By Ben Richards

Solar-Cell Power Converter

Let the power of the sun keep your battery costs down

☐SOLAR CELLS PRODUCE VERY LOW VOLTAGE OUTPUTS AT fairly high current when energized by the light of the sun or other similar light. A series of enough interconnecting small solar cells to operate a 9-volt transistor radio can be expensive. It costs less to use a single, relatively large cell, and raise the voltage with a DC-to-DC converter capable of running at the low voltage that the single solar cell supplies. Such a Solar-Cell Power Converter could be very welcome in case of emergencies or natural disasters, where all you may have are dead dry batteries, or discharged Ni-Cd's with no 60-Hertz line power to recharge them.

How It Works

Figure 1 is the schematic diagram of the Solar-Cell Power Converter. Initially, one transistor begins to conduct a little more than the other when power from solar cell D1 is applied, and that results in a regenerative increase of current in one transistor, and a decrease in current in the other one. Very shortly, one transistor is at current saturation (full-on), and the other, at zero conduction (full-off). That condition persists until the transformer saturates and creates regenerative turn-on of the previously conducting (on) transistor. That rapid current-switching repeats cyclically at a high rate. The build up and collapse of current in the primary winding (browm and orange leads) of T1 induces a stepped-up AC voltage across the output winding (gray and white leads).

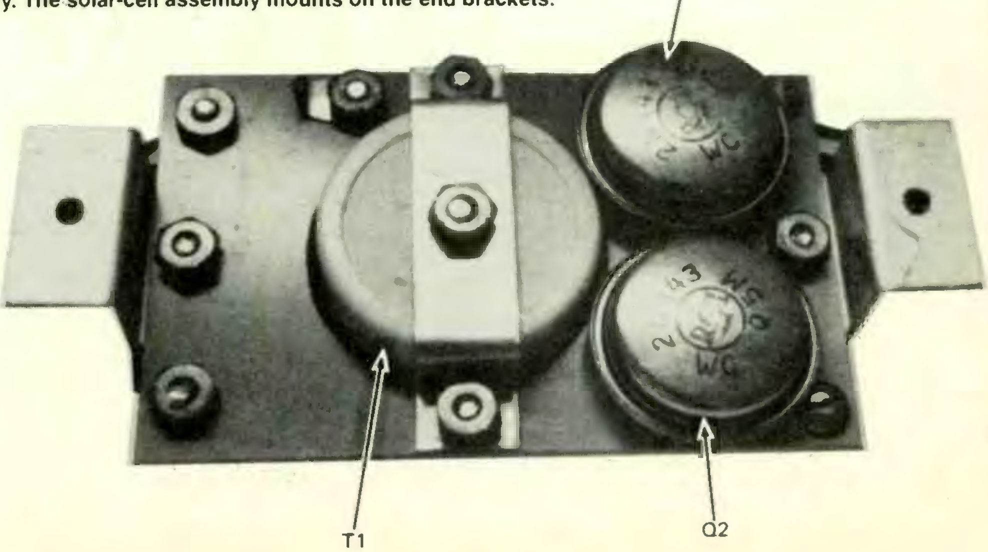
A full-wave doubler rectifier, D2 and D3, is used to produce the required DC voltage output. A Zener diode, D4, is used to set the upper limit on the output voltage when the load current is minimal, but D4 is not intended to keep the output voltage constant. The radio-frequency choke, RFC1 and the .01 µF capacitor, C1, hold down RF noise generated by the switching circuit to an acceptable level.

You may be wondering about the use of power-transistors, Q1 and Q2, of a much higher power rating than would appear necessary. The reason is that the transistors have an extremely low voltage drop at the current levels encountered in changing the roughly 1/2-volt output of the single solar cell to high-frequency AC. Much smaller transistors could handle the current easily, but at two to three times the voltage drop. Since we're starting with a very low DC input voltage, a large voltage drop would result in a circuit whose efficiency was too low to be practical.

Construction

The mechanical layout of the Solar-Cell Power Converter is

A SMALL AMOUNT OF sheet-metal work is required to develop a chassis to mount the power-switching transistors Q1 and Q2, transformer, T1 and the other parts that make up the Solar-Cell Power Supply. The solar-cell assembly mounts on the end brackets.



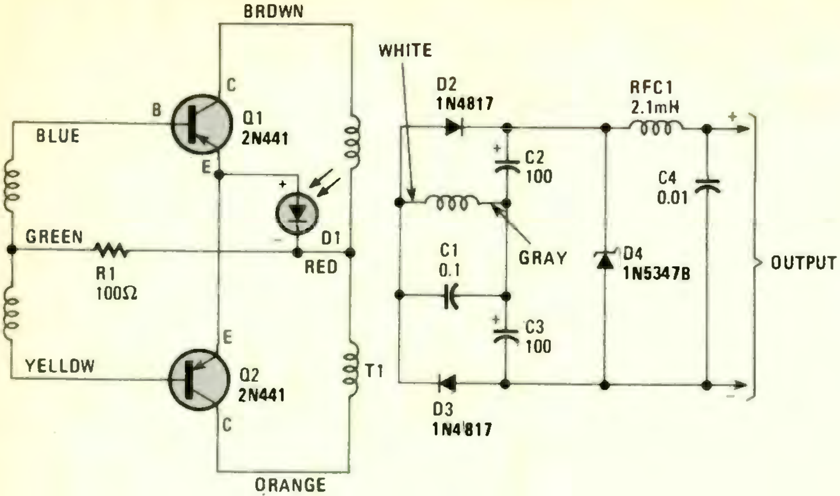


FIG. 1—THE POWER to drive this circuit is obtained from solar cell D1 that produces .45-volt DC at 333 mA in bright sunlight. That's 150 milliwatts of power—is more than enough to drive a transistor radio if its output was 9-volts DC. The five coil elements (other than RFC1) are wound on the same coil form to make up transformer T1. The circuit is designed to obtain minimum switching losses and maximum current reversals in the collector circuits of Q1 and Q2. The remainder of the circuit is a fullwave, voltage-doubler rectifier with filtering and Zener diode regulation.

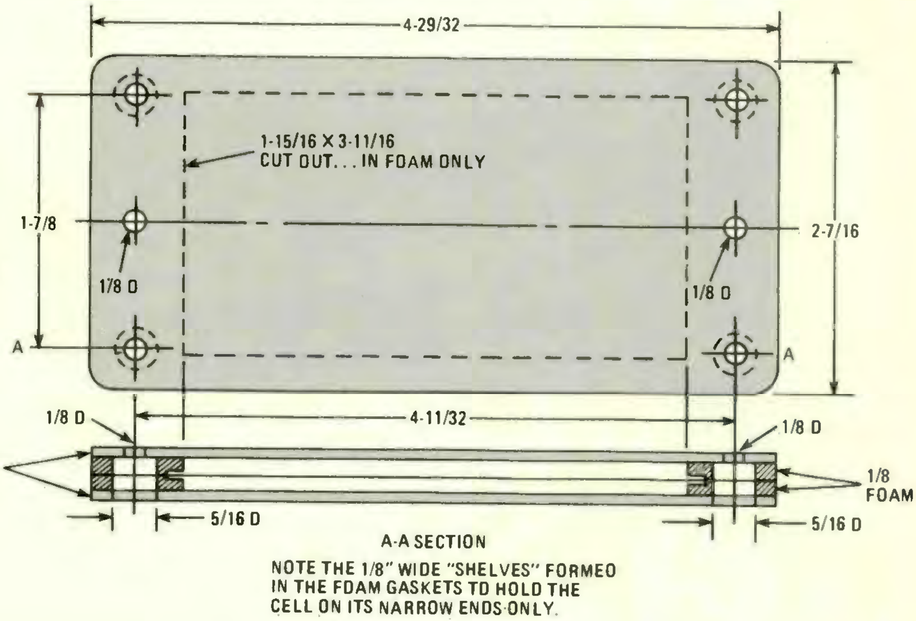


FIG. 2—CONSIDERING the high cost of solar cells and their fragile construction, it is wise to mount them in a suitable holder that is gentle to them and rugged enough to offer protection from rough handling. The diagram shows how the cell is mounted between two pieces of clear plastic and suspended by bits of foam material. Duplicate the author's efforts for suitable solar cell protection.

PARTS LIST FOR SOLAR-CELL POWER CONVERTER

SEMICONDUCTORS

D1—2- × 4-inch (5- × 10-cm) solar cell (Radio Shack 276-126 or equivalent)
D2, D3—1N4817 rectifying diode
D4—1N5347B, 10-volt Zener diode
Q1, Q2—2N441, 2N442 or 2N443 germanium, PNP power transistors

ADDITIONAL PARTS AND MATERIALS

R1—100-ohm, ¼-watt, 5% resistor
C1—0.1 μF, 100-WVDC, tubular capacitor
C2, C3—100 μF, 6-WVDC, electrolytic capacitor
C4—0.01 μF, 50-WVDC, ceramic-disc capacitor
RFC1—2.1-mH, radio-frequency choke
T1—EC-0201-IP saturable transformer (available from Milwaukee Electromagnetics, P.O. Box 07476, Milwaukee, WI 53207, for $6.95 postpaid)
4 × 2⅛ × ⅝-inch plastic box (Radio Shack 270-231 or equivalent), plastic sheets, foam sheet, scrap aluminum, wire, solder, hardware, cement, etc.

not critical, but some specific dimensions are suggested for those who wish to duplicate the original project.

Begin by preparing the plastic-sheet chassis according to Fig. 3. A chassis punch or hand-grinding tool with a fluted cutting bit can be used to form the large-diameter hole through which the inverter transformer, T1, is mounted with the aid of the aluminum mounting strip. Attach the transistors, Q1 and Q2, the end-mounting brackets, the transformer, and the corner-mounted soldering lugs as shown in the photograph. Make sure that the power-transistor cases do not touch each other or the screws which fasten the four, corner, solder lugs to the plastic chassis. Be sure to provide heat-sink thermal connection to the base and emitter terminals of the transistor when applying the soldering-iron heat.

Solder fine, insulated, stranded-wire leads to the solar cell, D1, very carefully using a small, low-wattage, soldering iron. The full surface ohmic connection on the back of the solar cell is the positive terminal and the comb-like electrode on the opposite surface is the negative terminal. If in doubt, check the solar cell's output polarity with a voltmeter.

The plastic and foam sheets which make up the solar-cell assembly should be formed as shown in Fig. 2. As shown in the drawing, the solar cell is mounted between a set of plastic and foam sheets so that it is supported only on the narrow

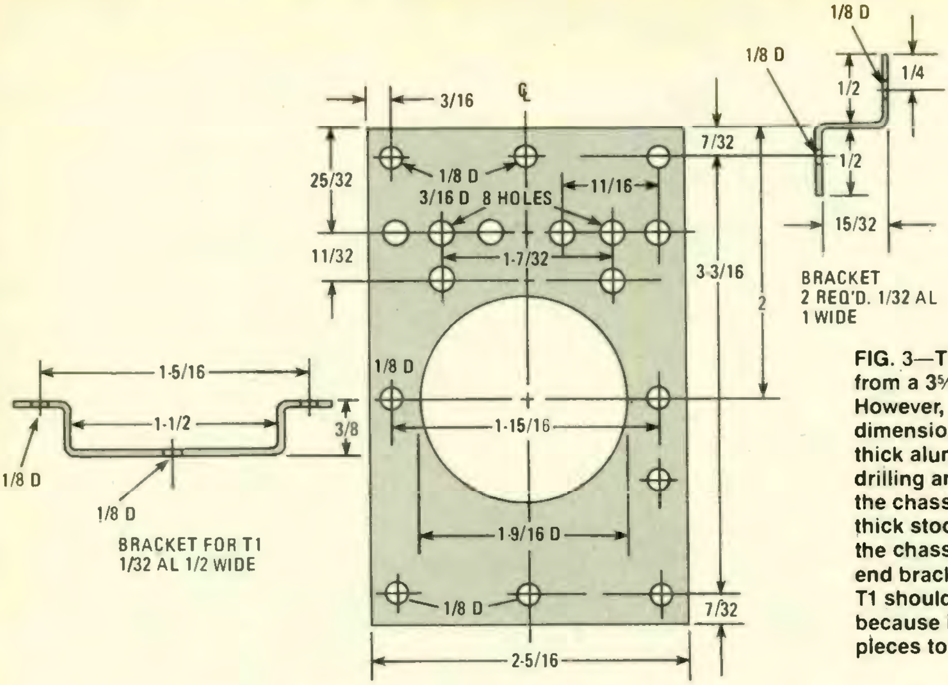
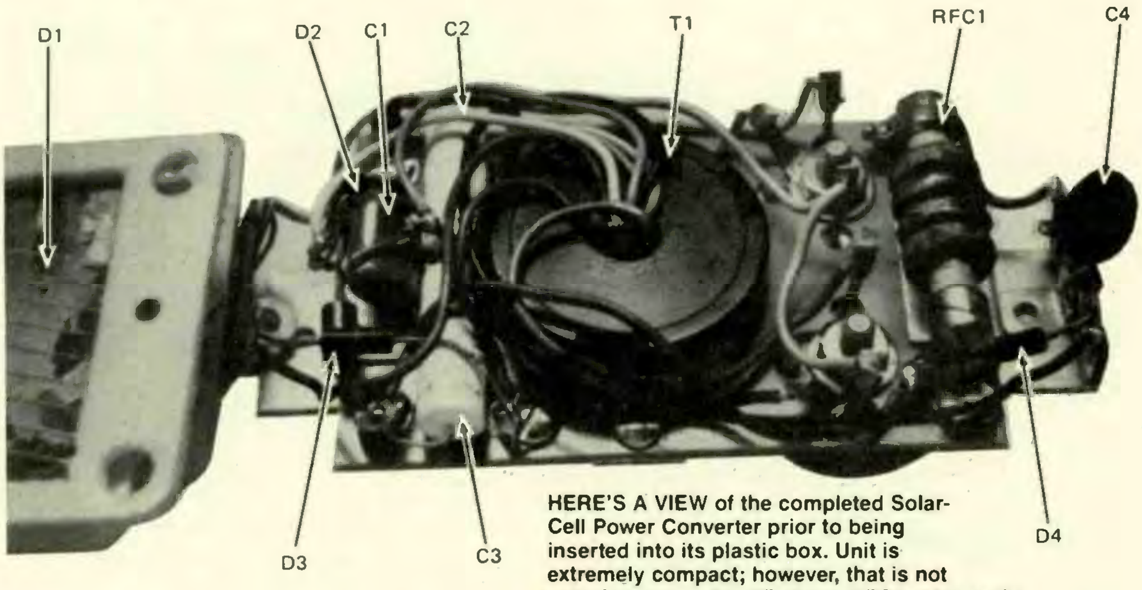


FIG. 3—THE ALUMINUM CHASSIS is made from a 3⅝-in. by 2$\frac{5}{16}$-in. sheet. However, it is wise to scratch the overall dimensions on a scrap sheet of $\frac{1}{32}$-in. thick aluminum, and do all the necessary drilling and hole punching before trimming the chassis down to size. Or, should $\frac{1}{16}$-in.-thick stock, or better, be used to make the chassis, that is not necessary. The end brackets and the bracket for transformer T1 should be of $\frac{1}{32}$-in. aluminum stock because it will be easier to bend the cut pieces to the shapes required.



HERE'S A VIEW of the completed Solar-Cell Power Converter prior to being inserted into its plastic box. Unit is extremely compact; however, that is not a design necessity. RF choke RFC1 reduces the high-frequency hash generated by switching circuit.

ends by a ⅛-inch shelf cut into the foam gaskets. The plastic used was an acrylic such as used for glazing windows and can be cut using a scribe-and-break technique. The foam gaskets were made from a tray used to package food; they can be cut to shape with a razor blade. Be careful not to crack the solar cell during assembly. By the way, neither wiring dress nor parts layout are critical. The wired chassis and solar cell assembly are joined with the end brackets shown in Fig. 3. The combined chassis-solar cell assembly is fastened to the plastic case with four mounting screws.

Testing and Use

Probably the easiest thing to do is hook up the output leads to the load and walk out into the sunshine to enjoy solar-powered music. If you want to test the converter first, just connect a voltmeter across the output leads. Expect 9 to 11 volts under light load and moderate illumination.

A small amount of RF noise between stations (if you're powering a receiver) is normal and shrinks to virtually nothing when the radio's AVC takes over.

If the converter doesn't work, check the polarity of the solar cell output. If it's OK, check the wiring for an incorrect, broken, or shorted connection. By the way, you can bench-test the converter alone by disconnecting one lead of the solar cell and applying 0.6-volts DC from a variable power supply.

Intended use of the Solar-Cell Power Converter is to power small AM transistor radios. Our tests indicate that you'll get satisfactory operation under sunlight conditions ranging from overcast to full noonday sun. The Solar-Cell Power Converter is not intended for FM receivers, because they are sensitive to small supply-voltage changes such as might occur when fast-moving clouds pass by. It is not advisable to leave the circuit wiring exposed indefinitely to the elements, so you should seal the circuit thoroughly. ■