ANALOG REVERB FOR YOUR HI-FI

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Duplicate the acoustics of a large concert hall with this accessory for your stereo system. The construction details are presented here.

Part 2 IN SEPTEMBER WE described an analog reverberation unit that adds realism to recorded music. Have that issue handy as we continue by showing you how to build your own.

Construction

Foil patterns for the double-sided PC board are shown in Figs. 8 and 9. Note that the component-side of the board is laid out so that, when trimmed, it will be divided into two electrically-isolated sections. Almost all of the reverberation unit's components are mounted on the PC board (refer to Fig. 10). The board is double-sided, so unless it is plated-through, care must be taken to connect the two sides using jumpers where the foil patterns on both sides of the board coincide. Generally, components (including integrated circuits) that connect to the ground plane should be inserted first and soldered to minimize static-electricity problems—especially if you are not using sockets. Do not install LED 1—you'll need it to check out the unit. Note that connections to the off-board components (front panel controls, input jacks, etc.) are made to the pads labeled "A" through "U," corresponding to similarly labeled points in the schematic.

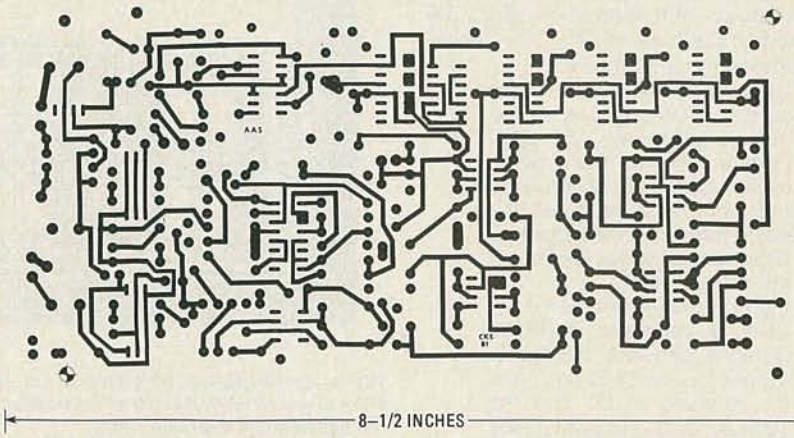

FIG 8—FOIL PATTERN for the bottom side of the PC board. Note that the PC board is double sided (see Fig. 9).

The front-panel controls should be connected to the board before they are mounted mechanically. The AC ground (point "E") is common to the INPUT LEVEL, OUTPUT LEVEL, and REVERB controls; wiring one end of each of those pots together and then wiring to point "E" on the PC board is the simplest way to make that connection. The wires from the controls to the PC board should be about 8 inches long.

Care must be taken to isolate the output jack from the chassis (AC ground). The easiest way to do that is to put an insulating layer of electrical tape or Mylar film over the chassis hole (from the inside), and cut a similar, but slightly smaller, hole through the tape or film. If that is done, the jack will not come in electrical contact with the chassis when it is installed.

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The jumper from "T" to "U" *must be left disconnected* during checkout to reduce the chance of damaging the output stage. Also, R57, which sets the bias current in the output stage, should be set at its minimum value (i.e., D8 shorted to the base of Q5). The checkout procedure is as follows:

1. Using an ohmmeter, make sure that all sections of the ground plane (on the component side of the board), *except for the one that runs to the right-hand edge of the board,* are connected together. (That section is V_{EE}; the others are AC ground).
2. Plug the unit in, and turn it on. Using a voltmeter, read the voltages between the transformer's center tap (V_{EE}) and the cathode of D1 and the cathode of D3. In both cases the voltage should be 25-volts DC.
3. Referring to voltmeter readings to V_{EE}, check the positive voltage on pin 8 of each op-amp (IC1, IC2, IC6, IC7, and IC9). It should be about 18 volts. The voltage at the ground plane on the left-hand side of the board should be about 10 volts.
4. With the LEVEL and OUTPUT LEVEL controls set at their minimum values, and the DELAY and FEEDBACK DELAY controls set at 50% of full scale, the output (pins 1 and 7) of all op-amps should be about 10 volts.
5. Check the clock pulses at the outputs of the CMOS D flip-flops (IC11-a and IC11-b). The DC reading should be about 9 volts at those points; the AC reading should be 5-10 volts, depending on the type of meter used.
6. To adjust the bias current in the output stage, temporarily connect LED 1 from point "T" to V_{CC}. Current flowing through Q1 and Q2 (also Q3 and Q4) will now flow through the LED. (If you wish, an ammeter can be connected between point "T" and V_{CC} and used in place of the LED for this checkout procedure.) Adjusting R3 will cause Q1 and Q2 to conduct and LED1 to glow. Since distortion is reduced with increasing current level, it is desirable to keep the bias current reasonably high; however, if the current is too high, reliability will be reduced. Carefully touch the power FET's (Q1-Q4) and adjust R57 until LED1 glows brightly but the FET's do not get hot. You should read about 15 mA if you're using an ammeter. After the bias current has been set, LED1 should be installed between R77 and point V and a jumper placed between points "T" and "U."

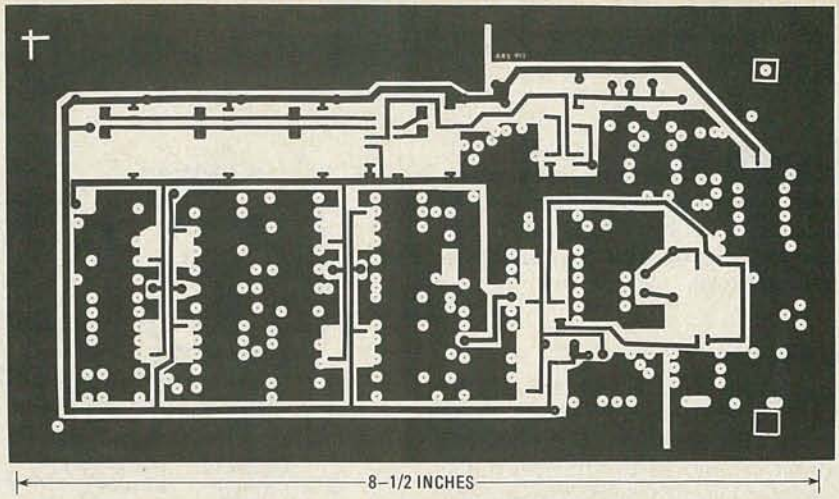

FIG. 9—COMPONENT (TOP) SIDE of the double-sided PC board. This pattern is NOT a negative—there is no foil around many of the holes so the component leads can pass through the board without contacting the ground plane.

Once you've completed the checkout procedure and are sure that everything is correct, the PC board, potentiometers, transformer, and jacks should be mounted securely in the case. The PC board should be mounted on standoffs. The case used, and its layout, are not critical as long as everything fits comfortably (the case shown in Fig. 11 is included with the kit available from the supplier listed in the Parts List).

Setup

The reverberation system is connected to your stereo system using the stereo's tape-monitor output. The output of the delay unit can be connected to a high-efficiency speaker. That speaker is generally placed at the rear of the listening room. Set up that way, the analog reverberation system can simulate the sound reflected from the rear of a concert hall.

Use of the controls on the front panel is reasonably straightforward. The INPUT LEVEL control adjusts the sensitivity of the unit for maximum dynamic range. With the OUTPUT LEVEL control set so that the output level is low (to avoid overloading the amplifier), the INPUT LEVEL control is set so that the level is as high as possible without overloading on loud passages. Initially, the REVERB control should be kept at its minimum position. The DELAY control is adjusted for the desired (first-arrival) delay; this is best done with your system playing at a low level so that both outputs can be heard at the same time. The FEEDBACK DELAY control is not likely to have a dramatic effect on the sound quality. While that control's presence in the circuit breaks up the "standing-wave" effect, its precise setting is unimportant. Adjust the FEEDBACK DELAY control for minimum noise. (The presence of two clock-signals causes a limited amount of intermodulation, heard as whistles and tweets. They are eliminated by adjusting the FEEDBACK DELAY control).

The degree of reverberation is adjusted with the REVERB control. There is a definite threshold where audible reverberation begins. Beyond that point, the reverberation becomes both more pronounced and more artificial; the system will actually oscillate if the REVERB control is turned up too high. Even before oscillation occurs, there is an increase in the peak signal-level that may force you to turn down the INPUT LEVEL control.

The most difficult adjustment to make is setting the OUTPUT LEVEL control. There is a strong temptation to make the delayed signal too loud. Bear in mind that the more subtle the effect of the reverb, the more impressive it will be! That seeming contradiction is something one usually learns the hard way; perhaps this advice will help.

Speaker selection

The choice of a rear speaker is important if the system is to work properly. The delayed channel does not have as wide a bandwidth as the front channel, so a wide, flat, powerful high-frequency driver is unnecessary. With about one watt of power available, efficiency is far more important than power-handling capability.

Looking at some of the "mini-speakers" that are currently on the market can help us understand the reverberation system's speaker requirements. Those small, acoustic-suspension, two-way systems have two notable features: most have excellent high-frequency response, and all are inefficient. Their lack of efficiency prevents them from playing loudly, but their output is more than adequate for most purposes. The high-frequency response is, if anything, a point against that type of unit. The high frequencies do not help the reverberation system

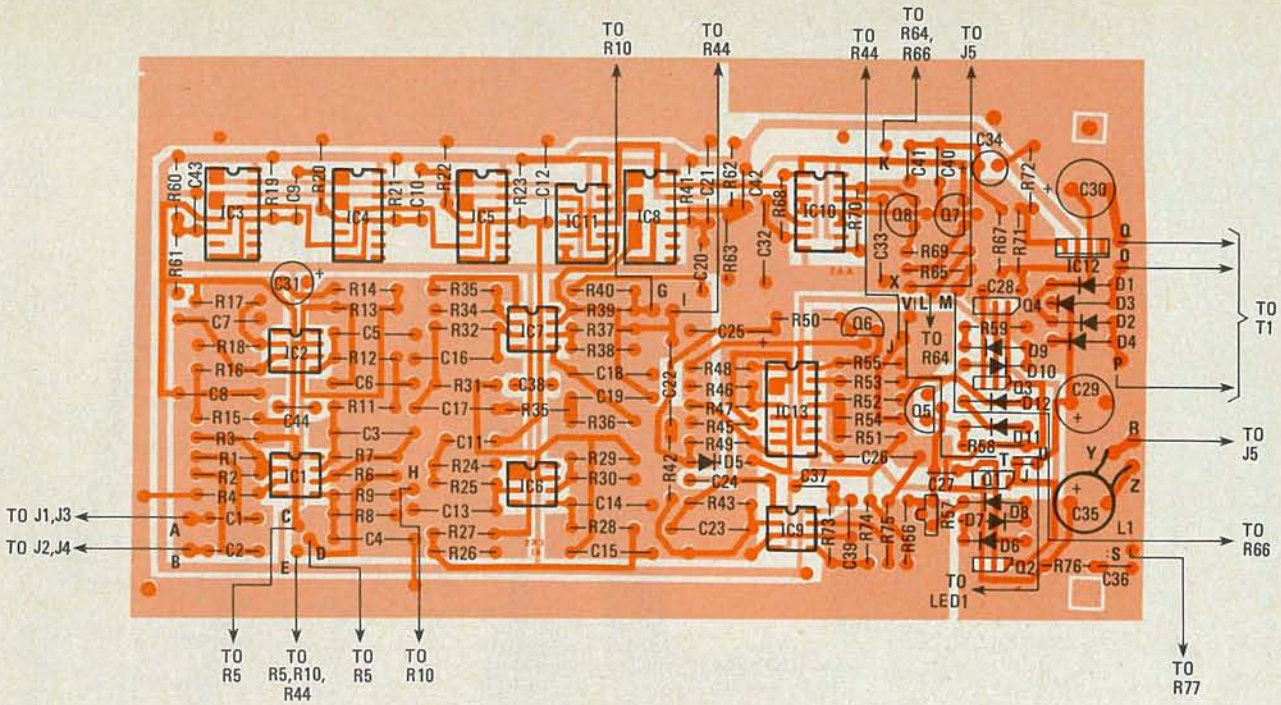

FIG. 10—DOUBLE-SIDED BOARD should be trimmed so that foil on component side is split into two areas to separate areas of differing potential. Also, be sure transistors Q1-Q4 are positioned with beveled edges at lower right.

PARTS LIST

Resistors ¼ watt, 5%, unless otherwise noted

R1, R2, R8, R20, R22, R24, R39, R40, R47, R73, R74—100,000 ohms
R3, R45—200,000 ohms
R4—39,000 ohms
R5, R44—5000 ohms, potentiometer, audio taper
R6, R7, R11, R12, R14-R16, R18, R25, R31-R36, R38—18,000 ohms
R9, R17, R30, R43—30,000 ohms
R10—100,000 ohms, potentiometer, linear taper
R13—5600 ohms
R19, R21, R23, R41, R48—47,000 ohms
R26—24,000 ohms
R27—75,000 ohms
R28—27,000 ohms
R29, R60, R62—15,000 ohms
R37—22,000 ohms
R42, R58, R65, R69, R72, R77—3000 ohms
R46—2000 ohms
R49—100 ohms
R50—43,000 ohms
R51—620,000 ohms
R52—180,000 ohms
R53—360,000 ohms
R54—62,000 ohms
R55—470,000 ohms
R56—5000 ohms
R57—5000 ohms, trimmer potentiometer
R59—20,000 ohms
R61, R63—910 ohms
R64, R66—20,000 ohms, potentiometer, linear taper
R67, R75—200 ohms
R68, R70—300 ohms
R71—7500 ohms
R76—10 ohms

Capacitors

C1, C2, C9-C11, C20—.22 μF, 100 VDC, Mylar
C3-C8, C12-C19, C21, C23, C24, C26—.001 μF, polystyrene
C22—.01 μF, polystyrene
C25, C27, C31, C34—4.7 μF, 16 VDC, electrolytic
C28, C37-C44—.1 μF, ceramic disc
C29, C35—2,200 μF, 25 VDC, electrolytic
C30—1000 μF, 25 VDC, electrolytic
C32, C33—510 pF, ceramic disc
C36—.01 μF, 400 VDC, electrolytic

Semiconductors

D1-D4—1N4002, 100 PIV, 1 amp
D5-D12—1N914
LED1—jumbo red LED
Q1-Q4—VN46QF VMOS transistor (Siliconix)
Q5-Q8—2N4403 PNP transistor
IC1, IC2, IC6, IC7—NE5512 low-noise dual op-amp (Signetics)
IC3-IC5, IC8—TDA1022, 512-stage bucket-brigade device (Philips)
IC9—NE5532 low-noise dual op-amp (Signetics)
IC10—NE556-1 dual timer (Signetics)
IC11—CD4013 dual D flip-flop (RCA)
IC12—μA78MG adjustable voltage regulator (Fairchild)
IC13—NE5517 TCA (Signetics)
L1—10 turns of No. 22 wire wound around C35
T1—36 VCT, 300 mA

Miscellaneous: PC board (double-sided with plated-through holes), case, hardware, etc.

NOTE: The following are available from Advanced Analog Systems, Inc., 790 Lucerne Dr., Sunnyvale, CA 94086 (Tel. 408-730-9786): ARS-911—complete kit including case, $149.95; PC-911—PC board only, $24.00; IC-911—IC1-IC13 and Q1-Q8 only $49.95. Visa and Mastercard welcome. California residents please add sales tax. Prices include shipping (within continental U.S. only).

FIG. 11—THE COMPLETED REVERB unit. Enclosure shown is included with kit available from supplier listed in Parts List.

recreate the feeling of a large hall, but instead make any system-noise or distortion much more obvious. We found that disconnecting the tweeter and operating the woofer over the full range gave impressive performance.

Generally, a single full-range speaker is adequate for the reverberation system. Better still, an array of speakers will help improve the "spaciousness" of the reverberation. As long as there are no gross frequency-response irregularities, the characteristics of most speakers are generally no worse than the frequency-response variations found in actual concert halls. Those variations are caused by the resonances of the reflecting walls and ceilings in the hall, and the frequency-dependent sound-absorption properties of those walls and ceilings.

One major problem that you may have initially is amplifier-overload. It's rather obvious that you won't get rock-

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concert levels from the rear speaker with just one watt of power. However, the level of the reverberation should be 10 to 20 dB lower than the level of the front channel. That corresponds to a difference of 5 to 50 watts. Furthermore, the distortion in the system that's caused by the rear (delayed) channel appears to be 10 to 20 dB lower than actually measured because the music from the louder front-channels serve to mask that distortion.

The reverberation effect is not obvious as the reverberation or output levels are gradually increased. It's only when the reverberation decreases or disappears that you really notice it. The effect should be subliminal—you should not be able to hear the reverberation unless you really listen for it, but your mind will always know it is there. There will be a "fullness," without an increase in volume, that is deceiving. You'll often find that you are listening to your stereo system at a lower volume level than before simply because the music no longer needs to be loud just to full a room with sound. **R-E**