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User Manual

BMS123 Smart

Introduction

After the introduction of affordable LiFePO4 batteries, off-grid solutions became available for wide public. It is vital that such batteries are charged very carefully. In other words, they can easily be over-charged, or over-discharged. Cell-temperature and current are also very important, in order to guarantee a long life.

The GWL Battery Management System (or : BMS) is primarily intended for prismatic LiFePO4-LiFeYPO4-cells, but can also be adapted by the end-user for other cells like Li-Ion and LiPo, provided the cell-voltage is in the range of 2V to 5V.

Keep the batteries in perfect condition

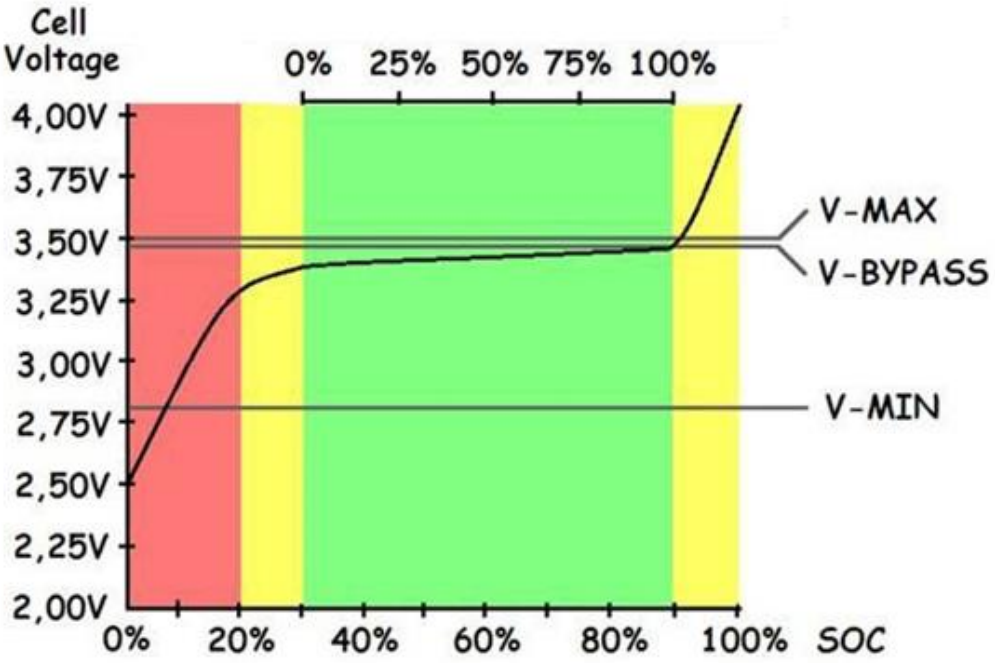
The drawing below shows that your expensive batteries are in good hands with 123 electric.

The system sets the coulomb counter to 100% when either all cells get to V-bypass or one cell reaches V-max. (You can change these settings with the PC software by yourself.)

Calibrating the coulomb counter to 100% is important, as otherwise small errors will appear, because of changes in the charging efficiency, aging of the batteries etc. etc.

The width of the green (safe) area, can also be selected by yourselves. If you use 90 Ah cells, for instance, and you only want to use 60% of the capacity, you can enter 60% of 90 Ah = 54 Ah in the field for Cell-capacity.

by V-min.



Package contains (12 Volt, 4 cells)

- IN Cell Board
- OUT Cell Board
- 2 Cell Boards
- 2 Current sensors
- Piece of 0,75 mm² wire for the interconnections
- Connector unlock tool

Specification

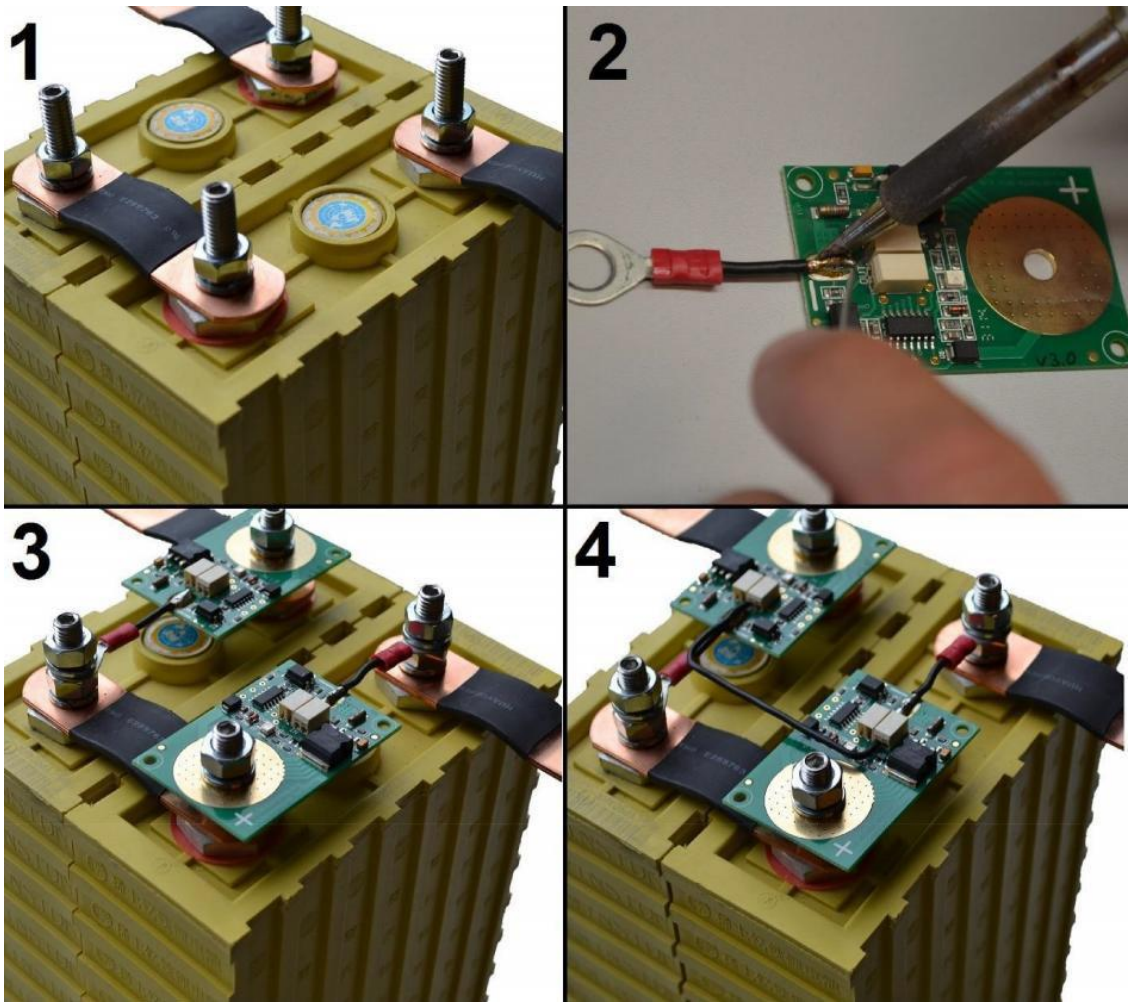
Item	Specifications
Idle Current of the BMS-IN / OUT Modules inclusive current sensors and standby Bluetooth	< 2 mA
OUT Module current when Bluetooth connection is active	<25mA
Idle Current BMS-modules	< 100 uA
Balancing Current	1 Amp.
Number of Cells	2 - 255
Current-sensors	100 Amp.
Resolution	10 Bit A/D converter
App compatibility	iOS, Android

Placing the cell modules

Please be aware that your battery-pack contains a large amount of energy, which can be potentially dangerous. Use isolated spanners, to prevent any short circuits. High inrush currents, causing arc-ing (sparks) and ultra-high electromagnetic levels, can easily damage electronic circuits.

We therefore strongly recommend to always FIRST connect the so called "large current connections" in a new setup, and THEN separately connect the BMS-boards.

A good way of doing this is indicated on photo number one. After thorough cleaning of the cell-poles, the copper strips are bolted-on. Don't forget to also attach wires to the first and last cell in the same way, and connect these to the solar panels, MPPT, charger and the load.



Mounting the IN Module

Start to mount the IN-Board on the first cell**. It is important this is the cell on the minus (-) side of the battery pack.** Solder a wire on the solder pad of the IN-Board. (Photo 2) Connect this wire to the minus (-) side of the cell. After the IN-Board is connected the LED will start blinking every second, this shows the IN-Board is trying to send out data messages to the following cell board.

Install a current sensor in the incoming power line (solar panels, PMMT, charger) and connect this current sensor to the IN-Board connector"J1" marked "I-1". Install the other current sensor in the power line of the consumers (inverter) and connect this sensor to the IN-Board connector "J2" marked "I-2". Make sure the arrow on the current sensor is pointing in the right direction. The direction where the current is flowing (see picture on the following page).

Note: when only using 1 current sensor, connect this sensor to J1.

Mounting the „Between“ cell Modules

After the IN-Board was installed, please proceed by the cell boards. Now, prepare the BMS-boards as shown on photo number two. Use thick solid-copper wire for this, for optimum accuracy. (the bypass-current has to flow through these wires)
Take your time: the result has to look good!
The BMS module always has to be mounted on the 'plus' pole of the cell. This '+' is also indicated on the cell modules. Connect all the modules as shown in photo number three.

Mounting the OUT module

On the last cell (+ side of the battery pack) the OUT-Board has to be installed. This works the same way as the other cell boards. It’s normal you will hear some clicking relays when you power up the OUT board.

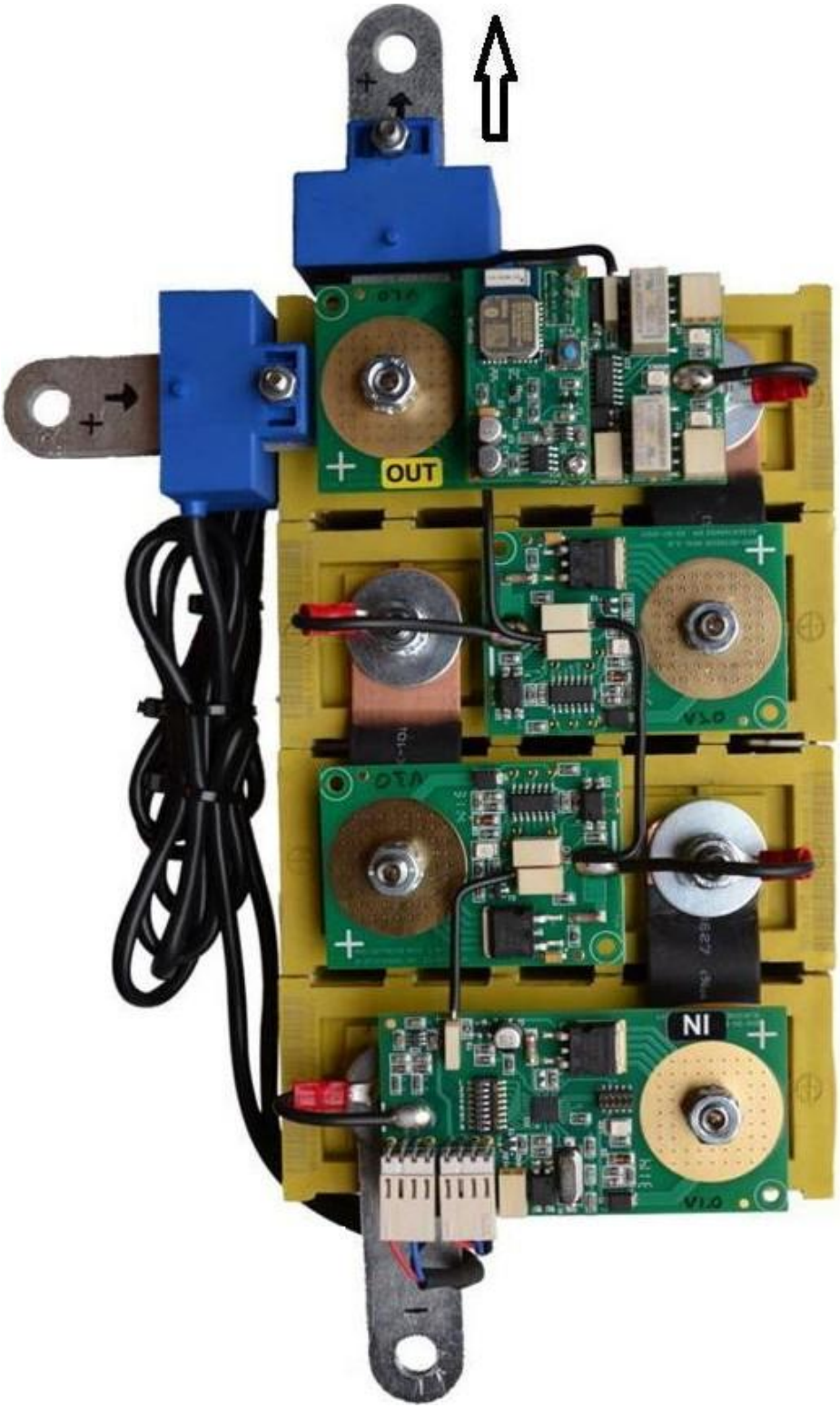
Cell boards interconnections

After all cell boards are installed the interconnection can be made. Start the interconnection of the IN-Board to the following cell board. Make a connection from the single connector marked “OUT” on the IN-Board to the double connector position 1 Marked “IN” on the following cell board**. Please be careful while you’re doing this in order to prevent a short circuit. The single wire is now under power. Do not touch any other part of circuit by this wire except the correct connector. It could damage the board.** After you have made the interconnection between the IN-Board and the first cell board you will notice the green LED on the next cell board will flash as well every second. This confirms the cell board was correct installed and the interconnection between the cell boards are made correct. Now go on with the other cell boards. Make connections from the double connector position 1 market “OUT” to the next cell board connector position 1 market “IN” If the flashing LED’s stop somewhere in the middle of the cell chain there is an error, in this case check the wiring.

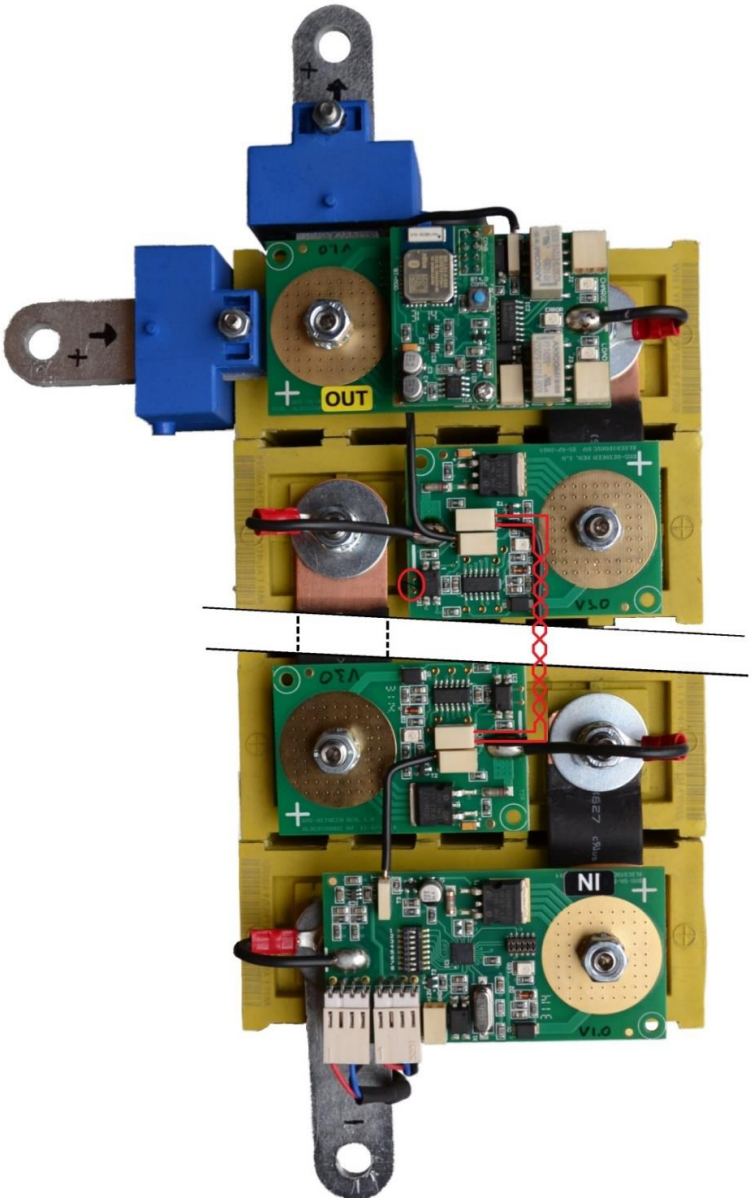
A four cells 12 volt system needs three connections:

IN-Board	J4 “OUT”	→	Cell-Board	“IN” position 1
Cell-Board	“OUT” position 1	→	Cell-Board	“IN” position 1
Cell-Board	“OUT” position 1	→	OUT-Board	J1 “IN”

The picture below shows a basic setup of a 12 Volt battery pack



The picture below shows a setup with separated battery banks.



When the battery pack has separated battery banks the interconnection has to be changed to prevent interference from other components in the system. The data connection has to be galvanic isolated. This can be done by the following procedure:

1- Cut of the PCB track between the two gold dots. (red circled in the picture above)

Use a twisted pair cable and use both terminals.

IN-Board 'option switch' functions

Settings

The option switches can be changed when the system is active.

The table below shows you the functions of the option switches.

Important: Don't use switch number 8, this will overwrite hidden factory settings

Switch:	1	2	3	4	5	6	7	Function:
	Fast message	V-Bypass	Bigger blind spot	Set zero	Mode	V-Bypass		
	ON							Messages every 0,5 Sec.
	OFF							Messages every 1,0 Sec.
			ON					Blind spot around zero AMP enable
			OFF					Blind spot around zero AMP disable
				OFF				Auto zero inactive
				ON				Auto zero active
					OFF			Normal mode (recommended)
					ON			Critical mode
		OFF				OFF	OFF	V-Bypass 3,4 Volt
		OFF				OFF	ON	V-Bypass 3,5 Volt
		OFF				ON	OFF	V-Bypass 3,6 Volt
		OFF				ON	ON	V-Bypass 3,7 Volt
		ON				OFF	OFF	V-Bypass 4,0 Volt
		ON				OFF	ON	V-Bypass 4,1 Volt
		ON				ON	OFF	V-Bypass 4,2 Volt
		ON				ON	ON	V-Bypass 4,3 Volt

Option switch nr 1: The frequency of the cell board messages can be changed by these option switch. For fastest information set the switch to ON, for saving energy set the switch to OFF.

Option switch nr 3: To prevent the current sensor is too sensitive around 0 Amps and this will cause miscalculations in the SOC calculation, enable option switch 3. Now the current sensor has a little blind spot around zero. (this function is available in version 1,1 or newer)

Option switch nr 4: When the current sensors need to be calibrated follow the next procedure: Make sure there is running absolutely no current through the current sensors during the zero calibration procedure. On the IN

module you will find the option switches. Set option switch number 4 to the ON position. Now the “Auto zero” procedure will be active. The currents on the App screen will show 0 Amps in a couple of seconds. Set the option switch number 4 back to the OFF position again.

Option switch nr 5 (v1.5+): OFF (recommended): the BMS works in normal mode. The SOC is reset to 100% when all cell voltages are at or above Vbypass. The relays are controlled by the BMS charge/discharge algoritm. Please see section “Algoritm” for more info.

ON: the BMS does not act on SOC anymore and only switches the relays off in critical conditions like communication error, too low voltage, too high voltage, too low temperature and too high temperature. The SOC is reset to 100% if the total pack voltage is at or above Vbypass x Number of cells.

Option switch 2, 6 and 7: Set option switch 2, 6 and 7 in the right positions for the Bypass voltage you like. See table for details.

Hidden factory settings

The settings below are normally pre-programmed during the production.
For programing other current sensors or change the number of cells follow the next procedure:

Set all switches below in the right positions for current sensor and number of cells and toggle switch 8 ON and OFF again.
The hidden settings are now stored in the BMS. Set the switches back in the original positions. Please be aware it could be necessary to follow the current sensor calibration procedure again.

Switch:	1	2	3	4	5	6	7	Function:
	Current sensor			Number of cells				
	OFF	OFF	OFF					25 Amp
	OFF	OFF	ON					50 Amp
	OFF	ON	OFF					100 Amp (Default)
	OFF	ON	ON					250 Amp
	ON	OFF	OFF					400 Amp
	ON	OFF	ON					500 Amp
	ON	ON	OFF					-
	ON	ON	ON					-
				OFF	OFF	OFF	OFF	4 Cells
				OFF	OFF	OFF	ON	8 Cells
				OFF	OFF	ON	OFF	12 Cells
				OFF	OFF	ON	ON	16 Cells
				OFF	ON	OFF	OFF	20 Cells
				OFF	ON	OFF	ON	24 Cells
				OFF	ON	ON	OFF	28 Cells
				OFF	ON	ON	ON	32 Cells
				ON	OFF	OFF	OFF	48 Cells
				ON	OFF	OFF	ON	64 Cells
				ON	OFF	ON	OFF	80 Cells
				ON	OFF	ON	ON	96 Cells
				ON	ON	OFF	OFF	128 Cells
				ON	ON	OFF	ON	156 Cells
				ON	ON	ON	OFF	204 Cells
				ON	ON	ON	ON	255 Cells

The App

First connection

Go to the App store for Apple devices and search for “BMS123 Smart”. Install the BMS123 Smart App on your Apple device. For Android devices go to the Play store and search for “BMS123 Smart”. Install the App on your Android device. Enable the Bluetooth functionality of your device.

Start the App, You will see an overview of an off-grid system. Tab the screen to show the title bar on the top of the screen. Tab settings to open the settings section.

In case of the first connection push the little blue button on the OUT Board to wake up the

Bluetooth section of the OUT-Board. Now your BMS will be discovered, Tab on the discovered BMS123 Smart device to make a connection. The App will ask for a password, this password is stored in the BMS to prevent everybody with a Bluetooth device can control your BMS. The standard password is “1234”. After the connection has been made it’s time to configure the system.

Normally the BMS will search for Bluetooth devices every 30 seconds. This is done to save energy, because a BMS is to protect, balance and monitor battery packs while consuming as less as possible energy. So normally it can take at much 30 seconds before the BMS will be discovered. If the connection has been made one time before, the device will re-connect automatically when you start the App the next time. Every time you like to direct connect press the blue button.

Settings

Solar peak power: Set the maximum power of your incoming energy source, for example solar panels. If the system contains 10 solar panels of 250 Watt each, the total power of 2,50 kW has to be configured.

Inverter peak power: Set the maximum power of the consumers, for example an inverter.
When your inverter can supply 5 kilo Watt, 5,00 kW has to be configured.

Battery capacity: The battery capacity can of course be set to the total capacity of the battery pack. We advise however to take only 75% of the rated capacity, to comply with cell aging and temperature effects.

Change PIN: It is strongly recommended to change the password of the BMS to prevent intruders can sabotage the system. Tab the “change PIN” line and follow the instructions.

Clear energy counters: Totals of incoming and outgoing energy will be stored into the BMS. If you like to set these total counters to zero, tab the “Clear energy counters” line and follow the instructions.

V min: If one of the cells gets below this minimum cell voltage threshold the “Vl“ warning indicator on the battery details screen is switched on. The capacity will be set to 0% SOC and of course the “allow to discharge” relay to control external devices will be switched off.

V max: If one of the cells gets above this maximum cell voltage threshold the “Vh“ warning indicator on the battery details screen is switched on. The “allow to charge” relay to control external devices (solar charger) will be switched off.

V bypass: This is the voltage where you want all the cells to end up. Above this Voltage the cell modules start to dissipate 1 Ampere to balance the cells. This setting can be changed with the option switched on the IN-board and will only be displayed.
T min: If one of the cells gets below this minimum cell temperature threshold the “Tl“ warning indicator on the battery details screen is switched on.

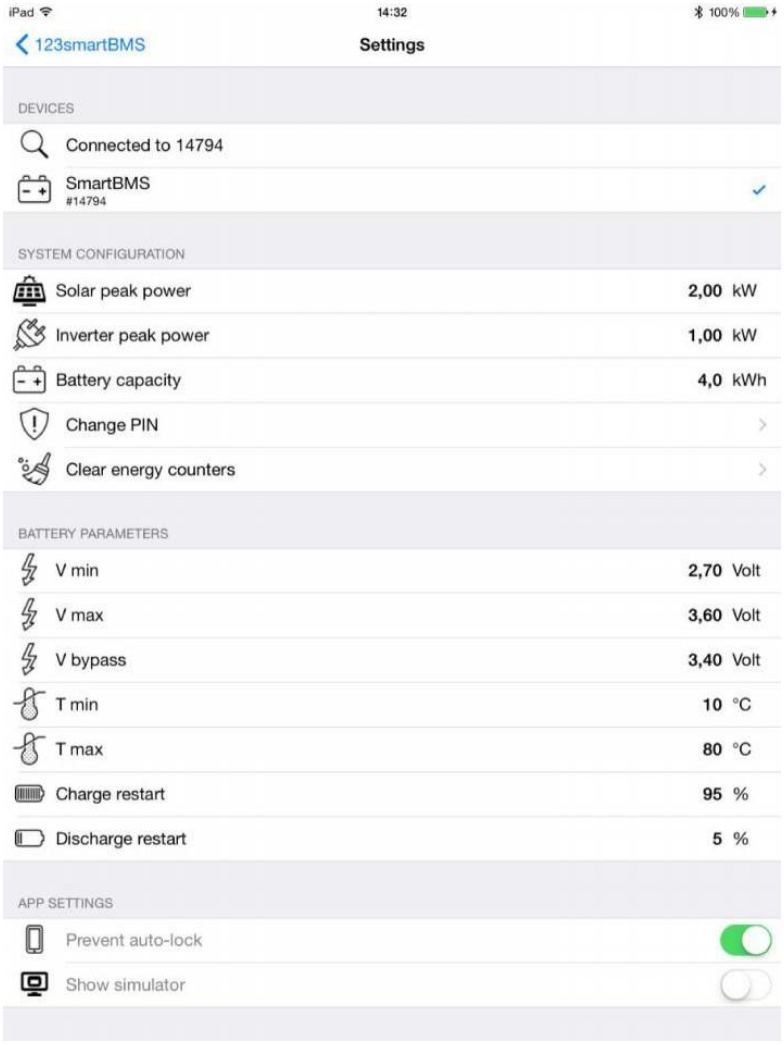
T max: If one of the cells gets above this maximum cell temperature threshold the “Th“ warning indicator on the battery details screen is switched on.

Charge restart: When the battery pack capacity is 100% SOC, In case of all cells are above the Bypass threshold the charge relay switched OFF and switches ON again if the capacity is below the programmable “Charge restart”. This is to prevent toggling relays.

Discharge restart: The load relay will be switched off if the battery pack capacity is 0% or one of the cells goes below the programmable minimum cell voltage, and switches on again if the capacity is above the programmable “Discharge restart”.

Prevent auto-lock: Enabling this function prevent the device goes into sleep mode.

Show simulator: If you don’t have an BMS123 Smart but you like to discover the App, you can run a simulator.



After the settings has been done, Tap the "**< BMS123 Smart**" button to show up the overview

Dashboard

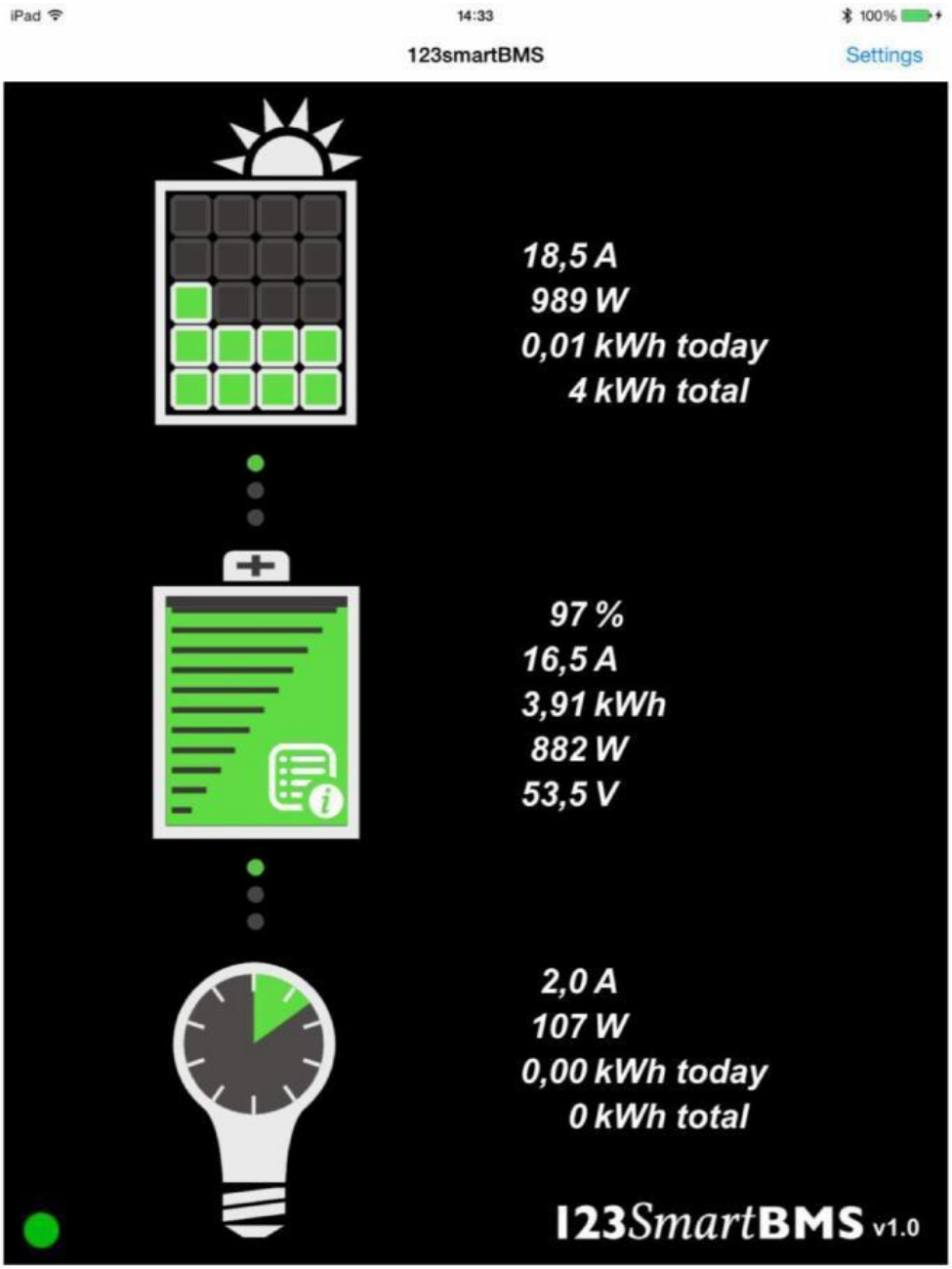
The overview dashboard shows you all information you like to know.

The Solar panel shows the status of the incoming energy, next to this graphic presentation you will find details like: Incoming charge current, Incoming power, harvest energy today, total of harvest energy.

The battery shows the SOC (State of charge) of the battery pack. Next to this graphic presentation you will find details like: State of charge percentage, Incoming / outgoing current of the battery, Stored power in kWh, Incoming / outgoing power, Total battery pack voltage.

The light bulb shows the status of the outgoing energy, next to this graphic presentation you will find details like: consumed current, consumed power, consumed energy today, total of consumed energy.

When you Tap the “ i ” sign off the battery you will enter the battery details section.



Battery details

The battery details shows you detailed info of the battery pack. Voltage and temperature of each cell is displayed. Please be aware the temperature during bypass mode is much higher than the really cell temperature. Green values are in the safe range, yellow values shows balancing cells and red values are out of the safe range cells (above V max or below V min for example)

On top of the screen five warning lights will show critical errors. “E” Cell board communication error, “Vh” Exceeding maximum cell voltage, “Vl” Exceeding minimum cell voltage, “Th” exceeding maximum cell temperature, “Tl” exceeding minimum cell temperature.

Controlling external components

On the OUT Module you will find two bi stable signal relays to control external components of your off-grid system. This can be “solar chargers”, “Maximum power point trackers”, “inverters”, etc. An example is the “enable” pin on many Victron inverters. The maximum current through these relays may be 1 ampere.

Charge relay
There is one relay to control incoming energy components of the system, like MPPT, solar charger et. This relay is called the “CHARGE” relay. When charging is allowed the green CHARGE LED next to the CHARGE relay will flash every second.
When charging is allowed Pin 1 and 2 of the CHARGE relay contacts (See OUT-Board details) are closed. (Pin 2 & 3 are open)
When charging is NOT allowed Pin 2 and 3 of the CHARGE relay contacts are closed. (Pin 1 & 2 are open)

Note: when switching inductive loads like a relay/contactor, make sure there is a protection against flyback of the coil. A simple example is the flyback diode parallel to the coil.

Load relay
The other relay is to control outgoing energy components of the system, like inverters or other consumers. This relay is called the “LOAD” relay. When discharging is allowed the green LOAD LED next to the LOAD relay will flash every second.

When discharging is allowed Pin 1 and 2 of the LOAD relay contacts (See OUT-Board details) are closed. (Pin 2 & 3 are open).

When discharging is NOT allowed Pin 2 and 3 of the LOAD relay contacts are closed. (Pin 1 & 2 are open).
Note: when switching inductive loads like a relay/contactor, make sure there is a protection against flyback of the coil. A simple example is the flyback diode parallel to the coil.

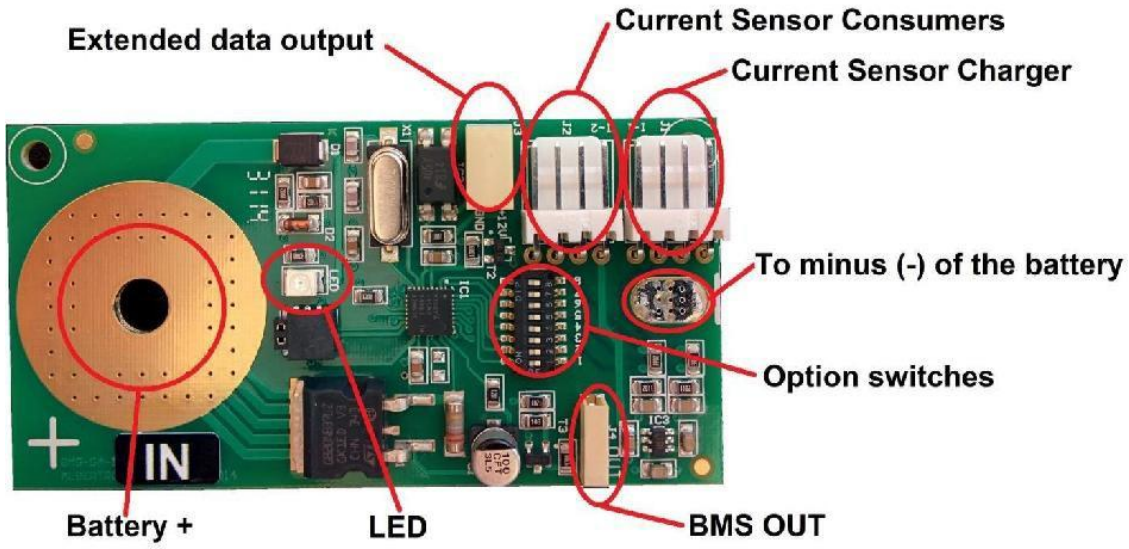
Algoritm
Charging is not allowed when one of the cells reaches the programmed “V-MAX” limit. Charging will be allowed again after the “State of charge” has decreased to the value of the “Charge Restart” percentage and all cells are below “V-Max”.

Discharging is not allowed when one of the cells goes below the programmed “V-MIN” limit. Discharging will be allowed again after the “State of charge” has increased to the value of the “Discharge Restart” percentage and when all cells are above ”V-MIN”.

Discharging and charging will be stopped when there is a communication error. For example when there is a loose contact in the string of cells. In this case the OUT module has no information of the cells before, and will stop charging and discharging for safety reasons.
Discharging and charging will be both stopped when the temperature limits will be exceeded.

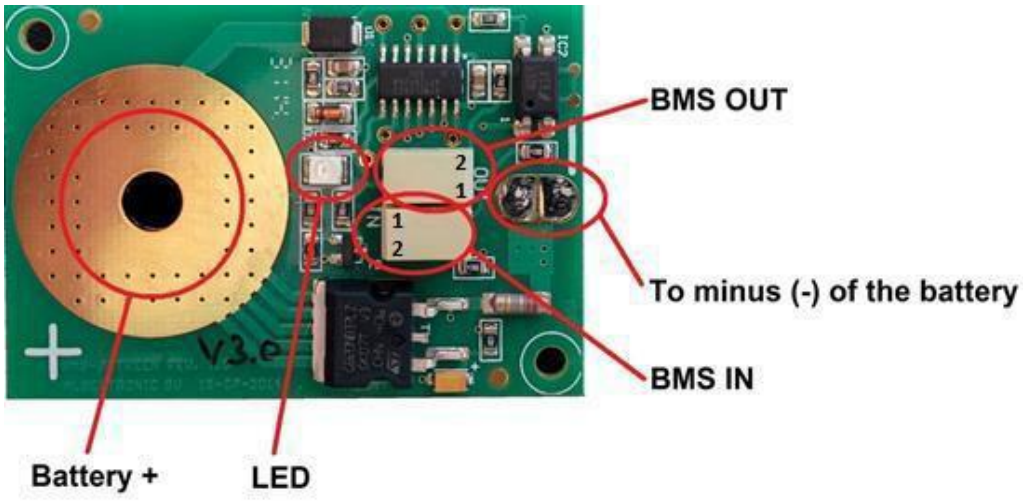
Module details

In Board



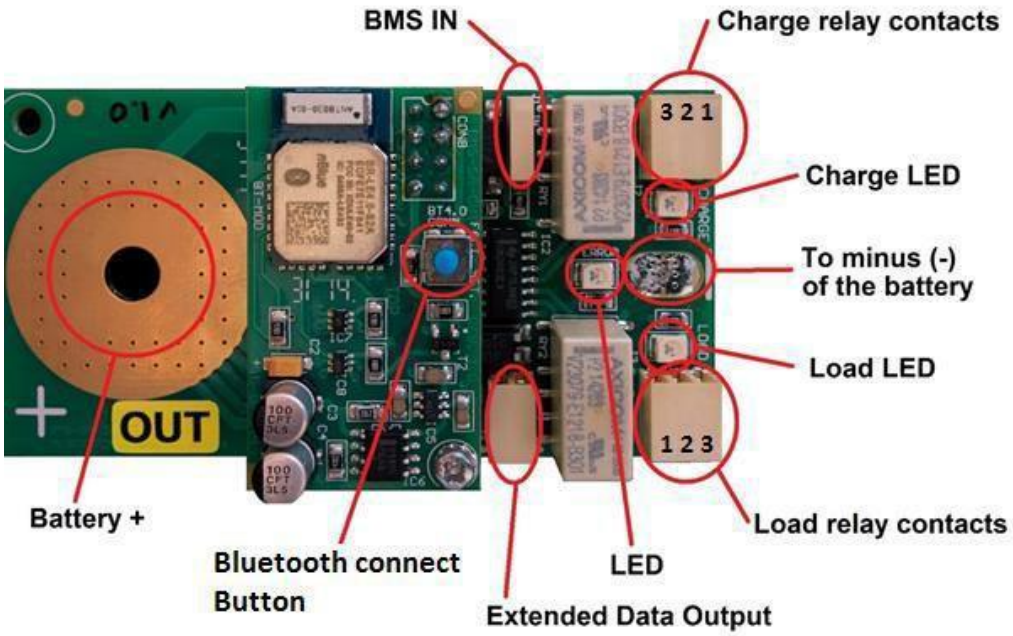
Battery +	Mount hole for the 'plus'-pole of the cell.
LED	Indicator LED, Flashes when data will be send, continuous ON when the bypass mode is active
BMS OUT	Interconnection connector for the data link to the next cell board
Option switches	See page 7
To minus (-) of the battery	Solder a wire on the solder pad and connect this wire to the minus (-) side of the cell.
Current sensor charger	Connector for the current sensor of the incoming current (solar)
Current sensor consumers	Connector for the current sensor of the outgoing current (consumers)
Extended data input	Data input

Between Cell boards



Battery +	Mount hole for the 'plus'-pole of the cell.
To minus (-) of the battery	Solder a wire on the solder pad and connect this wire to the minus (-) side of the cell.
LED	Indicator LED, Flashes when data will be received / send, continuous ON when the bypass mode is active
BMS IN	Data input from the previous cell board or IN-Board. Use the inner connector hole marked with the text IN
BMS OUT	Data output to the next cell board or OUT-Board. Use the inner connector hole marked with the text OUT

Out Board



Battery +	Mount hole for the 'plus'-pole of the cell.
To minus (-) of the battery	Solder a wire on the solder pad and connect this wire to the minus (-) side of the cell.
LED	Indicator LED, Flashes when data will be received, continuous ON when the bypass mode is active
Load LED	Flashes when consuming energy is allowed, load relay is active
Charge LED	Flashes when charging energy is allowed, charge relay is active
BMS IN	Interconnection connector for the data link to the previous cell board
Connection button	Direct connect button for Bluetooth devices
Charge relay contacts	Relay for cutting off chargers, MPPT, solar chargers etc. In case of full batteries
Load relay contacts	Relay for cutting off consumers like invertors, etc. In case of empty batteries
Extended data output	Data output for external modules

FAQ:

Communication error No battery data on the app and the “E” sign will light ON in the battery details tab of the App. Check the flashing LED’s on the string of cells. The position where the LED’s stop flashing is the location of the problem. Check wiring or replace cell modules.

Forgot my password Press and hold the Bluetooth button for 5 seconds, the password will be set the standard “1234”.

Reset the OUT-Module Disconnect the OUT Module of the battery cell. Press and hold the Bluetooth button while you re-connect the OUT Module on the cell.

Current sensor isn’t zero in idle mode Make sure there is running absolutely no current through the current sensors during the zero calibration procedure. On the IN module you will find the option switches. Set option switch number 4 to the ON position. Now the “set to zero” procedure will be active. The currents on the App screen will show 0 Amps in a couple of seconds. Set the option switch number 4 back to the OFF position again.

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