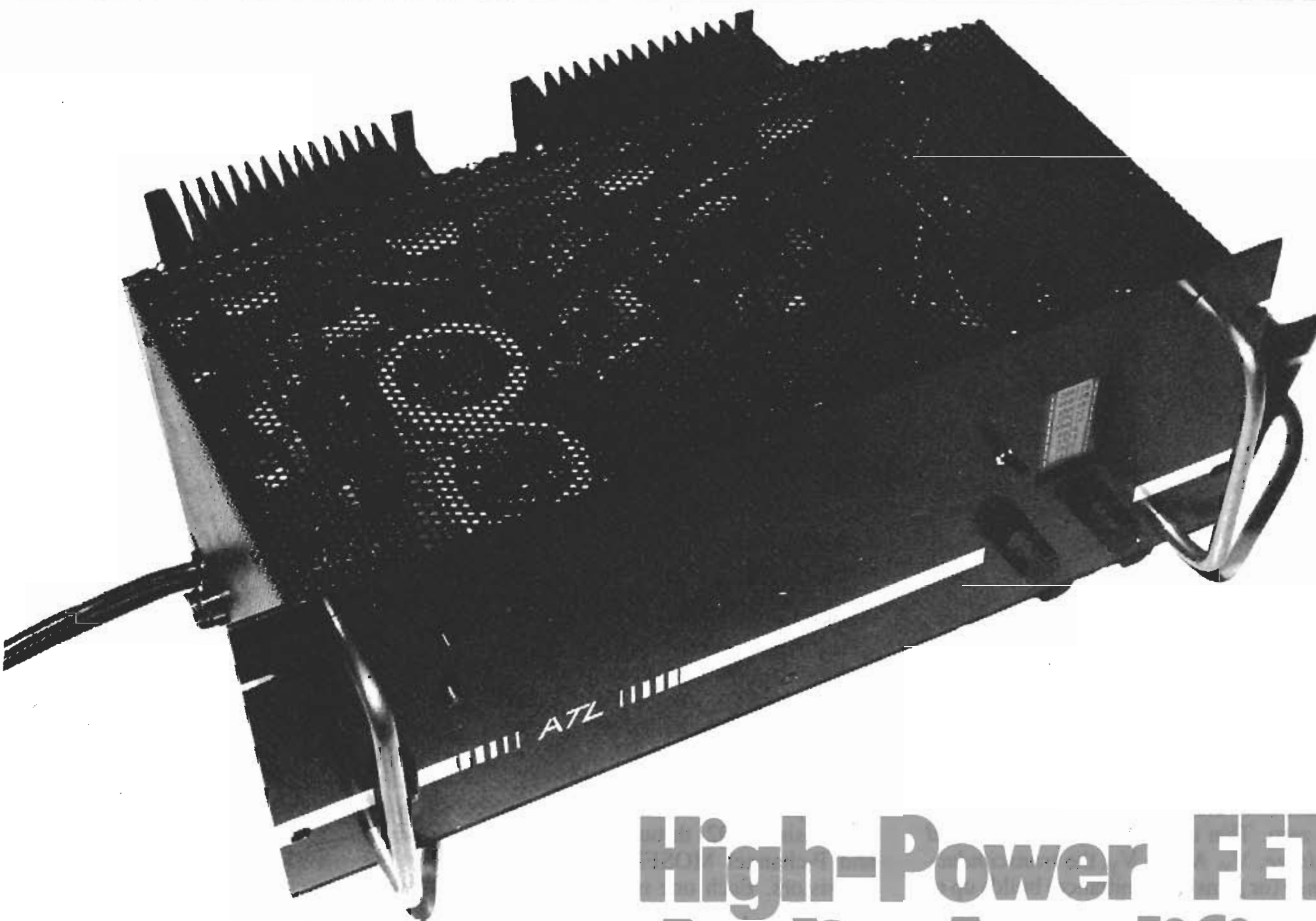


High-Power FET Audio Amplifier

REINHARD METZ

Get high performance and high fidelity from this FET stereo amplifier. It feels equally at home in your living room or in a disco!

YOU'VE PROBABLY ALWAYS WANTED TO own a high-performance, high-power stereo amplifier. If you don't have one, there are two likely reasons why: You are not sure you need that much power and you are deterred by the cost. But these days, with the increasing popularity of digital audio disc players, there is a new motivation for owning a high-power amplifier that can faithfully reproduce a wide dynamic range without distortion. And while the cost of commercial high-power amplifiers is still high, we'll describe a very high-performance design that you can build at a reasonable cost. Just what do we mean by "high performance?" Table 1 summarizes the characteristics of our design.

One of the most important features of the design is the use of power MOSFET output transistors in a complementary configuration. Those transistors, by themselves, eliminate a number of the problems usually associated with their bipolar counterparts.

The highly desirable characteristics of power MOSFET's for audio amplifiers have been recognized for a few years. However, for many years only N-channel devices were available—only recently have their P-channel counterparts appeared at reasonable prices, making it possible to design amplifiers with remarkable performance but little complexity.

As we'll see shortly, MOSFET's aren't the only transistors used in the amplifier. Ahead of the output stage, a fully complementary bipolar design combines simplicity with high performance.

Why MOSFET's?

Although the evolution of power MOSFET's has primarily been (and still is) fueled by power-supply applications, there are a couple of reasons why MOSFET's make ideal devices for audio-amplifier output stages. First, they allow the design of amplifiers with very wide bandwidths, high slew rates, low distortion, and straightforward simplicity. Also, MOSFET's lack a secondary-breakdown mechanism. (Secondary breakdown in bipolar devices is a localized heating effect in which "hot spots" develop under high-current conditions. A hot spot then conducts even more current, creating more heat, which, in a positive-feedback manner, may lead to a catastrophic destruction of the device.)

Because of secondary breakdown, bipolar devices must be operated within a "safe" area that often falls far short of the device's stated static current and power-dissipation characteristics. Safe-operation-area limiter circuits (whose misoperation has often been notorious) must be used in bipolar circuits. Because MOSFET's do not exhibit secondary breakdown, simpler and more reliable designs can be used.

TABLE 1—SPECIFICATIONS

Power output:
250 watts/channel into
a 4- or 8-ohm load

Frequency response (−3dB):
5 Hz to 1.1 MHz @ 1 watt
5 Hz to 330 kHz @ 250 watts

Distortion:
< 0.05% IM to 250 watts
< 0.05% THD 20 Hz–20 kHz

Signal-to-noise ratio:
> 100 dB

Damping factor:
> 500 to 1 kHz with 8-ohm load

Risetime:
< 0.5 μs @ 80 volts P-P

Slew rate:
> 160 volts/μs

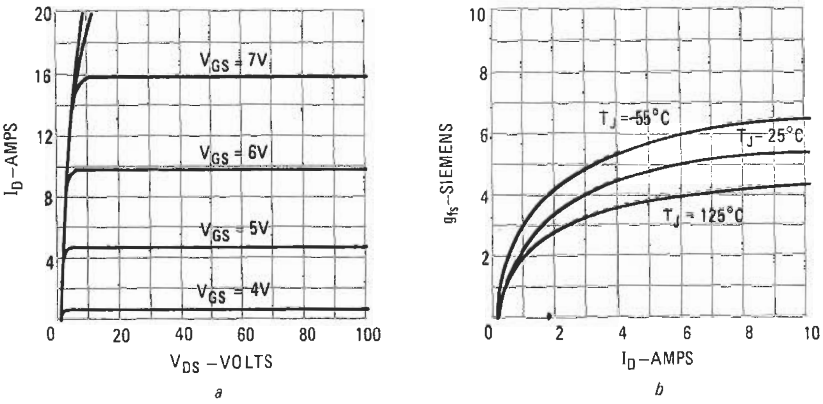


FIG. 1—MOSFET CHARACTERISTICS. Shown in *a* are the typical output characteristics of the IRF630. Shown in *b* is the typical transconductance as a function of drain current for the same device.

The characteristics of the MOSFET's used in this amplifier are shown in Fig. 1. They are, of course, voltage-controlled devices. When the gate-to-source voltage, V_{GS}, drops below about 3.5 volts, the drain-to-source current, I_D, quickly drops to zero. That is called the *gate threshold voltage*, V_T. Above V_T, the *transconductance* (or transfer admittance) builds up to an asymptotic value, averaging about 3 amps of drain current per volt increase in gate-to-source voltage, V_{GS}. (Measured with V_{DS} constant, $\Delta I_D/\Delta V_{GS}$ = 3 siemens)

A look at the circuit

The stereo power amplifier consists of four main stages: input, voltage-amplifier, inverter/driver, and output. Since the MOSFET outputs are the center of attraction, we'll begin there and work our way backward. The amplifier schematic (for one amplifier channel) is shown in Fig. 2.

Transistors Q21 through Q28 are the N- and P-channel MOSFET power output transistors. Each one is capable of contributing a minimum of 6 amps of the output current for peak current requirements. Since the output transistors are in a common-source configuration, the output stage can have voltage gain, and the transistors must be biased with respect to the supply rails. The major advantage of that approach is that the bipolar driver-stage does not have to swing very much voltage, but the outputs may swing from rail to rail. (A common-drain output stage would require the driver to swing the entire output-voltage range which, with bias, would mean that either a pair of separate higher-voltage supplies would be required for the drivers, or that the output would not swing from rail to rail. That

PARTS LIST

All resistors ¼-watt, 1% unless otherwise indicated. (5% types—values shown in parenthesis—can be substituted
R1—10,000 ohms, audio-taper potentiometer
R2—2050 (2000) ohms
R3, R4, R13, R14—10,500 (10,000) ohms
R5, R6, R11, R12, R22—100 ohms
R7—2490 (2400) ohms
R8—500 ohms, potentiometer
R9—2470 (2700) ohms
R10, R29—100,000 ohms
R15, R16—1000 ohms, 2 watts
R17, R18—1000 ohms
R19—5000 ohms, 10-turn potentiometer
R20—8660 (8200) ohms
R21—1500 ohms, 2 watts
R23–R26—511 (510) ohms
R27, R28—2000 ohms, 5 watts
R30—50 (47) ohms
R31–R38—24.9 (24) ohms
R39—162 (160) ohms
R40—5110 (5100) ohms, ½ watt
R41—4.64 (4.7) ohms
R42—4.64 (4.7 or 5) ohms, 10 watts

Capacitors
C1—10 μF, Mylar film
C2—220 pF, ceramic disc
C3, C4, C11—150 pF, ceramic disc
C5—220 μF, 63 volts, electrolytic
C6—8 pF, ceramic disc
C7—0.1 μF, 50 volts ceramic disc
C8, C9—0.1 μF, 100 volts, ceramic disc
C10—1500 pF, 50 volts, ceramic disc
C12–C15—100 μF, 100 volts, electrolytic
C16, C17— 25,000 μF, 75 volts, electrolytic (Sprague 253G075CF2A or similar)

Semiconductors
Q1–Q4—2N5210
Q5–Q8—2N5087
Q9—ECG289A
Q10—ECG290A
Q11, Q12, Q17, Q18—ECG129
Q13–Q16—ECG128
Q19—ECG373
Q20—ECG374
Q21–Q24—IRF9630
Q25–Q28—IRF630
Q29—ECG123AP
BR1—25 amps, 400 PIV bridge rectifier
D1, D2—1N4148
D3–D5—1N4002
D6, D7, D21—1N4735A 6.2 volts, 1 watt, Zener
D8–D11, D23—1N4750A 27 volts, 1 watt, Zener
D12, D13—1N4737A, 7.5 volts, 1 watt Zener
D14, D15—1N4738A 8.2 volts, 1 watt Zener
D16—1N4728A 3.3 volts, 1 watt Zener

Other components
L1—1 μH (15 turns of No. 16 wire wound on R42—see text)
NE1, NE2—Neon bulbs, 110 volts
F1—5 amps, fast-blow fuse
F2–F5—6 amps, fast-blow fuse
F6—10 amps, fast-blow fuse
T1—106 volts, center-tapped power transformer
S1—SPST power switch
J1—Phono jack for input

Miscellaneous
Heat Sinks, Wakefield 512 series, 2×7 inches or equivalent; TO-5 heat sinks for Q12, Q13, Q15, and Q18; chassis; handles; fuse holders; capacitor clamps; power cord; input jacks; binding posts; wire; hardware; insulators, etc.

The following items are available from A&T Labs, Box 552, Warrenville, Illinois, 60555: Etched, drilled, plated-through PC boards, $22 each; Power transformer, $69 each; Set of 8 matched power FET's, $66; Drilled heatsink (type 512), $27. Add 5% shipping and handling, 12% for transformer. Illinois residents include 5¼% sales tax.

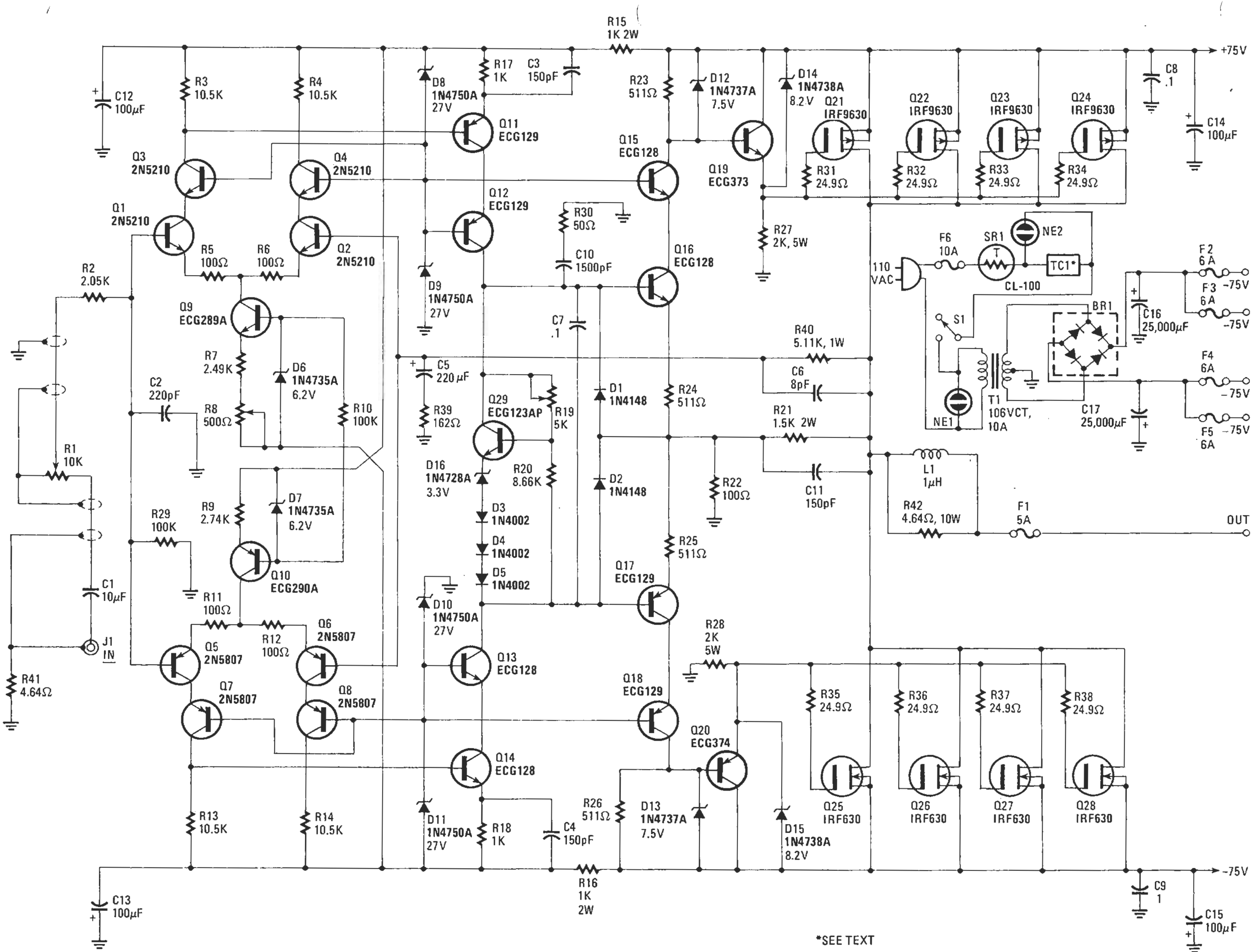


FIG. 2—AMPLIFIER SCHEMATIC for one channel. The power supply shown is sufficient for two channels. While not necessary for home use, the optional thermal cut-out device and inrush limiter shown should be used, for example, in a disco.

would make the stage operate far less efficiently.) The relatively high gate-capacitance of the power MOSFET's is also somewhat easier to drive in the common-source configuration.

Resistors R31 through R38 help to suppress the parasitic oscillations that might otherwise occur with the extremely fast transistors used. Zener diodes D14 and D15 limit the amount of drive available to the output. Finally, L1 and R42 serve to isolate the amplifier output from capacitive loads at very high frequencies.

The inverter/driver stage consists of Q15 through Q20. Its purpose is to deliver bias and drive signals to the FET output stage. Their basic requirement is to sit at about 3.5 volts with respect to the source, increasing about .3 volt per ampere of output current. Transistor Q29 forms a conventional voltage multiplier, which, in this case, multiplies the voltage across D3, D4, and D5 and D16 to about 7 volts. The 7-volt bias is presented to the bases of Q16 and Q17, which form the bottom transistors of a pair of complementary cascode amplifiers.

An output-stage gain of 10 is set by R21, R22, R25, and R26. Therefore, the voltage generated by Q29 is split in half and reflected up against the two supply rails as a pair of bias voltages across R23 and R26. Those voltages, along with the AC drive-signals from the previous stage, are passed along to emitter followers Q19 and Q20, which have the high-current drive capacity required by the gate capacitance of the output devices. Using cascode stages here, as well as in the input and voltage-gain sections, serves the dual purpose of splitting the emitter-collector voltage and power drops among two transistors per rail, while increasing the open-loop frequency response of the amplifier.

The voltage-gain stage consists of transistors Q11 through Q14, again configured as complementary cascode amplifiers. The collector loads for Q12 and Q13 are essentially the input impedance of Q16 and Q17. That is in the neighborhood of 50K, leading to a stage gain of about 50 (the quotient of 50K and R17 or R18). Capacitors C3 and C4 increase the frequency response of the stage. Zener diodes D8, D9, D10 and D11 set the base voltages for the upper transistors in the cascodes.

Now we'll look at the input stage, which consists of Q1 through Q8. Those transistors are connected as complementary-cascode differential amplifiers, supplied by current-sources Q9 and Q10. The gain is set at about 100 by the ratios of R3 to R5 and R13 to R11.

Resistor R8 is used to zero the output voltage by varying the collector currents of Q1–Q4, compensating for any V_{BE} offsets that may exist in Q1,Q2, Q5, and Q6. That is important, because with an extremely low output-impedance such as this amplifier has, even very low output offsets (in the tens of millivolts) can deliver many amps into a short.

The overall voltage-gain of the amplifier is set at about 30 by the ratio of R40 to R39. A 3-dB rolloff is set at about 3 Hz by C5. High-frequency compensation is provided by C10, R30, C6, and C11.

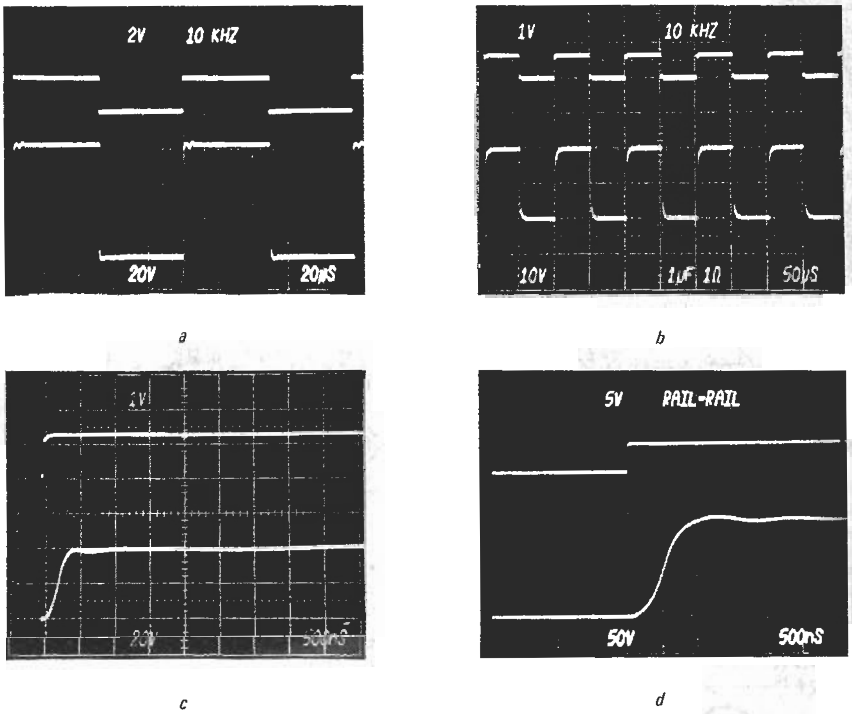


FIG. 3—AMPLIFIER RESPONSE CHARACTERISTICS. *A* **shows the response to a 10-kHz squarewave input at 150 watts into an 8-ohm load, while** *b* **shows the response into a 1-ohm, 1µF load. Shown in** *c* **and** *d* **are the step responses at 50 watts and full output, respectively (both with input filter C2 removed). Note the excellent slew-rate and risetime capabilities.**

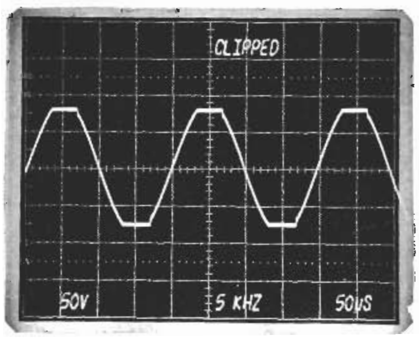


FIG. 4—FULL-POWER OUTPUT with a 5-kHz sinewave input. Note the clipping level is about ±75 volts.

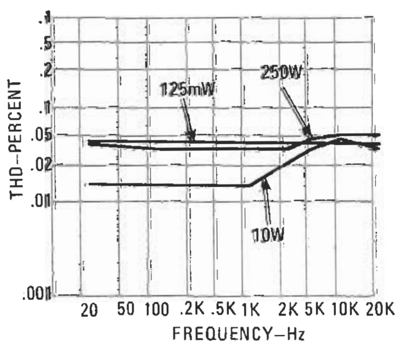


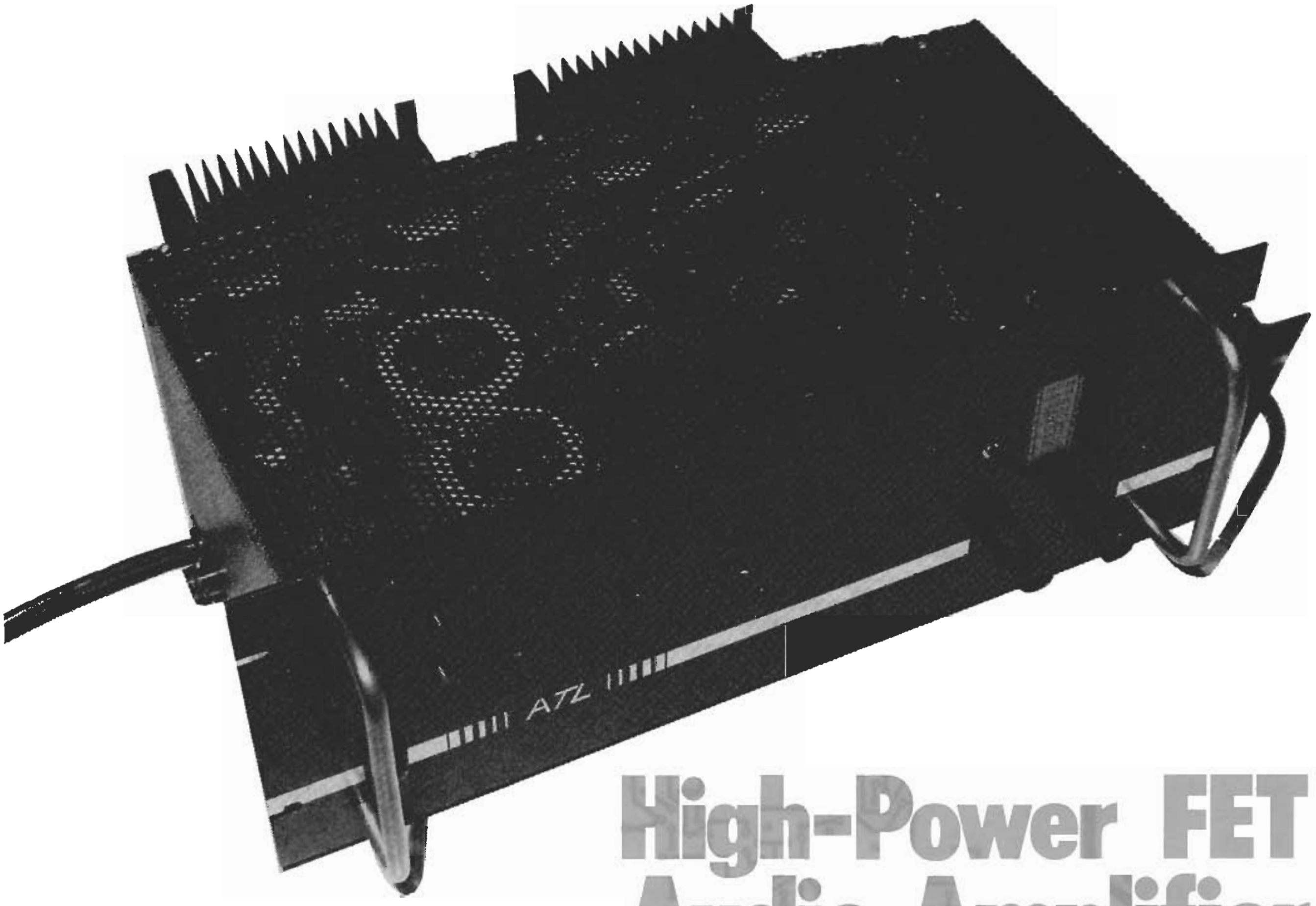
FIG. 5—TOTAL HARMONIC DISTORTION (THD) at 1 kHz.

Some optional components are shown in the schematic, notably in the power-supply section. First, there is TC1, the thermal cutout made by Elmwood sensors (1655 Elmwood Ave., Cranston, RI 02907). It is normally closed, and opens at 70°C. Another optional component is SR1, an inrush limiter made by Keystone (Thermistor Div., St Marys, PA 15857). For home applications, those shouldn't be necessary. However, if you plan to run the amplifier continuously at high power (in a disco, for example), you should include all the protection you can.

Amplifier performance

Some of the response characteristics of the amplifier are shown in the oscilloscope photographs in Fig. 3. For example, in Fig. 3-a we see the response to a 10-kHz squarewave at 150 watts into 8 ohms. Figure 3-b shows the response with a 1-ohm, 1-µF load. Figures 3-c and 3-d show the step response at 50 watts and full output, respectively. (Those two risetime tests were made with input-filter capacitor C2 removed.) Figure 4 shows the full-power output with a 5-kHz sinewave input. Figure 5 shows the total harmonic distortion from less than 1 watt to 250 watts at 1 kHz.

Unfortunately, that's all we have room for this time. Whe we continue, we'll show you how to build the amplifier and provide the foil patterns that are essential for the successful completion of the project. **R-E**



High-Power FET Audio Amplifier

REINHARD METZ

Get high performance and high fidelity from this FET stereo amplifier. It feels equally at home in your living room or in a disco!

Part 2

NOW THAT WE KNOW how our FET power amplifier works, let's now turn our attention to building the unit.

Building the amplifier

It is essential that a printed-circuit board be used for the amplifier. Figures 6 and 7 show foil patterns for the component and solder side respectively. Note that one board is required for each channel. If you don't want to etch your own boards, etched, pre-drilled, and plated-through boards are available; see the Parts List for information. If you *do* want to etch your own boards from the patterns shown, keep in mind that the board uses plated-through holes. You can, of course, get around that by soldering some of the components, including the output transistors, on both sides of the board. Note that the wiring to the output transistors is incorporated in the PC-board layout. That keeps the wire lengths to the output devices to a minimum. (It also simplifies construction by eliminating 48 wires, reducing the chance of error in that particularly critical area!)

Before we begin with the construction details, we should point out that the values shown in the schematic are for 1%-tolerance resistors. For most applications, it is not essential that you use such parts. Thus, the parts list also shows acceptable values for 5%-tolerance resistors. (One source for 1% resistors is Digi-Key Corporation, Highway 32 South, P.O. Box 667, Theif River Falls, MN 56701.)

Once you have your boards and components, you can begin construction by referring to the parts-placement diagram in Fig. 8 and by installing the fixed resistors. Check the values with an ohmmeter as you go, and be sure that the leads are sufficiently far from the ground plane!

Next, install capacitors, carefully checking values and ensuring that the polarized electrolytic types are properly oriented. Follow by installing the diodes, except for D3--D5. (Those three diodes mount on the output-transistor heat sink, and should not be installed yet.) Again, be careful of the polarity—the diode band indicates the cathode. Next, install the transistors (except for the output transistors Q21–Q28). Transistors Q19 and Q20 should be mounted with insulators and heatsink compound. (If you look closely at Fig. 9, you'll see some heatsink compound around those transistors.) Transistors Q12, Q13, Q15, and Q18 use TO-5-type heat sinks.

Adjust potentiometers R8 and R19 to their middle positions and install. (For R19, which is a multiturn potentiometer, you will need to use an ohmmeter.) You will have to make L1: Wind 15 turns of 16-gauge magnet wire on R42. Solder to the leads of R42, and install the assembly. The PC boards are now complete.

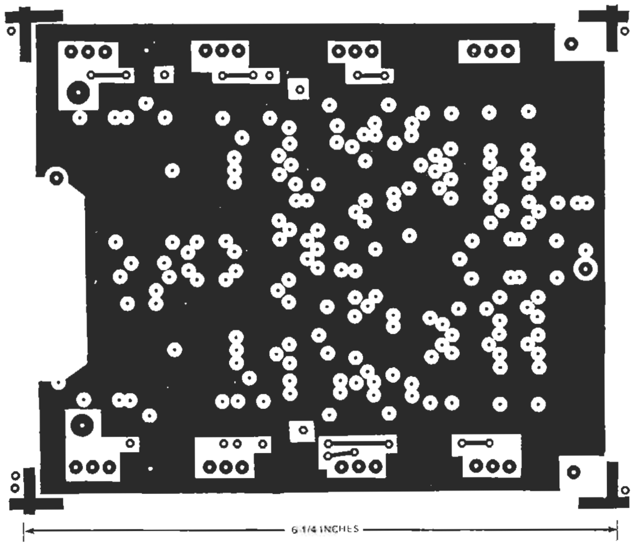


FIG. 6—THE COMPONENT SIDE of the amplifier board is mainly used as a ground plane.

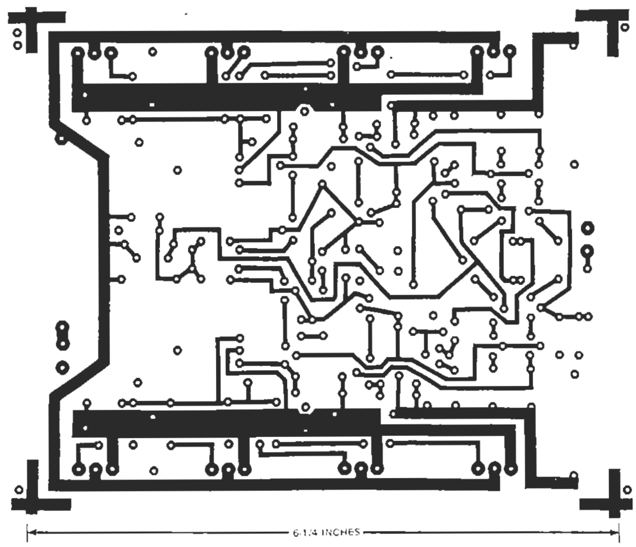


FIG. 7—THE SOLDER SIDE of the amplifier board. Remember that you need one board for each channel.

Preparing the heat sink

The Wakefield heat sinks that are used for the output transistors (see Fig. 10) were not chosen arbitrarily. Their design is almost 100% more efficient for natural convection applications than conventional designs of equivalent volume.

You can use other heat sinks but a minimum surface area of 800 square inches per channel is required. A flat-backed heat sink is desirable for the TO-220 package, but is not essential.

The Wakefield type 512 is available in a 14-inch long extrusion, which needs to be cut in half to yield the two 7-inch pieces called for. After you cut it, drill holes for the output transistors according to the layout shown in Fig. 11. To keep the transistor-mounting hardware to a minimum, you might want to drill and tap the heat sink. However, screws with nuts may also be used. The optional over-temperature sensor and thermal-compensating diodes D3–D5 should also be glued to the heat sink as shown in Fig. 11.

If you have a confined-space application, you can mount the two heat sinks back to back; they will then readily accept a muffin fan for forced convection. For home applications, however, we recommend natural convection—to eliminate the noise, filter, and/or temperature-sensing aspects typically associated with fans. We should make a final note that wiring length should be kept to a minimum, with less than 2 inches from transistor to PC board. Even with that length, a ferrite bead is necessary on each gate lead, and using coaxial cable is recommended.

Preparing the chassis

The design and construction of a chassis for the amplifier is not critical. The author's prototype was built with rack mounting in mind. It consists of an 8 × 17 inch bottom plate with 1 inch turned up at the front and back. The front plate is 19 × 17 inches. As shown in Fig. 10, the two heat sinks mount on the back of the unit, leaving a 2½ × 7-inch strip for a small plate where the input and output jacks and fuses are mounted. Finally, an 8¼ × 31-inch U-shaped piece of perforated metal makes up the cover.

Begin mounting the components with the transformer, bridge rectifier, filter capacitors, and fuse-holders. Then, mount the power switch, pilot lights, and level controls on the front panel.

Next you'll have to make up a suitable mounting plate and install output jacks that are insulated from their mountings. Install the input-fuse holder and the power cord with a strain relief. Then wire the transformer primary and secondary as shown in the schematic. If you plan to use the optional thermal cutouts, leave a pair of wires to go to the heat-sink area. Use 18-gauge (minimum!) wire in the power supply. We recommend that you use some simple color code for the DC wiring—it will help reduce the possibility of errors during subsequent tests.

Locate a suitable single-point ground, such as a screw through the bottom of the chassis near the power supply, and attach the filter capacitors' common power-supply ground to it. If you use a 3-wire power cord, do not ground or terminate the cord's ground lead.

Checkout procedures

The amplifier checkout is by far the most important part of building this amplifier, so, shift into low gear and **proceed with great care through the following steps!**

First we strongly advise you to make a final visual check of all parts placements on the circuit boards and the power-supply wiring. Then, before applying any power, measure each supply terminal with an ohmmeter to ground. An initial low reading should slowly move up to high resistance as the capacitors charge. Install the main power fuse and, with the DC fuses F2–F5 not installed, apply power. Check the two supplies for ± 75 volts. Remove power, and discharge the filter capacitors through a 1K resistor.

Next, install a pair of ¼-amp fuses for F2 and F3. Measure the resistance from each power-supply input to ground on both driver boards. The reading should be greater than 100K. If it is, temporarily connect one board to F2, F3 and ground. Connect a clip-lead from the collector of Q1 to the collector of Q3. Connect another clip-lead from the collector of Q7 to the collector of Q8. Temporarily clip-lead D3, D4, and D5 into the circuit. Apply power, and measure the voltage between the bases of Q16 and Q17. It should near 7 volts. Adjust R19, and observe this voltage changing. Leave it at 6.8 volts. Measure the voltage from the emitter of

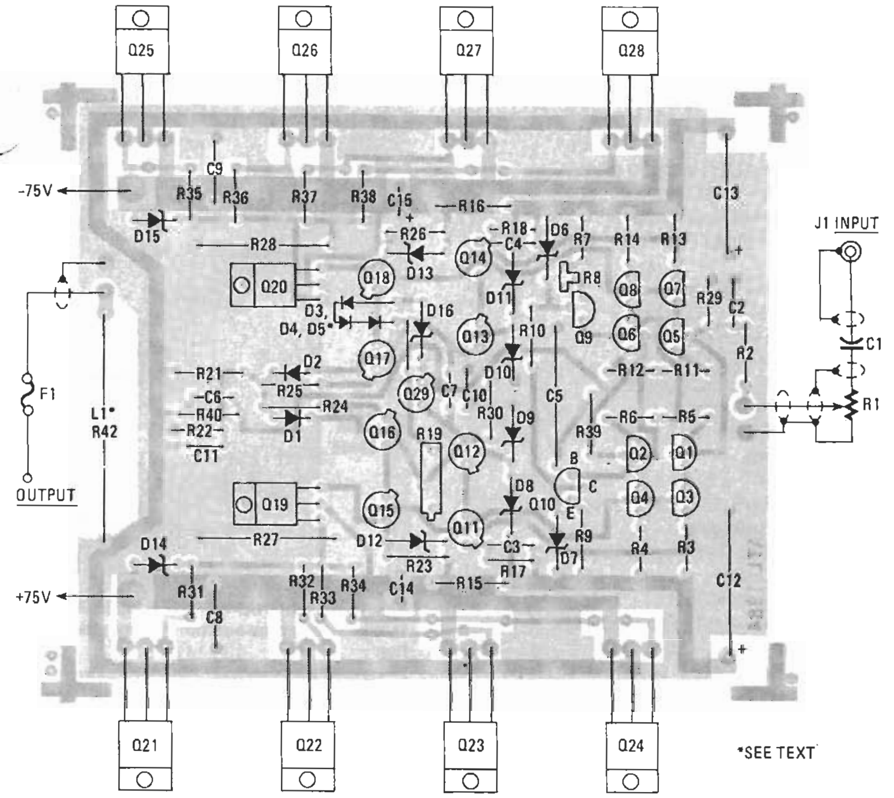


FIG. 8—PARTS-PLACEMENT DIAGRAM for the amplifier board. Refer to the text for information on mounting the output transistors (Q21–Q28) on a heat sink.

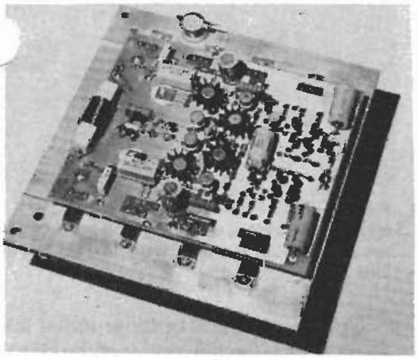


FIG. 9—AMPLIFIER BOARD is shown here mounted on heat sink. Note that Q12, Q13, Q15, and Q18 use TO-5 type heat sinks.

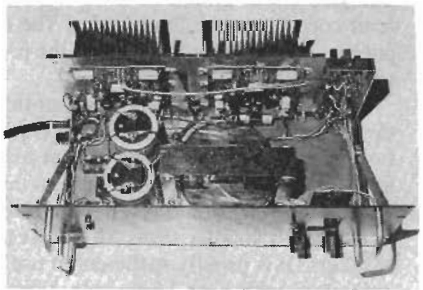


FIG. 10—COMPLETE STEREO AMPLIFIER with cover removed. The chassis configuration is not at all critical.

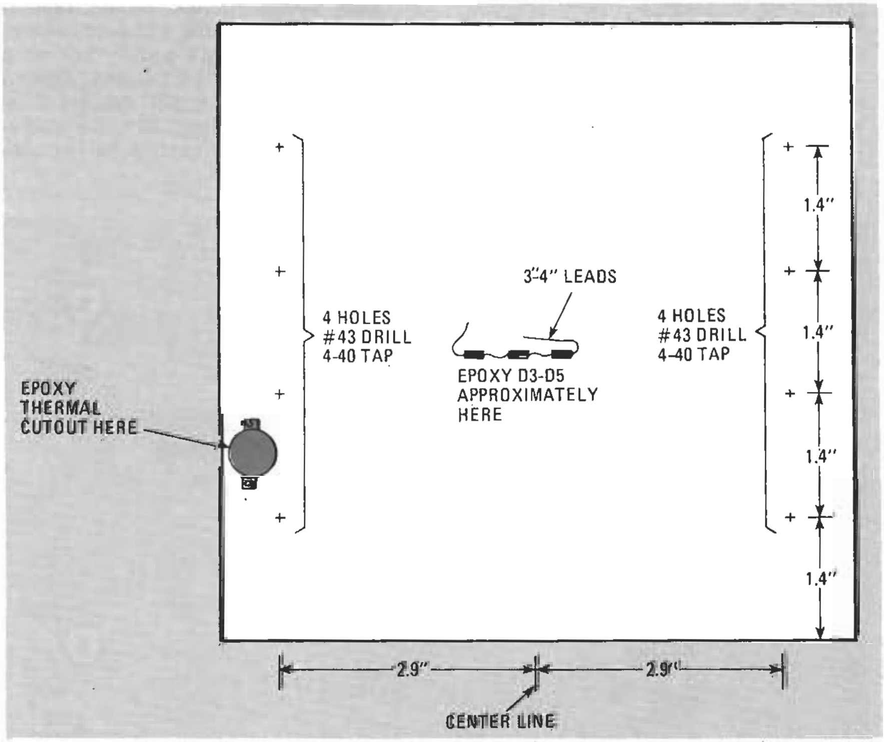


FIG. 11—HEAT-SINK DRILLING GUIDE. Note that some parts are fastened with epoxy to the heat sink.

9 to the +75-volt supply, and the voltage from the emitter of Q20 to the −75-volt supply. One should be around 7 volts and the other about .6 volt. Remove power, discharge the filter capacitors, remove clip leads, and repeat with the other driver board.

Next, solder the output transistors to the driver board. Note that it is important that the transistors be matched (within each particular type) so that they will share the output current equally. A simple circuit for checking the matching is shown in Fig. 12. They should be matched to be within 100 millivolts of gate voltage at 50 mA of drain current and 200 millivolts of gate voltage at 2 amps of drain current. Make the 2-amp measurement quickly, or with the transistor heat-sinked.

To mount the transistors, first bend the leads up at a 90-degree angle right at the point where their width changes. Spread the leads a bit and insert in board. Solder carefully while aligning the transistors as much as possible in a common plane. (They may temporarily be screwed to the heat sink as a holding fixture for this operation.) Solder short leads from D3–D5 to the bottom of the driver board, carefully observing polarity. Apply heat-sink compound and insulators to the transistors, and screw the driver and output-transistor assembly to the heat sink, using insulating shoulder washers. Tighten carefully.

Measure each transistor's tab (or case, if you are using TO-3's) to the heatsink. The readings should all be infinite, indicating no insulator shorts. (If you are using TO-3 output parts, it will be necessary to run individual leads to each transistor. When doing that, be extremely cautious: Double-check all your connections and keep your leads as short as possible. Don't forget to install a ferrite bead on each gate lead if you are using TO-3's. In no case should the wiring to the transistors be more than 2 inches in length.) Install the heatsink and driver assemblies.

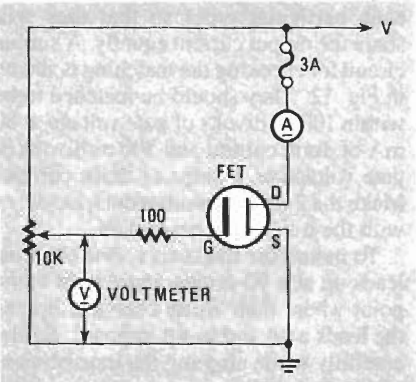


FIG. 12—TO CHECK THE MATCHING OF TRANSISTORS, you might want to use this simple circuit. Start by setting the potentiometer's wiper voltage to zero. Then turn it up to the desired drain current and measure the voltage as shown. For N-channel devices (IRF630), V should be +5 volts. For P-channel devices (IRF9630), V should be −5 volts.

Wire one channel to F2 and F3 with 18-gauge (minimum) wire. Connect a wire from the circuit board ground, near the output, to the chassis single-point ground. Install a ½-amp fuse for F3, and a 1-mA fuse for F2. Apply power, and check for a current through F3 of less than 500 mA. Also check that the output voltage at L1 is between ± 1 volt. If either of those tests fail, immediately turn off power, and look for the source of the problem before proceeding. Adjust R19 to set the current through F3 to about 250 mA, corresponding to an output idle current of about 150mA. Next, adjust R8 carefully to bring the output voltage at L1 as close as possible to zero. Turn off the power, and repeat for the second channel, using fuse positions F4 and F5.

PARTS LIST—BARGRAPH DISPLAY and CLIPPING INDICATORS

All resistors are ¼ watt, 5%, unless otherwise specified.
R43—24,000 ohms
R44, R46, R53—12,000 ohms
R45, R52, R70—22,000 ohms
R47, R54—1000 ohms
R48, R55—470,000 ohms
R49, R51, R58, R59, R61, R62—10,000 ohms
R50, R56—150 ohms
R57, R60—53,000 ohms
R63, R65—1200 ohms
R64, R66—7500 ohms
R67—350 ohms, 20 watts
R68—15,000 ohms
R69—2200 ohms, 5 watts

Capacitors
C18, C19—1 µF, 10 volts, electrolytic
C20—2.2 µF, 10 volts, electrolytic

Semiconductors
IC1—LM139 Quad op-amp
Q30—ECG291
D17, D18—1N4001
D19, D20—1N4741A 11 volts, 1-watt, Zener
D21—1N4735A 6.2 volts, 1 watt, Zener
D22—1N4744A 15 volts, 1 watt Zener
D23—1N4750A 27 volts, 1 watt, Zener
LED1, LED2—Standard red LED
DISP1, DISP2—NSM39158 logarithmic bargraph display with driver (National)

Other components
S2, S3—SPDT

The following items are available from A&T Labs, Box 552, Warrenville, Illinois, 60555: Etched, drilled, plated-through PC boards, $22 each; Power transformer, $69 each; Set of 8 matched power FET's, $66; Drilled heatsink (type 512), $27. Add 5% shipping and handling, 12% for transformer. Illinois residents include 5-1/4% sales tax.

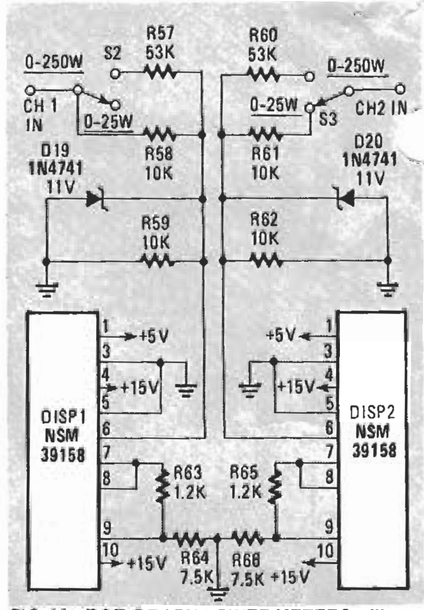


FIG. 14—BAR-GRAPH POWER METERS will certainly make a nice addition to any stereo amplifier.

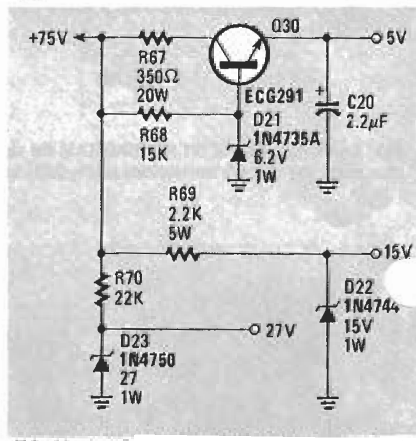


FIG. 15—THIS POWER SUPPLY is needed if the clipping indicators and bar-graph power meters are added. Note that Q30 requires a 10-watt heat sink.

Upon completion of those initial tests, finish wiring the remainder of the chassis. Run at least 18-gauge wire from each driver-board output, along with a ground from the board to the output binding posts. Shielded cable should be used from the level controls to the input jacks. The input-coupling capacitors mount at the level controls.

For continuous full-power applications, it will be necessary to use 5-amp fuses for F2–F5, and 8-amp output fuses for F1. However, for normal, or even loud general listening situations, it is advisable to use much smaller fuses to protect the speakers. It is usually sufficient to use 2-amp supply and 1- or 2-amp output fuses, and work up from there if necessary.

You may want to add clipping indicators and/or bar-graph power meters to your amplifier. The clipping indicat shown in Fig. 13, the power meter, in Fig. 14, and the power supply needed for the two additions is shown in Fig. 15. **R-E**

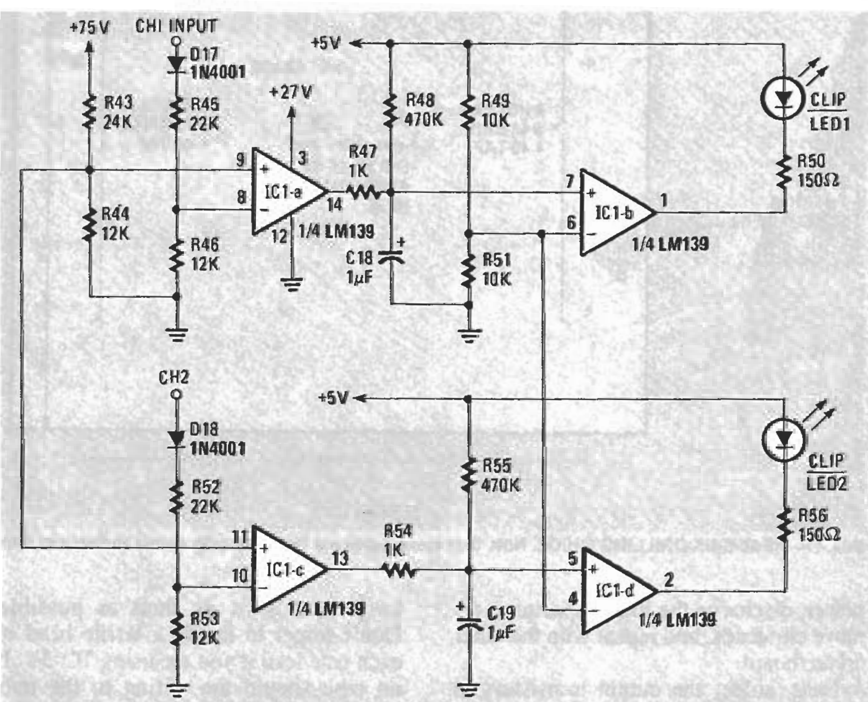


FIG 13—CLIPPING INDICATORS can be added to your amplifier, if desired.

WRITE TO:

LETTERS
Radio-Electronics
200 Park Ave South
New York, NY 10003

A couple of errors have been called to our attention regarding the high-power audio amplifier schematic that appeared in our December and January issues. First, the outputs of the power supply were shown as −75 volts. Only two of them should be—the upper two are +75-volt outputs. Also, the neon lamps shown should really be pilot lamps (which include current-limiting resistors). Q5–Q8 are 2N5087 transistors. The schematic showed them incorrectly.

The parts-placement diagram that appeared in the January issue also had an error: The base and collector leads of Q10 should be exchanged. Note that the leads for Q9 and Q10 are not in the standard plastic-package configuration. Be careful when you install them.

In the "Checkout Procedures" section (in the January issue), one of the procedures (in the last paragraph on page 60) should have read: "Connect the collector of ***Q4*** to the collector of Q3." On page 62, we told you to install a 1-mA fuse for F2. We should have told you not to install anything—just use the F2 position to measure for 500 mA.

I must dispute the myth, repeated in Mr. Kanter's article "Curing Static Electricity," (**Radio-Electronics**, August 1984), that relative humidity is the dominant factor in controlling the buildup of static electricity.

My statements are based on 50 years of experience in the manufacture of photographic films. Those films are very susceptible to damage by static discharges, and could never be handled at 72°F and