Number 9 on your Feedback card

Backup Battery Monitor/Charger/Alarm

Be prepared for emergencies.

by J. Frank Brumbaugh KB4ZGC

The well-equipped ham station has one or more deep-cycle storage batteries to provide operating voltage during interruptions of commercial AC power. Battery backup is invaluable during emergencies, natural or man-made, and allows operation when commercial power outages are local in nature—when wind, ice or other elements down power lines, affecting small areas.

Storage batteries require care and must be maintained at full charge so they will be available immediately when needed. While delivering power to operate modern 100 watt solid-state transceivers, storage batteries must not be discharged by more than 60% of their ampere-hour capacity or they may be damaged. Replacing deep-cycle storage batteries can be an expensive proposition.

Because modern solid-state 100 watt transceivers draw about 20 amps keydown, at even the 33 to 50 percent duty cycle of SSB or CW this will limit emergency operation to 10 to 20 hours maximum if 100 Ah batteries are used. Normal operation is considered to be 10 percent transmit and 90 percent receive.

These transceivers often will not function properly at low voltage, and storage batteries can be damaged if discharged too deeply, so it is advantageous to be able to tell the state of charge of batteries at a glance instead of having to check the specific gravity of each cell with a hydrometer. Also, a visual or audible alarm to warn when the battery has been discharged by 60 percent—only 40 percent charge remaining—alerts the operator to cease operation or risk permanent damage to expensive deep-cycle storage batteries.

The battery monitor/charger/alarm described in this article will:

- Monitor the state of charge of station backup batteries.
- Maintain batteries at full charge, preventing overcharging.
- Provide a visual and/or aural alarm that warns of low battery voltage.
- Indicate voltage and current supplied to the transceiver.

Table 1. Battery Condition Meter Calibration

Lead-Acid Battery		Lead Calcium Battery	
Color	**Voltage**	**Color**	**Voltage**
Red	11.6 and below	Red	11.6 and below
Yellow	11.6-12.0	Yellow	11.6-12.0
Green	12.0-13.8	Green	12.0-13.5
Red	13.8 and higher	Red	13.5 and higher

The Circuit

See Figure 1. This project includes a voltage-limited regulated power supply operated from the AC line and provides up to 3 amperes to maintain the batteries at full charge. Charging voltage is constant at the normal full-charge level, so the charging current drops as full charge is approached, and full charge is maintained with a trickle current. This charging voltage can be adjusted between approximately 10 and 15 VDC to accommodate lead-acid (13.8V) or lead calcium (13.2V, 13.5V maximum) deep-cycle storage batteries.

A separate connection is provided so an external charger can be used when greater than 3 amperes is needed to charge a partially discharged battery. Any standard automobile battery charger can be used, setting the charging current at no more than 10 percent of the ampere-hour capacity of the battery. Internal circuitry will maintain the charging voltage to the battery at the nominal full-charge voltage level, regardless of the voltage supplied by the external charger, which will be 2 volts or more greater than that applied by the regulator to the storage battery. **WARNING: Do not fast-charge deep-cycle storage batteries!**

A pair of meters calibrated to indicate 20 VDC and 20 ADC full-scale monitor voltage and current provided to the rig when battery power is used.

A separate, suppressed zero, expanded-scale meter calibrated over the range of about 10 to 15 VDC allows immediate and constant indication of the state of charge of the station's backup battery. This meter scale is calibrated in bands of red, yellow and green, as explained in Table 1. The narrow yellow segment is based on the assumption that solid-state transceivers may not operate properly below +12 VDC. The internal power supply is used to calibrate this meter. A DMM should be used for greatest accuracy. Colored markers can be used to produce the multicolored scale.

An alarm circuit is included to indicate when the battery has been discharged by 60 percent to the 11.6 VDC level. When battery voltage is above 11.6, the green LED will be illuminated; when voltage falls to 11.6, the green LED goes out and the red LED lights. A piezo audible alarm sounds at this low voltage level unless silenced by the toggle switch controlling it.

A pair of fixed three-terminal regulators are included to provide +9 and +6 VDC for station accessories with outputs terminated in RCA jacks. An additional RCA jack provides regulated voltage from either the internal AC supply or the storage battery for accessories requiring this voltage.

Most small 12 volt relays have a coil resistance of 100-300 ohms and require 50 to 150 mA for operation. Because this current must flow through switch transistor Q4, the power dissipated is much higher than can be handled by any of the small signal transistors usually available (2N3904, etc.). Although at first glance it may seem

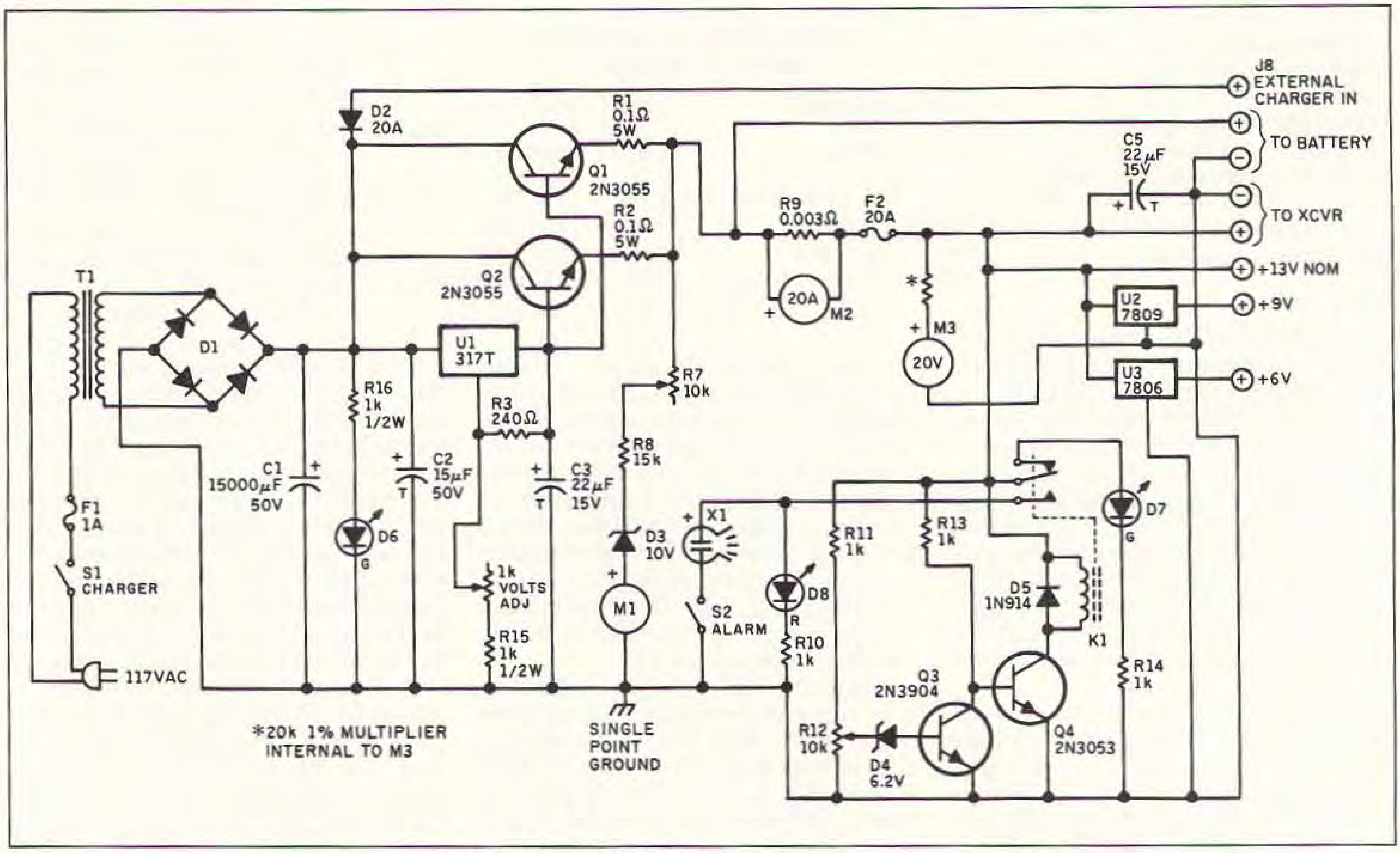

Figure 1. Backup battery monitor/charger/alarm schematic diagram.

wasteful to use a 5 watt VHF transistor (2N3053) as Q4, its power dissipation capability is necessary.

Circuit boards for this project are available from FAR Circuits (18N640 Field Court, Dundee IL 60118) for $9.50 plus $1.50 S & H. If you use PC board and mount transistors Q1 and Q2 onto the board, they must be heat-sinked. The transistors may be external to the board and wired back to the PC board.

Construction

This equipment should be constructed in a metal enclosure to present a neat appearance as a permanent item of station gear, but the actual layout and overall size will be a function of what is available and of each builder's needs and desires. The circuit is straightforward and many of the parts can be found in the junk box. What may not be on hand or available from other local hams or at hamfest flea markets can be obtained from mail order dealers, and from Radio Shack.

About Meters

The voltmeter and ammeter I used were originally 40-VDC meters. These 3-1/2"-square plastic-cased meters both had basic 0-1 mA movements and internal 40k multiplier resisters mounted inside. I took the meters apart, removed one 40k resistor and soldered it in parallel with the 40k resistor in the other meter, changing it to indicate 20 VDC full-scale. The remaining meter had the resistor replaced with a short piece of wire and then was a 1 mA meter which would require a shunt so it would indicate 20 amperes full-scale. By careful erasure of the numbers on both meter faces and use of a fine-tip felt pen to change the numbers, I calibrated both scales at 5, 10, and 20.

To make the shunt for the 20 ampere meter, I measured the resistance of the 1 mA movement (60 ohms) with a DMM. Ohm's law indicated that 0.06V across 60 ohms would cause full-scale current of 1 mA to flow through the meter movement.

I had some AWG-16 enamel-covered copper wire in the junk box, ideal for the shunt. Referring to a copper wire table, AWG-16 wire has a resistance of 4.016 ohms per 1,000 feet, or 0.004 ohms per foot and 0.00033 ohms per inch.

To determine the resistance needed for the shunt using Ohm's law, I divided 0.06V by 20A, resulting in a value of 0.003 ohms. Dividing this shunt resistance by the 0.00033 ohms resistance of one inch of AWG-16 wire indicated that a length of nine inches of AWG-16 wire was needed for the 20 amp shunt. I temporarily wound this length of wire, plus 1/2" at each end for connections, on the body of a felt-tip marker to make a small coil and then removed it and connected it across the 1 mA meter. Violà! A 20 amp meter!

Your meter movement may be different, but the method for determining the proper shunt will be the same, as explained above.

The voltmeter multiplier resistance, if needed, can be determined by applying 20 VDC, if you have it, across a series circuit consisting of the meter and a potentiometer of at least 25k ohms for a 1 mA movement. (Less resistance will be needed if your meter is 5 or 10 mA or more, but greater if a more sensitive meter—50, 100 or 200 μA—is used.) Set the pot at maximum resistance and then adjust for a full-scale indication on the meter. Remove the voltage and measure the resistance in that portion of the pot in the circuit at full-scale. This is the value of the multiplier resistor for a 20 VDC full-scale indication. A trimpot and a series resistor used as the multiplier will allow accurate calibration of full-scale voltage.

If you do not have a source of 20 VDC, you can use 15V for three-quarter scale or 10V for half-scale indication. The amount of resistance will be the same.

The battery condition meter (M1) is a suppressed zero, expanded-scale DC voltmeter set by external components to cover an approximately 5 volt range between 10 and 15 VDC. Refer to Figure 1. The 10 volt zener diode (D3) suppresses the zero so the meter will not begin to indicate until at least 10 volts are applied to its cathode. Between this point and +15 VDC, as established by the multiplier resistor (R7 and R8 in series), the meter becomes a 5 VDC meter, indicating only that segment between 10 and 15 VDC.

Although this same range is obviously indicated on the 20V meter (M3), the 5V range covering from below fully dis-

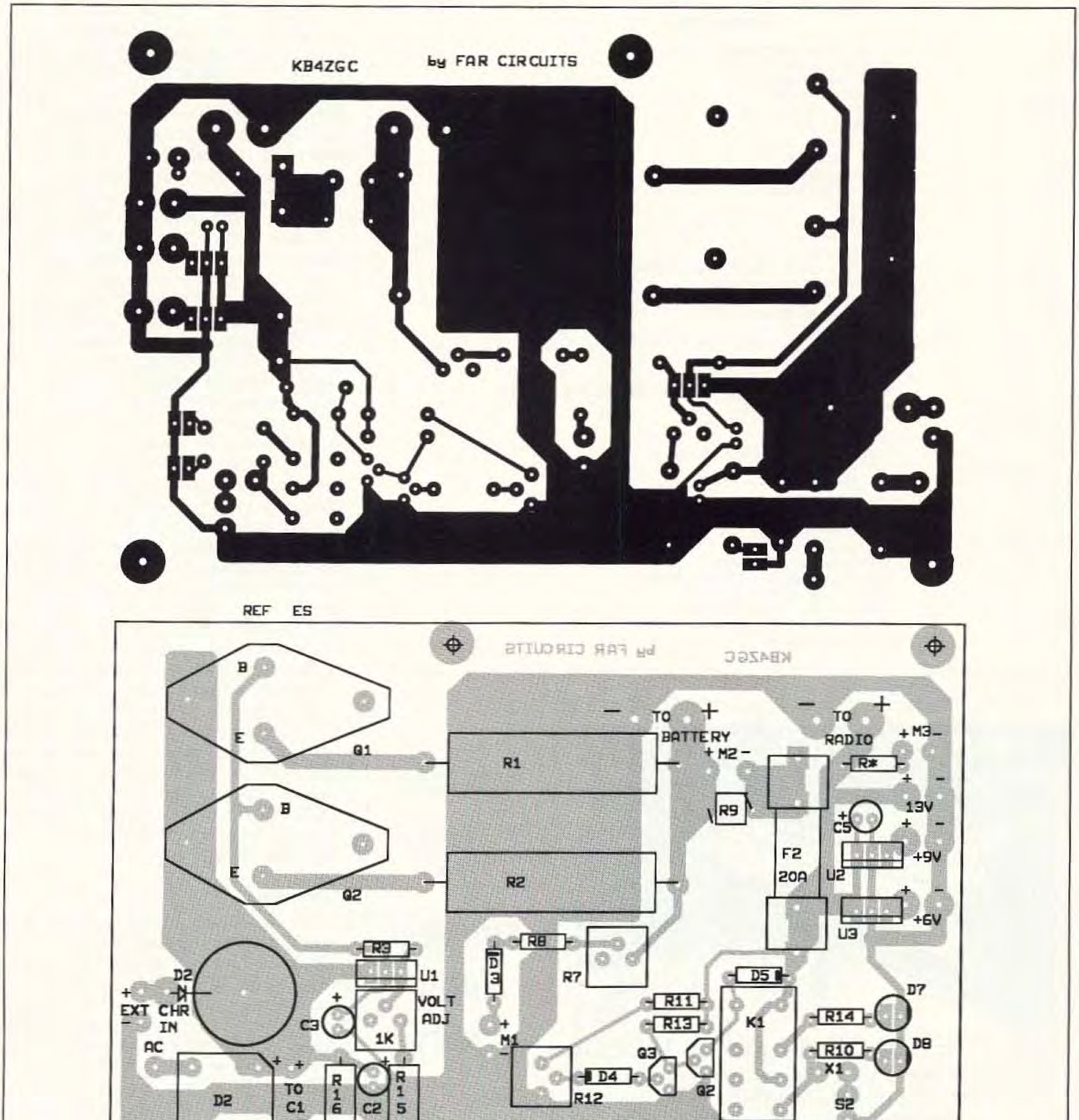

Figure 2. Circuit board and parts placement for the Backup Battery Monitor/Charger/Alarm. Note: If transistors Q1 and Q2 are mounted on the PC board, they must be heat-sinked. The transistors may be external to the board and wired back to the PC board.

charged to above fully charged condition of the storage battery is expanded over the full scale of the battery condition meter M1, making voltage (and charge level when calibrated) changes much easier to see.

The resistance of the meter multiplier I used was based on the 265 μA full scale deflection of the small surplus meter I used. Depending upon the full-scale current of your meter, the multiplier resistance can be determined, as explained above, for 5 VDC full-scale indication.

Final Adjustment

Apply AC power and set output voltage at 11.6 VDC, using a DMM for accuracy. Adjust R12 so the green LED D7 just extinguishes and the red LED D8 is illuminated. Operate S2 to check operation of the piezo aural alarm.

Increase output voltage to 13.8 VDC (lead-acid battery) or 13.5 VDC (lead calcium battery). Note that as output voltage is increased, the red LED D8 extinguishes and the green LED is illuminated. Now remove the power.

Parts List

C1	15,000 μF, 50V electrolytic
C2	15 μF 50V tantalum
C3, C5	22 μF 15V tantalum
C4	0.01 μF disc ceramic
C6, C7, 8	0.1 μF 16V disc ceramic
D1	6A bridge rectifier
D2	20 ampere stud diode
D3	10V zener diode
D4	6.2V zener diode
D5	1N914, 1N4148, etc.
D6, 7	Green LED
D8	Red LED
F1	1 amp fuse
F2	20 amp fuse
J1, J2	2-terminal barrier strip, 25 ampere capacity
J3, J4	Binding posts, red and black
J5, J6, J7	RCA jacks (optional)
J8	Insulated terminal post
K1	12-VDC relay, SPDT
M1	Surplus meter, 200 uA to 1 mA
M2, J3	0-1 mA DC meters
Q1, Q2, J2	2N3055 (on large heat sinks)
Q3	NPN small signal transistor (2N3904, 2N4124, 2N2222, etc.)
Q4	NPN 2N3053 (see text)
R1, R2	0.1 ohm, 5W
R3	240 ohm, 1/4W, 5%
R4	1,000 ohm pot, screwdriver adjust
R5, R6, R10, R14	1000 ohm 1/4W 5%
R7, 12	10k ohm trimpot
R8	15k ohm 1/4W 5%
R9	20 ampere shunt (see text)
R11, R13	1,000 ohm 1/4W 5%
R15, R16	1,000 ohm 1/2W 5%
S1, R2	SPST toggle or slide switch
T1	18-25 VAC secondary, 3A transformer
U1	LM317-T adjustable regulator
U2	7809 regulator (9 VDC) 1 amp
U3	7806 regulator (6 VDC) 1 amp
X1	Piezo alarm buzzer, 12-VDC

Pre-etched and drilled circuit boards are available from FAR Circuits, 18N640 Field Court, Dundee IL 60118, for $9.50 plus $1.50 S & H.

Connect J1 to the battery positive terminal and J2 to the battery negative. Also connect J2, or the negative terminal of the battery, to the station DC ground. Note the indication on the battery condition meter (M1)—it should be in the green area above 12 VDC. Apply power while watching ammeter M2. If 3A or less are indicated, the battery can be left on trickle charge.

If the battery condition meter M1 indicates low in the green or yellow area, do not apply power or you may blow the primary fuse or overheat the transformer. Instead, connect the positive lead of an external battery charger of the type used to charge automobile storage batteries to J8 and the negative terminal to the negative terminal of the storage battery. Set the charger for an indication on ammeter M2 of not greater than 10 percent of the battery's ampere-hour capacity—10A for a 100 Ah battery, for instance.

Note that the voltmeter M3 and the battery condition meter M1 indicate full charge for the type battery you are charging, and that D7 is illuminated.

Ignore the indication on the battery charger voltmeter if one is provided. It will indicate somewhat higher voltage than is required for a fully-charged battery, but the internal regulator in this equipment will hold the voltage applied to the battery to the proper level and will not allow the battery to be overcharged. Charging current will gradually be reduced as the battery accepts the charge, eventually tapering off to a trickle: under 1 ampere. At this time, or at any time thereafter, the external charger can be disconnected and the power applied to this equipment and it will then maintain the battery fully charged for use whenever needed.

Conclusion

The large-capacity deep-discharge storage battery used for backup power in the station represents a sizable investment. When properly maintained and used, it will provide satisfactory service for many years. Building and using this simple equipment will ensure that power will be available when needed. With the battery fully charged and connected to this equipment, which should be powered from the AC line and turned on at all times, no further attention is required.

However, as with any storage battery in backup service, monthly hydrometer readings should be taken of each cell and recorded, in accordance with the battery manufacturer's instructions. Water which may be evaporated from the battery over time should be replaced when necessary with *only distilled water*, available in numerous supermarkets and drug stores throughout the country.

WARNING: Do not use tap water or any bottled water except distilled water or the battery may be damaged or its capacity to hold a charge reduced.