Build a Portable 12-volt Battery Pack with Built-in Battery Charger

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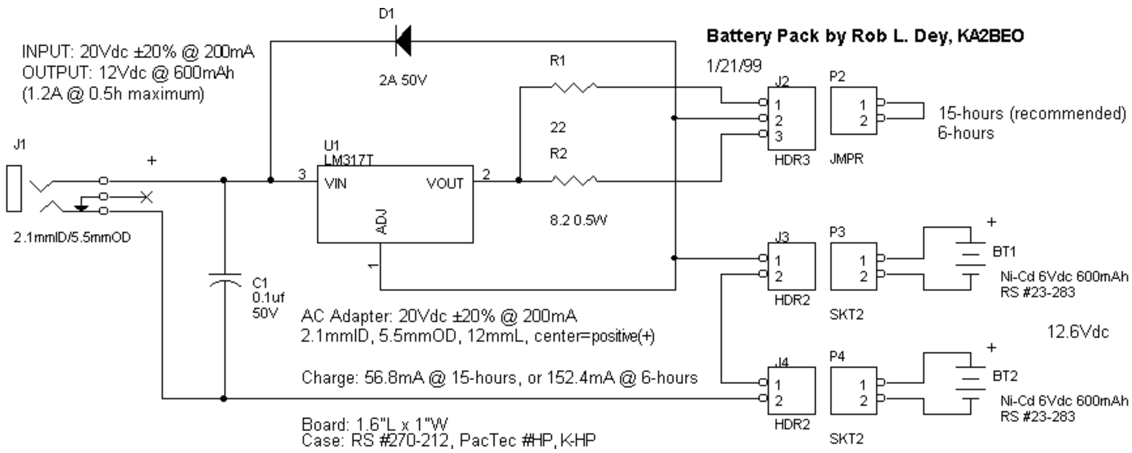
February 9, 1999

After building a small 5-watt CW transceiver, I needed a small 12-volt battery pack to complete my portable QRP station. I purchased a 38-Special transceiver kit from NorCal (http://www.fix.net/norcal.html) in February 1997, almost two years before building the QRP rig in January 1999. It was so long ago that NorCal no longer sells this particular kit. To minimize the size and cost, I decided to design and build the battery pack myself. Also, to save money, I kept the battery capacity down to the minimum required for a 12-volt dc, 5-watt transceiver, about 600mAh (milliampere-hours), which can deliver up to 1.2-amps for a half-hour (key-down). For operating convenience, I also included an internal battery charger circuit.

Circuitry

In order to keep the parts count down, I configured a common 3-terminal voltage regulator IC (Motorola #LM317T) as a constant-current source. You can obtain data sheets on the LM317T device from the Motorola Web site (http://www.motorola.com). Only two components, a resistor and capacitor, are needed to support this chip. I chose to use nickel-cadmium (Ni-Cd) rechargeable batteries because lead-acid types are typically heavier, more costly, and require more complex charging schemes.



Referring to the schematic, a dc voltage between 16 and 24-volts (20Vdc ±20%) is applied to the input jack (J1) to charge the battery pack. This same connector is used to provide the 12-volt power from the battery pack. The input bypass capacitor (C1) reduces the sensitivity of the integrated circuit (U1) to input line impedance. This allows for the use of a long power cable when charging the battery pack. The value of the 22-ohm resistor (R1) was chosen to set the charge-current for the standard C/10 (one-tenth the amp-hour capacity of the battery) at a charge-rate of 15-hours. At room-temperature (about 25°C), over-charging should not be a concern. The 15-hour charge-rate can extend the battery life by up to 50%. The 22-ohm, 1/4-watt, 5% resistor (R1) provides about 56.8mA of charge-current. The 8.2-ohm resistor (R2) was added to optionally set the charge-current to C/3 (one-third the amp-hour capacity of the battery) at a charge-rate of 6-hours (for rapid charging). The 8.2-ohm, 1/2-watt, 5% resistor (R2) provides about 152.4mA of charge-current. The jumper (P2) selects the charge-rate of 15 or 6-hours. This is a standard 2-position jumper found on most PC (personal computer) boards.

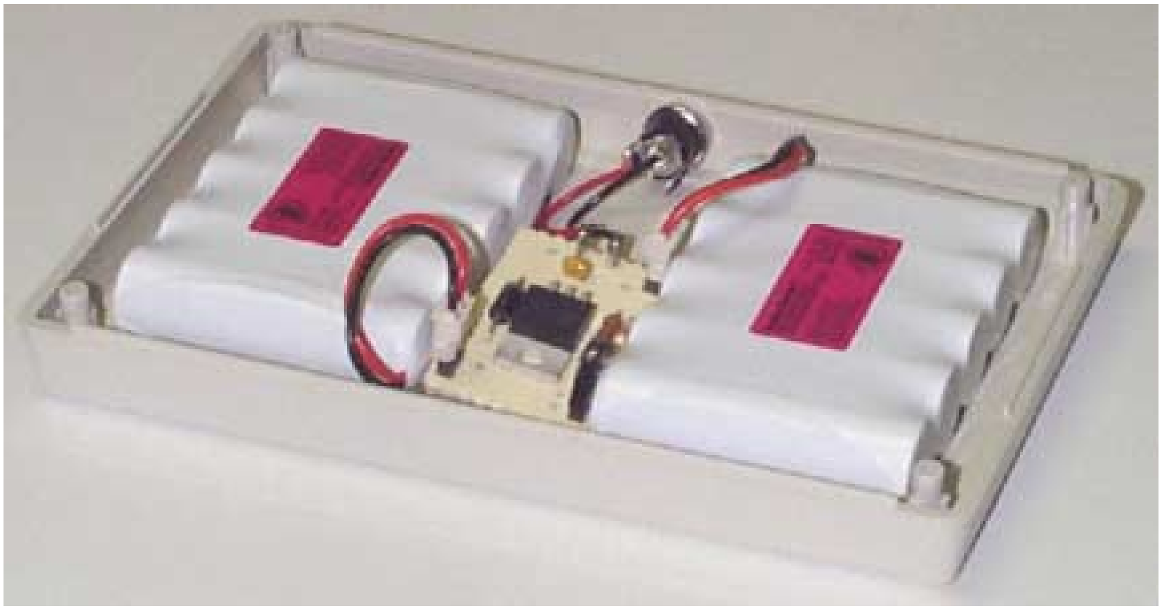
Two 6-volt, 600mAh, Ni-Cd batteries (containing five 1.2-volt cells each) are connected in series to create about 12.6Vdc, when they are fully charged. The batteries used (RadioShack #23-283) are replacement batteries for the following cordless telephones:

AT&T #5470
AT&T #9100
RadioShack #43-1016
Tropez #900DX

The steering diode (D1) allows current to flow in the reverse direction when the battery pack is in use, without harming the IC regulator. The output voltage is about 12Vdc, due to the forward-biased voltage drop of the diode, typically about 0.6Vdc.

Construction

The layout and construction of the battery pack is not critical. I built this simple circuit on standard prototyping "Vectorboard". However, any common technique should work fine, including PC (printed-circuit) board, breadboard, or dead-bug (Ugly) construction. My board measures 1.6" long by 1" wide. Standard #22 AWG stranded, insulated, hook-up wire can be used to connect the power jack (J1) to the board. The plastic case (RadioShack #270-212 or PacTec #HP or #K-HP) was chosen for its low-profile design and compactness. The bone-colored case measures only 3.60"W x 5.75"L x 1.12"H. Unfortunately, RadioShack has replaced this case with a similar unit (#270-213) that contains a built-in 9-volt battery holder. I suspect that the original #270-212 is equivalent to RadioShack #RSU 11340247, but I have not been able to confirm my suspicion. When the main construction is complete, you can wrap the batteries in clear plastic bubble-wrap to protect and secure the batteries. Before buttoning up the enclosure with its four screws, I slipped a copy of the schematics inside a small plastic bag, and placed the bag inside the case.



The final step in the assembly process is to make the power cable that is used to connect the battery pack to a 12-volt device, such as a QRP transceiver. Using two coaxial power plugs (RadioShack #274-1569A), and some 4-wire telephone cable (with two wires in parallel per terminal), I created a 12” long power cable. Using a larger wire gauge (#24 AWG or lower), you could easily make a longer cable for your battery pack.

Components

All of the parts for the battery pack (except the AC adapter) should be available at RadioShack (http://www.radioshack.com). If you cannot get the parts there, try other electronics distributors such as Digi-Key (http://www.digikey.com), Mouser (http://www.mouser.com), Jameco (http://www.jameco.com), JDR Microdevices (http://www.jdr.com), Newark (http://www.newark.com), or Farnell (http://www.farnell.com).

The power connector (J1) is a standard coaxial power jack (RadioShack #274-1582) with the center wired to the positive (+) input lead. It has an inside diameter (ID) of 2.1mm, an outside diameter (OD) of 5.5mm, and accepts plugs from 9 to 12mm long. The connectors (J2 through J4) are standard headers with 0.025" square posts on 0.1" centers, which are available almost anywhere. You can pull them off of old PC (personal computer) boards. The battery plugs are designed for round posts, so you will have to use some force to push the plugs onto the headers. While the internal connection works great, the round holes in the plastic are just a little too small for the square posts.

If you are unable to find the 8.2-ohm resistor for R2, use a 10-ohm, 1/2-watt, 5% resistor instead. Also, using an LVD (low-voltage-drop) diode for D1, such as a Schottky diode, will yield higher output power.

To eliminate the need for an external power supply when charging the battery pack, you could use a transformer, diode bridge, and capacitor filter to make your own built-in AC adapter. However, because transformers are fairly large, I decided to use a wall-mount AC adapter to keep the battery pack small for field use. I used the following AC adapter, but many different power sources can be used to charge the battery pack.

AC Adapter:
Symbol #54410-00-00
James #13932

Hosfelt #56-485 ($5.95 each @ 1 pc)
Surplus Traders #MB682 ($8.95 each @ 10 pcs)
Case: Black ABS plastic with 6'L black cord
Style: Wall-mount, UL Listed
Size: 3"L x 2-5/8"W x 1-7/8"H
AC Plug: 3-conductor NEMA
DC Plug: Coaxial (0.082") 2.1mmID or (0.098") 2.5mmID,
(0.215") 5.5mmOD, (0.354") 9mmL, Center = positive(+)
Input: 120Vac @ 60Hz
Output: 16Vdc @ 700mA

Battery Pack Requirements:
Input: 20Vdc ±20% @ 200mA (16 to 24Vdc)
DC Jack: Coaxial (0.082") 2.1mmID, (0.215") 5.5mmOD,
(0.472") 12mmL, Center = positive(+)

Changes

If you are planning to build a stand-alone charger, or are using different batteries, keep in mind that the 50 to 60mA was chosen for 500 or 600mAh batteries (at a 15-hour charge-rate), and the input voltage range of 16 to 24Vdc was for a 12.6-volt battery. The 15-hour charge-rate is safe against over-charging (at room-temperature), and provides up to 50% longer battery life.

If you are using different batteries, your charger must be different. The resistor value of R1 (in ohms) can be determined by: R1 = 1.25V / Ichg (where Ichg is the charge current in amperes). The absolute minimum input voltage is: Vin = 3.5V + Vbat (where Vbat is the battery voltage in volts). Of course, a few volts higher than this is required for normal operation.

For your own protection, use a 2-amp, fast-blow fuse in series with the power jack (J1).

WARNING: If the battery pack is not over-current protected by a fuse, circuit-breaker, or other device, such as a PTC resettable fuse, inadvertent short-circuits could cause it to explode!

Instead of the fast-blow fuse, I decided to use a PTC device (Raychem #RXE135 or Littelfuse #60R135), which trips at about 2-amps, and folds the current back to 1.35-amps. When an overload condition is removed, the PTC automatically resets. However, because I didn't have these resettable fuses on hand, I used two PTCs (Raychem #RXE075) in parallel. This configuration has a 1.5-amp current-holding value, and trips when more than 2-amps is drawn. Because the voltage drop of these devices is about 0.2Vdc at full-load, this modification might require a better diode to reduce the overall voltage-drop at the output. I changed the 2A, 50V rectifier diode to a 10A, 45V Schottky diode (Motorola #MRB1045).

Conclusion

The battery pack works great. There appears to be no heat build up, even after 15-hours of charging, and the power is sufficient for casual outings with the family. I like to bring my QRP station along with me while fresh-water fishing, just in case my finned-friends aren't cooperating. Using about 4-watts of RF output on CW, my battery pack lasts more than 4-hours. Additionally, I plan to use my off-the-shelf solar-panel (14.5Vdc @ 110mA) to charge the battery pack. The solar-panel is the size of a license-plate, and originally had a cigarette-lighter plug on the end of the cable. As purchased, it has an internal diode for reverse-current protection. It should take about two complete work days of bright sunshine to naturally charge the battery pack.

I carry both the 38-Special transceiver, and the battery pack in a soft nylon case that can hold up to 16 cassette tapes, and has a zippered side-pocket that is perfect for storing logging essentials. My particular black case is made by BMI (Beaux-Merzon, Inc.) from the "Case it" series #CAS-16, which I found at K-

Mart for less than $7.00. This padded, high-impact, water-repellent, tear and puncture-resistant case measures about 9.5"L x 7"W x 3"H. I removed the hard-plastic tray from the bottom before using the case for portable QRP operation.

If your experience is anything like mine, you should have a lot of fun with this mini power station. Good luck!

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