

Portable Packet Digipeater for Emergency Service

by John Neeley K6YDW

During the forest fire season, California has many major fires, some raging for several weeks. A call to amateurs for assistance in communications by various local, state and federal agencies is filled by the volunteers. During these disasters, the agencies involved need more portable packet stations and portable digipeaters. Some locations are not accessible directly from the stations at the remote fire camps due to mountainous terrain or other obstacles. The need for highly portable, battery-operated digipeaters is obvious. Packet stations are used to pass logistical messages to and from the camps, along with health and welfare messages from the firefighters.

The August and September 1987 issues of *CTM Magazine* contained a two-part article by Robert Hoover KA6HZF titled "Captain Kirk's Lunch Box," which was about a totally self-contained, battery-operated, solar-charged portable digipeater. Mr. Hoover's article dealt with a complete package housed in a single GI ammo box. It included a Yaesu FT-23 2 meter HT, an MFJ-1270 TNC and a single 14 amp-hour motorcycle battery, along with an external solar panel.



Photo A. The HT/TNC and battery box connected.

I thought this was a great idea, but I didn't have the tiny HT that Mr. Hoover had. I did have an older Kenwood TR-2500 2 meter HT as a spare, and a spare TNC, the MFJ-1270. Since the TR-2500 is much larger than the FT-23, I had to rethink how I could get this all into a compact package. The answer

was to use two boxes: one for the HT/TNC and the other for a dual-battery pack which also included the solar controller circuit board (Photo A). The following article is a guide to building your own unit, no matter

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Photo B. Inside the HT/TNC box.

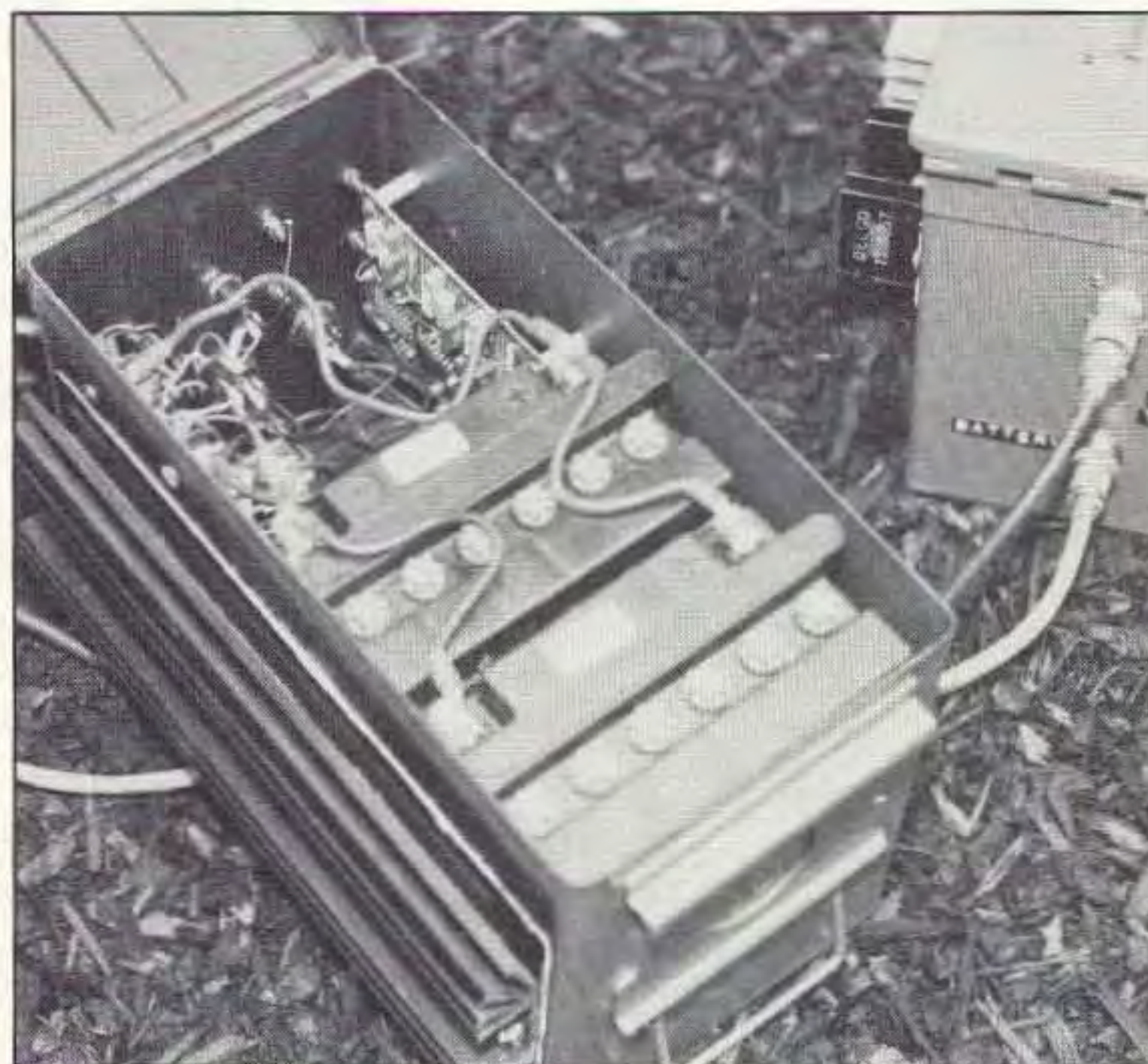


Photo C. Inside the battery box. The solar controller board is in the upper right corner.

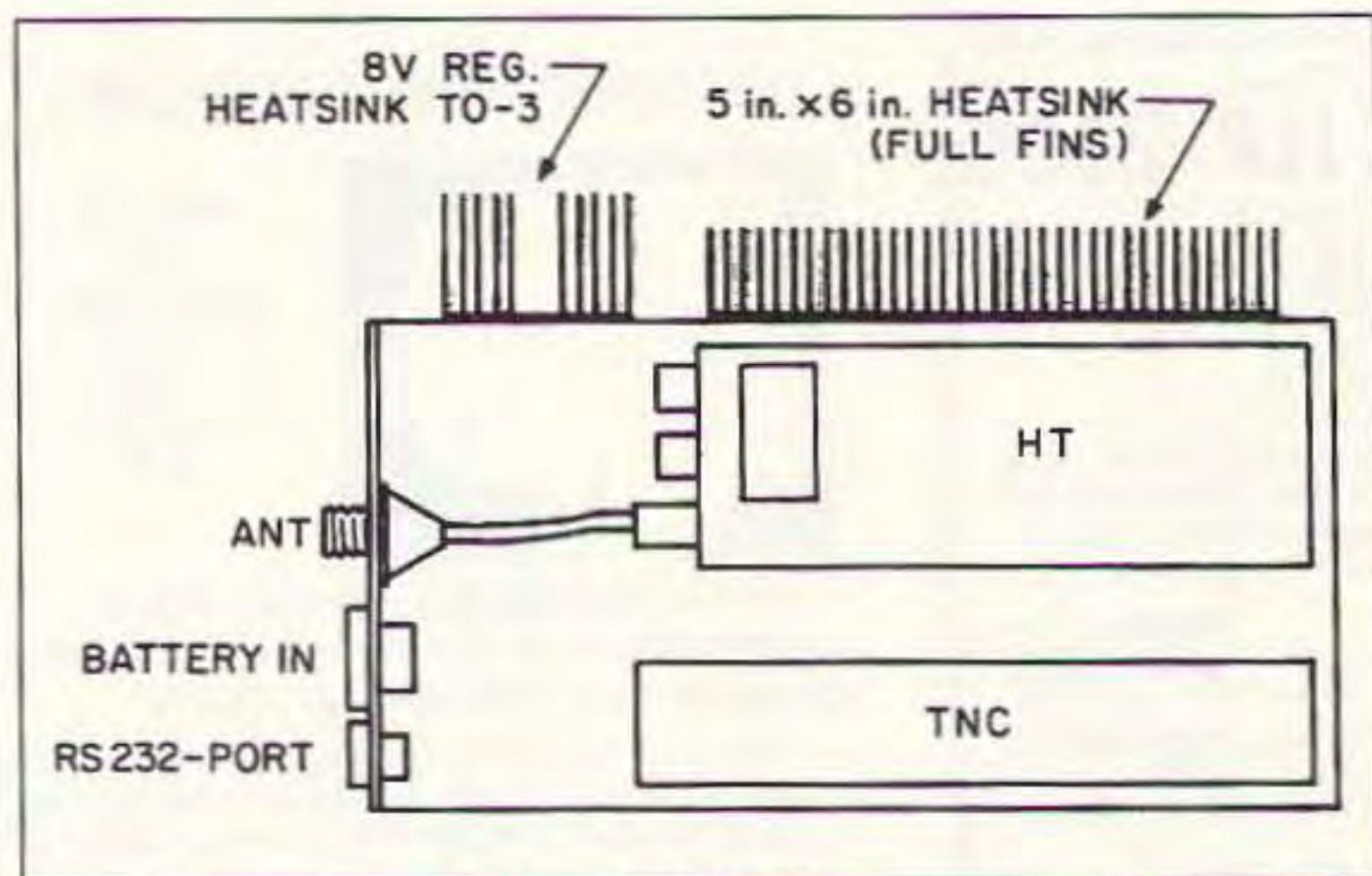


Figure 1. Radio/TNC box, top view.

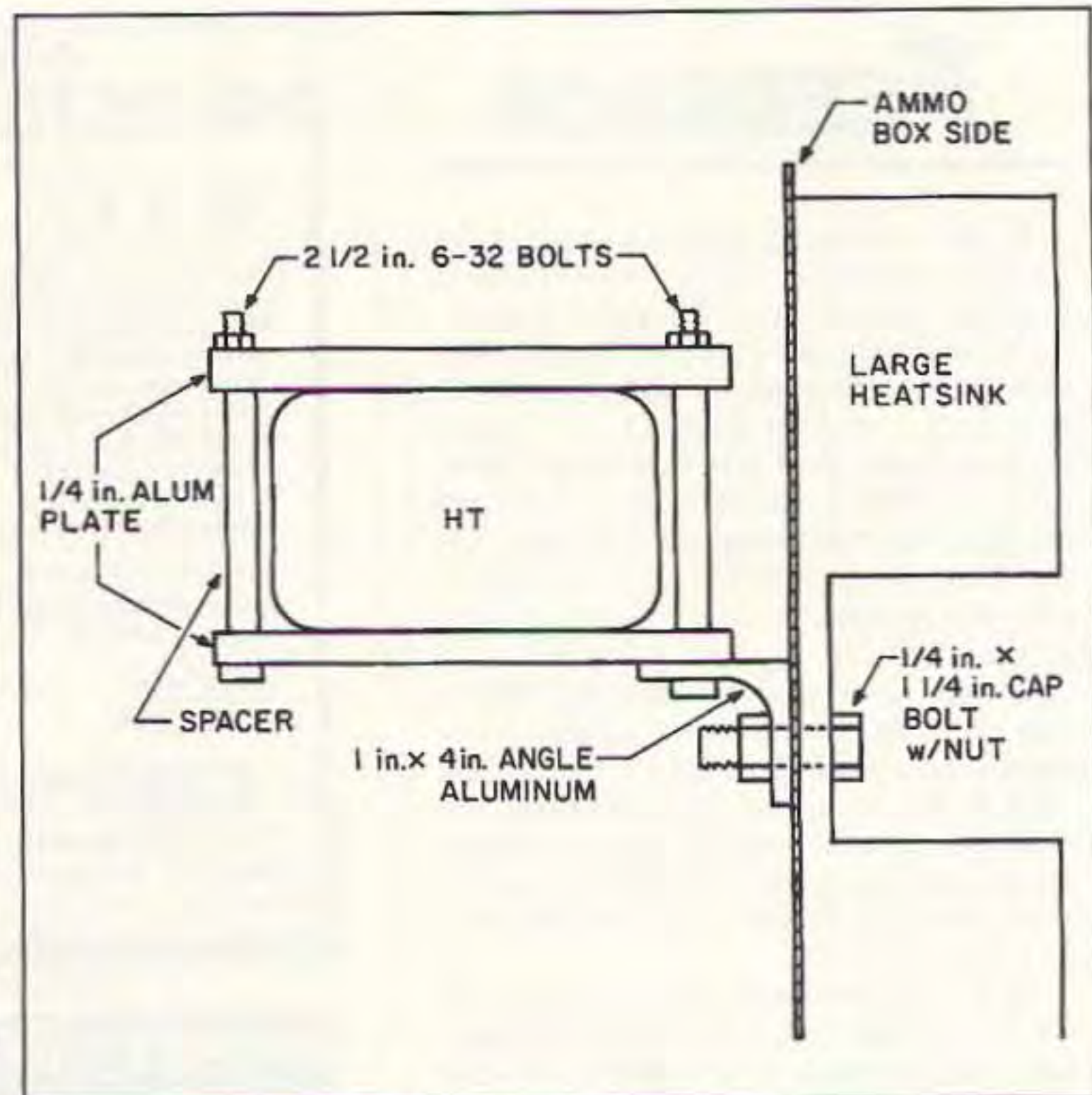


Figure 2. HT mounting scheme.

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what kind of HT or TNC you use.

Radio/TNC Box

The GI ammo boxes are the standard type of box found in most army surplus stores or at flea markets. The size of the box is 5-1/2" W x 7-1/4" H x 11-3/4" (Photo B).

How you prepare the mount for the HT or TNC inside the box depends on which brand you use. Most of the older type of HTs are approximately the same physical size so most will fit in the box the way it was done here.

The MFJ-1270 TNC must first be removed from its enclosure so it will fit inside the box. There are four mounting holes in the circuit board. Take a stiff piece of paper, the same size as the board, and mark all four holes. This will be the drilling template for the TNC board mounting holes. Notice that there is a 5 volt regulator on the end of the board. This must be mounted flush to the inside of the box. First, remove all five LED lamps as they are not required for digipeater

service. I did leave the "Power ON" LED, but bent it up into a position that would clear the inside of the box. This gives me an indication that there is power going to the box. Before mounting the TNC board to the box, using 1/2" metal spacers, first scrape away any paint from the area where the 5 volt regulator is going to touch and apply a liberal amount of heat-sink compound. Also, the top two mounting holes will require the use of flat-head type bolts instead of roundhead types. This allows the top lid of the box, which has some long sides, to clear the boltheads.

The mounting of the HT unit will depend on just what you are going to use, but most can be mounted in this fashion. See Figures 1 and 2. I used some scrap 1/4" aluminum plate for both the top and bottom shelves. The bottom shelf is bolted to a piece of 1"

aluminum angle stock, approximately four inches long, and this angle stock is then bolted to the side of the box. On the outside of the box, where the bottom shelf attaches, is a large heat sink to dissipate any excessive heat generated either by the units inside or by any direct sunlight on the box. There are different ways in which the heat sink can be mounted to the surface of the box, depending on what style of heat sink is used, so I will not go into the details.

In cutting the bottom shelf for the HT, place the HT down on the plate and trace out the outer dimensions. Now, mark the plate 3/8" larger on all sides, as this will give

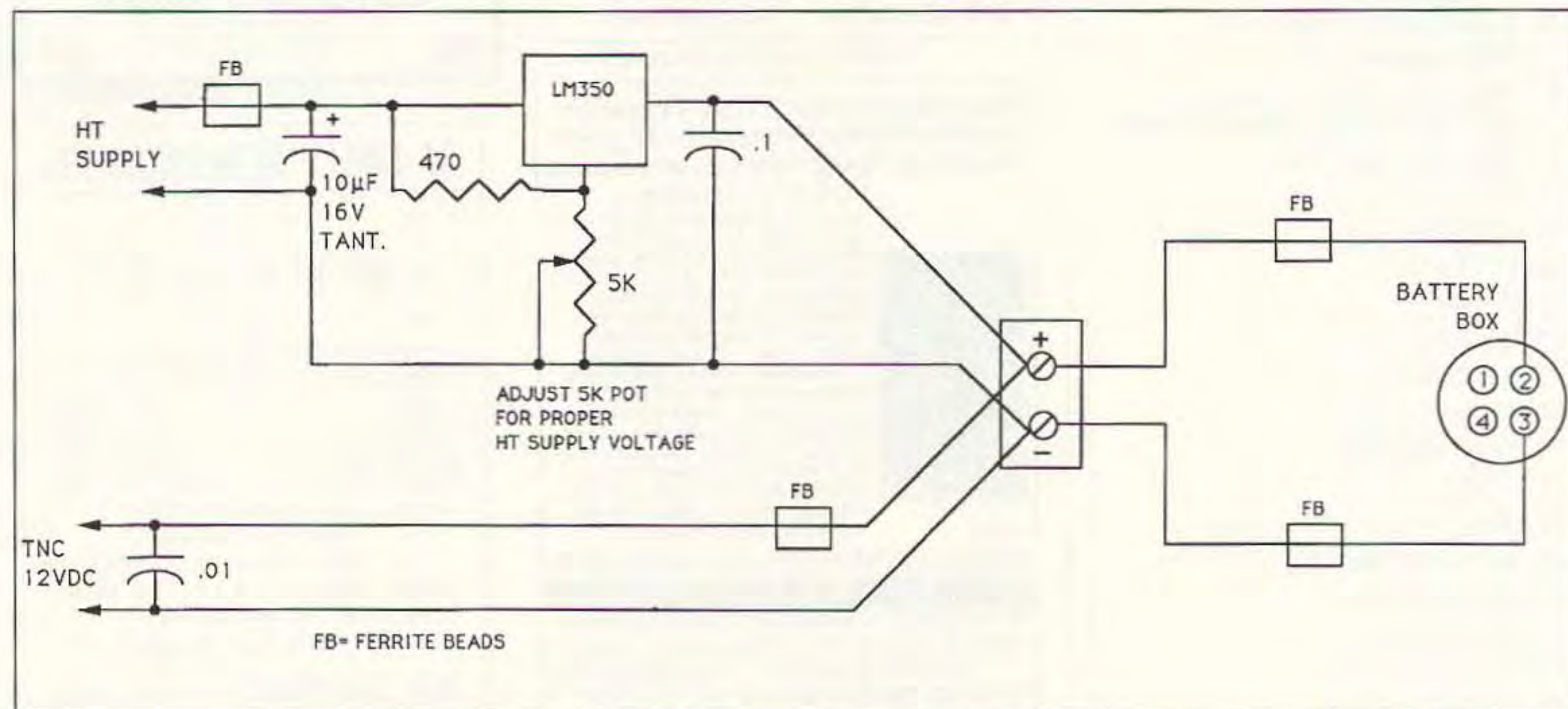


Figure 3. 1.2-32 volt variable power supply.

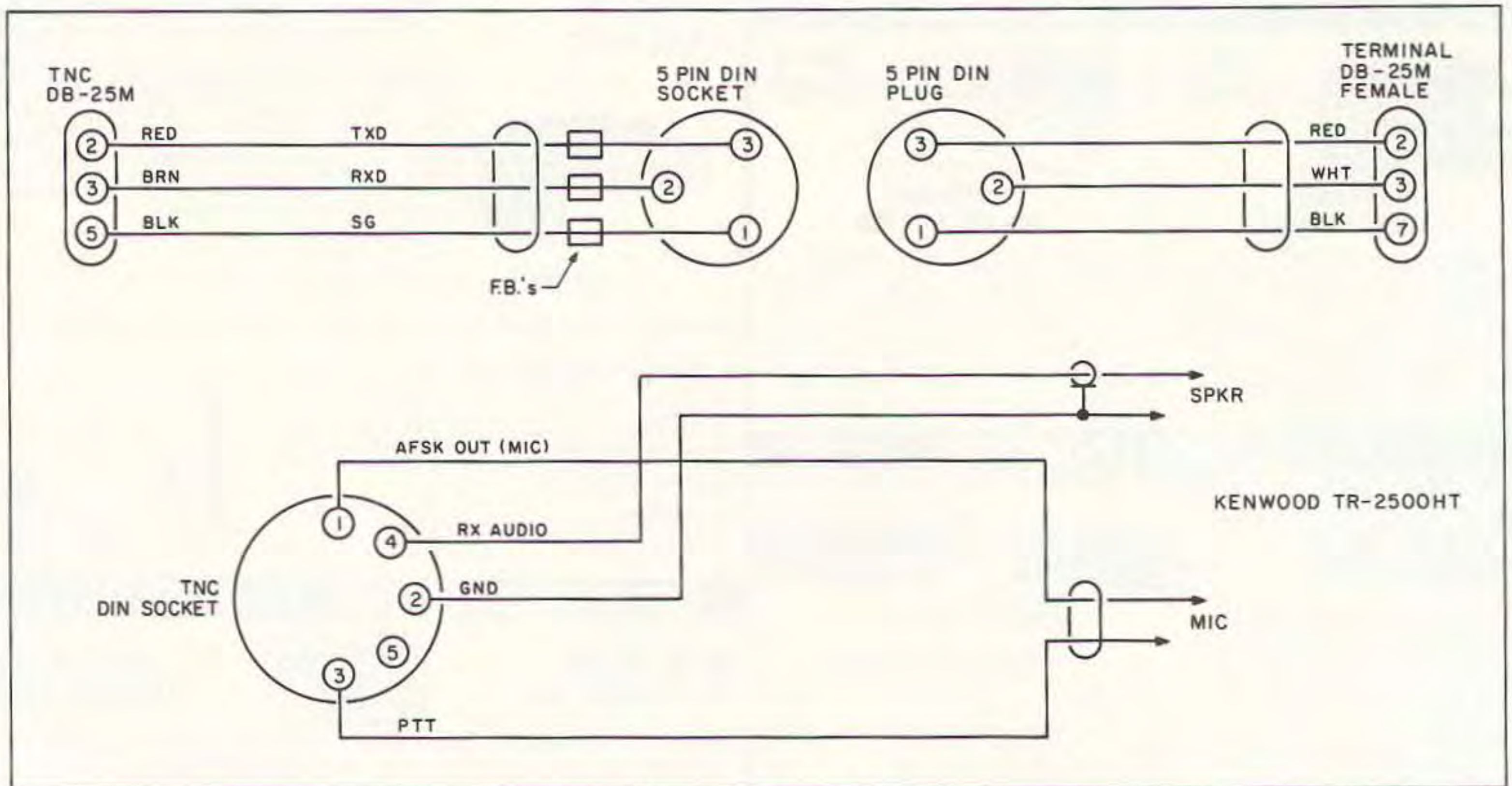


Figure 4. Detail "A."

room to place the mounting bolts. Make the top shelf the same size as the bottom, cutting out for any controls, displays, etc. I used 2-1/2" x 6/32" bolts, using metal spacers to get the correct height needed between the two shelves. Once they are tightened down the HT is very secure.

Three holes are required in the end of the box for the antenna output, the battery input and the RS-232 I/O port.

Since the Kenwood TR-2500 HT uses an 8.4 volt battery pack for power, I installed an LM-340-8K voltage regulator on the outside of the box, next to the large heat sink. Be sure to heat-sink this TO-3 package.

The power voltage required will depend on what HT you plan on using. Some use 12 volts, some less. For voltages other than 12 volts, a simple regulated supply is on the same board as the solar controller and uses a

LM350 regulator. The 5k variable resistor will change the HT supply voltage and can be adjusted for the TH you use (see Figure 3).

Different brands of TNCs are of various physical sizes. Some may mount in the box without having to remove the enclosure. Be sure that the TNC has a "watchdog" circuit to prevent a locked keydown condition. Some TNCs do not have this feature.

Since I planned on using the unit as a portable packet station, I put a 5-pin DIN jack on the outside of the box for my RS-232 I/O port. Placing a DB-25m plug on a 3-conductor ribbon cable, which connects to the DB-25f connector on the TNC, the other end is connected to the 5-pin DIN (see Figure 4). Place a single ferrite bead on each line to the DIN jack. Also, place as many ferrite beads as possible on all lines within

the box. This is just a precaution against any stray RF that may be floating around inside the box. [Note: I have had no problems with stray RF within the box and next to the bare board TNC, even with the plastic case of the TR-2500.]

Battery/Solar Charge Controller Box

I was unable to install a single motorcycle battery inside the same box as the HT and TNC so I had to get a second box. There was plenty of room inside this second box so I decided to use two batteries, which would give me a total of 24 Ah (see Figure 5 and Photo C). Mounting the batteries is fairly simple as they will fit in sideways, leaving approximately four inches on one end for the solar charge controller board and associated output jacks. Be sure to measure the size of the batteries to make sure they will

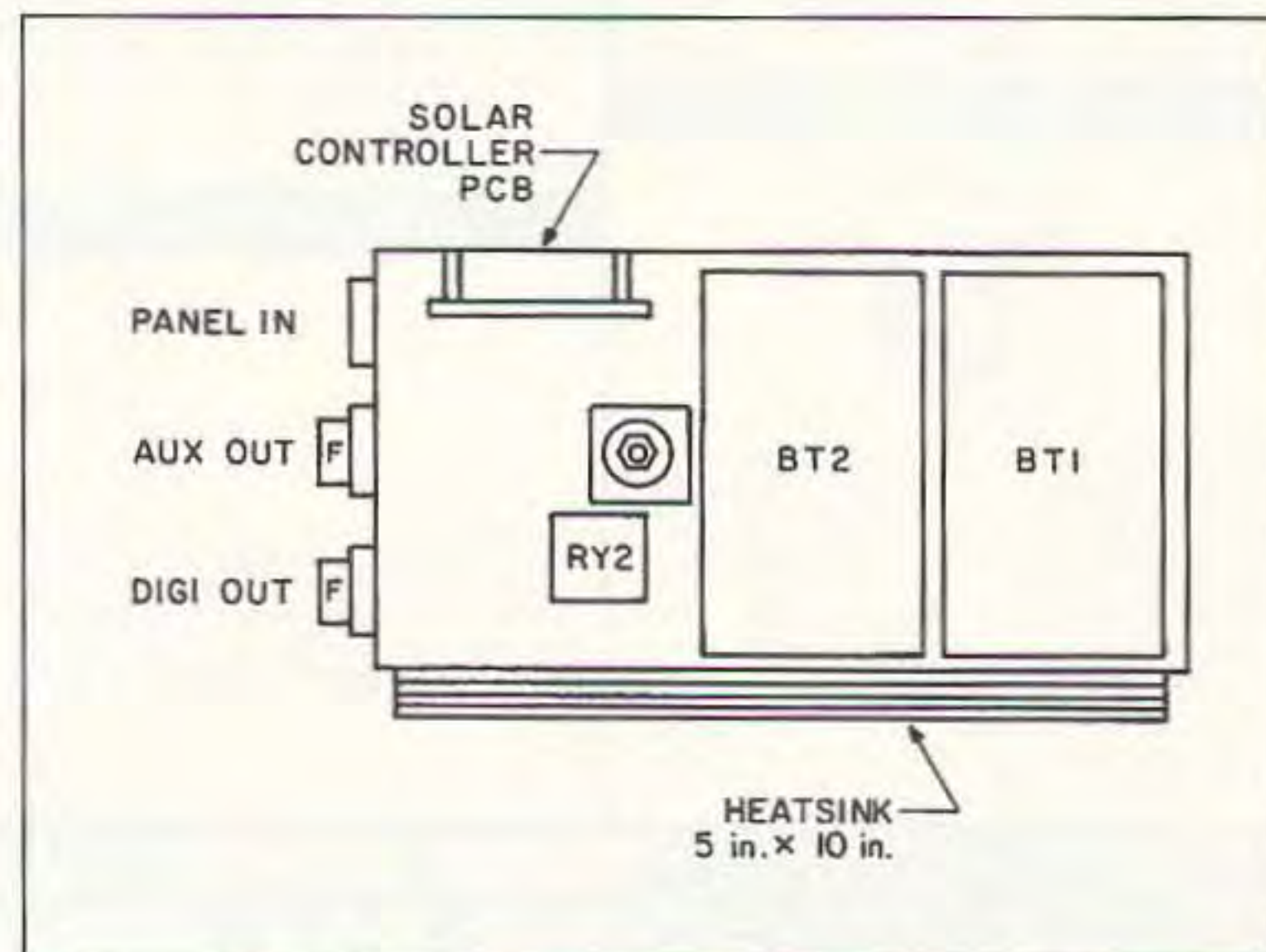


Figure 5. Battery solar controller box, top view.

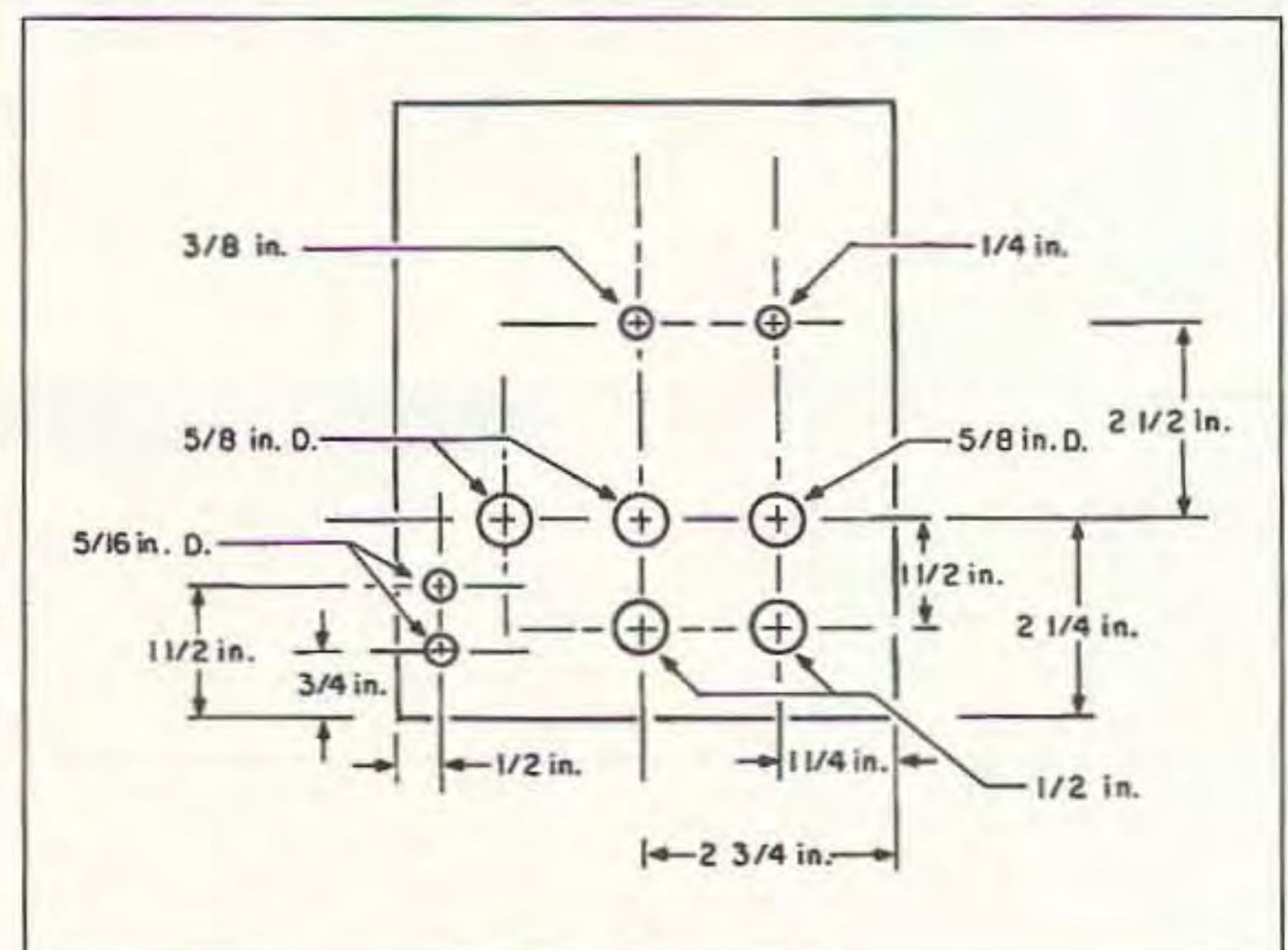


Figure 6. Battery box.

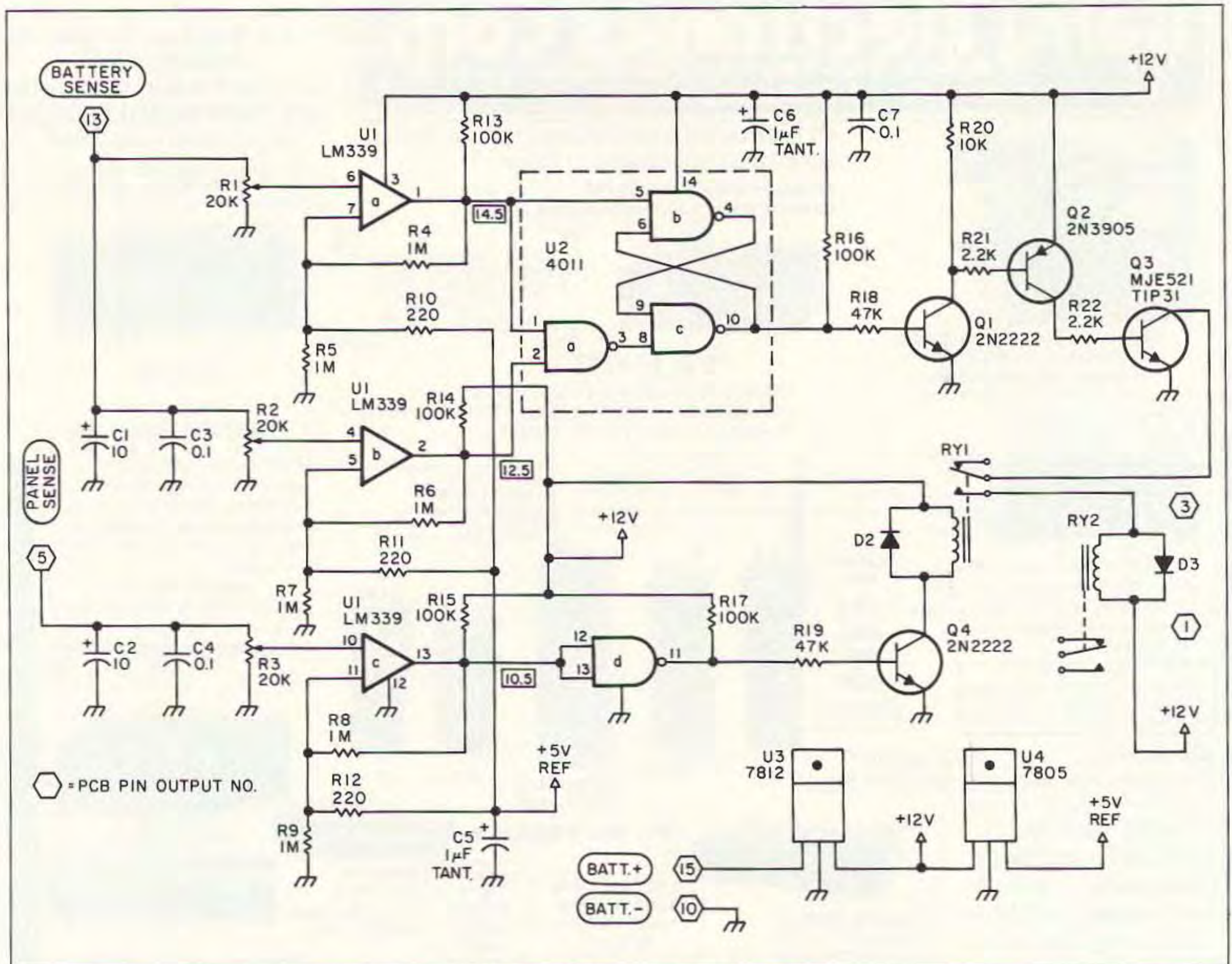


Figure 7. Schematic for the solar controller.

fit inside the box. It is a snug fit, but not binding. Make a metal bracket to hold the batteries in place so they won't shift around. I used a piece of angle steel stock for my bracket.

The output jacks on the outside of the box

are for DIGI, AUX OUT and PANEL IN. The DIGI jack is the power for the RADIO/TNC box and has a one amp fuse inline with its output. The AUX OUT jack is a parallel jack with the DIGI jack, with a 3 amp fuse inline. This AUX OUT jack can be

used to power any external unit, like a transceiver, another digipeater, etc. The PANEL IN jack is the solar panel input to the charge controller. You will see in the template drawing of the box (Figure 6) that I have placed two 5/16" holes near the bottom of the box. These are for the breather tubes coming from the batteries. Also, the "Charge" LED and power switch for the controller are mounted on the end

of the box.

Solar Charge Controller

The basic circuit for the controller uses three sections of an LM-339 voltage comparator IC (see Figure 7). Two sections are used to monitor the HIGH and LOW battery voltage, and the third section is used to monitor the voltage output from the solar panel. I found several articles dealing with solar charging in various publications, and by combining features of these articles I came up with my own simplified version. The project can be built on a printed circuit board available from FAR Circuits, 18N640 Field Court, Dundee IL 60118 for \$8 plus \$1.50 S & H.

Alignment of the circuit will require a variable power supply (+10-15V), a digital VOM and a logic probe. First, connect both the battery sense and panel sense input lines to the same point. Adjust the voltage output of the supply to 14.5 volts and place the logic probe on pin 1 of the 339. Adjust the 20k pot, R1, to where the probe goes LOW. Set the power supply to 10.5 volts and adjust R3 to where pin 13 goes LOW. Rock the supply to make sure all the set voltage points are set

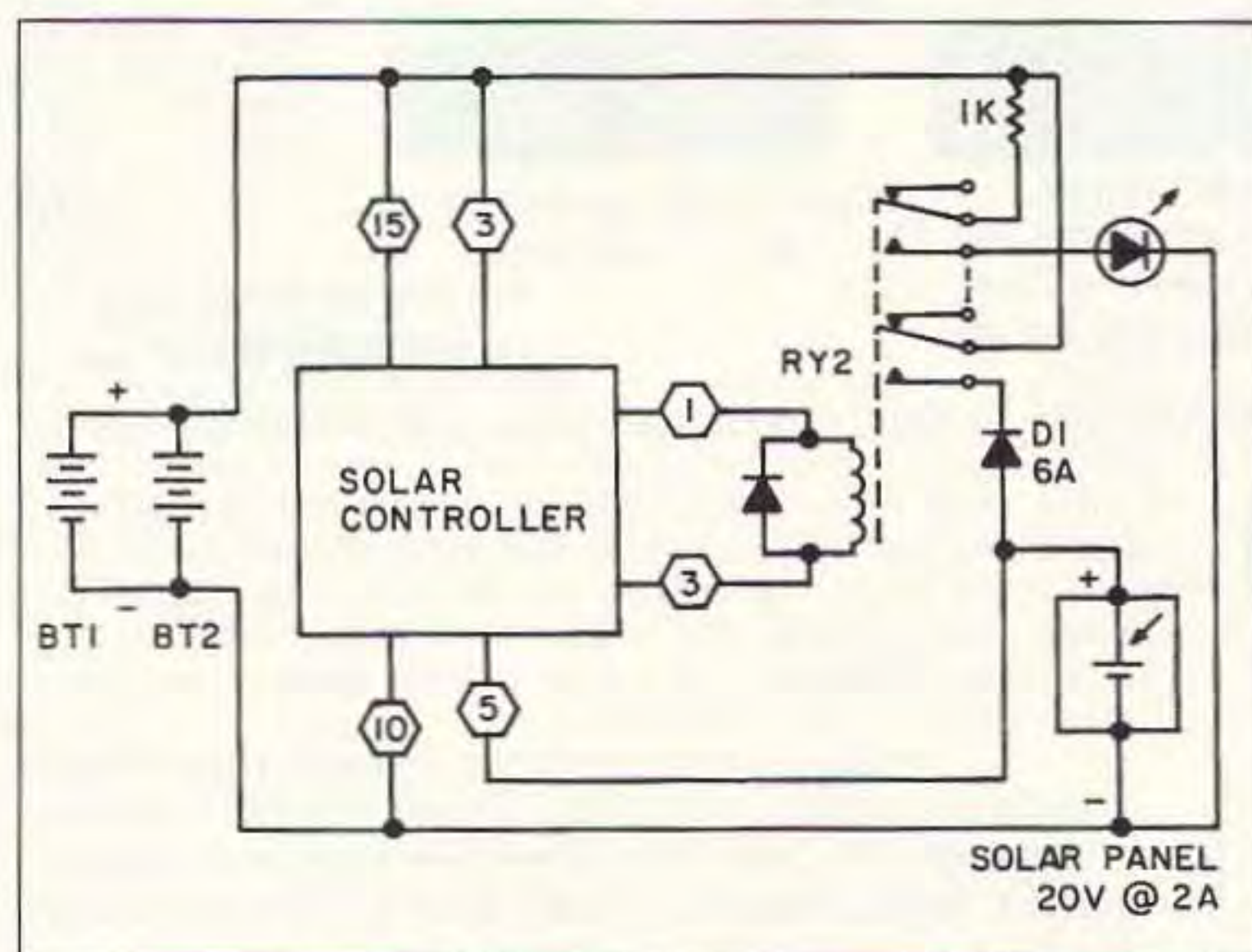
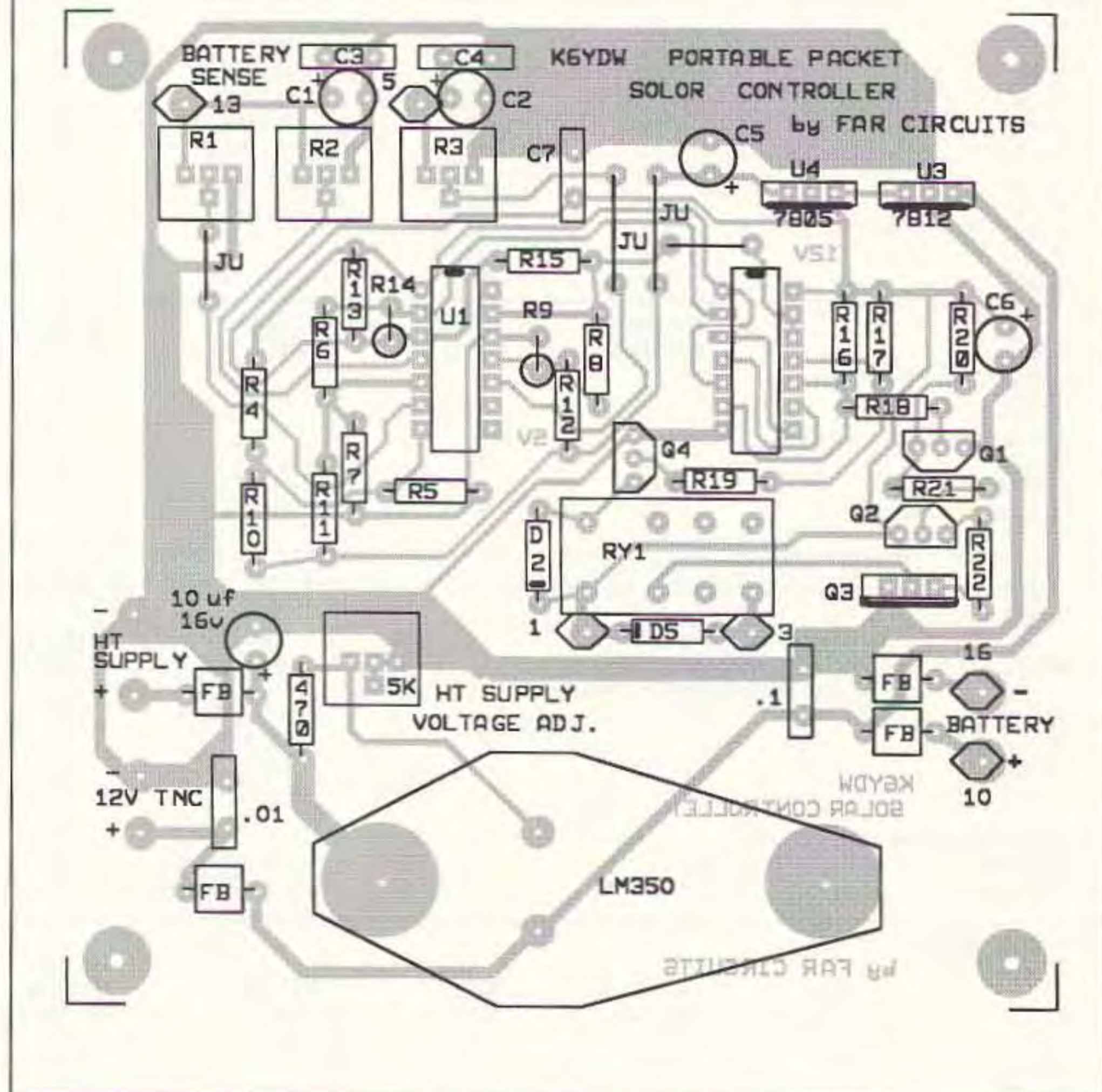
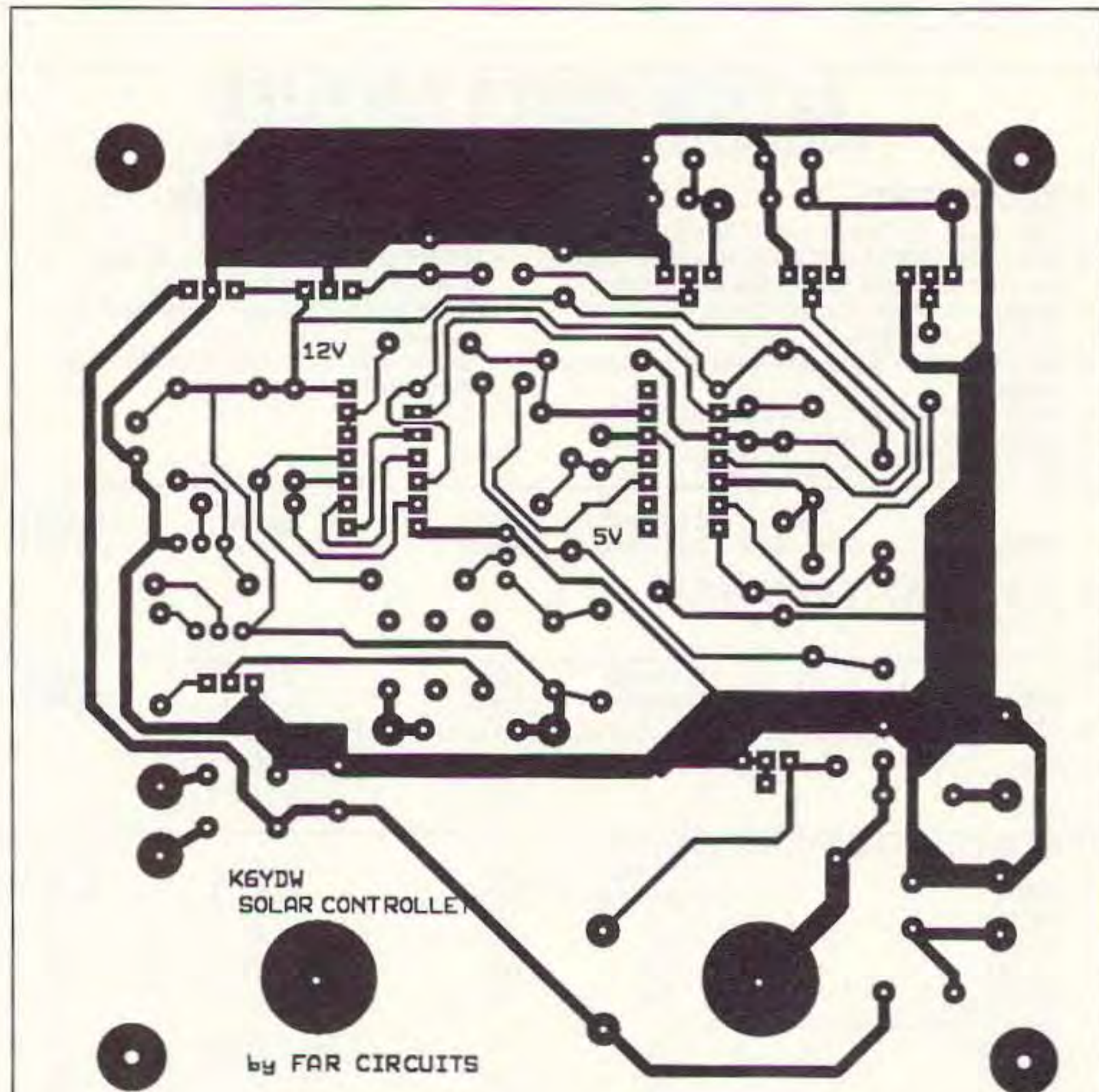


Figure 8. Solar controller external wiring.



correctly. The controller is now ready to be mounted in the box.

Attach the battery sense line to the positive battery post on the battery. Do not attach it to any other point. Then, attach the panel sense line to the output of the solar panel, making sure you have connected it on the anode side of the blocking diode, D1. The blocking diode is used so the panel sense circuit will not be fooled by the voltage output of the batteries. The 10.5 voltage sensor portion of the circuit is not required; it's just as an added feature. The charge circuit will work without it, but I use it as a "day-night" switch. See Figure 8.

Operation of the controller is fairly simple. As long as the panel sense voltage is above 10.5 volts the circuit is active. If the panel sense voltage falls below 10.5 volts, then RY1 is disabled, thereby preventing any charge voltage to the batteries. When the voltage from the solar panel rises to above 10.5 volts, RY1 is connected between the collector of Q3 and the coil of RY2, which allows any charge voltage from the solar panel to flow when requested by the controller circuit.

When the battery post voltage falls to 12.5 volts, pin 2 of the LM339 comparator goes LOW, thereby turning on RY2, allowing current to flow from the panel to the batteries for charging. When the battery post voltage reaches 14.5 volts, pin 1 of the 339 will go LOW, turning off RY2. The "float charge level" is 14.5 volts for most lead-acid batteries.

General Information

The total weight of both boxes is 33 pounds, fully loaded. This weight is a bit excessive, but you have a rugged and, for the most part, weatherproof unit that can be placed in any location desired, like under a large boulder, bush or tree, and it will provide signals to reach from your remote location to the next digipeater.

For an antenna I use a modified Hustler CG-144 5.8 dB mobile whip to which I have attached three radials. This antenna is then mounted on a 5-foot section of TV mast. Three other 5-foot sections are added to give a total height of 20 feet, which can be placed in the rocks or self-supported with some nylon rope. For coax, a good choice is RG-8/x mini-foam, as it is quite flexible and has good characteristics at this frequency. For the two-conductor cable between the two boxes, use a good quality cable which has a heavy outer sheath. I also use this type of cable between the box and the solar panel. For all power connections I use 4-pin microphone connectors. This type of connector provides screw mounting, which gives security in remote locations where other types of connectors could be pulled out by animals walking by. For this reason, do not use phono type connectors.

For extra weatherproofing protection, you can cover the boxes with a small tarp. This

Figure 9. PC board and parts placement.

will also shield the boxes from any direct sunlight. Also, turn both boxes to where the heat sinks are facing north, or are in the shade all the time.

The boxes should be painted with a good quality rust inhibitor paint. The bottom and the side on which the large heat sinks are mounted should be a flat black finish. Other areas should have a light-color finish to help reflect heat.

The dual-battery setup will provide plenty of backup power in case of poor voltage output from the solar panel due to clouds, smoke or haze. I have run a test using just the fully charged batteries alone, with no charger in the circuit. When I set the TNC to beacon one line of text every 10 seconds, and the HT to full power of 2.5 watts out, it ran for five days with only a half volt (0.5V) drop through the test period. There is no reason you cannot use just a single battery instead of two. The total package would be lighter by about 15 pounds.

Operation

The system should be set up before you transport it to a remote location. Plug your terminal into the RS-232 I/O port on the HT/TNC box, then apply power to the system by plugging in the power cable from the battery box.

The following parameters are for the TNC-2 type, for unattended digipeater service:

CONOK-OFF: DWAIT=0:
TXDELAY=50: DIGI=ON:
USERS=0: MON=OFF:
HID=ON

Unplug the power cord and disconnect the terminal. You are now ready to use this system when needed.

Whatever HT/TNC and battery combination you use, it will have to be a special design to fit your needs.

Parts List for Solar Controller

Integrated Circuit		
U1	LM339 voltage comparator	RS276-1712
U2	4011 CMOS quad two-input NAND gate	RS276-2411
U3	12 volt voltage regulator	RS276-1771
U4	5 volt voltage regulator	RS276-1770
Transistors		
Q1,Q4	General purpose NPN (2N2222, 2N3904, etc.)	
Q2	General purpose PNP (2N3905, etc.)	
Q3	TIP31 NPN	RS276-2017
Diodes		
D1	Silicone 50V at 6 amps (1N5400, etc.)	
D2,D3	1N4001	
Resistors		
R1,R2,R3	20 kilohm 15-turn trimmers	RS271-340
R4,R5,R6,R7,R8,R9	1 megohm 1/4 watt	
R10,R11,R12	220 ohm, 1/4 watt	
R13,R14,R15,R16,R17	100 kilohm, 1/4 watt	
R18,R19,R22	47 kilohm, 1/4 watt	
R20	10 kilohm, 1/4 watt	
R21	2.2 kilohm, 1/4 watt	
Capacitors		
C1,C2	10 μ F, 35V electrolytic	
C3,C4,C7	0.1 μ F, 50V disc	
C5,C6	1 μ F, 35V electrolytic	
Relays		
RY1	12V DPDT (16-pin DIP)	RS275-249
RY2	12V DPDT (10 amp contacts)	
Batteries		
BT1,BT2	12V at 14 Ah motorcycle-type or gel-cel	

Circuit boards are available from FAR Circuits, 18N640 Field Court, Dundee IL 60118 for \$8 plus \$1.50 S & H.

This article is intended as a simple guide. Any comments are welcomed, and a SASE will be appreciated for any return comments.

Acknowledgements:

"Captain Kirk's Lunch Box, Part 1," by Robert Hoover KA6HZF, *CTM Magazine*, August 1987, page 21.

"Captain Kirk's Lunch Box, Part 2," by

Robert Hoover KA6HZF, *CTM Magazine*, September 1987, page 28.

"Total Solar" by Michael Bryce WB8VGE, *73 Magazine*, May 1986, page 60.

"The Battery Topper," by Michael Bryce WB8VGE, *CTM Magazine*, June/July 1987, page 25.