BATTERY MANAGEMENT SYSTEM
REC 2Q BMS
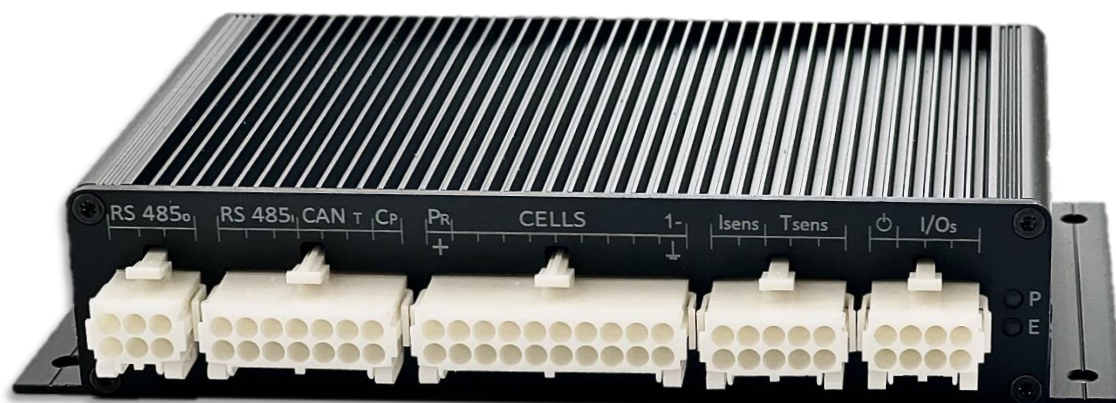
REC
Control your power!

REC 2Q BMS Features:

- robust and small design
- 5-16 cells connections (14 – 68 V system)
- up to 4 digital temperature sensors DS18B20
- single cell voltage measurement (0.1 – 5.0 V, resolution 1 mV)
- single cell - under/over voltage protection
- single cell internal resistance measurement
- SOC and SOH calculation
- over temperature protection
- under temperature charging protection
- 4 Ω passive cell balancing with temperature protection
- shunt current measurement (resolution 19.5 mA @ ± 500 A)
- two galvanically isolated user defined multi-purpose digital output
- internal DC opto-relay output
- galvanically isolated RS-485 communication (in and out port with enable)
- CAN communication
- error LED + buzzer indicator
- PC user interface/Wi-Fi for changing the settings and data-logging (optional accessory)
- Remote ON/OFF
- Control pilot (CP) for EVSE
- Integrated 25 Ohm pre-charge with adjustable time delay
- Integrated RTC with last 7 errors
- ISO16315, ISO10133, EN61558-1, EN61558-2 and EN50498 compliant

INDEX:

General Description of the BMS Unit:

The Battery Management System (BMS) monitors and controls each cell in the battery pack by measuring its parameters. The capacity of the battery pack differs from one cell to another and this increases with number of charging/discharging cycles. The Li-poly batteries are fully charged at typical cell voltage 4.16 - 4.20 V or 3.5 – 3.7 V for LiFePO4. Due to the different capacity this voltage is not reached at the same time for all cells in the pack. The lower the cell's capacity the sooner this voltage is reached. When charging series connected cells with a single charger, voltage on some cells might be higher than the maximum allowed voltage. Overcharging the cell additionally lowers its capacity and number of charging cycles. The BMS equalizes cell's voltage by diverting some of the charging current from higher voltage cells to power resistors – passive balancing. The device's temperature is measured to protect the circuit from over-heating. Number of cells being balanced is reduced to the most critical near the maximum BMS internal temperature setting. Battery pack's temperature is monitored by Dallas DS18B20 digital temperature sensor/s. Maximum 4 temperature sensors per unit may be used. Current is measured by a low-side shunt resistor. Battery pack current, temperature and cell's voltage determine state of charge (SOC). State of health (SOH) is determined by comparing cell's current parameters with the parameters of a new battery pack. The BMS default HW parameters are listed in Table 1.

Hardware Parameters:

Table 1: BMS hardware parameters.

PARAMETER	VALUE	UNIT
BMS maximum pack voltage	68.0	V
BMS minimum pack voltage	10	V
BMS minimum pack voltage (HW UVP)*	-	V
BMS cell voltage range	0.0 to 5.0	V
Shunt common mode input voltage interval (Shunt+, Shunt -) to the Cell 1 negative	-0.3 to 3.0	V
Shunt sensor max differential input voltage interval (Shunt+ to Shunt -)	-0.25 to 0.25	V
Cell voltage accuracy	+/-1	mV
Pack voltage accuracy	+/-5	mV
DC current accuracy	+/- 1	LSB
Temperature measuring accuracy	+/-0.5	°C
DC Current sample rate	4	Hz
Cell voltage sample rate	1	Hz
Cell balancing resistors	4.0	Ω
Maximum operating temperature**	70	°C
Minimum operating temperature**	-20	°C
Maximum storage temperature**	30	°C
Minimum storage temperature**	0	°C
Maximum humidity**	75	%
Max continuous DC current opto-relay @ 100 V DC	3	A
Max DC current @ optocoupler 1, 2	15	mA
Max DC voltage@ optocoupler 1, 2	62.5	V
BMS unit disable power supply @ 48 V	1.5	mW
BMS pre-charge resistance	25	Ω
BMS unit operation power supply @ 48 V	180 - 190	mW
BMS unit cell balance fuse rating	3 slow	A
Internal relay fuse	3.15 slow	A
Dimensions (w × l × h)	190 x 98.4 x 38	mm
IP protection	IP32	
HW version	1.35	n.a.

*installed on request
**defined by internal RTC back-up 2032 battery

Default Software Parameters:

Table 2: Default BMS parameter settings*.

PARMETER	VALUE	UNIT
Chemistry	3 (LiFePO$_4$)	n.a.
Capacity	100	Ah
Balance start voltage	3.45	V
Balance end voltage	3.58	V
Cell over-voltage switch-off per cell	3.85	V
Over-voltage switch-off hysteresis per cell	0.25	V
Cell end of charge voltage	3.58	V
End of charge hysteresis per cell	0.25	V
SOC end of charge hysteresis	5	%
Maximum cell float voltage coefficient	0.8	n.a.
Cell-under voltage protection switch-off	2.80	V
Under voltage protection switch-off hysteresis per cell	0.10	V
Cell under voltage discharge protection	2.90	V
Battery pack under voltage protection switch-off timer	2	s
Cells max difference	0.25	V
SOC discharge hysteresis	5	%
BMS over-temperature switch-off	55	°C
BMS over-temperature switch-off hysteresis	5	°C
Cell over temperature switch-off	55	°C
Cell over temperature switch-off hysteresis	2	°C
Under temperature charging disable	-10	°C
Under temperature charging disable hysteresis	2	°C
Voltage to current coefficient 200A/50mV	0.01953125	A/bit
Current measurement zero offset	0.0	A
Maximum charging/discharging current per inverter device	100/200	A
Number of inverter/charger devices	1	n.a.
Charge coefficient	0.6	1/h
Discharge coefficient	1.5	1/h
CAN communication bit-rate @ 11-bit ID	500	kbit/s
SW version	1.3	n.a.

*all parameters' values may be changed with PC Software BMS Master Control user interface/Wi-Fi module.
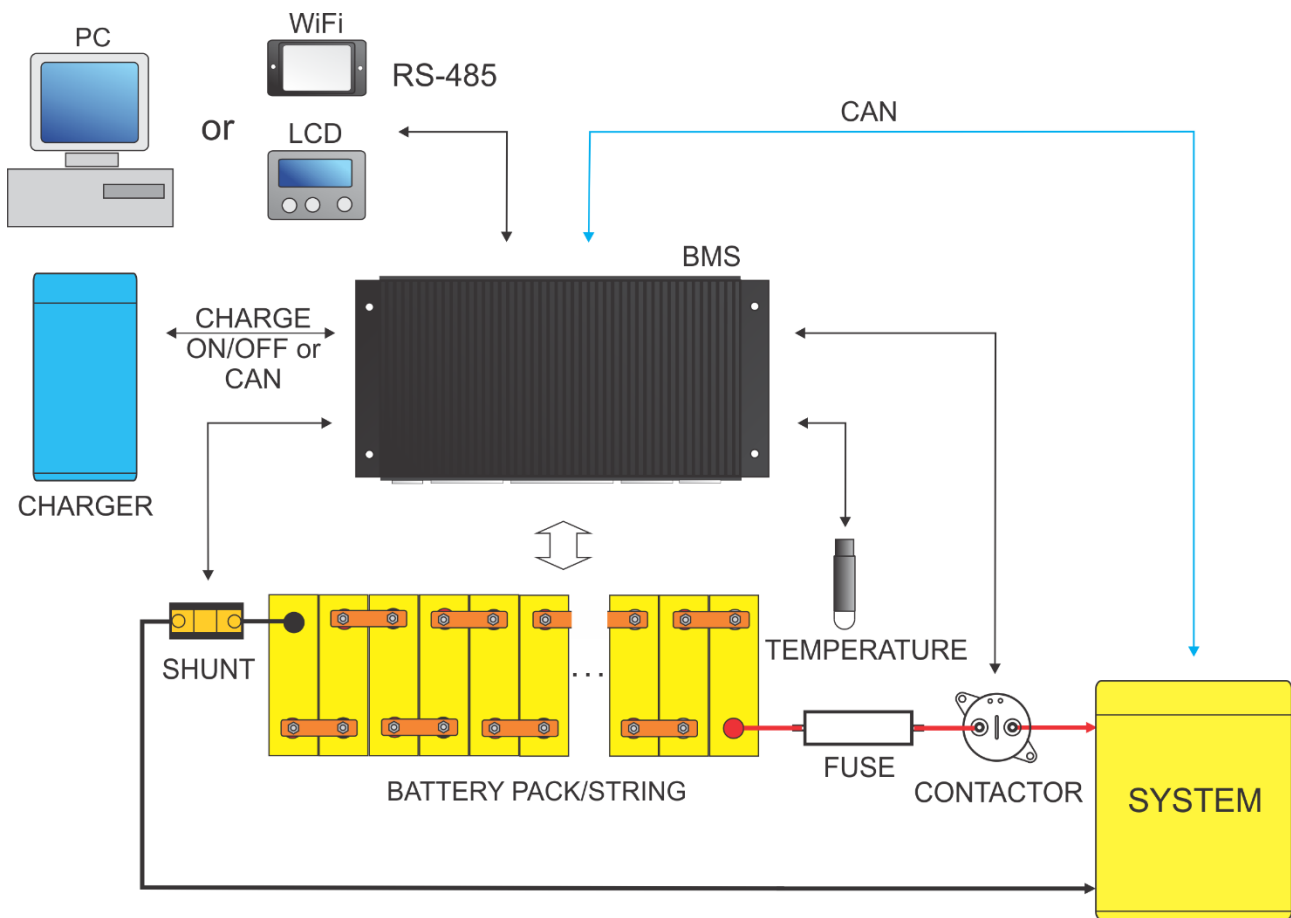
System Overview:

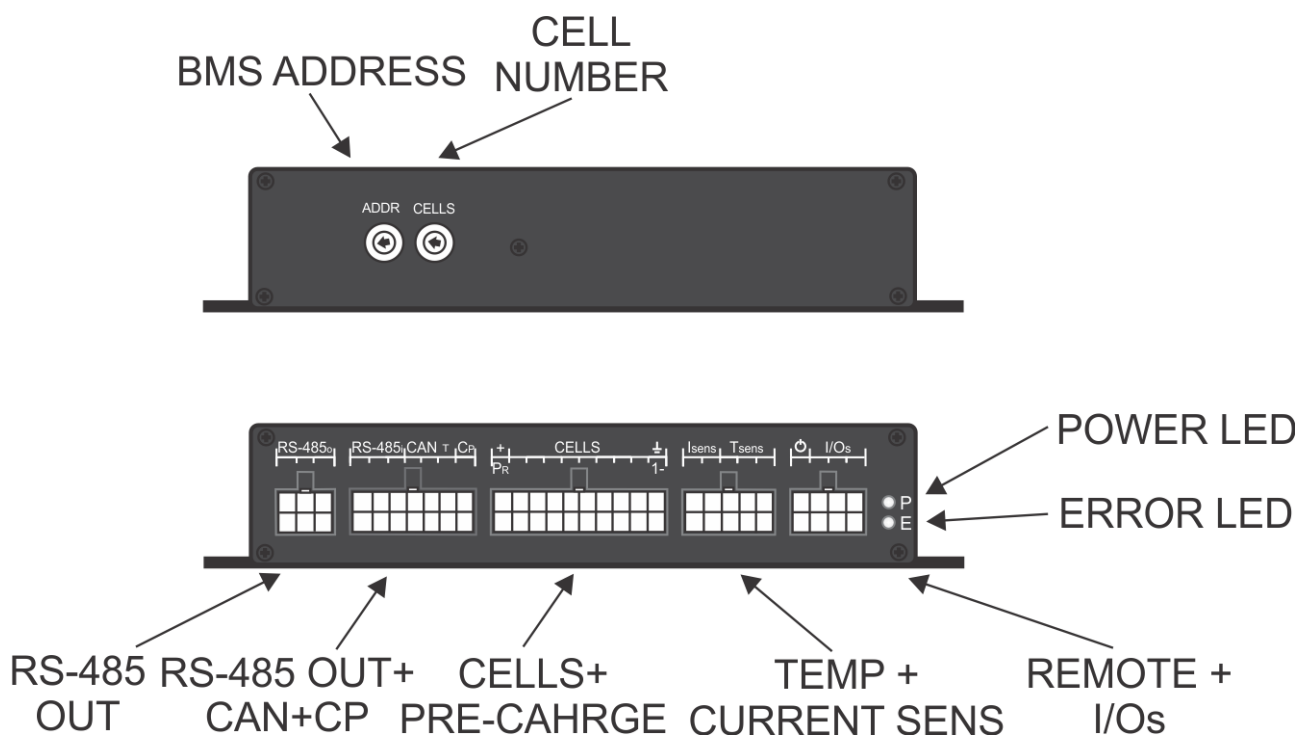**Figure 1:** System overview.

BMS Unit Functional Overview:

Figure 2: BMS unit functional overview.
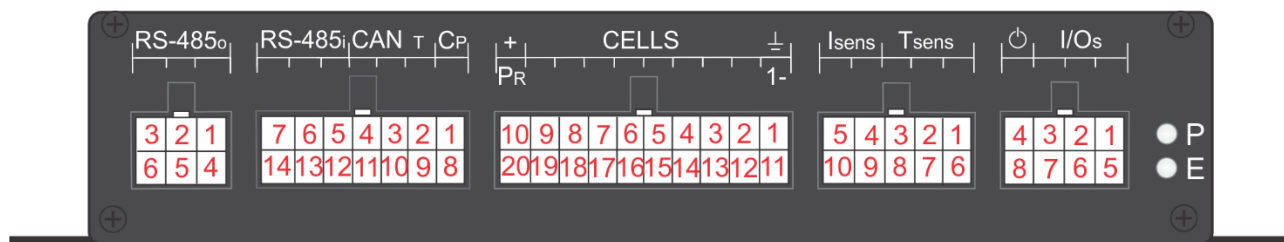
BMS Connections:

Figure 3: BMS Connections description.

Table 3: RS-485 communication output connector's pin description.

Pin	Connection	Description	Plug
1	RS-485 B out	Signal B out	
2	RS-485 A out	Signal A out	
3	RS-485 +5 V ENABLE out	BMS Enable output from Master BMS in Master-Slave configuration	794190-1
4	RS-485 +5 V out	RS-485 +5 V Power supply	
5	RS-485 GND out	RS-485 Power supply GND	
6	RS-485 CABLE SHIELD out	SHIELD OUT	

Table 4: RS-485 communication input, CAN communication and Control Pilot connector's pin description.

Pin	Connection	Description	Plug
1	CP AGND	EVSE CP ground	
2	CAN TERMINATION L	120 Ω CAN termination low	
3	CAN L	CAN signal low	
4	+ 5V CAN	CAN driver power supply in case of required galvanic isolation (+5 V between pin 11 and pin 4)*	
5	RS-485 +5 V ENABLE in	BMS Enable input from Master BMS in Master-Slave configuration	
6	RS-485 B in	Signal B in	
7	RS-485 A in	Signal A in	794202-1
8	CP	EVSE CP signal	
9	CAN TERMINATION H	120 Ω CAN termination high	
10	CAN H	CAN signal high	
11	CAN GND	CAN ground - BMS GND. If galvanically isolated use as +5V supply AGND.*	
12	RS-485 CABLE SHIELD in	SHIELD IN	
13	RS-485 GND	RS-485 Power supply GND	
14	RS-485 +5V	RS-485 +5 V Power supply	

* Galvanically isolated CAN communication is upgraded upon request.

Table 5: Power supply, cell measurement and pre-charge connector's pin description.

Pin	Connection	Description	Plug
1	CELL 1-	Cell 1 negative (PACK -)	1-794106-0
2	CELL 2+	Cell 2 positive	
3	CELL 4+	Cell 4 positive	
4	CELL 6+	Cell 6 positive	
5	CELL 8+	Cell 8 positive	
6	CELL 10+	Cell 10 positive	
7	CELL 12+	Cell 12 positive	
8	CELL 14+	Cell 14 positive	
9	CELL 16+	Cell 16 positive	
10	PRE-CHARGE OUT	Pre-charge out – connect to System + side of the contactor	
11	PACK-	BMS Power supply negative (Cell 1 negative)	
12	CELL 1+	Cell 1 positive	
13	CELL 3+	Cell 3 positive	
14	CELL 5+	Cell 5 positive	
15	CELL 7+	Cell 7 positive	
16	CELL 9+	Cell 9 positive	
17	CELL 11+	Cell 11 positive	
18	CELL 13+	Cell 13 positive	
19	CELL 15+	Cell 15 positive	
20	PACK +	BMS Power supply positive	

Table 6: Current and temperature sensor connector's pin description.

Pin	Connection	Description	Plug
1	1-WIRE GND port 1	1-WIRE temperature sensor DS18B20 Supply GND	794196-1
2	1-WIRE SIGNAL port 1	1-WIRE temperature sensor DS18B20 signal	
3	1-WIRE +5 V port 1	1-WIRE temperature sensor DS18B20 Supply +5 V	
4	CURRENT SENS -	Shunt sensor Kelvin connection negative	
5	CURRENT SENS CABLE SHIELD	Current sensor cable shield	
6	1-WIRE GND port 2	1-WIRE temperature sensor DS18B20 Supply GND	
7	1-WIRE SIGNAL port 2	1-WIRE temperature sensor DS18B20 signal	
8	1-WIRE +5 V port 2	1-WIRE temperature sensor DS18B20 Supply +5 V	
9	CURRENT SENS +	Shunt sensor Kelvin connection positive	
10	-	-	

Table 7: Remote ON/OFF and I/O connector's pin description.

| Pin	Connection	Description	Plug
1	OPTOCOUPLER 1 EMITTER	Optocoupler 1 emitter (negative)	
2	OPTOCOUPLER 2 EMITTER	Optocoupler 2 emitter (negative)	
3	OPTO-RELAY OUT	Opto-relay output signal	
4	REMOTE ON/OFF -	BMS Remote ON/OFF input	
5	OPTOCOUPLER 1 COLLECTOR	Optocoupler 1 collector (positive)	794192-1
6	OPTOCOUPLER 2 COLLECTOR	Optocoupler 2 collector (positive)	
7	OPTO-RELAY IN	Input supply + for the OPTO – RELAY (100V DC, 3 A max)	
8	REMOTE ON/OFF +	BMS Remote ON/OFF source (connect to REMOTE ON/OFF – pin 4 to enable the BMS)	
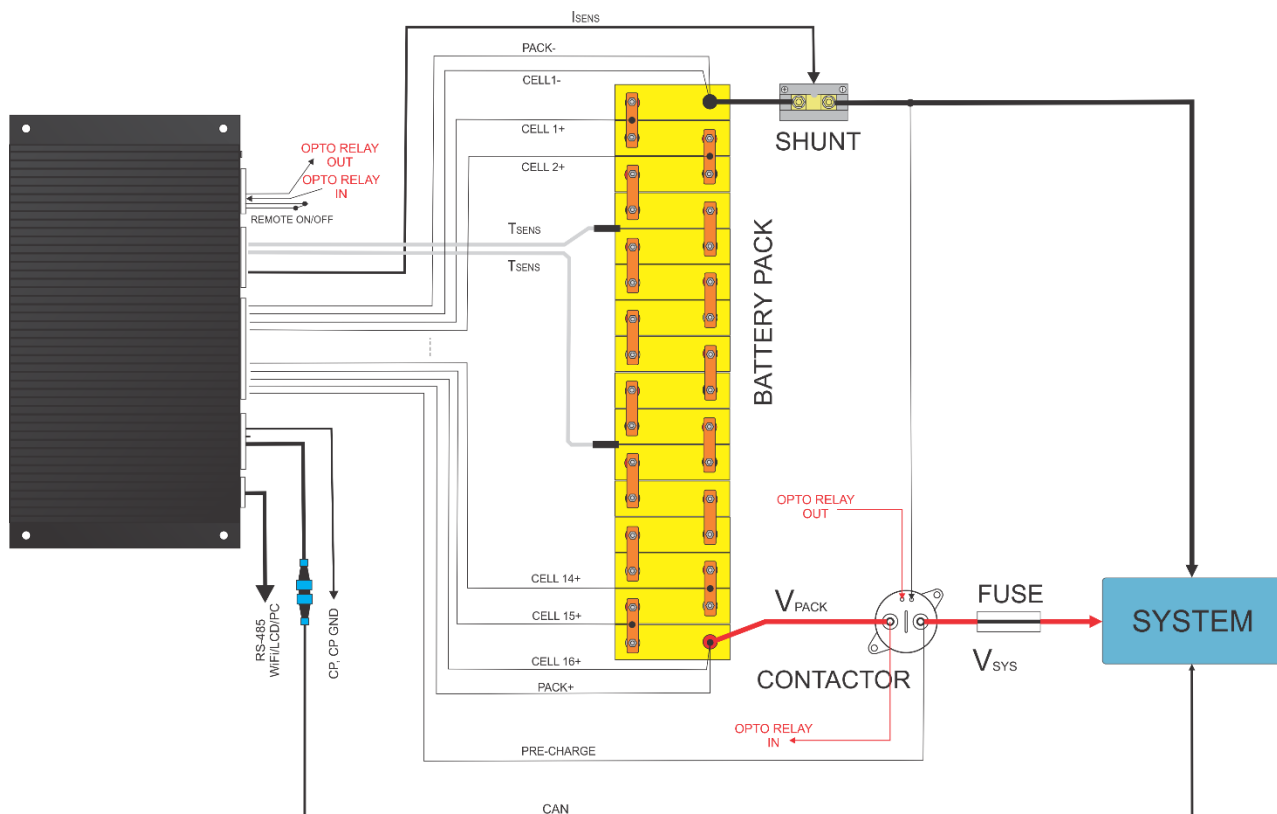
Figure 4: Typical 16S (48 V) BMS configuration.

Setting Number of Cells and the RS-485 Address:

Before powering the device, the end user must set the correct number of cells that will connect to the unit and **if multiple BMS units are used it is also required to set a unique address for each unit to avoid data collision on the RS–485 communication bus.**

The number of cells connected to the BMS unit is selected via the **CELLS** rotary switch, while the BMS address is set via **ADDR** rotary switch at the back of the BMS unit. User should set 4-16 cell and address from 1-15. Address 16 is used for Master BMS 9M.

Figure 5: BMS address and cell selection rotary switches.

Table 8: Number of cells **CELLS** settings.

Selection	Setting
0	1 cell (ERROR 6)
1	2 cell (ERROR 6)
2	3 cells (ERROR 6)
3	4 cells
4	5 cells
5	6 cells
6	7 cells
7	8 cells
8	9 cells
9	10 cells
A	11 cells
B	12 cells
C	13 cells
D	14 cells
E	15 cells
F	16 cells

Table 9: BMS address **ADDR** settings.

Selection	Setting
0	Address 0 (ERROR 6)
1	Address 1
2	Address 2
3	Address 3
4	Address 4
5	Address 5
6	Address 6
7	Address 7
8	Address 8
9	Address 9
A	Address 10
B	Address 11
C	Address 12
D	Address 13
E	Address 14
F	Address 15

BMS Cell Connector:

Connect BMS power supply, each cell and pre-charge BMS cell connector 20-pin plug. We recommend using silicon wires with a cross section of $0.5 - 1$ mm^2.
! **Before inserting the cell connector check the voltage level and polarity of each connection!**
! **When working on cells/connections – the BMS' cells connector must be unplugged, otherwise the BMS may be damaged!**
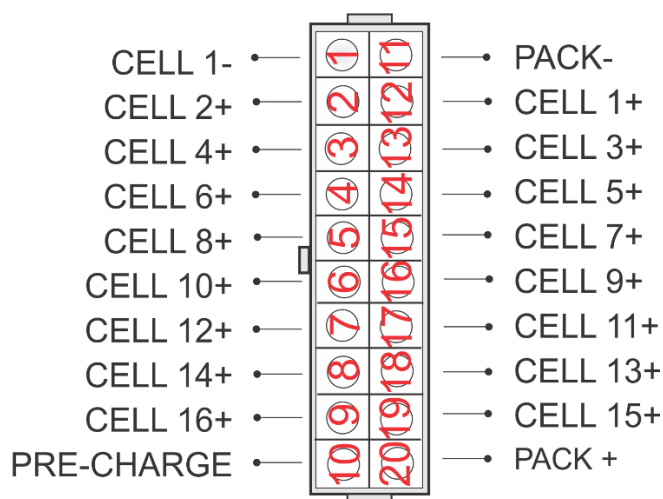

Figure 6: Battery pack BMS cell connector.

BMS Unit Power Supply:

BMS unit is always powered from the PACK + and PACK – connections. **An additional connection from the battery pack positive voltage (Pack +) and the battery pack negative voltage (Pack -) should be connected to pins 20 and 11. Do not bypass the Cell 1- and the highest cell to this connection. It decreases the measurement accuracy since the power is connected through the measurement cells connection.**
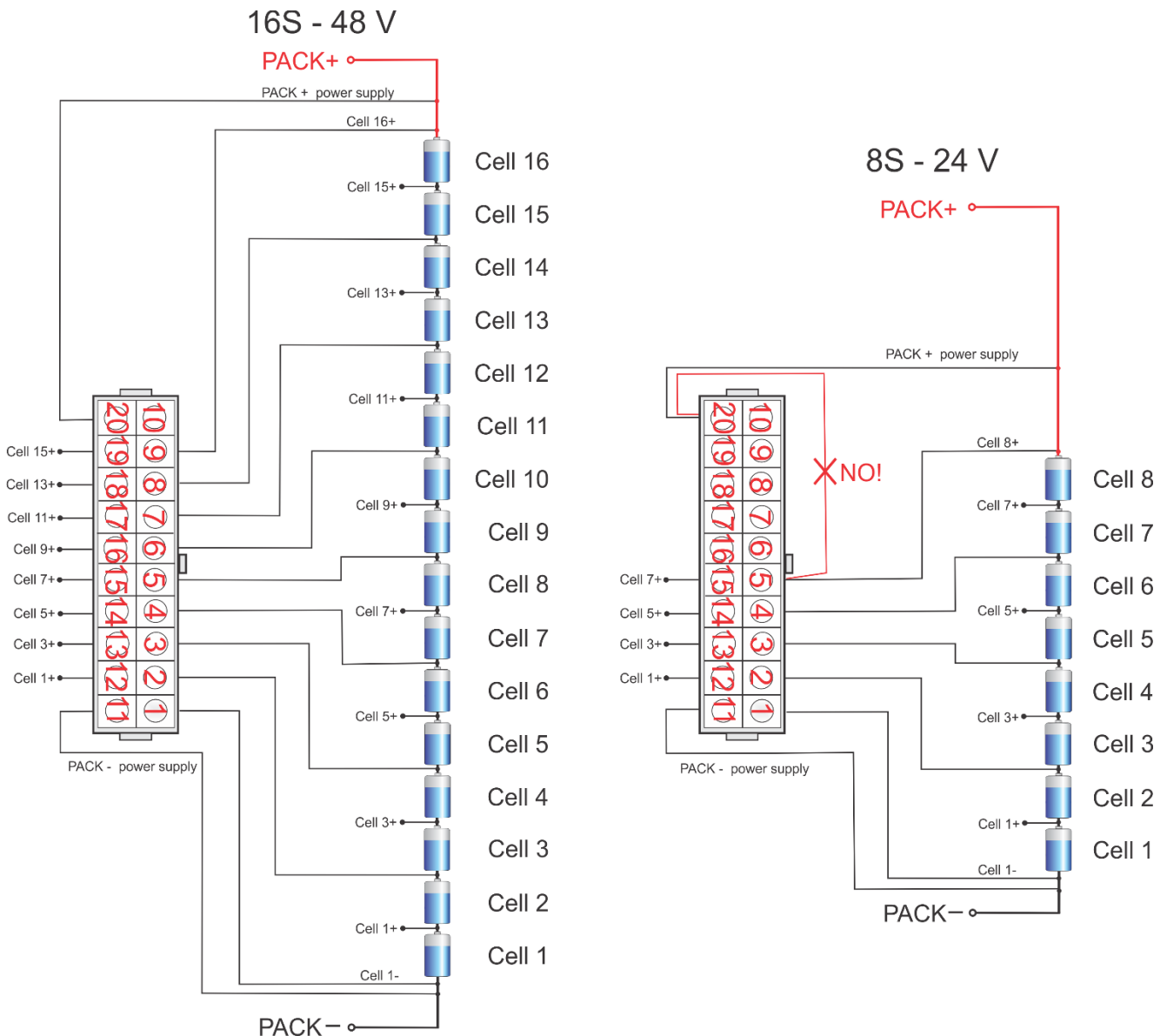

Figure 7: BMS unit power supply.

Parallel Cell Connection:

Battery pack capacity may be increased in two ways. By adding a parallel string with the same cells using BMS Master unit and multiple 2Q BMS in Slave configuration or paralleling on the cell connection level. Master-Slave configuration makes system more redundant, but also more expensive and bulkier. Connecting cells in parallel as a sub-pack that are later connected in series have to be designed properly to enable same current distribution amongst all the parallel cells in the sub-pack. Lithium cells have very low DC impedance, sub 1 mOhm. Connecting the sub-pack with 1 mOhm cell connection difference causes the cells with the lowest connection to double the current in/out of the cell. A result is a cell with higher temperature that self-discharges faster and ages faster than the rest of the cells in the sub-pack.
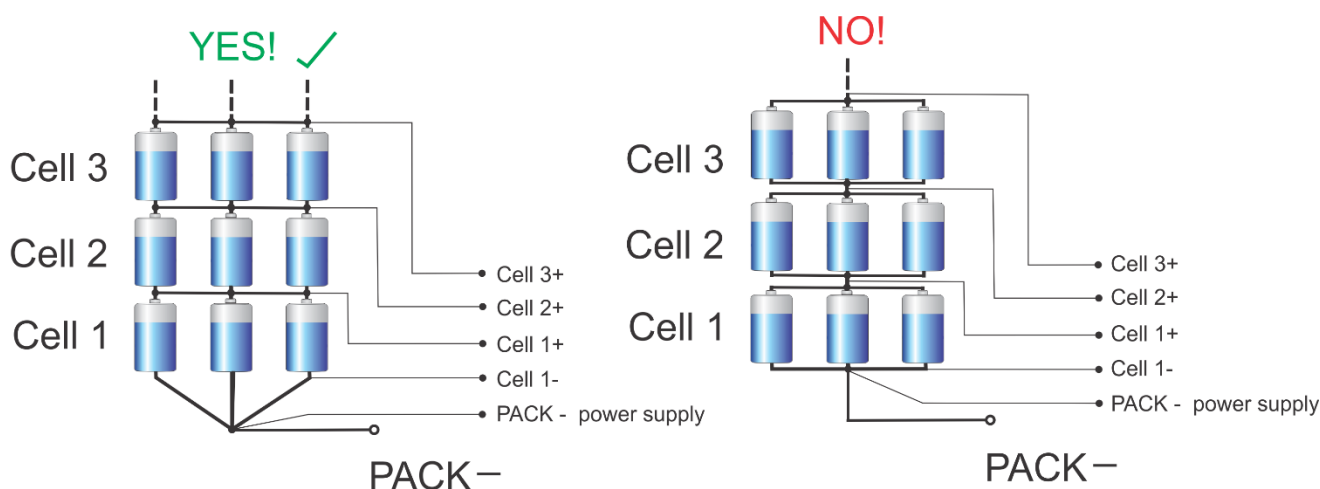

Figure 8: Parallel cell connection.

BMS Unit Connection Instructions:

Connect the BMS unit to the system by the following order described in Fig. 9. It is important to disable all the BMS functions by turning enable switch OFF before plugging any connectors. **All cells should be connected last and simultaneously**. When all the system components are plugged in, the enable switch can be turned ON and the BMS starts the test procedure.
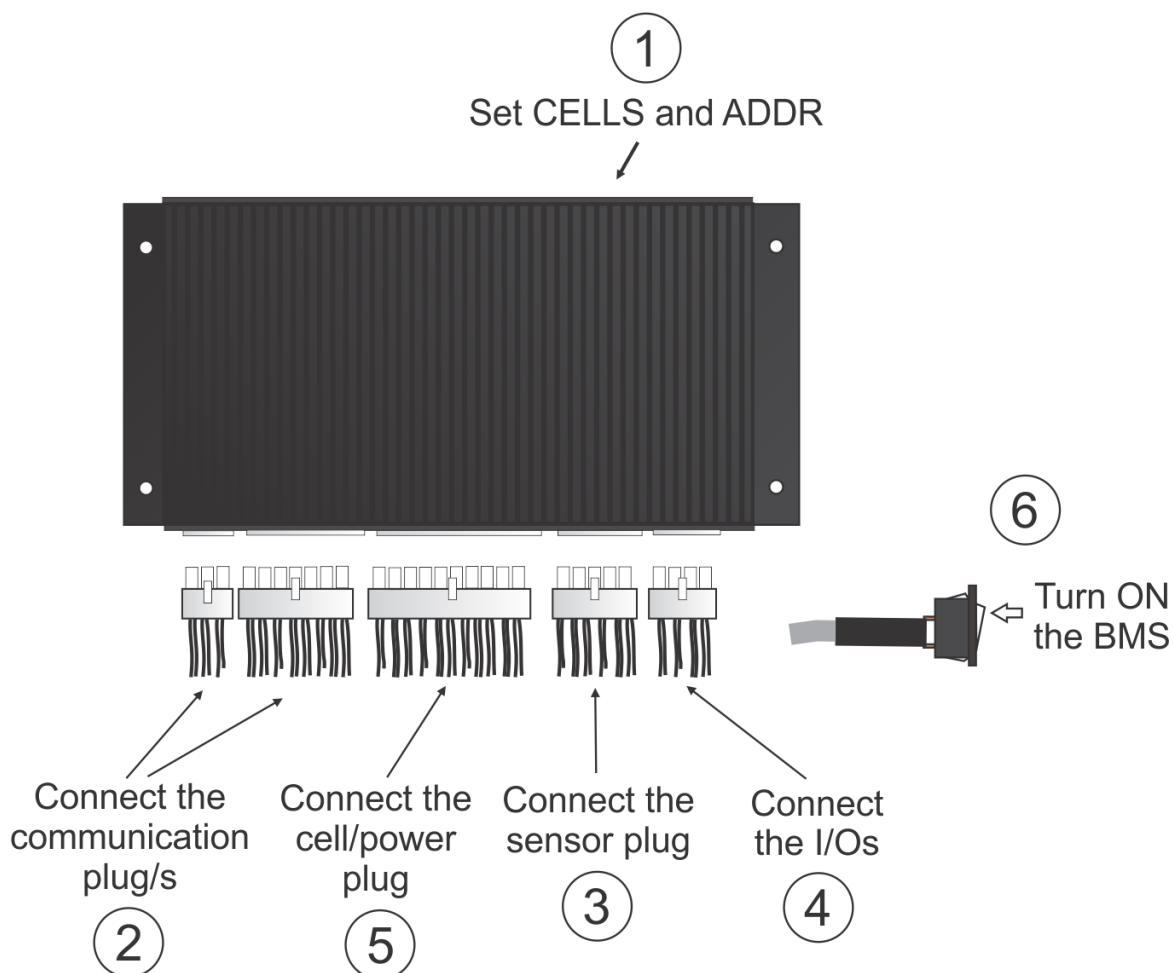
Figure 9: BMS connection/disconnection procedure.

When disconnecting the unit from the battery pack, the procedure should be followed in reverse order.
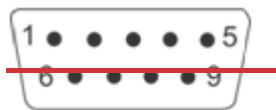
RS-485 Communication:

Figure 11: RS-485 DB9 connector front view.

Table 4: RS-485 DB9 connector pin designator.

PIN	DESIGNATOR
1	-
2	AGND
3	B
4	A
5	-
6	+5V to AGND
7	-
8	-
9	-

2Q BMS uses two ports for the RS-485 communication. Both may be used in a single connection -stand-alone version, while in case of Master-Slave configuration one is used as the input and later as output. Master can also turn the Slave on via *RS-485 +5 V ENABLE* by applying the 5 V on this bus. The REMOTE ON/OFF may be setting OFF since an OR logic is used. Either the REMOTE ON/OFF is turned on for permanently enabled stand-alone unit or *RS-485 +5 V ENABLE* is applied so the whole system is turned off when Master BMS is turned OFF. RS-485 communication bus has to be terminated on both ends with 470 to 1200 Ω resistor. Lower value improves immunity but also increases BMS power consumption.

Galvanically isolated RS-485 bus (EN 61558-1, EN 61558-2) observing battery pack data, changing BMS parameters and data logging. Dedicated PC Software BMS Master Control, REC Wi-Fi module, REC LCD touch display or another RS-485 device may be used for the communication. Default RS-485 BMS address is 1. **Unlock password:** Serial without the first minus e.g. 1Q-XXXX.

Protocol:
Messages are comprised as follows:
STX, DA, SA, N, INSTRUCTION- 4 bytes, 16-bit CRC, ETX
- STX start transmission <0x55> (always)
- DA - destination address <0x01> to <0x10> (set as 6)
- SA - sender address <0x00> (always 0)
- N – number of sent bytes
- INSTRUCTION 4 bytes for example.: LCD1? - (combined from 4 ASCII characters, followed by '?', if we would like to receive the current parameter value or ' ','xx.xx' value in case we want to set a new value
- 16-bit CRC - big endian, for the whole message except STX in ETX - https://www.lammertbies.nl/comm/info/crc-calculation.html
- ETX - end transmission <0xAA> (always)

Dataflow:
- Bit rate: 56k
- Data bits: 8

- Stop bits: 1
- Parity: None
- Mode: Asynchronous
- Little endian format when an array is sent

Table 10: RS-485 instruction set.

INSTRUCTION	DESCRIPTION	BMS ANSWER	SETTING INTERVAL
*IDN?	Identification	Answer "REC-BMS 2Q"	Read only
GENERAL ARRAYS INSTRUCTIONS			
LCD1?	Main data	First answer is 28 – how many byte data will be sent and then data message follows as 7 float values: LCD1 [0] = min cell voltage, LCD1 [1] = max cell voltage, LCD1 [2] = current, LCD1 [3] = max temperature, LCD1 [4] = pack voltage, LCD1 [5] = SOC (state of charge) interval 0-1-> 1=100% and LCD1 [6] = SOH (state of health) interval 0-1-> 1=100%	Read only
LCD3?	Main data	First answer is 8 – how many byte data will be sent and then data message follows as 8 byte values: LCD3 [0] = min cell BMS address, LCD3 [1] = min cell number, LCD3 [2] = max cell BMS address, LCD3 [3] = max cell number, LCD3 [4] = max temp. sens. BMS address, LCD3 [5] = max temp. sens. number, LCD3 [6] = Ah MSB, LCD3 [7] = Ah LSB	Read only
CELL?	Cell voltages	BMS first responds with the number of BMS units connected, then it sends the values of the cells in float format	Read only
PTEM?	Cell temperatures	BMS first responds with how many BMS units are connected then it sends the values of the temperature sensors in float format	Read only
RINT?	Cells internal DC resistance	BMS first responds with how many BMS units are connected then it sends the values in float format	Read only
BTEM?	BMS temperature	BMS first responds with value 1, then it sends the values of the BMS temperature sensor in float format	Read only

ERRO?	Error number description array	First answer is 4 – how many byte data will be sent and then data message follows as 4 byte values: ERRO [0] = 0 – no error, 1 – error ERRO [1] = BMS unit ERRO [2] = error number (1-16) and ERRO [3] = number of the cell, temp. sensor where the error occurred	Read only
VOLTAGE SETTINGS INSTRUCTIONS			
BVOL? or BVOL x.xx	Balance end voltage	Returns float voltage [V]	2.5 to 4.30 V
BMIN? or BMIN x.xxx	Balancing start voltage	Returns float voltage [V]	2.5 to 4.30 V
CMAX? or CMAX x.xx	Cell over-voltage switch-off	Returns float voltage [V]	2.0 to 4.30 V
MAXH? or MAXH x.xx	Cell over-voltage switch-off hysteresis per cell	Returns float voltage [V]	0.005 to 2.0 V
CMIN? or CMIN x.xxx	Cell-under voltage protection switch-off	Returns float voltage [V]	1.8 to 4.00 V
MINH? or MIN x.xxx	Cell uder-voltage switch-off hysteresis per cell	Returns float voltage [V]	0.005 to 2.0 V
CHAR? Or CHAR x.xxx	Cell End of charging voltage	Returns float voltage [V]	2.0 to 4.30 V
CHIS? Or CHIS x.xxx	End of charging voltage hysteresis per cell	Returns float voltage [V]	0.005 to 2.0 V
CFVC? Or CFVC x.xxx	Maximum cell float voltage coefficient	Returns float value	0.0 to 1.0
RAZL? or RAZL x.xx	Cells max difference	Returns float voltage [V]	0.005 to 1.0 V
UBDI? or UBDI x.xx	End of charge cell difference	Returns float voltage [V]	0.000 to 0.025V, default 8 mV
TEMPERATURE SETTINGS INSTRUCTIONS			
TMAX? or TMAX x.xxx	cell over temperature switch-off	Returns float temperature [°C]	-20 to 65 °C
TMIN? or TMIN x.xxx	Under-temperature charging disable	Returns float temperature [°C]	-30 to 65 °C
TBAL? or TBAL x.xxx	BMS over-temperature switch-off	Returns float temperature [°C]	-20 to 65 °C
BMTH? or BMTH x.xxx	BMS over temperature switch-off hysteresis	Returns float temperature [°C]	1 to 30 °C
CURRENT SETTINGS INSTRUCTIONS			
IOFF? or IOFF x.xxx	Current measurement zero offset	Returns float current [A]	-2.0 to 2.0 A
IOJA? Or IOJA x.xxx	Voltage to current coefficient	Returns float value	0.0005 to 0.5
BATTERY PACK SETTINGS INSTRUCTIONS			
CYCL? or CYCL xx	Current number of full battery pack cycles	Returns integer value	0 to 8000
CAPA? or CAPA x.xxx	Battery pack capacity	Returns float capacity [Ah]	1.0 to 5000.0 Ah

CHEM? or CHEM xx	Cell chemistry	Returns unsigned char value	1 to 7
SOC SETTINGS INSTRUCTIONS			
SOCH? or SOCH x.xxx	SOC end of charge hysteresis	Returns float value 0 – 1.0	0.005 to 0.99
SOCS? or SOCS x.xx	SOC manual re-set	Returns float value 0 – 1.0	0.01 to 1.00
SYSTEM COMMUNICATION SETTINGS INSTRUCTIONS			
CHRG? or CHRG x	System connection configuration	Returns unsigned char value 0 - 12(default 0)	0 to 12 Table 10
CHAC? or CHAC x.xxx	Charge coefficient (0-3C)	Returns float value 0-3.0 (default 0.6)	0.01 to 3.0
DCHC? or DCHCx.xxx	Discharge coefficient (0-3C)	Returns float value 0-3.0 (default 1.5)	0.01 to 3.0
MAXC? or MAXC x.xxx	Maximum inverter device charge current	Returns float current [A]	5.0 to 360 A
MAXD? or MAXD x.xxx	Maximum inverter device discharge current	Returns float current [A]	5.0 to 360.0 A
CLOW? or CLOW x.xxx	cell under-voltage discharge protection	Returns float voltage [V]	1.8 to 4.20 V
CCMX? or CCMX x.xxx	Maximum battery charge current	Returns float current [A]	10 to 2000
DCMX? or DCMX x.xxx	Maximum battery discharge current	Returns float current [A] default is 2 * shunt value	10 to 2000
CHUC? or CHUC xx	Charge current coefficient for non-ESS systems	Returns float value 0.1 – 1.0 (default 1.0)	0.1 to 1.0
SISN? or SISN xx	Number of inverter devices	Returns unsigned char value	1 to 15
CANS? or CANS xx	CAN bitrate/ID format	Returns unsigned char value of 0 to 132	Table 11
WHIN?	Wh in counter	Returns unsigned long value	Read only
WHOU?	Wh out counter	Returns unsigned long value	Read only
WHRE	Wh counters reset	Returns "Cleared energy counter"	
WCIB?	Balanced cells	Returns unsigned int value	Each bit represents cell balancing status LSB = cell 1, MSB = cell 16, 0 = not balancing, 1 = balancing
TIME?	RTC time	Returns a string "HH:MM:SS"	
DATE?	RTC date	Returns a string "DD:MM:YYYY"	
ERROR LOG INSTRUCTIONS			
VMAX? or VMAX xx	Number of exceeded values of CMAX	Returns integer value	0 to 100000
VMIN? or VMIN xx	Number of exceeded values of CMIN	Returns integer value	0 to 100000
ERRL?	ERROR log data	Returns a single string "ERR: xx ELE: yy TIME: HH:MM:SS DATE: DD:MM:YYYY"	Each ERRL? Message returns older error in the Error log. When the last (7th) is read it jumps back to the most recent one.
ERRD 1	Erase RTC Error log	Returns string "DELETED_LOGS"	Sending ERRD?

FUSE?	First use date and hour	Returns a string "DD:MM:YYY,HH h"	
FUSE1	First use	Sets the BMS first use date from the current RTC date	
LUSE?	Last use date and hour	Returns a string "DD:MM:YYY, HH h"	HAS TO BE implemented
BMS SETTINGS INSTRUCTIONS			
SWVR?	BMS software version	Returns string "1.3"	Read only
HWVR?	BMS hardware version	Returns string "1.0"	Read only
EAVC? or EAVC xx	Even cells calibration value	Returns float voltage [V]	(up to +/-0.05 typ. 0.001)
ODDC? or ODDC xx	Odd cells calibration value	Returns float voltage [V]	(up to +/-0.05 typ. 0.001)
REFC?	ADC reference voltage 5.000 V +/- 3 mV	Returns float voltage [V]	Read only
OP1L? or OP1L x.xxx	Optocoupler 1 setting level	Returns float voltage [V]	
OP1H? or OP1H x.xxx	Optocoupler 1 setting hysteresis level	Returns float voltage [V]	
OP1T? or OP1T x.xxx	Optocoupler 1 task setting	Returns unsigned long	Use Wi-Fi module "TASKS" tab
OP1V?	Optocoupler 1 current task setting value	Returns unsigned long	Read only
OP2L? or OP2L x.xxx	Optocoupler 2 setting level	Returns float voltage [V]	
OP2H? or OP2H x.xxx	Optocoupler 2 setting hysteresis level	Returns float voltage [V]	
OP2T? or OP2T x.xxx	Optocoupler2 task setting	Returns unsigned long	Use Wi-Fi module "TASKS" tab
OP2V?	Optocoupler 2 task setting current value	Returns unsigned long	Read only
PRCT? or PRCT xx	25 Ω Pre-charge timer	Returns char value 1-30 (default 4)	1 to 30 s
RESE	RESET instruction	Used for firmware update only	
RSTN?	RESET counter	Returns unsigned long	Read only

Parameter accepted and changed value is responded with 'OK' or "NOT OK" answer.
Example: proper byte message for 'LCD1?' instruction for BMS address 2 is:

<0x55><0x01><0x00><0x05><0x4C><0x43><0x44><0x31><0x3F><0x46><0xD0><0xAA>

RS-485 message is executed when the microprocessor is not in interrupt routine so a timeout of 350 ms should be set for the answer to arrive. If the timeout occurs the message should be sent again. Little endian format is used for all sent float or integer values. In case of single data is sent ASCII characters are used e.g. -1.2351e2
Custom made instructions can be added to the list to log or set the parameters that control the BMS algorithm or its outputs.

Video instruction link for settings change: REC Changing Settings - YouTube
Video instruction link for firmware update: REC Firmware Update Procedure - YouTube
and REC Wi-Fi Module Update and REC BMS Firmware Update Using REC Wi-Fi Module - YouTube

CAN Communication:

CAN communication is used to communicate with the system. There are eight ESS hybrid inverter protocols pre-programmed in the BMS and three CAN supported chargers. ESS/charger selection is performed by the RS-485 instruction *CHRG*. After changing the protocol, the user must also select the CAN bitrate using RS-485 instruction *CANS*, that is updated with the BMS restart. Both parameters are described in the tables below.

Table 11: CHRG and CANS instruction selection list.

ESS/CHARGER	*CHRG* SETTING	*CANS* SETTING	DESCRIPTION
REC BMS CAN protocol	0	Select desired bit-rate from the table 11	
Victron	1	2 or 3	250kb or 500kb @ 11-bit ID
SMA	2	3	500kb @ 11-bit ID
Solax	3	3	500kb @ 11-bit ID
Studer Innotec	4	3	500kb @ 11-bit ID
Growatt	5	3	500kb @ 11-bit ID
Solis	6	3	500kb @ 11-bit ID
Pylontech, Deye	7	3	500kb @ 11-bit ID
TBB power	8	3	500kb @ 11-bit ID
TC Charger	9	130	250kb @ 29-bit ID
Zivan	10	1-3 see charger settings	125kb, 250kb or 500kb @ 11-bit ID
Custom	11	Select desired bitrate from the table	
Piktronik	12	1-4 see charger settings	125kb, 250kb, 500kb or 1Mb @ 11-bit ID
SPE	13	2	250kb @ 11-bit ID
Axima 100	14	2	250kb @ 11-bit ID
Axima 200	15	2	250kb @ 11-bit ID
Axima 400	16	2	250kb @ 11-bit ID
Bassi	17	2	250kb @ 11-bit ID

Skrijemo za uporabnika!!!

Table 12: CANS instruction description.

BAUDRATE	STANDARD 11-BIT ID	EXTENDED 29-BIT ID
100k	0	128
125k	1	129
250k	2	130
500k	3	131
1M	4	132

Examples:
250k with standard 11-bit ID, send CANS 2.
500k with extended 29-bit ID, send CANS 131.

CAN bus should be terminated at each end of the daisy chain connection. **Short pins 2 and 9 to enable 120 Ohm termination inside the BMS.** Additional RJ45 connector plug with 120 Ohms across CANL and CANH is usually used for the end device on the CAN bus for end termination.

REC BMS CAN protocol

11-bit TX identifiers: 0x031, 0x032, 0x033, 0x034, 0x035, 0x036, 0x037 and 0x038.
CANS bitrate/ID is set by default to 0. User may set the desired *CANS*.

CAN messages are sent every 100 ms.

Table 13: CAN message structure description for ID=0x031, dlc=8.

Byte	Description	Type	
1	State of charge (SOC) [%]	Unsigned char	0-200 LSB = 0.5 % SOC
2	State of health (SOH) [%]	Unsigned char	0-200 LSB = 0.5 % SOH
3	Battery pack voltage high byte	Unsigned integer	0-65535, LSB = 10 mV
4	Battery pack voltage low byte		
5	Battery pack current high byte	Signed integer	LSB = 20 mA
6	Battery pack current low byte		
7	Error number	Unsigned char	0-16
8	Number of the cell or temp. sensor where the error occurred	Unsigned char	0-16

Table 14: CAN message structure description for ID=0x032, dlc=8.

Byte	Description	Type	
1	Cell temperature sensor 1	Signed char	-127 to 127 LSB = 1° C
2	Cell temperature sensor 2	Signed char	-127 to 127 LSB = 1° C
3	Cell temperature sensor 3	Signed char	-127 to 127 LSB = 1° C
4	Cell temperature sensor 4	Signed char	-127 to 127 LSB = 1° C
5	Cell temperature sensor 5	Signed char	-127 to 127 LSB = 1° C
6	Cell temperature sensor 6	Signed char	-127 to 127 LSB = 1° C
7	Cell temperature sensor 7	Signed char	-127 to 127 LSB = 1° C
8	Cell temperature sensor 8	Signed char	-127 to 127 LSB = 1° C

Table 15: CAN message structure description for ID=0x033, dlc=8.

Byte	Description	Type	
1	Cell 1 voltage high byte	Unsigned integer	0-65535, LSB = 1 mV
2	Cell 1 voltage low byte		
3	Cell 2 voltage high byte	Unsigned integer	0-65535, LSB = 1 mV
4	Cell 2 voltage low byte		
5	Cell 3 voltage high byte	Unsigned integer	0-65535, LSB = 1 mV
6	Cell 3 voltage low byte		
7	Cell 4 voltage high byte	Unsigned integer	0-65535, LSB = 1 mV
8	Cell 4 voltage low byte		

Table 16: CAN message structure description for ID=0x034, dlc=8.

Byte	Description	Type	
1	Cell 5 voltage high byte	Unsigned integer	0-65535, LSB = 1 mV
2	Cell 5 voltage low byte		
3	Cell 6 voltage high byte	Unsigned integer	0-65535, LSB = 1 mV
4	Cell 6 voltage low byte		
5	Cell 7 voltage high byte	Unsigned integer	0-65535, LSB = 1 mV
6	Cell 7 voltage low byte		
7	Cell 8 voltage high byte	Unsigned integer	0-65535, LSB = 1 mV
8	Cell 8 voltage low byte		

Table 17: CAN message structure description for ID=0x035, dlc=8.

Byte	Description	Type	
1	Cell 9 voltage high byte	Unsigned integer	0-65535, LSB = 1 mV
2	Cell 9 voltage low byte		
3	Cell 10 voltage high byte	Unsigned integer	0-65535, LSB = 1 mV
4	Cell 10 voltage low byte		
5	Cell 11 voltage high byte	Unsigned integer	0-65535, LSB = 1 mV
6	Cell 11 voltage low byte		
7	Cell 12 voltage high byte	Unsigned integer	0-65535, LSB = 1 mV
8	Cell 12 voltage low byte		

Table 18: CAN message structure description for ID=0x036, dlc=8.

Byte	Description	Type	
1	Cell 13 voltage high byte	Unsigned integer	0-65535, LSB = 1 mV
2	Cell 13 voltage low byte		
3	Cell 14 voltage high byte	Unsigned integer	0-65535, LSB = 1 mV
4	Cell 14 voltage low byte		
5	Cell 15 voltage high byte	Unsigned integer	0-65535, LSB = 1 mV
6	Cell 15 voltage low byte		
7	Cell 16 voltage high byte	Unsigned integer	0-65535, LSB = 1 mV
8	Cell 16 voltage low byte		

Table 19: CAN message structure description for ID=0x037, dlc=8.

Byte	Description	Type	
1	Max charge voltage high byte	Unsigned integer	0-65535, LSB = 0.1 V
2	Max charge voltage low byte		
3	Max charge current high byte	Unsigned integer	0-65535, LSB = 0.1 A
4	Max charge current low byte		
5	Max discharge current high byte	Unsigned integer	0-65535, LSB = 0.1 A
6	Max discharge current low byte		
7	Min discharge voltage high byte	Unsigned integer	0-65535, LSB = 0.1 V
8	Min discharge voltage low byte		

Table 20: CAN message structure description for ID=0x038, dlc=5.

Byte	Description	Type	
1	Ah high byte	Unsigned integer	0-65535, LSB = 1 Ah
2	Ah low byte		
3	BMS temperature	Signed char	-127 to 127 LSB = 1 °C
4	I/Os output status	Unsigned char,	0 – OFF, 1 - ON LSB - PRE-CHARGE Bit 2 - PRE-CHARGE Bit 3 – OPTO-RELAY Bit 4 – OPTOCOUPLER 1 Bit 5 – OPTOCOUPLER 2
5	-	-	-
6	Cell balancing status high byte	Unsigned integer	LSB cell 1, MSB cell 16; 0 – OFF, 1 - ON
7	Cell balancing status low byte		
8	Contactor shunt-down in progress	Unsigned char	0 – Contactor stays ON 1 – Contactor will turn OFF in 2 s

Victron

11-bit TX ID identifiers: 0x351, 0x355, 0x356, 0x35A, 0x35E, 0x35F, 0x360, 0x372, 0x373, 0x374, 0x375, 0x376, 0x377, 0x379, 0x380 and 0x381.

11-bit RX heart-beat 0x305 message from GX unit is neglected.

CANS bitrate/ID is set by default to 3. User may set the desired *CANS* to 2.

CAN messages are sent every 100 ms.

SMA

11-bit TX ID identifiers: 0x351, 0x355, 0x356, 0x359, 0x35C and 0x35E

CANS bitrate/ID is set by default to 3. User may set the desired *CANS*.

CAN messages are sent every 200 ms.

Solax
11-bit TX ID identifiers: 0x351, 0x355, 0x356, 0x359, 0x35C and 0x35E
CANS bitrate/ID is set by default to 3. User may set the desired *CANS*.
CAN messages are sent every 200 ms.

Studer Innotec
11-bit TX ID identifiers: 0x351, 0x355, 0x356, 0x359, 0x35C and 0x35E
CANS bitrate/ID is set by default to 3. User may set the desired *CANS*.
CAN messages are sent every 200 ms.

Growatt
11-bit TX ID identifiers: 0x311, 0x312, 0x313, 0x314, 0x315, 0x316, 0x317, 0x318, 0x319, 0x320 and 0x321
CANS bitrate/ID is set by default to 3. User may set the desired *CANS*.
CAN messages are sent every 100 ms.

Solis ESS
11-bit TX ID identifiers: 0x351, 0x355, 0x356, 0x359
CANS bitrate/ID is set by default to 3. User may set the desired *CANS*.
CAN messages are sent every 200 ms.

Pylontech/Deye ESS
11-bit TX ID identifiers: 0x351, 0x355, 0x356, 0x359, 0x35C and 0x35E
CANS bitrate/ID is set by default to 3. User may set the desired *CANS*.
CAN messages are sent every 100 ms.

TBB
11-bit TX ID identifiers: 0x351, 0x355, 0x356, 0x359, 0x35C and 0x35E
CANS bitrate/ID is set by default to 3. User may set the desired *CANS*.
CAN messages are sent every 200 ms.

TcCharger
29-bit TX ID identifiers: 0x1806E5F4, 0x1806E6F4 and 0x1806E7F4 + REC BMS CAN protocol
CANS bitrate/ID is set by default to 130. User may set the desired *CANS* to 131.
CAN messages are sent every 100 ms.

Zivan
11-bit TX ID identifiers: 0x6C1 and, 0x6A1
CANS bitrate/ID is set by default to 2. User may set the desired *CANS*.
CAN messages are sent every 100 ms.

Custom
If a custom CAN protocol is required, REC team can implement it as a CUSTOM protocol set as *CHRG* = 12.
CANF may be changed to the desired bitrate and ID length.

BMS Unit Start Procedure:

When the BMS is turned ON it commences the test procedure. BMS checks if the user tries to upload a new firmware. After the timeout the RED error LED turns on to signal the system's test procedure. The procedure starts by testing the balancing switches, the BMS address and cells number, temperature sensor/s detection, self-calibration and EEPROM memory parameters. The test completes in 2 seconds. In case of no Errors the RED LED turns off and the BMS unit starts working in normal mode after a beep sound. If an error is detected a sound alarm/blinking red LED signal will notify the user. Each error is coded to a number. The most common errors at system startup are listed below.

- Error 6 = improper DIP switch setting.
  In case of Address=0 or 16 or a cell number <4, error 6 informs the user to properly set the rotary switches. BMS has to be turned off before the pins are changed.
- Error 8 = temperature sensor not detected.
- Error 10 = reference failure
- Error 15 = balancing transistor failure
- Error 16 = TWI communication failure

An overview of all possible system errors is presented in the System Error Indication Section.

Voltage/Temperature/SOC Hysteresis:

Most of the BMS setting thresholds also have a dedicated hysteresis parameter. This way the BMS prevents ringing due to the oscillation of the controlled parameter above and under the set threshold. If the threshold limits the top value of the parameter like *Maximum cell voltage CMAX* or temperature *TMAX*, the value of hysteresis should be negative to prevent the ringing. If the threshold limits the bottom value of the parameter like *Minimum cell voltage CMIN* or temperature *TMIN* the value of hysteresis should be positive to prevent the ringing. For a simplicity, all the BMS settings are set without the sign and the BMS firmware takes care for proper sign value.

BMS Unit LED Indication:

Power LED (green) signals the state of the battery pack. Low SOC is signaled by a single ON blink. Normal mode is signaled by 2 consecutives ON blinks while the balancing mode is indicated by 3 consecutives ON blinks before the longer pause. When the battery pack is fully charged and *SOC/End of Charge Hysteresis* are set POWER LED is turned 100% on.

Error LED (red) is turned on in case of system error and signals the error number with 50 % duty cycle. Between repeated error number 1 s timeout is introduced.

Cell Voltage Measurement:

Cell voltages are measured every second. The cell measurement performs 16-bit 4 ms cell measurement by Sigma Delta ADC. Each cell voltage is measured after the balancing fuse, in case the fuse blows, BMS signals error 10 or 15 to notify the user.

BMS Cell Balancing:

Cells are balanced passively by discharging each cell through a 4.0 Ω power resistor. Since the balancing resistors dissipate heat an additional temperature measurement inside the enclosure of the BMS unit is performed to prevent overheating the integrated circuits. If the BMS temperature rises near the set threshold, balancing is restricted to the cells that deviate the most. If the BMS temperature exceeds the maximum BMS temperature threshold *TBAL* error 5 is indicated by the ERROR LED until the temperature drops under the set hysteresis value *BMTH*.

Balancing START Voltage (*BMIN*):

If errors 2, 4, 5, 8, 10, 12 are not present, the charging current is above 0.2 A and at least one cell's voltage rises above the balancing start voltage threshold the BMS initiates the balancing algorithm. The algorithm calculates a weighted cell voltage average which takes into account the internal dc resistance of each cell. On the basis of the calculated average the BMS determines which cell will be balanced. BMIN cell voltage setting should be set to the voltage that corresponds to 90 % of the usable capacity.

Balancing Voltage END(*BALV*):

If errors 2, 4, 5, 8, 10, 12 are not present, any cell above balance END voltage is balanced regardless of the battery pack current. We advise to set the *BALV* voltage to the same value as the Endo of charge voltage *CHAR*.

Cell Internal DC Resistance Measurement:

Cell internal DC resistance is measured as a ratio of a voltage change and current change in two sequential measurement cycles. If the absolute current change is above 15 A, cells internal resistance is calculated. Moving average is used to filter out voltage spikes errors.

Battery Pack Temperature Measurement:

Battery pack temperatures are measured by Dallas DS18B20 digital temperature sensor/s. Up to two sensors can be used in parallel @ each 1-wire port, connected directly to the wiring. Up to 8 sensors may be used with a junction box and a custom firmware. BMS should be turned off and the sensor 10-pin connector should be disconnected before adding sensors. Temperature sensor/s use shielded 3-wire cable and a common mode line chock to prevent EMI. Cable length should be as short as possible. Placing temperature cable near the power connection should be avoided. Route temperature sensor 90° to the power cable to avoid EMI that may cause communication error no. 8.

BMS Current Measurement:

Low-side **only** precision shunt resistor for current measurement is used. Connect the shunt as close as possible to the battery negative power connection (cell 1-). Fuses or manual DC switch should be placed to the system side of the shunt. System fuse may be also placed in the system positive – before the contactor. A 4-wire Kelvin connection is used to measure voltage drop on the resistor. As short as possible **shielded cable** should be used to connect the power shunt and BMS. The average battery pack current is calculated in every measurement cycle. A high precision Sigma-Delta ADC is used to filter out the current spikes. The first current measurement is timed at the beginning of the cell measurement procedure for a proper internal DC resistance calculation. Four more 300 ms measurements are performed through the whole BMS measurement interval Shunt connection is shown in Fig. 10. If the BMS measures charging/discharging current that is higher than the *CCMX* or *DCMX* that are set to double value of the rated shunt by default for more than 2 consecutive cycles error 12 is triggered. This serves for a shunt, contactor and fuse protection in case of the short circuit.
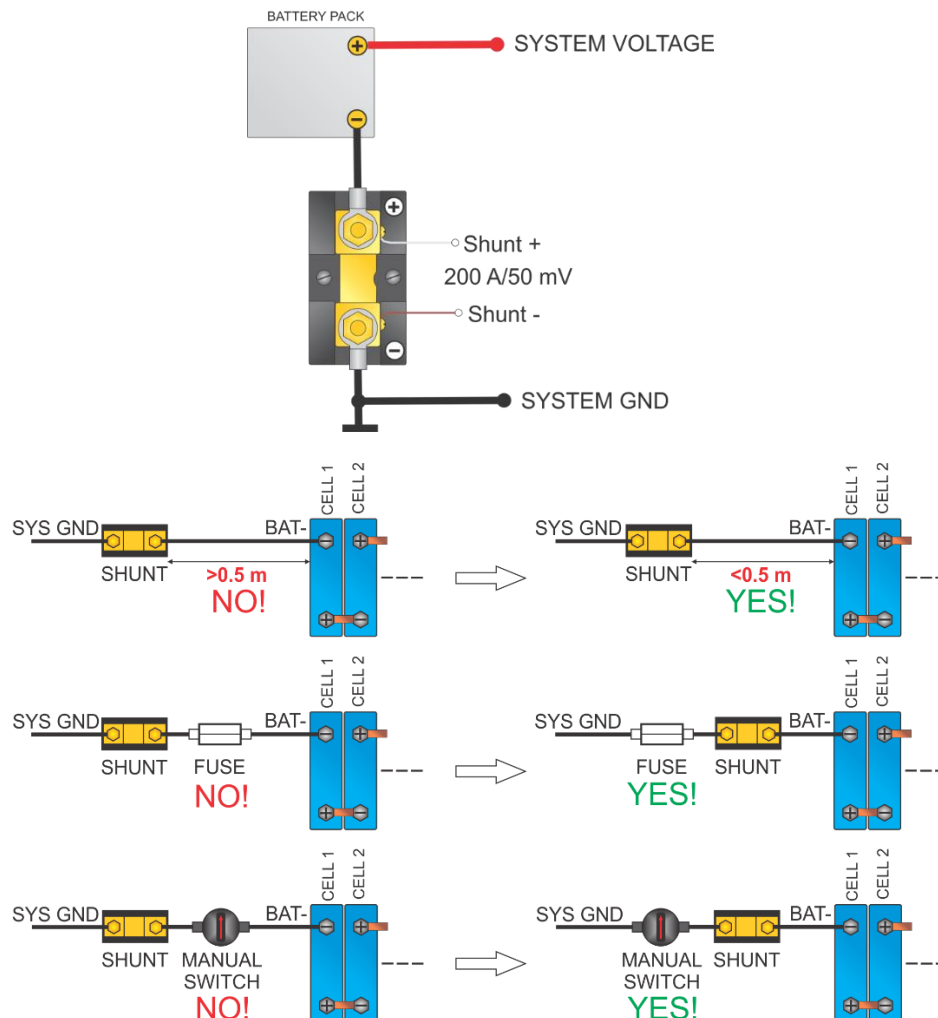
Figure 10: Shunt resistor connection.

Different size and resistance shunts can be used, since the voltage-to-current coefficient can be changed in the BMS Control software as *IOJA* x.xxxx or selected from the drop menu in the REC Wi-Fi module Settings

tab. Offset may be corrected using *IOFF* x.xx instruction. Non-listed shunts coefficients should be entered manually. Current is calculated by the voltage drop at the shunt resistor. 1 LSB of the 18-bit ADC represents different current values according to the shunt resistance. The LSB coefficient can be calculated as:

$$k_{LSB} = 0.01171875 \cdot \frac{0.05 \text{ V}}{300 \text{ A}} \cdot \frac{I_{currentx}}{V_{dropx}}$$

where the V_{dropx} represents the voltage drop on shunt resistor at current $I_{currentx}$.

Table 21: Voltage-to-current coefficients for typical shunt resistors

SHUNT RESISTOR	VOLTAGE-TO-CURRENT COEFFICIENT SETTING
100 A/50 mV	0.00390625
200 A/50 mV	0.0078125
300 A/50 mV	0.01171875
500 A/50 mV	0.01953125

Battery Pack SOC/SOH Determination:

SOC is determined by integrating the charge in or out of the battery pack. Different Li-ion chemistries may be selected:

Table 22: Li-ion chemistry designators.

NUMBER	TYPE
1	Li-Po Kokam High power
2	Li-Po Kokam High capacity
3	Winston/Thunder-Sky/GWL LiFePO$_4$
4	A123
5	Li-ion NMC/ LiMn$_2$O$_4$
6	LTO
7	Li-ideal

Temperature and power correction coefficient are taken into consideration at the SOC calculation. Li-Po chemistry algorithms have an additional voltage to SOC regulation loop inside the algorithm. BMS calculates battery self-discharge upon selected chemistry, SOC and temperature. *State of health* (SOH) is calculated as number of cycles compared to battery end of life cycles and compensated with SOC and temperature. Operational capacity is recalculated by the number of the charging cycles as pointed out in the manufacturer's datasheet.

When BMS is connected to the battery pack for the first time, SOC is set to 50 %. SOC is reset to 100 % at the end of charging. Charging cycle is added if the coulomb counter had reached the *Battery Pack's Capacity* CAPA.

Battery Pack's ESS Charging Algorithm:

The communication between the REC BMS and system is established through the CAN bus. All the parameters that control the charging/discharging behavior are calculated by the BMS and transmitted to the system in each measurement cycle.

The charging current is controlled by the Maximum charging current parameter. It's calculated as *Charge Coefficient CHAC* x *Battery capacity CAPA*. The parameter has an upper limit which is defined as *Maximum Charging Current*. Lowest value is selected:

Table 23: Maximum charging current calculation.

SETTING	VALUE	UNIT
Battery Capacity (*CAPA*)	100	Ah
Charge Coefficient (*CHAC*)	0.6	1/h
Maximum Charging Current per Device (*MAXC*)	75	A

Charge Coefficient CHAC x *Battery Capacity CAPA* = 0.6 1/h x 100Ah = 60 A
Maximum Charging current per device MAXC = 75 A

Maximum charging current is set to **60 A** due to lower value of the *Charge Coefficient CHAC* x *Battery Capacity CAPA*.

When the highest cell reaches the *End of charge CHAR* voltage setting, charging current starts to ramp down to 1.1 A x *Number of Inverter/Charger Devices* SISN until the last cell rises near the *End of Charge Voltage CHAR* (CC/CV). At that point the Maximum charging voltage allowed is set to Number of cells x (*End of Charge Voltage per cell CHAR– Maximum Cell Float Voltage Coefficient CFVC* x *End of charge hysteresis per cell*). *End of Charge SOC hysteresis SOCH* and *End of charge cell voltage hysteresis CHIS* is set to prevent unwanted switching. If *CFVC* is set to 0.0, charging current is set to 0.0 A until the *End of Charge Hysteresis CHIS* and *End of Charge SOC hysteresis SOCH* have been met.
SOC is calibrated to 100 % and Power LED lights ON 100 % Charge optocoupler is turned off. Maximum allowed charging current is set to 50% to allow supplying DC loads from charging devices like MPPTs. Charging current is limited to 30 % of the maximum charging current, but more than 5 A near both ends of temperature (*Max cell temperature TMAX* and *Min temperature for charging TMIN)* and when the battery is empty (Max discharging current is set to zero).

Charging is stopped in case of systems errors (See System Errors indication chapter). SOC is calibrated to 96 % when the maximum open circuit cell voltage rises above the 0.502 x (*Balance start voltage BMIN + End of charge voltage* CHAR), minimum open circuit voltage above balance start voltage and system is in charge regime.

In case BMS is not able to control the MPPT/Non-Victron charging sources directly (MPPT should be set to charge when the remote is in short), a small signal relay can be used to amplify the signal. MPPT should be programmed with its own charging curve set as End of charge voltage x number of cells. Digital output may be programmed with another task on request e.g. heater, under-voltage alarm, …
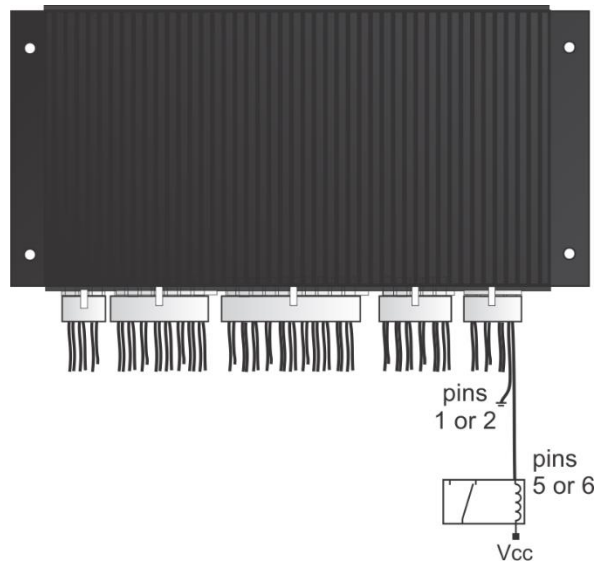
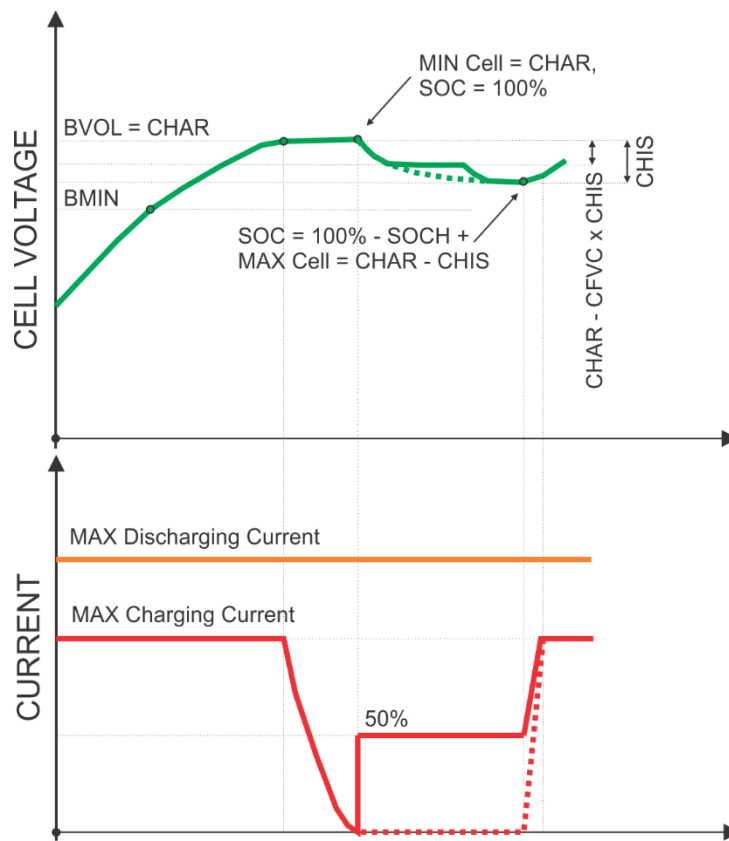**Figure 11:** External signal relay with Vcc rated coil connection schematics.

Figure 12: Charging diagram.

Maximum Cell Float Voltage Coefficient (CFVC):

Maximum Cell Float Voltage Coefficient CFVC has been introduced into the charging algorithm to enable cell float voltage change after the full charge. It may be set from 0.0 to 1.0 of the *End of Charge Hysteresis CHIS*. When *End of Charge Hysteresis CHIS* and *End of Charge SOC hysteresis SOCH have* been met, full charge is enabled again. @ *CFVC* 50 % of maximum charging current is allowed to supply DC loads from

MPPTs directly without discharging the battery pack below *End of Charge Hysteresis CHIS* and *End of Charge SOC hysteresis* SOCH. If *CFVC* is set to 0.0, charging current is set to 0.0 A until the *End of Charge Hysteresis CHIS* and *End of Charge SOC hysteresis* SOCH have been met.

Battery Pack's ESS Discharging Algorithm:

Calculated maximum discharging current is sent to the system by CAN communication in each measurement cycle. When the BMS starts/recovers from the error or from Discharging SOC hysteresis, maximum allowed discharging current is set. It is calculated as *Discharge Coefficient DCHC* x *Battery Capacity CAPA*. If this value is higher than *Maximum Discharging Current per device MAXD*, maximum discharging current is decreased to this value.

Table 24: Maximum discharging current calculation.

SETTING	VALUE	UNIT
Battery Capacity (*CAPA*)	100	Ah
Discharge Coefficient (*DCHC*)	1.5	1/h
Maximum Discharging Current per Device (*MAXC*)	100	A

Discharge Coefficient DCHC x *Battery Capacity CAPA* = 1.5 1/h x 100Ah = 150 A
Maximum Discharging Current per device MAXC = 100 A
Maximum discharging current is set to **100 A**.

When the lowest cell open circuit voltage is discharged bellow the set threshold *CLOW* maximum discharging current starts to decrease down to 0.02 C (2 % of Capacity *CAPA* in A). After decreasing down, maximum allowed discharging current is set to 0 A. At discharge currents lower than 0.05 C or positive, SOC is reset to 3 % and Discharging SOC hysteresis is set to 5 %. If the cell discharges below *Minimum Cell voltage CMIN*, BMS signals Error 2 and internal relay switches off. If the battery current is lower than 0.05 C, SOC is reset to 1 %. If the Charger/inverter is connected to the grid maximum allowed discharge current is drawn from the grid. Otherwise, 100 % load current is drawn from the battery until maximum allowed discharging current is set to 0 A. Discharging current is also limited near both ends of temperature (*Max cell temperature TMAX* and *Min temperature for charging TMIN*) to 30 %, but more than 5 A. If the minimum cell discharges under the *Cell-under voltage protection switch-off CMIN* x 0.95 for more than 30 s BMS goes to deep sleep mode to protect the cells from over-discharging. OFF-ON switch sequence wakes the BMS from this state. *CLOW* cell voltage setting should be set to the voltage that corresponds to 3 % of the usable capacity.
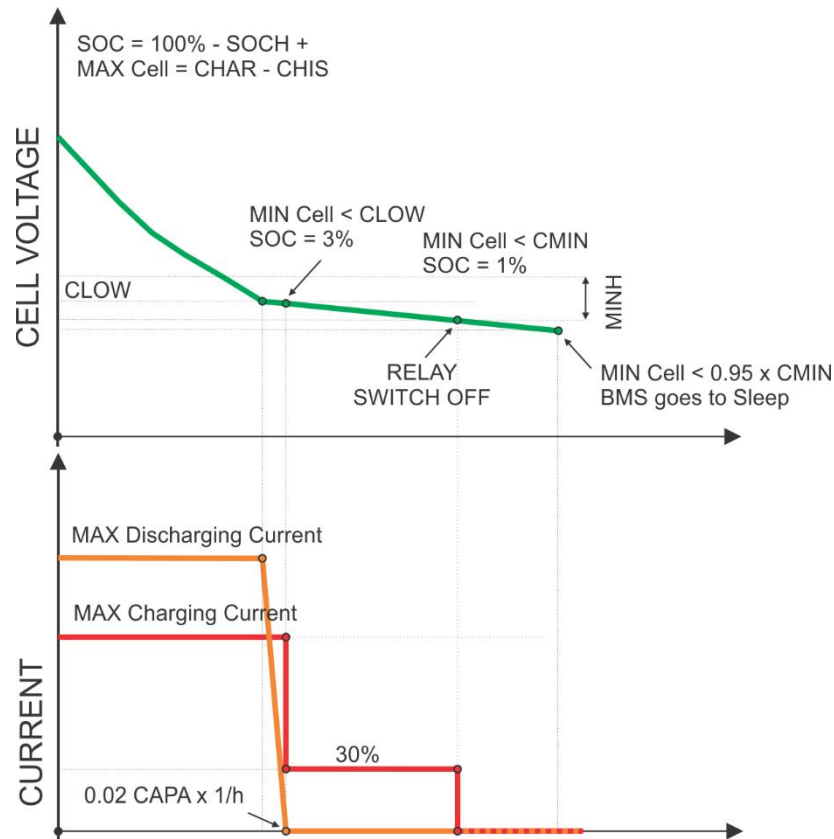
Figure 13: Discharging diagram.

EVSE Control Pilot Connection

BMS 2Q offers two wire Control Pilot (CP) connection control. CP and AGND should be connected to the BMS. BMS controls the maximum AC charging current, when a charger is set by an *CHRG* (Tc Charger, Zivan…)

Digital Outputs

BMS 2Q offers two digital outputs – OPTOCOUPLER 1 and OPTOCOUPLER 2. Both use Darlington NPN transistor optocoupler and employ over-voltage protection using SMBJ58A, reverse voltage output protection with BAT46WH diode and an over-current protection using a 160mA resettable fuse.
OPTOCOUPLER 1 and OPTOCOUPLER 2 are set/assembled as outputs.
Digital output one – OPROCOUPLER 1 can also be re-assembled as an input when the order is placed. "UNCONNECTED" parts are used to form an 5-24 V input galvanically isolated digital input. A hardware change also requires a firmware change.
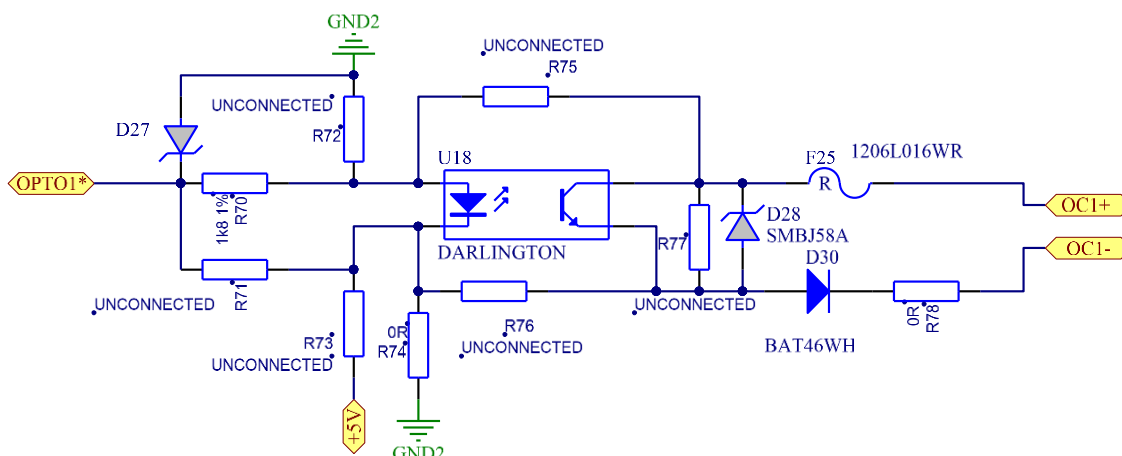
Figure 14: OPTOCOUPLER 1 digital output/input electrical circuit schematics.
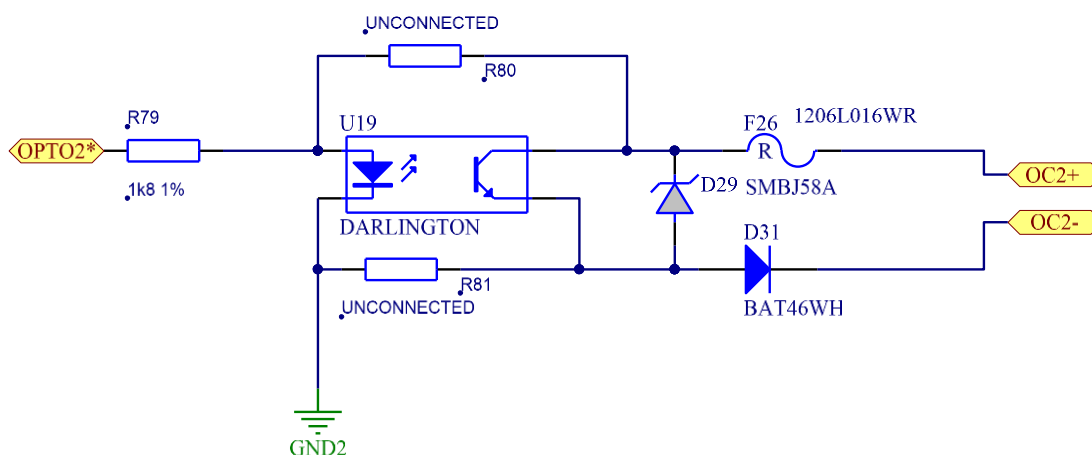
Figure 15: OPTOCOUPLER 2 digital output electrical circuit schematics.

Both outputs may be configured by using Wi-Fi module in the Tasks tab. User has to select the variable for the optocoupler to change state, its value, hysteresis and logic. Additionally, a checklist of errors is used to disable the functionality in case the error is set.

Figure 16: Digital output configuration in Task tab - Wi-Fi module.

Opto-Relay Output

An opto-relay output is used instead of normal mechanical relay to drive the contactor. Opto-relay prevents DC signal contact welding in mechanical relay implementation. 100 VDC and 2 A bi-directional driver is connected in parallel as uni-directional to double the current capacity. Diode D32 is used for reverse protection.
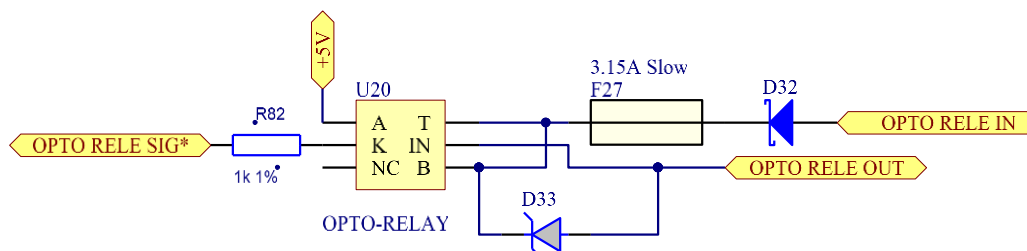

Figure 17: Opto-relay electrical circuit schematics.

Pre-charge Connection:

An integrated pre-charge circuit with a 25 Ω is used to charge the system input capacitors. Before the BMS turns the internal opto-relay to enable contactor, a pre-charge phase is initiated. BMS connects pre-charge resistance between BMS power supply positive (PACK +) and pre-charge connection (PRE-CAHARGE OUT)

that should be connected to the system side of the contactor. After the set pre-charge timer (pre-charge time setting *PRCT*), the contactor is turned ON.

User should always test the pre-charge circuit and time setting effectiveness by measuring the system voltage without the contactor. System voltage should rise @ least to the inverter/charger minimum operational voltage or 85% of the battery pack voltage.

If this condition is not possible to achieve with the prolonged PRCT timer, an external pre-charge may be used. External Pre-charge unit V3.0 may be utilized by controlling its power supply positive by the BMS internal opto-relay and shorting the BMS input GND to the power supply GND. When the pre-charge unit gets powered, it immediately starts the pre-charge phase. Pre-charge may also be used as designed by controlling the BMS input GND by an optocoupler 1 or 2 and power supply connected to the Pac- and PACK-. The only down side of this connection is its power supply that is always draining the battery.

An external pre-charge should also be used in case of driving two contactors – one in System- and the second in System + connection -pre-charge unit V3.1 or driving a bi-stable latching contactor/relay.

https://www.rec-bms.com/wp-content/uploads/2022/07/UserManualPrecharge_3_0_Timeset.pdf

When the BMS encounters an error and the contactor should be turned OFF, it sends an Alarm message via CAN bus so the system/inverters can start the Stand-by or Turn-off procedure prior of contactor turning OFF.
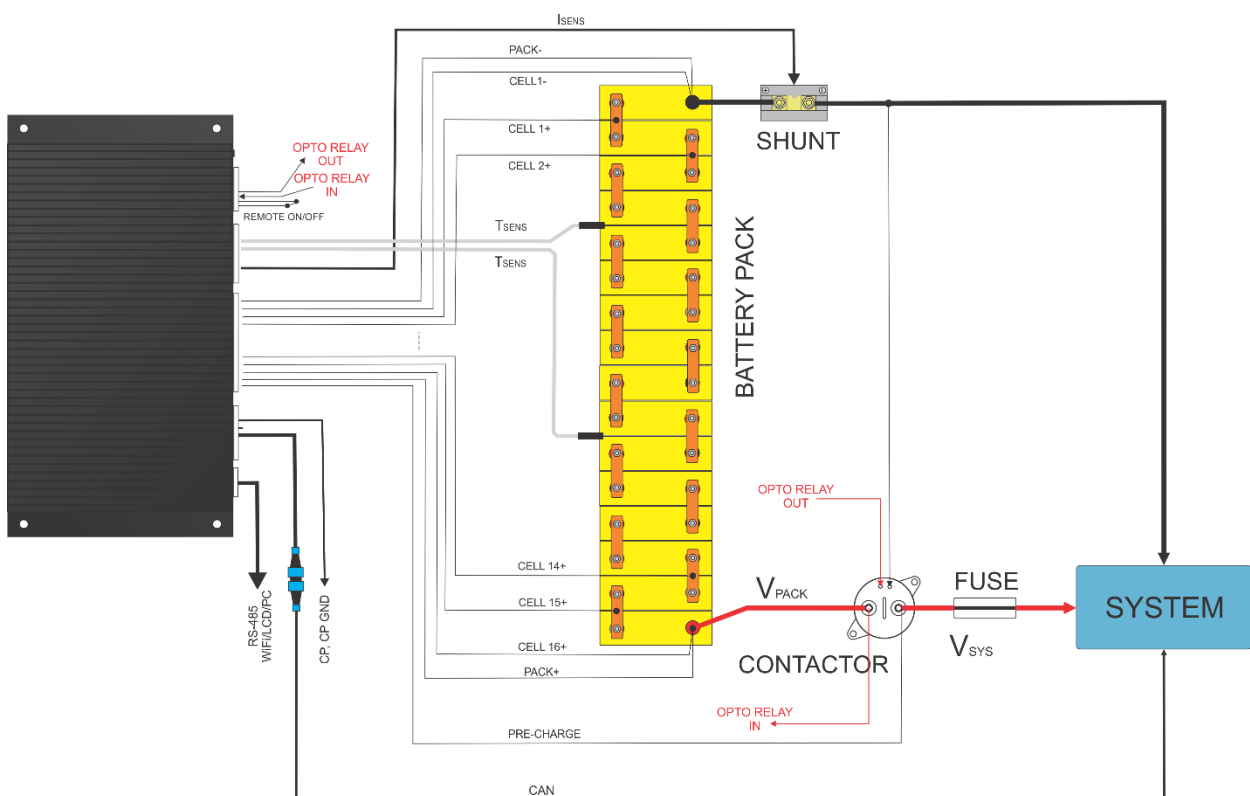

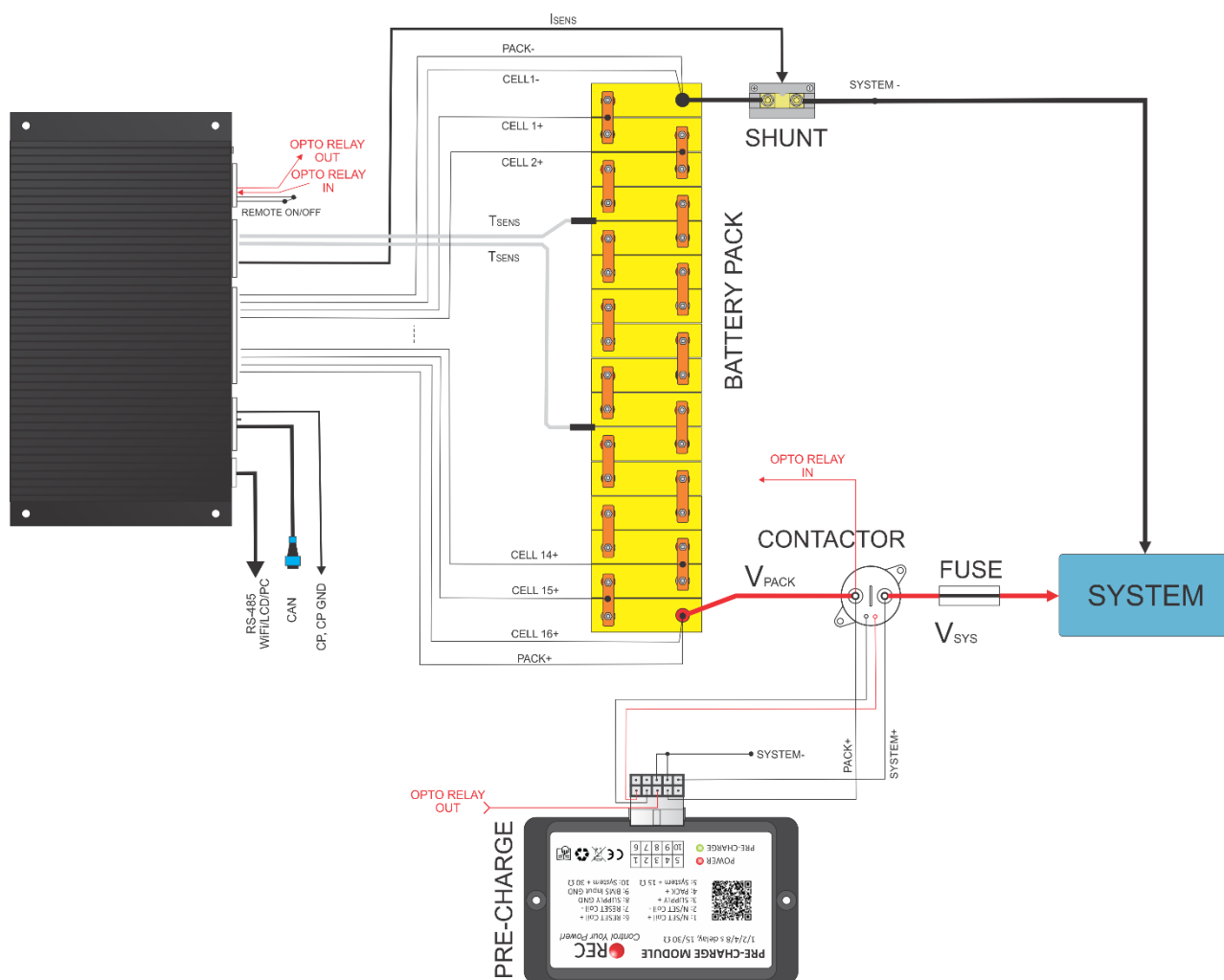**Figure 18:** BMS with internal pre-charge connection schematics.

Figure 19: BMS with an external pre-charge unit V3.0 connection controlling the unit power supply.

System Error Indication:

System errors are indicated with red error LED by the number of ON blinks, followed by a longer OFF state. Each and every error number trigger algorithm has a normal delay time of 3 measuring cycles with sensed/measured error – 3 x 1.25 s before the error is triggered.
Errors 2 and 10 are set to trigger @ the first measured error when the BMS is turned ON. If the two errors are not present normal delay timer is set.

Table 25: BMS error states.

NUMBER OF ON BLINKS	ERROR	BMS	OWNER
1	Single or multiple cell voltage is too high (cell over voltage switch-off per cell *CMAX* - cell over-voltage switch-off hysteresis per cell *MAXH*).	BMS will try to balance down the problematic cell/cells to safe voltage level (2.5 s error hysteresis + single cell voltage hysteresis is applied). Charging is disabled, discharging is enabled. Internal opto relay is disconnected.	• Wait until the BMS does its job.
2	Single or multiple cell voltage is too low (cell under voltage protection switch-off per cell *CMIN* + under voltage protection switch-off hysteresis per cell *MINH*).	BMS will try to charge the battery (2.5 s error hysteresis + single cell voltage hysteresis is applied). SOC is reset to 1 % in case of discharge current lower than 0.05C or positive. Charging is enabled, discharging is disabled. Internal opto relay is disconnected.	• Plug in the charging sources. Lower *MIN* VCell setting *CMIN* for enabling the internal relay.
3	Cell voltages differ more than set (cells max difference *RAZL* – 20 mV hysteresis)	BMS will try to balance the cells if balancing is enabled (20 mV voltage difference hysteresis). Charging is enabled, discharging is enabled. Internal opto relay is connected.	• Wait until the BMS does its job. If the BMS is not able to balance the difference in a few hours, contact the service.
4	Cell temperature is too high (cell over temperature switch-off *TMAX* + cell over temperature switch-off hysteresis –> 2°C).	Cells temperature or cell inter-connecting cable temperature in the battery pack is/are too high. (2.5 s error hysteresis 2°C hysteresis). Charging is disabled, discharging is disabled. Internal opto relay is disconnected.	• Wait until the pack cools down.

5	BMS temperature is too high –internal error (BMS over temperature switch-off *TBAL* - BMS over-temperature switch-off hysteresis *BMTH*).	Due to extensive cell balancing/hardware error the BMS temperature rose over the upper limit (*BMTH* temperature hysteresis). Charging is enabled, discharging is enabled. Internal opto relay is connected. Balancing is disabled.	• Wait until the BMS cools down.
6	Number of cells, address is not set properly.	Charging is disabled, discharging is disabled. Internal opto relay is disconnected.	• Set proper BMS address
7	The temperature is too low for charging (under-temperature charging disable *TMIN* + under temperature charging disable hysteresis of 2°C).	If cells are charged at temperatures lower than operating temperature range, cells are aging much faster than they normally would, so charging is disabled (2 °C temperature hysteresis). Charging is disabled, discharging is enabled. Internal opto relay is connected.	• Wait until the battery's temperature rises to usable range.
8	Temperature sensor error.	Temperature sensor is un-plugged or not working properly (5 s error hysteresis). Charging is disabled, discharging is disabled. Internal opto relay is disconnected.	• Turn-off BMS unit and try to re-plug the temp. sensor. If the BMS still signals error 8, contact the service. The temperature sensors should be replaced.
9	Communication error.	RS-485 Master-Slave communication only.	
10	Cell in short circuit or BMS measurement error (Max cell voltage > 4.5 V or Min cell voltage < 0.8 V).	Single or multiple cell voltage is close to zero or out of range, indicating a blown fuse, short circuit or measuring failure (15 s error hysteresis + 10 mV voltage difference hysteresis). Charging is disabled, discharging is disabled. Internal opto relay is disconnected.	• Turn-off the BMS and check the cells connection to the BMS and fuses. Restart the BMS. • If the same error starts to signal again contact the service.

11	Main relay is in short circuit.	If the main relay should be opened and current is not zero or positive, the BMS signals error 11. Charging is disabled, discharging is disabled. Internal opto relay is disconnected.	• Restart the BMS unit. If the same error starts to signal again contact the service.
12	Current measurement disabled or charging/discharging current >2 x shunt max current or > CCMX, DCMX	BMS is not able to measure current or current is too high (short circuit). Charging is disabled, discharging is disabled. Internal opto relay is disconnected. 15 s pause is introduced before the new connection is established.	• Check the system settings/HW configuration. If the BMS still signals error 12, contact the service or change the BMS settings.
13	Wrong cell chemistry *CHEM* selected.	In some application the chemistry pre-set is compulsory. Charging is disabled, discharging is disabled. Internal relay is disconnected. Charge optocoupler is disabled.	• Use PC Control Software to set proper cell chemistry.
14	EEPROM data corruption	During start-up or shut-down EEPROM read/write was interrupted. The corrupted setting/settings was/were set to a default value. If the setting/settings was/were changed after the first installation it/they should be corrected. Charging is enabled, discharging is enabled. Internal opto relay is connected.	• Use PC Control Software to set proper settings
15	Cell balancing/measurement failure	During the start-up a burned fuse or cell balancing failure was detected. Charging is disabled, discharging is disabled. Internal opto relay is disconnected.	• Restart the BMS unit. If the same error starts to signal again contact the service.
16	BMS internal communication failure	I2C or SPI communication failure. BMS signals error 16 and does not start normal procedure Charging is disabled, discharging is disabled. Internal opto relay is disconnected.	• Restart the BMS unit. If the same error starts to signal again contact the service.

17	Charging/discharging current > 1.2 x current charging/discharging max limit *MAXC, MAXD*	Battery current is out over the set limit. Maximum allowed charging/discharging current sent to the inverter unit is reduced. Internal opto relay is connected.	• Wait until the BMS/system reduces the battery current.

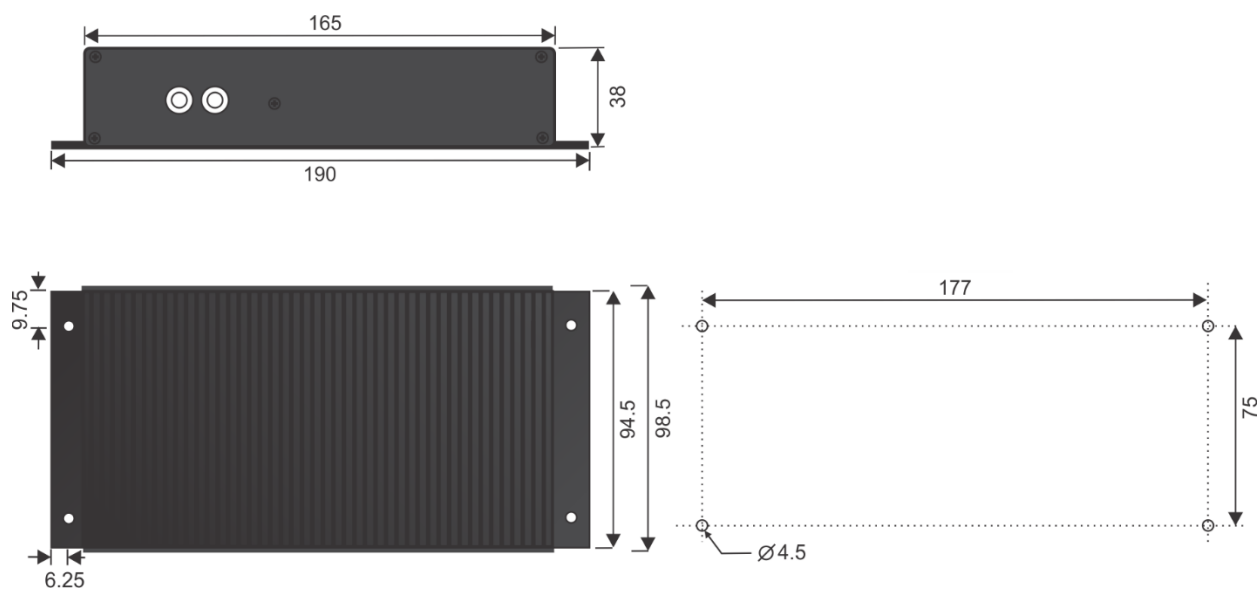## BMS Unit Dimensions:

Figure 20: BMS dimensions.

Wiring harness:

A pre-fabricated 2Q BMS wiring harness kit is available:
- RS-485 in plug (CAN connection with 5 pin circular connector 0.5 m + termination)
- Cell, power-supply and pre-charge plug (1 m all with wire labels)
- Current and temperature sensor plug (current sensor 2 m, single temperature sensor 2 m)
- I/O and remote ON/OFF plug (I/O connections with wire labels 1 m, remote 1 m with ON/OFF micro rocker switch)
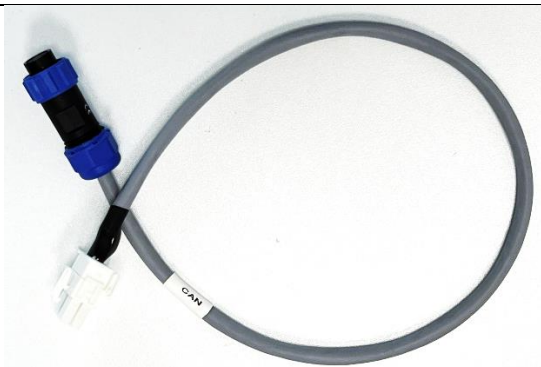
Cell, Power supply and pre-charge connector wire harness	I/O and remote ON/OFF connector wire harness
CAN wire harness	Sensor wire hareness

Figure 21: 2Q BMS wiring harness.