Introduction to *CMPower* LiFePO4 Marine Batteries

LiFePO4 (lithium iron phosphate) is a lithium-ion battery technology that is safe, powerful and plug compatible with most lead acid battery charging systems. This battery technology offers **many advantages over lead acid and AGM technology including high capacity storage, delivery of consistently high power, longer cycle life, less weight, longer shelf life and rapid efficient charging**.

LiFePO4 batteries are the safest type of lithium batteries as they will not overheat, and even if punctured they will not catch fire. The cathode material in LiFePO4 batteries is not hazardous, and thus poses no negative health hazards or environmental hazards. ***CMPower* LiFePO4 batteries are plug compatible with lead acid batteries and will accept a charge from most lead acid configured chargers. The charge voltage and amperage should be within the range specified for the LiFePO4 batteries.**

A ***CMPower*** (Custom Marine Products) LiFePO4 battery has two primary components, the **LiFePO cells (LFP)** and the **Battery Management System (BMS)**. Both are housed in a strong sealed battery case. The quality of each component is key to the longevity and performance of the battery. LiFePO cells are wired in parallel to form a module producing 3.2 volts. Four of these units are connected in series to form a rated 12.8 volt LiFePO4 battery; eight for a 25.6 volt battery. The temperature, charge and discharge of each cell is monitored and managed by the BMS, a computer of sorts built into each battery. In addition to cell monitoring and management, the BMS will prevent over discharging of cells by disconnecting the load and will prevent cell over charging by reducing charge current or stopping the charge process. The BMS will also shut down the system if the battery temperature is out of range. CMPower batteries also have short circuit protection should the positive and negative terminals be connected by mistake.

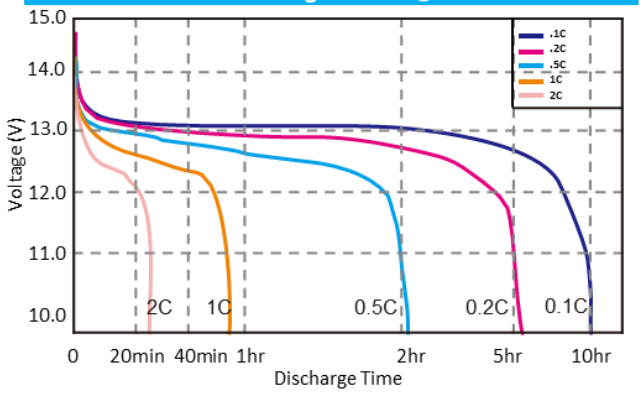
Continuous Discharge Current - In addition to Amp Hours and Watts, LiFePO4 batteries are also rated as to their maximum continuous discharge capacity; 80 - 100 Amps max continuous discharge capacity is typical. Most ***CMPower*** LifePO4 batteries have a continuous discharge capacity of 150 Amps to robustly accommodate both house demands and heavy draw requirements from appliances such as an electric winch, windlass or engine starting motor. We use a heavy duty BMS in our batteries. One way to look at the continuous discharge current rating is the size of the pipe leading from the battery to the load. 150 Amps continuous and 300 amps for a short time is a pretty big pipe.

Advantages and Features of *CMPower* LiFePO4 Marine Batteries

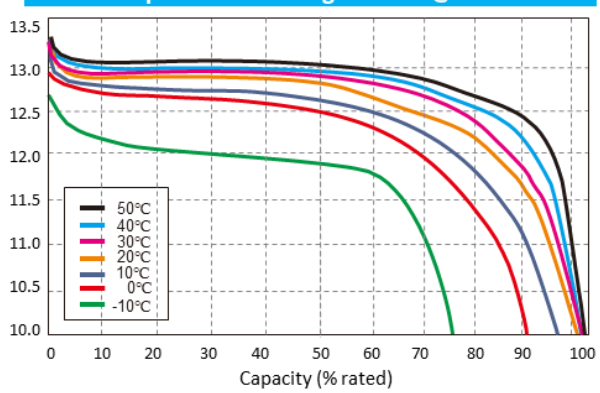
Below are graphs showing the performance characteristics of a 100 Ah LiFePO4 battery.

This data can be extrapolated for larger or smaller batteries. The data is explained in the text that follows.

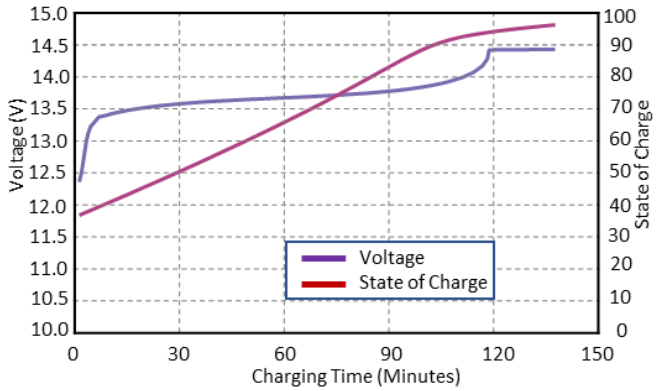
Rate of Discharge Curves @ 25°C



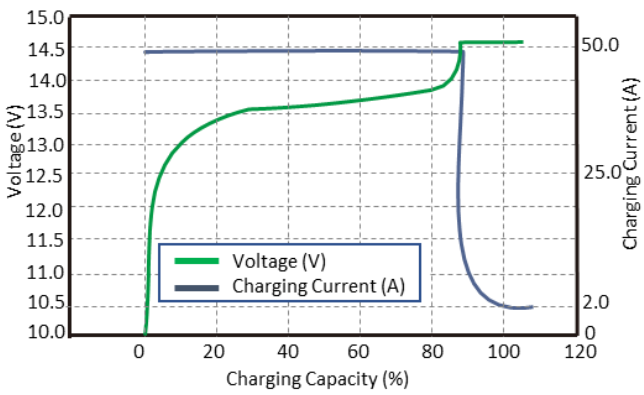
Temperature Discharge Curves @ 0.5C



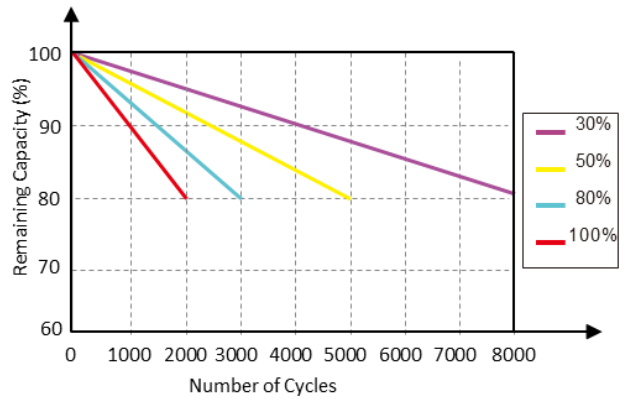
State of Charge @ 0.5 C 25°C



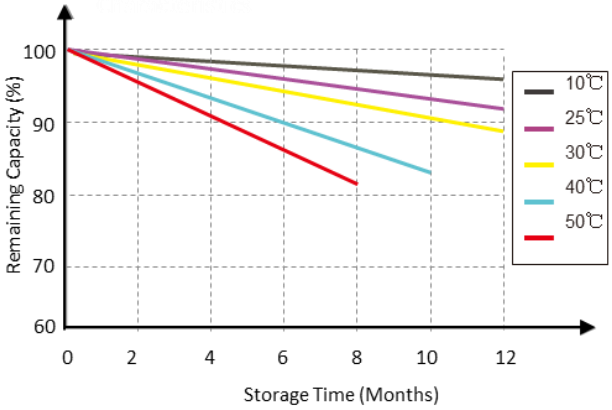
Charging Characteristics @ 0.5 C 25°C



Depth of Discharge Cycle Life @ 1C



Temperature - Self Discharge



Charge/discharge cycles – ***CMPower*** LifePO4 batteries have an expected life of 2,000-5,000 charge/discharge cycles at a discharge to 90%. Lead acid batteries have an expected life of 300-500 charge/discharge cycles at a discharge to 50%. Expected life is defined as the number of charge/discharge cycles until the battery performance is 80% of its rated capacity (operating at 80 Ah for a 100 Ah battery). A cycle is counted each time the battery is drawn below a State of Charge of about 50% and recharged.

Discharge profile - ***CMPower*** LifePO4 batteries stay at a voltage of 12.8 to 13.3 volts during discharge of up to 95+% or 5% of rated capacity remaining. Voltage then drops off rapidly. A lead acid battery decreases in voltage from 13 to below 12 volts as more current is drawn. This means many appliances will operate more efficiently throughout the discharge cycle using LiFePO4 batteries because the can operate at a consistently higher voltage.

Discharge rate - The BMS built into ***CMPower*** batteries has a 100 amp or 150 amp continuous discharge capacity. This means the batteries can sustain a heavy continuous discharge without damage or degradation. Continuous Discharge capacity is the number of amps the battery can release continuously. Rapid charge is also a benefit of the high-power heavy duty BMS built into ***CMPower*** batteries.

Battery Monitoring - ***CMPower*** LiFePO4 batteries are equipped with Bluetooth and a free app for easy and effective monitoring the battery State of Charge (SOC). SOC is the amount of power retained in the battery as a percentage of its rated capacity. A 60% SOC for a 100 Ah battery means 60 Ah of useable power remains in the battery. This is important because unlike lead acid batteries, LiFePO4 batteries maintain a nearly constant voltage between 12.8 and 13.4 volts so a volt meter is of limited value for measuring SOC. A built in Bluetooth capability enables real time monitoring of each battery through an app on an Android or IOS smartphone or tablet. The app displays the state of charge (SOC) of the battery, the amp draw and voltage level, the temperature, the time to full charge and the number of charge/discharge cycles. This capability is nearly equivalent to having a built-in battery bank monitoring system. Monitoring is for individual batteries, not an entire battery bank.

Compatibility - While the optimal charging parameters vary between LiFePO4, AGM and lead acid battery technology, the BMS built into ***CMPower*** LiFePO4 batteries compensates for this. Thus, ***CMPower*** LiFePO4 batteries are compatible with most lead acid and AGM battery charging systems. We recommend a charger with a minimum capacity of 10 amps.

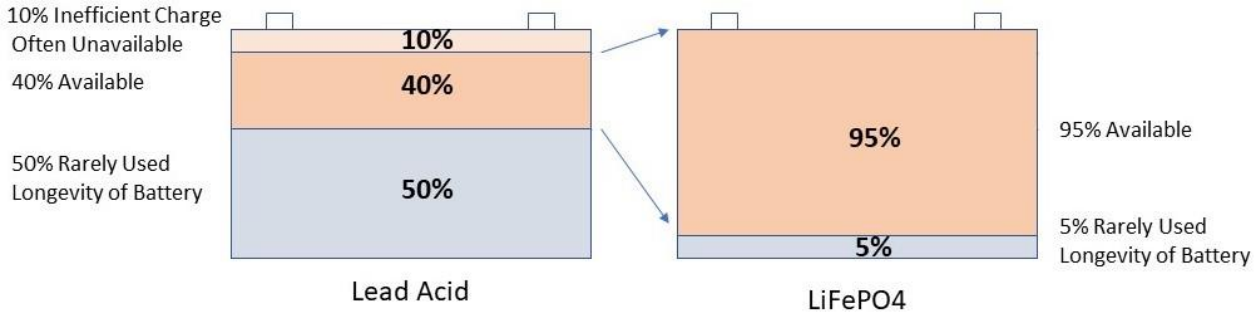
Safety – Lithium-ion batteries have a reputation for catching fire. This is not so with LiFePO4 batteries, a very different technology. The built-in Battery Management System (BMS) monitors the state of charge of each cell group and manages the temperature, charge and discharge rates. The BMS will prevent over-charging and over-discharging by disconnecting from the source. There are no toxic chemicals or gases as in many types of lead acid batteries. Also, the individual cells within the battery are designed so that they will not “run away” and overheat from excessive discharging.

Efficiency – In off-grid applications such as solar and wind, energy efficiency can be of crucial importance. The round-trip energy efficiency (discharge from 100% to 0% and back to 100% charged) of the average lead-acid battery is 80%. That is, 80% of the power applied to charge the battery is actually stored. The round-trip energy efficiency of a LiFePO4 battery is over 98%. The charge process of lead-acid batteries becomes particularly inefficient when the 85% state of charge has been reached, resulting in charging efficiencies of 50% or even less. In contrast, a LiFePO4 battery will still achieve 98% efficiency under most charge/discharge conditions. This means more of the charging power is actually stored in the LiFePO4 battery.

Weight/Power Ratio - A typical 100 Ah LiFePO4 battery weighs about 31 pounds. A comparable lead acid battery is over twice that. Because LiFePO4 batteries can be safely drawn down 90% vs 50%-60% for lead acid, fewer batteries are required to achieve the same power. Battery weight combined with useable power capacity means battery weight can be cut by more than half using LiFePO4 batteries. Also, LiFePo4 batteries will occupy up to 40% less space than equivalent lead acid batteries.

For example, 3 group 31 110 amp hour lead acid batteries weighing a total of 200 pounds can be replaced by 2 group 31 size 100 amp hour LiFePO4 batteries weighing a total of 66 pounds. Both configurations have roughly the same power capacity because the lead acid can be safely drawn down 50% (330 amps @50% = 165 amps) and the LiFePO4 can be safely drawn down 95% (200 amps @ 95% = 190 amps). Also, the lead acid will endure 300-500 cycles and the LiFePO4 over 2,000 cycles.

Example:	**Lead Acid**	**LiFePO4**
Battery Bank	3 Group 31 110 Ah	2 Group 31 size 100 Ah
Rated Capacity	330 Amps	200 Amps
Useable Capacity	165 Amps	190 Amps
Charge/discharge cycles	300-500	2,000-4,000
Weight	200 pounds	62 pounds



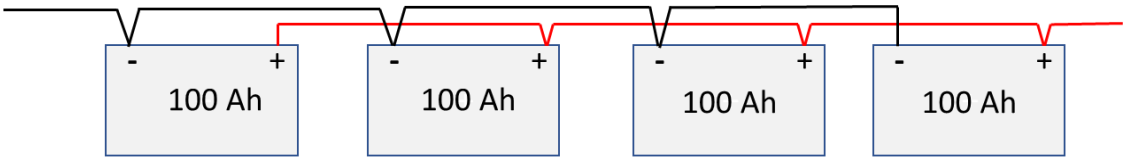
Bottom line - ***CMPower LiFePO4 marine batteries are lighter, can be drawn down 95%, hold a steady voltage, are plug compatible with most lead acid chargers, and charge more quickly than lead acid batteries. They are nontoxic and safe. They are more expensive than lead acid however their advantages often outweigh the additional expense.***

Installation and Operating Considerations – *CMPower* Batteries

Mounting - The batteries can be positioned and secured in any direction; bottom or side. There is nothing to leak out. The area around the batteries should be ventilated for heat dissipation.

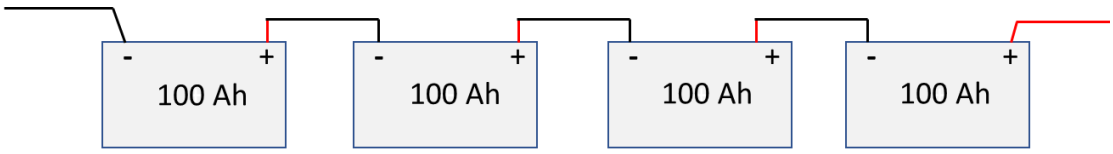
Wiring – **Up to four batteries may be wired in series and up to ten batteries may be wired in parallel** . See wiring diagrams below:

Parallel – Up to ten batteries may be connected in parallel to increase the current capacity of the battery bank. When batteries are connected in parallel, the voltage of the system does not change, but the current capacity of each battery is additive. For example, two 100 Amp batteries connected in parallel can deliver 200A continuously. All cables and connections MUST be able to accommodate the high currents that can be delivered by the battery bank. Appropriate fuses and circuit breakers are also highly recommended to protect downstream appliances.



Parallel - 12 V 400 A Draw Capacity 360 Ah Capacity at 90%

Series - Up to four batteries may be connected in series to increase the voltage of the battery bank up to a 48V system. When batteries are connected in series, current capacity remains the same, and the system voltage is additive. For example, three 100 Amp batteries connected in series can deliver 100 A continuously at a nominal 36V.

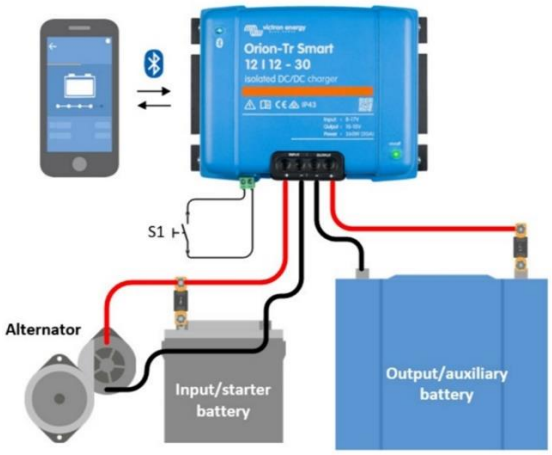


Series - 48 V 100 A Draw Capacity 90 Ah Capacity at 90%

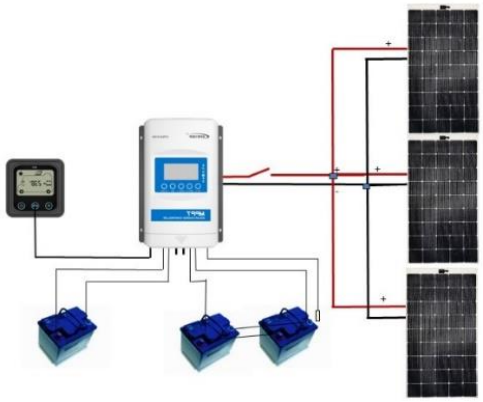
It is important that all batteries be of equal charge greater than 80% before connecting them in series or parallel.

Breaking in the Batteries – New LiFePO4 batteries tend to become more efficient as they are used. It may take up to ten charge cycles for a LiFePO4 battery to reach its full potential in charging and discharging.

Charging dissimilar battery banks from a single charging source – LiFePO and lead acid or AGM batteries should never be combined. They are not compatible. Charging a lead acid or AGM engine start battery and a LiFePO4 house battery bank is possible if the proper equipment is used. A DC to DC charger is an excellent option. The following wiring diagram is an example of how a Victron Orion DC-DC charger can be installed to charge both battery banks from an alternator or generator. The start battery is directly charged and the Orion manages the charge to the LiFePO4 house bank enabling two different charge profiles from one charging source.



Charging two dissimilar battery banks from a single solar controller - A second alternative to charging from a single solar source is a dual output MPPT solar controller. The EP Solar DuoRacer is such a device. It is designed to put full charge into the house bank and a trickle charge to the start battery to keep it topped off. The following wiring diagram illustrates how this solar controller can be installed.



Calibrating the BMS – The BMS has a built-in learning function that monitors the performance of each LiFePO cell. It will take up to three charge/discharge cycles (charge to 100%, discharge to 10%) for the BMS to calibrate to the actual performance of the battery.

Note: The State of Charge (SOC) shown on the battery Bluetooth app for each battery may vary by as much as 30% initially when wired together in series or parallel. If after several charge/discharge cycles the SOC varies significantly between batteries, separate the batteries and charge each one to 100% SOC. Then reconnect. This should bring them into sync. This may need to be done annually for batteries wired in series.

Parameters for Charging LiFePO4 Batteries –

If a "LiFePO4" setting is not available on the charging device (controller), use the "USER" function to program and set the following parameters:

- **Absorption voltage:** 14.4 volts (acceptable range is 14.2 to 14.6 volts)
- **Absorption Time:** The recommended setting is half an hour or more per 100ah of LiFePO4 battery. (for example: for two 100Ah batteries select 1 hour) The default on most controllers is 2 hours.
- **Float Voltage:** 13.5 volts (13.4 to 13.6 volts is acceptable for LiFePO4 batteries although float is not necessary)
- **Equalization voltage: Do not** equalize LiFePO4, turn off the equalize function, but in case it ever runs a cycle or equalization can't be turned off set to below 14.6 volts.
- **Low Temperature cut-off:** -5 degrees C, 20 degrees
- **Charging Amperage -** The recommended charging amperage is .2C to .5C continuous where C is the rated capacity of the battery. (For a 100 Ah battery 20A to 50A).
- **Temperature Compensation** - Temperature compensation is not needed or recommended with our LiFePO4 batteries.

Bluetooth Battery Monitoring System - The built in Bluetooth feature enables the monitoring of each battery State-of-Charge (SOC) via a Smartphone or tablet app. ***CMPower*** uses several apps depending on the BMS used. The app displays the amps currently charging or discharging from the battery at a point in time, the voltage of the battery, SOC %, the temperature of the battery, the time to full charge, the time to full discharge and the number of charge/discharge cycles the battery has incurred. If the battery part number ends in BL1 or BL5 the name of the app is Smartec-BMS. If the battery part number ends in ML or ML5, the name of the app is CMPower. More information on the apps is found at the end of this manual.

Operating and Storage Temperature Range - LiFePO4 batteries can be stored in temperatures of -10°F (-20°C) to 100°F (+38°C). It is recommended they not be charged and discharged at temperature below -4°F (-20°C) It is recommended that the negative terminals be disconnected for winter for long-term storage so there is no chance of draining the batteries while in storage. Complete discharge of LiFePO4 batteries for an extended period of time will likely damage the cells or significantly reduce the charge/discharge cycle life. LiFePO4 batteries should be recharged every 6 months.

Disposal - LiFePO4 batteries marked with the recycling symbol must be processed via a recognized recycling agency. Batteries must not be mixed with domestic or industrial waste.

Other Installation Considerations – Summary

- Batteries can be mounted on bottom or any side
- Batteries should be mounted in a moderate temperature environment

  – not in the engine room
- All positive wires should be fused near the battery bank per ABYC standards
- All batteries should be within 3% State of Charge before connecting together
- Lead acid or AGM batteries should not be connected with LiFePO4 batteries
- Battery monitor - Peukert constant should be set to 1.04 (1.25 for lead acid)
- Charging parameters for charging sources may need to be adjusted (max voltage, etc)
- Charging source should have a charging capacity of at least 10 amps.

Things to Unlearn when moving from Lead Acid or AGM Batteries to LiFePO4 Batteries -

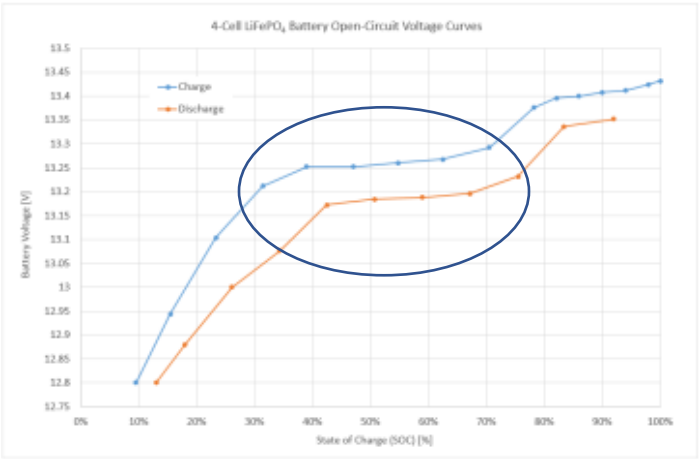
- **Constant Voltage** - Voltage does not decrease significantly as battery power is used.
- **Battery charging** – Charging to full is not necessary. 95% of power rating is available, not just top 50%.
- **Battery Charging** – Short absorption stage, no equalization, float stage is not necessary.
- **State of Charge** – 50% State of Charge is fine. 45% of power is still available.
- **Faster more efficient charging** – More power is saved faster.
- **Discharging** – Constant discharge voltage so appliances run more efficiently resulting in decreased power usage.
- **Maintenance** – No toxicity. No water level to check, no heat to be concerned about.
- **Easy Winter Storage** – Simply disconnect until next season.
- **Easy Monitoring** – Bluetooth app displays SOC and power remaining anytime from Smartphone.

Battery Monitoring Considerations

Programming a Battery Monitor – Battery monitors measure the power charging and discharging the battery bank. Most battery monitors are designed to operate with lead acid battery technology. Unless properly programmed, battery monitors can be inaccurate with LiFePO4 batteries. The key to improving the accuracy of a battery monitor is properly setting the Peukert coefficient. (This is F08 on the Xantrex Link series monitors.) **We have found the proper Peukert coefficient for LiFePO4 batteries is 1.02 to 1.04.** We have also found that increasing the rated battery capacity by 90% is helpful. For example, set a 200Ah battery bank to 180Ah. This is because the charging and discharging efficiency of LiFePo4 batteries is significantly higher than lead acid or AGM batteries and because most battery monitors assume only 50% of the rated battery capacity is useable which is the case with lead acid and AGM batteries.

Measuring State of Charge (SOC) –

Unlike lead acid batteries, LiFePO4 batteries maintain a near constant voltage until discharged up to 90%. This voltage ranges from 12.8 to 13.4 volts. Thus, a voltmeter provides only an approximation of the battery SOC. See table below:



Battery Voltage at Rest

13.3 V or higher	Over 80% full
13.2 V or higher	At least 70% full
13.15 V or less	Less than 40% full
13.0 V or less	Less than 25% full

To more accurately monitor battery SOC, ***CMPower*** batteries are equipped with a Bluetooth capability so the battery SOC can be monitored from a smartphone or tablet.

Bluetooth Battery Monitoring System - The built in Bluetooth feature enables the monitoring of each battery State-of-Charge (SOC) via a Smartphone or tablet app. ***CMPower*** batteries use several APPS depending on the BMS used. The app displays the Amps currently charging or discharging from the battery at a point in time, the voltage of the battery, SOC %, the temperature of the battery, the time to full charge, the time to full discharge and the number of charge/discharge cycles the battery has incurred.

See details for installing and using the Bluetooth apps at the end of this manual.

Low Battery Alarm – Some ***CMPower*** batteries are equipped with a buzzer alarm that sounds when the battery is at a 20% and a 15% State of Charge. The alarm feature can be turned on and off using the button on the top of the battery. Press the button switch down to turn on the alarm system and release to turn off the alarm system. This alarm is particularly useful on boats using the battery bank as both a house and a start power source. It is also useful for fishing boats that us the same battery for both starting the main engine and powering the trolling motor.

Caution

Do not reverse polarity of the battery as this will damage both the battery and the devices being connected.

- Do not submerge the battery.
- Do not expose battery to excessive heat or fire.
- Do not short circuit the battery.
- Do not mishandle, drop, throw or apply excessive force to the battery.
- Do not operate with loose terminal connections
- Do not combine lead acid and LeFePO4 batteries in the same system. All batteries should be of the same make and model.
- **Be sure all batteries are at the same State-of-Charge before connecting in series or parallel.**
- Recharge batteries every 6 months at a minimum when in not in use. Remove all connections from the negative terminal when storing for long periods of time.

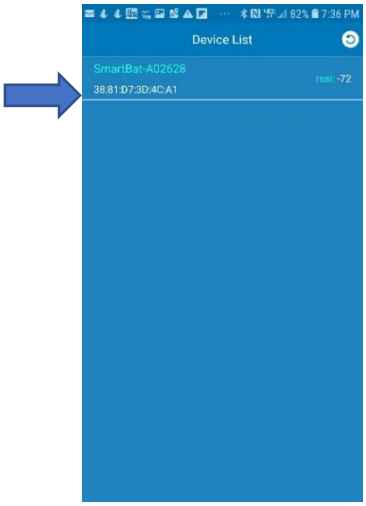
Warranty- 5 Years+

Custom Marine Products warrants each branded battery to be free of defects for a period of 1 year from the date of sale as determined by either the customer's sale receipt, or other proof of purchase plus an additional 4 years prorated. Within the warranty period CMP will credit, replace or repair the product and/or parts of the product if determined to be defective in material or workmanship. *CMPower* batteries are built to last a minimum of 2,000 cycles and still maintain 80% of rated energy capacity. This warranty applies to the original owner but may be extended at the customer's request.

Custom Marine Products (CMP) has no obligation under this Limited Warranty for products subjected to the following conditions (including but not limited to):

- Damage due to improper installation; loose terminal connections, under-sized cabling, incorrect series (maximum of 4 batteries) or parallel connections (maximum of 10 batteries), reverse polarity connections or insufficient space for airflow
- Environmental damage such as inappropriate storage conditions as defined by CMP, exposure to extreme hot or cold temperatures, fire or freezing, or water damage, impact or collision
- Battery was not stored in compliance with CMP instructions
- Damage due to improper operation or maintenance such as under- or over-charging the battery, cold temperature charging, lack of cleaning resulting in corroded terminal connections or build-up of dirt, debris, organic matter, fossil fuels or chemicals on the battery casing
- Product that has been opened, modified or tampered with
- Product that was used for applications other than which it was designed and intended for by CMP or product that was under-sized for the application

Bluetooth Battery Monitor App for *CMPower* LiFePO4 Batteries – BL1 and BL5 Series



Download the App
Android: Google Play – Smartec-BMS
Apple: Apple Store – Smartec-BMS

Select the battery to be monitored from the list of batteries.

Refresh the list by pressing the round button in the upper right corner of the page.

Note: the rssi number to the right of each listed battery is a measure of the strength of the Bluetooth signal. The higher the number, the weaker the signal.

The battery monitor page shows the current being charged to or discharged from the battery, the voltage level of the battery and the State of Charge (SOC) of the battery.

Note: The Cycle number is the number of times the battery has been discharged to 80% and recharged.

The battery will withstand between 2,000 and 4,000 cycles if properly cared for.

Swipe right to left to go to the next page.

The graphic indicates the temperature of the battery and the amp hours remaining (RMC) at the current rate of discharge.

The rated capacity (DCAP) and the full charge capacity (FCC) is shown below the graphic. The FCC is computed based on the temperature of the battery and other factors.

The bottom of the page shows the average minutes to full charge and to full discharge based on the current state of charge or discharge. The value of 65535 is displayed when there is no activity with the battery.

Bluetooth Battery Monitor App for *CMPower* LiFePO4 Batteries – ML Series

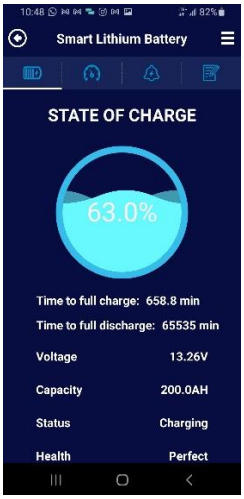
Download the BMS app.

Android:	Google Play – CMPower
Apple:	Apple Store – CMPower

Activate the app to see a list of the *CMPower* batteries within range.

Select the battery to be monitored.

Note: the rssi number to the right of each listed battery is a measure of the strength of the Bluetooth signal. The higher the number, the weaker the signal.



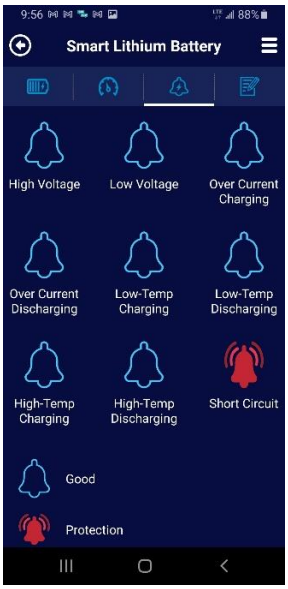
The second battery monitor page shows the State of Charge (SOC) of the battery, its voltage, its capacity, its status (standby, charging, discharging) and the health of the battery.

Select the next screen by pressing the icon at the top of the screen or swiping right to left.

The third battery monitor page shows the current being charged to or discharged from the battery, the voltage level of the battery, the temperature of the battery and the number of charge/discharge cycles that have been recorded.

Note: The Cycle number is the number of times the battery has been discharged to 80% and recharged.

The battery will withstand between 2,000 and 5,000 cycles if properly cared for.



The fourth page displays alarms activated by the Battery Management System to protect the battery cells. The image shows an alarm on due to a short circuit in the boat wiring.

The alarm icons are turned off when the battery is charged.

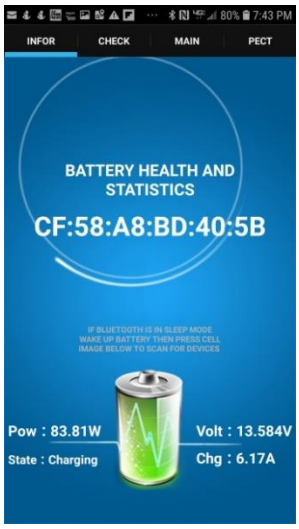
Bluetooth Battery Monitor App for CMP LiFePO4 Batteries – GC Series

Download the App

Android: Download from CMP website Apple: Smart-BMS

Press the green battery image to activate the list of available batteries to observe. Select the battery to be monitored from the list of batteries and Bluetooth appliances.

If the word NULL is displayed on the screen, the Bluetooth system is in sleep mode. Wake it up by putting a charge or discharge on the battery. Connect to the battery of choice by pressing on the green battery image. Once connected, the battery serial number will be displayed.



The State of Charge information will be displayed next to the image of the battery.

Swipe right to left to go to the next page.

Press the check button in the upper left area of the page to activate the battery health check process.

The four areas of health will be tested and the results will be displayed at the bottom of the page. If all four item appear with a red X, chances are the battery connection has been interrupted and the Bluetooth feature must be reactivated.

The bottom of the page shows the average minutes to full charge and to full discharge based on the current state of charge or discharge. The value of 65535 is displayed when there is no activity with the battery.

Swipe right to left to go to the next page.

The Main data page is used to monitor the current activity of the battery. The battery image displays the charge remaining in the battery.

Note: LiFePO4 batteries consist of four sets of cells wired together in series. The Battery Management System (BMS) monitors each of the cell sets and displays the voltage of each set on this page.

The BMS also tracks the number of charge and discharge cycles. This battery should support at least 3,000 charge and discharge cycles.

Swipe right to left to go to the next page.

The last page displays battery status in detail. This page is used to troubleshoot issues with the battery should they occur. This page displays the min and max points for various operating aspects of the battery.