BATTERIES FOR AMATEUR RADIO PORTABLE AND EMERGENCY POWER

By: Gordon Bousman, NW7D

This article describes the battery choices and components that can be used to create a portable power solution for portable, Go Box, and emergency Ham radio HF operations. Of course, portable generators are always an option but in situations where you want to minimize the weight and amount of equipment to be transported into a portable operating site (or use for an emergency Ops station), this article is for you.

First, let's look at the basics of lead-acid batteries:

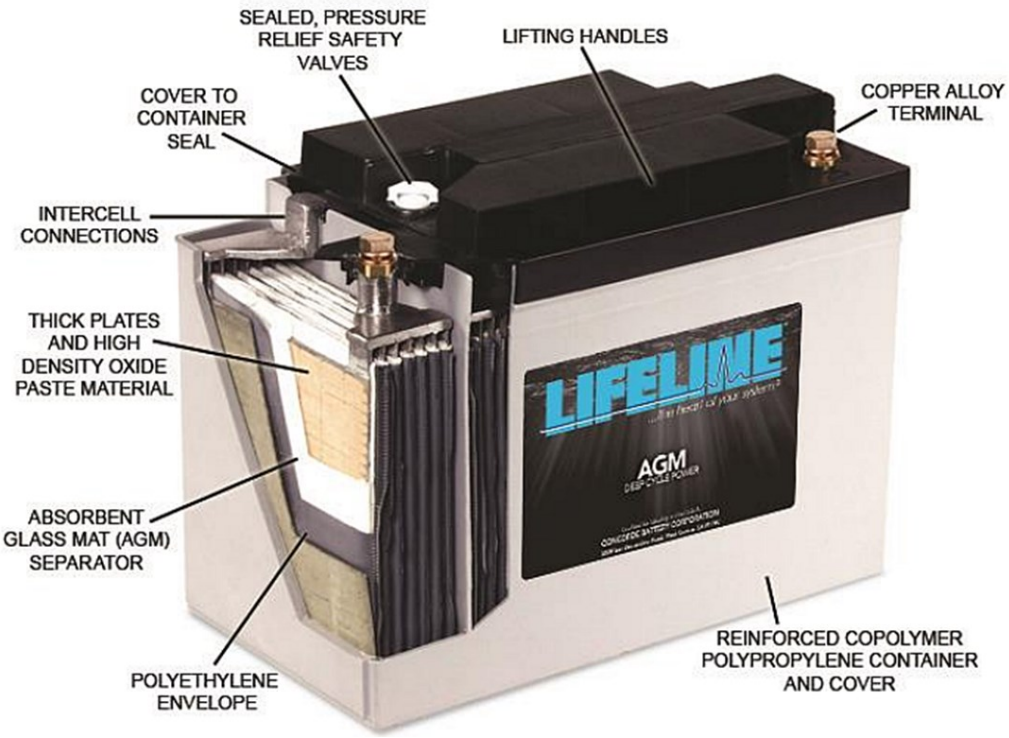
Flooded Lead-Acid batteries have been around seemingly since the beginning of time (actually 1859). Constructed with numerous thin lead plates with liquid electrolyte filling the spaces between the plates, they can provide very high surge currents in automobiles needed for the starter motor (400 to 600 amps or more). The electrolyte of a fully charged battery consists of 36 % sulfuric acid and 64% water and as the battery is discharged, the acid ratio diminishes. Overcharging can result in the release of hydrogen gas which must be vented out of the battery case. Undercharging or long periods of non-use results in sulfur deposits becoming coated on the lead plates (known as sulfation), which is the principal reason why lead-acid batteries eventually head to the graveyard. The other main damaging factor is excessive heat -meaning for example that car batteries in Arizona have a shorter life compared to Seattle….and why some car manufacturers may have placed the battery in the trunk away from engine heat.

The standard lead-acid battery needs maintenance which entails keeping the electrolyte levels topped off with distilled water and if this level dips below the top of the lead plates, the battery can be damaged. This battery type is subject to damage caused by vibration, tilting, or low electrolyte levels. These batteries can be heavy, 50 pounds or more. However, many automobile batteries sold today are of the sealed no-maintenance type.

NOW FOR THE BAD NEWS: Never, ever, use a Non-Sealed lead-acid battery for portable Ops

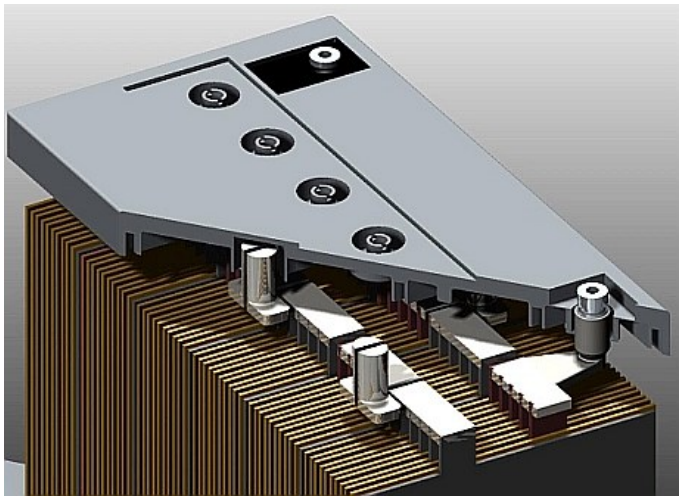
The electrolyte, which is a very caustic acid, can spill out if the battery is tipped or dropped and can seriously damage your skin or eyes, burn holes in your clothing, and damage anything else that the liquid electrolyte gets on. We have only discussed the flooded lead-acid battery here for informational purposes but **never use** a battery that has removable fill caps for portable amateur radio operation. You risk injuring yourself and possibly others.

AGM (Absorbent Glass Mat) battery: These batteries are also Lead-Acid type with the main difference being that a fiber-glass mat is placed between the battery plates and the battery is totally sealed. The purpose of the fiberglass is to hold the acid electrolyte in suspension. This battery type (and the GEL type) incorporate a gas safety valve (known as VRLA – Valve Release Lead Acid) that will expel any excessive amounts of oxygen and hydrogen gas created during accidental excessive charging voltages - otherwise the oxygen and hydrogen gas normally gets recombined into water in the electrolyte with normal use. There are essentially two types of AGM batteries, those used in automobiles for high starter motor cranking currents and those considered to be deep cycle use (example being for a boat trolling motor). They are not necessarily light; a suitable battery size will weigh about between 45 and 50 pounds. An AGM battery suitable in size for operating a 100-watt transceiver will cost approximately $100 to $150. They can normally only be discharged to 50% capacity as discussed further on.



GEL Batteries: First conceived in the 1930's, they weren't fully commercialized until the 1970's. Gel-cell batteries use a gel electrolyte paste between the battery plates rather than liquid electrolyte and the battery is totally sealed. They have a longer lifetime cycle compared to standard lead-acid batteries—as much as 2-1/2 times and are maintenance-free and deep-cycle. Their characteristics are superior to the AGM battery discussed below but they come with a higher price point. They can be damaged by overcharging and charging must cease as soon as they reach a specific voltage level. They are not suitable for providing high currents which the AGM battery can do. They are more tolerant of heat compared to the AGM battery.

Deep Cycle Batteries: These are GEL and AGM lead-acid batteries that incorporate thicker lead plates, and which have 2 to 3 times more reserve capacity than your standard lead-acid battery. Deep Cycle batteries should not be discharged below 50% of their capacity per charge/discharge cycle for maximum longevity. These batteries require a unique 3-step charging methodology and need a charger that provides higher charging currents than standard lead-acid types. Overcharging can also damage such batteries.



GEL LEAD-ACID BATTERY CONSTRUCTION

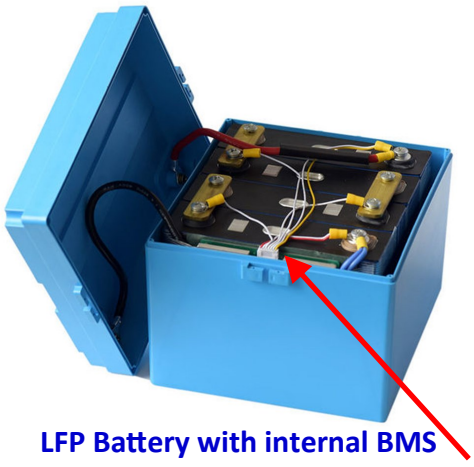
Dual-Purpose: Designed to supply not only high currents for starter motors as well as having more reserve capacity for deep-cycle use. They are typically used for marine purposes to start motors as well as to provide power for electronics. These types are not that practical for portable ham radio use. Costs generally range from $200 to $400

Lithium-ION Batteries: First developed in 1996, They are also considered to be small deep-cycle batteries but cannot be manufactured in sufficient energy size to power an HF transceiver. Many of the batteries supplied today for HT's are lithium-ion manganese oxide (LMO) composition which is a fairly stable chemistry. Older HT batteries are usually NiMH or Ni-Cd type. Since an HT may also be used at a portable operation site, we've included them in this discussion. You may know that Lithium batteries previously had a bad reputation of occasionally shorting out and possibly catching on fire (known as thermal runaway). Microscopic metal impurities in the battery would cause a short in a cell resulting in heating reaching temperatures high enough to start a fire. Today, top quality manufacturers with UL and/or CE certifications X-Ray their batteries during the quality inspection process and have otherwise improved the quality to where the incident rate for thermal runway has become extremely low, about 1 in 1 million. Nonetheless, low quality (non-UL or CE) Li-ION battery producers making knock-offs are the root cause of why some skateboards were catching on fire in recent times.

NOTE: The term "Lithium-Ion" can be confusing since there are multiple battery types in the Lithium battery family and some manufacturers use the term incorrectly, i.e., Lithium-Iron-Phosphate (LFP) batteries discussed below are sometimes incorrectly referred to simply as Lithium-ION. The dangerous batteries that create all the bad press are Lithium-Cobalt-Oxide (LCO), Lithium-Nickel-Cobalt-Aluminum (NCO), and Lithium-Nickel-Manganese-Cobalt (NMC). The Lithium Iron Phosphate battery discussed below is considered to be a much safer battery with very stable chemistry and construction.

LiFePO4 Batteries: Lithium Iron Phosphate (aka LFP): These batteries are the cream of the crop for amateur radio HF portable operation. They are 2 to 3 times lighter compared to the AGM lead-acid battery, have lots of reserve power, and will maintain their useful voltage until they are over 90% depleted whereas an AGM battery in comparison will only be useful down to about 50% depletion. The downside is that they are also more expensive compared to the AGM or GEL lead-acid battery type although prices are slowly declining. If low battery weight and near constant battery voltage are important to you, then the LFP battery will work best, especially if you need to carry a battery to a portable operating site. LFP batteries can also be placed sideways or upside down. LiFePO4 is the safest, most chemically stable battery on the consumer market. It would require extreme negligence or willful abuse to cause a fire in one of these batteries. One downside of LFP batteries is that they lose performance under very low temperatures, i.e., below freezing.

LFP Battery Management System (BMS): LFP batteries are made up of individual cells which carry an average voltage of 3.2 volts, thus 4 LFP cells are used to make up a 12.8 volt LFP battery. Such cells will never perfectly equally balance out, some cells will reach full charge before others in a LFP battery pack. Thus, a Battery Management System (BMS) is necessary in order to keep the cells balanced and at equal charge during charge and discharge cycles. The BMS also protects each cell from overcharging beyond 4.2 volts which can result in permanent damage to the individual battery cell. Undervoltage (below 2.0 volts) during the discharge cycle can also damage the battery cell thus the BMS will disconnect the battery if it detects such an incident. Most LFP battery manufacturers install an internal BMS module to keep the battery cells equalized, otherwise an external BMS device is required to keep the battery fully stable.



LFP Battery with internal BMS module inside battery case

Life-Cycle: The life of an AGM, GEL, or LFP battery is not measured by the calendar but rather on cycle count; how many times you charge and discharge a battery and to what depth you discharge the battery known as Depth-of-Discharge (DoD). The less you discharge a battery until full recharge will extend the useful life of all three battery types. The average life-cycle of the LFP battery ranges from 3000 to over 10,000 cycles depending on the DoD. In comparison, an AGM deep-cycle battery has a life-cycle ranging from 300 to 1600 cycles. These numbers will vary somewhat depending on the manufacturer. Most manufacturers consider AGM or GEL batteries at end-of-life when they measure 80% of original capacity.

Shelf Life: Lead-Acid AGM deep-cycle batteries need to be trickle charged (also called a "float charge") while in storage. Thus, it's best to keep an AGM type charger on the AGM battery to maintain its normal life. LFP batteries do not require trickle charging and can be keep on a shelf for an extended period….if the ambient temperature is moderate to low (25 C down to 0 C.). None of these batteries like extensive heat.

Battery Sizes and Cases: Having a battery encased in a carrying case is highly recommended not only for safety purposes but also for the ability to carry it to a portable operating site since almost all battery cases have handles or straps. Depending on the type of battery that you purchase will dictate what battery box is best for a specific battery type. The Group 24 size **(**10-1/4" x 6-13/16" x 8-7/8") is the most common size of battery utilized for portable operation and you will want to purchase a size 24 battery box. More sophisticated battery boxes have multiple ports available for providing 12-VDC as well as a built-in DC voltmeter. West Mountain Radio (**Link**) (and Powerwerx (**Link**) sell various types of battery boxes. You can find others on Amazon and elsewhere.

Charging of Batteries: All of the batteries discussed here each have unique charging requirements and you will need to purchase a charger suitable to the specific type of battery although many of the newer style chargers allow you to select the battery type. AGM batteries for example, have a different charging algorithm than the standard lead-acid battery while LFP batteries require yet another methodology for charging. GEL batteries have yet still another type of charging requirement. You can purchase a universal battery charger that has switchable charging parameters, there are quite a number to choose from on Amazon or elsewhere.

Wire Size: At 12 volts performing 100-watt HF transmitting, there will be a significant flow of current (20 to 24 amps) and thus appropriate wire sizes need to be used. Generally speaking, #10 AWG is needed for a 100-watt transceiver but if your power leads from the battery to the rig exceed 15 feet, then you should use #8 size wire. Include a 30-A fuse.

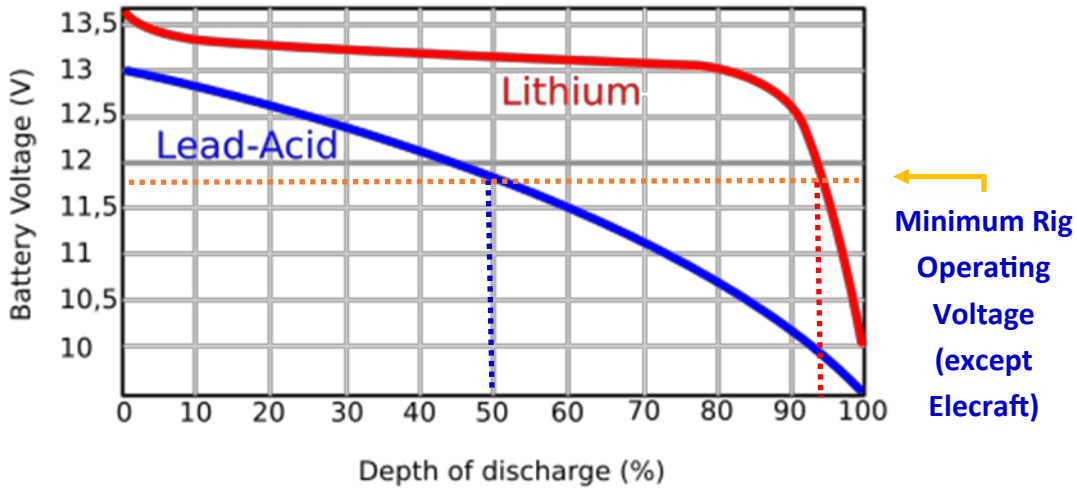
Precautions: Batteries can be extremely dangerous if the terminals are not properly protected or if one is careless in using tools around a battery or its wire leads. Batteries can provide very high currents in the range of 400 to 600 amps. Dropping a metal wrench across the battery terminals for example can cause a dead short to the battery resulting in a sparks and metal fragments flying in the vicinity of the user as well as possible fire or explosion of the battery. It is smart to remove wedding rings or other jewelry before working on a battery and to wear safety glasses. Generally, treat batteries from a safety aspect just as you would when working on 120 or 220 VAC circuits. From my experience in working as an X-Ray field service engineer, while working on large battery sets for portable X-Ray machines, we would always wrap our battery tools with electrical tape if we might accidently drop a tool on the battery terminals.

Solar Power for Charging: Solar panels will generally put out about 21 volts DC (no load) and this will need to be converted down to a lower voltage in order to charge batteries such as LFP batteries (14.6 charging volts). Powerwerx (DC-DC converter] sells several types of DC-DC convertors with the size dependent on the wattage that will be utilized for battery charging. Of course, if you chose to use the West Mountain Radio Epic PWRgate® [Link] for power management, then the DC-DC conversion takes place internally in the PWRgate device and a separate DC-DC converter is not needed. There is software for the PWRgate available to monitor the charging voltage, current, and for changing the charging settings.

LFP Useful Duty Cycle: Your type of operation will directly impact the size of battery that you will need. For casual SSB, CW, or FM operation, the average duty cycle will generally be 80% receiving and 20% transmitting. For Field Day type operations, the duty cycle changes to 50% receiving and 50% transmitting. Obviously, the latter will reduce your available battery operating time significantly. For example, when using a LFP battery, a 100-watt transceiver in SSB or CW mode can be operated in 20/80 mode for 15 hours using a 30 Ah LFP battery. For the 50/50 operation, the usable battery life is cut approximately in half (from 15 hours to 6.8 hours). Of course, if you have a means by which to charge the battery at least partially (such as via a solar panel during the daytime) then your available operating time goes up substantially. Also keep in mind that with both RTTY and FT4/8 operation, the transmissions are 100% key-down and will draw down the battery significantly faster than with SSB or CW operation. [*refer to the appendix for details of specific battery/transceiver operating times for LFP batteries*]

Folding Solar Panel

AGM Useful Duty Cycle: There is a significant difference between what an AGM/GEL vs. LFP battery can provide in terms of <u>useable</u> output energy. Keeping mind that we don't want to use our HF rigs below the manufacturer's minimum operating voltage, we can generally conclude that we don't want to use a typical AGM battery much below its 50% capacity. Thus, for example, a 40 Ah AGM or GEL battery is only going to give you about 20 Ah of actual use vs. 36 Ah for a LFP battery. If you wanted to match the useable battery charge or energy of a 40 Ah LFP battery, you would need a 70 Ah AGM/GEL battery to make the available operating energy equal. Of course, this is just a generalization and will vary depending on your operating mode and duty cycle, but I think you can understand that the LFP battery gives you a lot more bang for the available Ah (longer operating times), much lower weight, and longer life.



This chart depicts how much energy you can draw from a battery before you hit the minimum operating voltage for the rigs listed below. Note that with Lead-Acid (AGM or GEL), you hit the lower voltage between 50% and 60% of the battery capacity whereas you can utilize above 90% of the available capacity of a Lithium-Iron-Phosphate (LFP) battery.

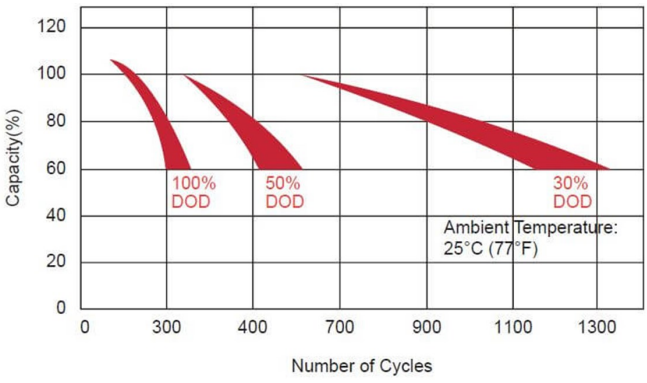
ELECRAFT	**11.00**
FLEX	**11.75**
ICOM	**11.75**
KENWOOD	**11.75**
YAESU	**11.50**

Minimum HF Transceiver Operating Voltages

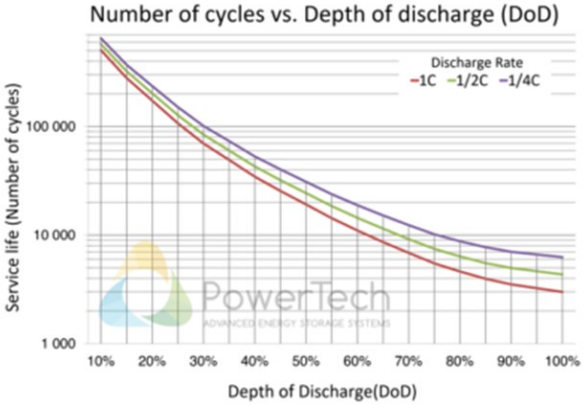
CONCLUSION: If useful battery life is important to you, the LFP battery wins over the AGM battery by 3X. If carrying weight is important, the LFP battery will weigh 2 to 3 times less than a comparable AGM or GEL battery. You'll also get more useful voltage over time for your HT rig out of the LFP battery whereas you should stop using an AGM or GEL battery when it is about 50%-60% depleted. The BioennoPower® brand of LFP batteries may be a good choice for your operation especially when married with a Powerwerx PWRbox® and the West Mountain Radio PWRgate®. You should devise a method to monitor the battery voltage, either with a battery box built-in voltmeter or externally with an inexpensive LED voltmeter. It's wise to stop operating your rig when the battery voltage dips below the rig's minimum voltage operating limit. A solar panel utilized at your portable operating site will add valuable useable operating time during the daytime. Yes, the LFP battery is more expensive but the positive benefits outweigh the price differential vs. an AGM or GEL battery in the author's opinion. Keep in mind that the deeper that you discharge any of these batteries for each usage cycle, the sooner your battery will reach end-of-life as illustrated below. On the following pages, you will find what I constructed for my portable power needs as well as an appendix showing duty times for LFP batteries.

73,

Gordon, NW7D

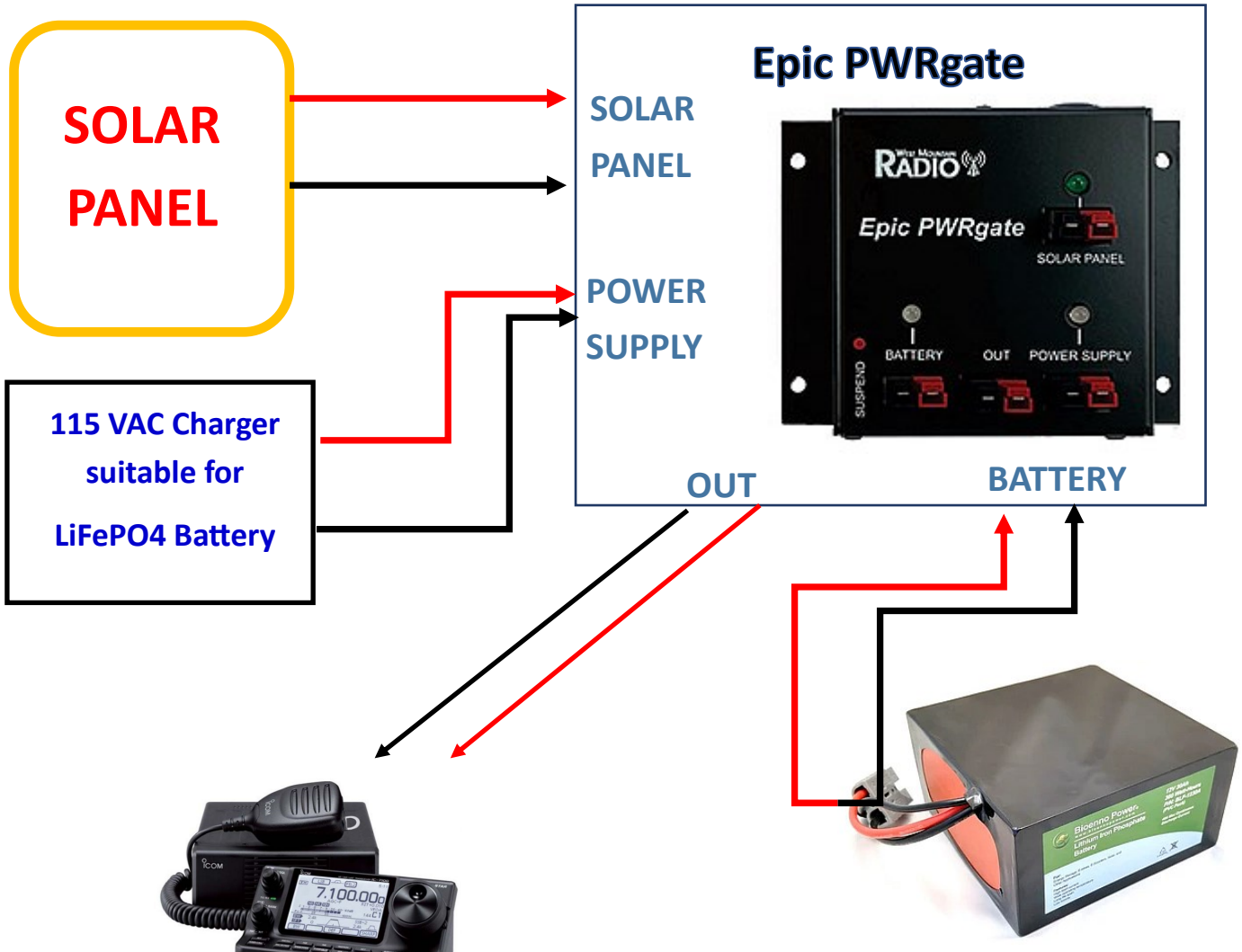


Cycle Life of an AGM battery relative to Depth of Discharge (DoD)



Cycle Life of an LFP battery relative to Depth of Discharge (DoD)

Example of how the life of an AGM and a LFP battery varies by how deeply you discharge it during each cycle. You will get about 1300 cycles out of the AGM battery if you only discharge it to 30% of capacity whereas discharging it 100% for each cycle will only give you a useful life of approximately 300 cycles. The LFP battery for example using 80% discharge cycles will give a life of about 3000 cycles



Transceiver: Icom 7100

Bionneo 40 Ah Lithium Iron Phosphate Battery (housed in battery box)

This is the setup that I used for my portable operation. The Icom 7100 is a great rig as it has a 100-watt output on HF SSB, CW, FT8, and RTTY and also works well on 2M and 440 MHz . You could certainly substitute an AGM or GEL battery for the LFP battery knowing that the falling voltage output limits you to 50% or 60% of the battery capacity where the LFP battery exceeds 90%.

Powerwerx battery box with 40 Ah BionneoPower® The Epic PWRgate is attached to the side of the box with Velcro. The Powerwerx 110W folding solar panel helps keep the battery charged during the daytime using a 25' Powerwerx extension cable. There is room beside the battery to store the 115 VAC charger (not shown).

APPENDIX

BIOENNO POWER MOBILE TRANSCEIVER DUTY CYCLE GUIDE: *20/80*

The Bioenno Power 20/80 Guide approximates standard consumption values based on average benchmark figures across the various radio models and assumes median calculated values, actual runtimes may vary depending on make, model, and vintage of radio.

BIOENNO POWER 20/80 STANDARD DUTY CYCLE FOR MOBILE TRANSCEIVER (*Compatible with all 12V Mobile Radio Transceivers*)							
TRANSMIT (W)	RECEIVE (W)	TOTAL (W)	MODEL	VOLTAGE (V)	CAPACITY (AH)	CAPACITY (WH)	RUNTIME (HOURS)
5	5	5	BLF-1203W/A/AB	12	3	36	7.2
			BLF-12045W	12	4.5	54	10.8
			BLF-1206A/AB	12	6	72	14.4
			BLF-1209A/AS/WS	12	9	108	21.6
			BLF-1212A/AB/AS	12	12	144	28.8
10	5	6	BLF-1203W/A/AB	12	3	36	6
			BLF-12045W	12	4.5	54	9
			BLF-1206A/AB	12	6	72	12
			BLF-1209A/AS/WS	12	9	108	18
			BLF-1212A/AB/AS	12	12	144	24
			BLF-1215A/AS	12	15	180	30
20	5	8	BLF-1206A/AB	12	6	72	9
			BLF-1209A/AS/WS	12	9	108	13.5
			BLF-1212A/AB/AS	12	12	144	18
			BLF-1215A/AS	12	15	180	22.5
			BLF-1220A/AS	12	20	240	30
25	5	9	BLF-1206A/AB	12	6	72	8
			BLF-1209A/AS/WS	12	9	108	12
			BLF-1212A/AB/AS	12	12	144	16
			BLF-1215A/AS	12	15	180	20
			BLF-1220A/AS	12	20	240	26.7
50	5	14	BLF-1209A/AS/WS	12	9	108	7.7
			BLF-1212A/AB/AS	12	12	144	10.3
			BLF-1215A/AS	12	15	180	12.8
			BLF-1220A/AS	12	20	240	17.1
75	5	19	BLF-1209A/AS/WS	12	9	108	5.6
			BLF-1212A/AB/AS	12	12	144	7.5
			BLF-1215A/AS	12	15	180	9.4
			BLF-1220A/AS	12	20	240	12.6
100	5	24	BLF-1212A/AB/AS	12	12	144	6
			BLF-1215A/AS	12	15	180	7.5
			BLF-1220A/AS	12	20	240	10
			BLF-1230A/AS/LB	12	30	360	15
200	5	44	BLF-1220A/AS	12	20	240	5.4
			BLF-1230A/AS/LB	12	30	360	8.2
			BLF-1240A/AS	12	40	480	10.9
			BLF-1250A/AS	12	50	600	13.6
			BLF-1260AS/L	12	60	720	16.3
			BLF-1280AS	12	80	960	21.8
			BLF-12100AS	12	100	1200	27.2

*All transmit and receive figures represented are for mobile radio transceivers, handheld units and basecamp units are not represented. Bioenno Power bases the recommendations for compatible battery models herein on average benchmark figures across multiple models, actual performance may vary in accordance to how an individual radio transceiver is set up.

BIOENNO POWER MOBILE TRANSCEIVER DUTY CYCLE GUIDE: *50/50 HEAVY DUTY*

The Bioenno Power 50/50 Heavy Duty Cycle Guide approximates higher Field Day/Event consumption values based on increased transmit percentage benchmark figures across the various radio models and assumes median calculated values, actual runtimes may vary depending on make, model, and vintage of radio.

BIOENNO POWER 50/50 FIELD DAY HEAVY DUTY CYCLE FOR MOBILE TRANSCEIVER (*Compatible with all 12V Mobile Radio Transceivers*)							
TRANSMIT (W)	RECEIVE (W)	TOTAL (W)	MODEL	VOLTAGE (V)	CAPACITY (AH)	CAPACITY (WH)	RUNTIME (HOURS)
5	5	5	BLF-1203W/A/AB	12	3	36	7.2
			BLF-12045W	12	4.5	54	10.8
			BLF-1206A/AB	12	6	72	14.4
			BLF-1209A/AS/WS	12	9	108	21.6
			BLF-1212A/AB/AS	12	12	144	28.8
10	5	7.5	BLF-12045W	12	4.5	54	7.2
			BLF-1206A/AB	12	6	72	9.6
			BLF-1209A/AS/WS	12	9	108	14.4
			BLF-1212A/AB/AS	12	12	144	19.2
			BLF-1215A/AS	12	15	180	24
			BLF-1220A/AS	12	20	240	32
20	5	12.5	BLF-1209A/AS/WS	12	9	108	8.6
			BLF-1212A/AB/AS	12	12	144	11.5
			BLF-1215A/AS	12	15	180	14.4
			BLF-1220A/AS	12	20	240	19.2
			BLF-1230A/AS/LB	12	30	360	28.8
25	5	15	BLF-1209A/AS/WS	12	9	108	7.2
			BLF-1212A/AB/AS	12	12	144	9.6
			BLF-1215A/AS	12	15	180	12
			BLF-1220A/AS	12	20	240	16
			BLF-1230A/AS/LB	12	30	360	24
50	5	27.5	BLF-1215A/AS	12	15	180	6.5
			BLF-1220A/AS	12	20	240	8.7
			BLF-1230A/AS/LB	12	30	360	13
			BLF-1240A/AS	12	40	480	17.4
75	5	40	BLF-1220A/AS	12	20	240	6
			BLF-1230A/AS/LB	12	30	360	9
			BLF-1240A/AS	12	40	480	12
			BLF-1250A/AS	12	50	600	15
			BLF-1260AS/L	12	60	720	18
100	5	52.5	BLF-1230A/AS/LB	12	30	360	6.8
			BLF-1240A/AS	12	40	480	9.1
			BLF-1250A/AS	12	50	600	11.4
			BLF-1260AS/L	12	60	720	13.7
			BLF-1280AS	12	80	960	18.2
			BLF-12100AS	12	100	1200	22.8
200	5	102.5	BLF-1260AS/L	12	60	720	7.2
			BLF-1280AS	12	80	960	9.3
			BLF-12100AS	12	100	1200	11.7
			BLF-12150AS	12	150	1800	17.5
			BLF-12200AS	12	200	2400	23.4

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