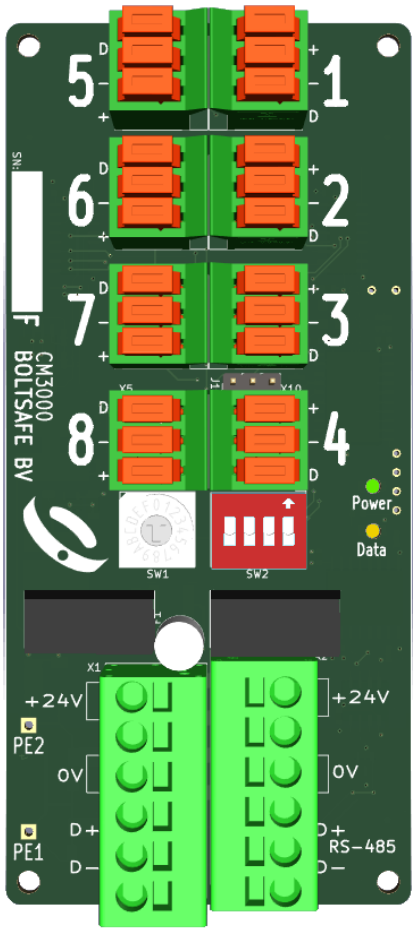

User Manual

Boltsafe CM-3000 F

version 201

WARNING

EXPLOSION HAZARD

DO NOT CONNECT OR DISCONNECT WHILE THE CIRCUIT IS LIVE OR UNLESS THE AREA IS FREE OF IGNITIBLE CONCENTRATIONS

If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired. Do read this manual!

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History

20240918	SGS	001	Initial version
20240927	SGS	100	Adapted to version B
20250305	SGS	200	Update to version F hardware
20250527	SGS	201	Detailing after discussions

Contents

1 Introduction

This document should help you to quickly get familiar with the CM-3000 communication box. The CM-3000 communicates with up to 8 CMS force sensors, collects configuration data from the sensors and reads all sensors continually for the load value. All those values are available for other devices over a RS-485 Modbus RTU connection.

The steps to be taken are: physically install the sensors, physically install the CM-3000, connect the wiring, set the configuration, power up and communicate.

1.1 Usage in Hazardous Areas (Ex or ATEX)

The CM-3000 has a Ex (ATEX) marking and can be used in some hazardous areas with the following restrictions:

- Intended for indoor use only.
- Ambient temperature between -20 and +60°C
- Lid can only be removed when in a safe environment.
- Same for coupling and decoupling of CMS sensors.
- In combination with proper wiring and grounding.

Apart from international standards also national or even site restrictions may apply. Be informed!

Note that the sign: ⏚ indicates a grounding point intended to connect a ground wire. One connection is found outside the box for up to 6mm^2, one is provided inside the box for supplementary bonding. Both are marked as such.

2 Installing the CM-3000

The CM-3000 must be used indoor in an environment that meets the specifications as outlined in chapter “8 ” page 15. The box must be firmly mounted and cabling must be installed according to regulations.

The aluminium box has 2 mounting holes for M4 screws (max head diameter 8mm) in a rectangular pattern of 52 x 163mm, top left and bottom right. The box may be mounted in any orientation.

The field wiring should enter through the cable glands provided. The glands can freely be used as in and output. Also the connection to the two terminal blocks are free to use for in and out. Only on the last CM-3000 there should be a terminating resistor on the network connections. And the unused gland should be plugged. So, a CM-3000 with a cable coming in and going out should not have a terminating resistor.

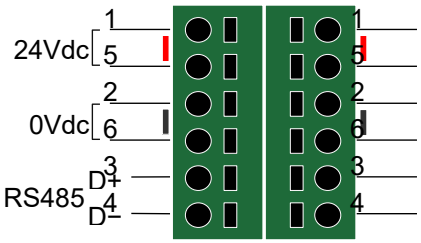
Set the switches as needed. See page 7 chapter “4 ”. Next close the lid!

Now connect all sensors and used a blind plug or cap for all other M12 connectors.

Only after all that, power it up.

3 Connecting the CM-3000

The CMS sensors are connected through M12 connectors. They are a proven technology in industrial applications. The signal levels on this connector are up to 5Volt and intrinsically safe (IS). When the communication with a sensor is lost, this is reflected in the data readout. When the connection is re-established the sensor will be part of the normal operation again.

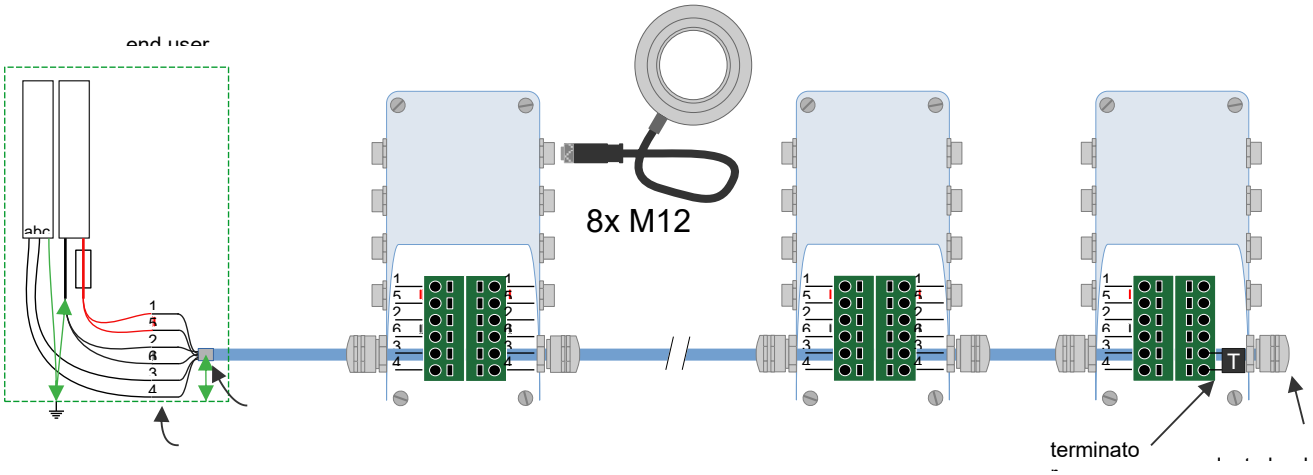


The CM-3000 has two spring cage terminal blocks for field wiring that have a 1-to-1 wiring between them. Either can be used for incoming or outgoing cabling. On each of the blocks here are two terminals for the network and two for +24V and two for 0V.

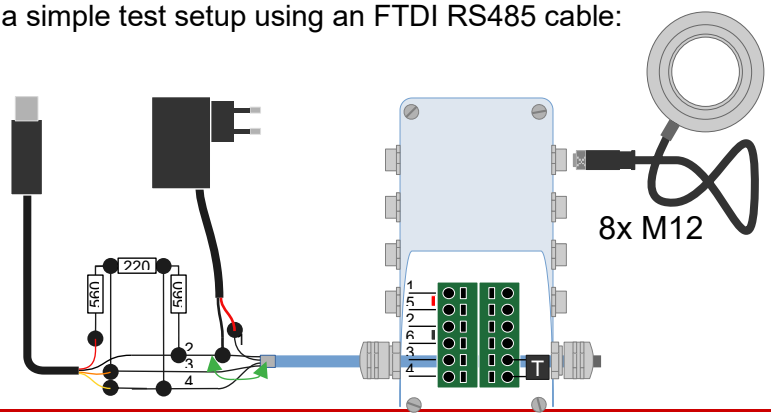
Preferably a shielded cable is used. To have proper operation of the network, twisted pair cable is to be used. For a short network (<100m) with a few CM-3000s (<4) a cable with two pairs (0,5mm^2) will be sufficient. Larger configurations will use a shielded cable with three pairs. If two pairs carry power, each pair carry both +24V and 0V. It is part of the installation design to select the cable, the fuse before that to should limit the cable into the cable and a sufficient power supply. A CM-3000 draws less than 50mA so just a 1 Amp power supply is often enough. And safe for the cable.

It is assumed that the power supply 0V is grounded to the same potential as the shielding. Also the gateway communication interface “common” connection is to be grounded.

Example of the installation:



Or a simple test setup using an FTDI RS485 cable:



Orientation of the BoltSafe sensor

Place the BoltSafe sensor with the “thin” section facing the nut, as indicated in the drawing. The effect of reversed orientation is within the stated system accuracy of 1% FS.

Mechanical considerations

The design of the BoltSafe sensor is optimized to be very insensitive to mechanical boundary conditions. However, one has to bear in mind that the BoltSafe ‘washers’ are high-technology sensors, which means some precautions will have to be taken when installing them.

• The BoltSafe sensor should always be placed directly under the nut on the opposite side of the tool. This results in less rotation of the sensor. If placed under the nut where the torque wrenches or spanners are used, a hardened flat washer may be used between the nut and the sensor to avoid surface scratching of the sensor. This will however reduce the accuracy of the sensor reading slightly.

• The cable inlet is the weakest point on the BoltSafe CMS sensor, and care must be taken when installing the sensor to avoid too much bending and stress on the cable inlet.

• Point load from irregularities on the nut or flange face may affect the sensor. Even though the effect on accuracy is small, the nut and flange face should always be checked for irregularities.

• The marking side of the nut should not be placed against the BoltSafe sensor.

• The BoltSafe sensor is a specially designed sensor to monitor the bolt load in bolted joints, and should not be used for other applications or purposes without consulting BoltSafe.

4 Configuration

There is little to configure. The address on the network needs to be selected and transmission speed can be set. The rotary switch is rather obvious however the setting “0” sets the address to 16. The dip switches are clearly marked 1 to 4. Placing switch 1 in the “ON” position increases the address by 16. Switches positions 2 and 3 have no function assigned and are reserved for future use. Switch 4 selects between 19200 (off) and 115k2 (on) Baud. The photo shows configuration for 115k2 at address 4. This will be used for a first setup.

The switches are read within a second after power-on only. The resulting configuration is used for as long as the unit is powered. Changing the switches during operation has no influence.

SW1	Address
0	16
1	1
2	2
…	…
9	9
A	10
B	11
C	12
D	13
E	14
F	15

SW2-1	“ON” adds 16 to the address.
SW2-2	<reserved for future use>
SW2-3	<reserved for future use>
SW2-4	“OFF” = 19200 Baud “ON” = 115k2 Baud.

5 Service and maintenance

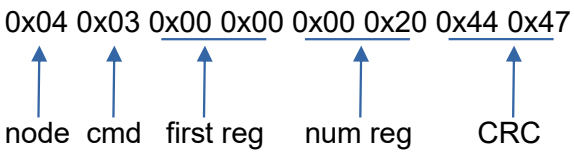
There are no user serviceable parts inside the CM-3000. Also does it not require any maintenance other than to use it in an orderly fashion. Avoid getting it wet and keep dust away. See to it that it does not get mechanically damaged.

6 Communication

When trying to establish RS485 communications a few things need to be right. The RS485 is a bus network with a strict master-slave operation. The CM-3000 is a slave to the network. There may be up to 32 slaves on one network section. The network may be up to 1200 meters long. On both ends the network needs to be “terminated”. For this there is a termination resistor in each CM-3000. CM-3000s with a through connection should have the termination resistor removed (also to free the connection). The master on the network may be a simple USB to RS-485 connector, a gateway or a PLC or the like. The master should supply a bias to the network. Often the master is one end of the network with an active termination that also biases the network.

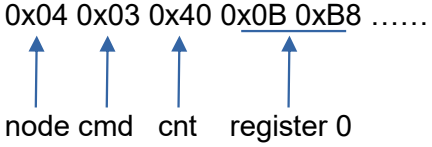
Also the transmission speed needs to be set. For reasons of compatibility to the Modbus RTU standard the CM-3000 can communicate on 19200 Baud. But a higher speed of 115k2 is also available. The data format is 8 bits with even parity as the specification requires.

And lastly the protocol needs to be correct, including the checksum. We expect that only command 3 is used to read multiple registers. To establish the first communication one may send a 0x03 command that retrieves 32 registers starting from number 0. The following sequence of bytes resemble that command:



The bytes should be sent without a carriage return or line feed following. Just 8 bytes. After a time out of around 2 milliseconds a reply is sent back. Sending those requests and getting back answers can be done many times per second. The values are always up to date. The answer is is 69 bytes long including the checksum. Here too a timeout signals the end of the transmission.

Obviously it would be desirable to check the checksum and only interpret the data if the checksum is correct. The answer may start like this:



The node number and command are the same as the command. The third byte is a count of the number of data bytes that follow (0x40 = 64 which is 32 registers). The two bytes at the very end are the checksum and will vary with the content of the message.

7 Modbus

The commands 0x03, 0x06 en 0x10 are implemented to a maximum length of 32 registers in a single communication. It is expected that only command 03 is used, modifying register is not advised. Attempts to access non-existing registers or too many registers at once results in an error reply.

7.1 Register description

All relevant registers are described below. All other registers are reserved for future use. Simply do not bother about those registers.

Registers 0 to 3 (the first four registers) contain a hardware and software identification, next two registers are reserved, and the next five registers 6 to 10 contain a unique ID for this CM-3000.

Register 0 – HARDWARE_ID

This register is read only.

It contains an unsigned 16-bit word.

	Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
reg 0	HARDWARE_ID[15:0]																

- Bit 15:0 – HARDWARE_ID

  This is the identification for the hardware and contains 0x0BB8, so 3000.

Register 1 – HARDWARE_MODEL

This register is read only.

It contains an unsigned 16-bit word.

	Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
reg 1	HARDWARE_MODEL[15:0]																

- Bit 15:0 – HARDWARE_MODEL

  This is the hardware version. The first released hardware is 6. Obviously this number may go up.

Register 2 – SOFTWARE_ID

This register is read only.

It contains an unsigned 16-bit word.

	Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
reg 2	SOFTWARE_ID[15:0]																

- Bit 15:0 – SOFTWARE_ID

  This is the identification for the software. It contains 0x4253.

Register 3 – SOFTWARE_VERSION

This register is read only.

It contains an unsigned 16-bit word.

	Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
reg 3		SOFTWARE_VERSION[15:0]															

- Bit 15:0 – SOFTWARE_VERSION

  This is the software version. The first released software is 0x0078 which is 120 for version 1.20. Obviously this number may go up.

Register 6...10 – HARDWARE unique ID

Those registers are read only.

Five consecutive registers each containing an unsigned 16-bit word. Together they form a 40-bit unique ID.

	Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
reg 6		HWID_0[15:0]															
reg 7		HWID_1[15:0]															
reg 8		HWID_2[15:0]															
reg 9		HWID_3[15:0]															
reg 10		HWID_4[15:0]															

This concludes the more formal registers. Next come registers that have to do with the sensors and operation in general.

Register 12 – general status register

This register is read only.

The register contains a signed 16-bit word.

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
reg 12	-	-	-	-	Vi	Vs	OV	UV	S8	S7	S6	S5	S4	S3	S2	S1

- Bit 15:12 – <not used>
- Bit 11 Vi problem with internal voltage
- Bit 10 Vs problem with sensor power supply
- Bit 9 OV over voltage intern
- Bit 8 UV under voltage intern
- Bit 7 S8 this bit indicates if sensor 8 is present (1 = present).
- Bit 6 S7 this bit indicates if sensor 7 is present (1 = present).
- Bit 5 S6 this bit indicates if sensor 6 is present (1 = present).
- Bit 4 S5 this bit indicates if sensor 5 is present (1 = present).
- Bit 3 S4 this bit indicates if sensor 4 is present (1 = present).
- Bit 2 S3 this bit indicates if sensor 3 is present (1 = present).
- Bit 1 S2 this bit indicates if sensor 2 is present (1 = present).
- Bit 0 S1 this bit indicates if sensor 1 is present (1 = present).

Register 13 – sensor 1 force in kN

This register is read only.

The register contains a signed 16-bit word.

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
reg 13	S1_F_kN[15:0]															

- Bit 15:0 – S1_F_kN

  Contains force in kiloNewton of sensor 1. The values zero and below indicate a status.

"0" indicates no sensor is connected

"-1" the measured force is under the range for this sensor

"-2" the measured force is over the range for this sensor (overload)

"-3" internal supply voltage low

"-4" internal supply voltage high

"-5" communication between CM-3000 and CMS sensor has a problem.

Register 14 – sensor 2 force in kN

See register 13.

Register 15 – sensor 3 force in kN

See register 13.

Register 16 – sensor 4 force in kN
See register 13.

Register 17 – sensor 5 force in kN
See register 13.

Register 18 – sensor 6 force in kN
See register 13.

Register 19 – sensor 7 force in kN
See register 13.

Register 20 – sensor 8 force in kN
See register 13.

Register overview

	Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
reg 0		Hardware ID															
reg 1		Software ID															
reg 2		Serienummer_0															
reg 3		Serienummer_1															
reg 4		Serienummer_2															
reg 5		Modbus adres															
reg 6		<register reserved>															
reg 7		<register reserved>															
reg 8		<register reserved>															
reg 9		<register reserved>															
reg 10		<register reserved>															
reg 11		<register reserved>															
reg 12		general status register															
reg 13		Force in kN for sensor 1															
reg 14		Force in kN for sensor 2															
reg 15		Force in kN for sensor 3															
reg 16		Force in kN for sensor 4															
reg 17		Force in kN for sensor 5															
reg 18		Force in kN for sensor 6															
reg 19		Force in kN for sensor 7															
reg 20		Force in kN for sensor 8															
reg 21		Temperature in °C of sensor 1															
reg 22		Temperature in °C of sensor 2															
reg 23		Temperature in °C of sensor 3															
reg 24		Temperature in °C of sensor 4															
reg 25		Temperature in °C of sensor 5															
reg 26		Temperature in °C of sensor 6															
reg 27		Temperature in °C of sensor 7															
reg 28		Temperature in °C of sensor 8															
reg 29		<register reserved>															
reg 30		<register reserved>															
reg 31		<register reserved>															

8 Technical data

Conditions of Acceptability		
Input Voltage nominal / max	24V / 35V	
Input Current	5A max	
Cable temperature	≤ 70°C	(at termination point)
Grounding for Ex version	external 6mm^2	
Lid must be closed	so that switches cannot be operated.	

The device may only be powered by a power supply unit with a limited energy electric circuit in accordance with CSA/UL/EN/IEC 61010-1:2010 chapter 6.3.1/6.3.2 and 9.4 or class 2 according to CSA 223/UL 1310 with max 24 ± 10% Vdc, 5A

Specifications		
Input Voltage range/nominal	21,6 … 26,4 V / 24,0 V	
Input power	1,2 Watt max	(regardless of number of CMS sensors)
Through connection current	5A max	
Output voltage to CMS sensors	5,0 Volt	
Short circuit current to sensors	< 20 mA	(active only one at the time)
Grounding for Ex version	external 6mm^2	
Max size wire in and out	1,5 mm^2	(AWG 15)
Ingress protection	IP66	

Network	
Electrical norm	RS-485
Network protocol	Modbus RTU
Data format	8bit even parity 1 stopbit
Data speed	19k2 and 115k2 Baud
Isolated interface	1,5 kV

Mechanical		
Box and Lid material	die cast aluminium	
Dimensions	80 x 175 x 57mm	(3,2” x 6,9” x 2,25”)
Unit weight	780gram	(27,5 oz)
Number of mounting holes	2 x Ø4,5mm (in 163 x 52mm rectangle) (6,4” x 2,05”)	
Cooling system	by natural convection	

Environment

Limitation	For indoor use only
Ambient temperature	-20 to +60°C
Storage temperature	-20 to +60°C
Humidity	5 to 95% RH (non-condensing)
Operating altitude	Max. 2000 m
Pollution degree	2

Protection

Internal fuse	1A 125V with 10kA breaking capacity (not serviceable)
Power in IS domain when short	< 560mW
Ingress protection	IP66
Isolation power in to network	1,5kV
Isolation power to IS	1,5kV
Isolation of any domain to PE	1,5kV
Bleeder of any domain to PE	10MegΩ

CMS sensors

Voltage (nominal)	5,0V	
Current (maximal)	17,0mA	
Power (maximal)	85mW (0.085Watt)	
Sensor capacitance	100nF (0.1µF)	(in total)
Sensor inductance	150µH	(maximum)
Grounding	Not needed as it is part of a construction.	
Cable is attached, length is fixed	to order, maximum is 10m	
Cable capacitance*	3.9nF	(for a 10m cable)
Cable inductance*	5.9µH	(for a 10m cable)

*) Measured the real cable using LCR Researsch type LCR PRO1 s/n:615109 calibrated March 6, 2025

Safety Standards / Directives

Hazardous Location / ATEX	Class I, Division 2, Group B, C, D T4, Ta= -25°C to +60°C
Tested according to	CSA C22.2 No.61010-1-12 + UPD1:2015, UPD2:2016, AMD 1-18 CSA C22.2 No. 213-17 + UPD1:2018, UPD2:2019, UPD3:2021 ANSI/UL 61010-1-2018 (Third Edition) ANSI/UL 121201-1-2021 (Ninth Edition)