Are Lithium Batteries for You? Part I of II

Published on September 8, 2021
Submitted by Dave and Sherry McCampbell
SV Soggy Paws, St Francis 44 Mk 2 Catamaran

About a year ago, after much careful study, we embarked on replacing our 13-year-old quality Sonnenschein Gel batteries with lithium LiFePO4 prismatic cells. In doing so we quickly learned the following:

- The technology and supporting equipment are still evolving with a multitude of choices available.
- No serious cruiser should change from lead acid to lithium batteries unless they are willing to spend a substantial amount of time in research, effort and money for a proper installation.
- There are many opinions regarding how best to do this; even the experts' opinions differ. But there are several trusted information sources. See the list at the end of this article.
- Competition among sellers of lithium equipment is stiff, especially among cell and battery management system (BMS) producers.
- Not everything you read on seller websites is true, some important things that are not there are true, and more specifications are better.

In order to create a successful installation, you must have an open mind, be curious about what others have done and be involved in all of the installation work.

Our installation is optimized for a catamaran cruising full time overseas. We have little tolerance for jury rigs, marginally safe practices and unnecessarily high-cost equipment. We believe that if installing lithium on a boat, it is necessary to develop the skills to make repairs ourselves with adequate spares and proper tools. After significant research, money expended and living with the new technology for about 9 months, below find our thoughts on how to complete a DIY LiFePO4 lithium cell installation on a cruising sailboat. This may differ significantly from an installation for an off-grid home, an electric vehicle and even a power boat used for coastal cruising.

When we purchased our St. Francis 44 catamaran 6 years ago, the house bank consisted of six 6-volt Sonneschein Solar Block 200 batteries, for a total of 600Ah. They are very high-quality German Gel batteries. In early 2020, locked down by COVID, and with our gel battery bank now 13 years old, we decided it was a good opportunity to upgrade to new Lithium technology. The Gels might have lasted several more years according to Gel literature, but given our location in SE Asia, and the time we had available, this was a good opportunity to upgrade. Had we not had a year's time to study the technology, place the orders, and make the many necessary electrical system changes, we would not have taken this on. It is not a project for those not willing to spend time learning how to do the installation properly themselves.

Lead Acid (LA) vs Lithium (LFP) Differences

Because of the vast differences between these two types of batteries, great care must be taken to not make a mistake during planning and installation. A number of different lithium type cells are available now, but LiFePO4 is the best choice for cruiser batteries. Below are some differences between LiFePO4 and LA technologies:

- LiFePO4 do not require a full charge on a daily basis; in fact, charging to only 90%, or even less, will give a somewhat longer service life.
- With LFP no absorption or float charging is needed, only bulk.
- 80-90% of LiFePO4 capacity is useable on a regular basis vs a maximum of 50% for LA under ideal conditions.
- Cell level monitoring and balancing are required with LiFePO4, whereas only total battery voltage is typically monitored for charging with LA.
- There may be some significant electrical system modifications required for a proper LiFePO4 installation. These include purchase of a reliable BMS, installing separate charge and load busses and using separate inverters and chargers.
- Charging with an alternator requires some modifications or you risk burning your alternator internals. You must either make sure the alternator is externally regulated by a smart alternator regulator with alternator temperature control, or use battery-to-battery charging, possibly with a lead acid battery connected to the alternator.
- Finally, long term storage requires placing LiFePO4 cells at about 50% state of charge (SOC) and in a relatively cool location for best longevity.

LiFePO4 Cells

After a great deal of research, we settled on prismatic style aluminum cased LiFePO4 cells, purchased directly from RJ Lithium in China. There are a number of other Chinese cell companies from which we could have bought, but other cruising friends locally had researched this and were buying from RJ. Their reputation was good, they offered documented grade A cells, the sales representatives were responsive, the website was informative, and they offered a 5-year warranty.

We purchased eight grade A 3.2-volt 271 Ah LiFePO4 cells, for about $150 each plus about $35 shipping each, for a total house bank capacity of 542 Ah. (Note that the shipping cost was excessively high due to the peculiarities of shipping into the Philippines via Hong Kong).

Of that 542 Ah, about 450 Ah are useable, so we increased our capacity by about 50% over our Gel battery bank's useful capacity. And we were able to remove 390 lbs of Gels and replace it with only 100 lbs of lithium cells.

All eight of our cells with taped terminal just out of the shipping boxes

Four of our prismatic cells with A testing stickers intact

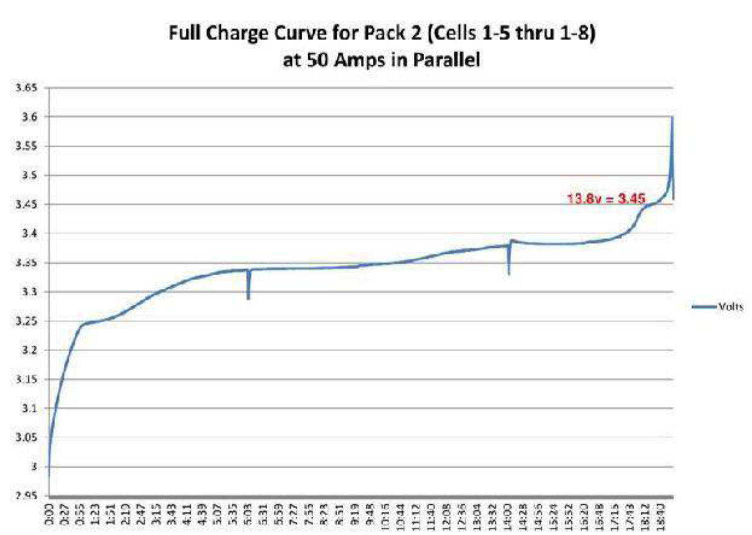
Later we discovered that we could have bought similar well-regarded EVE or Lishen cells for about \$100 each and modest shipping cost, sourced locally here in the Philippines, but without the longer warranty. So, our cost for the RJ cells was about \$1500 US including shipping. Lishen or Eve cells would have been around \$900 including shipping. The LFP cell market is constantly changing and competition is fierce, so this pricing may no longer valid.

Drop-In LiFePO4 Batteries

We do not recommend installing what is commonly referred to as ‘drop in lithium batteries’ on a serious cruising boat. They are better suited to coastal power/sail boats and outboards for the following reasons:

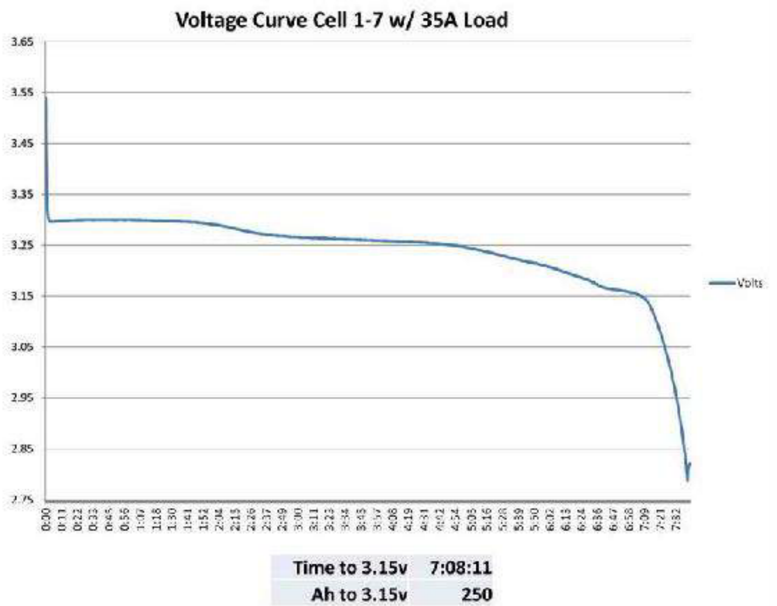
- The cells and BMS are often secured inside a sealed battery box and may be inaccessible if there is a problem.
- Typically, the BMS provided is SE Asian and uses small internal Mosfet relay components that must control the high currents usually found on cruising boats. If anything goes wrong the owner may have to replace the entire battery and BMS.
- There may be little adjustment available to the charging and other control parameters which you may want to customize for your installation and longer service life.
- They can be frightfully expensive compared to a DIY installation using individual cells and separate BMS.
- You will still need to do many of the same modifications to your electrical system as with a DIY system.
- If you can't take the time to do a proper DIY installation yourself, or with help from a knowledgeable friend who will teach you the system, we recommend buying quality Gel batteries to install into your existing electrical system.

Cell Matching and Balance



Charge curve for 4 cells in parallel charging at 50 amps for 18hrs and 40 minutes (small downward spikes are when we paused charging for the day) Note vertical voltage rise at approx. 3.5vpc (14.0v in a 12v system)

Factory matching of cell capacity and internal resistance is important to being able to maintain cell voltage balance. But it is a labor intensive, and therefore expensive, process. The cell charging curve is very flat in the middle between 3.20-3.4v per cell. Then it goes nearly vertical (the knee) as the cell approaches full state of charge (SOC) at about 3.40v per cell and above.



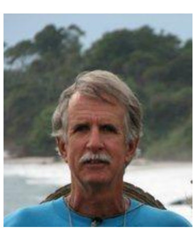
Likewise, as the battery is discharging, the voltage stays very flat until dropping off rapidly below about 3.15vpc as the battery reaches 10-15% state of charge.

This curve reflects one cell being discharged from "full" at 35 amps continuously. Of note is the relatively flat curve until the cell reaches 3.15 vpc, and the rapid drop-off after that.

Look for Part II of this article in October, 2021, in the Cruisers' Workshop on the SSCA website.

Comments on this article and other technical matters are welcomed in the Tech Talk Forum on the SSCA website at www.ssca.org. As a member, you can opt into this special interest forum by going to:
Member Profile→ Forums→ Forum Memberships→ Available Forums→ SSCA Tech Talk Forum.

Click the green icon to the right of the forum name to subscribe. When the pencil icon appears, click it to manage your forum preferences. If you have issues subscribing, contact Home Base at office@ssca.org.




Authors: Dave and Sherry McCampbell. Dave is a retired US Naval Diving and Salvage officer with over 40 years cruising and 8 sailboats worth of maintenance experience. Sherry is a retired computer programmer and is the navigator on their St Francis 44 catamaran, s/v Soggy Paws. The McCampbells are currently based in the Philippines.

If you've found this article useful, you'll find more similar information aimed directly at sailors/cruisers on the members-only portion of the SSCA website (www.ssca.org).

Are Lithium Batteries for You? Part II of II

Published on October 6, 2021
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If the cells are not perfectly matched in capacity and internal resistance, one cell can get to 3.65 volts per cell (vpc) well before the others when charging. This is an over voltage situation that can destroy that cell before the total battery voltage reaches an alarm condition. Likewise, when discharging, if one cell is slightly more depleted than the others, its voltage can drop rapidly to below 2.5vpc, a destructive under voltage situation, again while the overall battery voltage is still at a safe level.

Also, cells that are not well matched will have slightly different charge curves that might cause an automatic balancer to balance the wrong cells during charging. Our cells are not perfectly matched so their charge curves intertwine voltage levels as they are being charged. Sometimes the low voltage cell at the start of charging becomes the high voltage cell at charge termination. A good cell balancer can handle this and keep cell balance levels within a reasonable delta.

Well-regarded lithium factories produce thousands of individual cells a week. During initial testing those that match advertised specifications are graded as A cells. Those that do not become grade B cells and could have a range of problems. Both are sold on the open market. Grade A cells are usually a bit more expensive, have QR and testing stickers intact and usually have warranties. Grade B cells are often sold to off grid applications that use hundreds of cells so that they can afford to have a few that have problems. Cruisers would do well to always buy Grade A cells as it ensures full bank capacity and makes balancing much easier.

Even after being assured we had grade-A cells, and after exhaustive testing upon receipt, we ended up with one bad cell that would excessively self-discharge compared to the others. It lost a half millivolt (mv) at rest on a daily basis, which resulted in it quickly falling behind the others at charge termination. This is one symptom of a grade B cell. After much testing and consultation with RJ to discover the source we determined it to be an internal problem. To their credit, RJ replaced the cell under warrantee with us paying the $20 US shipping cost. Meanwhile, we had purchased two grade B similar cells from a Lishen internet store in Manila. They have performed well so far, but we will eventually go back to using all RJ cells in our house bank. The Lishen cells will become spares. And as we all know, cruisers can <u>never</u> have too many spares.

Configuration:

Banks of lithium cells are typically wired in sets of four 3.2 volt cells in series for a nominal 12 volt battery system. If you have a 24 volt electrical system, wire 8 cells in series. For more capacity than 4 or 8 single cells will allow, first wire cells in equal parallel sets, then those sets wire in series. We originally planned to configure our 8 cells into two 4-cell "batteries", with a 1-2-Both selector switch so we could switch between batteries if we ran into a problem with one battery. However, once we started wiring up the two required BMSs, we found that trying to control the separate loads, charging sources and two buses with two BMS's got very difficult. We also found that rearranging the cells from an 8-cell single bank to a 4-cell bank, if we ran into a very rare sudden cell problem, to be pretty simple.

So we ended up with 4 sets of 2 cells in parallel to make 4 "supercells", then those 4 cells in series for a 542Ah at 13.2v single bank. This also had the advantage of requiring only one BMS instead of two. Since we had ordered two BMSs we now had a spare. And as all cruisers know….. Whether this is called 2P4S or 4S2P configuration depends on who you ask. It is written both ways all over lithium literature and the internet. So be mindful of this when asking questions on lithium forums.

Cell Compression:

Most literature and experts on LFP cells recommend using a 'compression box' to house the cells. This is more of a 'limitation box' that prevents the cells from chafing against each other, terminals being damaged by connector tension as a result of expansion during charging, and sliding around as a bank in rough weather. Also, according to EVE Energy, one of the largest lithium cell manufacturers in China, their aluminum case cells require compression in order to reach their full service life. Many others agree.

So we built a compression box to store the cells using epoxy coated ¾" marine plywood and 3/8" SS threaded rod. Between the cells we used 1mm Formica to prevent the cell sides from shorting together. The box is strongly secured, has a polycarbonate cover, and is mounted under our main cabin settee only about 3 feet from the BMS and buses. Recommended is the addition of calibrated springs on the threaded rods which would allow us to control the amount of compression. We haven't gotten that far yet.

Our 8 LiFePO4 cells in their compression box in a 2P4S configuration.

RJ provided quality cell terminal connecting straps, which are made of multiple layers of flexible copper. With some research aluminum straps could also be used. All connections should be firmly fastened to the terminals.

Front of our battery box, cover on and secured.
Red cable is positive and brown negative. Small gray wire is solar MPPT sense.

Battery Management System (BMS):

A good BMS is a critical component of a LiFePO4 system. Unlike most lead acid battery monitors that display overall battery voltages, a good BMS should monitor individual cell voltages. So a BMS can watch the voltage and state of charge of each cell, and make appropriate decisions regarding when to disconnect charge sources in case of an over voltage event (HVD) or disconnect loads in case of an under voltage event (LVD) in order to prevent cell damage.

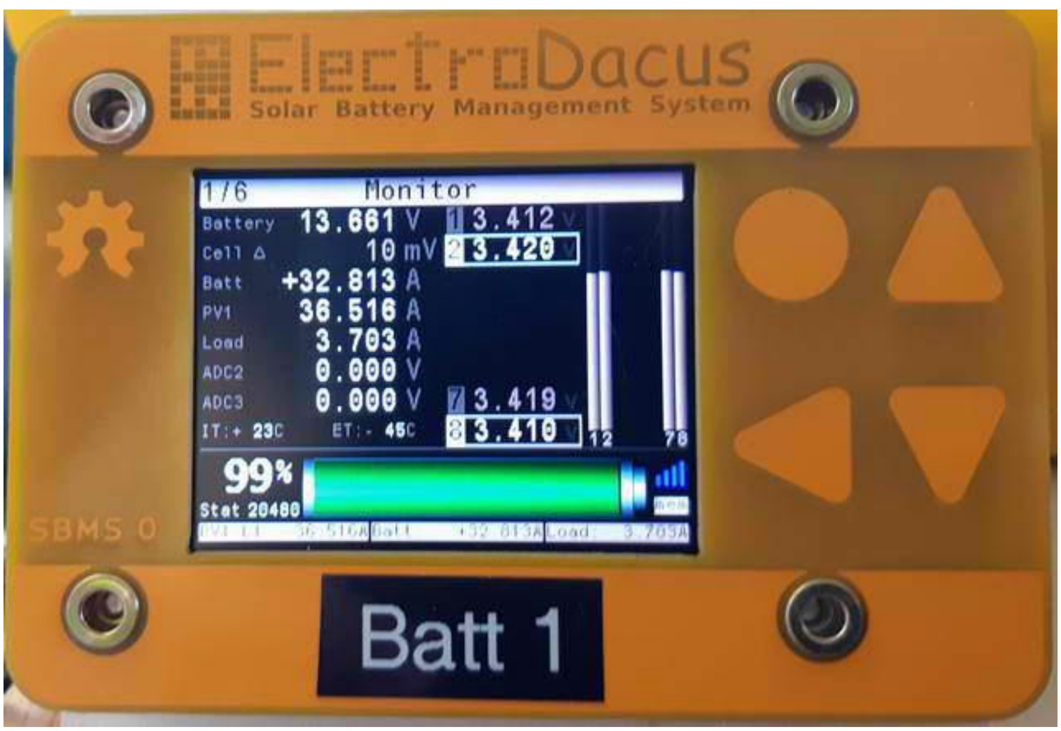
There are two types of BMSs. One uses small internal MOSFET relays to turn on and off charging and loads when required. The other type of BMS can control much larger and more sophisticated external relays to do the same. Since loads like inverters and windlasses and charging sources like alternators and generators might involve relatively high currents, cruising boat systems are better done with a BMS that uses high-capacity external relays.

An important BMS feature is its ability to display what it is doing and important battery details such as voltage, current and SOC. Options include hard wiring to a display device such as a computer, wireless Wifi, and wireless Bluetooth using an application. We are using WIFI so that we can see what is happening with our system when on or off the boat.

Also, a good BMS will have some sort of cell balancing capability. A couple hundred milliamps are sufficient to keep most reasonably matched and balanced cells in line. Although most BMSs use some form of low current passive balancing, and that is usually sufficient, larger active balancers that remove excess amp hours from high voltage cells and place it in lower cells are commonly available. This just reduces the time it takes to balance wayward cells with the others.

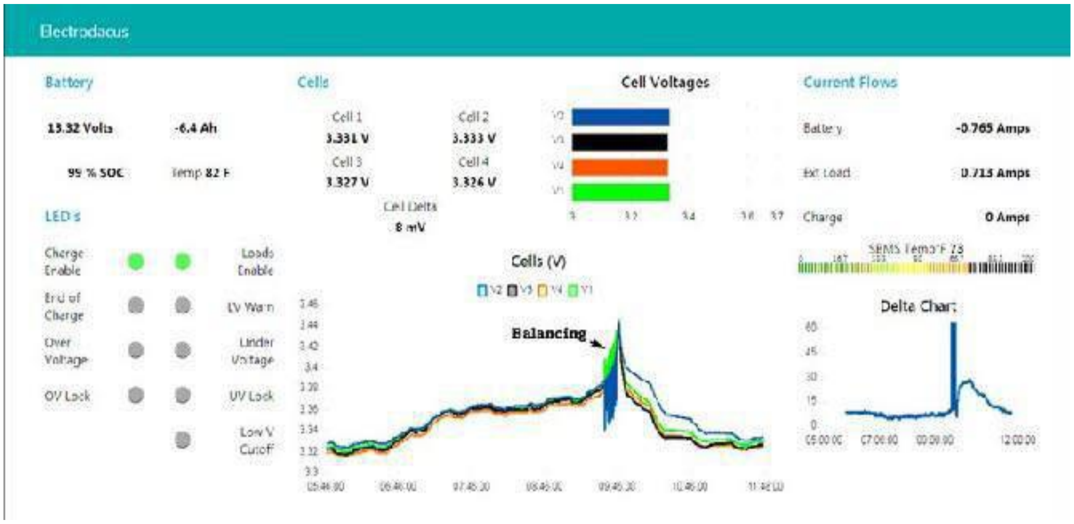
BMSs range in price from inexpensive/dumb $15 USD small open boards with no user interface, to high-quality programmable BMSs that will integrate seamlessly with existing proprietary equipment like smart Victron components for about $600 USD. Price doesn’t always give you the best equipment with features you may want, but better BMSs are priced over about $100 US. There are many internet sources for comparing BMSs. But remember serious cruisers cannot afford unreliable gear, so paying for quality and reliability is worthwhile.

We chose a smart programmable BMS, an ElectroDacus SBMS0, made in Canada by a very well regarded small company. This one is targeted at the DIY Solar community and can control multiple external relays with many adjustable parameters. It has a very detailed monitor, a small balancer, excellent HVD/LVD protection capability, and a Wi-Fi interface. Just about every parameter for charging, discharging, balancing and HVD/ LVD control is adjustable by the user. The HVD/LVD controls have 6 different ways to set the control functions.



The SBMS0 main monitor screen, one of about two dozen screens available

The ElectroDacus SBMS0 also has built-in historical logging, and with the addition of an optional Wi-Fi module, can provide a wireless MQTT feed to integrate into any Internet of Things (IoT) system. This allows user configuration of system information screens such as ours below. Using this setup (and leaving a computer aboard, running, connected to the internet) we can monitor what our system is doing using internet from anywhere in the world. That is pretty amazing!



Our battery management monitoring screen, using the MQTT feed from the ElectroDacus, and built using Mosquitto and Node-Red. This is under constant revision by our onboard IT person. (Read more about this here.)

We are pleased with our choice of BMS, but it has involved a steep learning curve. (LiFePO4 in general is a big learning curve!) Considerable help on this BMS is available from the detailed User Manual, an even more helpful user-built Beginners' Guide, two forums with experienced users and the developer, Dacian, answering questions, and multiple articles and YouTube videos. Dacian will even diagnose problems and fix them if necessary, usually at no charge, if you send the unit to him. And then there is the detailed information about our installation on our ElectroDacus page on our website.

Wiring & Fuses:

It is important to use proper wire sizes, quality terminals, and make good connections because proper monitoring and balancing involve millivolts and milliamps (that's thousandths of volts and amps). Any weak connection will affect readings and function. The display and balancing wires are typically 20 gauge or smaller, so you might need better crimping and stripping tools. For example, the ElectroDacus system uses twisted solid Cat 5/6 24-gauge wires for connections to the SBMS0. Common stripping tools won't strip those small wires. Our tool recommendations are below.

Fusing and circuit breakers must be of quality construction and function as advertised. These relatively small batteries can produce huge amounts of instantaneous amps if shorted. Although fires are rare with LiFePO4 technology, a shorted cell can melt tools instantly and cause sparking that can ruin your day and your boat. Proper installation will also prevent disapproval of an insurance claim should something go wrong. It is worth checking your insurance policy to see if there are any specific clauses about LFP batteries.

Charging Using Relays & Shunts:

When using a BMS capable of controlling external relays, care must be taken regarding which relays to use for which circuits. And quality shunts must be used in order to display accurate current and State of Charge (SOC). Below is a list of those we used, but there are many other options:

- Solar charging: In case a High Voltage Disconnect (HVD) event occurs we used two of the ElectroDacus DSSR20 relays for the SBMS0 BMS to disconnect the four 200 watt panels from the Morningstar Tristar-60 MPPT solar controller. They can each handle up to 20 amps of current (50-amp version available soon), so are perfect for our 800 watts of 24v solar panels. For now, the MPPT handles the daily charging and termination to 13.8 v (3.45vpc). Our MPPT has a battery sense wire, so has a very accurate measure of battery voltage (not all MPPT's have battery sense wires).

  The SBMS0 cuts off charging in case of a cell high voltage event at 3.55 vpc. The SBMS0 could handle both disconnects, but we need the MPPT in this circuit anyway since it handles the voltage conversion from the 24v 72 cell panels to the boat's 12v electrical system. And the MPPT gives us an extra layer of independent disconnect protection.

  If the panel voltage matched the boat's voltage there would be no need for the expensive solar controller, and the BMS could handle charge termination without any solar controller (one of the useful features of the ElectroDacus design).

- Shore Power Charging: We have a Sterling Power Pro 60 Amp AC charger, which we bought specifically because it has a "LiFePO4" charge profile. Unfortunately, that charge profile is unrealistic for LiFePO4 cells. The minimum absorb setting is 60 minutes, so if it is controlling the charging it will have to be manually shut off when the battery reaches charge termination.

  However, cutting off charging can be controlled by the BMS using a Fotek 40 amp AC-DC solid state relay (SSR) placed in the AC load wire between shore and the charger. This allows the BMS to control the charge termination or a high voltage event by disconnecting the AC, not the DC wiring. We rarely use shore power for charging even at a dock, so for now we are just disconnecting the unit manually from the batteries using a large circuit breaker in the DC wiring.

- Alternator Charging: We have two small 60 amp externally regulated alternators, one on each engine. Our Very Smart Regulators (VSR) can be easily configured to handle LiFePO4 charging with both time and tail current regulation and temperature and voltage sensors. (Our VSR's are the predecessor to the popular Wakespeed 500 Smart Alternator Regulator). They also have an output throttle which we have set to curtail charging amps to 75% of maximum possible.

  The SBMS0 controls the alternator HVD by disconnecting the ignition/enable wires from the regulators using 10 amp Fotek DC-DC solid state relays (SSRs). This is preferable to disconnecting the alternator field wire from the regulator because it safely turns off both the alternator and regulator. Since we don't normally use the alternators for charging, we also have a simple on off switch in the ignition wire so charging can be shut down when the engine is running. However, we are still refining this system.

- Switches and Resistors: Most of these relays are a little larger than a matchbox and use about 5 milliamps or less when energized. Because we rarely need to use the AC charger or alternators, we also have small on-off switches in their control circuits from thbue BMS to turn the relays off when not in use. These relays require a small resistor in the circuit to prevent excess current getting to the SBMS0 in case of a short.

- Bus Disconnects: As a second line of defense in case of over/under voltage problems, the SBMS0 also controls two high capacity Victron Battery Protect relays. These are placed between the battery shunts and buses. They can separately disconnect the entire charge or load buses from the battery in case of a problem that wasn't handled by the charging sources or other relays. Their HVD/LVD voltages are set at cell voltage maximum/minimums of 3.65 and 2.50 vpc.

- Shunts: In order to be able to sense current and calculate SOC, shunts are required. If one is used for the battery and one for the charging sources, charge, battery, and load currents can all be displayed. In the ElectroDacus system, both shunts are mounted in the positive battery wiring. We used quality shunts from Reidon, properly oversized for our equipment.

Initial Testing and Balancing:

Not everyone will have the time or want to do the initial testing that we did. We had purchased the cells with an electrical engineer friend--a total of 24 prismatic 271 Ah cells. Our friend had the proper large load and bench power supply equipment available, and we wanted to fully test that the capacity of the cells we received matched the manufacturer specs. This may be the only way to discover early on a cell lacking capacity or with a high internal resistance.

As is normal, the cells were shipped to us at about 60% SOC. We started by charging all cells up individually to 3.6 vpc. Then we discharged them individually to 2.8 vpc and graphed the resulting discharge curve and capacity. Finally, we made a graph of the charge curves taking them back up to 3.6 vpc. (See graphs earlier.)

After removing the charge, each cell fell back to a rest voltage of about 3.35 vpc. All capacities were within a few amp hours but just below 271 Ah, since we did not fully charge or discharge them. The charge and discharge curves were similar, but not exactly the same. Internal resistance for all cells was measured to be .076 ohm at 3.0 vpc.

Top Balancing:

Later we did what is commonly referred to in the literature as a 'top balance'. That is taking all cells in parallel to some voltage above 3.5 vpc, in our case 3.62 vpc, and letting them absorb to about 5 amp or less tail current. This should get them all balanced to within a few millivolts of each other at charge termination. Although we did this a second time to less than 1 amp tail current, we did not find it to be very effective at getting the cells closer than about 100 mv apart at charge termination of 3.45 vpc. It might have been better to take them only to our charge termination voltage and let them absorb there to an absolute minimum tail current. There are a number of opinions on the internet as to exactly how best to do this.

We found the most effective balancing technique to be using our bench power supply and adjustable load equipment to manually get the cell voltages closer at charge termination. This consists of attaching the equipment to individual or a group of cells to raise or lower their voltage by adding or subtracting milliamps over time.

Regardless of how the cell voltages look at rest, they will always have a much higher delta when the voltage reaches the knee because one cell will always reach the knee ahead of the others. After a week or so of adding and subtracting milliamps, cell voltage deltas can be reduced to an acceptable to us 20-30 mV. Many consider deltas in the 100 mV range to be acceptable. Then the small passive automatic balancer in the SBMS0 can be used to keep them in balance, despite our not well-matched cells.

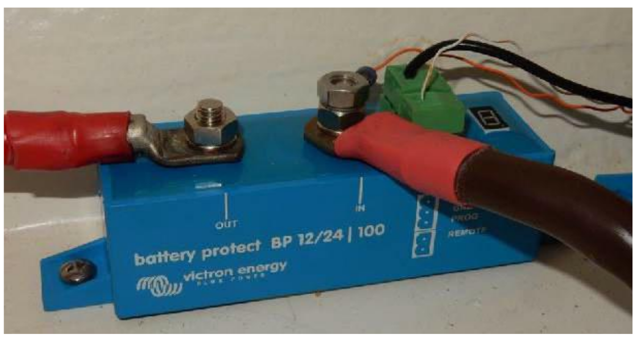
The balancing mechanism on our BMS uses resistors that are selectively latched in during charging. When the cell voltage delta goes above the minimum balancing set point, these suppress charging to the highest cell(s). So the lowest cells receive full charge current while the higher ones receive less.

Our cells are now resting with a 7 mV delta and 20-30 mV delta at charge termination. We consider these figures are entirely adequate for cell balance.

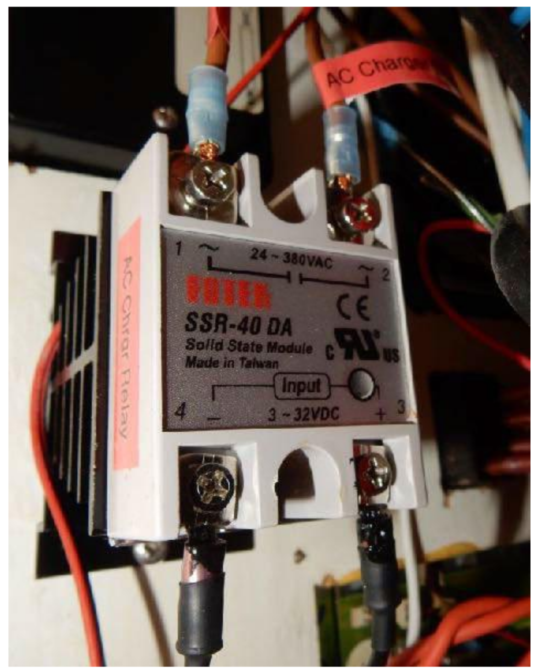
Tools and Equipment: We purchased the following equipment to help us better do the installation:

- Long Wei PS1310F DC bench power supply. Amazon Link
- 20 amp 180 watt adjustable load Amazon Link
- ISDT BattGo BG-8S 2 ea monitor balancer Amazon Link (used for cell voltage monitoring prior to receiving ElectroDacus)
- UNI-T UT-61E very accurate multimeter with logging Amazon Link
- UNi-T UT-210E clamp multimeter Amazon Link
- Titan 11477 ratcheting terminal crimper, yellow and black handles Amazon Link
- Klein Katapult 11063W wire stripper Amazon Link
- Klein 11074 blade for 16-26 ga (cat 6) wire Amazon Link
- Manual large terminal crimper for #8 to 2/0 terminals (onboard)
- Various wire terminals from 2/0 to 24 ga, heat shrink tubing, Cat 6 cable
- Assortment of 1 watt resistors
- Fotek AC-DC 40 amp SSR - with cover and heat sink Amazon Link
- Fotek DC-DC 10 amp SSR -2 each w/ covers and heat sinks
- Reidon 100/150 amp 100 mv shunts- 1 each Reidon or Amazon Equivalent
- Victron BP-100 Battery Protect (100 amp for charge side) PKYS
- Victron BP-220 Battery Protect (220 amp for load side) PKYS
- ElectroDacus SBMS0 BMS with Wifi ElectroDacus
- ElectroDacus DSSR20 relays- 2 each ElectroDacus
- RJ 271 Ah prismatic aluminum case cells- 8 each RJ Lithium
- Spare SBMS0, cells, DSSR20 relays, SSR relays

Two ElectroDacus DSSR20's provide HVD for solar panels



Battery Protects for the Buses



Solid State relay for AC Shore Charger HVD

Best Reference Sources

For those contemplating a LiFePO4 upgrade on their boats, below are the resources we found best to educate yourself before you get started.

We have consolidated our knowledge and experience (with contributions from others) for the ElectroDacus SBMS0 BMS on a separate [ElectroDacus] page on our website.

Have fun learning about this new technology, but remember that not everything you read is true, and the experts don't all agree. The forums, especially, are full of inaccurate opinions. So, study carefully, and subscribe as we did, to the preponderance of evidence from the trusted sources below.

A good way to start is to watch some of Will Prouse's YouTube videos, then graduate to some of those from Andy's Off Grid Garage, and finally read MarineHowTo and NordkynDesign. Once finished you will be ready to start your LFP project.

YouTube Videos:

Will Prowse's DIY Lithium and Solar

https://www.mobile-solarpower.com
https://www.YouTube.com/c/WillProwse/playlists

Andy's Off Grid Garage

https://off-grid-garage.com/
https://www.YouTube.com/c/OffGridGarageAustralia/playlists

Bused_As NZ's DIY Lithium, Solar & ElectroDacus SBMS0 on YouTube
https://www.youtube.com/channel/UC4GxNZdpXjhiHCWCcCUVjdA

Articles:

MarineHowTo.com's LiFePO4 on a Boat
This is an excellent beginner's guide.

NordkynDesign.com's Lithium Pages
This is a much more detailed and technical discussion divided into seven separate articles, all recently updated.

Stan Honey's Thoughts on LiFePO4 Batteries on Boats (PDF)

Beginner's Summary of BMS Functions, Types, and Features
An excellent summary of BMS features

DIY Solar Forum "Beginner's Resources"

Comments on this article and other technical matters are welcomed in the Tech Talk Forum on the SSCA website at www.ssca.org. As a member, you can opt into this special interest forum by going to:
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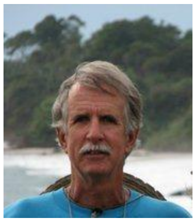


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