_2*	0, 1, 2	1	unsigned 8	rw
	3	*Error_Mode_Analog_Output_3*	0, 1, 2	1	unsigned 8	rw
	4	*Error_Mode_Analog_Output_4*	0, 1, 2	1	unsigned 8	rw

This object defines whether an output is set to a predefined error value (see object 6444_h) in case of an internal device failure.

The following modes are defined:

Error mode	Meaning
0	set to 0
1	set to error value (6444_h)
2	leave current value



7.10.4 Analog Output Error Value integer (6444_h)

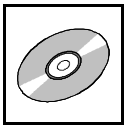
Index	Sub-Index	Description	Value range	Default	Data type	Access mode
6444_h	0	*Number of entries*	4	4	unsigned 8	ro
	1	*Analog_Output_1*	80000000_h ... $7FFFFFFF_h$	0	integer 32	rw
	2	*Analog_Output_2*	80000000_h ... $7FFFFFFF_h$	0	integer 32	rw
	3	*Analog_Output_3*	80000000_h ... $7FFFFFFF_h$	0	integer 32	rw
	4	*Analog_Output_4*	80000000_h ... $7FFFFFFF_h$	0	integer 32	rw

This object contains the left adjusted value to which the outputs shall be set at device failure if the corresponding error mode is active (see object 6443_h).

7.11 Manufacturer Specific Profile Area

7.11.1 Overview of the implemented Objects

Index	Name	Data Type
2404_h	*Calibration Offset Value 16 Bit*	integer 16
2405_h	*Calibration Gain Value 16 Bit*	integer 16



7.11.2 Calibration Offset Value (2404_h)

Index	Sub-index	Description	Value range	Default	Data type	Access mode
2404_h	0	*Number of entries*	4	4	unsigned 8	ro
	1	*Calibration_Offset_1*	8000_h ... $7FFF_h$	$Offset_{Factory}\_1$	integer 16	rw
	2	*Calibration_Offset_2*	8000_h ... $7FFF_h$	$Offset_{Factory}\_2$	integer 16	rw
	3	*Calibration_Offset_3*	8000_h ... $7FFF_h$	$Offset_{Factory}\_3$	integer 16	rw
	4	*Calibration_Offset_4*	8000_h ... $7FFF_h$	$Offset_{Factory}\_4$	integer 16	rw

In this object an offset value for the correction of the A/D-value can be specified. The offset affects the objects 6401_h and 6402_h (see also figure on page ?).

The default values $Offset_{Factory}\_x$ (x = 1 ...4) are determined in the factory calibration of the CAN-CBX-AO412. With object 1011_h (*restore_manufacurer_parameter*) these module-specific default values can be restored.

Value range:

Value of the variable *Calibration_Offset_x*																Offset voltage
Binary (bit 31...0)																Hexadecimal
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8000_h	-10.24 V
:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	$FFFF_h$	-4.7684 nV
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0000_h	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0001_h	+4.7684 nV
:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	$7FFF_h$	+10.24 V $-(1\ LSB_{VARIABLE})$

Resolution of the offset value:
1 LSB based on the variable *Calibration_Offset_x* (x = 1...8):
$1\ LSB_{VARIABLE}$ => 10.24 V / 8000_h => 312.5 µV

7.11.3 Calibration Gain Value (2405_h)

Index	Sub-index	Description	Value range	Default	Data type	Access mode
2405_h	0	*Number of entries*	8	8	unsigned 8	ro
	1	*Calibration_Gain_1*	8000_h...$7FFF_h$	$Gain_{Factory\_}1$	integer 16	rw
	2	*Calibration_Gain_2*	8000_h...$7FFF_h$	$Gain_{Factory\_}2$	integer 16	rw
	3	*Calibration_Gain_3*	8000_h...$7FFF_h$	$Gain_{Factory\_}3$	integer 16	rw
	4	*Calibration_Gain_4*	8000_h...$7FFF_h$	$Gain_{Factory\_}4$	integer 16	rw

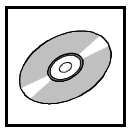
With this object the gain of the A/D-converter channels can be corrected. The gain value, with which the measured A/D-converter value is multiplied, is calculated as:

$$Gain\_x = 1 + \frac{Calibration\_Gain\_x}{2^{18}}$$

with x= 1 ... 4

The resulting value range for the gain factor is: 0.875 ... 1.125

The default values $Gain_{Factory\_}x$ (x = 1 ...4) are determined in the factory calibration of the CAN-CBX-AO412. With object 1011_h (*restore_manufacurer_parameter*) these module-specific default values can be restored.



7.12 Firmware Update via DS-302-Objects $1F50_h$...$1F52_h$

The objects described below are used for program updates via the object dictionary.

Attention:
The firmware update must be carried out only by qualified personnel!
Faulty program update can result in deleting of the memory and loss of the firmware.
The module then can not be operated further!

Note:
esd offers the program CANfirmdown for a firmware update.
Please, contact our support for this.

In normal CiA 301 mode the object $1F50_h$ can not be accessed.
The objects $1F51_h$ and $1F52_h$ are also available in normal CiA 301-mode.
For further information about the objects and the firmware-update please refer to [5].

Index	Sub-index	Description	Data type	Access mode
$1F50_h$	0	Boot-Loader: Firmware download	domain	rw
$1F51_h$	1	Boot-Loader: FLASH command	unsigned 8	rw
$1F52_h$	0,1,2	Boot-Loader: Firmware date	unsigned 32	ro

7.12.1 Download Control via Object ($1F51_h$)

INDEX	**$1F51_h$**
Name	Program Control
Data type	unsigned 8
Access type	rw
Value range	$0...FE_h$
Default value	0

Note:
The value range of this objects in the implementing of the CAN-CBX-module differs from the value range specified in [5].
For further information about object $1F51_h$ and the firmware-update please refer to [5]

7.12.2 Verify Application Software ($1F52_h$)

Index	Sub-index	Description	Value range	Default	Data type	Access mode
$1F52_h$	0	*Number of entries*	2	2	unsigned 8	ro
	1	*Application_Software_Date*	$0...FFFF\ FFFF_h$	-	unsigned 32	rw
	2	*Application_Software_Time*	$0...0526\ 5C00_h$	-	unsigned 32	rw

Description of the variable:

Application_Software_Date — Date of the generation of the firmware used, specified in number of days since 1. January 1984

Application_Software_Time — Time of the generation of the firmware used, specified in milliseconds since midnight.

8. References

[1] CiA 301
CANopen Application layer and communication profile V4.2.0 (12.2011)
CAN in Automation (CiA) e.V., Nürnberg, Germany

[2] CiA Draft Standard Proposal 401 V3.0 (10.2006)
CANopen Device profile for generic IO modules

[3] CiA Draft Recommendation 303 V1.3 (08.2006)
CANopen Additional specification, Part 3: Indicator specification

[4] CAN Application Layer for Industrial Applications CiA/DS202-2 February 1996
CMS Protocol Specification

[5] CiA Draft Standard Proposal 302 V4.1 (04.2010)
Additional Application Layer functions, Part 3: Configuration and program download

[6] Linear Technology, Data sheet: LTC 2600/LTC2610/LTC2620 Octal 16-/14-/12-Bit Rail-to-Rail DACs in Lead SSOP, USA, 2600fa, LT/TP1103 1K RevA

[7] Phoenix Contact GmbH & Co. KG, Blomberg.
Technical data is taken from the Phoenix Contact website:
https://www.phoenixcontact.com/online/portal/de;
PCB plug connector - FKCT-2,5/4-ST KMGY - 1921900, downloaded 2013-10-09

[8] Phoenix Contact GmbH & Co. KG, Blomberg.,
Technical data is taken from the Phoenix Contact website:
https://www.phoenixcontact.com/online/portal/de;
PCB plug connector - FK-MCP 1,5/ ...-STF-3,81 - 1851261, downloaded 2013-10-09

9. EU 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-CBX-AO412

Typ, Modell, Artikel-Nr.
Type, Model, Article No.
C.3040.02

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.
H-K00-0358-09

Das Produkt entspricht damit der EU-Richtlinie „EMV"
Therefore the product corresponds to the EU Directive 'EMC'
2014/30/EU

Das Produkt entspricht der EU-Richtlinie „RoHS"
The product corresponds 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, 2014-07-28

Thorsten Ramm
Rechtsgültige Unterschrift / *authorized signature*

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10. Order Information

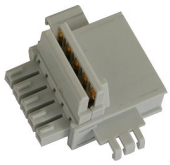
Type	Features	Order No.
CAN-CBX-AO412	CAN-CBX-AO412 4 analog outputs, 12 bit, ± 10 V output voltage range including 1x CAN-CBX-TBUS (C.3000.01)	C.3040.02
Accessories		
CAN-CBX-TBUS 	Mounting-rail bus connector of the CBX-InRailBus for CAN-CBX-modules, (one bus connector is included in delivery of the CAN-CBX-module)	C.3000.01
CAN-CBX-TBUS-Connector 	Terminal plug of the CBX-InRailBus for the connection of the +24 V power supply voltage and the CAN interface Female type	C.3000.02
CAN-CBX-TBUS-Connection adapter 	Terminal plug of the CBX-InRailBus for the connection of the +24 V power supply voltage and the CAN interface Male type	C.3000.03

Table 13: 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.

Order Information

Manuals		Order No.
CAN-CBX-AO412-ME	Manual in English	C.3040.21
CAN-CBX-AO412-MD	Manual in German	C.3040.20

Table 14: 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.