Battery Box Basics (etc)

For Ham Radio Communications/Camping

- Michael Hamby KI4UJY (General)
- Electrical Engineer
- Intent of this presentation is general overview of Battery Box Ideas and Approach
- Show and tell format – I've brought some of my battery assemblies
- Pause presentation for discussion

Terms:

- Flooded Lead Acid – Car Batteries, Deep Cycle RV and Marine Batteries (standard Construction)
- AGM (Absorbent Glass Matt) Lead Acid technology but with a Sealed Lead Acid SLA construction (think of it as a lead acid with an acid-soaked sponge construction) – these are safer for use indoors (RV, computer UPS) (Optima Brand)
- Nicad (old portable battery technology subject to charge/discharge ‘memory’)
- Lithium (used in Laptop, cordless Power Tools, Electric Vehicles)
- Lithium Iron Phosphate – Lipo4Fe – deep cycle RV replacement nominal 14.4 voltage max (13.5 mid range)
- Amp Hours – capacity of the battery
- Reserve Capacity – term used on lead acid batteries for depleting the battery below it’s suggested capacity (reduces the life)

Terms Continued

- Group 31 – international Battery size 13 inches long, 6.81 inches wide and 9.44 inches tall – (importance of this will be explained later)
- Buck Boost converters – solid state DC/DC converters can go from high or low DC voltages to the desired voltage – Uses Linear regulator and very efficient. (used in conjunction with drill packs, laptop batteries)
- BMS – Battery Management System – balances individual cells, over temperature shut off, over/under voltage protection, charge/supply regulator. Better units have a low temperature protection. Lithium and Lipo4fe batteries require use of a BMS. Internally battery operates around 17.6 volts max down to ~ 12.8 minimum voltage
- Anderson Power Poles (rated 15, 20 and 30 amps nominally) modular DC power connection products – Distribution assemblies available as well

Battery comparison ~Group 31 or equivalent

<u>Led Acid</u>
Interstate Battery SRM-31
1 year warranty
98 amp/hour*
$189.95

Interstate Lithium
60 amp hour
equivalent is $599.95 60 amp /hour

59 lbs

<u>Sealed Lead Acid</u>
Optima BLUETOP® D31M
Deep cycle/starting 3 times the life of lead acid
75 Amp /Hour*
$329

59 lbs

<u>Lipo4fe</u>
Time USB LifePO4 Battery
100 amp BMS, Overcurrent, Overtemp protection
100 amp/hour
~8 year lifespan*
100 amp/hour
<u>(disposal?)</u>
$167* subject to import tariffs (China)

23 lbs

*Led Acid types produce ½ name plate amp/hour typically and have reduced capacity in cold weather. Slower charge rates, lower discharge rates (1/10 amp/hour rating)

Low temperature charging can ruin battery low temp protection run ~$210
Add $100 for self heating*
*subject to change

History: Battery Box/Ham shack Power

- First batteries where Lawn Mower types in standard battery box(flooded Lead Acid)
- Later builds where plastic tool box with AGM
- Given an UPS battery assembly with ten AGM 7.5 amp hour batteries (reconfigured for 12 volt)
- Novel Re-use of consumer Jump Starters (converted into 12 volt power distribution boxes)
- Deep Cycle Marine – Camper and Radio operations (Group 31 sizes)
- Converted Nicad, Laptop Batteries, cordless tool batteries (with 12 volt buck boost converters)
- Exotics – Early Lithium Batteries with Buck Boost Converters
- Early Battery Boxes
- Latest Evolution – build considerations

History: the early days

- First batteries were Lawn Mower or deep cycle types (flooded Lead Acid)
  - Realized very quickly that battery needed to be connected to loads and required some basic wiring functions
- Later builds where plastic toolbox with AGM
- Connections used Anderson Power Poles, RCA jacks, BNC, spring clips and banana plugs
- Distribution Automotive Fuse Blocks,
- Ground wire joints
- Purchased automotive/hardware Items
- Repurposed Items

Goals of Battery Boxes

- Allows for application and protection of the Battery
- Recharge HT's, run VHF mobile
- 12 volt receptacle
- 12 volt Binding Post
- Power 12 volt LED lights (field day) (RCA Jacks)
- Portability/ environmental protection (rain and dirt)
- Modularity/Reusability
  - Cost Effective (eyes of the beholder)
- Run Radio's for Event Nets
- Portable power for home outages (12 volt LED lights, cell recharging stations)
- Camping (HF GO box)
- Separate Radio Go Box from Power Go Box (weight consideration)

AGM Era: UPS Battery box

- At one time held 10 7.5 AGM batteries (120 VDC) for a UPS
- Anderson Power Pole Connection
- Rewired to parallel , then as internal batteries died replaced with one Motorcycle AGM
- Still viable today (4 years)
- Will eventually replace with (4) 10 amp/hour Lipo4fe batteries.
- AGM Safe charger needed (or universal one)

Transition Typical AGM to Lipo4fe conversion

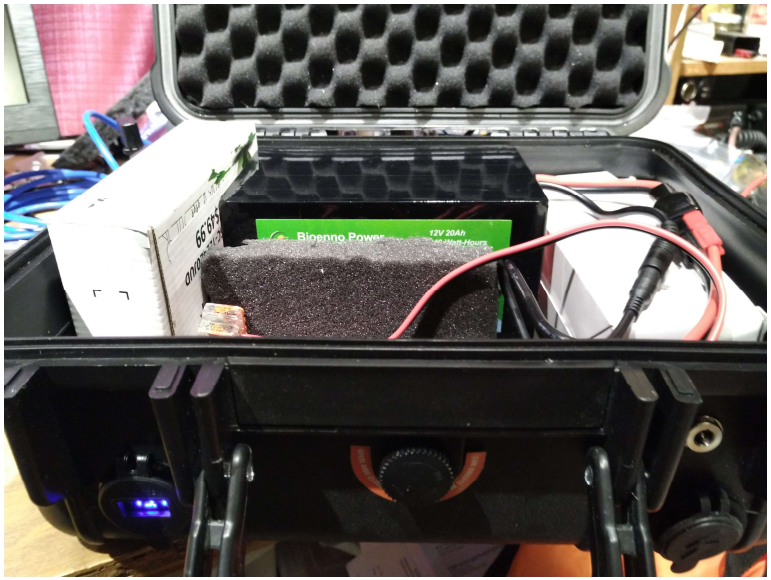
- AGM 7.5 amp hour direct replacement with 10 amp hour lipo4fe battery (most likely cylindrical or foil pack cells)
- Some rework of the internals – added RCA jack and external charging jack.
- Internal charging circuit will not fully charge Lipo4Fe (need ~14.4 volts to fully charge and <u>balance</u> the cells)
- Provides portable/light box for camping lights, 12 volt mattress pumps etc.
- Battery is $30
- Convenient in a power outage or camping
- I have a similar box that started out life as a Jump starter – it now is outfitted with Anderson Power Poles.

Lipo4fe anatomy

- Constructed of 3.2 V Grade A, B or C cells (10 – 320 amp/hour)
- Constructed from round or mylar pouch cells smaller capacities
- Possible to build your own from parts!
- Cells range from ~2 amp/hour to 320
- 12, 24 , 48 and 60 nominal volt configurations (larger voltages for inverters / home solar)
- BMS must be compatible for parallel and Series use
- BMS wired to every cell for balancing.
- Cells require slight mechanical pressure to resist bulging
- Batteries are aged more rapidly if completely discharged often .. But there are electronic parts that can fail as well. Every ~3 months need to fully charge to maintain balance of the cells – crucial for battery life
- Capacity amperages in the 100(s) is typical (Safety!)
- Discharging: -4°F to 140°F; Charging: 32°F to 113°F

Lipo4fe Era https://www.chattradio.com/

- Battery Box build from Harbor Freight Case
- Separate charge port
- Anderson Power Poles
- USB Charging Ports
- Voltage Indicator
- 12 Volt Binding Post
- 20 Amp/Hour Lipo4fe with BMS
- Initial purchase were expensive
- 20 amp/hour ~$200
- Lithium Charger required



Lipo4Fe considerations

- Upper temperature Limits (battery will shut down on **high temperature** or hard duty cycle due to over temp) keep them shaded from sun
- Low temperature operation – reduced performance – charging current must be greatly reduced in cold temps (**near freezing**) good rule of thump is 2% of battery current rating (100 amp /hour battery ~2 amps of charging.) (nominally the battery can easily take 50 – 100 amps at room temperature conditions) other option is to bring the battery in and bring to room temp before charging
- More expensive batteries have internal structures to correct for this low temperature performance but cost 1.5x to 4x the cheaper versions (SOK, Battle Born and EarthX battery brands are premium) Heated mats, internal heaters, cold charging protection circuits, and insulation
- Not for motor starting unless specifically designed.
- Treated properly Battery cells will outlast the electronics on the BMS board.. Typical 10,000 cycles or ~8-10 years
- Cheap Chinese batteries are sealed and are not meant to be repaired by the end user.
- Some high end have maintainable and serviceable models (SOK brand) ~1.5 to 4x cost and marine rated construction models.
- Capacity Ranges 5 amp/hours to 314 amp/hours
- 1/3 to 1/2 weight
- Safety – theses batteries can produce 50 to 100 amp continuous – use of rubber mats during hookup, build and maintenance and safe tool handling a must!
- <u>Caution required when charging via car alternator (in motor homes, sail boats)</u>

lipo4Fe DIY Battery Box start Small

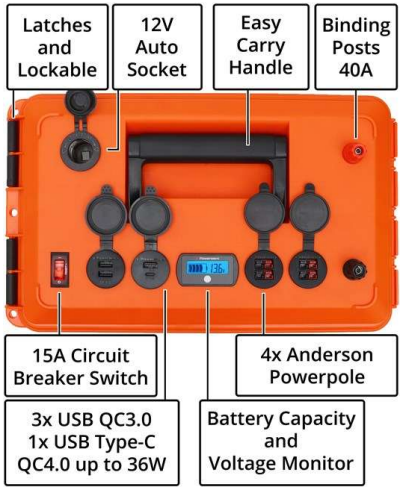
- 15 amp/hour Bioenno Power Battery $175
- RCA Jack/ External Charge Port
- Andersons Power Poles
- USB power
- Voltmeter
- DC Power Binding Post
- Harbor Freight Bunker Hill plastic amo box

Lipo4fe Battery Progress

- Battery construction has become more robust,
- Cheaper (20 amp/hour) is $75
- Near drop in replacement for AGM batteries
- Solar charging controllers must be adjusted for maximum voltage and float voltage
- Existing solar panels are compatible with lipo4fe batteries
- Modular compatible with Battery Boxes – screw terminals to Anderson Power Pole assembly

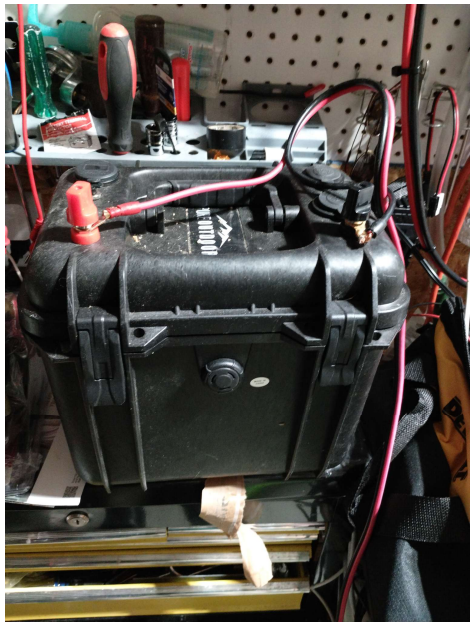
Anatomy of Factory Battery Box

- I own a similar one to this model – they are expensive but not so much once you add up the parts.
- One I bought was ~$150
- https://www.chattradio.com/
- Works well with up to 30 amp hour batteries
- 50 amp Anderson for battery connection (reduces voltage drop)



Lipo4fe – go bigger/more power

- 50 amp/hour build
- VHF Radio Power via Binding Post on top
- Power Portable camper Fridge (45 watts intermittent) for over 24 hours
- $109 battery
- Case $44
  - IP67 case 11x8x10” (battery is thick)
- 12 volt cigarette lighter plug, external battery terminals,
- Usb/voltage gauge / charging plug
- 20 lbs
- M6 battery bolts (they said m8 in the flier)
- Small size made assembly like building a ship in a bottle – final termination of battery post made with lid only partially open



Lipo4fe: Dawn of the big boys Group 31

- Abandonment of Deep cycle marine for camper/ham radio
- Almost 1/3 the weight
- ~twice the power for the size
- Last years (~8) if properly treated
- $167 on sale / on par with interstate lead acid/cheaper than Optima AGM
- Issues

Caution on charging with an Alternator

- Alternators designed for flooded lead acid batteries – self regulating on charging.
- Lipo4FE - Large BMS currents – up to 100's of amps load on alternator
  - In the case of a battery box could blow the fuse on the connection to the battery (30 amp)
  - Issue even worse on sailboats with 15 HP motors!
  - Only an issue if battery is drained.
- BMS abruptly stops charge – can blow the diode of the alternator
- Possible high current draw at car idle – can overheat the alternator
- DC to DC smart chargers are recommended. (limits charging current to 18 amps) assures lipo4fe is fully charged from alternator ($160)
  - Setup by smartphone (Bluetooth)
  - Remote On/Off
  - Not weather rated (must be enclosed)
- Victron is the better brand for Lipo4fe power control products
- https://youtu.be/jgoIocPgOug?si=m3djooG3AitgoWdn

Lipo4Fe Biggest Issues (application) - Termination

- M8 bolts native to the batteries do not render themselves convent for retrofit with bulky legacy ring terminal wiring
- Voltage drop issues discovered
- Unwillingness to leave batteries installed with trickle loads – batteries best charged every ~3 months –
- Brass bolts and nuts explored
- Quick connections and drop-in replacements explored.
- Modularity / variety of uses

Lipo4Fe Battle Born Batteries (expensive option)

- “Drop in replacement” Group 27 and Group 31
- 10-15 year life (warranty)
- Low Temp protection
- Better Lug Terminations
- 100 amp/Hour is $750

Lipo4fe - termination solutions (cost effective)

- Replace factory M8 bolts with Brass M8 Terminal Binding Post
- Or threaded rod/nuts/washers
- Permanent Battery Box wiring under the lower nut set of the post – temporary connections on top
- Reduces voltage drop
- Trolling motor battery box for housing

Lipo4fe: Group 31 Stock Battery Box

- Two 50 amp Anderson power poles
- Camper wiring harness now uses one Anderson 50 amp plug (drop in install)
- Other available for powering fridge or solar power input
- Camper charging circuit does not keep battery fully charged
- RCA and recharging port added
- Improved external battery lugs added
- Available from NAPA for $69!

1. 12V DC Cigarette Socket
2. Digital Voltmeter
3. 5V (1A / 2.1A)USB Sockets
4. 16 Amp Resettable Circuit Breaker Switch
5. Clear Insulated Tube
6. Positive (+) External Terminal
7. 2 x 50 Amp Connectors (60 Amp Fused)
8. Clear Insulated Tube
9. Negative (-) External Terminal
10. Tie Down Strap

Battery Box #2

- Modified consistent to other box with similar features to standards RCA/charger
- 50 amp Anderson to standard Anderson power pole adapter
- Power port #1 to Ham Radio go box
- Port #2 to solar regulator
- Use it to run camping fridge for longer durations without shore power

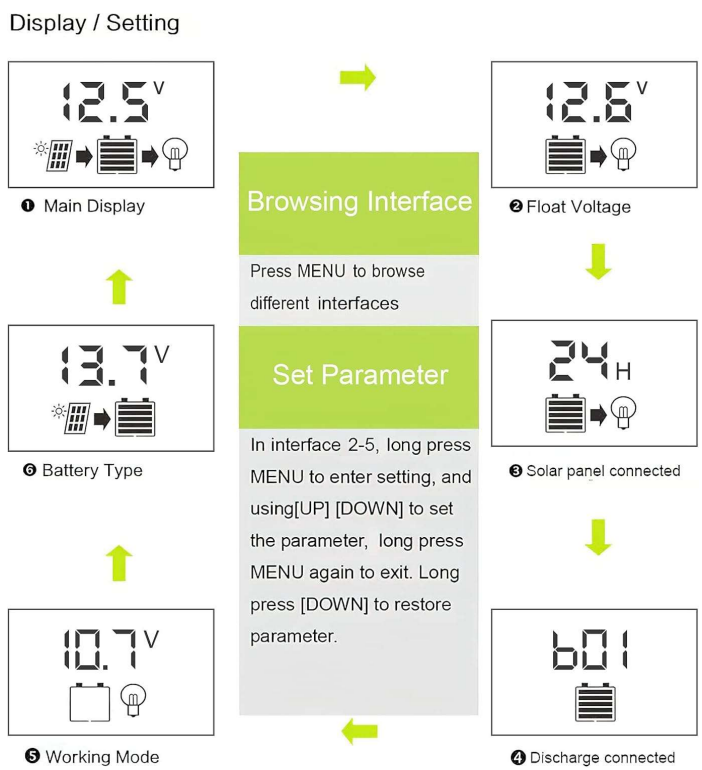
Solar Recharge Basics

- Most consumer grade Solar Regulators are adjustable for the type of battery and are usually set up for Lead Acid. (pretty crappy)
- I use End Crimps for cable assemblies
- Connect Battery first then solar panel
- Controller near battery, both near loads (panels can be some distance away)
- I use Anderson Power Poles for all connections

All Power 20 A Solar Controller 12/24 V Setup

Set to 14.6 Volts

Set to 11.9 Volts



Set to Float Voltage 13.5

See battery name plate for settings

Incidental Cables:

- XT60 to Anderson
- Anderson to Ring (replace rings with 30 amp Andersons
- Solar (MC4 type) to Anderson
- Connectors are also available with adapters to ring terminals or flying leads

Battery Box uses (outside the box)

- Power DIY Household lights in an emergency
  - Repurposed several Legacy Camping lanterns/lamps for DC operation
  - Rewired 6 volt compact fluorescent driver to 12 volt direct power circuit.
  - 12 volt plastic bucket lamps
  - 12 VOLT LED element
  - Other Canning Jar LED lights use 12 volt LED arrays and powered via RCA jack
  - Power patched by Audio/Video cables or cigarette lighter
- Power USB lamps using Phone Charge jacks
- 100 amp/hour Battery Boxes in series can recharge Ecoflow Delta 2 that powers home fridge or freezer in an outage (built a custom cable)

Power Distribution considerations

- Repurposed Jump Starter,
- Repurposed jumper cables (longer length)
- 12 volt wing nuts (SS/brass)
- Anderson power poles
- Bannan jacks (lower current rating than Binding Post)
- Voltage Gauge
- Inconveniently located LED light (bulb replaced)
- USB Phone Charge port
- 12 volt cigarette lighter jack
- Primary use camping – distribution of 12 volt power to canopy lights
- Connects to camper battery on setup

Smaller Distribution Block – another repurposed Jump Starter

- Repurposed for 12 volt Distribution Only – no internal battery
- Wago Block based Power Distribution
- Anderson Power Poles
- RCA jack (LED Lights)
- 12 Volt Outlet

References

- BOM

Comments/ Questions