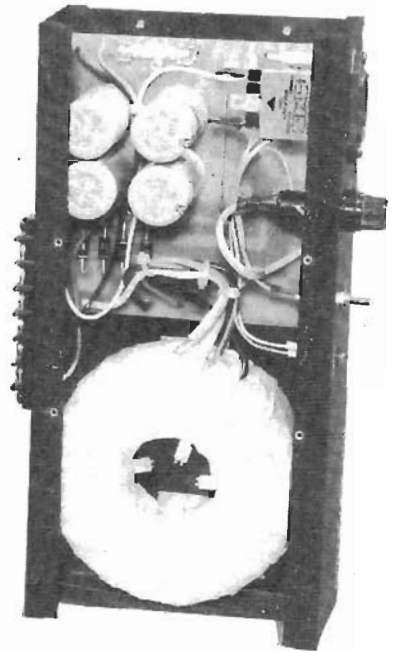
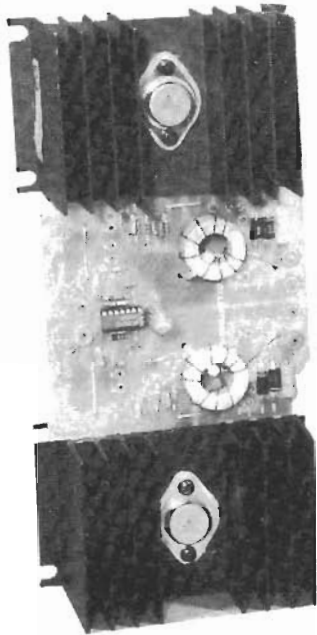


BUILD THIS

HIGH-POWER HI-FI AUDIO AMP



FOR YOUR HOME OR CAR

With rock-n-roll power, here's a stereo amplifier that you can build.

L.K. ROSS and AMP WATTS

EVERY SO OFTEN A NEW IC COMES ONTO the market that excites the experimenter's imagination with all sorts of possibilities. One such IC is National Semiconductor's LM12 power op-amp: And when we say power, we mean power. That single IC can pump out 100-watts RMS of audio into 4-ohms; twice that amount of power is available if you use two LM12 IC's in a bridge configuration.

Today,—especially with compact-disc audio, and its wide dynamic range—even moderate levels of sound reproduction require a power amplifier that won't clip the peak inputs. The LM12 can supply those peak-power demands—and so the *Opto-Amp* idea took shape from that beginning. Two separate power supplies were also designed: one for 110-volt AC home operation, and another for 12-volt DC car operation.

The LM12 power-amp has many features that make it ideal as an audio amplifier. You'll first notice the extremely low parts count that permits compact size, reliability, and ease of assembly. All kinds of circuitry are built right into the LM12 IC: controlled turn-on, thermal limiting, over-voltage shutdown, output-current limiting, and complete protection against overloads including shorts to the supplies!

Table 1 shows the complete *Opto-Amp* specifications. Notice the excellent distortion specification (THD less than .01%, slew rate as high as 9V/ μ s), which should appeal to serious audio buffs and sound professionals. Possible applications of our amplifier include just about whatever your imagination dreams up: car-stereo booster amp, sub-woofer amp, PA system, yacht-stereo amp, stage-

monitor amp, or guitar-practice amp.

How it works

The *Opto-Amp* has two identical channels (for stereo), so we'll analyze in detail the right channel only. The LM381 (IC3) pre-amplifier has an input-voltage range of 0.75 to 1 volt, with a voltage gain of about 10; the LM12 (IC1 and IC2) power-amps will provide a voltage gain of about 4 each. In keeping with the design goal of low parts count, the LM381 is an ideal choice. It's easy to operate, and requires only a single positive supply with simple filtering provided by R9 and C9. Audio goes to the inverting input, while the non-inverting input is at AC ground through C10. Resistors R6 and R3 determine the gain, and R5 provides bias. Coupling-capacitor C11 isolates the audio input from the amplifier biasing.

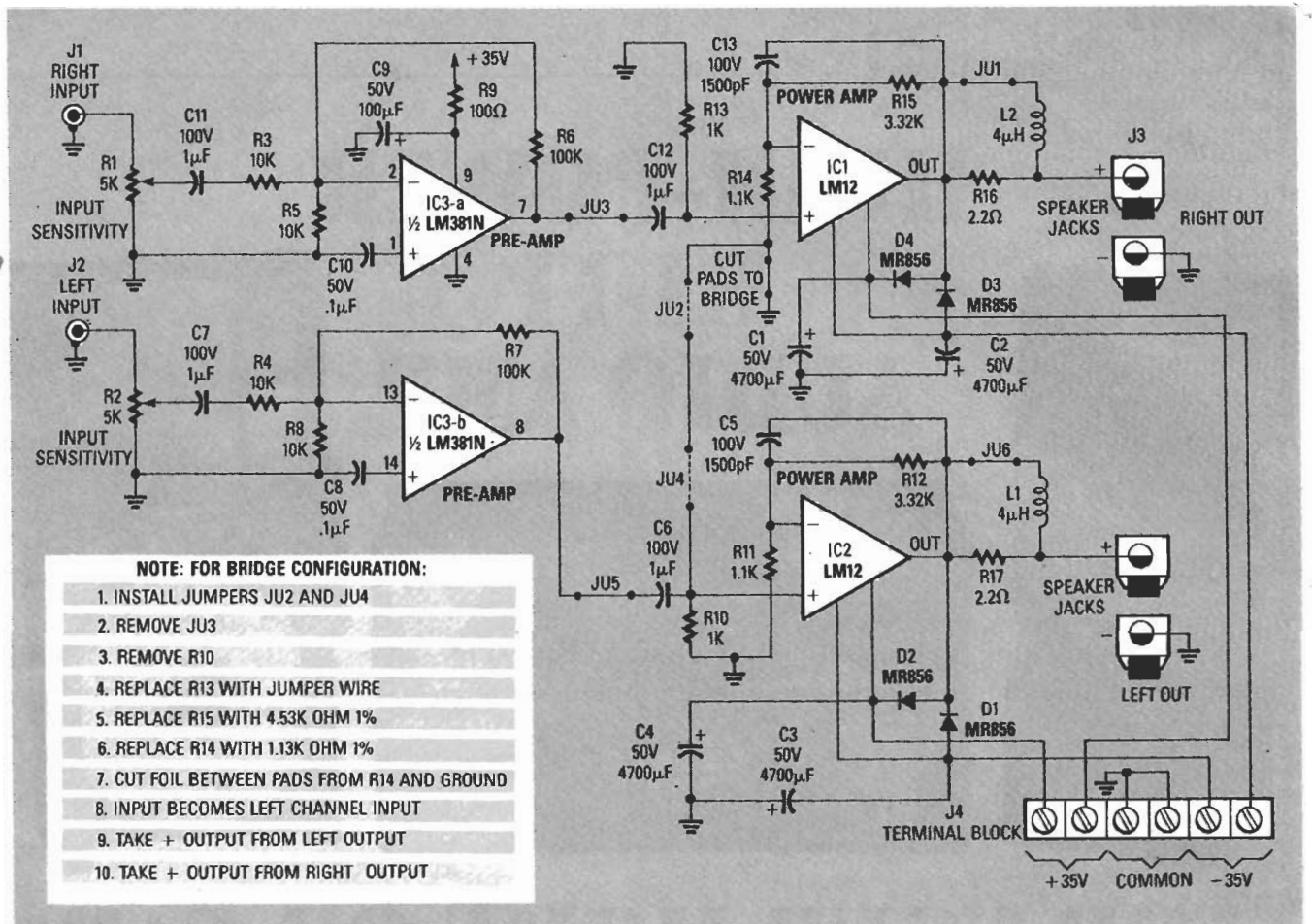


FIG. 1—THE OPTO-AMP IS NORMALLY SET UP FOR STEREO, but can be re-configured for monaural—with twice the output power.

TABLE 1: OPTO-AMP SPECIFICATIONS

POWER RATING: CONTINUOUS

STEREO: 60 WATTS RMS PER CHANNEL CONTINUOUS INTO 8 OHMS
100 WATTS RMS PER CHANNEL CONTINUOUS INTO 4 OHMS

BRIDGED: 120 WATTS RMS INTO 8 OHMS
200 WATTS RMS INTO 4 OHMS
WILL DRIVE 2 OHM LOAD LIMITED TO 150 WATTS PER CHANNEL
TOTAL POWER DISSIPATION IS 150 WATTS MAX EACH CHANNEL.

DISTORTION: THD IS LESS THAN .01%

SLEW RATE: 9V/ μ s

SIZE: 10.2" x 2.6" x 5"

INPUT: LINE LEVEL WITH INPUT SENSITIVITY ADJUSTMENTS

The pre-amp output is AC-coupled through C12 to IC2, which is set up as a non-inverting amplifier. The gain is equal to (R14 + R15)/R14. Diodes D3 and D4 are necessary to clamp the output to the supply rails in case the speakers (which are inductive loads) kick back. Inductor L2 and resistor R16 provide output isolation enabling

the amplifier to drive capacitive loads, which audio power amplifiers must be able to do. Capacitor C13 is in the feed-back loop for frequency stability. Large supply-capacitors C1 and C2 are located close to the IC to prevent changes in load current from returning to the amplifier's input—a precaution that also reduces the

power-supply filtering requirement.

Examine the PC-board layout and note some of the design features that are not seen in the schematic. For example, all grounds are returned to a single point for each amplifier, and the +V and -V supplies are kept separate for each IC amplifier.

Bridging to mono

The *Opto-Amp* is capable of being bridged for twice the power, namely, for monaural applications. To convert the *opto-amp* from a stereo to monaural (bridge) operation, you'll have to perform some PC-board surgery like moving jumpers around and cutting copper lands. That's because IC2 stays in the non-inverting configuration, while IC3 is changed to an inverting amplifier. Both amplifier outputs are then equal in magnitude, but opposite in phase. Any speaker connected between the two outputs will have twice the signal amplitude of either amplifier referenced to ground. (When two amplifiers are bridged across a speaker, the output ground of

Each amplifier is no longer used for the audio's return path through the speaker.)

But there's more: The values of the gain-setting resistors in IC2 must be changed, because the gain for an inverting amplifier is $R15/R14$ with $R14$ no longer connected to ground at one end. The right input pre-amplifier is no longer needed, so remove JU3. The input to IC2 is from the left input pre-amplifier, so install JU4 and JU2. The positive input of IC2 is connected to ground by replacing $R13$ with a jumper wire. Refer to the note in Fig. 1 for bridge conversion.

Power supplies

There are two different power-supplies depending on where you want to use the *opto-amp*: one for 110-volt AC home operation, and another for 12-volt DC car or boat operation.

Figure 2 shows a 12-volt power supply that you can use to operate the *Opto-Amp* in your car or boat. The 12-volt to 70-volt (± 35 volt) converter uses a toroidal-core transformer (T1)

that has two center-tapped primary windings. Transistors Q1 and Q2 are hefty 30-amp transistors that switch 12 volts through the primary-windings No.1 and No.3. The center-tapped winding No.2 is connected to 12 volts, while windings No.4, No.5, and No.6 are the base-drive windings for Q1 and Q2. Power-resistors R1 and R2 provide bias. The base-drive windings are connected out of phase with the main primary windings, so Q1 and Q2 switch on and off to alternate the current into the transformer primary. The secondary winding has a turns ratio of approximately 5 times the primary, which yields after rectification and filtering an output voltage of ± 35 volts for a 12-volt input.

The 12-volt supply is ultra simple and ultra reliable. The tape-wound toroidal-core transformer is custom-made and available from the source in the Parts List. Other types of cores will not work; this is one of those times when the exact part must be used. The supply will pull about 2 amps under no load, and can supply 5

PARTS LIST OPTO-AMP

All resistors are 1/4-watt, 5%, unless otherwise noted.

R1, R2—5000-ohms trimmer potentiometer

R3, R4, R5, R8—10,000 ohms

R6, R7—100,000 ohms

R10, R13—1000 ohms, 1%

R11, R14—1100 ohms, 1%

R12, R15—3320 ohms 1%

R16, R17—2.2 ohms, 2-watt

Capacitors

C1—C4—4700 μ F, 50 volts, axial electrolytic

C5, C13—1500 pF, 100 volts, polyester foil

C6, C7, C11, C12—1 μ F, 100 volts, ceramic monolithic

C8, C10—0.1 μ F, 50 volts, axial ceramic monolithic

Semiconductors

IC1, IC2—LM12CL, 150-watt power op-amp

IC3—LM381N, audio pre-amp

D1—D4—MR856, rectifier diode, 3-amp, 300-volts

Inductors

L1, L2—Inductor, 4 μ H

Miscellaneous: Thermalloy 6421B heat-sink, AW-12 PC board, enclosure, hardware, phono jacks, speaker terminals, power terminal strip, rubber feet, hookup wire, magnetic wire, 14-pin DIP socket.

amps with the output voltage dropping down to ± 30 volts when heavily loaded.

Figure 3 shows the 110-volt AC power supply that uses a toroidal power transformer to supply 70 volts (± 35 volts) at 5 amps; traditional laminated-core transformers can be used as well. The advantage of the toroid transformer is that it's self-shielding because the flux lines stay inside the core. The AC-line input uses an RFI/EMI filter, a power on/off switch, and line fuse. (A nice feature is the detachable AC line cord with standard plug that mates to the EMI-filter module.) The transformer secondary is rectified by diodes D1—D4 and filtered by C2 and C3 to provide two output voltages (± 35 volts) with a common ground. Each output is fused for 5-amps.

Notice that the supply outputs are unregulated. Bleeder resistors R2 and R3 serve two functions. First, the bleeders maintain a minimum load to prevent a large increase in output voltage when the amplifier is disconnected. Second, when the power is

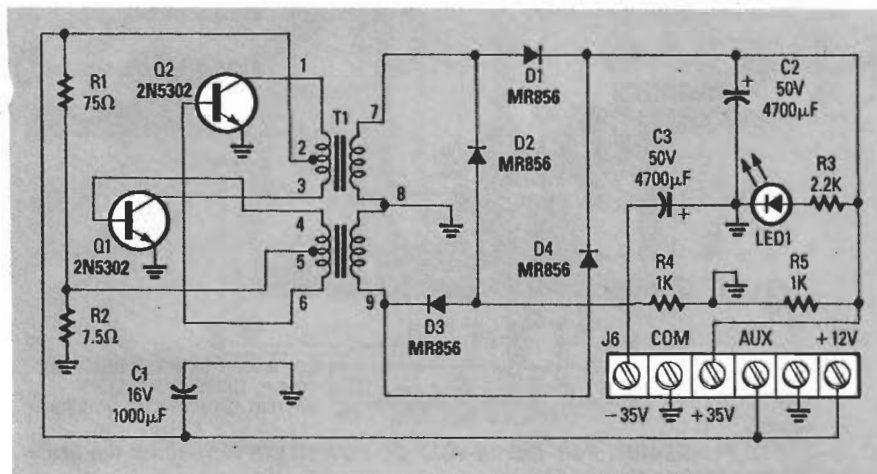


FIG. 2—THE 12-VOLT DC POWER SUPPLY is perfect for operating the *opto-amp* from a car or boat battery.

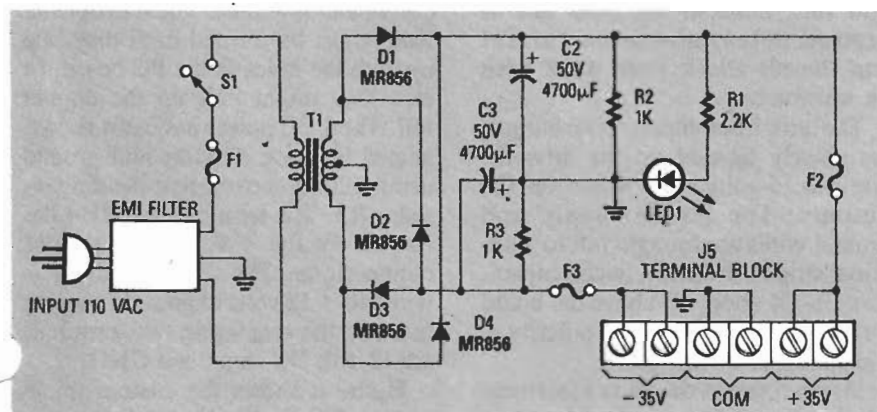


FIG. 3—THE 110-VOLT AC POWER SUPPLY is perfect for operating the *opto-amp* from your household AC current.

turned off, the resistors bleed the current off the filter capacitors, thereby eliminating the possibility of a shock hazard from a charged capacitor. LED1 functions as an on/off indicator that operates from secondary voltage.

The PC board for each power supply is single-sided and available from the source in the Parts List, or you can etch your own using the PC Service layout. Component polarity is critical for the electrolytic capacitors and the diodes, so make sure that you double-check them prior to soldering.

Construction tips

As shown in Fig. 4, inductors L1 and L2 are simple to wind by hand with 10 turns of magnet wire on a ferrite core. The core type is not critical; indeed, any 1"-diameter ferrite-core will work just fine. Use 4" tie-wraps to secure the wound inductors to the PC board. Before you solder magnet wire to the PC board, scrape off the varnish and tin the bare copper with a hot soldering iron.

Take extra care when installing the IC amps on the large heat sinks. Modify the IC insulator with a knife to accommodate the two extra pins on the LM12, and remove any burrs from the heat-sink. Make sure that you use tubing on the four IC leads to prevent shorts to the heat-sink. Apply heat-sink compound on both sides of the insulator to facilitate heat transfer. When you install the LM12 on the heat sink, tighten the mounting screws before soldering the IC pins to the PC board. **CAUTION: Note that the heat-sink will ultimately be at ground potential, that the case of**

PARTS LIST—12-VOLT POWER-SUPPLY

- Q1, Q2—2N5301, NPN transistor
 - LED1—(Light Emitting Diode) green with panel mount
 - D1—4—MR856, rectifier diode, fast, 3-amp, 300 volts.
 - R1—75 ohms, 10-watt, 5%
 - R2—7.5 ohms 5-watt, 5%
 - R3—2000 ohms, ¼-watt, 5%
 - R4—1000 ohms, ¼-watt, 5%
 - R5—1000 ohms, ¼-watt, 5%
 - C1—1000µF, 16 volts, axial electrolytic
 - C2, C3—4700µf, 50 volts, axial electrolytic
 - T1—T1270, custom transformer
- Miscellaneous**
- PS-1270 PC board, chassis assembly, hardware, 6-terminal power strip, hookup wire.

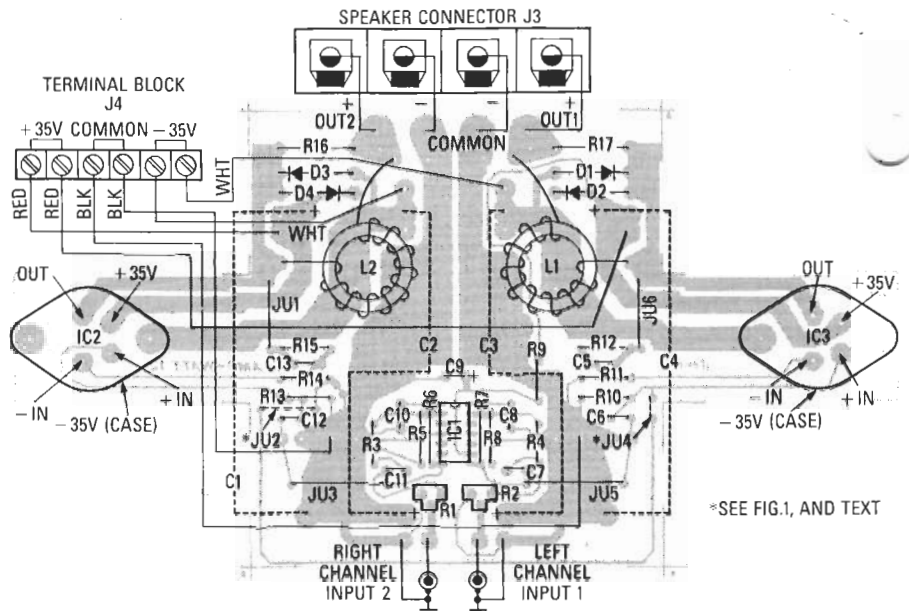


FIG. 4—PARTS PLACEMENT FOR THE OPTO-AMP. The inductors should be wound exactly as shown.

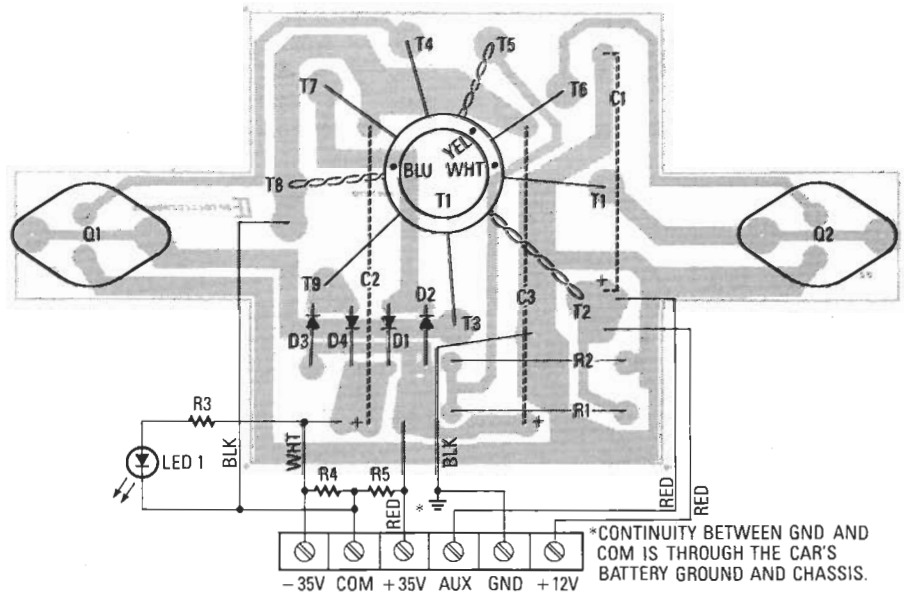


FIG. 5—PARTS PLACEMENT FOR THE 12-VOLT DC POWER SUPPLY. Notice the placement of the toroidal transformer T1.

the LM12 is the -35-volt supply, and that none of the pins are at ground potential—so be careful and double-check your work with an ohmmeter.

The amplifier inputs and outputs are clearly labeled on the artwork. Use No.16-gauge bus wires on the outputs. The power supply and ground wires are brought out to a terminal strip JU4. Lastly, install capacitors C1-C4 about ¼" above the board on the solder side, with the polarity as indicated on the artwork.

Figure 5 shows the Parts Placement for the 12-volt DC supply. Mounting the 2N5301 power transistors using

insulated heat sinks, and heat-sink compound is a must. The transformer leads must be formed until they line up with the holes in the PC board, or else they might pull up the copper foil. The LED power indicator is connected between 12 volts and ground using a 2000-ohm current-limiting resistor R3. The terminal strip JU4 has outputs for the +V, -V, and COM connections. The AUX terminal is wired to +12 volts to power a cooling fan, and the remaining two terminals are 12-volt DC input and GND.

Figure 6 shows the custom transformer (T1) for the 12-volt DC power supply. Anyone wishing to build it

PARTS LIST—AC POWER-SUPPLY

D1-D4—MR856, rectifier diode, fast, 3-amp, 300 volts

LED1—(Light Emitting Diode) green with panel mount

C1-C4—4700 μ F, 500 volts, radial electrolytic

R1—2200 ohms, 1/4-watt, 5%

R2, R3—1000 ohms, 1/4-watt, 5%

T1—Toroidal transformer, 110-volts primary, 70-volts, center-tapped secondary

Miscellaneous: EMI line-filter (Standex, LR57454, 3-amp 250-volt), 3-prong AC line-cord, SPDT switch, PS110/70 PC-board, PC-mount fuse clips, 5-amp fuses, chassis-mount fuse-holder with 3-amp 250-volt fuse, chassis assembly, hardware, 6-terminal strip, and hookup wire.

will want detailed information about the transformer that uses a standard tape-wound core. As you might have already guessed, tape-wound cores are not very common, and it is unlikely that you will find an equivalent core—except from the manufacturer, Magnetics, Inc., and their minimum order is \$100. In addition to that hurdle, the transformer is somewhat difficult to wind because of the large-wire sizes involved; therefore, Optoelectronics, Inc. will supply the complete T1270 custom-wound transformer. (For ordering information, refer to the Parts List.) Should you want

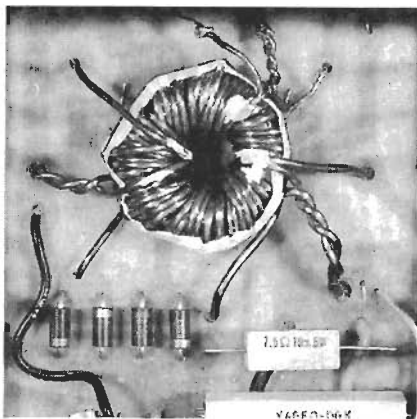


FIG. 6—HERE'S THE TORODIAL transformer used in the 12-VOLT DC to \pm 35-VOLT DC power supply.

to build your own transformer, here are the specifications you'll need:

- Description: 12-volt input, 64-volt center-tap output, with 6.8-volt center-tap base-drive winding.

- Core: 1 mil tape-wound with case dimension of 1.460" \times 0.915" \times 0.345". Magnetics, Inc. part number 50029-ID.

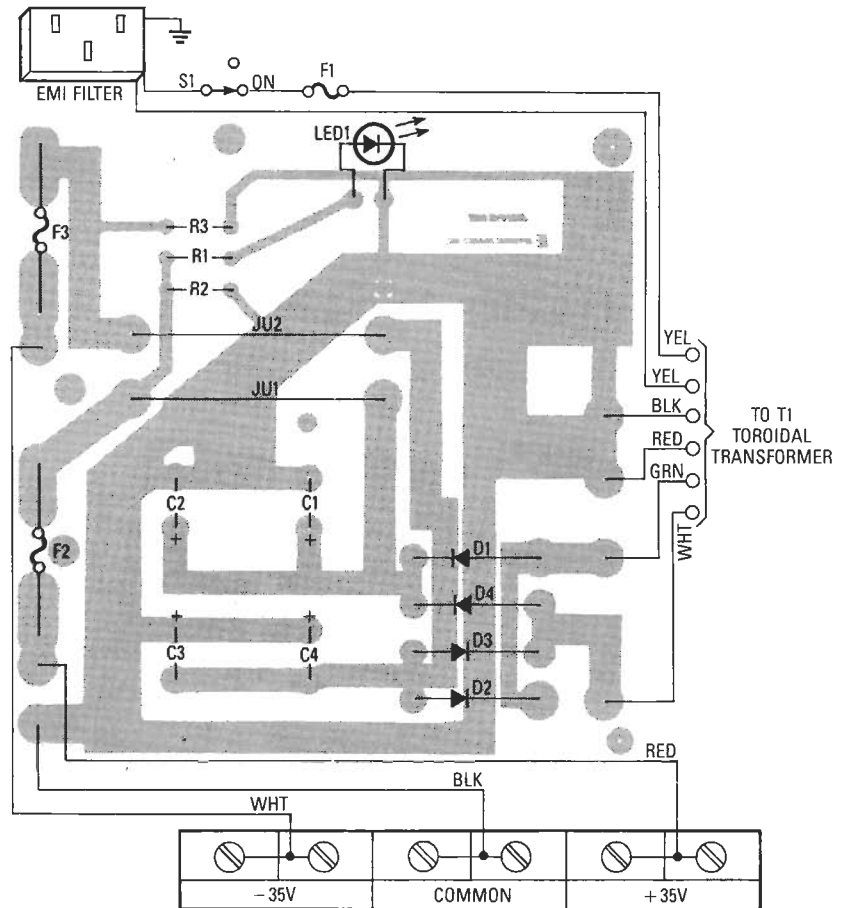


FIG. 7—PARTS PLACEMENT FOR THE 110-VOLT AC power supply.

- Windings: Primary 14-turns center-tapped, base-drive 7-turns center-tapped, secondary 19-turns center-tapped.

- Wire: Primary and secondary uses 12-gauge, base-drive uses 18-gauge.

Mount the transformer to the chassis using plastic ties with the transformer resting on plastic tie downs. Mount the PC board to the chassis on 1/4" spacers and No.4 hardware.

ORDERING INFORMATION

The following are available from Optoelectronics, Inc. 58821 N.E. 14th Ave., Ft. Lauderdale, FL 33334; phone (800) 327-5912, FL residents phone (305) 771-2050; include 5% shipping and handling; FL residents add 6% sales tax. Master Card and Visa OK for orders over \$200. *Opto-Amp amplifier complete kit* \$149; *12-volts power supply model 1270* for \$99.95; *AC power supply model 110/70* for \$119. Individual parts: any PC board \$25; LM12CLK \$29 each; heat-sinks \$9.95 each; T1270 tape-wound power transformer for 12-volt DC supply \$30; send self addressed stamped envelope for a complete price list of all parts.

Check to make sure that nothing is shorted to the chassis under the PC board. The output terminal strip is wired as indicated on the chassis artwork with two terminals for +V, two for -V, and two for ground. Again, use 16-gauge wires for output wiring. Use a 3-amp 250-volt rated fuse in the line-fuse holder, and 5-amp fuses in the outputs.

Figure 7 shows the 110-volt to \pm 35-volt power supply. Assemble the PC board and make sure that the polarity of the diodes and filter capacitors is correct. Install all hardware in the chassis and wire the transformer secondary to the PC board as indicated in the schematic. Solder one transformer-primary lead directly to one of the insulated terminals on the EMI filter. (Use heat shrink tubing over all primary connections to prevent electrical shock when servicing.) Connect the other transformer-primary lead to the center terminal of the toggle switch. The bottom terminal of the toggle switch gets wired to the chassis-mount fuse holder, while the fuse holder's center terminal gets wired to the other insulated terminal on the EMI filter.

Checkout

Use an ohmmeter to check for shorts from the LM12 to the heat-sink. Check all diodes, capacitors, and IC's for correct polarity. Stuffing components in backwards is the most frequent mistake in construction, and can be a fatal error—so check thoroughly. The next step is to check the power supply for correct output voltages. Keep in mind that, unloaded, the voltage can be 100–150% higher than the nominal voltage.

Now let's connect the *Opto-Amp* to the power supply, but with no output speakers or audio inputs connected. Nothing should get very hot and fuses should not blow. Center the sensitivity potentiometers (R1 and R2) on the PC board and then connect the speakers. Use a source input with a volume control to prevent damaging your speakers and ears.

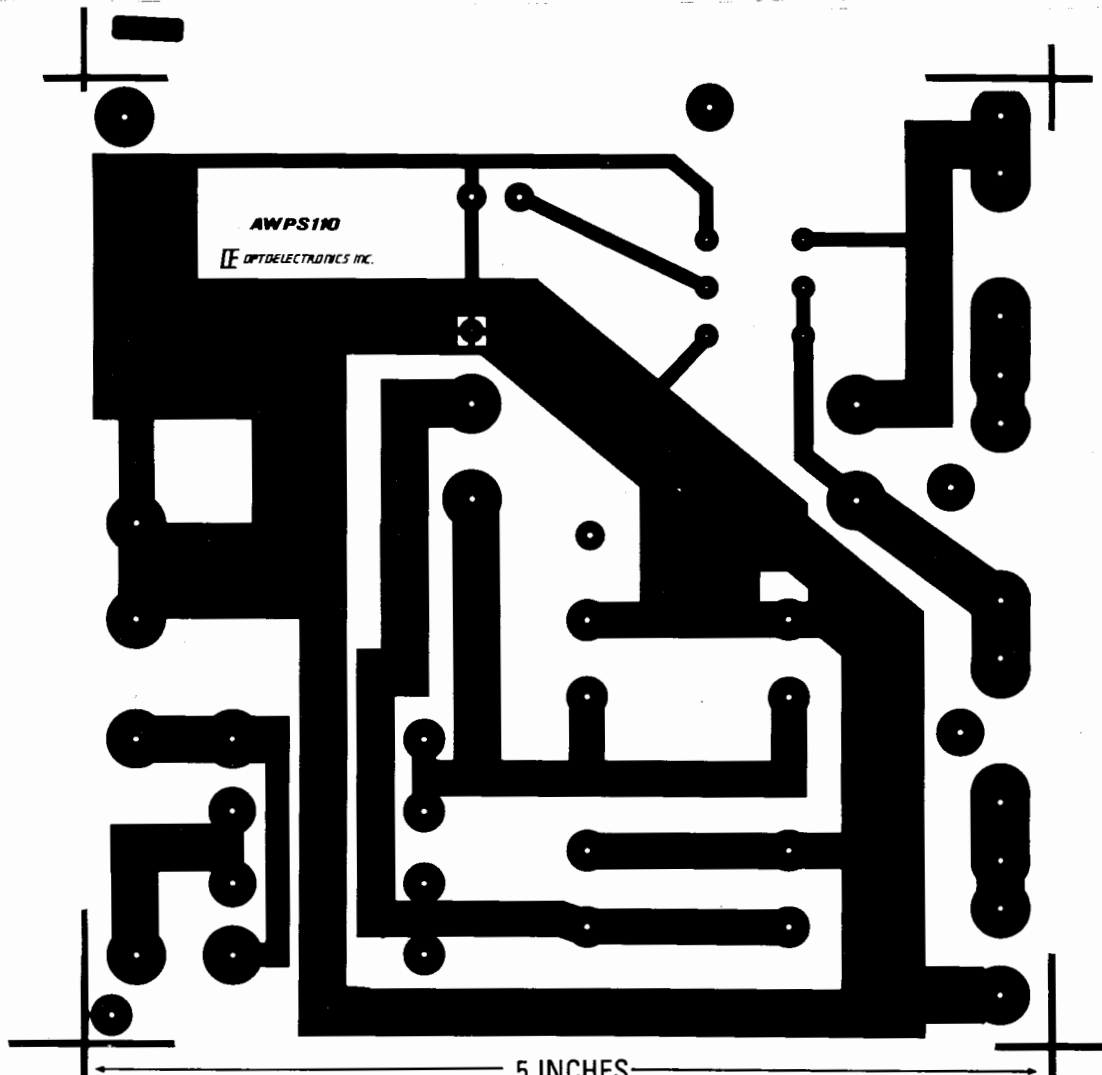
For 12-volt operation, the wire size going to the battery must be a minimum of 12-gauge for up to 8-foot

lengths, and larger gauge for longer distances. A 30-amp in-line fuse must be placed near the source of the power (battery); after all, we're dealing with significant amounts of power that could cause severe damage to the car's electrical system, the *Opto-Amp* power supply, or worse. Even a fire could occur if the 12-volt supply line is not properly fused.

Use a 30-amp relay to switch the power off and on. You can mount a switch under the dash, or use the power antenna output from the car radio to enable the *Opto-Amp*. You will want to make sure that the relay can not be energized unless the key is turned on to prevent draining your car battery to death. At full power, the load on the car electrical system is the same as leaving the headlights on.

Both the *Opto-Amp* and power supply are compact enough to mount wherever space is available. If there is no air flow—such as in the vehicle's trunk—then use a 12-volt fan to move air over the heat-sink fins in the power supply and *Opto-Amp*. One final note about bridging: If you are planning to bridge two amps in your car then you'll need at least two power supplies.

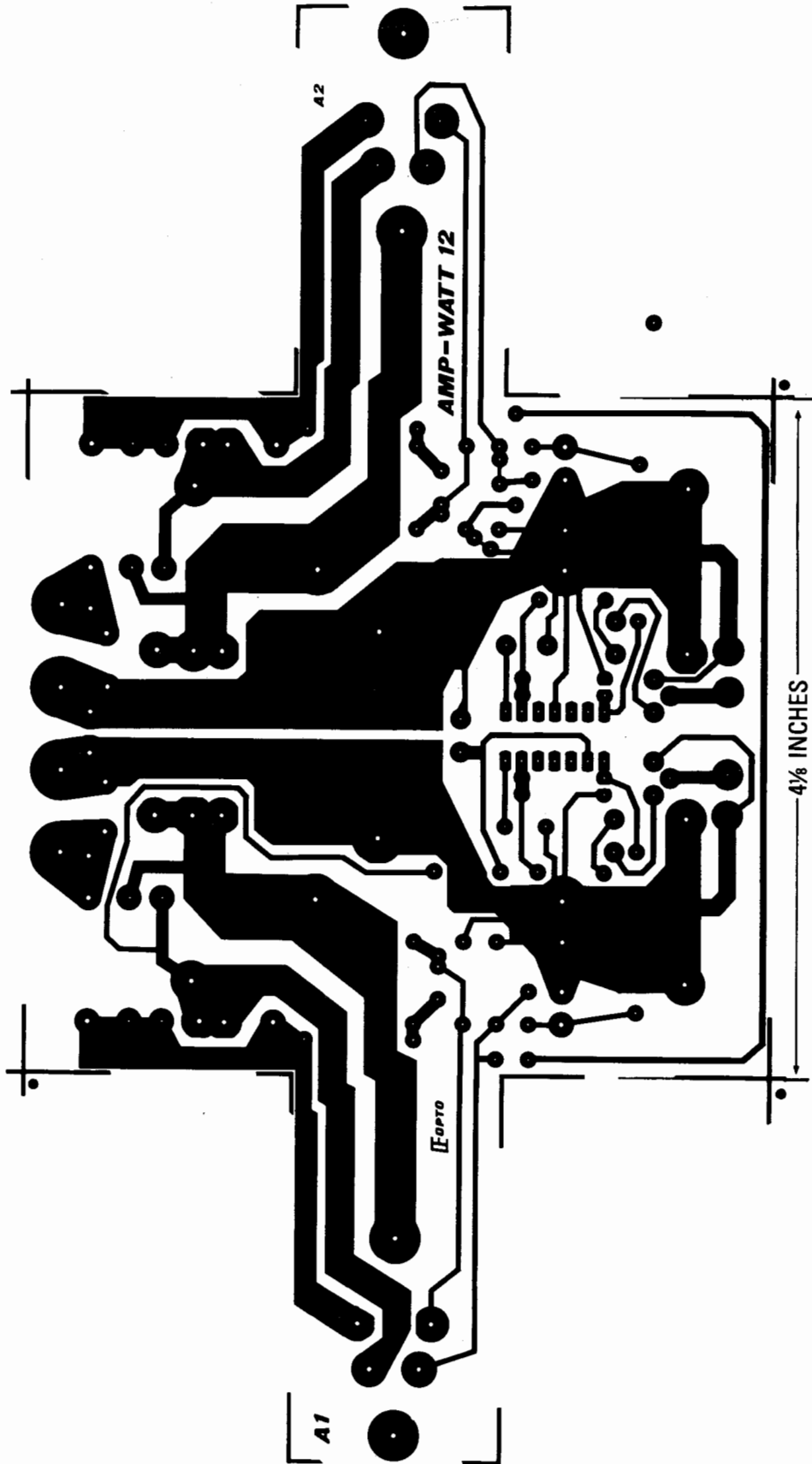
The 110-volt AC power-supply operation is straight forward. Keep in mind that there should be nothing to hinder air movement over the *Opto-Amp*. If there is any question about overheating, then add a quiet fan. The *Opto-Amp* can be mounted apart from its power supply or right next to it. Several *Opto-Amps* can be bolted and stacked into a rack mount. You can operate the *Opto-Amp* bridged from one power supply, but the fuses will blow if the 5-amp limit is exceeded; to prevent that from happening, use two power supplies for extra power. R-E



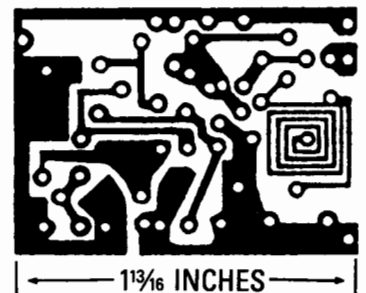
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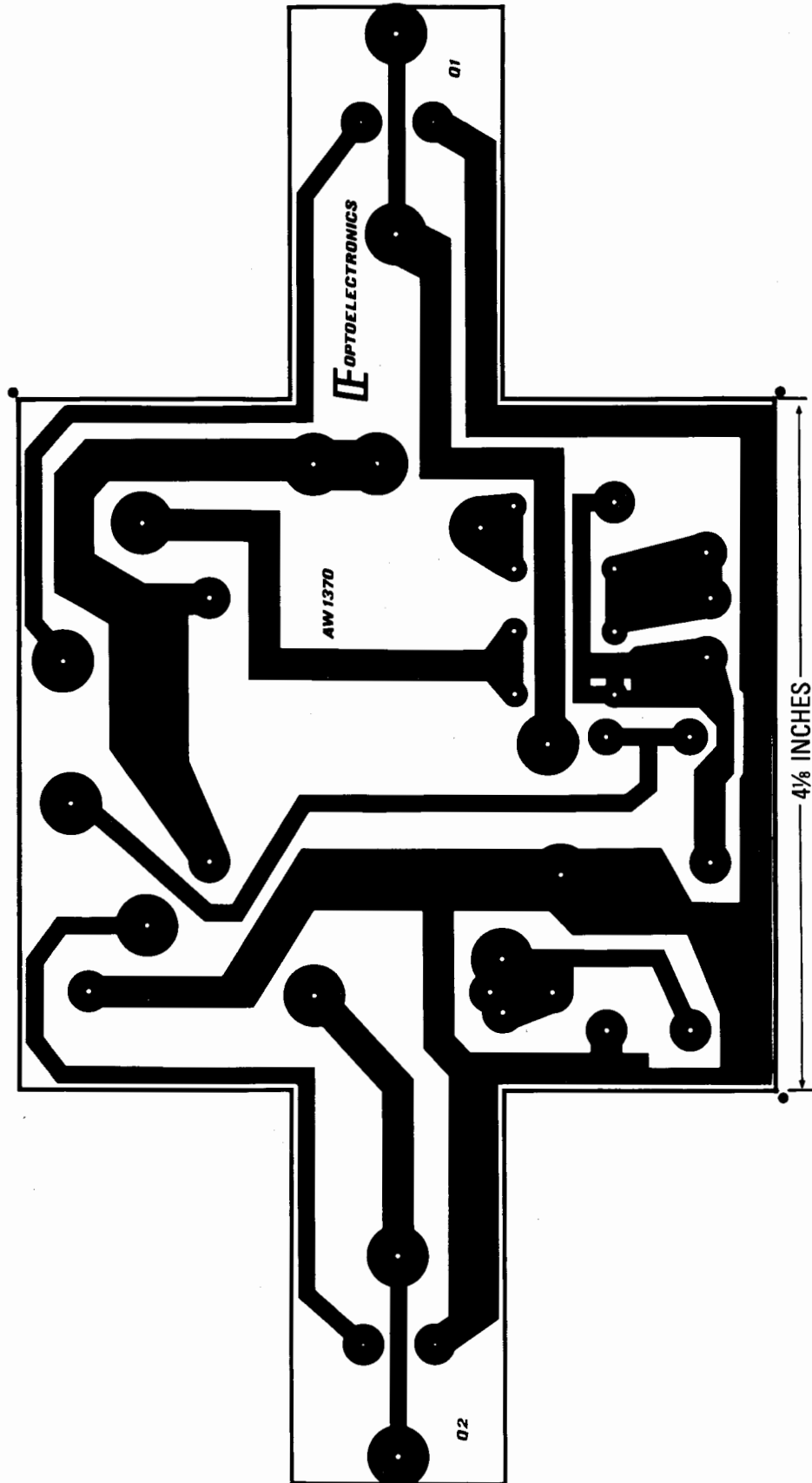
THE AC POWER SUPPLY for the high-power audio amplifier.



12-VOLT DC power supply for the audio amplifier.



WIRELESS FM transmitter.



THE HIGH-POWER audio amplifier's foil pattern.