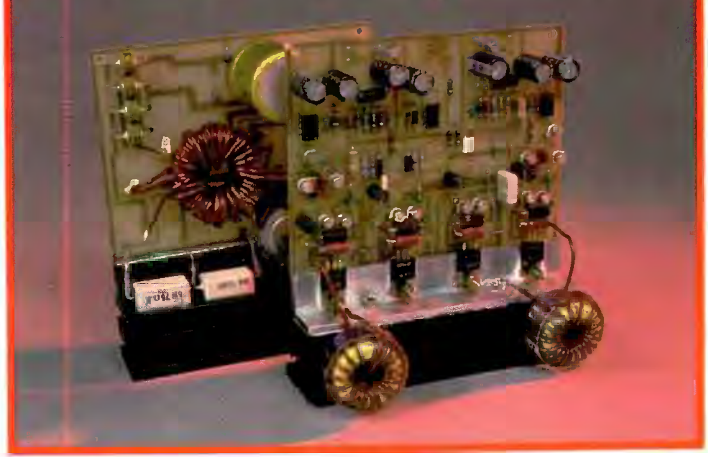
Project Breakthrough!

● DISTORTIONLESS DIGITAL, 100 WATT/CHANNEL, AUDIO POWER BOOSTER

● W APPLE IIGS NAL COMPUTER

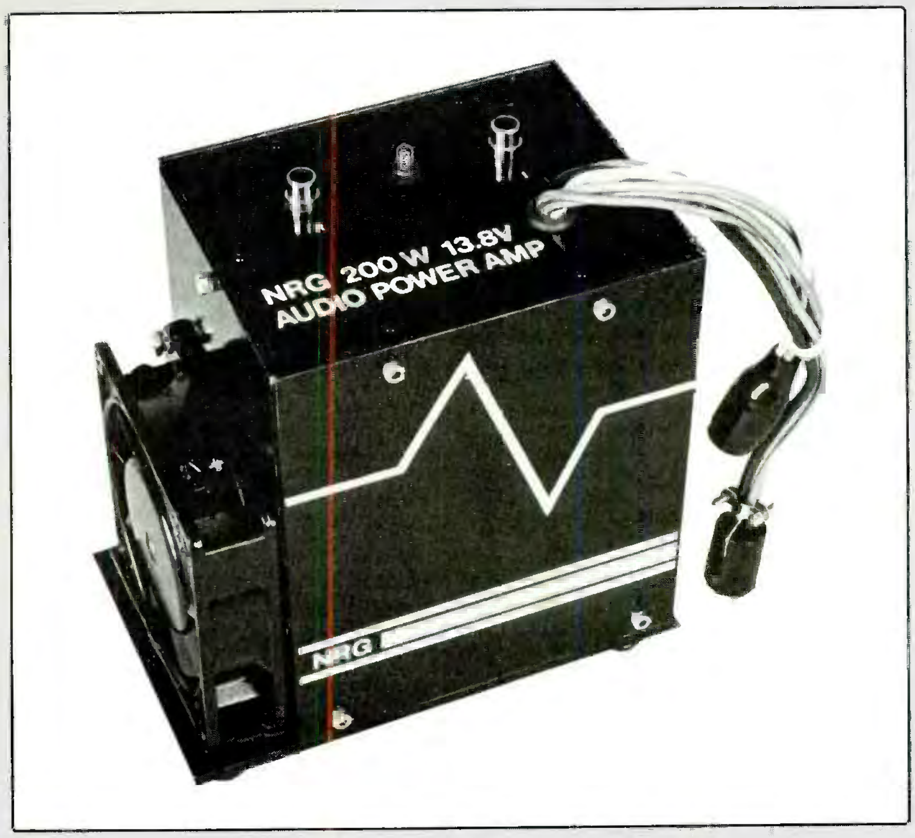


100-Watt/Channel Digital Car Booster Amplifier (p. 18)

100-Watt/Channel, Distortionless *Digital* Audio Amplifier Booster

Get truly sharp, clear, high-power stereo sound with this $150 leading-edge-technology power amp booster for your car's radio, tape cassette or CD player system

By C. Barry Ward



Now you can obtain high-power audio from your automotive sound system without adding any distortion! Through use of digital technology, coupled with a 250-kilohertz-plus switching of a constant-frequency square-wave signal that drives power MOSFETs, the audio power booster to be described can pump the cleanest 100 watts/channel (at 4 ohms) into your speakers that you ever heard. All you need is at least 5 watts per channel output from your present car radio's output (maximum 25 watts) to get a 20-fold increase in power . . . 200 watts total from a system that measures only 6" × 6" × 4".

Designed for use in automotive vehicles or any other environment that uses a "12-volt dc" power supply, the amplifier has its own dc inverting power supply to step up the basic 13.2 volts of the typical vehicle electrical system to a level sufficient to ensure that the full 100 watts/channel of output power is always available to speakers. Moreover, with a suitable ac-line-operated power supply and a preamplifier to boost input signals to a power level sufficient to provide effective booster drive, the digital amp can be used to drive low-efficiency speaker systems and to dramatically increase room sound level from only moderate-power audio amplifiers—all while maintaining the low distortion level of the primary source program material and equipment.

Owing to its 250-kHz switching frequency, no sound whatsoever is audible with no input signal. With an input signal, the square wave becomes pulse-width modulated at an audio rate to convey the audio information to the speakers. The amplifier works on a principle very similar to that used in a CD player, whose high sound quality is renowned.

How it Works

Most people are familiar with conventional analog audio amplifiers that enlarge an input signal's voltage to provide the current that, in turn, drives the speakers. Ideally, the output waveform should be identical in shape to the input, the only difference being an increase in amplitude.

Unlike the analog amplifier that (again ideally) delivers no power to the speakers when no input signal is present, the digital amplifier described here outputs a constant-voltage square wave with a 50% duty cycle to the filter choke and speaker under the same input conditions. As cited earlier, the very high frequency of this square wave does not allow the speaker cones to move, and therefore no sound is heard. When an audio signal is applied to the amplifier's inputs, however, it off-balances the square wave in direct proportion to the input signal level to move the speaker cones in and out. A positive input signal that has 10% of the amplitude of the input range gives the square wave a duty cycle of 60% high and 40% low, which yields a net positive output.

If the square wave were to be sent directly to a speaker at an audio frequency, it would generate 180 watts of output power! But in the digital amplifier, two factors average the output to a level of less than one inaudible watt. One is the combined inductance of the speaker and filter, the other is the frequency of the square wave. The duty cycle of the square wave is modulated by an extremely linear triangle wave that is produced by the switching signal across a timing capacitor (*C14* in

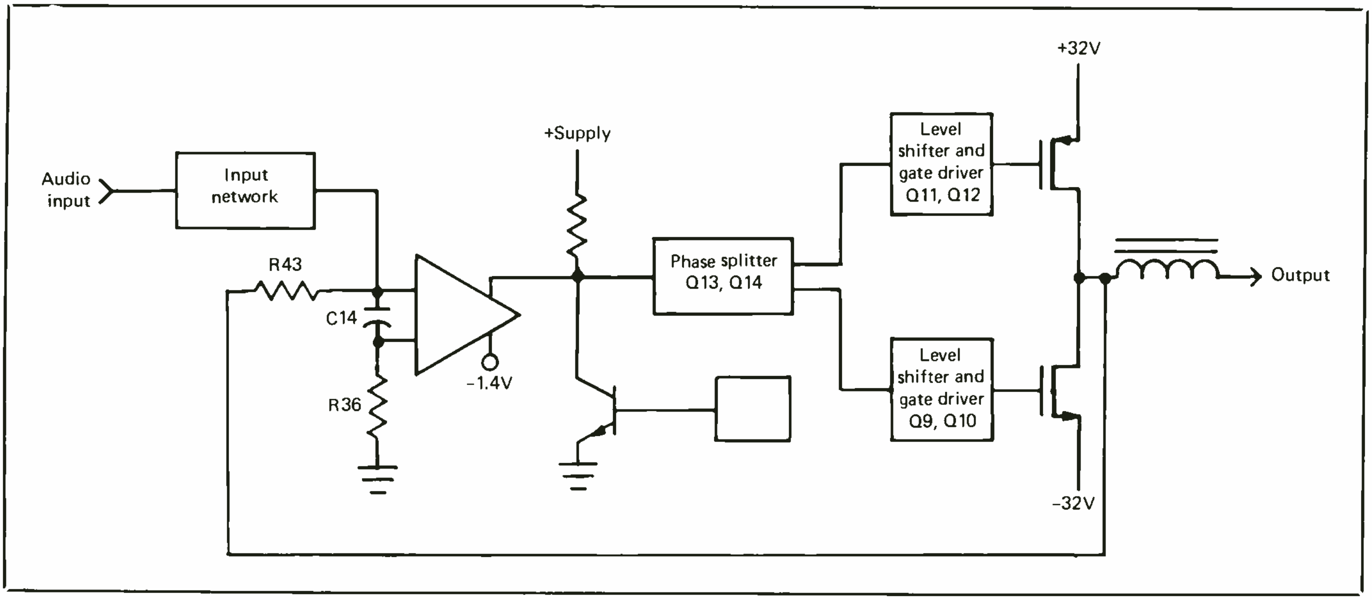


Fig. 1. Simplified block diagram of single channel of digital amplifier.

the single-channel simplified block diagram in Fig. 1). Tight waveform linearity is assured by the very large values of the timing resistor (*R36*) and timing capacitor.

Another factor that contributes to the linearity of the modulator is the 10-millivolt level of the triangle wave. This small voltage, combined with a large time constant, assures that only a small, very linear portion of the curve of the RC timing ramp is used (see Fig. 2).

Related directly to the square wave output signal, the triangle wave is compared to the audio input signal (Fig. 3). When the audio input goes in a positive direction, the output of the amplifier remains high for an increasingly longer percentage of the time available for that switching cycle. To keep the average voltage of the output within 10 mV of the input, the comparator must change state. This forces the output voltage to be error corrected to within 10 mV during every 2-microsecond switching cycle. Output clipping occurs just as it does in a conventional linear amplifier when the output can no longer be corrected to match the input signal's amplitude.

Figure 4 is the full schematic of both channels of the stereo power-MOSFET digital amplifier booster. Figure 5 illustrates the power supply schematic.

When power is first applied to the circuit, timing capacitor *C14* in the *U1* circuit is discharged. (Though we will discuss operation of only one channel, the following applies equally well to the other channel since both are identical.) This holds the comparator's output in an off state. Since *U1* is an open-collector device, its output very rapidly swings high. This high signal goes to phase-splitters *Q13* and *Q14*, where it is split into positive and negative excursions that are routed to positive level shifters *Q11* and *Q12* and negative level shifters *Q9* and *Q10*. Since the signal is going positive at this point, *Q11* and *Q12* turn on, which sends output p-channel power MOSFET *Q2* into conduction.

When *Q2* conducts, a high positive voltage appears on one end of timing resistor *R43*, which charges *C14*.

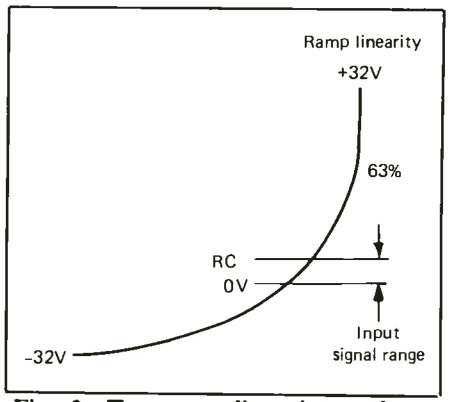


Fig. 2. To assure linearity, only a very small, linear portion of the charging ramp is used. Only 10 mV (0.00016%) of the 64 volts available charges the timing capacitor.

When the charge on *C14* reaches 10 mV, *U1*'s output switches state and the process reverses. Charging and discharging of *C14* is at a 250-kHz rate.

Note in Fig. 1 that the audio input goes to an Input Network. An ac-coupled 15-ohm resistor in this block provides a load for the car radio's output. (Some car radios require an output load to operate properly.) The output from the car radio's amplifier must be in a 5-to-20-watt range to be able to drive the amplifier to full power, as noted earlier. Inside the Input Network is also resistive decoupling between the timing ramp on *C14* and the input signal.

A small amount of preemphasis is added by the RC network made up of *R42* and *C13* (Fig. 4). This high boost minimizes the high-frequency rolloff caused by output filter inductor *L5*.

A time-delay circuit in the Input Network mutes the amplifier during the first few seconds after power is applied. This allows time for the amplifier and the car's radio to stabilize, removing the pops and thumps sometimes associated with high-power audio systems. The time delay is generated by timer IC *U2*. The high output of *U2*, held that way by *C5*, keeps *Q13* and *Q14* and output power MOSFETs *Q1* and *Q2* from conducting. When *C5* charges to ⅔ of the 12-volt supply, *U2*'s output goes low, turning off *Q15* and *Q18* and allowing the amplifier to oscillate and amplify.

Referring to Fig. 5, the power supply converts the 12 volts from the vehicle's electrical system to +32 and −32 volts. The power supply operates as a standard, self-oscillating inverter. Transistors *Q1* an *Q2* are driven from power transformer *T1*'s secondary winding. The third winding of *T1* provides the required output to rectifier diodes *CR1* through *CR4*. The pulsating dc from the output of the bridge circuit is filtered by capacitors *C2* and *C3* to produce the required output voltages. The power supply operates at a frequency of 25 kHz.

Power from the vehicle's electrical system can be applied to and removed from the amplifier's power supply with a switch or automotive relay. The booster should be turned on at the same time that the radio is turned on or after (*not* before). An electrically operated antenna can provide automatic turn-on when the radio is switched on with proper connections made to the antenna's power-control relay coil as illustrated.

Construction

Before you begin construction, separate the components for the power-supply and amplifier boards. Then in each case, separate the diodes and transistors according to type number. This way, you will be less likely to install these devices in the wrong locations, which could result in costly repairs. Keep in mind that the power MOSFETs are easily damaged by static elecricity. Therefore, practice the same safe handling procedures recommended for any other MOS-type device.

Due to the r-f nature of this project, printed-circuit construction is almost mandatory. Fabricate the amplifier and power supply boards using the actual-size etching-and-drilling guides given in Fig. 6. If you prefer not to fabricate your own boards, you can purchase ready-to-wire boards (and other individual parts or a complete kit of parts) from the source given in the Note at the end of the Amplifier Parts List.

When the boards are ready to be wired, indicate on each the hookup points for the power transformer on the power supply board, between-board wiring and off-board wiring. These include the numbers for *T1*'s windings on the power supply board and all numbers preceded by an E on both boards.

Wind toroid inductors *L5* and *L6* for the amplifier board. Due to the high operating frequency and high currents present in the output of the amplifier, a "multifilar" winding approach is recommended. Each turn is composed of several turns of small-diameter wire, wound in parallel with each other. Inductors wound in this manner exhibit much lower

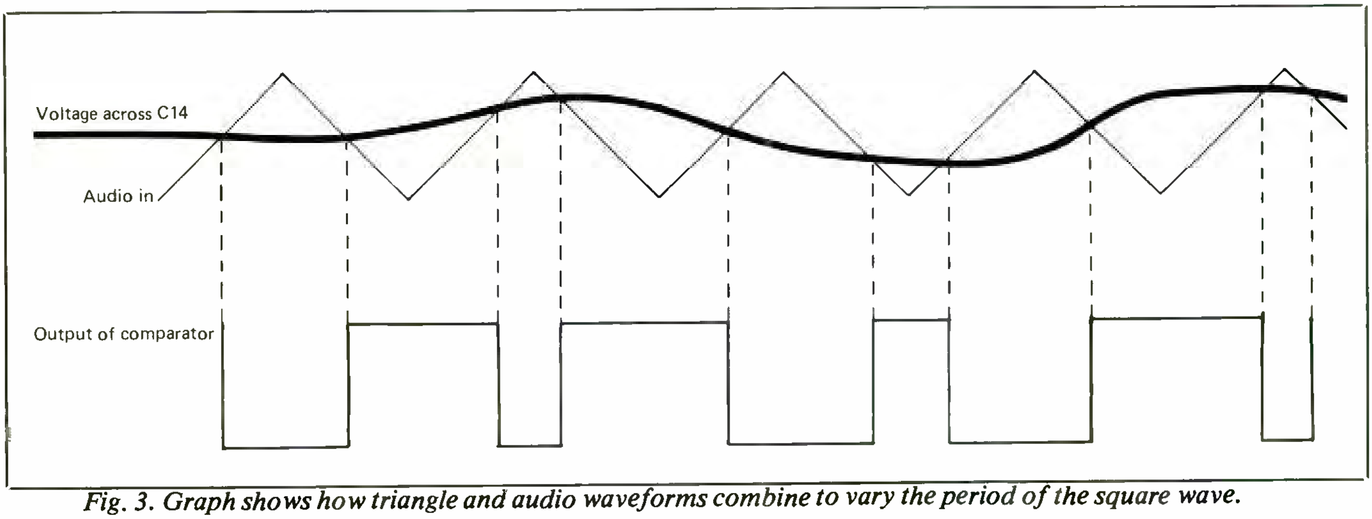


Fig. 3. Graph shows how triangle and audio waveforms combine to vary the period of the square wave.

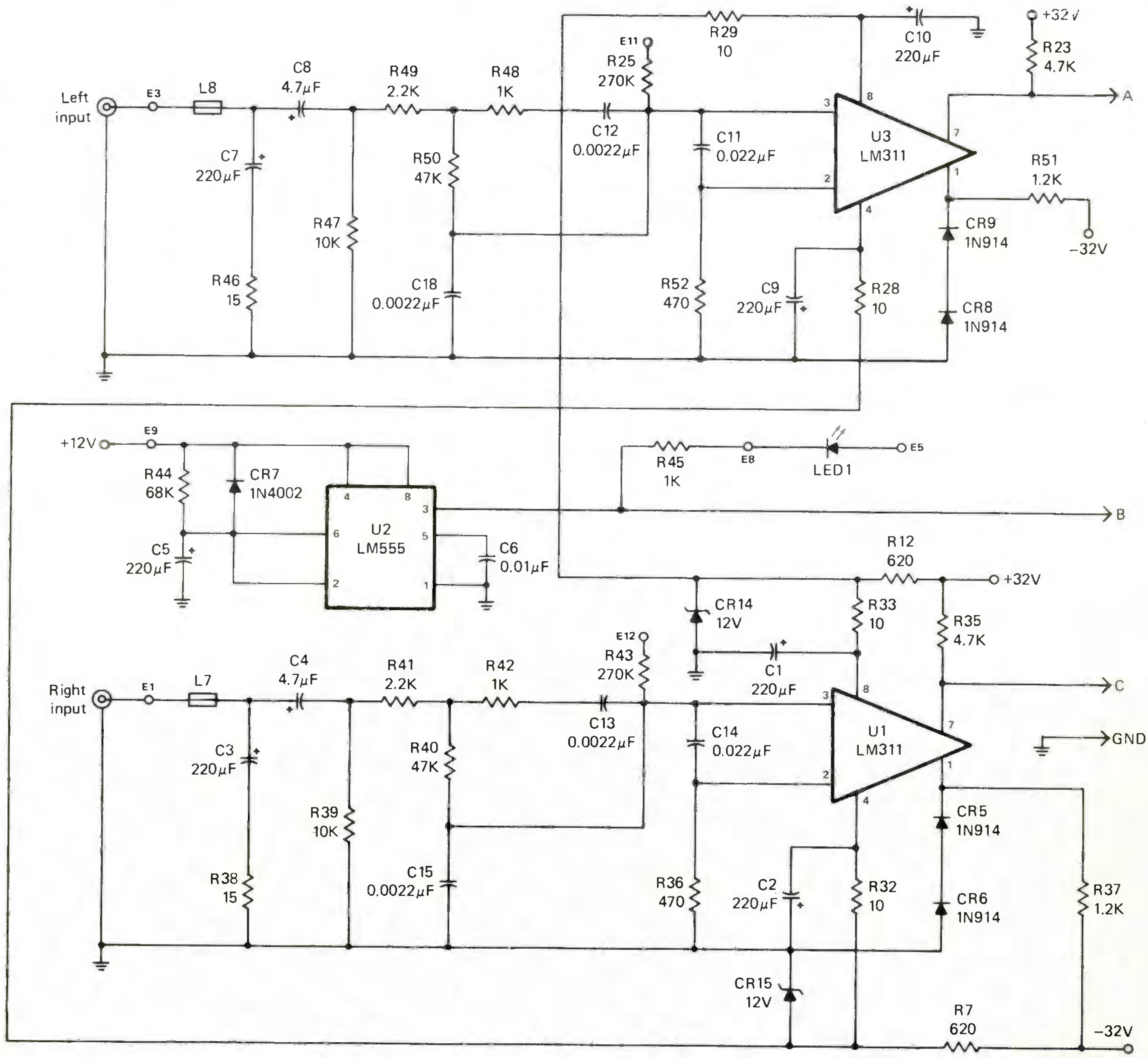
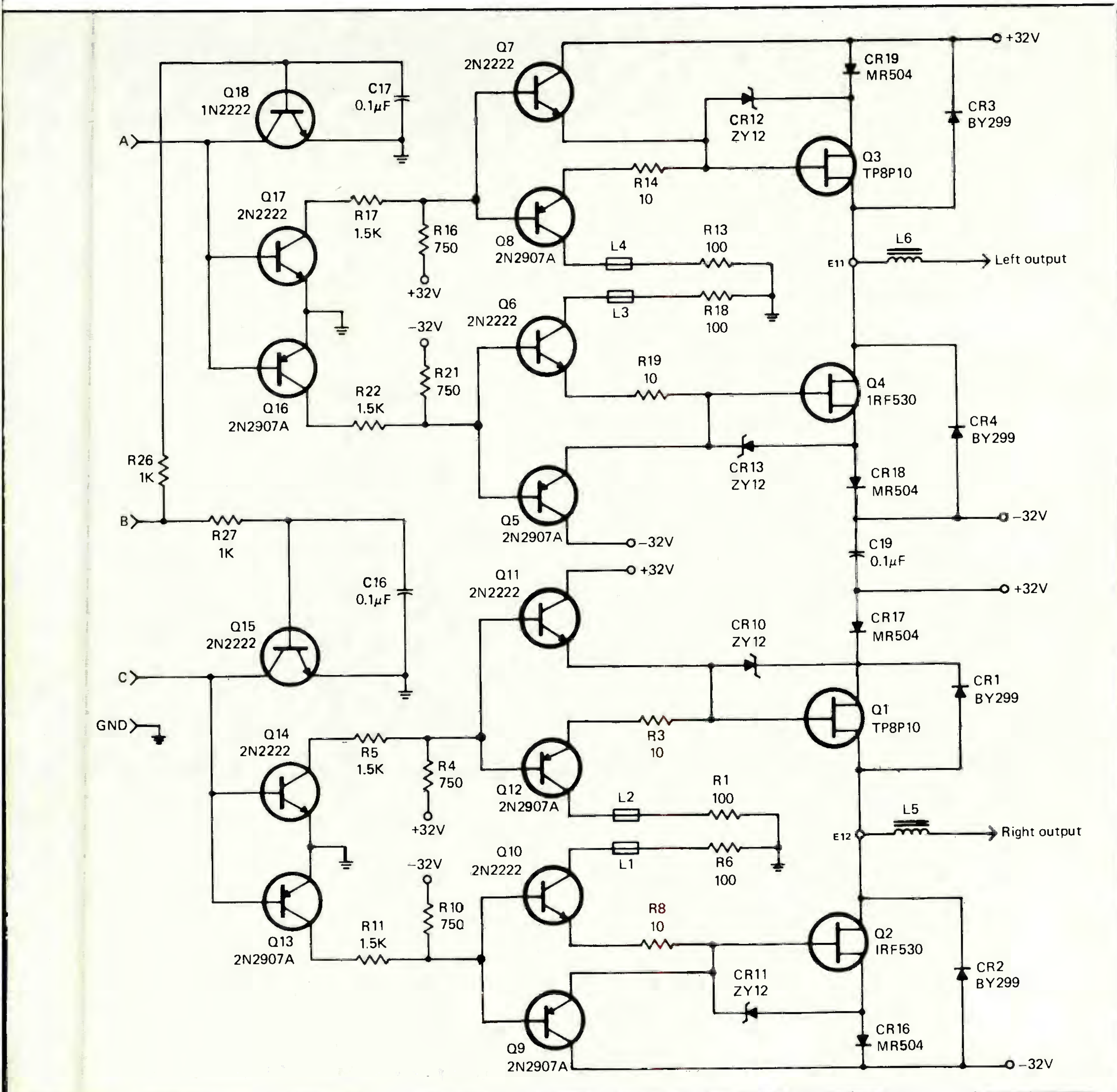


Fig. 4. Schematic diagram of amplifier portion of circuit shows both channels of basic amplifier but not inverting power supply.

losses at high frequencies. They are also easier to wind than if a large-diameter stiff wire were used.

Each inductor requires six strands of No. 25 AWG enameled copper wire, each approximately 6 feet long. Wind tightly, and avoid variations in the consistency of the wind. Wind both inductors in the *same* direction to eliminate any possible coupling between the two channels when *L5* and *L6* are wired into the circuit.

After winding the inductors, tightly twist together the conductors at each end and, using a soldering iron capable of developing at least 800°F tip temperature, tin the ends. Alternatively, scrape away ⅜" of enamel



from each wire end before twisting together the wires and then tin with a standard soldering iron. This latter approach is effective but tedious and time-consuming.

The multifilar winding technique is not appropriate for *T1* in the power supply because it could result in some undesirable side effects. Therefore, to avoid any problems, use solid wire to wind *T1*. Start with the primary winding, which is the most difficult because it consists of a very heavy and stiff No. 12 AWG enameled wire. Do not scrimp on the size of the primary wire. If you do, the power supply will develop less power and will overheat.

AMPLIFIER PARTS LIST

Semiconductors
CR1 thru CR4—BY299 or equivalent fast 2-ampere diode
CR5,CR6,CR8,CR9—1N914 or 1N4148 small-signal diode
CR7—1N4004 or similar 400-volt, 1-ampere diode
CR10 thru CR15—ZY12 or equivalent 12 volt, 1-watt zener diode
CR16 thru CR19—MR504 or equivalent 400-volt, 3-ampere diode
LED1—T-1¾ green light-emitting diode
Q1,Q3—TP8P10 or IRF953 p-channel-power MOSFET
Q2,Q4—IRF530 n-channel power MOSFET
Q5,Q8,Q9,Q12,Q13,Q16—2N2907A pnp transistor
Q6,Q7,Q10,Q11,Q14,Q15,Q17,Q18—2N2222A npn transistor
U1,U3—LM311 comparator
U2—555 timer

Capacitors
C1,C2,C3,C5,C7,C9,C10—220-µF, 25-volt electrolytic
C4,C8—4.7-µF, 50-volt electrolytic
C6—0.01-µF, 50-volt disc
C11,C14—0.022-µF, 50-volt stacked film
C12,C13,C15,C18—0.0022-µF, 50-volt polyester
C16,C17—0.1-µF, 50-volt ceramic disc
C19—0.1-µF, 50-volt polyester

Resistors
(Note: There are no resistors designated R2, R9, R15, R20, R24, R30, R31 and R34)
R1,R6,R13,R18—100 ohms, ¼-watt, 5% tolerance
R3,R8,R14,R19,R28,R29,R32,R33—10 ohms, ¼-watt, 5% tolerance
R4,R10,R16,R21—750 ohms, ¼-watt, 5% tolerance
R5,R11,R17,R22—1,500 ohms, ¼-watt, 5% tolerance
R7,R12—620 ohms, ½-watt, 5% tolerance
R23,R35—4,700 ohms, ¼-watt, 5% tolerance
R25,R43—270,000 ohms, ¼-watt, 5% tolerance
R26,R27,R42,R45,R48—1,000 ohms, ¼-watt, 5% tolerance
R36,R52—470 ohms, ¼-watt, 5% tolerance
R37,R51—1,200 ohms, ½-watt, 5% tolerance
R38,R46—15 ohms, 3-watt, 10% tolerance
R39,R47—10,000 ohms, ¼-watt, 5% tolerance
R40,R50—47,000 ohms, ¼-watt, 5% tolerance
R41,R49—2,200 ohms, ¼-watt, 5% tolerance
R44—68,000 ohms, ¼-watt, 5% tolerance

Miscellaneous
L1 thru L4,L7,L8—Ferrite bead
L5,L6—Toroid inductor (hand-wound; see text)
Printed-circuit board; heat sink, suitable enclosure (see text); 12-volt dc fan; transistor insulators; shoulder fiber washers; thermal grease or paste; hookup and magnet wire (see text); machine hardware; solder; etc.

Note: The following items are available from NRG Electronics, P.O. Box 24138, Ft. Lauderdale, FL 33307: Complete kit of parts, including power supply, enclosure and fan for $150.00 plus $4.50 P&H. Separate parts available are: amplifier pc boards for $10.00 each; power supply and amplifier heat sinks for $4.00 each; enclosure for $30.00; and fan for $15.00. Florida residents, please add appropriate sales tax. Other individual components and parts are also available (send SASE for parts/price list).

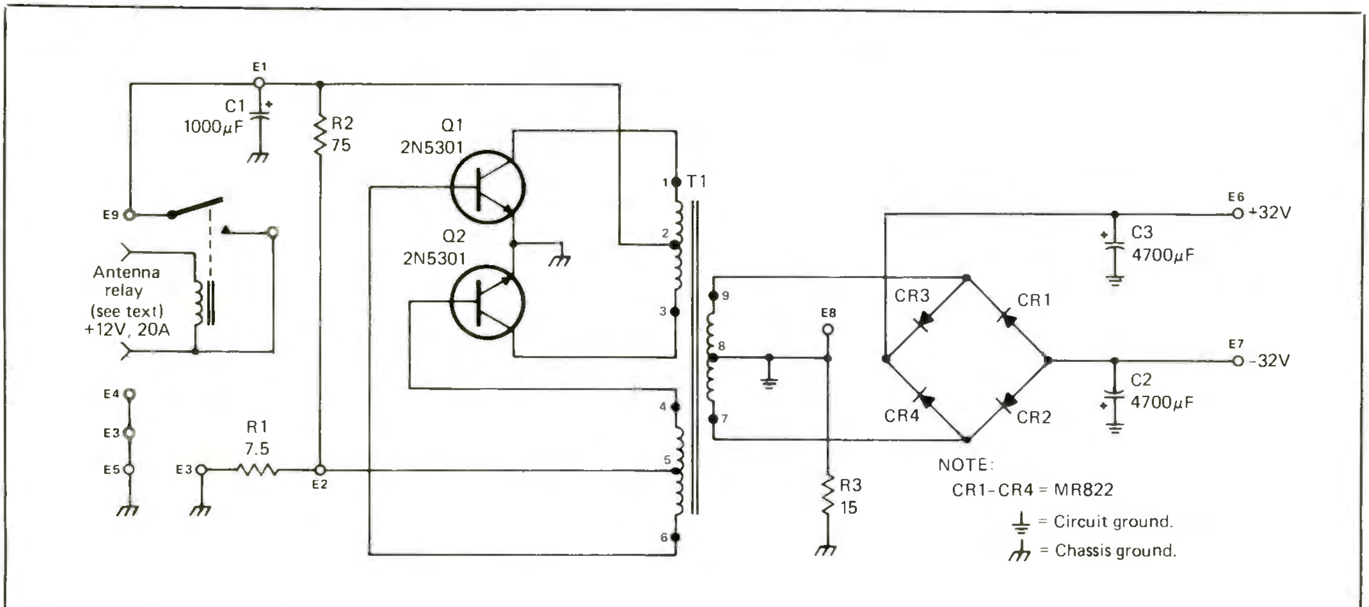


Fig. 5. Schematic of power supply. This is a basic inverter built around a hand wound toroid power transformer (T1).

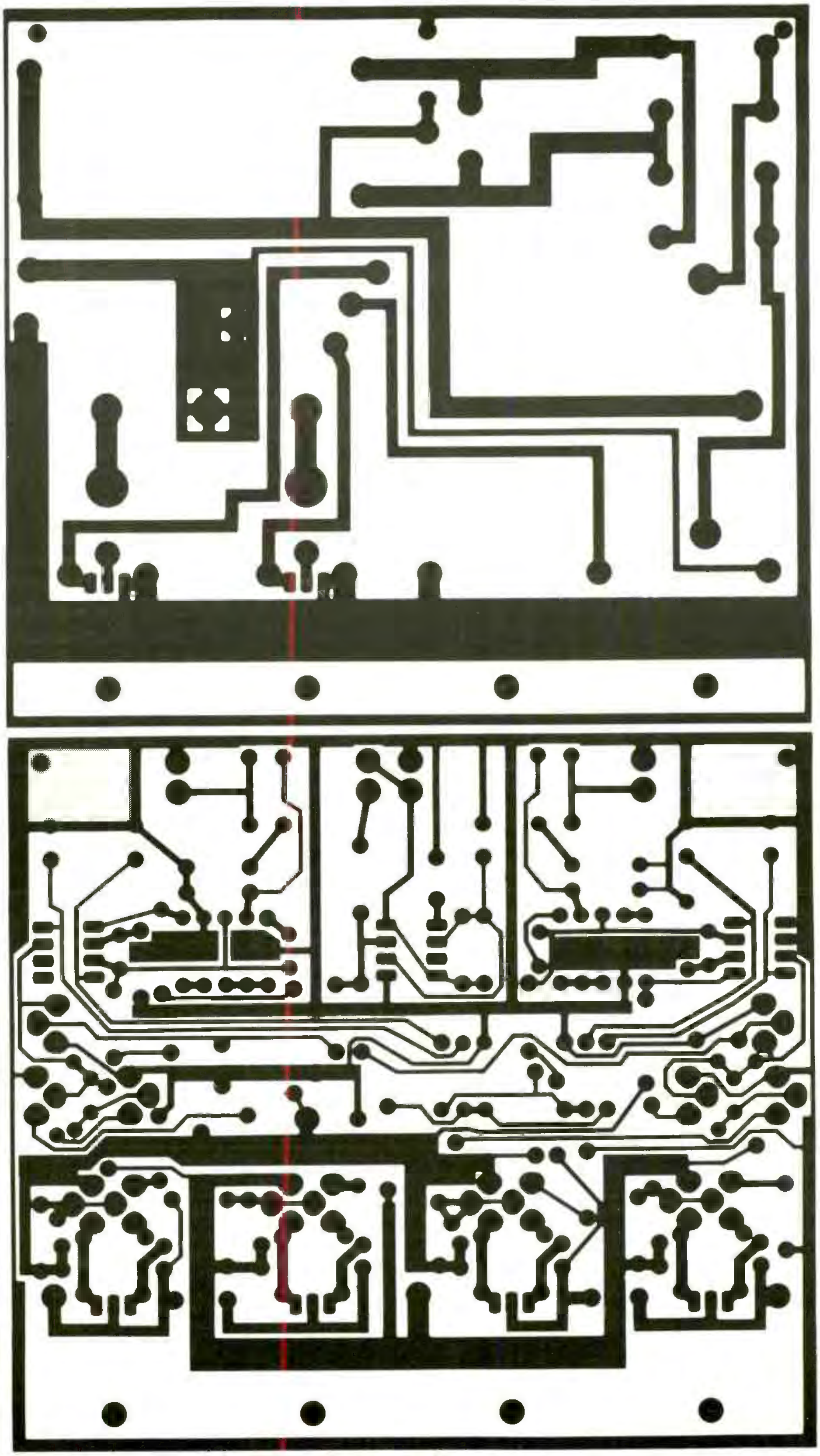


Fig. 6. The actual-size etching-and-drilling guides for the power supply (upper) and amplifier (lower) printed-circuit boards.

Starting with a 3″ leader labeled with the number 1, wind a 48″ length of this wire onto the toroid core. Pause at exactly seven turns to form the center tap by making a loop that, when folded on itself, is 3″ long. Twist this loop to form the center lead of the transformer's primary and label it number 2. Wind exactly seven more turns in the same direction. Trim the remaining wire to a convenient length (about 3″) and label this last lead number 3.

Wind the secondary in a similar manner, using 72″ of No. 14 enameled wire. This winding consists of 38 turns, with a 3″-long center tap at the 19th turn. Label the beginning, center tap and end of this winding with the numbers 7, 8 and 9, respectively. Wind in the *same* direction as you wound the primary.

Easiest to wind is the third (tertiary) winding because it consists of only eight turns (with a center tap at the

POWER SUPPLY PARTS LIST

- C1—1,000-μF, 25-volt electrolytic capacitor
- C2,C3—4,700-μF, 40-volt electrolytic capacitor
- CR1 thru CR4—MR822 or equivalent fast 200-volt, 5-ampere rectifier
- R1—7.5-ohm, 5-watt power resistor
- R2—75-ohm, 5-watt power resistor
- R3—15-ohm, 3-watt power resistor
- Q1,Q2—2N5301 npn power transistor in TO-3 case
- T1—Ribbon toroid transformer (see text)
- Misc.—Printed-circuit board; heat sink; TO-3 transistor insulators; thermal grease or paste; machine hardware; heavy-duty stranded hookup wire; solder, etc.

Note: See Amplifier Parts List for availability of kits and individual components.

fourth turn) of easily managed 16-gauge enameled wire. Label the beginning, center tap and end of this winding with the numbers 4, 5 and 6, respectively, and wind in the same direction as the primary and secondary.

Trim all power transformer leads to 1″ long, measured from the body of the toroid, except leads 2 and 3, which should be 1½″ and 2″ long, respectively. Carefully scrape ¼″ of the enamel from each lead and lightly tin with solder. Group the three leads from each winding so that they align with the appropriate holes in the power supply board.

Wire the power supply board as shown in Fig. 7 (Pay careful attention to the orientations of the electrolytic capacitors, transistors and diodes on both boards.) Leave *T1* for last. Bolt the heat sink to the board via only the two left holes.

Liberally coat both sides of two TO-3 insulators with thermal grease or paste and position them on the heat sink so that their holes line up with those in the heat sink. Mount *Q1* and *Q2* in their respective locations and bolt them down with 6-32 × ¾″ machine hardware with shoulder fiber washers between the heat sink and board. Make absolutely certain that the narrow necks of the shoulder fiber washers seat into the holes in the heat sink so that the transistors are fully insulated from the heat sink. Solder the base (B) and emitter (E) pins of *Q1* and *Q2* to the copper pads. The holddown screws make the collector connections.

Tie together and solder one lead each of power resistors *R1* and *R2*. Slip insulating tubing over each of the leads of both resistors, install them in holes E1, E2 and E3 and solder into place. Position these resistors so that they sit on the heat sink as shown. Finally, install *T1* on the board. Make sure all solder connections are mechanically and electrically secure.

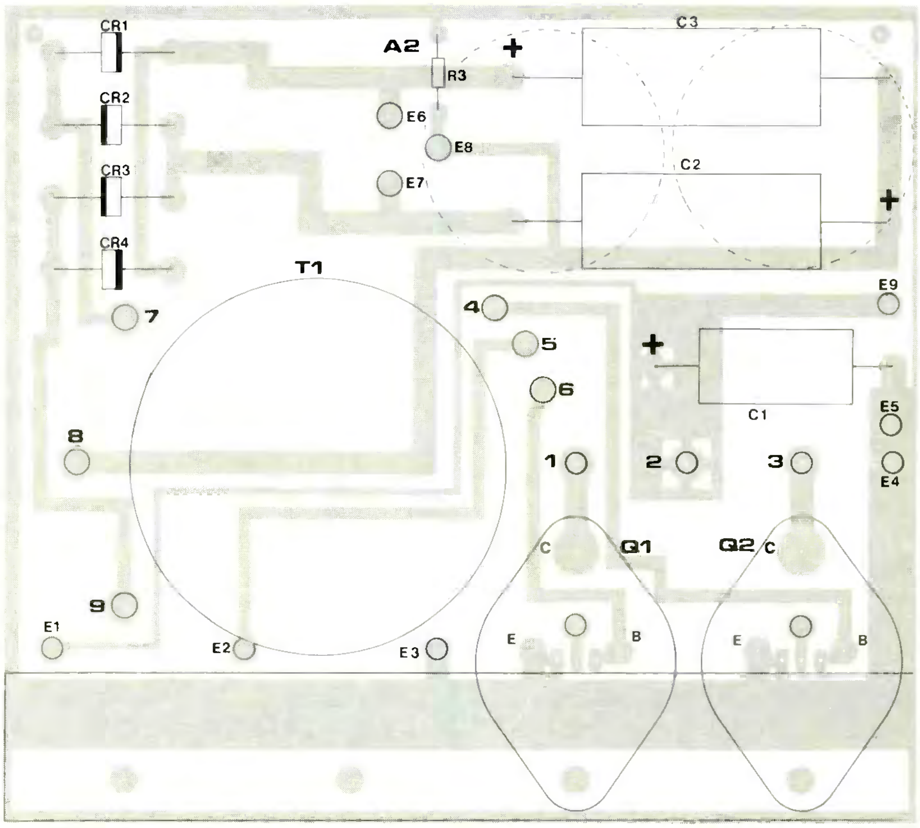


Fig. 7. Wiring guide for power supply board.

Wire the amplifier board as shown in Fig. 8. Start with the resistors, diodes and wire jumpers. The jumpers, identified by the letter with a number suffix, should all be solid wire, and J3, J5 and J6 should be insulated.

Install *Q5* through *Q18*. Make certain you install the correct transistor in each location. Any error in installation can cause instant (and expensive) component failure when the amplifier is first powered up. Mount *Q5* through *Q18* about ⅜″ above the board's surface and be sure to slip a ferrite bead over the collector leads of *Q6*, *Q8*, *Q10* and *Q12* before plugging them into the board.

Note that *Q5* through *Q18* can be in either a plastic or a metal package. With the plastic package's flat facing up and the bottom facing toward you, the leads are the emitter, base and collector from left to right. With the round metal package's bottom facing you, the leads are the emitter, base and collector reading clockwise from the tab on the case.

Install the capacitors, making sure that you properly polarize the electrolytics. Install the ICs directly on the board, soldering their pins to the copper pads. You can use sockets for the ICs, if you wish, though this is not necessary (nor is it recommended for an automotive environment that is normally subjected to mechanical stresses) because these low-current devices rarely fail if they are good to start with.

Install *L5* and *L6*, seating them on the heat sink as shown with double-sided foam tape. Then connect and solder *C15* and *C18* from pin 1 of *U1* and *U3*, respectively, to circuit ground on the *bottom* of the board. Solder these capacitors directly to

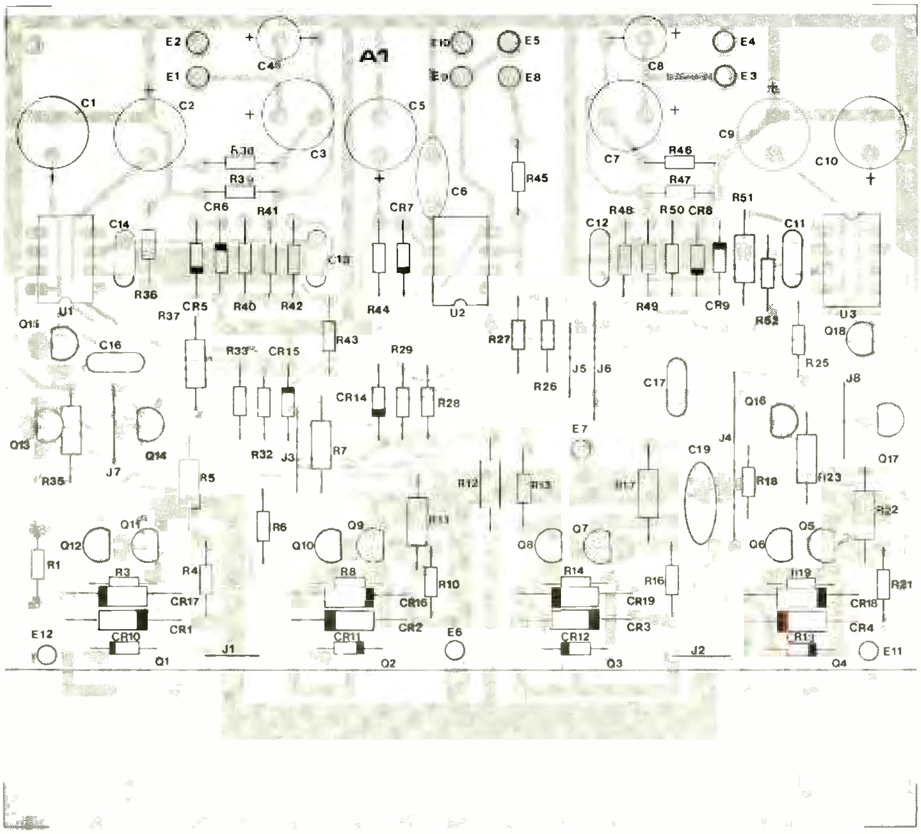


Fig. 8. Wiring guide for amplifier board.

the pin 1 stubs to get them as close as possible to the ICs.

Power MOSFETs *Q1* through *Q4* are in flat three-lead plastic packages that bolt down to the board and heat sink. As cautioned above, use safe handling procedures when working with these transistors to avoid damaging them with static electricity. Bend the transistor leads toward the rear metal surfaces of the cases at the point where they go from wide to narrow.

Coat both sides of four transistor insulators with thermal grease or paste and align them with the holes in the heat sink. Feed four 6-32 × ¾" machine screws through the four holes at the bottom of the amplifier board from the solder side. Drop a shoulder fiber washer onto each screw, narrow neck up, and lower the heat sink onto the screw ends. Carefully seat the necks of the fiber washers in the holes in the heat sink. Install the appropriate n- or p-channel power MOSFET in the *Q1* through *Q4* locations. Do not forget to use safe-handling procedures when handling these MOS devices. Drop onto each screw end a lockwasher and follow up with a 6-32 machine nut. Make the hardware only finger tight.

When mounting the power MOSFETs, be exceptionally careful to insulate them from the heat sink, due to the high r-f difference in potential between the metal parts.

Solder the leads of *Q1* through *Q4* to the copper pads on the bottom of the board. These must be solid electrical and mechanical connections. Make sure that you do not create any solder bridges between the closely spaced pads. Then tighten the hardware only enough to mechanically secure the assembly in place. Do not overtighten or you will crack the cases of the transistors.

Operational Checkout

A full operational check is highly recommended before you install the amplifier in your vehicle (see "Bench Testing the Amplifier" box). Be extremely careful as you check out the amplifier section. Keep in mind that the power supply produces dangerous voltages and currents. Do not short the power supply's outputs. If you do, the pc board's foil can be damaged. Also, shorting anything on the amplifier board will almost certainly destroy some of the semiconductors.

Check the power supply first, using an ohmmeter to verify that there are no short circuits between the 12 volt input and either of the two outputs to ground. If you have a 12- to 14-volt dc power supply, connect it in proper polarity across *C1* in the power supply.

When you turn on the power, you will hear a brief "chirp" from the power supply as the filter capacitors charge. With a dc voltmeter, you should measure +32 and −32 volts to ground at the positive and negative sides of *C2* and *C3*, respectively. If the voltage is low or zero, check the phasing of *T1*'s primary (terminals 1, 2 and 3) and of the feedback winding (terminals 4, 5 and 6). If there is no output at one side of the supply and you hear a high-pitched squeal coming from *T1*, that side has a direct short.

After checking the power supply, disconnect power from it and discharge the *C2* and *C3* with a 10-ohm, 5-watt resistor. Connect the power supply's output (leads E6, E7 and ground) to the amplifier circuit

(Continued on page 86)

board. Temporarily install *LED1* at E5 and E8 on the amplifier board.

With the output of both channels left open, apply power. You should *not* hear a sound from the power supply; if you do, this indicates a short circuit or excessive load. If your dc power supply has an ammeter, it should initially indicate between 3 and 3.5 amperes and then swing slightly up-scale as the output stages turn on and *LED1* lights.

Using a standard VOM—*not* a digital multimeter—to check the amplifier's output stage, you should obtain a dc reading of 1 volt or less. If you measure more than 1 volt positive or negative, there is a problem. If this occurs, shut off the power and correct the problem before proceeding. If it is a short circuit, continued operation of the amplifier board can destroy expensive components!

When both amplifier channels are oscillating properly, connect a small 4- or 8-ohm speaker to the left-channel output. When you turn on the power, there should be no noise coming from the speaker with no signal going into the amplifier's left input. Check for audio amplification by carefully touching (buzzing) pin 3 of *U3*. Repeat this check for the right channel.

After checking for basic operation, apply an audio signal from the speaker—*not* the earphone—output of a portable radio to each input. Connect the test speaker to the appropriate output and verify that each channel is functioning properly.

Bench Testing the Amplifier

In order to bench test your amplifier to full output, you will need a good-quality dc power supply capable of providing at least 20 amperes at 13.8 volts. During tests, keep all unshielded leads as short as possible and all inputs away from the speaker outputs.

You can use any 4-ohm load you wish. However, as the inductance of the test load increases, so does the r-f across the load. I have used automative tail lamps with their filaments in parallel. The type 1157 draws about 2.5 amperes at 12 volts (30 watts). This lamp can take quite a bit of abuse for a brief period. If you are going to monitor the amplifier's outputs with an oscilloscope, be prepared to see some unusual waveforms!

Looking at the output section ahead of the inductor will reveal a 64-volt peak-to-peak square wave. As the signal to the amplifier's input increases, the square wave's duty cycle will change at the frequency of the input signal. This effect will become immediately visible at input signal frequencies below 10 Hz. To test for full power output be sure that there is at least 13.8 volts reaching the power supply's input at *C1*.

Installation

The power supply and amplifier boards are best housed inside a well-vented heavy-duty metal enclosure like that shown in the lead photo. For maximum circuit protection, a fan is recommended to draw out the heat generated by the project. Mount the power supply and amplifier circuit boards so that their heat sinks will receive good air flow from the cooling fan.

Ordinary phono jacks serve for the audio input connectors to the amplifier. Since the input power is high-level, stranded heavy-duty hookup wire can be used between the input jacks and left (E3) and right (E1) input points on the amplifier board. (Reference both outputs to circuit—*not* chassis—ground.) Before plugging these wires into the board, slide ferrite beads *L7* and *L8* over them at the ends that plug into E1 and E3 on the board.

You can mount light-emitting diode *LED1* on the front panel with a lens clip or small rubber grommet. Alternatively, it can mount directly on the amplifier circuit board.

Provide good quality terminals for the 13.8-volt power input and the speaker outputs. Allow some method of terminating the shield from the speaker leads, which will be connected to a common ground point at the amplifier.

Install your amplifier in a location as close to the battery and main electrical system as possible. Use heavy stranded wire to provide dc power from your vehicle's electrical system to your amplifier. Keep in mind that any voltage drop in the primary side of the amplifier's power supply is multiplied almost six times after voltage step-up. Therefore, use at least 12-gauge wire. If you decide to mount the amplifier in your trunk or rear storage compartment, use 10-gauge or larger wire.

After installation, you can verify that adequate power is being delivered to the amplifier by cranking up the volume and measuring the voltage across *C1* in the power supply. With the engine running, you should measure not less than 12.5 volts. If you measure less than this, you need larger-gauge wiring.

Install a 20- or 25-ampere automotive-type fuse in the +12-volt line going into the amplifier's power supply. As mentioned, power to the amplifier can be automatically turned on and off at the right times via the relay that controls the electrically operated antenna in your vehicles. It can also be turned on and off via a heavy-duty switch or automotive accessory relay.

If you do not have the automatic switching capability, always turn on the amplifier at the same time as or after you turn on your car radio, and turn it off at the same time as or before you turn off your radio.

Use 14-gauge shielded cable to wire your speakers to the amplifier. Ground the shield only at the amplifier end to provide the best shield against radio-frequency interference.

The power amplifier is designed to be driven from standard speaker output stages of a typical car stereo radio. These radios often use full bridge output stages that do not have one side of the speaker grounded. To accommodate this arrangement, ac coupling and loading are provided on each amplifier input. To connect your radio to the amplifier, connect the positive (+) output of each channel to the amplifier's inputs and the radio's grounds to the amplifier's input grounds—*not* the power ground. The amplifier has isolated power and amplifier circuitry. Do *not* connect the amplifier power and input grounds together except through the connection physically located at the car radio. If you note interference from the vehicle's ignition and alternator, the two grounds are probably connected at more than one point.

Speaker Selection

Careful selection of good-quality speakers with satisfactory high-power-handling capacities and properly mounting them will give you sound levels and quality that you never experienced before in your vehicle. An automotive vehicle can provide a listening environment unlike anything you normally encounter in a home. With 200 watts of audio power inside a small, relatively nonresonant vehicle, you will be amazed at what you hear.

Always use the best baffle or enclosure you can afford and can fit into your vehicle. Never use a speaker without some type of enclosure. If you do, most of the sound coming from the front of the speaker will be canceled by the out-of-phase sound coming from the rear of the speaker. If you have piezoelectric tweeters, install a 50-ohm, 2-watt resistor in series with each to remove any remaining r-f from the amplified signal. These tweeters are very capacitive in nature and can drastically affect the performance of your amplifier. (Any remaining r-f not removed by the amplifier's filter inductor is averaged into dc power by any normal permanent-magnet speaker.)

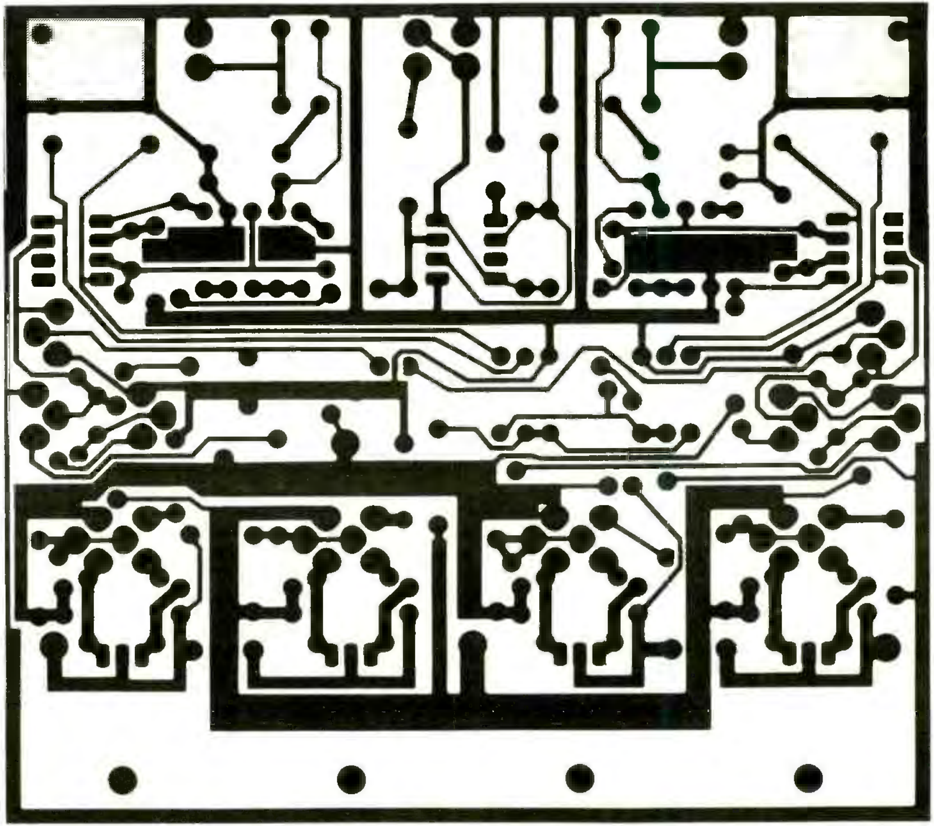
Keep in mind that the digital stereo amplifier will not reduce any distortion produced by your radio's amplifier. It will maintain the same distortion level beautifully, which other boosters do not. The better the radio amplifier, the better the booster's output quality. To fully appreciate the booster's capability, a very clean program source—in particular, that from a CD player—is desirable. Note, too, that cheap car radios do not generally produce the needed 5 watts/channel output. You would not want to match this digital power booster to it anyway. **ME**

Updates

• In the "100-Watt/Channel, Distortionless Digital Audio Amplifier Booster" in the Dec. 1986 issue, there appear to be a number of short circuits in the etching-and-drilling guide (lower) for the amplifier board. Is there a corrected guide available that I can use for making my own board?

J.E. Fuhrmann
Kew Gardens, NY

You're correct. During printing, a number of short-circuit paths between closely spaced pads and conductors did indeed develop as a result of ink "bleed." Here's the corrected pc guide. Let's hope that the outcome is good this time. . . . Ed.



• My "VCR Hookups With Cable Boxes" article looks very good. However, two of the illustrations need clarification. The A/B switch in Figs. 4 and 5 is actually a flat box with two connection points on the input end and one connection point on the output end. This box is identical to the switch box used with

(Continued on page 92)