Build A SINE-WAVE INVERTER

Boosts 12 volts dc to 117 volts ac at 100 watts, and also recharges storage batteries.

BY MARTIN MEYER

"CAMPING OUT," whether it be in one of the new modern campers, a trailer, a tent, or even a boat, is one of today's most popular ways of "getting away from it all." There always comes a time, however, when we miss some of the creature comforts that we left at home—comforts that can only be provided by electrical appliances. Unfortunately, appliances that work on 12 volts dc are relatively expensive.

You can, however, use a dc-to-ac inverter, enabling you to utilize ac equipment you already own. As some readers might have already discovered, though, most of these devices deliver a form of square wave that prevents their use with equipment that is sensitive to the interference caused by square waves. This includes TV receivers, audio equipment, CB gear and some test instruments. With the inverter described here, you can now get 117 volts of 60-Hz sine-wave power at 100 watts from a conventional 12-volt battery system. In addition, the inverter can be used to recharge vehicle batteries at 15 amperes from any 117-volt, 60-Hz power source.

The inverter can also be preset to deliver power at any frequency from 50 to 400 Hz, making it useful for operating some surplus electronic gear designed for 400 Hz. As an integrated standby power source it can even be used for power-failure emergencies in the home.

SPECIFICATIONS

Input:	12 V dc at 14 A
Output:	117 V ac, 50-400 Hz, 100 W
Distortion:	Less than 10% at 100 W
Charge Current:	15 A max. (self-limiting)

How It Works. As shown in Fig. 1, the first stage in the inverter is a low-distortion sine-wave oscillator (*IC1A*) whose frequency can be adjusted by *R1*. The output of the oscillator is amplified and isolated from the load by a combination of an op amp and

PARTS LIST

C1—0.082-μF Mylar capacitor
C2—0.002-μF disc capacitor
C3,C5,C6,C7—47-μF, 16-volt electrolytic capacitor
C4—220-μF, 16-volt electrolytic capacitor
C8—2.2-μF, 16-volt electrolytic capacitor
C9—1000-μF, 16-volt axial-lead electrolytic capacitor
C10—1000-μF, 16-volt, pc-type electrolytic capacitor
C11,C12,C13—0.01-μF disc capacitor
CB—18-A circuit breaker (Littlefuse)
D1 to D9—1N4001 diode
D10,D11—1N4148 diode
IC1—747 dual op amp
M1—30-0-30-A meter
P1—117-volt male socket
Q1—2N5232 transistor
Q2—2N5354 transistor
Q3,Q4—60407 transistor (RCA)
Q5 to Q10—2N3055 (matched gain at 5A)
R1,R11—50,000-ohm potentiometer
Following resistors are 10%, ¼-watt:
R2,R4—68,000 ohms
R3—2200 ohms
R5,R19,R22—220 ohms
R6,R7,R12,R13,R20,R21—10,000 ohms
R8—510 ohms
R9—4700 ohms
R10—1000 ohms
R14—1 megohm
R15—120,000 ohms
R16—470,000 ohms
R17—560,000 ohms
R18—220,000 ohms
S1—5-pole, double-throw switch
SO1—117-volt chassis-mounting socket
T1—1:3 step-up driver transformer
T2—6-V/117-V, 18-A primary output transformer (see below)
Misc.—Suitable chassis, rubber feet, grommet for battery lines, press-on type, silicone grease, aluminum for heat sink, ¾" standoff insulators.
Note—The following are available from Netronics Research and Development Ltd., Rt. 6, Bethel Meadows, Bethel, CT 06801: complete kit including case and heat sink at $69.95, plus $3.00 postage and handling. Also available separately are: output transformer T2 at $27.95; driver transformer T1 at $4.00; S1 at $2.70; meter M1 at $4.50; circuit breaker at $3.00; six matched 2N3055 transistors at $12.00; pc board at $4.00. Separate part orders add $2.00 postage and handling. Connecticut residents add sales tax.

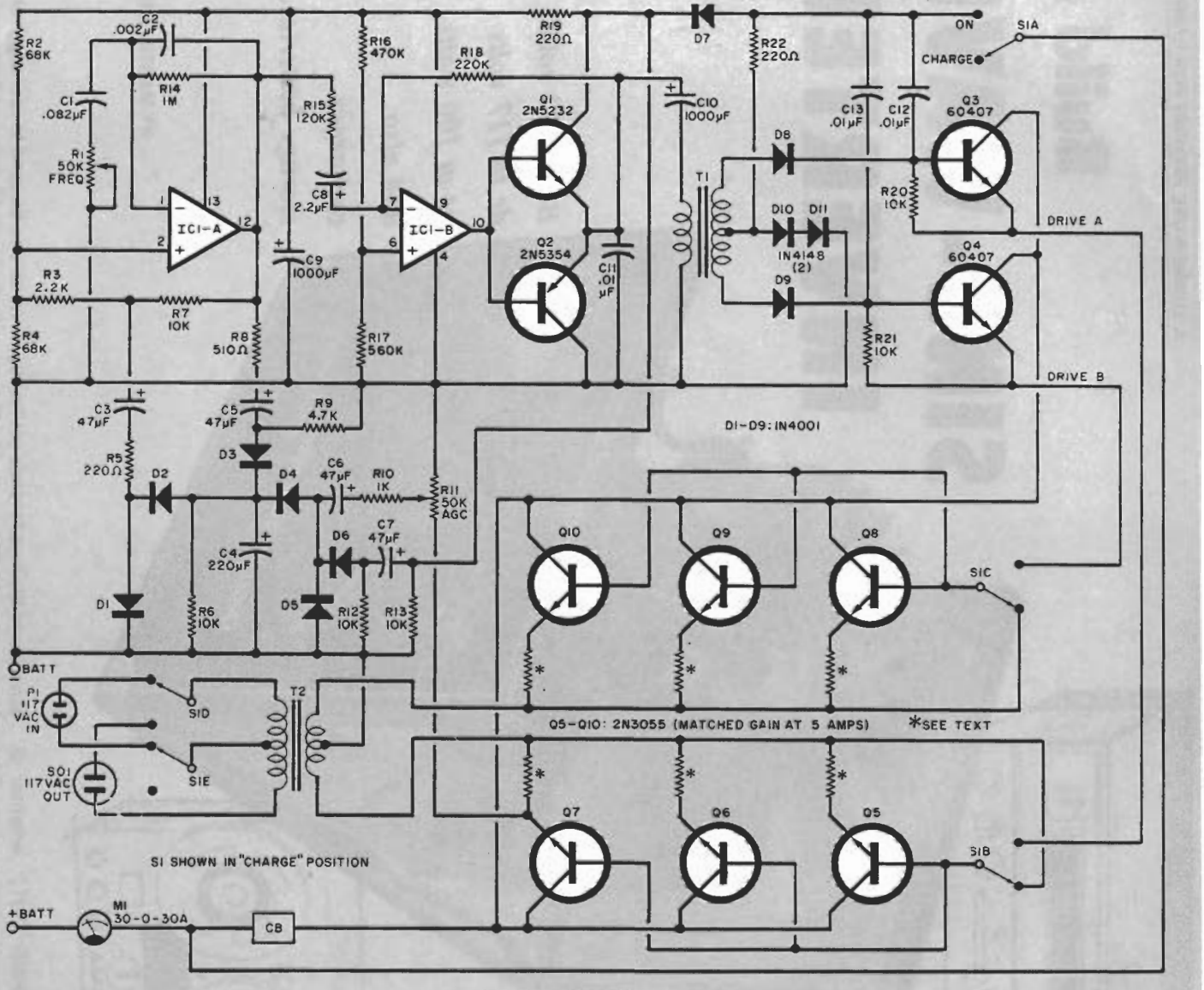


Fig. 1. A stable op amp audio oscillator is used to drive six high-power transistors, delivering 117 volts sine wave at any frequency between 50 and 400 Hz and with 100 watts of power.

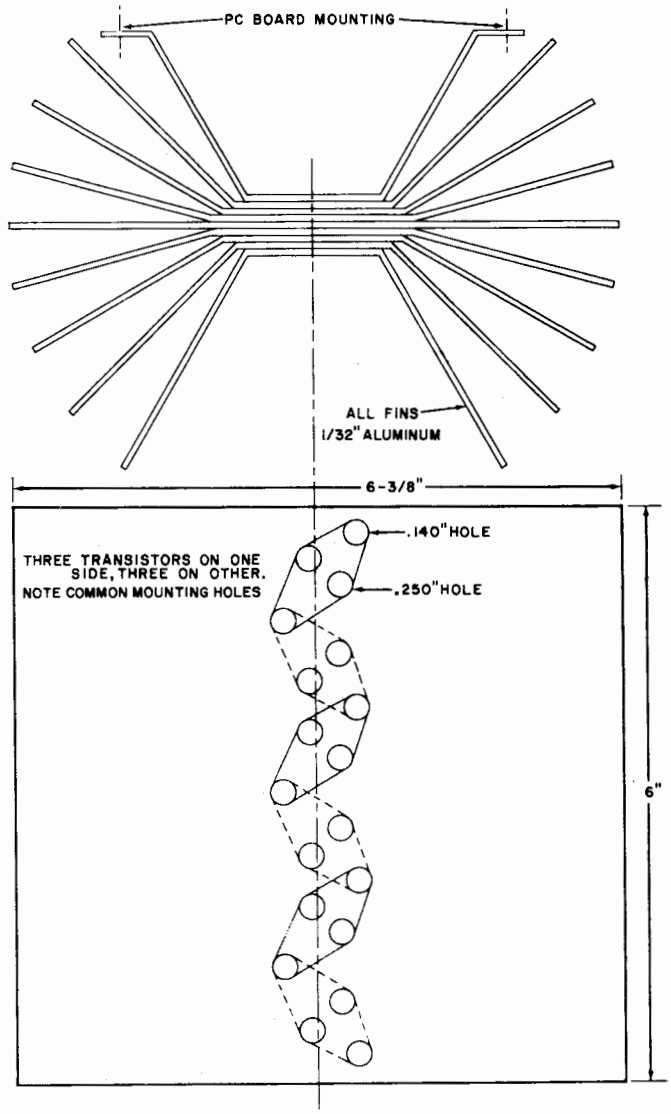


Fig. 2. Instructions and dimensions for making the heat sink. It must have at least 500 sq. in. of cooling surface.

discrete-transistor class-B pair (*IC1B*, *Q1* and *Q2*) and *T1*.

Transistors *Q3* and *Q4* are medium-power amplifiers, each one Darlington-connected to three high-power transistors (*Q8*, *Q9*, *Q10* and *Q5*, *Q6*, *Q7*). Transformer *T2* is the load for the high-power transistors and provides the 117-volt output at the preset sine-wave frequency.

Load regulation is provided by feedback from the emitter of *Q7* to potentiometer *R11* and then to the oscillator. Reguation from no load to full load is better than 6%.

When switch *S1* is set to CHARGE, the circuit (except for *Q5* through *Q10*) is disconnected from the battery, and the six high-power transistors act as rectifiers. The secondary of *T2* is connected so that the proper charging current is obtained.

An 18-ampere circuit breaker is mounted on the output stage heat sink to monitor the temperature and current drain. If the heat sink gets too hot due to improper ventilation, the current rating of the circuit breaker reduces proportionately. Thus, the inverter is protected from improper mounting or application.

The zero-center ammeter (*M1*) indicates the current drain when the circuit is inverting and the charging current when it is recharging a battery.

Construction. The crucial element in the assembly is the construction of the heat sink. To keep the operating temperature below 100°C, the heat sink must have more than 500 square inches of area. Details of the construction are shown in Fig. 2. Note that there are nine sections of 1/32"-thick aluminum in the heat sink, with holes drilled to mount the six power transistors.

After drilling the holes for the transistors, remove the burrs. The transistors share common mounting holes with three transistors on one side of the sink and three on the other. Use silicone grease under the transistors to insure intimate thermal contact with the heat sink. The transistor cases are not insulated from the sink as all collectors are connected in parallel. The heat sink is insulated from the metal case by four insulated stand-offs. Do not try to use a smaller heat sink or you will run the risk of damaging the transistors.

The remainder of the circuit is mounted on a pc board (Fig. 3). Note that the cases of diodes *D10* and *D11* are actually thermally bonded to the heat sink. The cutout in the board allows the diodes to contact the heat sink (with silicone grease to insure the contact). Transistors *Q3* and *Q4* are also mounted so they touch the heat sink. Their collectors are at the same potential as those of the power transistors. Drill suitable holes to attach the pc board to the lips on one end of the heat sink.

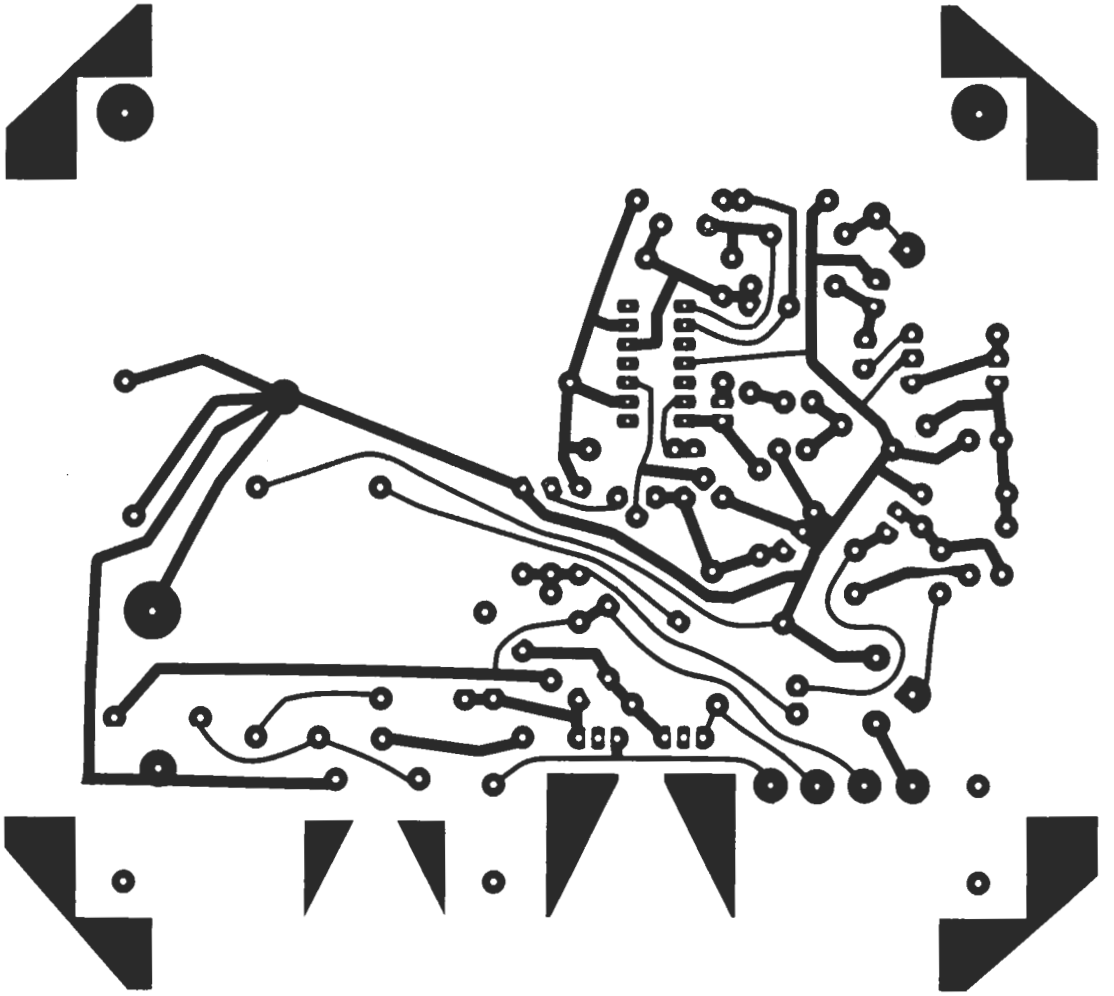
After selecting a chassis, mount the heat sink on four insulated stand-offs. The metal chassis must be floating, not connected to input or output.

The emitter resistors for transistors *Q5* through *Q10* are made of 14-inch lengths of #22 wire. It is important that the lengths of the resistors be as nearly the same as possible so that the transistors share equal amounts of the current. The secondary of *T2* is at 117 volts ac so use care in routing the leads. Dress leads away from the heat sink and use wire rated at 105°C.

The leads from the inverter to the battery (through the rear of the case) may carry as much as 18 amperes, so use heavy gauge wire or lengths of line cord with both leads in parallel for each side. If the connection is very long, use four parallel wires for each side to keep the voltage drop in the leads to less than 0.5 volt.

When assembly is complete, check again to make sure there is no connection between the case and the input or output.

Testing. With the cover off, set *R1* and *R11* to their mid-positions. Connect the battery leads to a high-current 12-volt source (vehicle battery). Turn the inverter on and note that the meter indicates less than 2 A drain. If this is not the case, immediately turn off the unit and determine the reason.



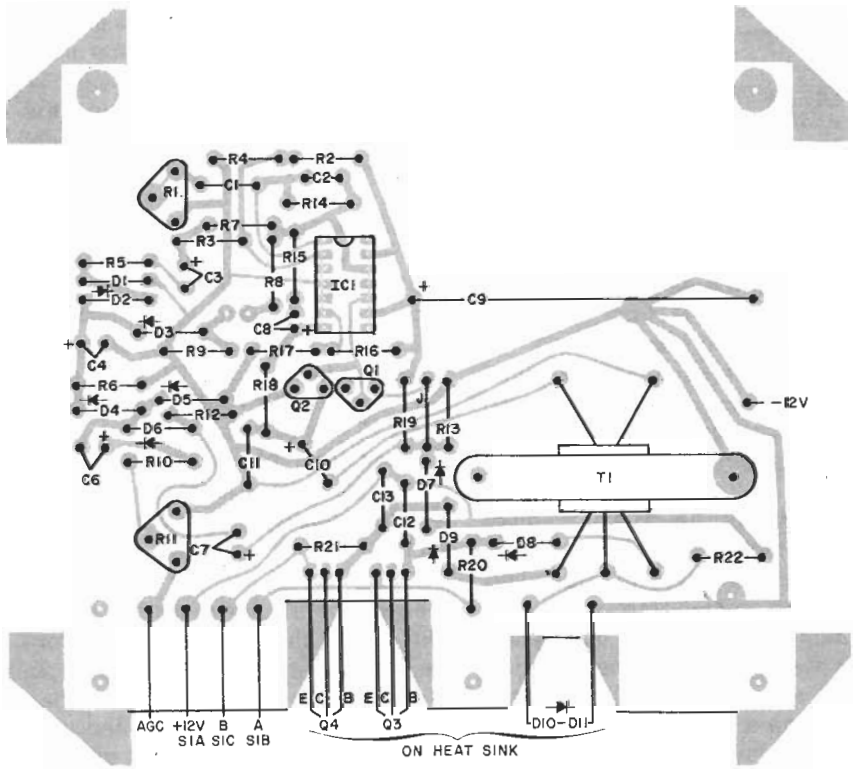


Fig. 3. Etching and drilling guide and component layout for pc board. D10, D11, Q3, and Q4 touch heat sink.

If the meter indication is correct, turn off the inverter and connect a 117-volt ac meter and a 100-watt lamp to *SO1*. Keep in mind that this is a hazardous voltage. Turn the inverter on and adjust *R11* to obtain 117 volts at *SO1*.

Use a frequency counter or the circuit shown in Fig. 4 to adjust *R1* for 60 Hz. In using the circuit in Fig. 4, adjust *R1* until the neon lamp does not flash (zero beat).

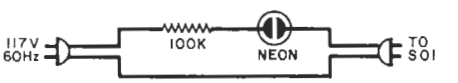


Fig. 4. Use this circuit to tune the inverter to 60 Hz.

Operation. This equipment, like any ac line-powered gear, must be treated with great care. The cabinet should be adequately ventilated at all times. The design is safe up to an ambient of 120°F. If the circuit breaker trips, check the ventilation and possibly reduce the output voltage slightly. It is good practice not to operate any electronic gear in an ambient in which a human is not comfortable. ◈