

## Trying to Figure Out our Battery Testing Anomalies

### 1.1 Background on our Setup

For a very complete description of our 540 Ah LifePO4 setup, see our web page here:

<https://svsoggypaws.com/electricalsystems.htm>

The short version is, it's an 8-cell 2P4S LifePO4 battery. The cells are prismatic type, 3.3v 270Ah, purchased from RJ Lithium in China in mid-2020, and finally put into normal use in about March 2021. They are supposedly Grade A cells.

The BMS is an ElectroDACUS SBMS0 same vintage.

We have 800A of solar, managed by a Morningstar TS-60 MPPT controller. We have 2 small alternators (one on each engine), managed by 2 WS500 charge controllers.

Our battery bank is mostly charged by solar. We have a very conservative charge profile, which cuts off Bulk at 13.8v, there is a 5 minute Absorb, and Float is set low enough, 13.30v, that the battery slowly discharges with normal house loads.

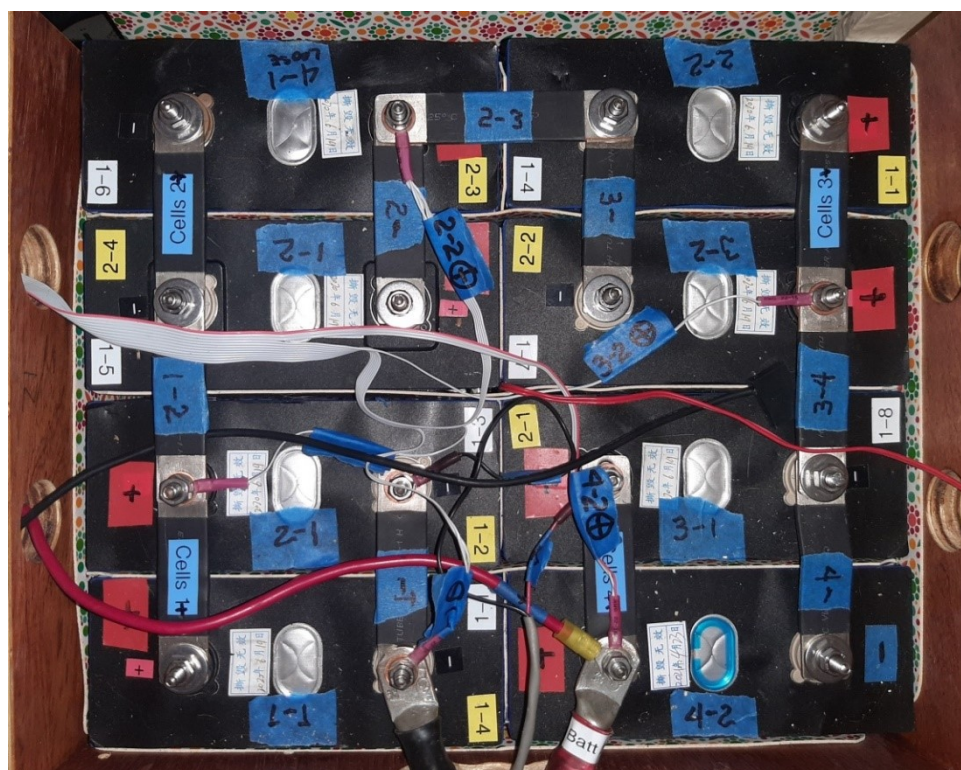
Max amp charge current is about 50A, normally midday it is 20-40A. We have cut-off switches on the alternators and only turn them on if we are deeply discharged, or there is no sun at all. If we have both alternators on (very rare), we might start out at 60-70A, but that drops off pretty quickly.

The ElectroDACUS BMS is set to cut off charging when any cell hits 3.55v. When the cells were all working properly (pretty much in balance), the MPPT would normally stop charging before the first cell hit 3.55v. We would then periodically (about every 2 weeks) manually put the MPPT into Equalize mode to run the cells up to 14.2v to reset the BMS SOC to 100%.

Our loads are normal boat loads. Largest is the windlass, which draws ~100A load every couple of days for very short periods of time. A refridge and freezer cycle on and off 24x7 at about 2-4A each. Those plus normal lights, fans, and electronics end up consuming about 150 Ah per day.

The cells are under compression in a box of my own design.

More pictures, a wiring diagram, and more details are on the website.



In June 2023, we ran all the cells through the same test cycle we are using now, and all behaved normally. The cell capacities ranged between 250-265 Ah. We matched up capacities of the cells when we put the bank back together to try to make each 2p cell set as close in total capacity as possible.

## **1.2 Test Equipment and Test Cycle**

We have a ZKETech EBC-A40L, which is a programmable Battery Tester. The EBC-A40L tester is designed to charge and discharge batteries within 5V at a large current (max current it supports is 35A in charging and 40A in discharging). [Andy's Off-Grid Garage Review on Youtube](#)

Our Capacity Test Parameters are as follows:

(See Parameter Settings box middle right side of the “Normal Test Curve” graphic below)

1. Charge cell with 30A continuous current to 3.65v and hold at 3.65v until charge amperage drops off to 5A, then cut the charge current (this is controlled by the EBL-A40L).
2. Wait 15 minutes (cell voltage drifts down)
3. Start a 30A load and discharge until voltage drops to 2.50v
4. At 2.50v, stop discharging and apply a 30A charge current
5. Charge up about 210-220Ah to put cell at a 85-90% state (don't want to let it sit at 100% while we are testing other cells).

The blue line and left side axis of the graph shows cell voltage. The red line and right side axis of the graph shows charge and discharge current (confusingly, always shows a positive line, whether charging or discharging).

The box in the upper right shows the results of the test. The critical value we are looking for is the “Capacity” column on the discharge cycle.

The box in the middle right shows the test parameters.

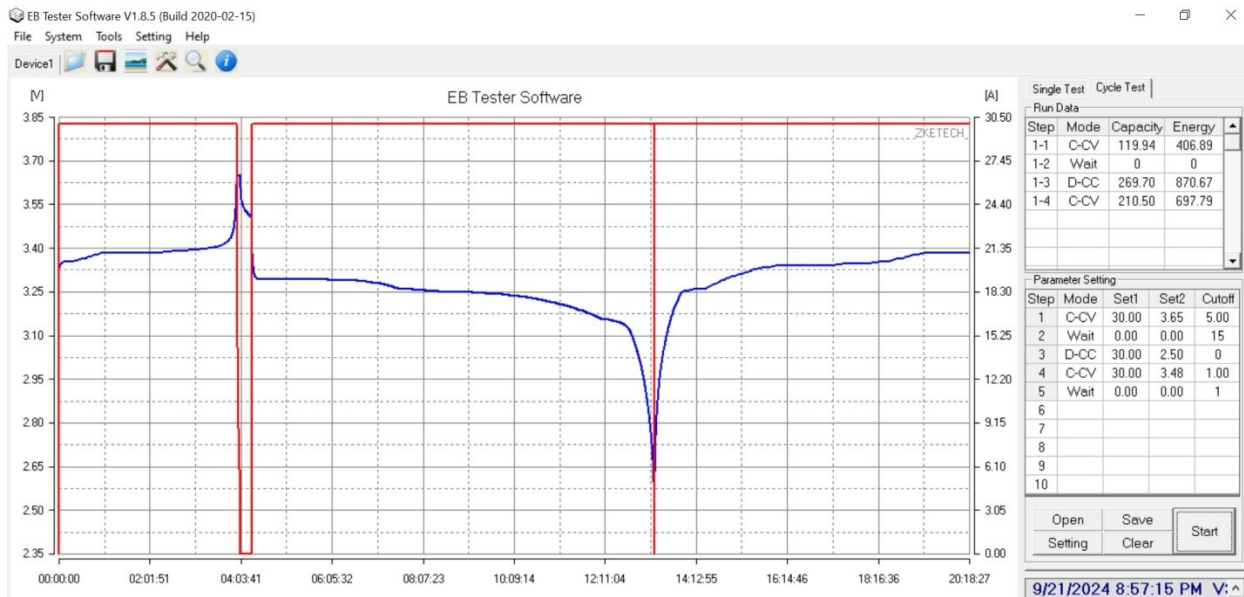
## **1.3 What a “Normal” test curve looks like**

**Charging Up:** The cell voltage starts around 3.3v and rises minimally with a 30A charge current, until the cell is “full” and then the voltage shoots up. The tester cuts off charging at 3.65v.

**Rest 15 Minutes:** The cell rests for 15 minutes and you can see the voltage drift down.

**Discharging at 30 Amps:** After 15 minutes of “resting”, a 30A load is applied. Then the cell voltage drops to about 3.28v, and very slowly drifts down under load until the cell gets near “empty” and then drops off precipitously. The tester cuts off the load when the voltage reaches 2.50v, and immediately starts charging again at 30A.

**Charging Back Up:** We then charge approx 210-220Ah, to about 85-90% and manually stop the test. (We don't want to charge the cells yet to 100% because we don't want them to sit “full” while testing the other cells.)



EBL Testing Graph – Normal Cell

Blue Line = Cell Voltage (L Axis) Red Line = Charge or Load Amps (R Axis)

The D-CC (discharge at constant current) line in the “Run Data” box, indicates this cell has a tested capacity of 269.7 Ah. (Pretty normal for a 3-4 year old 270Ah cell that has never really been used and kept stored at 50%)

#### 1.4 What our “Abnormal” Cells test curve looks like

These are cells from our house bank that were disconnected nearly full, and then manually discharged about 50-60Ah by putting on a 30A load for approx 2 hours.

**Charging Up:** When the test starts, the cell voltage starts around 3.28v and rises IMMEDIATELY to 3.65 as soon as the 30A charge current is applied, so the tester immediately dials back the charge current to about 16A (to maintain the constant voltage), and continues maintaining constant voltage until the charge current drops off to below 10A, when that part of the test is automatically ended.

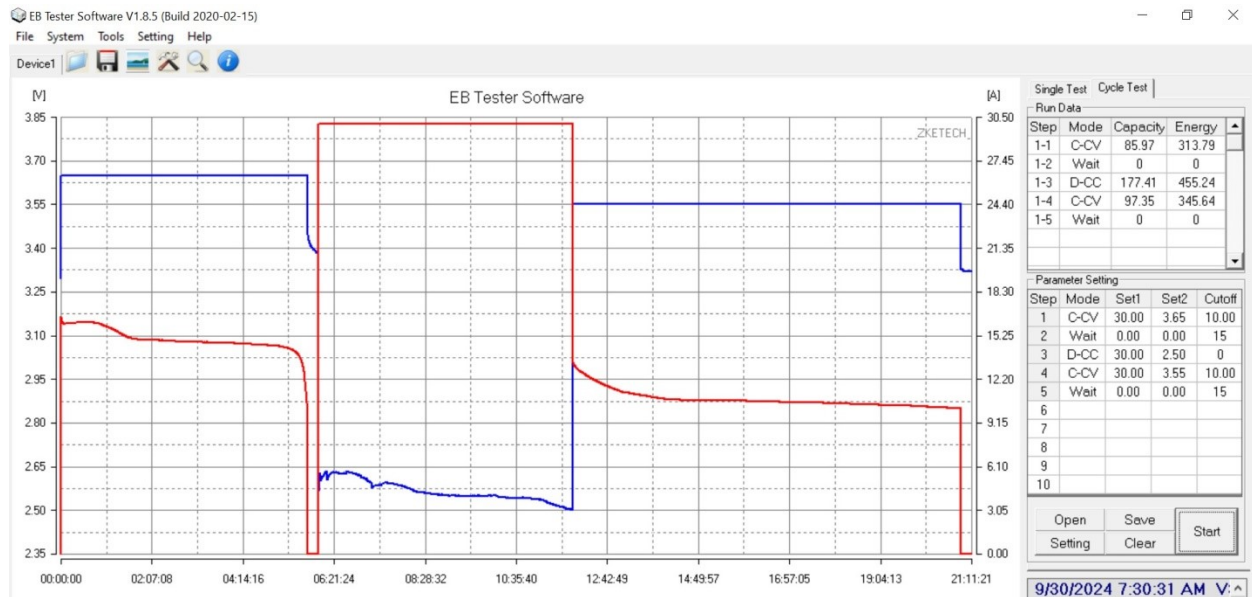
In theory, this means the cell is “full”??? and the tester cuts off charging.

The cell rests for 15 minutes and you can see the voltage drift down, which is normal.

**Discharging at 30 Amps:** After 15 minutes of “resting”, a 30A load is applied. As soon as the load is applied, the cell voltage immediately drops to about 2.63v!, and very slowly drifts down under load. The tester cuts off the load when the voltage reaches 2.50v, and immediately starts charging again at 30A.

In this test (with parameters set slightly different than our normal testing parameters, because the cell is not acting normally), we have the 2<sup>nd</sup> “charge up” voltage value set to 3.55v (trying to keep the charge amps up in the 30A range, to no avail).

When the charge amps are applied, the cell immediately goes from 2.50v to 3.55v, and the charge amps are immediately lowered automatically by the tester from 30A to ~13.6A and drifts down.



EBL Testing Graph – Abnormal Cell

Blue Line = Cell Voltage (L Axis) Red Line = Charge or Load Amps (R Axis)

#### 1.4.1 2025 Update

Trying to decide what to do with these cells... our original 8, plus 2 more we bought, and the RJ replacement for 1 cell, and 1 cell of unknown status but similar capacity we bought for a case of beer. Here is the current disposition.

- The 4 best cells are currently (temporarily) running the boat electrical systems while we are hauled out. Our 12 new cells have not been installed yet.
- Several of the cells have moderate cell bulging. These we are planning to dispose of (somewhere?)
- 4 cells have been re-tested as “reduced capacity, but functional” and we will try to sell to a desperate cruiser for not very much money.

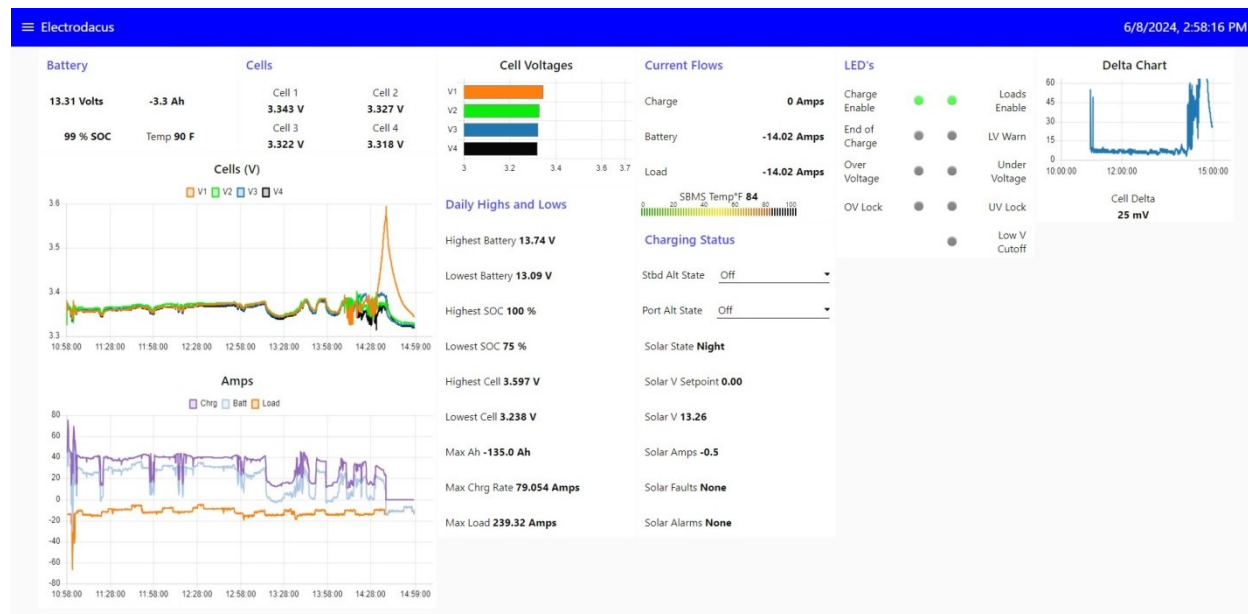
In the process of re-testing, we discovered that it’s very important that the “sense” connection (an alligator clip) on the tester not be touching the charge/discharge cable clamped onto the terminals. This is partially, we believe, what gave such concerning results in our 2024 testing.



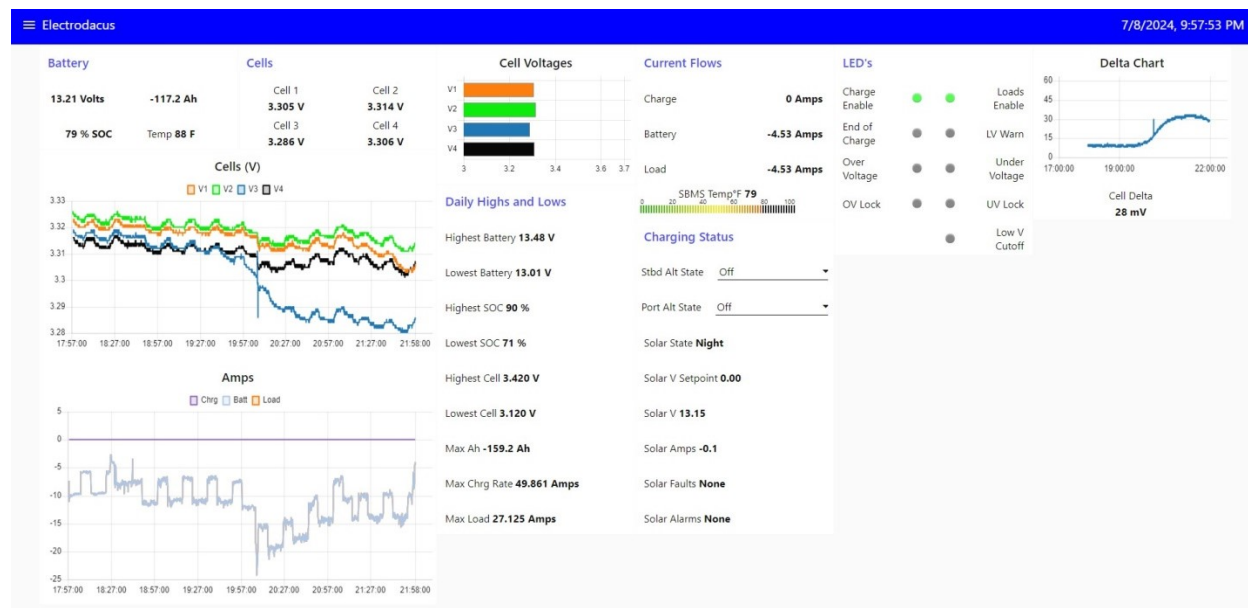
## 1.5 Monitoring System Snapshots

Our monitoring system uses inputs from the BMS, Solar controller, and WS500's, plus 2 shunts, to track and log our current status and daily maxes and mins. We also log every 10 seconds to a daily CSV file for a historical log. (The graphs on the monitoring screen are only 4 hrs long).

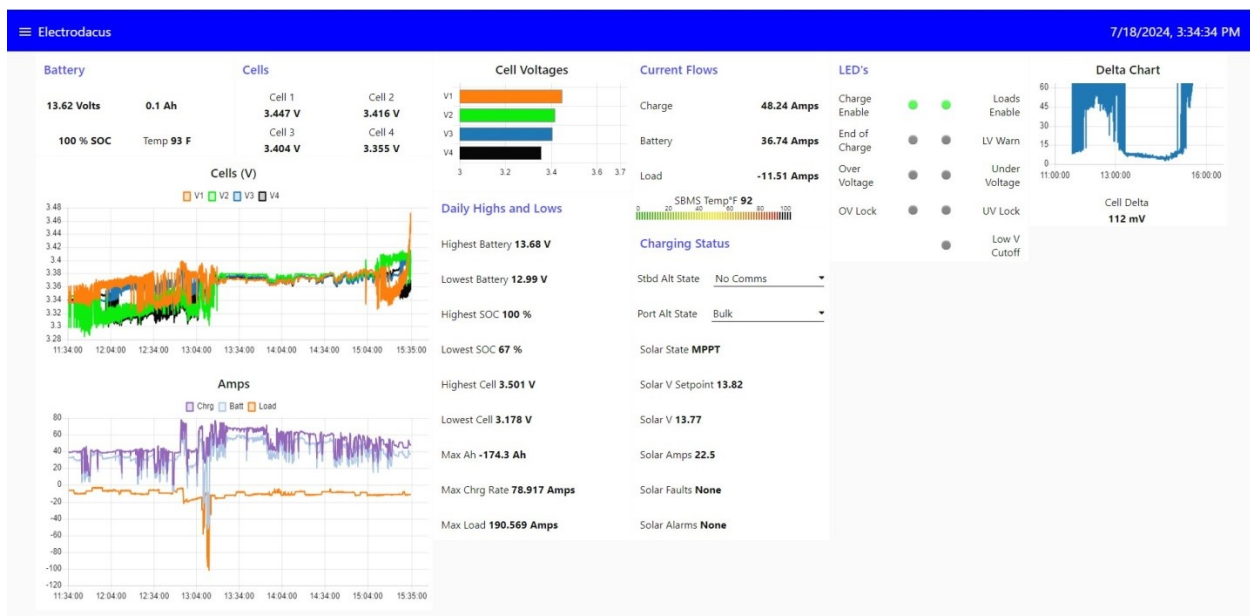
We knew we had developed a small problem because we consistently had one cell set go high well before the others. This is sort of normal in LifePO4 packs, so we weren't too worried about it, but the total battery voltage when this occurred slowly got lower and lower (but not yet alarmingly low).



At 100% just after charge cut-off by the BMS



At night, down to 79% SOC after several days of partial sun



At charge termination, just before cut off, with both Solar and 1 Alternator charging

## **1.6 Post Text for Lithium on a Boat and Electrodacus Forums**

*This is what we posted in several forums, seeking input from experts.*

Recently we have been testing our ~4 year old prismatic cells for capacity and performance.

We are hauled out, doing maintenance, and living in a nearby apartment. So it is a good time to pull our 4 year old LifePO4 pack apart and run all the cells through a capacity test and then top balance them.

We have an 8-cell 2P4S house pack and 4 spare cells that are spares and not used. All are 271 ahrs prismatic cells, advertised as Grade A. Initial capacity testing 4 years ago indicated they all met advertised specifications.

Now while running charge-discharge capacity tests with our ZKETech EBC-A40L Battery Tester, our four spare cells, that have been stored for almost 4 years at near mid SOC, acted like they did originally. They remained near 3.2-3.4v during charging and discharging until reaching the charge and discharge knees. Typically the start of the knees where the cells run rapidly to HVD and LVD are around 3.45v and 3.15v respectively. We have set the ZKETech to stop charging at 3.65v and stop discharging at 2.5v. The tested capacities of the four spare cells were in the 260-270ahrs range.

However, during testing, some of the active house bank cells acted very abnormally. As soon as a 30A charge current is applied, they shoot up to 3.6v, and as soon as a load is applied, they drop to about 2.7v. Also, this testing revealed capacities of these cells as low as 170ahrs.

I have a resistance tester, andn these cells and the spares all have internal resistances ranging .15-.19 milliohms

A couple of our cells are “bulging”. One is pretty bulged, another less so, and two more are slightly. The rest of the cells are not bulging at all. We are still completing testing on a few cells, so aren’t finished correlating their physical condition with their capacity (more on that later).

The entire bank of cells has been under compression in a custom battery box, as is recommended by RJ Lithium.

Anyone with experience in this area have an idea what might be causing this abnormal behavior among the house bank cells? It appears from testing that they have lost significant capacity.

Can these abnormal cells be safely included in the house bank with the other more normally performing cells or are they toast?

Our overall setup is described on our website, here:

<https://svsoggypaws.com/electricalsystems.htm>

More detail on the charging results (charge cycle graphs, etc) are in a PDF document we’ve just put together, here:

<https://svsoggypaws.com/files/Battery%20Testing%20Anomalies.pdf>