ARRL Periodicals Archive – Search Results

A membership benefit of ARRL and the ARRL Technical Information Service

ARRL Members: You may print a copy for personal use. Any other use of the information requires permission (see Copyright/Reprint Notice below).

Need a higher quality reprint or scan? Some of the scans contained within the periodical archive were produced with older imaging technology. If you require a higher quality reprint or scan, please contact the ARRL Technical Information Service for assistance. Photocopies are $3 for ARRL members, $5 for nonmembers. For members, TIS can send the photocopies immediately and include an invoice. Nonmembers must prepay. Details are available at www.arrl.org/tis or email photocopy@arrl.org.

QST on CD-ROM: Annual CD-ROMs are available for recent publication years. For details and ordering information, visit www.arrl.org/qst.

Non-Members: Get access to the ARRL Periodicals Archive when you join ARRL today at www.arrl.org/join. For a complete list of membership benefits, visit www.arrl.org/benefits.

Copyright/Reprint Notice

QST Issue: Dec 2003
Title: Emergency Power at W1ZR
Author: Joel R. Hallas, W1ZR

Click Here to Report a Problem with this File

By Joel R. Hallas, W1ZR

Emergency Power at W1ZR

Remember the recent Northeast power failure? Operate your station from battery power all the time and be ready for similar emergencies without operator intervention.

The review of the West Mountain Radio RIGrunner in the October 2002 issue of *QST*[1] finally stirred me into action to redo my station's 12 V dc power system. This had been under consideration for some time as a means to allow easy test of mobile and portable equipment. I was also getting tired of all the "wall wart" power supplies that seem to come with more and more accessories (TNC, keyer, RIGblaster, handheld radio charger), all of which seem to tie up at least two outlet receptacles due to their size.

By the time I was finished, I had deployed a complete emergency power system in addition to meeting my original objectives. The ability to operate HF and VHF on emergency power fits nicely into our regional ARES program. And, my recent completion of the excellent Level I ARRL Emergency Communication Course was in the back of my mind as I was doing this. The resulting system was configured in a way that made it a "no break" or "uninterruptible power supply" (UPS), so I don't even know there's a power failure unless I turn on the lights. As I went through the design, interesting issues arose that I wanted to share with others.

The System Concept

The basic concept is simple and can be divided into three pieces, as described below.

1. Provide a proper dc distribution system so that all necessary equipment can be powered by a single 12 V dc source (RIGrunner 4012 with Anderson PowerPole connectors).

2. Provide a 12 V rechargeable (battery) power source suitable for inside use (deep cycle, recombinant lead-acid, as described later).

3. Add a charging system that will keep the battery charged while in use and bring it back from discharge after power is restored (three-stage, 10 A, automatic).

The system is shown graphically in Figure 1. Some observations are in order. Consider the battery and charger as a replacement for the power supply that you would buy to run your radio from ac mains power. The battery acts a bit like a very large final filter capacitor with the result that a charger need only supply the average current of all the simultaneously operating equipment, while the battery provides for the peaks (much like the change in power supplies required for a 1950s-era 100 W AM transmitter, compared to today's low duty cycle SSB transmitter, if you go back that far!).

In my case, the HF radio needs (key down) a 20 A supply and the VHF radio, 10 A. The various dc powered accessory equipment (keyer, RIGblaster, TNC) perhaps another 1-2 A. If my HF and VHF radios both transmit together (as they do when on VHF packet while operating HF), I would need a 35 A supply to power everything from a single source. With the charger/battery arrangement, however, I need only provide about 5-6 A from the charger to keep the battery supplied during the time I am operating.[2]

A 10 A charger and a 12 V recombinant (described later) deep cycle battery cost more than a 35 A commercial supply, but less than the combined supplies from the two radio manufacturers. Unlike either of those, however, my system continues to operate W1ZR at full performance for about 11 hours without ac power. This is with no switching or reconnecting of cables—in other words, without operator intervention. Figure 2 shows the operating position at W1ZR.

What About the Battery?

The battery is at the core of this arrangement. For a number of years I had considered doing something like this, but was put off by the byproducts a lead-acid battery emits while under charge (hydrogen gas and a sulphuric acid). This was not a showstopper, but either seemed to require moving the batteries outside the house (with long connections), or the construction of a forced venting system from near the basement shack location to outside. Otherwise, hydrogen gas would fill the corner of my basement and could be detonated by the furnace pilot light, requiring a new ham station at a minimum!

Fortunately, technology came to my rescue. In the past few years, while most hams were watching the development of new solid-state devices, the lead-acid battery makers were quietly having a revolution of their own. There are now several technologies that provide for "recombinant" operation of storage batteries. In a recombinant battery, most of the hydrogen is not released, but recombines with oxygen within the battery to form water. Thus, you not only avoid the threat of explosion, but you never need to add water.

The recombinant technologies are found in batteries labeled AGM (absorbed glass mat), VRLA (valve-regulated lead-acid) or gel cell. These batteries hold the electrolyte against the plates in a way that avoids (but doesn't quite eliminate) the release of

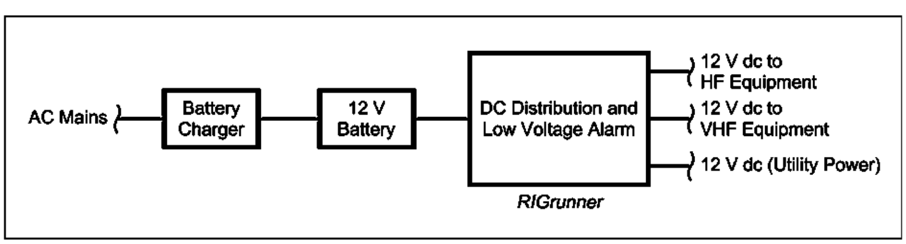

Figure 1—A system diagram of the uninterruptible battery power system at W1ZR.

[1]Notes appear on page 44.

Figure 2—The operating position at W1ZR.

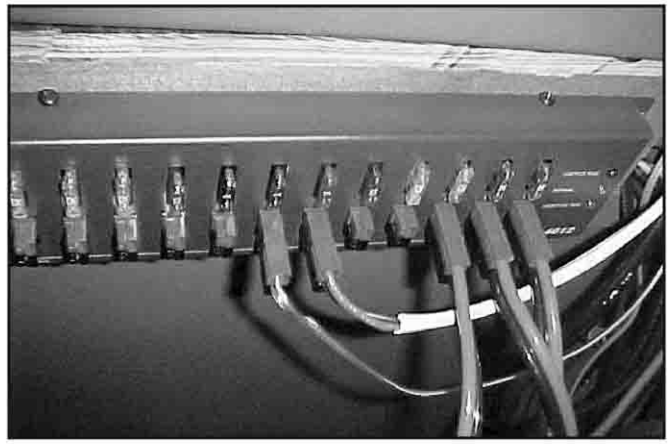

Figure 3—RIGrunner located on right end of the operating position. The battery and charger are on the other side of the wall in the basement utility room.

hydrogen during the charging cycle. A small amount of gas is released, but it is considered sufficiently small that these batteries can be used with normal household ventilation. They are used to power indoor computer UPS systems and motorized wheelchairs, for example. They also do not freeze or spill and will not leak acid.

Fortunately, these batteries are also of "deep cycle" design. A deep cycle battery, unlike the usual auto or marine "starting battery," is designed so that it can be 75% discharged hundreds of times, rather than just a few times, and still be recharged to provide full capacity.[3]

When selecting a battery, watch the description carefully, as not all "sealed" or "no maintenance" batteries are recombinant. Some simply have no ports for water addition and provide a bit more water to start with, but emit all the hydrogen of an open top battery. When the water level finally falls below the top of the plates they start to fail. They are not good for deep cycle use—or for avoiding explosion! Look for "AGM," "VRLA" or "gel cell" if you want to minimize hydrogen emission.

Once you have settled on the battery "family," there is a range of sizes and capacities to consider. The most important parameter for our application is "capacity" in ampere hours (Ah). My battery is rated at 80 Ah. Generally, the higher the Ah capacity, the higher the cost and weight. In an ideal world, 80 Ah would mean I could draw 1 A for 80 hours or 80 A for one hour. Looking at the fine print, one determines that this rating is for a given current. Mine is rated for 80 Ah at 4A, close to our design load.[4]

The RIGrunner has an alarm that can be set to let you know when the input voltage has dropped to 11.5 V. It may be a good idea to take advantage of that and stop transmitting before everything dies. With my HF transceiver, I received a report that I had keyclicks 100 kHz from my carrier just before the transceiver ceased operation at less than 11 V. I recommend, therefore, that you research the characteristics of your transmitter when it is operated below rated voltage, before you operate at low dc input voltages.

Charger System

The design of most chargers is such that they are current limited at their rated output. Thus, when drawing a load greater than the charger can supply, the excess current will come from the battery, not the charger. Still, the charger output should be fused at its rating (mine is fused at 10 A) to protect the charger from excessive load if something goes awry.

In order to be able to achieve the battery life described above, the charger needs to be able to support multiple phases of recharge, as well as different characteristics for different families of batteries (most gel cells should not be charged above 14.1 V, for example). The following description of a three-phase charger is from the Guest Company, the maker of the charger I selected.[5]

Stage 1: Bulk—When the battery is at 75% capacity or lower the charger pumps high amps at a relatively low voltage.

Stage 2: Absorption—As the battery is charged to 75% capacity, the charger lowers the amps and increases voltage (never exceeding battery's designed voltage maximums) to gradually bring the batteries to full charge.

Stage 3: Maintenance (often called "float")—When batteries are fully charged, the charger drops voltage to a maintenance level and gently maintains the battery at a full charge.

The alternative, again from Guest literature (no doubt with their product in mind):

Linear Chargers—When the battery is fully charged, units shut off until battery drops to 90% capacity and then turns on to bring it back to full charge. Result—Deep cycles have limited cycles built into them thereby reducing life of the batteries. Other types of batteries are charged at a higher voltage rate, which also reduces life. [There are linear 2 and 3 mode "smart" chargers available, however, that do not use microprocessor control. These use analog comparators to sense voltage and current.—*Ed.*]

For my station, I chose a Guest model 2610 that provides up to 10 A or two independent 5 A outputs to charge two batteries simultaneously. The charge current is applied in the three stages defined above. I have permanently mounted this adjacent to my station. A portable style charger could also be used and moved to the garage, boat or RV, as needed. One downside to a so-called "smart" charger: I note hash around 3.58 MHz, likely due to an internal processor clock. The conducted (radio on dummy load) level was S4, lower than the typical background noise at my location. I reduced it to the internal noise level by using a brute force choke[6] on the dc output. I still note some radiated noise, again on 80/75 meters when the antenna is connected, so shielding all wires and filtering on the ac line side would likely solve the problem. If it proves to be troublesome, a quick fix is to pull ac power off and run solely on dc power. There may be other chargers with similar charging characteristics but without this problem; however, I was not prepared to undertake an exhaustive study of all the available options. Analog "smart" chargers are available, however,

Table 1
Copper Wire System Loss

Wire Gauge (AWG)	*Resistance (W /1000 Feet)*	*20 A Loss for 4 Conductors × 6 Feet = 24 Feet Total (V)*	*Voltage at Load for 13.8 V Battery Terminal Voltage*	*Voltage at Load for 12 V Battery Terminal Voltage*
8	0.640	0.307	13.5	11.7
10	**1.018**	**0.489**	**13.3**	**11.5**
12	1.619	0.777	13.0	11.2
14	2.575	1.236	12.6	10.8
16	**4.094**	**1.965**	**11.8**	**10.0**
18	6.510	3.125	10.7	8.9
20	10.35	4.968	8.8	7.0

that do not use microprocessor control and hence avoid the clock noise problem. A useful site with several informative application notes is Ibex Manufacturing, Inc.[7] An alternative marine brand with a good reputation is Xantrex[8] (formerly Heart).

Watch that "Copper Loss"!

Everyone "knows" that wire has resistance, however, we are a bit conditioned into thinking that if there is 12 V at one end of a pair of wires, it will also be at the other end. While the difference is slight in the realm of low power stages, we're talking real amperes here with a significant resulting voltage drop. If we have 6 feet of wire between the battery and the RIGrunner and another 6 feet to the radio(s), that's 12 feet of two wires in series or 24 feet of wire resistance to consider. Table 1 illustrates the results for a 20 A load.

I have highlighted the entries for both 10 gauge and 16 gauge wire to make the point. What this says is if your radio draws 20 A and you have it connected via 6 plus 6 feet of 16 gauge wire to a typical 13.8 V dc power supply, it will still see 11.8 V at the equipment and will likely work fine. It may work fine on the battery if the charger is holding the voltage up well above 12, but when the charger is off and the battery is on its way down, it is very unlikely for the radio to work at the 10 V it will see! Move to 10 gauge wire and it is likely to work, but you'd still better check! My deep cycle battery specification says it will deliver 12 V until discharged 50% and then 11.5 V at a 75% discharge level.

Note that in Table 1 that half (for equal lengths) of the voltage drop shown is in the wire between the battery and RIGrunner and half the drop is between RIGrunner and the radio. If we connect a low power accessory to the RIGrunner (for the 10 gauge wire case) the voltage at the RIGrunner will be half the drop shown,or 12 V at the battery, 11.75 V at the RIGrunner and 11.5 V at the radio. The low powered accessory can use smaller wire from the RIGrunner (11.75 V) to it without a problem. For example, if the accessory draws 0.5 A, the drop in 6 feet (multiplied by 2 wires) of even 20 gauge wire between the RIGrunner and the accessory is only about 0.06 V, so even wire that small should work. This calculation should be made for the current drawn by each of the equipment types.

Please note that if your HF radio draws 20 A and your VHF radio draws 10 A and they will be both transmitting (key down) at the same time, you will have 1.5 times the "drop" shown on the wire from the battery to the RIGrunner, so take that into account, as well. Of course, if you follow the rules and "...use the minimum transmitter power necessary to carry out the desired communications" you may be able to use even less current. Unfortunately, the HF radios that I have checked do not reduce input current as fast as they reduce output power, although that may still be a significant benefit to dc power reduction. This same kind of analysis should also be made for any mobile or shipboard installation, especially if you operate with the engine off.

What can you do to circumvent these pitfalls? Use as large a gauge wire as you can find/afford/terminate/bend. Make it as short as possible. West Mountain Radio[9] provides 10 gauge and 12 gauge wire in various lengths, preterminated, at attractive prices. Marine supply dealers have nice tinned, extra flexible, red/black "duplex" wire in an outer jacket in various sizes. By the way, they also have all the other pieces you need for this project with the exception of the RIGrunner. Auto supply dealers may be another source for parts for the dc system, but I am more familiar with marine dealers in my area. Marine dealers also have "primary" wire in much larger sizes such as 2, 1, 1/0 and 2/0 gauge, for longer runs (to outside battery sheds, for example). If you go to a larger gauge than 10, you will have to have an intermediate connection block (a "barrier strip," for example) to transition to a size that will fit in a PowerPole to connect to the RIGrunner. Figure 3 is a view of the RIGRunner, installed near the operating table. Figure 4 shows the battery and charger.

Related Issues

Battery Safety

We tend to think of 12 V systems as safe (compared to the 1000 V to 3000 V behind the panels of our linear amplifiers, for example). They certainly are from the point of view of an electrocution hazard, but storage batteries of this sort have significant energy and can do serious thermal damage to people and objects. Our usual 12 V power supply will often "crowbar" to 0 V when shorted. The battery, however, will expend all of its energy in dramatic ways including possibly an explosion! Early in my career I vaporized part of my wedding ring by getting it between a wrench on a battery terminal and a steel floor in a military installation. Since my finger was in the ring, it was quite traumatic. Fortunately both my finger and my marriage survived (40 years to the lovely W1NCY). Please follow the following rules for battery safety.

- Always wear safety glasses when working around storage batteries.
- Do not have open flames near batteries, especially while under charge.
- Never use metallic tools long enough to reach between the battery terminals or connections.
- Install fuses as close to the battery terminals as possible.
- Protect the top of the battery (plastic battery box with lid, for example) so wires or equipment can't fall onto the terminals.
- Wash hands immediately following contact with the battery.
- Use proper size ring terminals on all battery connections. I use crimp-type connectors and solder them after crimping.
- Remove all metallic hand jewelry (rings, bracelets...see above!).

• Think twice; act once!

Other Applications

You may want to consider other types of loads depending on your environment. A key possibility is lighting. I did consider including dc lighting in my plan, but I've deferred that for the moment. Marine dealers (probably not the cheapest source of dc lights) have various boat cabin lights available. High efficiency focused lights typically draw 2 A, while a 50 W standard (12 V) bulb will draw more than 4 A…almost as much as the radio equipment! This will reduce your operating time by about half. I have some dry battery lanterns I thought I'd use and I may go to some kind of fuel-powered light in the future to save battery energy for the radios.

I also have not yet provided an inverter to generate 120 V ac. This is something that I will consider, but they are known as RFI generators. I don't see them as significant to radio work at my station. In a non-emergency power failure, I can imagine a request to run the refrigerator or furnace from time to time, and that may be a capability worth having if the load is reasonable.

While the TNC is on UPS power, my regular station computer is not. I do have a battery-operated laptop, which can be used for a number of hours once power is off. I have APC UPS systems (model CS500) for both of the main household computers. These do a great job of keeping the machines up for about half an hour and then gracefully shut them down via a serial (USB) connection to the PC. Unfortunately they, too, generate some conducted radio hash, so I opted not to use one for the station computer. There is also a UPS on the house Ethernet hub and DSL firewall router that keeps external Internet communications up while the laptop is operational.

Cost Considerations

This approach is straightforward, but I was surprised how thin my credit card was after buying all this! By the time I was done I could have purchased a new two-band VHF-FM radio for what I spent. If you are not ready to commit to this level of effort or expense, I think you could sneak up on it. Perhaps you already have a charger for other purposes and could find a partially used recombinant battery to use for a few years.

Another thought (thanks to Del Schier, K1UHF) is to use your current radio supply to keep a battery charged (on float). The "float voltage" level of the Douglas battery I have is 13.5 to 13.8 V dc, which is the typical output of an HF radio power supply. As with the charger, you need to confirm that the peak current divides between the battery and supply so that the maximum rating of the supply is not exceeded.

Figure 4—The battery and charger. Note the ferrite choke on the charger leads. The battery is normally covered to enclose its terminals.

The use of "any old" battery is not recommended for this application—unless you can obtain a surplus recombinant battery from a medical supply house or other source, or you are willing to provide a specially vented battery area. In my opinion, the risk of hydrogen gas explosion is not worth any possible savings.

Notes

[1]S. Ford, WB8IMY, "The RIGrunner," *QST*, Oct 2002, p 59.

[2]I calculated the average current requirements considering the duty cycle of transmit periods. In a typical operating hour, I listen more than I talk and use mostly CW (SSB is similar). My specified receive current for each radio is 1 A (confirmed by measurement). My peak HF current is about 15 A, once tuned. If I actually transmit 10 minutes in an operating hour and with CW used at a 50% duty cycle while transmitting, the result is, for HF: 1 A receive × 50/60 + 15 A × 0.5 × 10/60 = 2 A average. For VHF packet, I estimate that there are 30 ten second transmit bursts in an hour (I haven't confirmed this; if you use a DX cluster, you may want to check). During key-down, full power is used. So, for VHF packet: 1 A receive × 57/60 + 10 A × 1.0 × 3/60 = 1.45 A average. (Note that with 2 meter FM voice, the full transmit power is used the entire time the mic button is held down.) The total average current during an operating hour is therefore 2 A + 1.45 A + accessory A = 4.5 to 5.5 A.

[3]For more information about auto and deep cycle batteries, check **www.uuhome.de/william.darden**, which seems an authoritative source. The battery I purchased was a Douglas DG 12-80 available through marine dealers. They also have the best specification sheet I have found (**www.douglasbattery.com/gproducts/pdf/dg12-80.pdf**). This provides all relevant data on their battery's charge-discharge operation, the output voltage as a function of discharge and anticipated life.

[4]For my Douglas DG-12 battery, 80 Ah is specified at a 4 A load or 20 hours of operation at 4 A. At a 7 A load, we can draw current for 10 hours or get 70 Ah. For one hour of discharge, we can only draw 49 A, so the rating drops to 49 Ah. Interpolating, our 5.5 A load should discharge in about 15 hours. When the battery manufacturers talk about discharge, they are specifying the time to discharge to a terminal voltage of 10.5 V. This is the minimum safe terminal voltage for a lead-acid battery. When the per cell voltage reaches 1.7 V (10.2 V for a 12 V battery) permanent chemical and physical damage to the battery can occur. This is probably a lower voltage than we can use, especially considering copper losses (below). If we pick 11.5 V as our minimum usable voltage 75% of the 10.5 V Ah rating should be about right. You can find your minimum voltage using an adjustable supply connected at the battery location and observing when your radios stop being able to transmit ("stop being able to transmit" should be interpreted as "stop being able to transmit *cleanly*") but the receive function will generally continue to a lower battery voltage. The battery will last longer at this rate as well. For 100% discharge, my battery can repeat the charge-discharge cycle almost 200 times (to 60% capacity retention, 100 times to stay at 100%). At 75% discharge, this increases to 300 (200 for 100% retention), 400 at 50% and 1200 cycles for a 30% discharge each cycle. The use of two batteries will permit continued operation during an extended outage, with batteries alternately charged by an automotive or other outside system.

[5]The Guest Company, 95 Research Pky, Meriden, CT 06450; **www.guestco.com/Chargepro/chargepro.html**.

[6]See any recent *ARRL Handbook* for the description of a "brute force filter." I used a pi-section with 0.01 µF, 50 V (RadioShack 272-131) capacitors on the output of the charger and across the battery. For the series inductance I wound 8 turns (as many turns as I could fit) of 14 gauge "marine duplex" wire (from the charger to the battery) on a CWS (formerly Amidon) FT-240-61 toroid core. A future project will be to make a more permanent version for both dc and ac connections to the charger, mounted right at the charger terminals.

[7]Ibex Manufacturing, Inc, PO Box 294, Francestown, NH 03043; tel 603-547-6209; **www.ibexmfg.com**.

[8]**www.xantrex.com**.

[9]West Mountain Radio, 18 Sheehan Ave, Norwalk, CT 06854; tel 203-853-8080; **www.westmountainradio.com**.

All photos by the author.

Joel Hallas, W1ZR, of Westport, Connecticut, has been an active amateur since 1955. He received a BSEE from the University of Connecticut and an MSEE from Northeastern University, and has been a radar and telecommunications systems engineer for more than 30 years. Joel and his wife Nancy, W1NCY, have two grown children and a golden retriever. He holds WAS, WAC, CP-30, DXCC and DXCC-CW. Joel is the Product Review Editor at QST *and can be reached at* **w1zr@arrl.org**.