Real Time Battery Management System (RT-BMS)

Product Specification

RT-BMS MASTER version 2.1

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http://www.ev-power.eu

EV-Power.eu managed by i4wifi a.s. (member of GWL/Power group)
Prumyslova 11, CZ-10219 Prague 10, CZECH REPUBLIC (EU)
phone: +420 277 007 500, fax: +420 277 007 529, email: export@i4wifi.cz
**RT-BMS System Introduction**

The Real Time Battery Management System (RT-BMS) is an advanced battery management solution for any type of lithium-based cells. Unlike other management systems, the RT-BMS provides the battery management during the complete charge and discharge cycle. Each cell is managed individually and the master control unit manages the whole chain of cells.

If we consider a 100Ah traction battery with a cell capacity variance of ±2.5% being charged at 100A for 1 hour, a balancing current of up to 5A is needed, provided balancing is enabled throughout the whole duration of the charging cycle. Leaving the balancing only for the end of the charging cycle requires either a higher balancing current or a longer charging time. With a 200Ah battery, for example, a 10A balancing current is needed when charging at 200A, or a 2-hour charging time when charging at 100A.

The standard power RT-BMS solution allows to manage each cell with balancing currents up to 5A. For example, operating large-capacity LiFeYPO4 cells built into a 32-cells pack with a nominal voltage of 100V requires to release ~640W of balancing energy (= 5A [balancing current] × ~4V [cell voltage] × 32 cells). Although this may seem to be quite a large amount of wasted power, a individual balancing of the cells at 5A requires only ~20W of energy to be released from each managed cell.

**New in version 4.0:** the high power version of the Cell Balancing Units (CBU) allows to manage each cell with balancing currents up to 10A. This is especially beneficial for high speed charging applications or for large capacity cells.

The RT-BMS is designed according to the concept of single real-time balancers managing and balancing up to 192 individual cells. The individual cell-balancing units are controlled by the central Master RT-BMS Control Unit.

**New in version 4.0:** we offer two basic models: 1) RT-BMS main unit with one data line for managing up to 64 cells. 2) RT-BMS main unit with three data lines for managing up to 192 cells.

*Real Time Battery Management System (RT-BMS) operating block diagram*
Besides controlling the cell balancers, the Master Control Unit of the RT-BMS is designed to provide for the communication with the charger, motor controller, and other devices, as well as on-line transmitting of voltage levels, cell temperature, charge and discharge current, and signal data status for user display.

The individual cell balancers are also used for data recording the battery discharge cycle. In the same way as while charging, during discharging the Master Control Unit monitors the status of each individual cell (temperature, voltage, internal resistance, total current, differences in relation to other cells, etc.). If user-defined limits are exceeded, warning is signaled. The Master Control Unit can also provide additional warnings of approaching conditions, such as a near-to-full discharge, over current, high temperature, etc. It can control the various indicators (remaining charge, drawn current, etc.) either on its own, or it can relay this information to other systems via CAN data bus—to displays or motor controllers, for example. The Master Unit also collects stored data for later analysis. It is also able to identify the damaged or defective cells, thereby preventing potential emergencies or failed discharges.

The whole RT-BMS system is compatible with all current types of traction cells (Pb, A123, LiPol, LiFe, LiFePO4, LiFeYPO4, etc.) – with the exception of the NiXX cells – i.e. all types of rechargeable cells with an operating voltage between 2.7V and 5.0 Volts.

The RT-BMS Master Control Unit is able to communicate with a PC (parameter settings, transfer of online or stored data). The link is via galvanic-separated USB module.

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The RT-BMS System Components Overview

**Master RT-BMS Control Unit**

<table>
<thead>
<tr>
<th>Dimension (plastic box)</th>
<th>130 × 95 × 25 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (incl. box)</td>
<td>140 gram</td>
</tr>
<tr>
<td>Supply voltage</td>
<td>+12 V</td>
</tr>
<tr>
<td>Number of supported cells</td>
<td>64 or 192</td>
</tr>
<tr>
<td></td>
<td>64 (+ 64 + 64)</td>
</tr>
<tr>
<td>Power control outputs</td>
<td>8 × 12 V/8 A</td>
</tr>
<tr>
<td>Signal Indication outputs</td>
<td>4 × 12 V/1 A</td>
</tr>
<tr>
<td>Auxiliary digital outputs</td>
<td>3 × 3.3V / 10V</td>
</tr>
<tr>
<td>Auxiliary frequency output</td>
<td>1 × 3.3V / 10V</td>
</tr>
</tbody>
</table>

Unit current consumption:  
* in the operation mode: depends on the operating state and number of connected CBU modules  
* in the sleep mode: approx. 10 µA

Output impedance for outputs AD2, AD3, AD4:  
470 Ohm for 3.3V / 100 Ohm for 10V

Output impedance for output AD1:  
100 Ohm for 3.3V analog / 100 Ohm for 10V freq.

Output indication signals (connector A, pins 6 -9) are analog (connection of analog displays - voltmeters).

Outputs AD2, AD3 and AD4 (connector A) - it is possible to set by jumpers U3 the output voltage (either 0 up to 3.3V or 0 up to 10V) by jumper located between connectors "A" and „C“.

Output AD1 (connector A) - it is possible to switch between analog output (0 up to 3.3V) or a frequency output (internal converter U/f with output signal 10V).
Output switches operation (Connector „B“)

In the active state ("ON") each switch is connected to "ground" (GND) and the corresponding signal LED is "ON". In the inactive state ("OFF") the switch is "open" – not connected. The switches may be used for controlling power contactors or as switching signals of a controller or other equipment. (For better understanding are switches can be imagined as mechanical contacts. In reality power MOSFETs are used.)
Master RT-BMS Control Unit – Connector Overview

**Connector A (Indication Outputs):**
- **Pin 1:** Digital output open collector 4 (1A / 12V) – free (not used)
- **Pin 2:** Digital output open collector 3 (1A / 12V) – free (not used)
- **Pin 3:** Digital output open collector 2 (1A / 12V) – Error
- **Pin 4:** Digital output open collector 1 (1A / 12V) – Fuel reserve
- **Pin 5:** GND
- **Pin 6:** Analog. / digital. output 4 (range 0 / +3.3V / 10V) – min. U of cell [V]
- **Pin 7:** Analog. / digital. output 3 (range 0 / +3.3V / 10V) – max. U of cell [V]
- **Pin 8:** Analog. / digital. output 2 (range 0 / +3.3V / 10V) – Current [A]
- **Pin 9:** A / D / frequency output 1 (range 0 / +3.3V / 10V) – Battery charge [%]

**Connector B (Power Disconnecting Switches):**
- **Pin 1:** minus pole of battery 12V (power GND) – use a separate cable to provide sufficient power rating!
- **Pin 2:** minus pole of battery 12V (power GND) – use a separate cable to provide sufficient power rating!
- **Pin 3:** Main Load – Main Current – Switch (e.g. for motor controller)
- **Pin 4:** Anti-spark Switch (e.g. for motor controller)
- **Pin 5:** Charging Current 1 – LOW (MAIN or small power – final small current balancing)
- **Pin 6:** Charging Current 2 – HIGH (not connected or high power)
- **Pin 7:** Heating Switch
- **Pin 8:** Cooling Switch
- **Pin 9:** AUX 1 (Recuperation OFF)
- **Pin 10:** AUX 2 (Reserved)

**Connector C (Current Sensor):**
- **Pin 1:** Current probe supply (+5V or +12V)
- **Pin 2:** Sense +
- **Pin 3:** Current range of probe
- **Pin 4:** GND

**Connector E (System supply):**
- **Pin 1:** supply (+12V)
- **Pin 2:** minus pole of battery 12V (system GND)

**Connector F (BMS switch-on):**
- **Pin 1:** (system GND) minus pole of battery 12V – use a separate cable to provide sufficient power rating!
- **Pin 2:** internal switch-on supply (+12V)

**Connector H (I2C bus, connection of USBCOM – to PC USB port):**
- **Pin 1:** +5V / +12V output
- **Pin 2:** SCL
- **Pin 3:** SDA
- **Pin 4:** GND

**Connector I, J, K (10 pin connection data lines for CBU modules):**
connector I = section 1, cells 1 - 64, connector J = section 2, cells 65 - 128, connector K = section 3, cells 129 - 192
- **Pin 1:** feeding (+5V)
- **Pin 2:** feeding (+5V)
- **Pin 3:** line A
- **Pin 4:** feeding (+5V)
- **Pin 5:** line B
- **Pin 6:** GND
- **Pin 7:** GND
- **Pin 8:** GND
- **Pin 9:** switch-on modules
- **Pin 10:** GND

GND Pin 10 Pin 9: switch-on
GND Pin 8 Pin 7: GND
GND Pin 6 Pin 5: A line
feeding (+5V) Pin 4 Pin 3: B line
feeding (+5V) Pin 2 Pin 1: feeding (+5V)
Optional connectors (for RT-BMS-192)

Connector D (External temperature sensors) – available only in RT-BMS-192 version:
- Pin 1: sensor 1: KTY 81-210
- Pin 2: GND of sensor 1
- Pin 3: sensor 2: KTY 81-210
- Pin 4: GND of sensor 2

Connector G (port RS-232/485) – available only in RT-BMS-192 version:
- Pin 1: feeding (internal or external)
- Pin 2: RxD (232) / B line (485)
- Pin 3: TXD (232) / A line (485)
- Pin 4: GND

Connector L (CAN BUS) – available only in RT-BMS-192 version:
NOTE: If the control unit is terminal for CAN bus, is necessary to connect Jumper U2
- Pin 1: + 5V output
- Pin 2: CAN L
- Pin 3: GND
- Pin 4: CAN H

Connector M (auxiliary charger controlling):
- Pin 1: OPT +
- Pin 2: OPT –

Master RT-BMS Control Unit – On-board display status information

After the power-up, the display shows the firmware SW versions:

MM.MM
- MM is the software version of main unit, MM is the version of software for the CBU modules
Example: 17.28 - SW of main unit is 1.7, SW of CBU modules is 2.8

During the standard operation, the voltage values are displayed over and over:

Cx.xx  cell voltage with the highest value
dx.xx  cell voltage with the lowest value
X.xxx  difference between highest and lowest cell voltage in the whole pack
or
XXX.x  the total voltage of the whole battery pack  (depends on the software version of the BMS)
Example:
C3.14  - the cell with highest voltage has 3.14V
d3.02  - the cell with lowest voltage has 3.02V
0.127  - the difference of the pack is is 0.127V

In case of Error – the RT-BMS Master unit displays the Fault Status Messages:

FXXX  the address of the CBU unit that has cause the failure (000 to 191)
XXXX  the error number code
The RT-BMS error code indicates which CBU module reports fault (the address, e.g. F041 = cell number 42).

The list of error codes for the CBU modules faults:

0000  Data line communication error
0001  Internal EEPROM damaged – the CBU does not work properly
0002  Balancing FET failure – balancing current not flows and cell is not balancing
0003  Balancing FET failure – balancing current flows all the time and discharge cell !!!
0004  Internal DC/DC converter damaged
0005  CBU power FET overheating > 130 °C
0006  Internal temperature sensor damaged
0007  External battery temperature sensor damaged

Please contact the supplier in the case of CBU unit or RT-BMS Master unit failure.
Resetting the RT-BMS Master unit

In case you need to reset the RT-BMS master unit, press and hold both buttons during the power-up. (Disconnect from power /connector E/ and reconnect again.) Following the reset, the BMS Master will display F255 and the operating settings must be renewed using the PC software.

Q: My BMS Master displays F255 all the time. What does it mean?

Answer: The error F255 means: “All settings erased”. This means the EPROM of the BMS Master does not contain any operational settings. You need to connect the computer and make the settings using the BMS software. If F255 appears repeatedly, even after setting the values over PC software, please contact us for more support.

Q: After the Power-Up of the Master-Unit (with 4 connected CBU modules) the Master counted from 000...064 (LED-display), after the counting there was a "004" visible. After the "004" the system made a shut-down and afterwards there was no possibility for an PC-communication.

Answer: After the power-up, the BMS Master performs the Power-up sequence – searching for all CBU modules within the designated address range (0 to 64 or 0 to 192). After that, the BMS master returns to low-power Stand-by mode. In order to start the operation of the BMS, the +12V must be connected to Pin2 of the F connector (System Switch). Please observe carefully the polarity of the pins on the E connector and the F connectors!

Q: Does there exist an installation and operating manual of the RT BMS Master?

Answer: Yes, in fact you are just reading the manual! Additionally, there is a wide range of information provided on-line. At this moment, all information published related to the RT-BMS system is available on this link: http://gwl-power.tumblr.com/tagged/RT-BMS.

We recommend you first study carefully all available documents, before you start asking the questions. If you need any help or cannot find a solution in the available documents, please contact us for additional support.
Master RT-BMS Control Unit – additional components

Current sensor HALL 400

- Board dimensions: 55 × 43 × 23 mm
- The diameter of the hole for traction cable: Ø 22 mm
- Sensing current: ± 400 A
- Insulating voltage: 2500 VAC

Note:
The current sensor is galvanic separated from the measuring circuit. It is possible to insert it anywhere between the cells. The correct current flow direction must be observed.

Current sensor details and connection:

- To charger
- To controller (load)
- Load current (discharging current)
- Traction battery
- Charge current
- HALL 400

(LED “run”)

“plus” current direction

Connector

The current sensor with cable (approx 2 m)

- (brown) GND
- (white) current range
- (green) +SENSE
- (yellow) +12V

To the „C“ connector of Control unit
Note: Colors of the wires of the cable connected to the current sensor

The 10 pin data line flat cable and the connector for flat cable

The connectors for the RT-BMS input and output data connection

The USB communication module
USB communication module modul **USBCOM**

Cable for **USBCOM** module connection to RT-BMS

To the "H" connector of Control unit
Product Warranty

The RT-BMS producer guarantees this product to be free from factory defects in material and workmanship. Warranty liability shall be limited to repairing or replacing the unit to work again based on the product specifications.

The warranty may be claimed under the following conditions:
The product has been used in the compliance with the instructions for use and only for purposes stated in the instructions and provided that none of the conditions for which the warranty cannot be claimed (see below) occurred.

The warranty does not cover and therefore cannot be claimed for damages/defects caused by:
- Forced mechanical damage, crash, etc.
- Chemical substances interference
- Unqualified manipulation, incorrect installation
- The interference with the equipment (soldering, change of wires, change of any components, damaged circuit board, connectors, etc.)
- Reversal of poles, incorrect cabling
- Overloading with a higher number of cells than specified
- Powering from unspecified source (e.g. mains source instead of the specified cells)
- Shortcut on the outputs
- Overload
- Water, salt water or any other liquids
- Operations with not recommended (not suitable) connectors
- Not following the instruction in the manual or operating in conflict with recommendations or manual

The warranty also does not apply when:
- The components or parts are warn out by regular use
- The damage by natural disasters (e.g. strike by lightening)

Recycling

This symbol on the product and / or accompanying documents mean that used electrical and electronic products should not be mixed with general household waste.

For proper treatment, recovery and recycling, please take these products to designated collection points, where they will be accepted on a free of charge basis.

Electromagnetic Conformity declaration

For all products of the BMS family we confirm that the electromagnetic compatibility directives are met.

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