



# Lithium Battery Smart Manual

# Table of Contents

<b>1. Safety precautions</b>	<b>1</b>
1.1. General warnings	1
1.2. Charge and discharge warnings	1
1.3. Transportation warnings	2
1.4. Disposal of lithium batteries	2
<b>2. Introduction</b>	<b>3</b>
2.1. Lithium iron phosphate battery	3
2.2. Lithium Smart battery models	3
2.3. Battery Management System	3
2.4. VictronConnect	4
<b>3. System design</b>	<b>5</b>
3.1. The battery cell alarm signal	5
3.2. The pre-alarm signal	5
3.3. The BMS	5
3.4. BMS controlled loads or chargers	10
3.5. Charging from an alternator	11
3.6. Battery monitoring	12
3.7. Monitoring limitations	12
<b>4. Installation</b>	<b>13</b>
4.1. What's in the box	13
4.2. Download and install the VictronConnect App	13
4.3. Update the battery firmware	13
4.4. Charge batteries before use	14
4.4.1. Initial charge settings	14
4.5. Mounting	15
4.6. Connect the battery poles	15
4.6.1. Cable cross sectional area and fuse ratings	16
4.6.2. Connecting a single battery	16
4.6.3. Connecting multiple batteries in series	17
4.6.4. Connecting multiple batteries in parallel	17
4.7. Connect the BMS	18
4.8. Battery settings	19
4.8.1. Allowed-To-Discharge cell voltage	19
4.8.2. Cell under voltage pre-alarm threshold	20
4.8.3. Allowed-To-Charge minimum temperature	20
4.8.4. Battery temperature offset	20
4.9. Charger settings	20
<b>5. Commissioning</b>	<b>22</b>
<b>6. Operation</b>	<b>23</b>
6.1. Monitoring	23
6.2. Warnings and alarms	23
<b>7. Battery charging and discharging</b>	<b>25</b>
7.1. Charging	25
7.2. Cell balancing	25
7.3. Discharging	26
7.4. Cell under voltage pre-alarm	27
<b>8. Troubleshooting, support and warranty</b>	<b>28</b>
8.1. VictronConnect issues	28
8.2. Battery issues	28
8.2.1. Cell imbalance	28
8.2.2. Less capacity than expected	29
8.2.3. Battery very low terminal voltage	30
8.2.4. Battery is close to end of cycle life or battery has been misused	30

8.2.5. Micro-controller restart procedure .....	31
8.3. BMS issues .....	35
8.3.1. The BMS frequently disables the battery charger .....	35
8.3.2. The BMS is prematurely turning chargers off .....	35
8.3.3. The BMS is prematurely turning loads off .....	35
8.3.4. The pre-alarm setting is missing in VictronConnect .....	35
8.3.5. BMS is displaying alarm while all cell voltages are within range .....	35
8.3.6. How to test if the BMS is functional .....	36
8.4. Technical support .....	36
8.5. Warranty .....	37
<b>9. Technical data .....</b>	<b>38</b>
<b>10. Appendix .....</b>	<b>40</b>
10.1. Initial charge procedure without BMS .....	40

## 1. Safety precautions



Observe these instructions and keep them located near the battery for future reference.



The Material Safety Datasheet can be downloaded from the “Material Safety Datasheet menu” located on the [Lithium Smart product page](#).



Work on a li-ion battery should be carried out by qualified personnel only.

### 1.1. General warnings



While working on a li-ion battery wear protective eyeglasses and clothing.



Any uncovered battery material such as electrolyte or powder on the skin or in the eyes must immediately be flushed with plenty of clean water. Then seek medical assistance. Spillages on clothing should be rinsed out with water.



Explosion and fire hazard. The terminals of a li-ion battery are always live, therefore do not place metallic items or tools on top of a li-ion battery. Avoid short circuits, too deep discharges and too high charge currents. Use insulated tools. Do not wear any metallic items such as watches, bracelets, et cetera. In case of fire, you must use a type D foam or CO2 fire extinguisher.



Do not open or dismantle the battery. Electrolyte is very corrosive. In normal working conditions contact with the electrolyte is impossible. If the battery casing is damaged do not touch the exposed electrolyte or powder because it is corrosive.



Li-ion batteries are heavy. If involved in an accident they can become a projectile! Ensure adequate and secure mounting and always use suitable handling equipment for transportation.



Handle with care because a li-ion battery is sensitive to mechanical shock.



Do not use a damaged battery.



Do not wet the battery.

### 1.2. Charge and discharge warnings



Too deep discharges will seriously damage a li-ion battery and can even be dangerous. Therefore, use of an external safety relay is obligatory.



Use only with a Victron approved BMS.



If charged after the Lithium Battery was discharged below the “Discharge cut-off voltage”, or when the Lithium Battery is damaged or overcharged, the Lithium Battery can release a harmful mixture of gasses such as phosphate.



The temperature range over which the battery can be charged is 5°C to 50°C. Charging the battery at temperatures outside this range may cause severe damage to the battery or reduce battery life expectancy.



The temperature range over which the battery can be discharged is -20°C to 50°C. Discharging the battery at temperatures outside this range may cause severe damage to the battery or reduce battery life expectancy.

### 1.3. Transportation warnings



The battery must be transported in its original or equivalent package and in an upright position. If the battery is in its package, use soft slings to avoid damage.



Do not stand below a battery when it is hoisted.



Never lift the battery at the terminals or the BMS communication cables, only lift the battery at the handles.

Batteries are tested according to UN Handbook of Tests and Criteria, part III, sub section 38.3 (ST/SG/AC.10/11/Rev.5).

For transport the batteries belong to the category UN3480, Class 9, Packaging Group II and have to be transported according to this regulation. This means that for land and sea transport (ADR, RID & IMDG) they have to be packed according to packaging instruction P903 and for air transport (IATA) according to packaging instruction P965. The original packaging complies with these instructions.

### 1.4. Disposal of lithium batteries



Batteries marked with the recycling symbol must be processed via a recognized recycling agency. By agreement, they may be returned to the manufacturer.



Batteries must not be mixed with domestic or industrial waste



Do not throw a battery into fire.

## 2. Introduction

### 2.1. Lithium iron phosphate battery

The lithium iron phosphate battery (LiFePO<sub>4</sub> or LFP) is the safest of the mainstream lithium battery types. A single LFP cell has a nominal voltage of 3.2V. A 12.8V LFP battery consists of 4 cells connected in series and a 25.6V battery consists of 8 cells connected in series.

LFP is the chemistry of choice for very demanding applications. Some of its features are:

- Rugged - It can operate in deficit mode during long periods of time.
- High round trip efficiency.
- High energy density - More capacity with less weight and volume.
- High charge and discharge currents - Fast charge and discharges are possible.
- Flexible charge voltages.

The lithium iron phosphate battery is therefore the chemistry of choice for a range of very demanding applications.

### 2.2. Lithium Smart battery models

The Lithium Smart Battery is available in a variety of capacities and in two different voltages, namely 12.8V and 25.6V. These are all available battery models:

- LiFePO<sub>4</sub> Battery 12,8V/60Ah Smart
- LiFePO<sub>4</sub> Battery 12,8V/100Ah Smart
- LiFePO<sub>4</sub> Battery 12,8V/160Ah Smart
- LiFePO<sub>4</sub> Battery 12,8V/200Ah Smart
- LiFePO<sub>4</sub> Battery 12,8V/300Ah Smart
- LiFePO<sub>4</sub> battery 25,6V/200Ah Smart

For more information see the [Lithium Smart product page](#).

### 2.3. Battery Management System



The battery cells in the Smart Lithium batteries are protected against over-charge, under-charge, charging at too low temperatures as well as charging at too high temperatures.



As part of the protection the battery has an integrated Balancing, Temperature and Voltage control system, the BTV. The BTV connects to an external Battery Management System, the BMS. In case of multiple batteries, the BTVs of several batteries are daisy chained and then connected to the BMS.

This is how it works: The BTV monitors each individual battery cell; it balances the cell voltages and in case of high or low cell voltage or in case of high or low cell temperature, it will generate an alarm signal. The alarm signal is received by the BMS and the BMS will turn off loads or chargers accordingly.

A Victron Energy BMS is essential for a correct operation of the lithium battery. The lithium battery is not allowed to be used without one. In addition to this you will also need to ensure that the BMS correctly controls all loads and charge sources that are connected to the battery.

The BMS is not included with the battery. It needs to be purchased separately. There is a choice of 4 different BMS types:

BMS type	Voltage	Features
 <p>VE.Bus BMS</p>	12, 24 or 48 V	Controls MultiPlus or Quattro via VE.Bus Controls loads and chargers via on/off signals Pre-alarm control signal
 <p>smallBMS</p>	12, 24, 36 or 48 V	Controls loads and chargers via on/off signals Pre-alarm control signal Note: the smallBMS was previously named miniBMS

BMS type	Voltage	Features
 <p>Smart BMS CL 12/100</p>	12 V	100A dedicated alternator port Controls loads and chargers via on/off signals Pre-alarm control signal Bluetooth
 <p>BMS 12/200</p>	12 V	200A dedicated alternator port 200A dedicated load and charger port

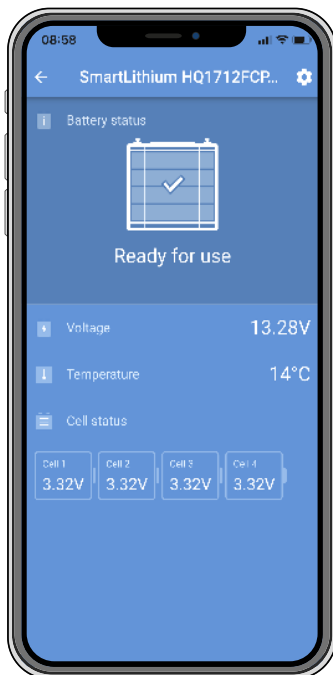
For more information see the [BMS product page](#)

The battery is equipped with BMS communication cables. These are used to connect the battery to the BMS. The cables are 0.5m long. In case the BMS cables are too short to reach the BMS, they can be extended using (not included) BMS extension cables:

- M8 circular connector Male/Female 3 pole cable 1m (bag of 2)
- M8 circular connector Male/Female 3 pole cable 2m (bag of 2)
- M8 circular connector Male/Female 3 pole cable 3m (bag of 2)
- M8 circular connector Male/Female 3 pole cable 5m (bag of 2)

For more information see the [BMS extension cable product page](#)

## 2.4. VictronConnect



The battery is equipped with Bluetooth and uses this to communicate with the VictronConnect app. The VictronConnect app is used for reading out battery information, for making or changing battery settings, receiving alarms and to update firmware. VictronConnect also contains a demo modus.

For more information see the [VictronConnect manual](#).

## 3. System design

When designing a system with a lithium battery, a basic understanding of how the battery interacts with the BMS and how the BMS interacts with loads and chargers is required.

### 3.1. The battery cell alarm signal

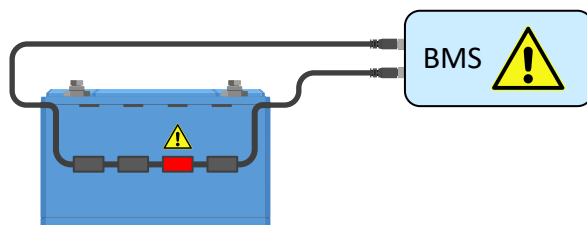
The battery communicates with the BMS via its BMS cables. If the system contains multiple batteries, all batteries are connected in series via the BMS cables and then the first and last battery is connected to the BMS.

The battery monitors its cells and it will send an alarm signal to the BMS in case of a:

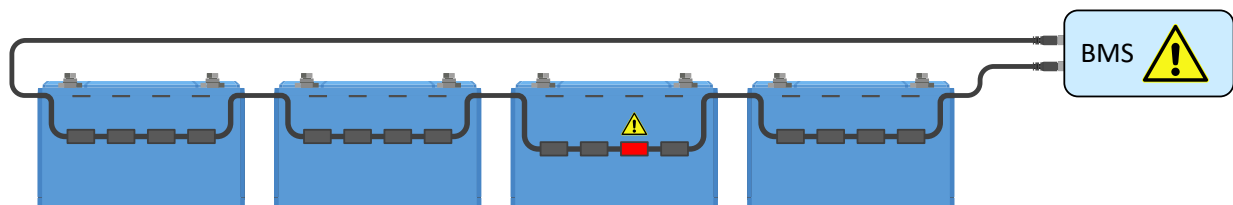
- Low cell voltage alarm signal
- Low cell voltage pre-alarm signal
- High cell voltage signal
- Low temperature signal
- High temperature signal

The BMS will act by turning loads and/or chargers off as soon it receives an alarm signal from one of the cells in the battery.

The alarm communication process between the battery and the BMS is depicted in images below.



*The BMS receives an alarm signal from a battery cell*



*The BMS receives an alarm signal from a cell in a multiple battery setup*

### 3.2. The pre-alarm signal

The purpose of the pre-alarm is to warn that the BMS is about to turn off the loads due to cell under voltage. For example; you would want an early warning that loads are going to be turned off while manoeuvring your boat, or if lights are turned off when it is dark. We recommend connecting the pre-alarm to a clearly visible or audible alarm device.

#### Switching behaviour

In case of an imminent under voltage shutdown, the pre-alarm output of the BMS will switch on. In case the voltage continues to decrease, the loads are switched off (load disconnect) and at the same time the pre-alarm output will switch off again. In case the voltage rises again (operator has enabled a charger or has reduced the load) the pre-alarm output will switch off, once the lowest cell voltage has risen above 3.2V.

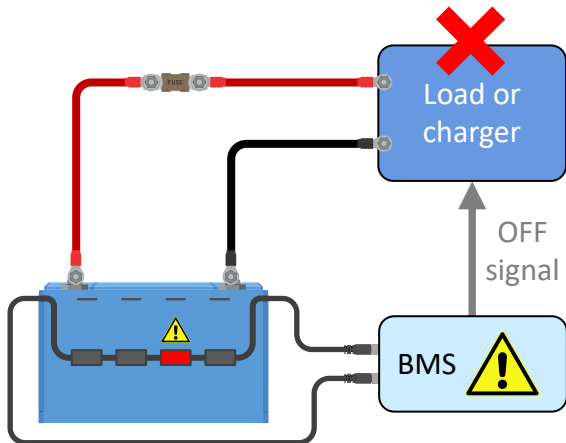
The BTV ensures a minimum delay of 30 seconds between enabling the pre-alarm and the load-disconnect. This delay is to allow the user a minimal amount of time to prevent the shutdown.

### 3.3. The BMS

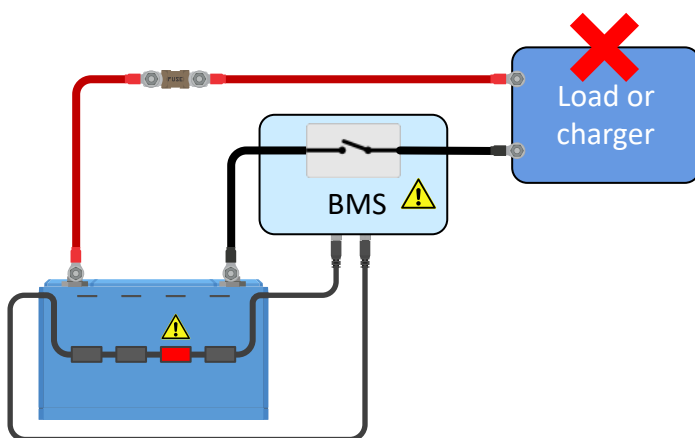
Besides making above pre-alarm signal available, the main purpose of the BMS is to control the chargers and the loads. There are two ways that it can do that:

1. By sending a signal to the charger or load.
2. By physically connecting or disconnecting a load or a charge source from the battery, using for example a large contactor.





The BMS sends an on/off signal to a load or charger



The BMS connects or disconnects from a load or charger

The available BMS types for the lithium battery either rely on one or both of these technologies. The BMS types and their functionality are briefly described in this chapter. For the full BMS information see the BMS product information page.

### The smallBMS

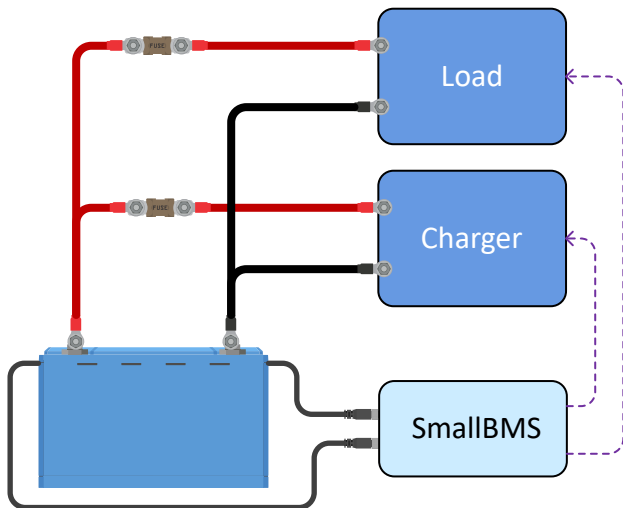
The smallBMS is equipped with a “load disconnect”, a “charge disconnect” and a pre-alarm contact.

- In the event of low cell voltage, the smallBMS will send a “load disconnect” signal to turn the load(s) off.
- Prior to turning the load off, it will send a pre-alarm signal indicating imminent low cell voltage.
- In the event of high cell voltage or low or high cell temperature, the smallBMS will send a “charge disconnect” signal to turn the charger(s) off.



smallBMS

For more information see the [smallBMS product page](#).



The smallBMS controls loads and chargers via “load disconnect” and “charge disconnect” signals

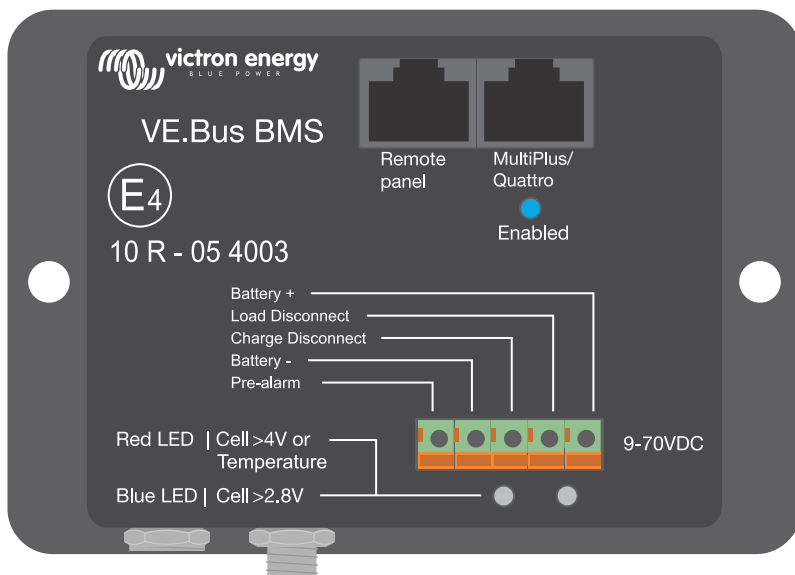
### The VE.Bus BMS

The VE.Bus BMS directly communicates with a Victron Energy inverter/charger system via the VE.Bus. Just like the smallBMS, it also features a “load disconnect”, a “charge disconnect” and a pre-alarm contact.

- In the event of low cell voltage, the VE.Bus BMS will send a “load disconnect” signal to turn off the load(s) and it will also turn the inverter of the inverter/charger off.
- Prior to turning loads off, it will send a pre-alarm signal warning of imminent low cell voltage.
- In the event of a high cell voltage or high/low cell temperature, the VE.Bus BMS will send a “charge disconnect” signal to turn the charger(s) off and it will also turn the charger of the inverter/charger off.

The mains detector ships together with the VE.Bus BMS.

Special programming of the inverter/charger is required for the BMS to be able to communicate with the inverter/charger.

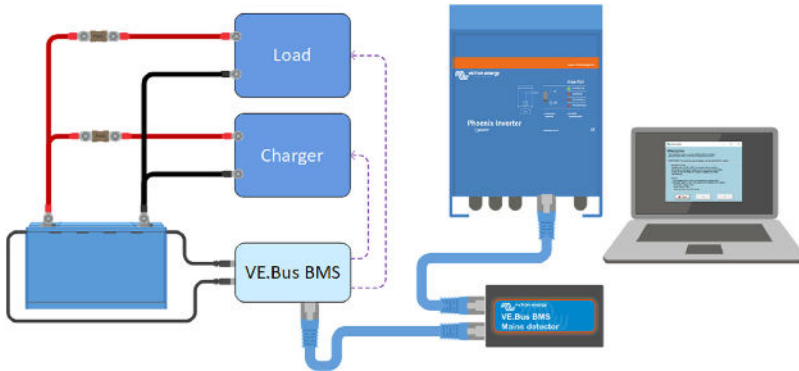


VE.Bus BMS



#### Mains detector

For more information see the [VE.Bus BMS product page](#).

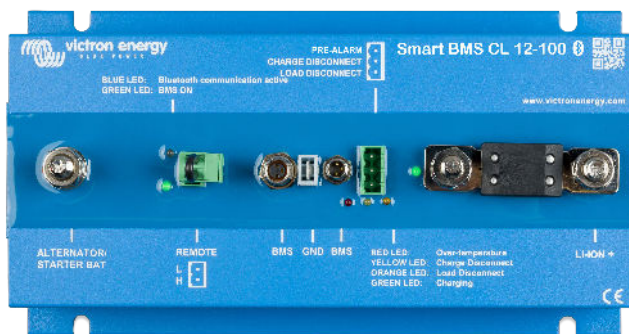


The VE.Bus BMS will turn loads and chargers off via "load disconnect", and "charge disconnect" and controls the inverter/charger

#### The Smart BMS CL 12/100

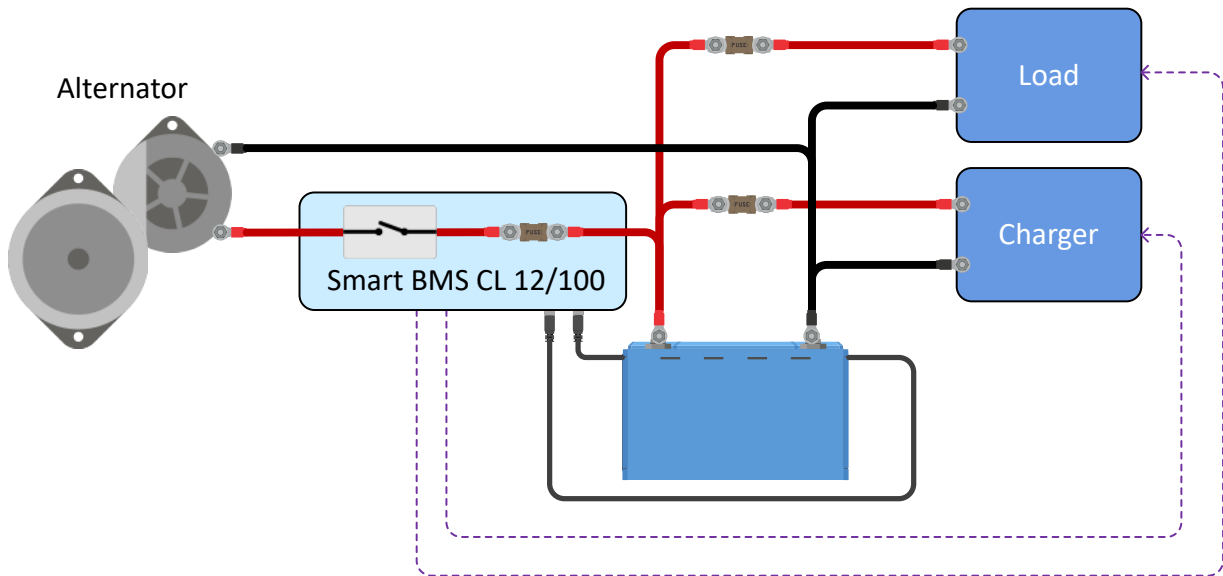
The Smart BMS CL 12/100 is equipped with a "load disconnect", a "charge disconnect" and a pre-alarm contact. It also features a dedicated 100A alternator port

- In the event of low cell voltage, the Smart BMS CL 12/100 will send a "load disconnect" signal to turn the load(s) off.
- Prior to turning load off it will send a pre-alarm signal indicating imminent low cell voltage.
- In the event of high cell voltage or low/high cell temperature, the Smart BMS CL 12/100 will send a "charge disconnect" signal to turn the charger(s) off.
- The alternator port controls and current limits the alternator.



#### Smart BMS CL 12/100

For more information see the [Smart BMS CL 12/100 product page](#).

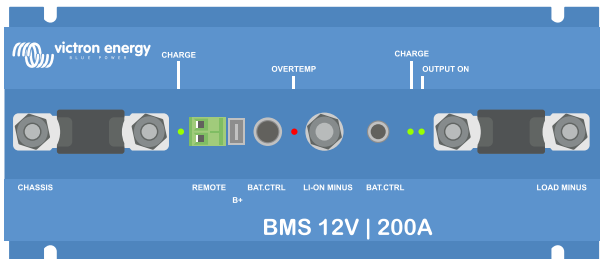


The Smart BMS CL 12/100 will turn loads and chargers off via "load disconnect" and "charge disconnect". It also controls and limits the alternator.

**The BMS 12/200**

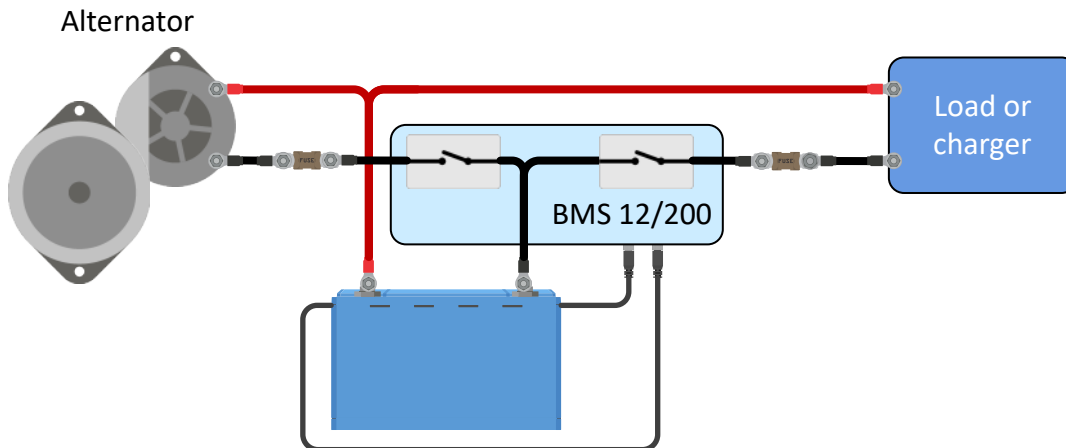
The BMS12/200 is equipped with a port to connect an alternator and a port to connect loads and/or chargers. The alternator port is rated to 80A and the load/charger port is rated to 200A.

- The alternator port controls and current limits the alternator
- The load port controls both loads and chargers



BMS 12/200

For more information see the [BMS12/200 product page](#).



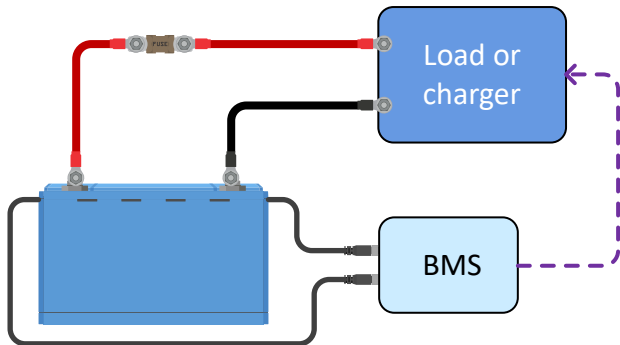
The BMS 12/200 disconnect loads and chargers. It also controls and current limits the alternator.

### 3.4. BMS controlled loads or chargers

The BMS sends a “load disconnect” signal to loads in case of a low cell voltage alarm and it sends a “charge disconnect” signal to chargers in case of a high cell voltage or a cell temperature alarm. The loads or chargers can be controlled by the BMS either directly or indirectly.

#### Direct control via a charger or load remote on/off terminal

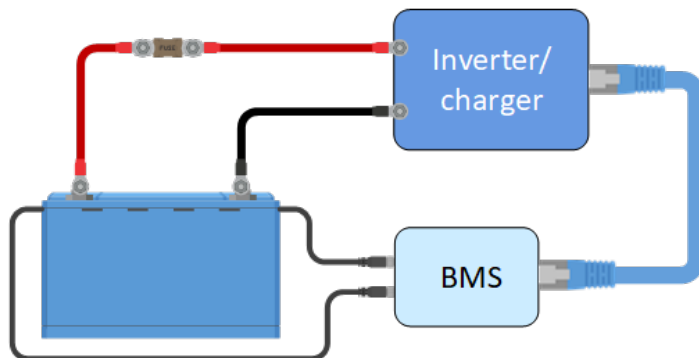
Products like chargers, inverters, solar chargers, DC/DC converters or DC/DC chargers are often equipped with a remote on/off terminal. The BMS “charge disconnect” or “load disconnect” signal connects directly to the remote on/off terminal.



The BMS directly controls the load or charger

#### Direct control via VE.Bus

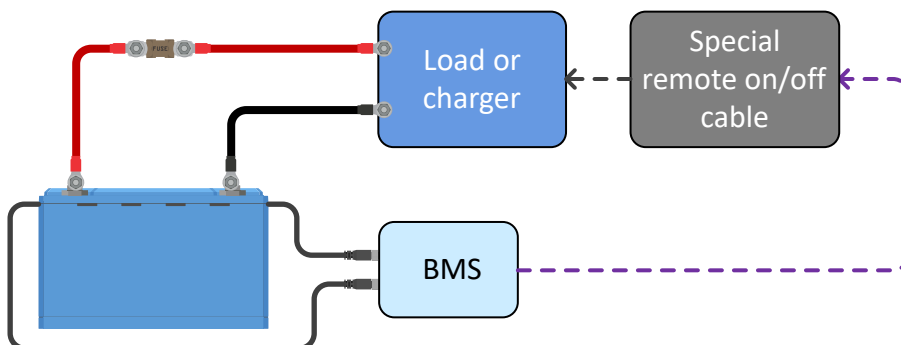
Inverter/chargers, like the MultiPlus, the MultiPlus-II or the Quattro are equipped with a VE.Bus RJ45 terminal. The VE.Bus BMS communicates directly to the inverter/charger via the VE.Bus and will turn off the inverter or the inverter/charger in case of a “load disconnect” or a “charge disconnect” event.



The BMS controls an inverter/charger directly via the VE.Bus

#### Direct control via a special “inverting” or “non-inverting” remote on/off cable

Not all Victron products have a remote on/off connector or the remote on/off connector might not be suitable to connect straight to the BMS. In these cases, a special “inverting” or “non-inverting” remote cable is needed, so that the BMS can turn off a product in case of a “load disconnect” or a “charge disconnect”.

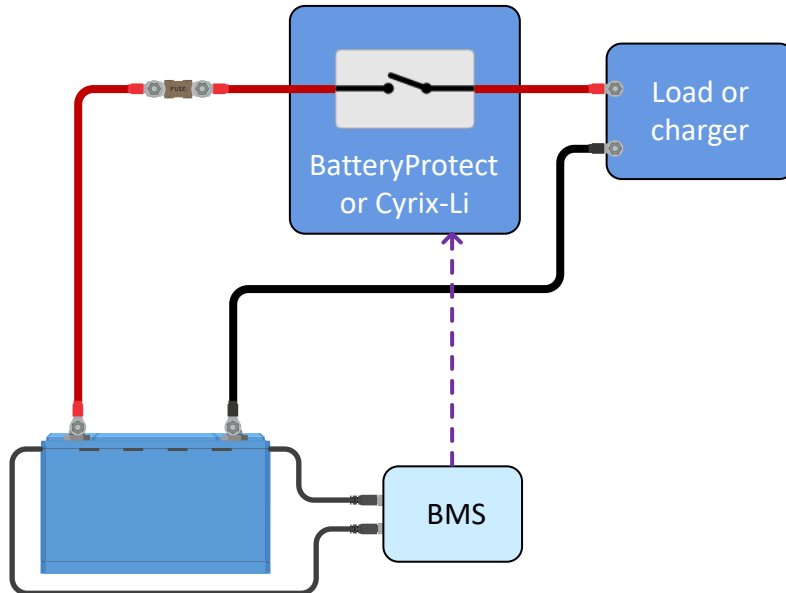


The BMS controls the remote on/off cable and the cable converts this to a signal suitable to control a load or charger

#### Indirect control

In case a load or a charger does not have a way of being remotely controlled, a device that can be controlled by the BMS must be connected between the battery and the load or charger. These are the options:

- The BatteryProtect is mainly used for loads, but can also be used for charge sources, but be aware that the current flow is one-directional. The BatteryProtect has a very low self-consumption while in protection mode.
- The Cyrix-Li relay is mainly used for charge sources but can also be used for loads. The current flow is bi-directional. But be aware that the Cyrix has a higher self-consumption when in protection mode than the BatteryProtect has.

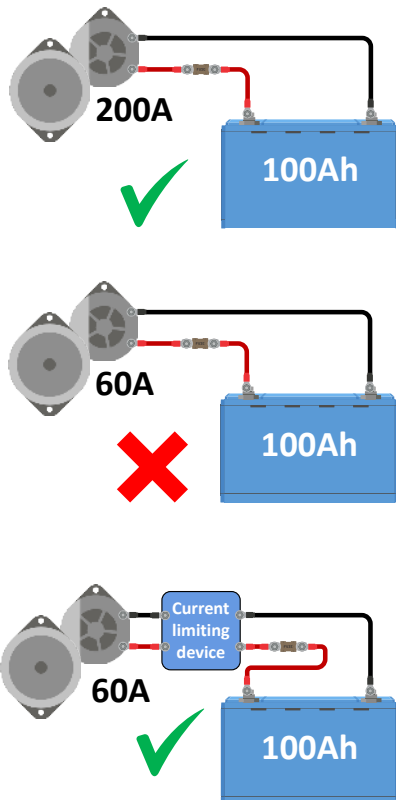


*The BMS controls the BatteryProtect or Cyrix-Li, which in turn disconnects the load or charger from the battery*

### 3.5. Charging from an alternator

Lithium batteries have a very low internal resistance and will readily accept a high charge current. Because of this, special care must be taken when lithium batteries are charged from an alternator. Most alternators are not able to limit the current going into a lithium battery and can be damaged when they are used to charge a lithium battery. To safely connect an alternator, there are two options:

- Either make sure that alternator rating is at least twice the battery rating. For example; a 400A alternator can be safely connected to a 200Ah battery.
- Or use an alternator that is equipped with a current limiting feature. If the alternator does not have a current limiting feature, a current limiting device needs to be added between the alternator and the starter battery. Possible current limiting devices that can be used in this scenario are:
  - The alternator port of a [Smart BMS CL 12/100](#).
  - The alternator port of a [BMS 12/200](#).
  - Add a [DC/DC converter or charger](#).



#### Alternator charging

For more information on charging lithium battery with an alternator, see the [Alternator lithium charging blog and video](#).

### 3.6. Battery monitoring

The battery internals (temperature & cell voltages, as well as alarms and other BTV parameters) can be monitored with the VictronConnect App. It connects to the battery via Bluetooth.

State of charge monitoring is not built into the battery or in the BMS. If state of charge monitoring is needed, an additional battery monitor such as a BMV, SmartShunt, Lynx shunt or GX device will need to be added to the system.

In case a GX device is part of the system, make sure to read the chapter: "Battery State of Charge" in the [GX device](#) manual to determine if a battery monitor is required or not.

When a battery monitoring device is used, special settings need to be made in the battery monitor to accommodate the lithium battery. This information can be found in the battery monitor manual. For more information see the [Battery monitor product page](#).

### 3.7. Monitoring limitations

It is not possible to connect a VE.Direct cable (or any other communication cables) to the battery. The VE.Direct to USB interface can also not be used. This also rules out the Windows version of the VictronConnect App, as the Windows version of the app does not support Bluetooth.

A GX device can also not be used to connect to the lithium battery. Although the battery has Bluetooth and the Victron GX monitoring device might also have Bluetooth, these are not compatible with each other, thus cannot communicate with each other.

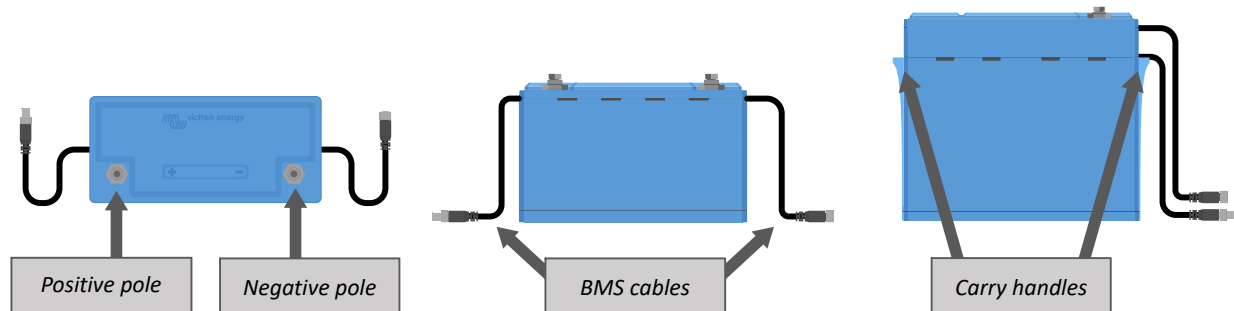
## 4. Installation

### 4.1. What's in the box

Take care when unpacking the battery. Batteries are heavy. Do not lift it by its poles or by its BMS cables. The battery has two carry handles on either side of the battery. The weight of the battery can be found in the "Technical data" chapter.

Familiarize yourself with the battery. The battery poles are located on top of the battery. The polarity of the battery poles is indicated at the top of the battery. The positive pole is indicated by a "+" symbol and the negative pole is indicated by a "-" symbol.

The battery has two BMS cables. These cables are used for communication with the BMS. One cable has a male 3-pole connector and the other has a female 3-pole connector. Depending on the battery model, the BMS cables are located on one side of the battery or on two opposite sides of the battery.



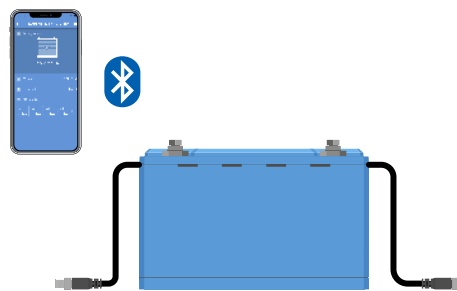
Top view battery showing battery terminals - Side view two different battery models showing BMS cables

Pay attention to the location of the BMS cables when handling the battery. The BMS cables can easily get damaged. Take care not to damage the BMS cables by lifting or moving the battery by pulling on the cables or crushing the cables by getting them stuck underneath the battery or in between two batteries.

### 4.2. Download and install the VictronConnect App

The VictronConnect App is needed to communicate with the battery. The app can run on an Android, iOS or macOS device. Although there also is a Windows version of the app, it is not possible to use the Windows version of the VictronConnect App for the Smart Lithium batteries, as Windows Bluetooth is not supported by the VictronConnect App.

For download location or help with the app see the [VictronConnect manual](#).





VictronConnect communicates with the battery via Bluetooth

### 4.3. Update the battery firmware

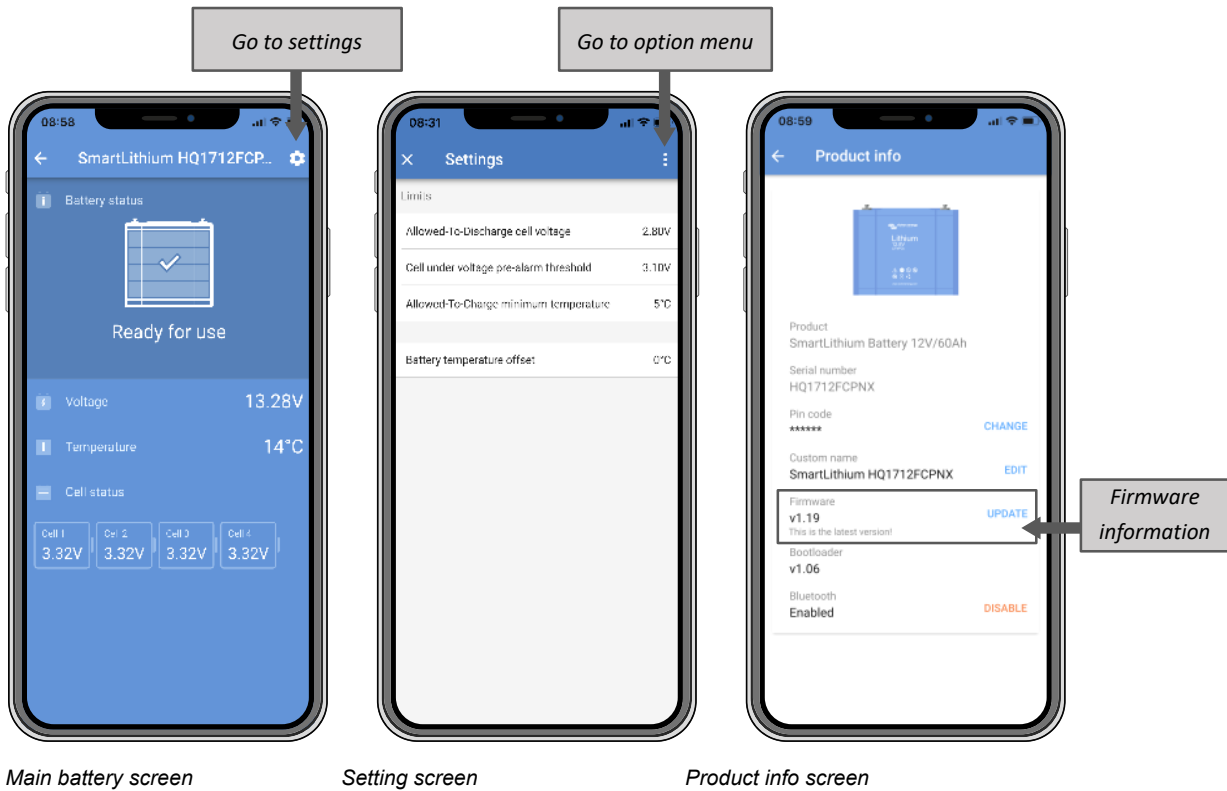
Before the battery is going to be used, it is important to check if the battery has the most up to date firmware. The firmware can be checked and updated with VictronConnect.

VictronConnect might ask on first connection to update firmware. If this is the case, let it perform a firmware update.


If it did not automatically update, check if the firmware is already up to date using the following procedure:

- Connect to the battery.
- Click on the settings symbol 
- Click the option symbol 
- Go to product info.
- Check if you are running the latest firmware and look for the text: "This is the latest version".
- If the battery does not have the most up to date firmware, perform a firmware update.





#### 4.4. Charge batteries before use


 When installing a single battery or multiple batteries in parallel, the procedure outlined in this chapter is not required.

If multiple batteries are going to be connected in series or in series/parallel, each individual battery needs to be charged before all batteries are interconnected.

Background: batteries are approximately 50% charged when shipped from the factory. This is because of transportation safety requirements. Due to differences in transportation routes and warehousing the batteries do not all have the same state of charge by the time they are installed.

And as the system is only able to correct small differences in state of charge from one battery to another, a large imbalance with newly installed batteries will not be corrected. Note that this type of imbalance, different state of charge between batteries, is different from imbalance of cells within a battery. For more information see chapter [Cell imbalance](#) [28].

##### 4.4.1. Initial charge settings

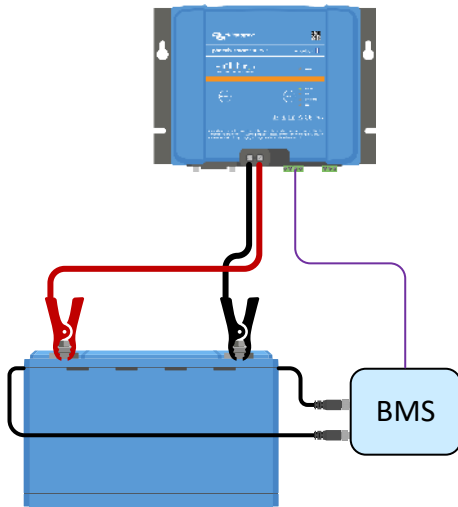
 Same as for when an already installed battery a BMS must be used.

Charger or inverter/charger settings for initial charge with a BMS (same settings as for normal operation):

Recommended charger settings					
Battery model	Max. charge current	Charge profile	Absorption voltage	Absorption time	Float voltage
12.8 V - 60 Ah	30 A	Lithium, fixed	14.2 V	2h	13.5 V
12.8 V - 100 Ah	50 A	Lithium, fixed	14.2 V	2h	13.5 V
12.8 V - 160 Ah	80 A	Lithium, fixed	14.2 V	2h	13.5 V
12.8 V - 200 Ah	100 A	Lithium, fixed	14.2 V	2h	13.5 V
12.8 V - 300 Ah	150 A	Lithium, fixed	14.2 V	2h	13.5 V
25.6 V - 200 Ah	100 A	Lithium, fixed	28.4 V	2h	27.0 V

Initial charge procedure:

- Connect each individual battery to a charger or to an inverter/charger and to a BMS (and repeat for every other battery).
- Refer to the BMS manual on how to set the BMS up.
- Set the charger to the charge profile as indicated in above table.
- Ensure that the battery, the BMS and the charger are communicating with each other. Check this by disconnecting one of the BMS cables from the BMS and verify if the charger turns off. Then reconnect the BMS cable and verify that the charger turns back on.
- Turn the charger on and check that the charger is charging the battery.
- Be aware that in case of unbalance, the charger will be turned off and on by the BMS multiple times. This will manifest as follows: The charger will be on for a short period of time, then the charger will be off for a few minutes and then on again for a short time and so on. This might be repeated many times. This is nothing to be worried about. This is part of the charge process in case of unbalance and is expected behaviour. If the cells are balanced, the charger will not be turned off until the battery is fully charged. For more information about cell unbalance and charger behaviour see paragraph: "Cells out of balance".
- The process is completed when the battery is fully charged, and all cells are balanced. Use VictronConnect to check this while the charger is still in absorption! The battery voltage must be 14.2V and each cell must be 3.55V +/- 0.02V. Restart the charger in case it has already dropped to float (13.5V). Note that, depending on the level of balance when starting this procedure, it might be necessary to restart the charger multiple times. More details in the "Cells out of balance" chapter.



Initial charge with using a BMS

## 4.5. Mounting

The battery needs to be mounted in an upright position. The battery is only suitable for indoor use and needs to be located in a dry location.

Batteries are heavy. When moving the battery into its destined location, use suitable handling equipment for transportation.

Ensure adequate and secure mounting as the battery can become a projectile if involved in an accident.

Batteries produce a certain amount of heat when they are charged or discharged. Keep a 20mm space on each side of the battery for ventilation purposes.

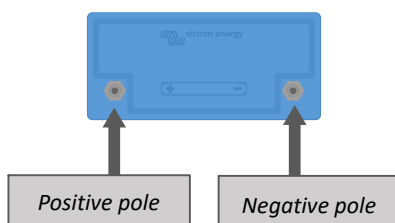
## 4.6. Connect the battery poles

The positive pole is indicated by a "+" symbol and the negative pole is indicated by a "-" symbol.

Observe the battery polarity when connecting the battery poles to a DC system or to other batteries. Take care not to short circuit the battery poles.

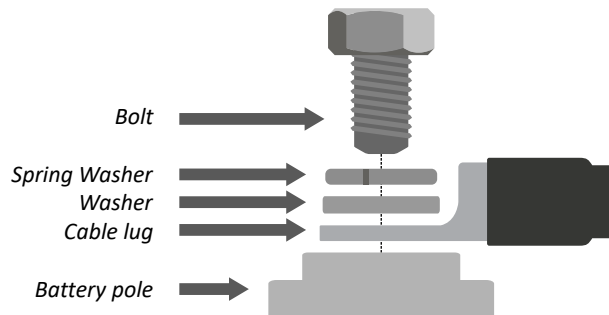
Connect the cables; place the cable's cable lug on the battery pole, place the washer, place the spring washer and then insert and tighten the bolt

When tightening the bolt, use the correct torque and use insulated tools that match the batteries spanner size



*Battery pole locations***Table 1. Battery pole connections**

Battery model	Nut size	Torque moment
12.8 V - 60 Ah	M8	10Nm
12.8 V - 100 Ah	M8	10Nm
12.8 V - 160 Ah	M8	14Nm
12.8 V - 200 Ah	M8	14Nm
12.8 V - 300 Ah	M10	20Nm
25.6 V - 200 Ah	M8	14Nm

*Battery cable connection***4.6.1. Cable cross sectional area and fuse ratings**

Use battery cables with a cross sectional area that matches the currents that can be expected in the battery system.

Batteries can produce very large currents; it is therefore necessary that all electrical connections to a battery are fused.

The battery fuse rating has to match the current rating of the battery cable that has been used. Both the battery cable and the fuse have to also match the expected maximum system currents.

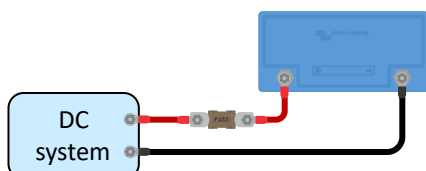
The battery maximum discharge rating is indicated in below table. The system current and therefore also the fuse rating should not exceed this current rating. The fuse has to match the lowest current rating, being the cable current rating, the battery current rating or the system current rating.

Maximum current rating Smart Lithium batteries	
Battery model	Maximum current rating
12.8 V - 60 Ah	120 A
12.8 V - 100 Ah	200 A
12.8 V - 160 Ah	320 A
12.8 V - 200 Ah	400 A
12.8 V - 300 Ah	600 A
25.6 V - 200 Ah	400 A

For more information on cable cross sectional area, fuse types and fuse ratings see the [Wiring Unlimited book](#).

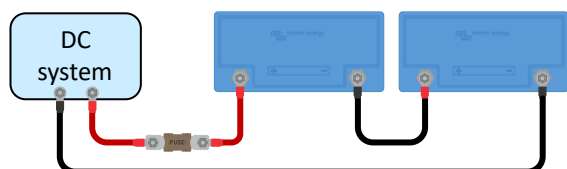
**4.6.2. Connecting a single battery**

- Fuse the battery on the positive side.
- Single battery Connect the battery to the DC system.

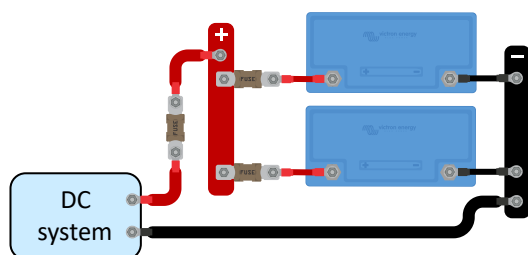


*Single battery***4.6.3. Connecting multiple batteries in series**

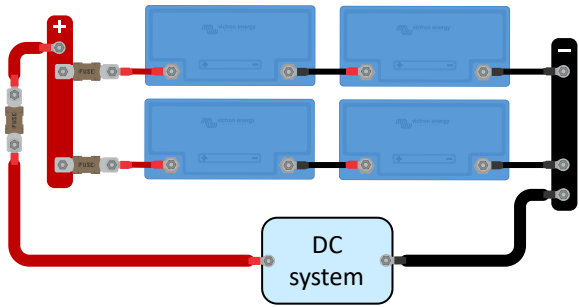
- All batteries need to be the same model and age.
- Each battery needs to have been fully charged individually.
- Connect a maximum of four 12.8V batteries or a maximum of two 25.6V batteries in series.
- Connect the negative to the positive of the next battery. Fuse the series string on the positive side.
- Connect the battery bank to the system.

*Multiple batteries in series***4.6.4. Connecting multiple batteries in parallel**

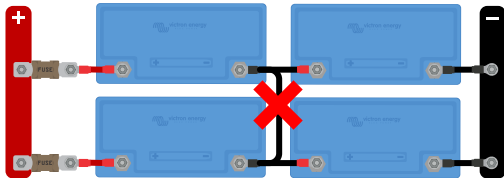
- All batteries need to be the same model and age.
- Connect a maximum of 5 batteries.
- Fuse each battery on the positive side.
- Connect the system cables diagonally to ensure an equal current path through each battery.
- Take care that cross-sectional area of the system cable is equal to the cross-sectional area of the string cable times the number of strings.
- Fuse the positive main cable going to the battery bank.
- Multiple batteries in parallel Connect the battery bank to the system.
- For more information on how to construct a parallel battery bank see the [Wiring Unlimited book](#).

*Multiple batteries in parallel***Connecting multiple batteries in series/parallel**

- All batteries need to be the same model and age.
- Connect a maximum of 5 batteries or battery series strings in parallel.
- Each battery needs to have been fully charged individually.
- Fuse each series string on the positive side.
- Multiple batteries in series/parallel Connect the system cables diagonally to ensure an equal current path through each battery string.
- Take care that cross-sectional area of the system cable is equal to the cross-sectional area of the string cable times the number of strings.
- Do not interconnect the intermediate battery to battery connections of two or more battery series strings.
- Fuse the positive main cable going to the battery bank.
- Connect the battery bank to the system.
- Do not interconnect midpoints or other between string points For more information on how to construct a series/parallel battery bank see the [Wiring Unlimited book](#).



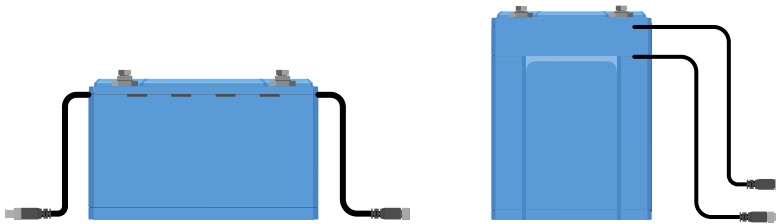
Multiple batteries in series/parallel



Do not interconnect midpoints or other between string points

### 4.7. Connect the BMS

Each battery has two BMS cables. Depending on the battery model, the BMS cables are located on either side or on one side of the battery.



BMS cables on either side

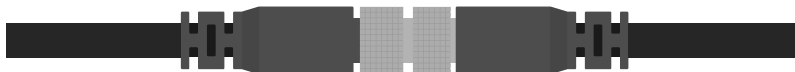
BMS cables on one side

One of the cables has a female 3-pole connector and the other cable has a male 3-pole connector. The BMS also has the same male and female connectors.



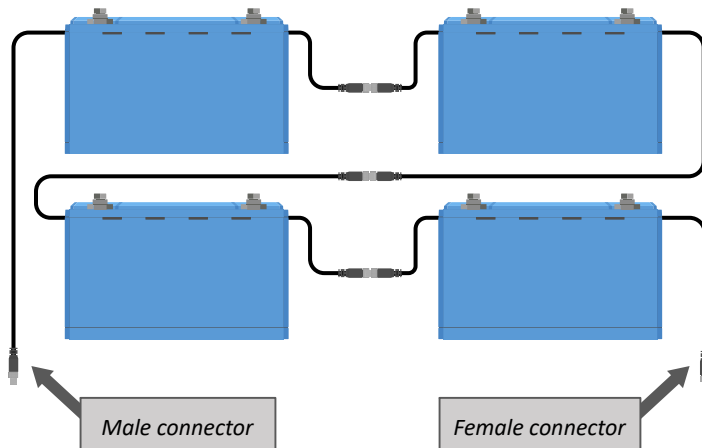
Female BMS cable connector

Male BMS cable connector



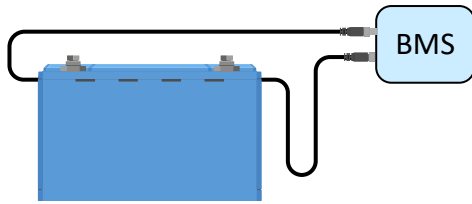
Connected male and female BMS cable connector

If multiple batteries are used, the BMS cables of the batteries need to be interconnected (daisy chained). The batteries can be interconnected in any order.

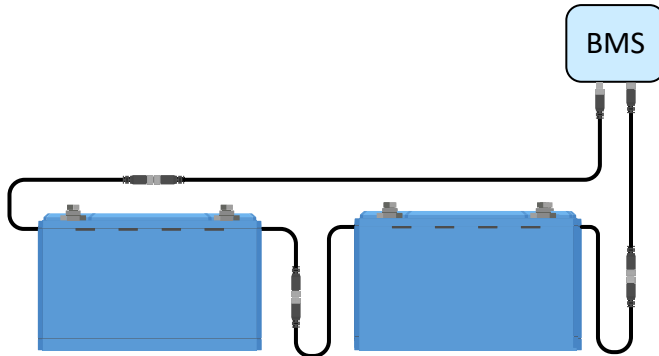


### Interconnecting BMS cables

Connect the BMS. In case of a single battery, connect both BMS cables to the BMS and in case of multiple batteries connect the first and last BMS cable to the BMS.



Single battery BMS connection



Multiple battery BMS connection with extension cables

If the BMS is too far away for the cables to reach, use the optional extension cables. The BMS extension cables are available as a pair and come in a variety of lengths. For more information see the [BMS extension cable product page](#).



BMS extension cable

## 4.8. Battery settings

The default settings in the Smart Lithium battery are suitable for almost all applications. There is no need to change these settings unless the application requires very specific conditions.

If settings need to be changed use the VictronConnect App. To access the settings, click on the settings symbol .

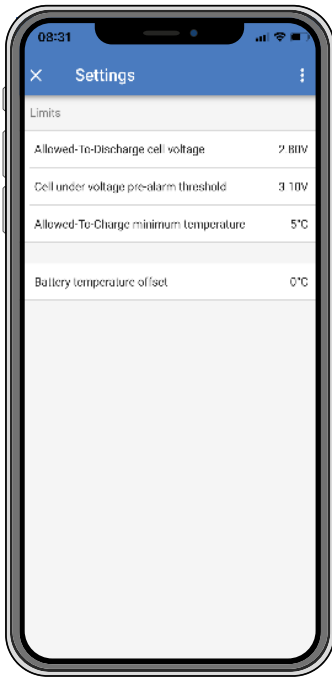
### 4.8.1. Allowed-To-Discharge cell voltage

This is the lowest battery cell voltage, at which discharging the battery is disallowed. A lithium battery cell will be damaged if the voltage drops too far. As soon as one of the cells reaches this voltage, the BMS will disable all loads by sending a signal to the load or to the load disconnection device. Keep this setting at the default 2.80V value.

The only scenario where a lower setting might be applicable is in emergency systems where it could be a requirement to discharge the battery as far as possible and therefore sacrificing part of the battery's overall lifetime.

Be aware that, if a lower value is selected, the battery needs to be recharged earlier after a low voltage shutdown to prevent a further permanent reduction of battery lifetime.

The default value is 2.80V, the range is 2.60V to 2.80V.



#### 4.8.2. Cell under voltage pre-alarm threshold

When the cell voltage drops below this threshold, the pre-alarm signal is sent to the BMS. The purpose of the pre-alarm is to warn the user that the system is about to shut down due to undervoltage. For more details see chapter: "System design".

The default value is 3.10 V and the range is 2.80 V to 3.15 V.

#### 4.8.3. Allowed-To-Charge minimum temperature

This setting defines the lowest temperature at which the BMS allows battery charging. A lithium battery cell will sustain permanent damage when it is charged at temperatures below 5°C.

The default value is 5°C and the range is -20°C to +20°C.



Setting this temperature below 5°C will void the warranty.

#### 4.8.4. Battery temperature offset

This setting can be used to set an offset to improve the accuracy of the battery temperature measurement.

The default value is 0°C and the range is -10°C to +10°C.

### 4.9. Charger settings

Set all charge sources to the following charge parameters:

Recommended charger settings							
Battery model	Recommended charge current	Maximum charge current	Charge profile	Absorption voltage	Absorption time*	Float voltage	Storage voltage**
12.8 V - 60 Ah	30 A	100 A	Lithium, fixed	Between 14.0V – 14.4V	2h	13.5 V	13.5 V
12.8 V - 100 Ah	50 A	200 A	Lithium, fixed	Between 14.0V – 14.4V	2h	13.5 V	13.5 V
12.8 V - 160 Ah	80 A	320 A	Lithium, fixed	Between 14.0V – 14.4V	2h	13.5 V	13.5 V

Recommended charger settings							
12.8 V - 200 Ah	100 A	400 A	Lithium, fixed	Between 14.0V – 14.4V	2h	13.5 V	13.5 V
12.8 V - 300 Ah	150 A	600 A	Lithium, fixed	Between 14.0V – 14.4V	2h	13.5 V	13.5 V
25.6 V - 200 Ah	100 A	400 A	Lithium, fixed	Between 28.0V – 28.8V	2h	27.0 V	27.0 V

\* Absorption time: 2 hours for a 100% charge, or a few minutes for a 98% charge.

\*\* Storage stage is not per se needed for a lithium battery, but if the charger has a storage mode, set it at the same as the float voltage.



## 5. Commissioning

Once all connections have been made, the system wiring needs to be checked, the system needs to be powered up and the BMS functionality needs to be checked. This is how to do this:

- Check polarity of all battery cables.
- Check cross sectional area of all battery cables.
- Check if all battery cable lugs have been crimped correctly.
- Check if all battery cable connections are tight (don't exceed maximum torque).
- Tug slightly on each battery cable and see if the connections are tight.
- Check all BMS cable connections and make sure the connector screw rings are screwed all the way down.
- Connect with VictronConnect to each battery.
- Check if each battery has the most up to date firmware.
- Check if each battery has the same settings.
- Connect the system positive and negative DC cable to the battery (or battery bank).
- Check the string fuse(s) rating (if applicable).
- Place the string fuse(s) (if applicable).
- Check the main fuse rating.
- Place the main fuse.
- Check if all battery charge sources have been set to the correct charge settings.
- Turn on all battery chargers and all loads.
- Check if the BMS is powered up.
- Disconnect a random BMS cable and verify that the BMS is turning off all charge sources and all loads.
- Reconnect the BMS cable and check if all charge sources and loads turn back on.

## 6. Operation

Once in operation, it is important to take proper care of the battery to maximise its lifetime.

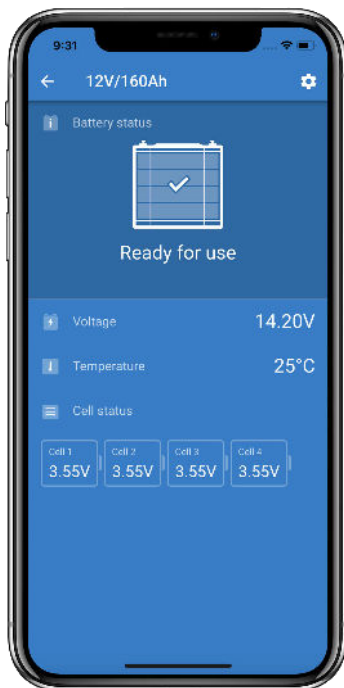
These are the basic guidelines:

- Prevent total battery discharge at all times.
- Familiarize yourself with the pre-alarm feature and act when pre-alarm is active to prevent a DC system shutdown.
- If the pre-alarm is active, or if the BMS has disabled the loads, make sure that the batteries are recharged as soon as possible. Minimise the time the batteries spend in a far discharged state as much as possible.
- The batteries need to spend at least 2 hours in absorption charge mode each month to ensure sufficient time in balancing mode.
- When leaving the system unattended for some time, make sure to either keep the batteries charged during that time, or make sure the batteries are almost full and then disconnect the DC system from the battery.

### 6.1. Monitoring

VictronConnect App can be used to monitor the battery via Bluetooth.

VictronConnect will show the voltage of each cell, the battery temperature and if there are active voltage and/or temperature alarms. Alarm messages can only be seen or received when VictronConnect is actively connected to the battery and the phone is actively showing the Smart lithium screen. The app is not active in the background or when the screen is off.



*VictronConnect*

This manual describes the Lithium Smart related functionality of VictronConnect. For more general information, we recommend to read the [VictronConnect manual](#).

### 6.2. Warnings and alarms

These are the possible warnings and alarms that can be generated by the battery:

#### Cell under voltage warning

The voltage of one or more cells is becoming too low and discharging has been disabled. To remedy this warning, recharge the battery as soon as possible.

#### Under voltage alarm

This alarm is generated when the battery has been deeply discharged and discharging has been disabled. To remedy this alarm, recharge the battery as soon as possible.



#### *Under voltage alarm*

#### **Over voltage alarm**

The voltage of the battery has become too high. Immediately disable all chargers and contact the system installer to check that all chargers are properly controlled by the “charge disconnect” contact on the BMS. When properly controlled, a high voltage situation is not possible, as the BMS disconnects all chargers well before raising the high voltage alarm.

#### **Under temperature alarm**

The battery has reached its low temperature threshold and charging is disabled.

#### **Over temperature alarm**

The battery has reached its high temperature threshold and charging is disabled.

#### **Settings data is corrupt**

To remedy this, go to the settings page and reset settings to factory defaults. This will also reset the Bluetooth bonding information and as such the product must be removed from the Bluetooth paired devices list in order to connect again. For more details see the [VictronConnect manual](#).

Please contact your Victron representative and ask him to escalate this to Victron Energy, as this error should never happen. Please include battery serial number and firmware version.

#### **Hardware failure alarm**

This alarm is generated when hardware has failed in the Battery. Contact your dealer or distributor to resolve this situation.

#### **Other alert and errors**

In case of any of these alerts or errors, contact your dealer or distributor to resolve this situation:

- Balancer failure
- Internal communication failure
- Cell 2 voltage error
- Cell 3 voltage error
- Balancer 1 update error
- Balancer 2 update error
- Balancer 3 update error

## 7. Battery charging and discharging

This chapter describes the charging, discharging and cell balancing process in more detail for those who are interested in the technical background.

### 7.1. Charging

Lithium batteries are easier to charge than lead-acid batteries. The charge voltage may vary anywhere from 14V to 15V for a 12.8V lithium battery and 28V to 30V for a 25.6V lithium battery, as long as no cell is subjected to more than 4.2V. Lithium batteries will become permanent damaged if they are over-charged.

Should a cell reach 4.2V, impossible on a properly installed system, all charge into that cell will be dissipated as heat.

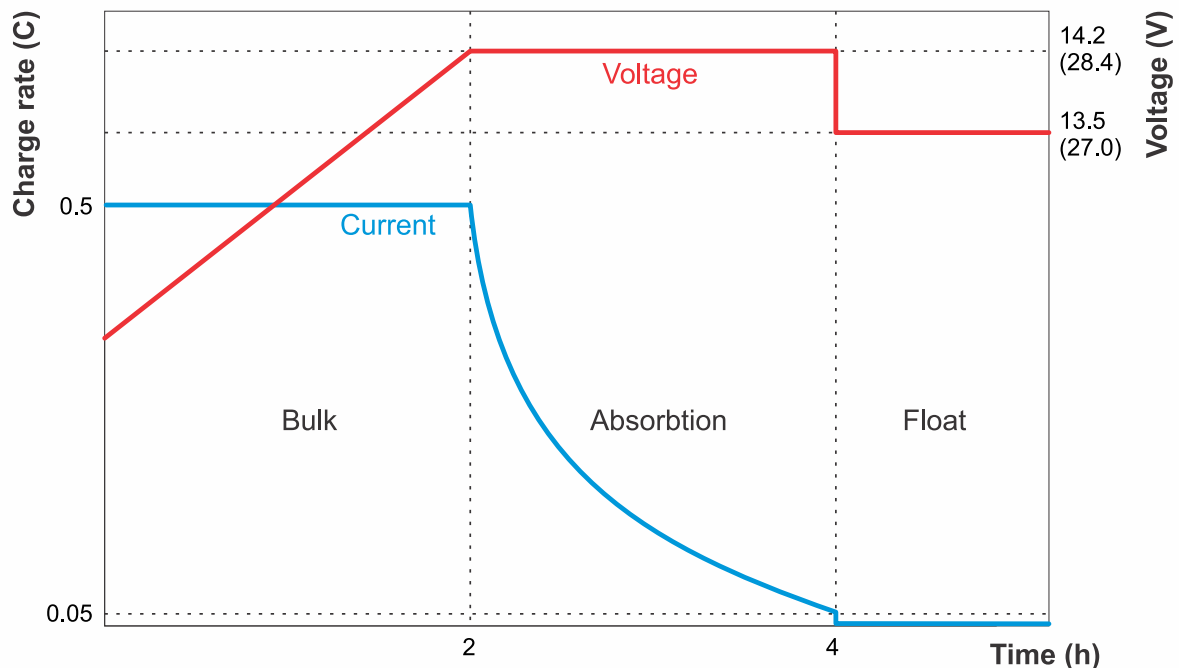
We advise to keep the absorption charge voltage between 14V (28V) and 14.4V (28.8) and the float voltage at 13.5V (27V).

Because of the flexibility in charge voltages, up to 5 batteries can be connected in parallel without much problems. No damage will occur if there are small differences in individual battery voltages because of varying cable resistances or internal battery resistances.

Once the absorption stage has been finalized, the battery charger goes into float. We recommend setting the float voltage at 13.5V (27.0V).

The storage stage is not per se needed for a lithium battery, but if the charger has a storage mode, set the storage voltage at the same value as the float voltage.

We recommend a charge current of 0.5C. This means that if the battery is completely empty, it will take 2 hours to charge the battery. A charge rate of 0.5C for a 100Ah battery is 50A charge current. The maximum charge current is 2C, for a 100Ah battery this is 200A. This will charge the battery in half an hour. But be aware that the batteries will produce more heat when high charge currents are used. More ventilation space is needed around the batteries and depending on the installation, hot air extraction or forced air cooling might be needed.



*Lithium battery charge graph*

The BMS will turn off all charge sources as soon as a battery cell voltage reaches 3.75V or if the battery temperature drops below 5°C or increases above 75°C. This means that all charge sources that are connected to the lithium battery need the ability to be controlled by the BMS.

### 7.2. Cell balancing

The battery consists of lithium cells that are connected in series. The 12.8V battery has 4 cells in series and the 25.6V battery has 8 cells in series.

Though carefully selected during the production process, the cells in the battery are not 100% identical. Therefore, when cycled, some cells will be charged or discharged earlier than the other cells. These differences will increase over time, if the cells are not regularly balanced,

The same happens in a lead-acid battery, but there the cells self-correct without the need for cell balancing electronics because a small current will continue to flow even after one or more cells are fully charged. This current helps to fully charge the other cells that are lagging behind, thus equalizing the charge state of all cells. The current through a lithium cell however, when fully charged, is almost zero, and lagging cells will not be charged further.

Cells do not get damaged if they have different balance levels, but the imbalance will manifest itself in a (temporary) battery capacity reduction.

To ensure that all cells are balanced, the battery is equipped with built-in "active" cell balancing. Each cell voltage is monitored and if required, energy will be moved from the cell(s) with the highest voltage to the cells with a lower voltage. This process will continue until all cell voltages are within 0.01V of each other.

The charge voltage, at which cell balancing starts, depends on the level of imbalance. In case of significant cell imbalance, the balancing process will start as soon as the first cell has reached 3.3V.

Cell balancing takes place at the end of the bulk charge stage and will continue during the absorption charge stage.

Lithium chemistry has a flat voltage curve. This means that the cell voltages will need to be at least 3.50V or higher to be able to correct the smaller cell differences. The absorption voltage (14.2V or 28.4V) is high enough for this to take place as it allows for a cell voltage of 3.55V for each cell when the battery is fully balanced. A 2-hour fixed absorption period is recommended for lithium batteries, so that there is enough time for all cell voltages to equalise.

It is important to regularly fully charge the battery (once a month). If the system is intensively used and has daily (or a few times per week) charge/discharge cycle or the system is deeply discharged, more absorption (cell balancing) time per month is needed.

Please note that a higher charge voltage will not speed up the cell balancing process. The cells are charged by current and not by voltage. Feeding current into a cell will cause the voltage to increase over time, but this is a fixed process and applying more voltage will not speed this process up. In addition to this, the balancing speed is determined by the maximum current (1.8A) of the active and the passive balancing circuits.

There are some applications in where the battery cells will become quicker unbalanced than usual. In these cases, a weekly full charge needs to be performed:

- Systems with series connected batteries
- Systems with high discharge currents
- Systems with short charge periods or low charge voltages

### 7.3. Discharging

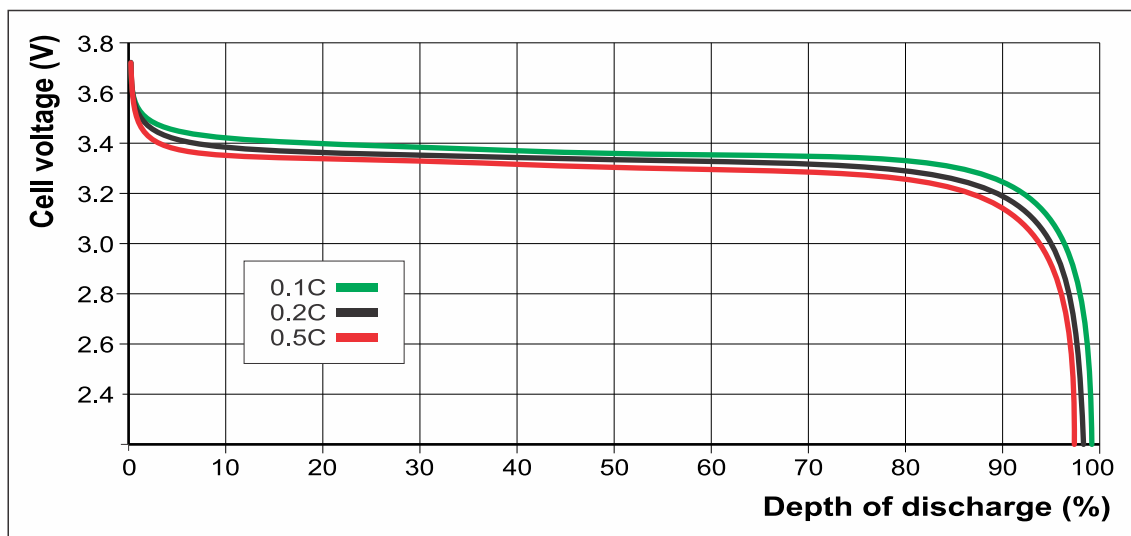
Nearly the whole available battery capacity can be used, with exception of the approximate last 3% of remaining capacity. Lithium batteries will become permanently damaged if they are discharged too deeply.

Lithium batteries can be discharged with high currents. The maximum discharge of the lithium battery is 2C. For a 100Ah battery this means a 200A discharge current. This current will discharge the battery in half an hour. However, we recommend not to discharge above a 1C rate. A 1C rate means that the battery is discharged in 1 hour. For a 100Ah battery this is a discharge current of 100A.

When using a higher discharge rate, the battery will produce more heat than when a low discharge rate is used. More ventilation space is needed around the batteries and depending on the installation, hot air extraction or forced air cooling might be needed. Also, some cells might reach the low voltage threshold quicker than the other cells. This can be because of a combination of heat and ageing.

To be able to tell if a battery is too deeply discharged you will need to look at the individual cell voltages. As the battery is being discharged, the cell voltage drops. This is indicated in below discharge graph. When the battery is almost empty, the voltage will drop faster. This is the sign that the battery is almost empty. This happens at around a cell voltage of 2.80V to 2.60V. Further discharge needs to be prevented, otherwise the battery will get damaged. So as soon as one of the cells has reached this voltage the BMS will disable all DC loads.

The under voltage shutdown threshold is configurable, if it is set to a higher voltage the reserve capacity is greater than if it is set at a lower voltage. It is set by default at 2.8V and the range is 2.6V to 2.8V.



Discharge graph showing cell voltage at various depths of discharge for different discharge rates

The BMS will turn off all loads as soon as a battery cell voltage drops below the low voltage threshold.

Although a BMS is used, there are still a few possible scenarios where the battery can be damaged due to over discharge. This can occur if small loads, such as: alarm systems, relays, standby current of certain loads, back current drain of battery chargers or charge regulators, slowly discharge the battery when the system is not in use.

In case of any doubt about possible residual current draw, isolate the battery when the system is not in use. Do this by opening the battery switch, by pulling the battery fuse(s) or by disconnecting the battery positive cable.

A residual discharge current is especially dangerous if the system has been discharged completely and a low cell voltage shutdown has occurred. At 2.8V cell voltage there is approximately 3% remaining capacity and at 2.6V there is about 1% remaining capacity.

After shutdown due to low cell voltage, a capacity reserve of 1% corresponds with 1Ah left in a 100Ah capacity battery. The battery will be damaged if the remaining capacity reserve is drawn from the battery. A residual current of 10mA for example may damage a 100Ah battery if the system is left in discharged state during more than 4 days (100 hours).

If all cells are 2.8V, this means that the battery terminal voltage is 11.2V (22.4V) and if all cells are 2.6V the battery terminal voltage is 10.4V (20.8V). Be aware that the BMS will turn the loads off as soon as one cell drops below the low voltage threshold. This might not necessarily correspond with the battery terminal voltage. So, if investigating low voltage scenarios, always use VictronConnect to look at the actual cell voltages and do not just rely on the battery terminal voltage.

## 7.4. Cell under voltage pre-alarm

The battery sends a signal to the BMS in case of imminent cell under voltage. This is used by the BMS to generate a pre-alarm signal. This signal will give an advanced warning that the BMS is about to generate a "load disconnect" signal and that the loads are going to be turned off. This happens at a default cell voltage of 3.10V and the range is 2.80V to 3.15V.

Please note that older batteries do not support pre-alarm.

## 8. Troubleshooting, support and warranty

Consult this chapter in case of unexpected battery behaviour or if you suspect a battery fault.

The troubleshooting and support process is to first consult the common battery issues as described in this chapter. Should this fail to resolve the issue, follow the advice in the technical support paragraph.

### 8.1. VictronConnect issues


#### Cannot connect with the VictronConnect App

It is highly unlikely that the Bluetooth interface is faulty. These are some pointers to try before seeking support:

- Is the product a Smart product? Non-Smart products do not support Bluetooth.
- Is the battery voltage still high enough? The Bluetooth module is turned off as a precaution as soon as the battery terminal voltage drops below 8V or when one of the cells drop below 2V. The Bluetooth module will power up again once the battery is charged. When recharging the battery after a low voltage event, use the low voltage charge procedure as described in paragraph: "Battery very low terminal voltage".
- Is the battery voltage still high enough? If the battery voltage drops to a very low level, the Lynx Smart BMS will eventually turn its internal electronics off, including Bluetooth communication.
- Is there already another phone or tablet connected to the product? Only one phone or tablet can be connected at any given time. Make sure no other devices are connected and try again.
- Are you close enough to the product? In open space the maximum distance is about 20 meters.
- Are you using the Windows version of the VictronConnect App? The Windows version cannot use Bluetooth. Use an Android, iOS or macOS device instead.
- Has Bluetooth been disabled in the VictronConnect settings?  
**IMPORTANT:** Disabling Bluetooth is an irreversible process. Once Bluetooth has been disabled, it can never be re-enabled.
- Does VictronConnect have an issue? Try to connect to another Victron product, does this work? If that also does not work, then there probably is an issue with the phone or tablet. Refer to the troubleshooting section of the [VictronConnect manual](#).

#### Pin code lost

If you have lost the PIN code, you will need to reset the PIN code to its default PIN code. This is done in the VictronConnect App.

- Navigate to the device list of the VictronConnect App. Click on the option symbol  next to the product listing.
- A new window will open which allows you to reset the PIN code back to its default: 000000.
- Enter the batteries unique PUK code as printed on the product information sticker on the product.
- More information and specific instructions can be found in the [VictronConnect manual](#).

#### Interrupted firmware update

This is recoverable, just try to update the firmware again.

## 8.2. Battery issues

### 8.2.1. Cell imbalance

#### How to recognize cell imbalance

- The BMS frequently disables the charger  
This is an indication that the battery is imbalanced. The charger will never be disabled by the BMS if the battery is well balanced. Even when fully charged, the BMS will leave the charger enabled.
- The battery capacity seems to be less than before  
If the BMS is disabling loads much sooner than it used to do, even while the overall battery voltage still looks OK, this is an indication that the battery is imbalanced.
- There is a noticeable difference between the individual cell voltages during absorption stage  
When the charger is in the absorption stage, all cell voltages should be equal and be between 3.50V and 3.60V. If this is not the case, this is an indication that the battery is imbalanced.
- A cell slowly drops in voltage when the battery is not used  
This is not imbalance, although it might look like it. A typical example of this is when the battery cells initially all have equal voltages, but when the battery is not used after a day or so, one of the cells has dropped 0.1 to 0.2V below the other cells. This cannot be fixed by rebalancing and the cell is considered to be defective.

#### How to recover an imbalanced battery

- Charge the battery using a charger that is configured for lithium and is controlled by the BMS.

- Be aware that cell balancing only takes place during the absorption stage. It will be necessary to manually restart the charger each time the charger has gone to float. Rebalancing can take a long time (up to a few days) and it will require many manual charger restarts.
- Be aware that during cell balancing it might look like nothing is happening. The cell voltages can remain the same for a long time and the lithium BMS will repeatedly turn the charger on and off. This is all normal.
- Balancing is taking place when the charge current is at or above 1.8A or when the BMS has temporarily disabled the charger.
- Balancing is almost finished when the charge current drops below 1.5A and the cell voltages are close to 3.55V.
- The rebalancing process is complete when the charge current has dropped even further, and all cells are 3.55V.



Be 100% sure that the charger is controlled by the BMS, dangerous cell overvoltage can occur if it is not. Check this by monitoring the cell voltages using the VictronConnect App. The voltage of the fully charged cells will slowly creep up until 3.7V has been reached. At this point the BMS will disable the charger and the cell voltages will drop again. This process will continuously repeat until balance is restored.

### Background information on cell balancing

#### What causes cell imbalance or a variation in cell voltages:

- *The battery has not spent enough time in the absorption charge stage.*  
This can, for example, happen in a system where there is not enough solar power to fully charge the battery, or in systems where the generator is not running long or often enough. During normal operation of a lithium battery, small difference between cell voltages occur all the time. These are caused by slight differences between the internal resistance and self-discharge rates of each cell. The absorption charge stage fixes these small differences. We recommend a minimum absorption time of 2 hours per month for lightly operated systems, such as backup or UPS applications and 4 to 8 hours per month for heavy used (off-grid type) systems.
- *The battery charger never reaches the storage (or float) stage.*  
The storage (or float) stage follows the absorption stage. During this stage, the charge voltage drops to 13.5V and the battery can be considered full. If the charger never enters this stage, it might be a sign that the absorption stage has not been completed (see previous point). The charger should be allowed to reach this stage at least once a month. This is also needed for battery monitor SoC (state of charge) synchronization.
- *The battery has been too deeply discharged.*  
During a very deep discharge, one or more cells in the battery can drop well below their low voltage thresholds. The battery might be recoverable by rebalancing, but there is also a realistic chance that one or more cells are defective, and that rebalancing will not be successful. Consider the cell to be defective. This not covered by warranty.
- *The battery is old and is near to its maximum cycle life.*  
When the battery is close to its maximum cycle life, one or more battery cells will start to deteriorate, and the cell voltage will be lower than the other cell voltages. This is not imbalance, although it might look like it is. This cannot be fixed by rebalancing. Consider the cell defective. This not covered by warranty.
- *The battery has a defective battery cell.*  
A cell can become defective after a very deep discharge, when it is at the end of its cycle life or because of a manufacturing fault. A defective cell is not unbalance (although it might look like it is). It cannot be fixed by rebalancing. Consider the cell defective. Very deep discharge and end of cycle life are not covered by warranty.

#### Calculation example of time required to restore a heavily imbalanced battery:

For this example, imagine a 12.8V, 200Ah battery with one heavily undercharged (discharged) cell.

A 12.8V battery contains 4 cells, each is 3.2V. And they are connected in series. Hence,  $3.2 \times 4 = 12.8V$ . Just like the battery, each cell has a capacity of 200Ah.

Let's say that the imbalanced cell is only at 50% of its capacity, while the other cells are fully charged. To restore the balance, the rebalancing process will need to add 100Ah to that cell.

The balancing current, which is a given fact, as per the specifications of the battery, is 1.8A. It will take at least  $100/1.8 = 55$  hours to rebalance the cell.

Balancing only takes place when the charger is in the absorption stage. If a 2-hour lithium charge algorithm is used, the charger will need to be manually restarted  $55/2=27$  times during the rebalancing process. If the charger is not restarted immediately, the balancing process will be delayed, and this will add to the total balancing time.



A tip for Victron distributors and professional users: To avoid having to restart the charger continuously, use the following trick. Set the float voltage at 14.2, this will have the same effect as the absorption stage. Also make sure to disable the storage stage, and/or set that to 14.2V as well. Or alternatively set the absorption time to a very long time. What matters is that the charger maintains a continuous 14.2V charge voltage during the rebalancing process. After the battery has been rebalanced, make sure to set the charger back to the normal lithium charge algorithm. Never leave a charger connected like this in a running system. Keeping the battery at such a high voltage will decrease the lifetime of the battery.

### 8.2.2. Less capacity than expected

If the battery capacity is less than its rated capacity these are the possible reasons for that:



- The battery has a cell imbalance, causing premature low voltage alarms, which in turn cause the BMS to turn loads off. Please refer to paragraph "Charge battery before use".
- The battery is old and is near its maximum cycle life. Check how long the system has been in operation, check how many cycles the battery has gone through and to what average depth of discharge the battery has been discharged? A way to find this information is to look at the history of a battery monitor (if available).
- The battery has been too far discharged and one or more cells in the battery are permanently damaged. These bad cells will have a low cell voltage faster than the other cells and this will cause the BMS to turn loads off prematurely. Has the battery perhaps been through a very deep discharge event?

### 8.2.3. Battery very low terminal voltage

If the battery has been discharged too far, the voltage will fall well below 12V (24V). If the battery has a voltage of less than 10V (20V) or if one of the battery cells has a cell voltage below 2.5V, the battery will have permanent damage. This will invalidate the warranty. The lower the battery or cell voltage is, the bigger the damage to the battery will be.

If the voltage has dropped below 8V, the battery will not communicate via Bluetooth anymore. The Bluetooth module is turned off when the battery terminal voltage drops below 8V or if a cell voltage drops below 2V.

You can try to recover the battery by using the below low voltage recharge procedure. Be aware that this is not a guaranteed process, recovery might be unsuccessful and there is a realistic chance that the battery has permanent cell damage resulting in a moderate to severe capacity loss after the battery has been recovered.

#### Charge procedure for recovery after low voltage event:

This recovery charge procedure is performed on an individual battery. If the system contains multiple batteries, repeat this procedure for each individual battery.

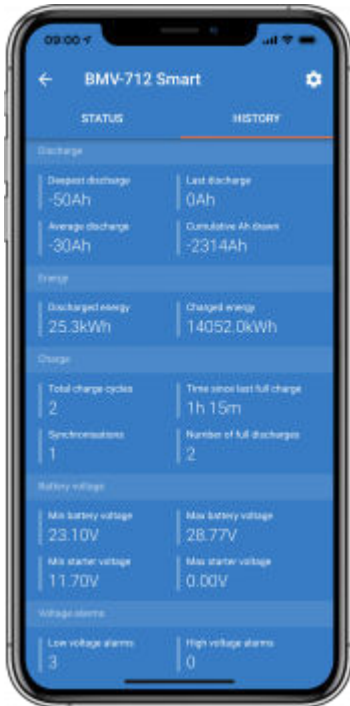


This process can be risky. A supervisor must be present at all times.

- Set a charger or power supply to 13.8V (27.6V).
- In case any of the cell voltages is below 2.0V, charge the battery with 0.1A until the voltage of the lowest cell increases to 2.5V. A supervisor must monitor the battery and stop the charger as soon as the battery is getting hot or is bulging. If this is the case the battery is unrecoverable damaged.
- Once the voltage of the lowest cell has increased above 2.5V, increase the charge current to 0.1C. For a 100Ah battery this is a charge current of 10A.
- Connect the battery to a BMS and ensure that the BMS has control over the battery charger.
- Make note of the initial battery terminal voltage and battery cell voltages.
- Start the charger.
- The BMS might turn the charger off, then on again for a short time and then off again. This can occur many times over and is normal behaviour in case there is a significant cell imbalance.
- Make note of the voltages at regular intervals.
- The cell voltages should increase during the first part of the charge process. If the voltage of any of the cells does not increase in the first half hour, consider the battery as unrecoverable and abort the charge procedure.
- Check the battery temperature at regular intervals. If you see a sharp increase of temperature, consider the battery as unrecoverable and abort the charge procedure.
- Once the battery has reached 13.8V (27.6) increase the charge voltage to 14.2V (28.4V) and increase the charge current to 0.5C. For a 100Ah battery this is a charge current of 50A.
- The cell voltages will increase more slowly, this is normal during the middle part of the charge process.
- Leave the charger connected for 6 hours.
- Check the cell voltages, they should all be within 0.1V of each other. If one or more cells has a much bigger voltage difference, consider the battery as damaged.
- Let the battery rest for a few hours.
- Check the voltage of the battery. It should comfortably sit above 12.8V (25.6V) like 13.2V (26.4V) or higher. And the cell voltages should still be within 0.1V of each other.
- Let the battery rest for 24 hours.
- Measure the voltages again. If the battery voltage is below 12.8V (25.6V) or if there is a noticeable cell imbalance, the battery is unrecoverable damaged.

### 8.2.4. Battery is close to end of cycle life or battery has been misused

It is hard to tell what has happened to the battery. But there are a few ways to get around this. You can check the battery settings in VictronConnect and check if the BMS is functional. You can also check the system voltages and cycle history in case there is a battery monitor in the system, or if the system is connected to VRM.



*VictronConnect BMV history*

**To check if the battery is close to its cycle life:**

- Find out how many charge-discharge cycles the battery has been subjected to? Battery lifetime is correlated to the number of cycles.
- How deep has the battery been discharged on average? The battery will last for less cycles if deeply discharged, compared to more cycles if discharged less deep.
- For more info on the life cycle see chapter: "Technical data".

**To check if the battery has been misused:**

- Is the BMS connected and functional? Not using the battery with a Victron Energy approved BMS voids the warranty.
- Is there mechanical damage to the battery, its terminals or the BMS cables. Mechanical damage voids the warranty.
- Has the battery been mounted upright? The battery can only be used in an upright position.
- Check the "allowed to charge minimum temperature" setting in VictronConnect? Also check if the battery temperature offset has not been set to an unrealistic value. Charging the battery below 5°C voids the warranty.
- Is the battery wet? The battery is not waterproof and is not suitable for outdoor use.
- Is there an indication that the battery has been totally discharged? Look at the battery monitor settings or VRM. Inspect the deepest discharge, minimum battery voltage and number of full discharge in the battery monitor. Total and very deep discharge voids the warranty.
- Is there an indication the battery has been charged with too high voltage? check the maximum battery voltage and the high voltage alarms in the battery monitor.

### 8.2.5. Micro-controller restart procedure



Note that when the system is installed and operated correctly, it will never be necessary to carry out this procedure. Carrying out this procedure is only necessary when the battery has been discharged far too deeply. And even then, only sometimes. Before opening the battery, carefully follow below instructions, to make sure this procedure is needed. Only use this procedure as a last resort, after all other troubleshooting options have been exhausted!



This procedure involves opening the battery cover and temporary disconnecting the positive terminal of the battery's internal circuit board. It should only be performed by Victron suppliers, technicians or professional users. If in doubt about performing this procedure consult your Victron supplier.

**Introduction and when to use this procedure:**

After a battery has been discharged far too deep, ie. terminal voltages below 8V for a 12V model and 16V for a 24V model, a special slow recharge procedure is required to try to recover the battery. This procedure is detailed in [chapter "8.2.3, Battery very low terminal voltage"](#) [30]. Read that chapter carefully. After such a too deep discharge, it can happen that the microcontroller

does not power up correctly. This chapter explains how to fix that by restarting the micro controller. Before opening the battery, first carefully follow below instructions to make sure that it's necessary.

Note that when installed and operated correctly, batteries will never be discharged to that level: make sure to understand why it happened, and amend installation and/or operation of the system accordingly.

Lastly, be informed that this chapter is added to the manual for the benefit of installers and technically qualified users – to help to recover from such a situation without having to ship the battery out for repair. This does not at all mean that it is required to carry out this procedure yourself. The Victron service points and repair centres are happy to carry out the procedure when that is preferred. And, again, do note that once discharged as deeply as described here (cell voltages below 2V), the battery will be damaged and its usable capacity will, at best, have been reduced. And in the worst case the battery needs to be replaced.

**How to recognise a stuck micro-controller:**

First, make sure the system is within operational parameters:




- The battery needs to be charged and the battery voltage above 13V (26V).
- The battery temperature needs to be above the low temperature cut-off (default is 5°C or 41°F).
- The BMS cables between the battery and the BMS need to be connected and in good working condition.

Now, verify that the BMS still signals loads and chargers to disconnect. This table details how to do that for all available BMS-es:

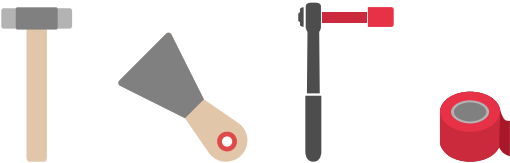
The BMS is not allowing loads and chargers to operate when:	
SmallBMS	The blue "Load On" LED is off and the red "Temp or OVP" LED is on.
VE.Bus BMS	The red LED is on, the blue LED is off and the MultiPlus/Quattro LED is on.
Lynx Smart BMS	In VictronConnect (or a GX device IO tab) both the "Allow-to-charge" and the "Allow-to-discharge" parameters are disabled.
Smart BMS CL 12/100	The yellow and orange LEDs are off.

Lastly, check that the battery is not visible in the VictronConnect device list. If the battery shows, the microcontroller is running normally and a power cycling is not required.


**Micro-controller restart procedure:**

-  Opening the battery will expose 12Vdc (or 24Vdc) voltages that can not be isolated.
-  Always use insulated tools when working on batteries.
-  Prevent short circuits between the battery poles, the battery cell poles the cell busbars and/or the internal circuit board. There is no fuse protection.

1



Tools needed:

-  Nylon or rubber hammer
-  Scraper, chisel or flat screwdriver
-  Insulated torque socket wrench M10 (electrical tape can be used to insulate the socket and part of the wrench)
-  Electrical tape

2



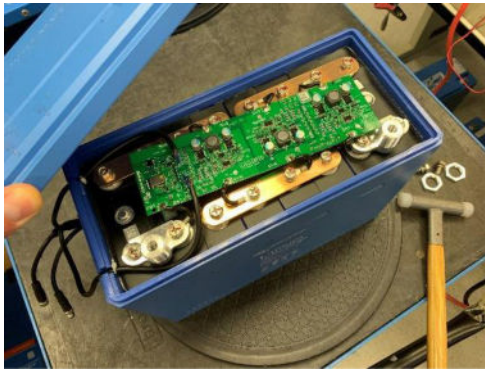
- Remove the battery terminal wiring.
- Remove the terminal hex nuts.

3



- Carefully loosen or break open the lid. This can be done with a scraper, flat screwdriver or chisel. When it creaks, it comes loose. Then continue a bit further until the lid is completely loose.

4



- Remove the top cover.

5

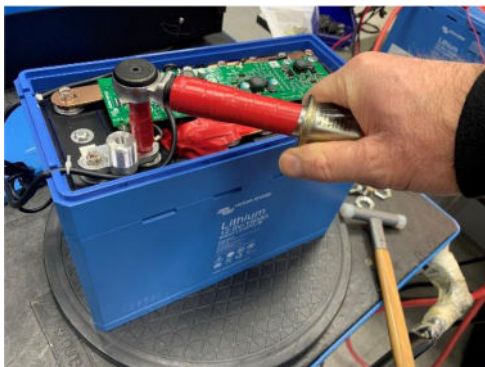


- Insulate the negative busbar terminal located next to the positive battery terminal. Do this by covering the busbar with electrical tape. See red tape in the image on the left.



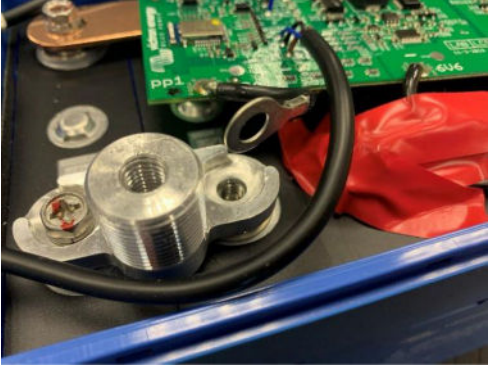
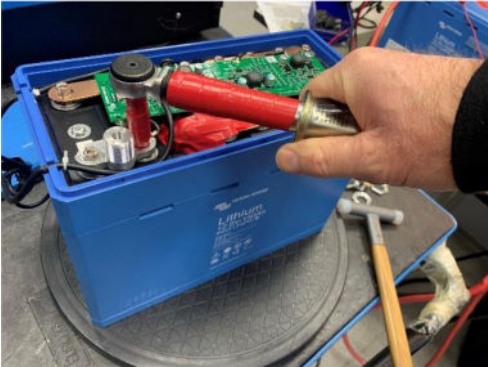
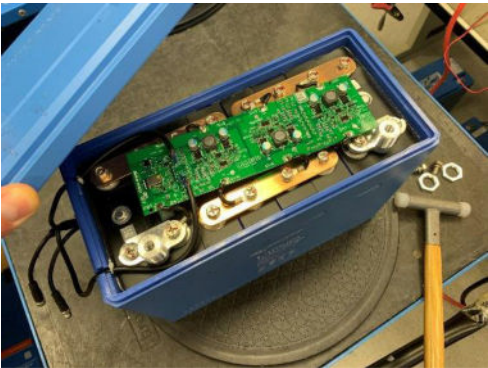
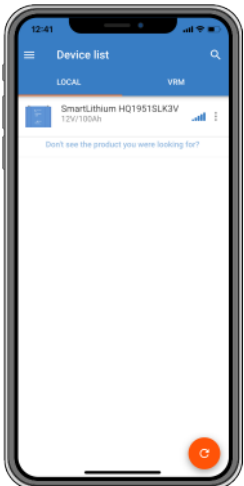
The electrical tape is a precaution to prevent a possible short-circuit between the positive battery terminal and the negative busbar.

6



- Loosen and remove the bolt that holds the positive circuit board wire cable lug.



<p>7</p>		<ul style="list-style-type: none"> <li>• Leave the positive circuit board cable lug disconnected for a few seconds.</li> </ul>
<p>8</p>		<ul style="list-style-type: none"> <li>• Reinstall the positive circuit board cable lug and the bolt.</li> <li>• Fasten the bolt using a 10Nm torque.</li> <li>• Remove the electrical tape.</li> </ul>
<p>9</p>		<ul style="list-style-type: none"> <li>• Put the cover back on the battery.</li> <li>• Reinstall the terminal hex nuts.</li> <li>• Reinstall the battery terminal wiring.</li> </ul>
<p>10</p>		<ul style="list-style-type: none"> <li>• Check if the BMS is now allowing loads and chargers to connect to the battery.</li> <li>• Check to see if the battery appears in the device list of the VictronConnect App*.</li> </ul> <p>If the BMS is allowing loads and chargers, the procedure was successful.</p> <p>* Note that if the battery does not appear in the device list, this can be because Bluetooth has been disabled. See the <a href="#">VictronConnect issues [28]</a> chapter for more information.</p>

## 8.3. BMS issues

### 8.3.1. The BMS frequently disables the battery charger

A well-balanced battery does not disable the charger, even when the batteries are fully charged. But when the BMS frequently disables the charger, this is an indication of cell imbalance.

In case of moderate or large cell imbalance it is an expected behaviour that BMS frequently disables the battery charger. This is the mechanism behind this behaviour:

As soon as one cell reaches 3.75V the BMS disables the charger. Whilst the charger is disabled the cell balancing process still continues, moving energy from the highest cell into adjacent cells. The highest cell voltage will drop, and once it has fallen below 3.6V the charger will be enabled again. This cycling typically takes between one and three minutes. The voltage of the highest cell will rise again quickly (this can be in a matter of seconds) after which, the charger will be disabled again, and so forth. This does not indicate a problem with the battery or the cells. It will continue with this behaviour until all cells are fully charged and balanced. This process might take several hours. It depends on the level of imbalance. In case of serious imbalance this process can take up to 12 hours. Balancing will continue throughout this process and balancing even takes place when the charger is disabled. The continued enabling and disabling of the charger can appear strange but rest assured that there is no problem. The BMS is merely protecting the cells from over voltage.

### 8.3.2. The BMS is prematurely turning chargers off

This could be because of a cell imbalance. One cell in the battery has a cell voltage above 3.75V. Check the cell voltages of all the batteries that are connected to the BMS.

### 8.3.3. The BMS is prematurely turning loads off

This could be because of a cell imbalance.

If a cell has a cell voltage below the "Allowed to Discharge" setting in the battery the BMS will turn the load off. The "Allowed to Discharge" level can be set between 2.6V and 2.8V. The default is 2.8V.

Check the cell voltages of all the batteries that are connected to the BMS using the VictronConnect app. Also check if all batteries have the same "Allowed to Discharge" settings.

Once the loads have been turned off due to low cell voltage, the cell voltage of all cells needs to be 3.2V or higher before the BMS will turn the loads back on.

### 8.3.4. The pre-alarm setting is missing in VictronConnect

Pre-alarm is only available if the battery supports it. The current battery models all support it, but older batteries do not have the hardware necessary for the pre-alarm feature.

### 8.3.5. BMS is displaying alarm while all cell voltages are within range

A possible cause is a loose or damaged BMS cable or connector. Check all BMS cables and their connections.

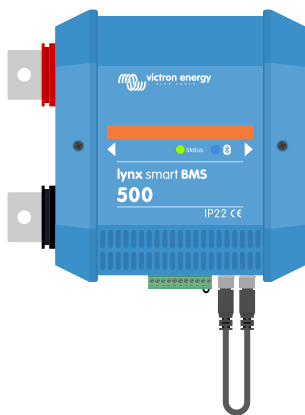
First rule out that the cell voltages and temperature of all connected batteries are in range. If they are all in range, then follow one of the following procedures.

Also consider that once there has been a cell under voltage alarm, the cell voltage of all cells need to be increased to 3.2V before the battery clears the under voltage alarm.

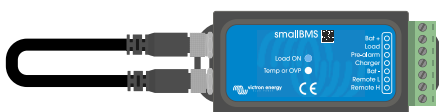
A way to rule out if a fault is originating from a faulty BMS or from a faulty battery, is to check the BMS using one of the following BMS test procedures:

#### Single battery and BMS check:

- Disconnect both BMS cables from the BMS.
- Connect a single BMS extension cable between both BMS cable connectors. The BMS cable should be connected in a loop, as in below diagram. The loop tricks the BMS in thinking that there is a battery connected without any alarms.
- If the alarm is still active after the loop has been placed, the BMS is faulty.
- If the BMS has cleared the alarm after the loop has been placed the battery is faulty and the BMS is not faulty.



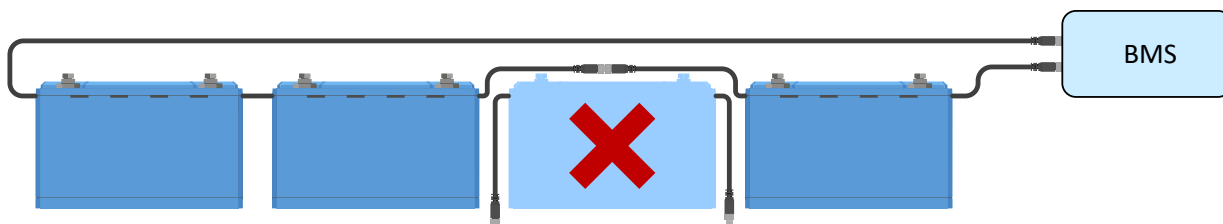
Testing a Lynx Smart BMS by connecting a single BMS extension cable to both BMS cable connections



Testing a Small BMS by connecting a single BMS extension cable to both BMS cable connections

**Multiple batteries and BMS check:**

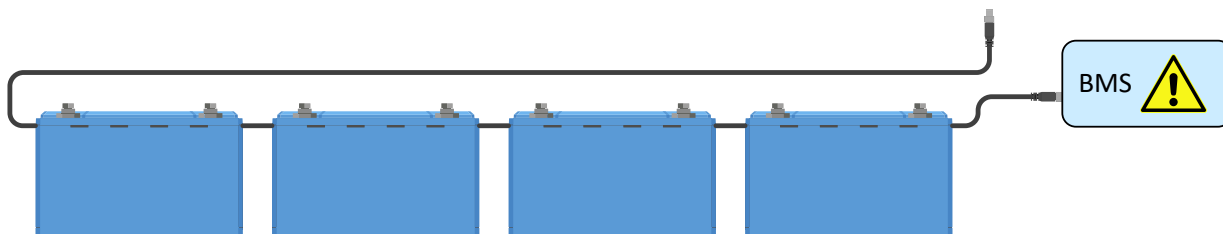
- Bypass one of the batteries by disconnecting both its BMS cables
- Connect the BMS cables of the neighbouring batteries (or battery and BMS) to each other, effectively bypassing the battery.
- Check if the BMS has cleared its alarm.
- If the alarm has not been cleared, repeat this for the next battery.
- If the alarm is still active after all batteries have been bypassed, the BMS is faulty.
- If the BMS cleared its alarm when a particular battery was bypassed, that particular battery is faulty.



Eliminating a BMS error by bypassing a suspect battery

**8.3.6. How to test if the BMS is functional**

To test if the BMS is functional, disconnect one of the BMS cables and see if the BMS will go into alarm mode.



Check BMS functionality by deliberately loosening a BMS cable

**8.4. Technical support**

For technical support contact the point of purchase. If the point of purchase is unknown, refer to the [Victron Energy Support web page](#).

## 8.5. Warranty

This product has a 3-year limited warranty. This limited warranty covers defects in materials and workmanship in this product and lasts for three years from the date of original purchase of this product. To claim warranty the customer must return the product together with the receipt of purchase to the point of purchase.

This limited warranty does not cover damage, deterioration or malfunction resulting from alteration, modification, improper or unreasonable use or misuse, neglect, exposure to excess moisture, fire, improper packing, lightning, power surges, or other acts of nature.

This limited warranty does not cover damage, deterioration or malfunction resulting from repairs attempted by anyone unauthorized by Victron Energy to make such repairs.

Non-compliance with the instructions in this manual will render the warranty void.

Victron Energy is not liable for any consequential damages arising from the use of this product. The maximum liability of Victron Energy under this limited warranty shall not exceed the actual purchase price of the product.



## 9. Technical data

Battery specification							
VOLTAGE AND CAPACITY	LFP-Smart 12.8/60	LFP-Smart 12.8/100	LFP-Smart 12.8/150	LFP-Smart 12.8/160-a	LFP-Smart 12.8/200-a	LFP-Smart 12.8/300	LFP-Smart 25.6/200
Nominal voltage	12.8V	12.8V	12.8V	12.8V	12.8V	12.8V	25.6V
Nominal capacity @ 25°C*	60Ah	100Ah	150Ah	160Ah	200Ah	300Ah	200Ah
Nominal capacity @ 0°C*	48Ah	80Ah	125Ah	130Ah	160Ah	240Ah	160Ah
Nominal capacity @ -20°C*	30Ah	50Ah	75Ah	80Ah	100Ah	150Ah	100Ah
Nominal energy @ 25°C*	768Wh	1280Wh	1920Wh	2048Wh	2560Wh	3840Wh	5120Wh
*Discharge current ≤1C							
CYCLE LIFE (capacity ≥ 80% of nominal)							
80% DoD	2500 cycles						
70% DoD	3000 cycles						
50% DoD	5000 cycles						
DISCHARGE							
Maximum continuous discharge current	120A	200A	300A	320A	400A	600A	400A
Recommended continuous discharge current	≤60A	≤100A	≤150A	≤160A	≤200A	≤300A	≤200A
End of discharge voltage	11.2V	11.2V	11.2V	11.2V	11.2V	11.2V	22.4V
OPERATING CONDITIONS							
Operating temperature	Discharge: -20°C to +50°C      Charge: +5°C to +50°C						
Storage temperature	-45°C to +70°C						
Humidity (non-condensing)	Max. 95%						
Protection class	IP 22						
CHARGE							
Charge voltage	Between 14V/28V and 14.4V/28.8V (14.2V/28.4V recommended)						
Float voltage	13.5V/27V						
Maximum charge current	120A	200A	300A	320A	400A	600A	400A
Recommended charge current	≤30A	≤50A	≤75A	≤80A	≤100A	≤150A	≤100A
OTHER							
Max storage time @ 25°C*	1 year						
BMS connection	Male + female cable with M8 circular connector, length 50cm						

Battery specification							
Power connection (threaded inserts)	M8	M8	M8	M8	M8	M10	M8
Dimensions (h x w x d) mm	240 x 285 x 132	197 x 321 x 152	237 x 321 x 152	237 x 321 x 152	237 x 321 x 152	347 x 425 x 274	317 x 631 x 208
Weight	12kg	15kg	20kg	20kg	22kg	51kg	56kg
*When fully charged							

## 10. Appendix

### 10.1. Initial charge procedure without BMS

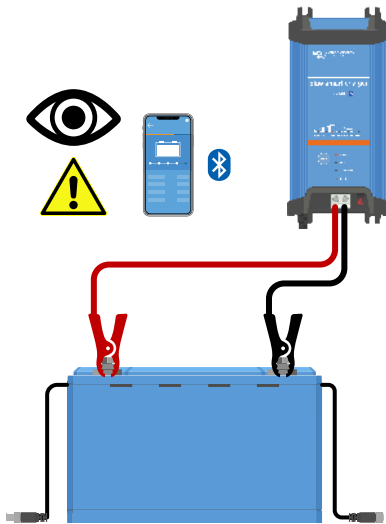
If, for a specific reason, the initial charge procedure needs to be performed without a BMS, this is the procedure for it. Please note that this is not something we recommend because this process can be risky. A supervisor must be present, who will need to watch their phone continuously for hours as the battery cell voltages must be checked continuously to safeguard that the voltage of the highest cell never exceeds 4V.



Charging without BMS is not the preferred method. It can be risky, and a supervisor must be present at all times.

These are the charger or inverter/charge settings when the battery is charged without a BMS:

Recommended charger settings when performing an initial charge without a BMS						
WARNING: Use these settings only during the initial charge process						
Battery model	Max. charge current	Charge profile	Absorption voltage	Absorption time	Float voltage	Storage voltage
12.8V - 60Ah	20A	Lithium, fixed	13.8V	12h	14.2V	13.5V
12.8V - 100Ah	30A	Lithium, fixed	13.8V	12h	14.2V	13.5V
12.8V - 160Ah	50A	Lithium, fixed	13.8V	12h	14.2V	13.5V
12.8V - 200Ah	60A	Lithium, fixed	13.8V	12h	14.2V	13.5V
12.8V - 300Ah	100A	Lithium, fixed	13.8V	12h	14.2V	13.5V
25.6V - 200Ah	60A	Lithium, fixed	27.0V	12h	27.6V	27.0V



*Initial charge without using a BMS*

Charge procedure:

- Use a battery charger that is suitable for Li-ion, such as a BluePower charger.
- Set the charger to the charge profile as indicated in above table.
- The supervisor connects with the VictronConnect app to the battery.
- The supervisor monitors the individual cell voltages at all times.
- The supervisor interrupts the battery charge process immediately should a battery cell voltage exceeds 4 Volt.
- The process is complete when all cell voltages are between 3.5V and 3.6V