250 WATT POWER INVERTER

Power small appliances from your car or any other 12-volt source with our 250-watt inverter.

JAMES MELTON

DO YOU EVER NEED TO POWER 120-volt ac equipment when there is no AC outlet available? Our affordable power inverter was designed to supply up to 250 watts to power line-operated equipment a a fraction of the cost of commercially built units.

The inverter described here has been used to power flood lamps, soldering irons (both resistance and transformer types), fans, televisions, and portable computers. It has even powered an air pump for the author's asthmatic son. The inverter will power almost any device that runs on 120 volts AC. Some motorized devices won't work well, however. A variable-speed drill may work, but only at one speed. Fans and other purely inductive loads seem to run at about ⅔ normal speed with the inverter. Synchronous motors will run at normal speed but will be a little "noisy."

Power FET's to the rescue

Power FET (field effect transistor) devices have gotten more versatile over the last few years and, at the same time, the prices for them have plummeted. Nothing can match a FET in its ease of interfacing with logic signals, and for the ease in which it can work in parallel with similar devices without the need for any extra components. To parallel the FET's, all you have to do is tie the source leads together. When the they get warm, FET's exhibit a positive temperature characteristic, which means as the temperature goes up, so does the resistance; as the resistance goes up, the current through the device is lowered. That makes FET's self-limiting when working in parallel.

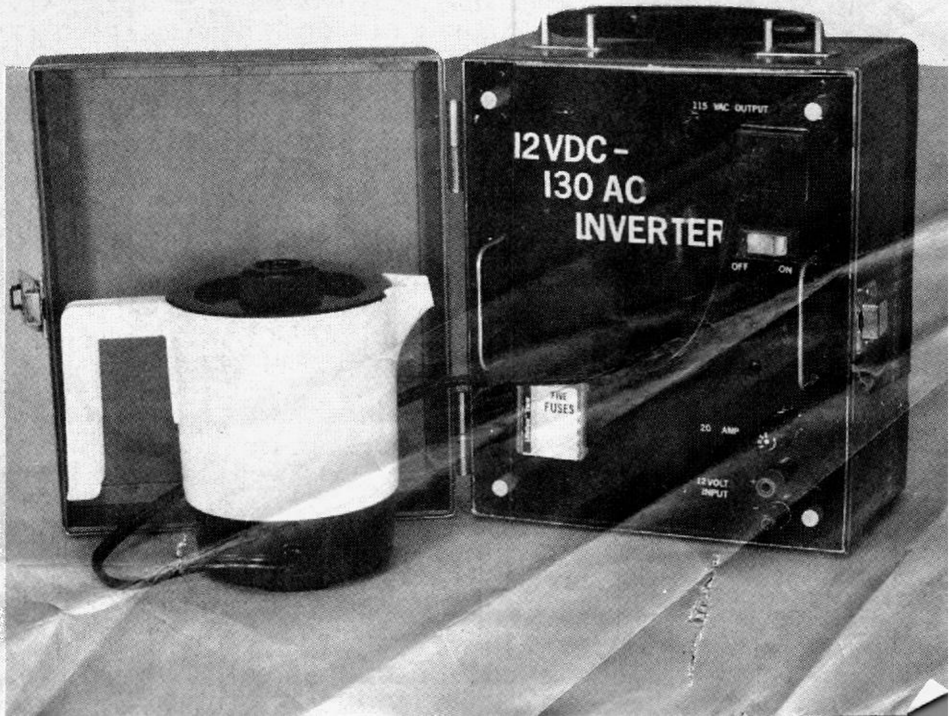
FET's are now being produced with power ratings that can often make parallel operation unnecessary. The ratings for the IRFZ30's that are used in this project are amazing: they can handle a 30-amp load with 50 volts across the source-drain leads and 75-watt power dissipation, all in a TO-220AB plastic package—for less than two bucks each when purchased in small quantities.

Operation

Figure 1 shows the schematic of the inverter. A 555 timer, IC1, along with R3, R2, and C2, generates a 120-Hz (± 2 Hz) signal, as set by the value of potentiometer R3.

The output of IC1 at pin 3 is fed to the CLOCK input of a CD4013BE dual D-type flip-flop, IC2-a, which is wired to divide the input frequency by two; that generatea the 60-Hz clocking for the FET array (Q1–Q6). The output from flip-flop IC2-a at pin 1 has a 50% duty cycle, which is necessary for the output transformer. The flip-flop also provides an inverted output ($\overline{Q}$, pin 2), which saves us from having to add additional components to invert the Q output. The second half of IC2 (IC2-b) is not used, so all of its input pins are grounded.

The Q and $\overline{Q}$ outputs from IC2-a are each fed, via R5 and R4, to three inputs of IC3, a CMOS CD4050BE hex buffer. Each group of three buffer outputs drives one bank of FET's in the power stage.



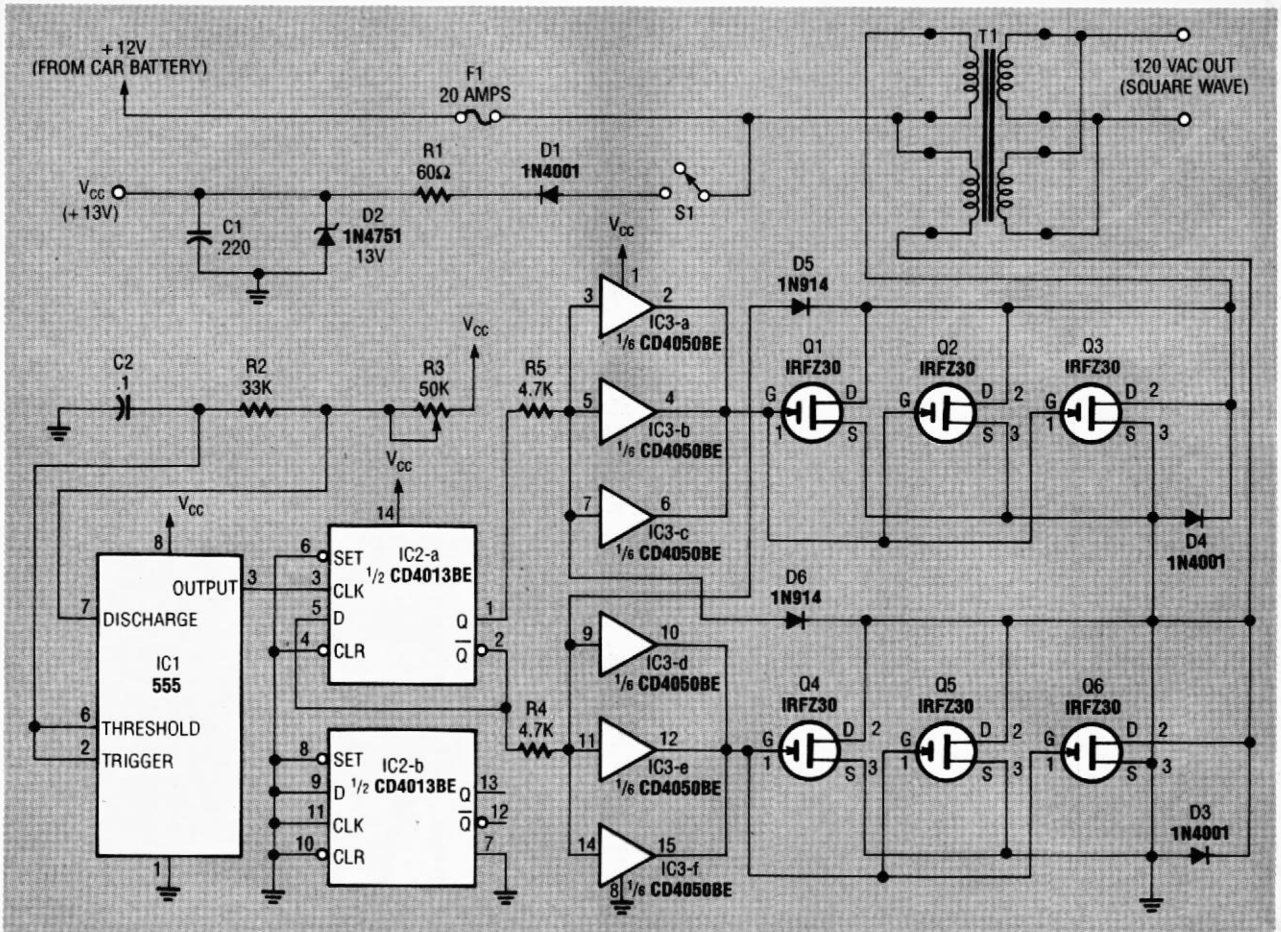


FIG. 1—INVERTER SCHEMATIC. A 555 timer (IC1) generates a 120-Hz signal that is fed to a CD4013BE flip-flop (IC2-a) which divides the input frequency by two to generate a 60-Hz clocking frequency for the FET array (Q1–Q6).

The inputs to the buffers are also controlled by D5 and D6, which are connected to the drains of the FET's so that the array that is turned-on essentially has control of the drivers of the opposite array. When one side is turned on and its drain is at ground potential, the other side cannot turn on because the input to the buffer for that array is also being held at ground. It stays that way until the controlling array has completely turned off and the drain voltage has gone above about 6 volts. That is necessary because the turn-off time for a FET is longer than its turn-on time. If the diodes were eliminated, both arrays of FET's would be turned on simultaneously during each transistion, which creates tremendous spikes on the battery, the equipment tied to the output of the inverter, and to the FET's themselves.

The FET array can be made as big or as little as your application requires. The author needed at least 250 watts, and used two IRFZ30's in parallel for each array. However, to play it safe, use three in parallel (or however many you need) for each array as we've shown in the schematic. Diodes D4 and D3 dampen inductive kickback from the transformer winding that would likely cause overheating and premature transistor breakdown.

Power-supply conditioning circuitry (D1, R1, D2, and C1) eliminates spikes, overloads, and other noise from a car's 12-volt supply. Even though the 555 can handle up to a 15-volt supply, power-supply spikes will surely damage it.

If the transformer you use has a center tap, the center tap must be connected to the 12-volt line and the two 12-volt windings must be connected to the drains of their respective driving transistors. The author used a Jefferson buck/boost transformer that's normally used to reduce or increase the line voltage for AC devices. If you are going to buy a transformer, you can use any center-tap 24-volt or dual-winding 12-volt transformer. It is important to use a transformer that can supply the ammount of current that your application requires.

Construction

Some of the components mount on a small PC board, for which we've provided the foil pattern. The parts-placement diagram is shown in Fig. 2. We recommend that you use sockets for the IC's. After soldering all components on the board, apply 12 volts and measure the frequency on the pads marked J4 and J2. Adjust R3 for a read-

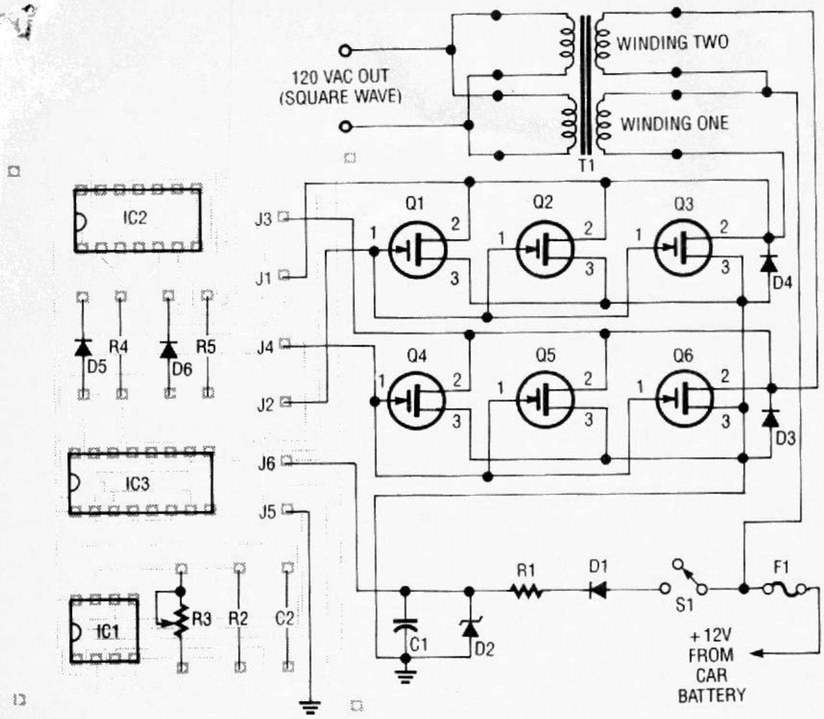


FIG. 2—MOST OF THE COMPONENTS mount on a small PC board. The off-board components can be mounted on a terminal strip or perforated construction board.

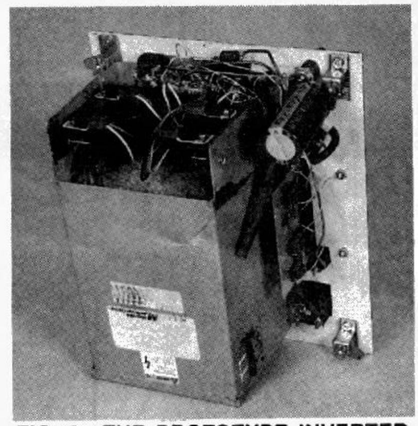


FIG. 3—THE PROTOTYPE INVERTER. The author used a car cigarrette lighter plug on the end of the power-input lead and an AC outlet for plugging appliances into.

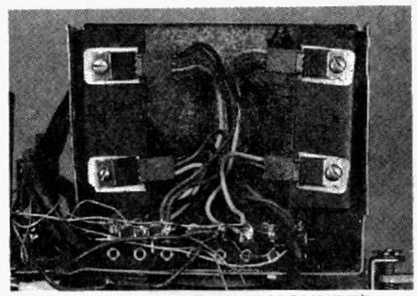
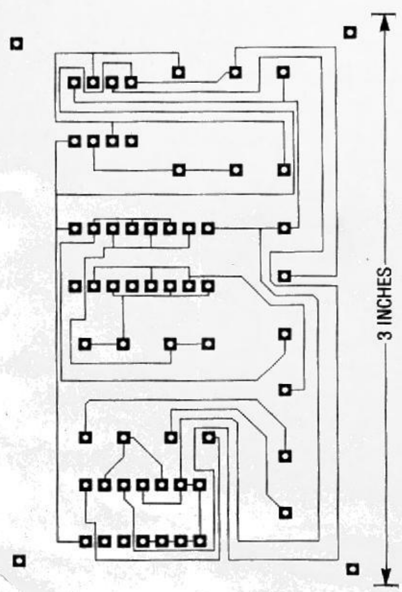


FIG. 4—THE FET'S ARE MOUNTED on metal plates used as heatsinks. If the heatsink is at ground potential, insulate the FET's from the heatsink.

ing of 60 Hz, and make sure the voltage is very close to ½ of the supply voltage on each pad. That tells you that your duty cycle is 50%.

Now connect the rest of the components. The small off-board components can be mounted on a terminal strip. However, be sure to mount the FET's on a heatsink. If the heatsink is at ground potential, also be sure to insulate the FET's from it.



FOIL PATTERN for the inverter board.

PARTS LIST

All resistors are ⅛-watt, 5%, unless otherwise noted.

R1—60 ohms, 1 watt, 10%
R2—33,000 ohms
R3—50,000 ohms, 10-turn potentiometer
R4, R5—4700 ohms

Capacitors

C1—220 µF, 35 volts, electrolytic
C2—0.1 µF, 50 volts, ceramic disk

Semiconductors

IC1—LM555 timer
IC2—CD4013BE CMOS dual D-type flip-flop
IC3—CD4050BE CMOS hex buffer
D1, D3, D4—1N4001 diode
D2—1N4751 13-volt Zener diode
D5, D6—1N914 diode
Q1–Q6—IRFZ30 30-amp, 60-volt FET

Other components

T1—Jefferson #216-1121 buck/boost transformer (contact WW Granger, Inc., 1250 Busch Pkwy, Buffalo Grove, IL 60015, 708-459-5445) or other 12- or 24-volt center-tapped transformer (see text)
S1—SPST switch
F1—20-amp fuse (or use value according to desired output current and transformer used)

Miscellaneous: fuse holder, cabinet, mounting hardware, AC outlet, car cigarette lighter plug, wire, solder, etc.

The author used a car cigarette lighter plug on the end of the power-input lead, but you are free to use alligator clips or whatever is most convenient for you. A standard AC outlet was mounted on the front panel of the unit. The prototype was installed in an old, rugged metal case, but you can use whatever you have on hand. Figure 3 shows the prototype inverter and how everything is assembled. Figure 4 shows a close-up view of the FET's and how they are mounted on metal plates used as heatsinks.

Operation

To operate the unit, plug the input power into your cigarette lighter socket, turn on the power switch, and turn on the appliance that's plugged into the inverter. When you are not using the inverter, be sure to turn it off, since the transformer will draw about 2 amps even with no load. That will drain your car battery fairly quickly! **R-E**