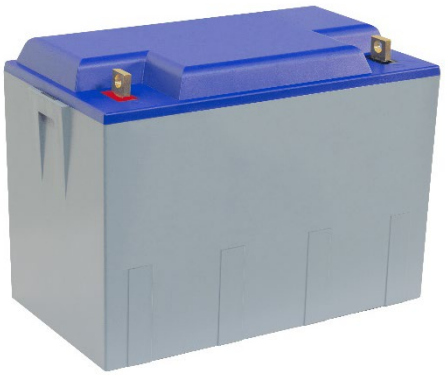
U.S. Battery Engineering 09/28/2023

12V, 100Ah Lithium-Ion Battery Teardown Comparison

U.S. Battery Engineering conducted tear-down comparisons between our “Essential Li” 12V 100Ah lithium-ion battery and the two top competitors in the RV and Marine market space. The results of this comparison clearly show the advantages of selecting U.S. Battery lithium-ion batteries for safety, performance, and reliability. In addition to the technical advantages, U.S. Battery’s Group 24 battery has the same capacity in a smaller footprint and has unique features like the Bluetooth compatible mobile application and LED indicators to help users always understand the status of the battery.

U.S. Battery US12VG24

Competitor A



Competitor B

1675 Sampson Avenue • Corona, CA 92879
(909) 371-8090 • (800) 695-0945
Fax (909) 371-4671

1895 Tobacco Road • Augusta, GA 30906
(706) 790-0218 • (888) 811-0945
Fax (706) 772-7756
Internet – http://www.usbattery.com

717 North Belair Road • Evans, GA 30809
(706) 868-0532 • (800) 522-0945
Fax (706) 860-9342

Comparison Summary – U.S. Battery vs Competitors

	U.S. Battery US12VG24	Competitor A	Competitor B
Battery Model	12V 100Ah Group 24	12V 100Ah Group 27	12V 100Ah Group 27
Battery Shell Construction	Fastened with Gasket (Repairable)	Glued (Not Repairable)	Glued (Not Repairable)
Environmental Protection	IP65	N/A	N/A
Cell Type	Prismatic LFP cells	Cylindrical LFP cells	Cylindrical LFP cells
Cell Configuration	4S x 1P = 4 Cells	4S x 28P = 112 Cells	4S x 30P = 120 Cells
On/Off Button & LEDs	Button and 6 LED Indicators	None	None
Bluetooth Capability	Yes (U.S. Battery Mobile App)	No	No
BMS Board/Software	Customized Board and Software with Bluetooth Communication	Purchased Board. Not Customized or Controlled.	Purchased Board. Not Customized or Controlled
Handle	Built-In Plastic Handles	Fabric Handle	None
Parallel Cell Welding	No Cells in Parallel	Spot Welded	Spot Welded
Series Cell Welding	Laser Welded	Spot Welded	Bolted at Single Point, Not Welded
Bus Bar Thickness	0.080" (16-20X competition)	0.005"	0.004"
Thermocouple	3 Thermocouples	1 Thermocouple	1 Thermocouple

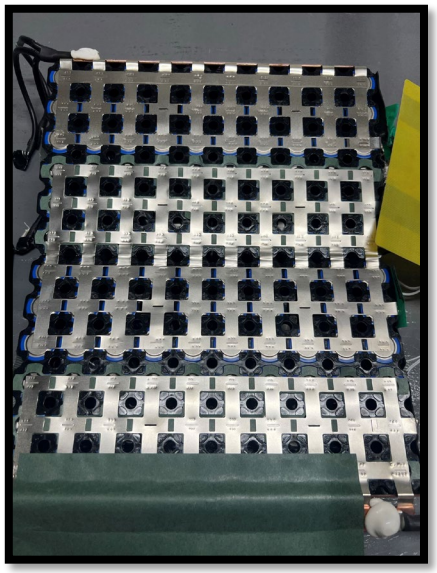
Cell Design Comparison

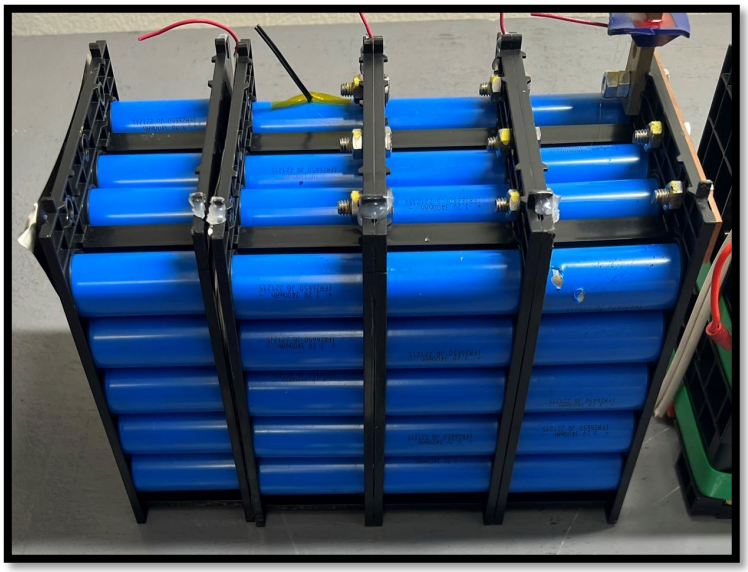
Both competitor batteries use cylindrical lithium iron phosphate (LFP) cells. While cylindrical cells offer advantages in cost and production capability, large numbers of cells are needed in parallel to reach the required capacity of the battery pack. This is because cylindrical cells are small capacity cells (~3.2 Ah), originally designed for consumer electronics such as power tools. Cell balancing, which is the management of individual cell state of charge (SOC) by the battery management system (BMS), is critical to life, performance, and safety. The large number of cells in the competitor batteries creates many points of failure and poses challenges to keeping cells balanced. The competition is trying to manage groups of cells in parallel while U.S. Battery's BMS is balancing single cells at a time.

For example, both competitors have 28-30 cells in parallel in each "stack". In total, the competitor batteries have 112 – 120 cells. U.S. Battery has no cells in parallel, instead four large format 100 Ah prismatic cells in series. This is advantageous due to the ability of the BMS to monitor and control single cells.

Competitor A & B:

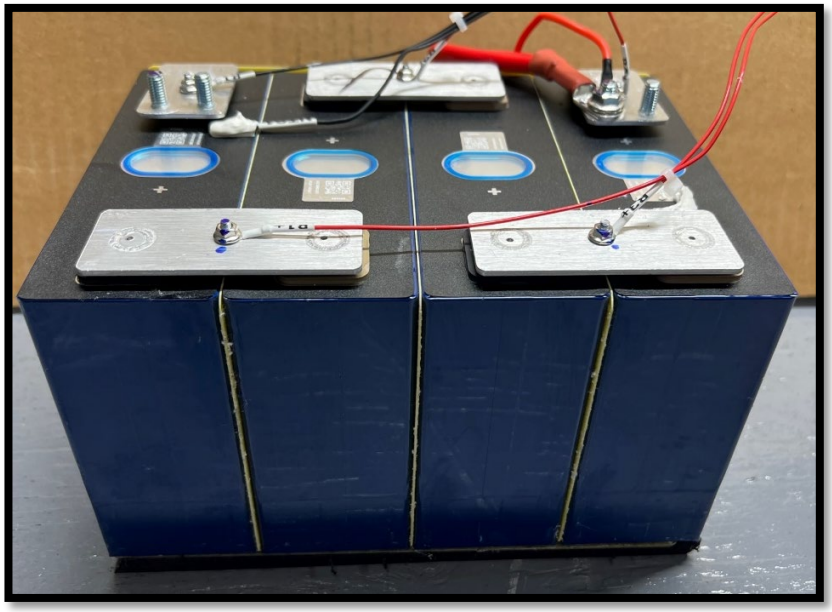
~112-120 cylindrical cells spot welded in parallel/series.





U.S. Battery:

Four Prismatic, 100 Ah cells laser welded in series.



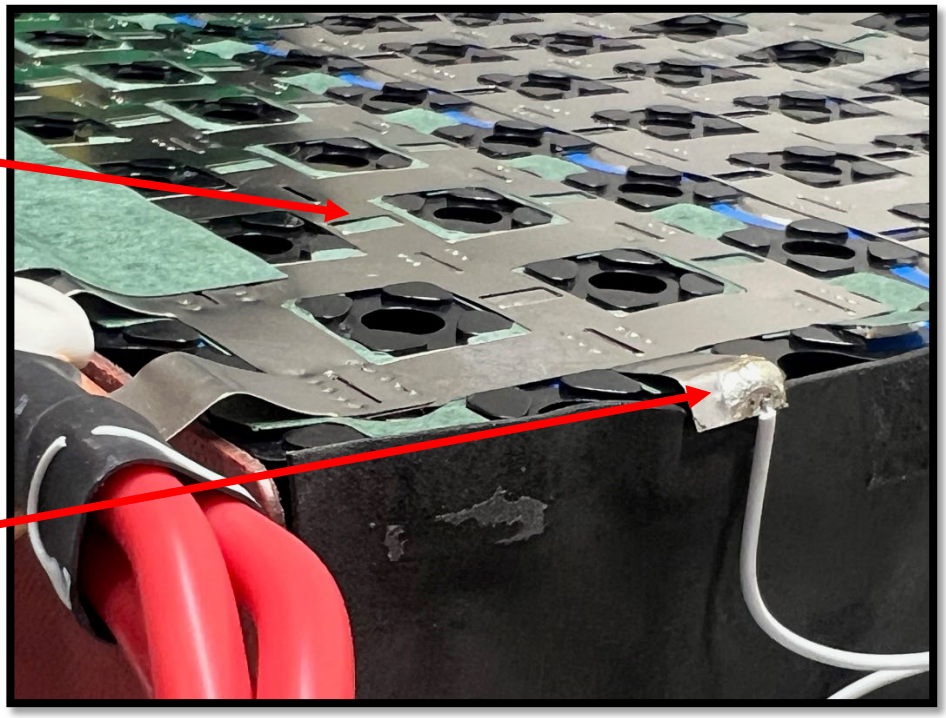
Weld Design & Quality Comparison

One of the major deficiencies of the competitor batteries is the quality and design of the series/parallel weld connections. This is concerning due to the high current ratings that are advertised on the spec sheets. The thickness of the material, the quality and type of welds, and in particular the way Competitor B has constructed the series connections is very alarming.

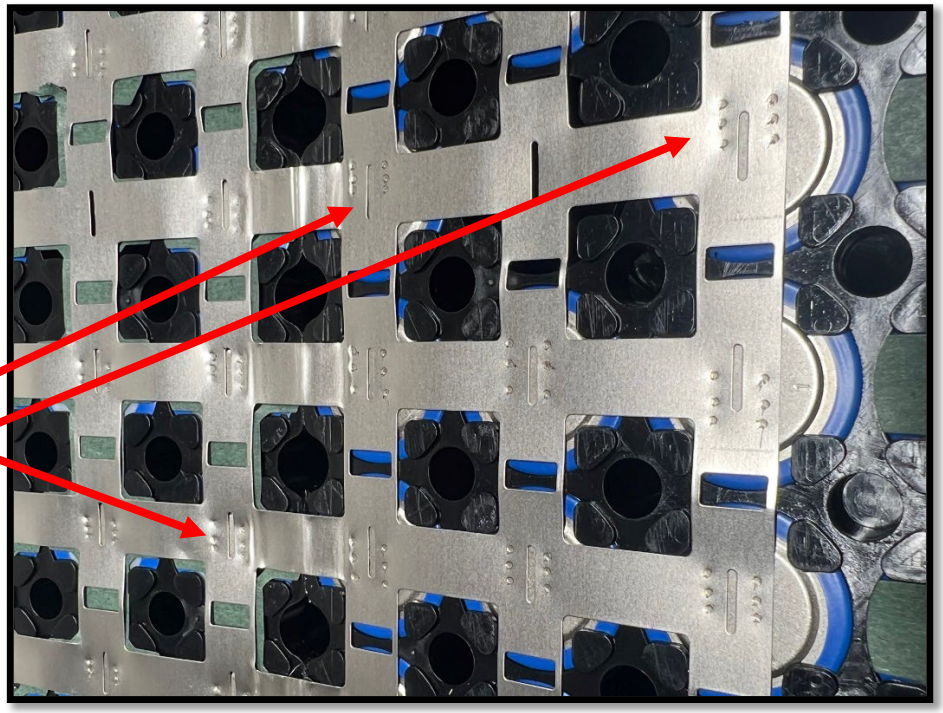
Competitor A:

Very thin material used for cell-to-cell connections (~0.005")

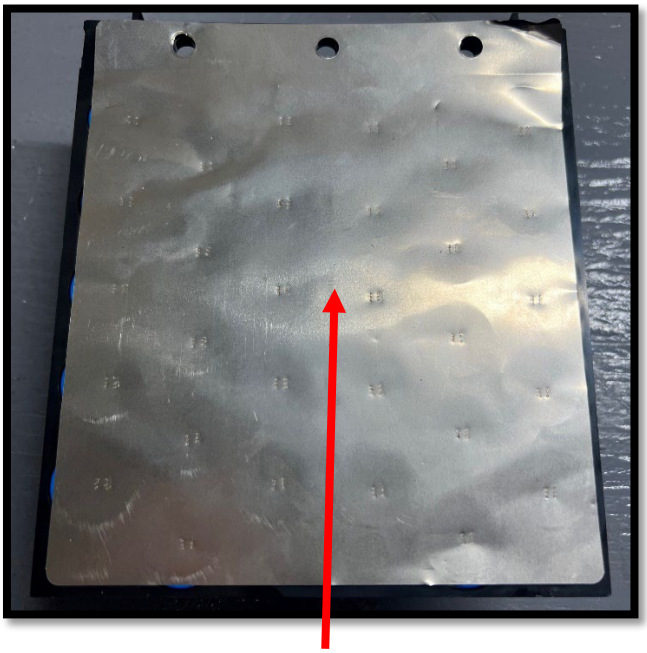
Poor voltage sensing and cell balancing tab welds with small wiring.



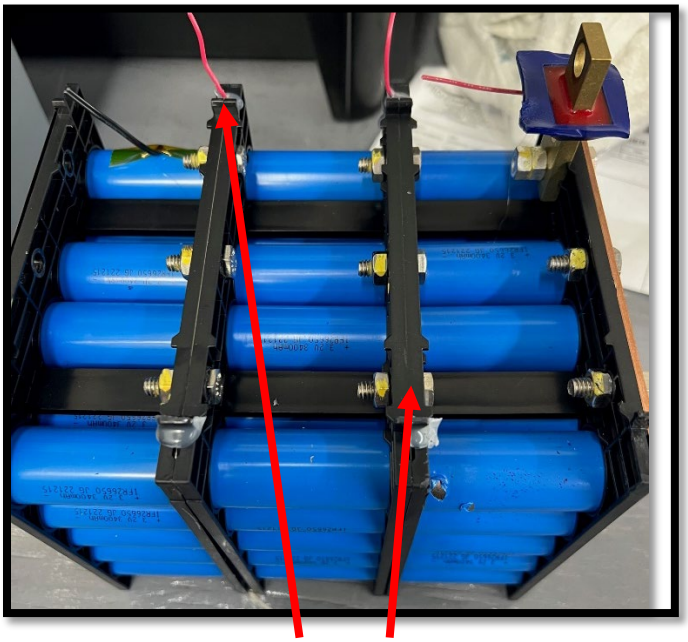
Poor quality spot welds that are small, inconsistent, and misaligned



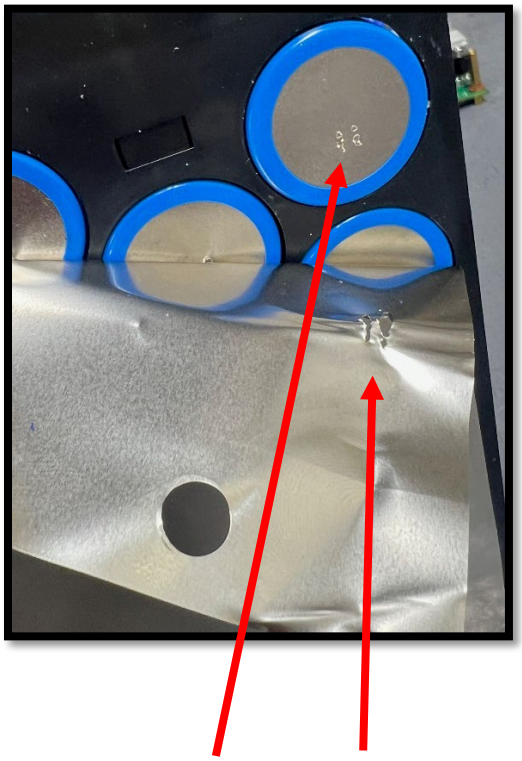
Competitor B:



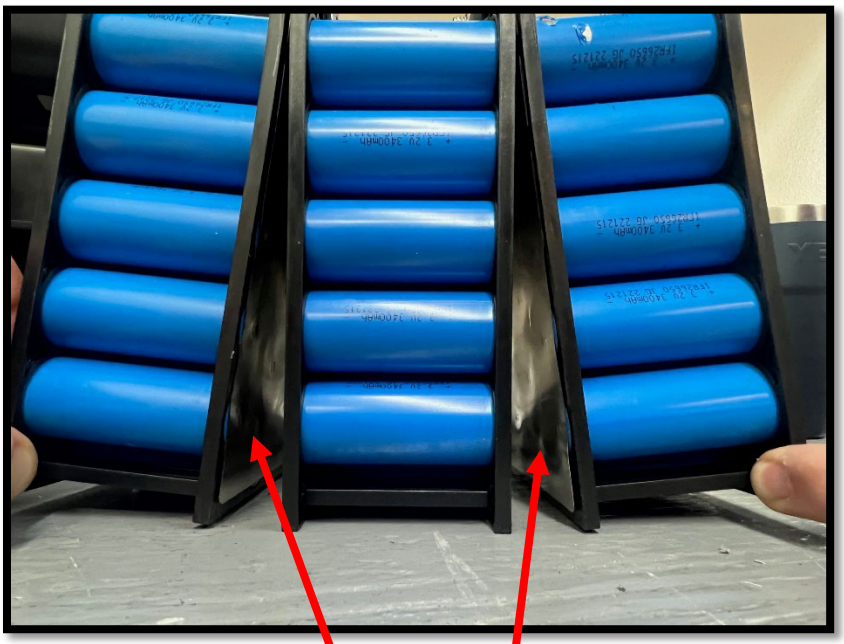
Very thin material used for cell-to-cell connections (~0.004")



Series connections are bolted and not welded. Hot glue used to attach voltage sensing and cell balancing leads



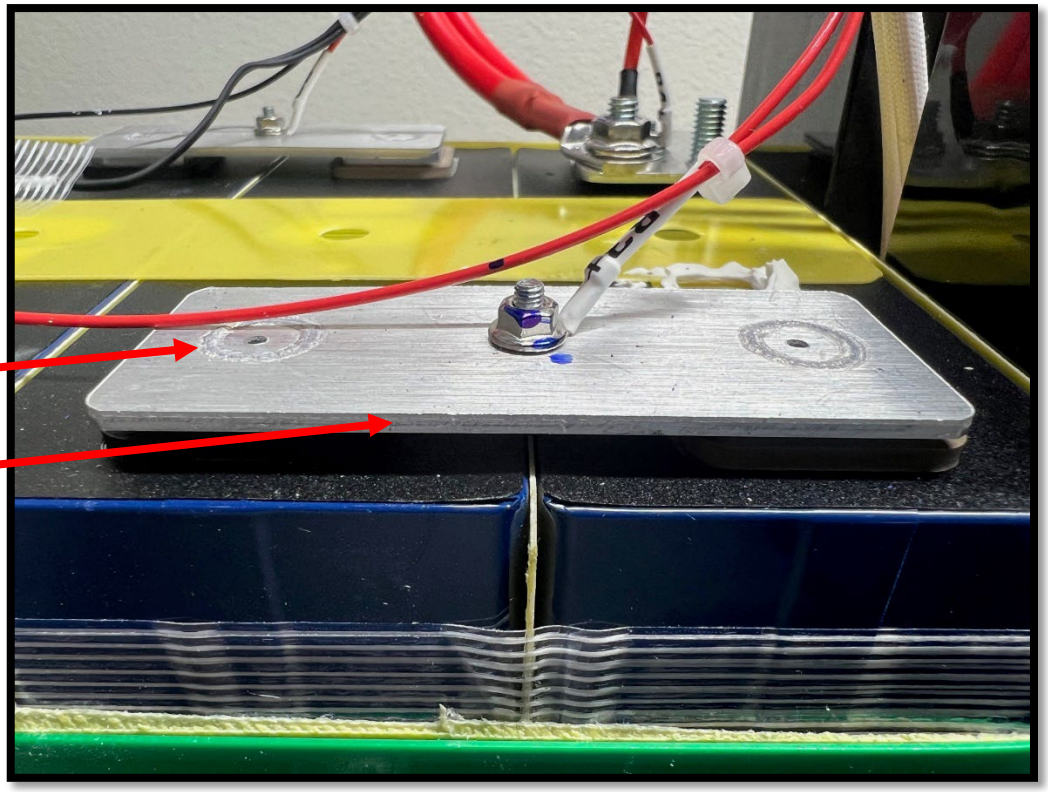
Poor quality spot welds. Intercell connections are easily pulled off by hand revealing limited weld contact area.



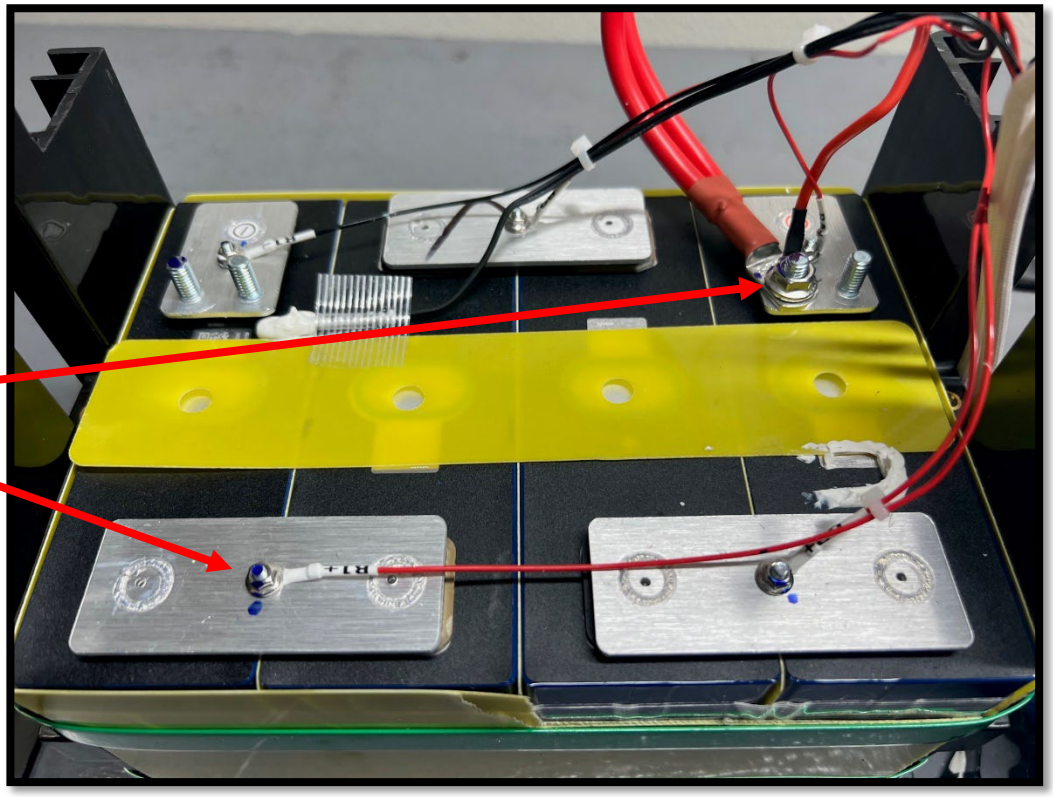
Most concerning is the cell groups not being welded together and only fastened at the top of the stack. Resistance at bottom of stack is higher than top leading to cell imbalance.

U.S. Battery:

Thick cell -to-cell connections (0.080") with laser welds. This results in high contact area, low electrical resistance, and high shock/vibration resistance.



High quality voltage sensing and cell balancing leads. Thick bus bar material and limited weld points significantly reduce risk of weld failure and internal heating.

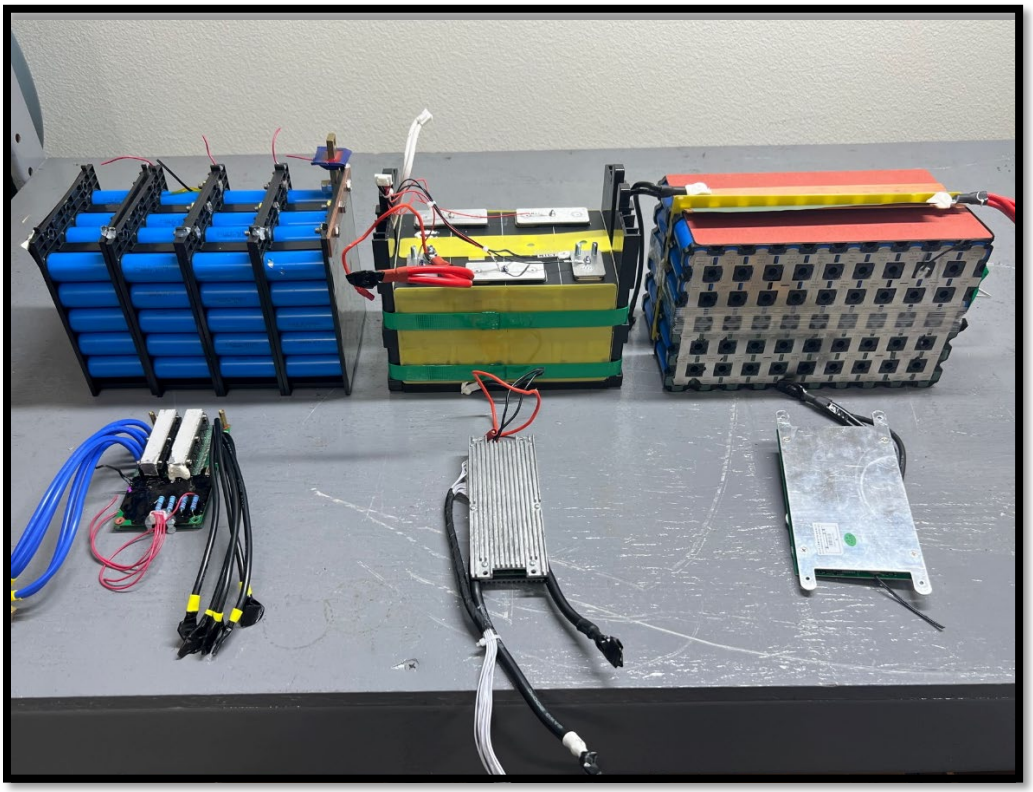


Battery Management System (BMS) Comparison

BMS comparisons are often difficult due to inability to understand software and electrical design intent. However, there are a few differences in the designs that should be highlighted.

- The competitor designs have limited heat dissipation characteristics. The U.S. Battery design uses two-sided heat sinks with fins to improve BMS heat removal. This design allows for higher sustained power draw.
- U.S. Battery's BMS has three temperature sensors compared to one on the competitor BMS boards. This is concerning due to the large number of cells in the competitor designs (one sensor for over 100 cells).
- Neither competitor has Bluetooth capabilities in their BMS designs.
- Neither competitor uses a BMS capable of feedback (button or lights). This means that users aren't able to see state of charge, know status of battery, turn the battery on/off, or be aware of any errors/faults.
- Competitor A uses a BMS that is sourced from a third party who builds generic BMS products for multiple uses.
- Competitor B uses a low cost off-the-shelf BMS that can be purchased on Amazon.

Each battery with the respective BMS



U.S. Battery's BMS contains dual heat sinks with fins for better heat dissipation