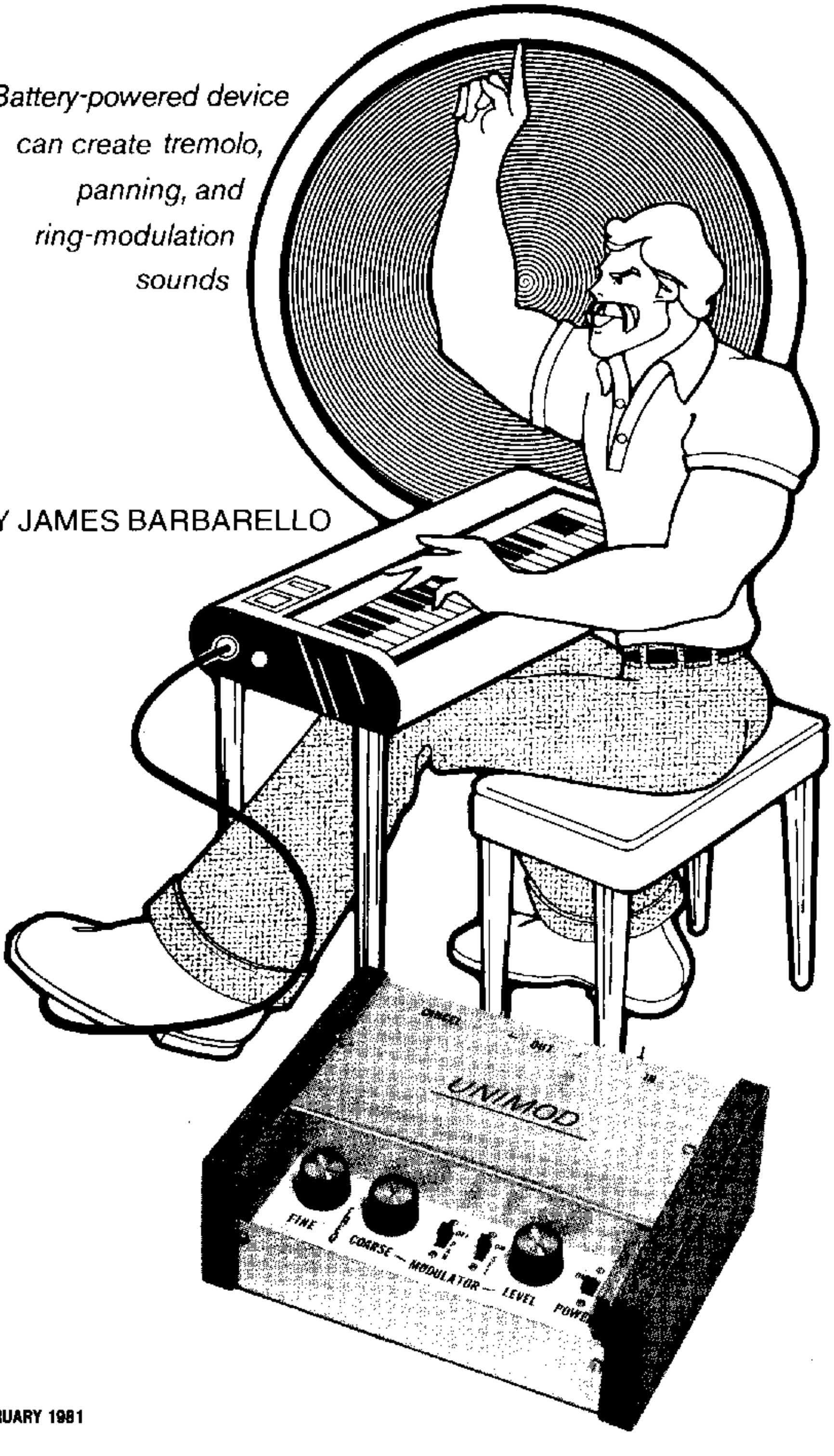
UNIMOD

A VERSATILE SOUND-EFFECTS GENERATOR

Battery-powered device can create tremolo, panning, and ring-modulation sounds

BY JAMES BARBARELLO



THE Universal Modulator (nicknamed "UniMod") is a versatile sound modifier for use with microphones and electric and electronic musical instruments. In essence, it is a preamplifier and amplitude modulator which can provide such effects as tremolo, automatic panning ("ping pong") and those unusual "ring modulator" sounds. Designed with the performing musician in mind, the project is battery-powered and controlled by a footswitch that cancels the sound effects when they are not wanted. Inexpensive, readily available components are used throughout, making it possible to construct the UniMod for about $30.

About the Circuit. The schematic diagram of the UniMod is shown in Fig. 1. This circuit can be considered the interconnection of four functional blocks: an input buffer (*IC1B*); two variable-gain amplifiers or amplitude modulators (*IC2* and *IC3*); a modulating-signal generator (*IC5A* and *IC5B*); and two output buffers (*IC1A* and *IC4B*).

The input buffer is a simple unity-gain inverting summer which provides a stable load for the signal source connected to input jack *J1*. Output signals from the buffer are capacitively coupled by *C1* and *C2* to the variable-gain amplifiers. Operational transconductance amplifiers (type CA3080E) are employed in this application. The gain of a CA3080E amplifier is proportional to the voltage difference between pin 4 (the chip's negative supply terminal) and the resistor connected to pin 5. Actually, the gain is determined by the *current* flowing into pin 5 of the IC, so the value of the resistor connected to it also influences the gain of a CA3080E.

The negative supply terminals of the CA3080E operational transconductance amplifiers employed in the UniMod are not connected to the full −9-volt negative supply voltage. Instead, they are connected to V_R −4.5 volts derived from the negative supply by a voltage divider (*R27* and *R28*). This is done so that the modulating-signal generator can fully turn off the operational transconductance amplifiers at the generator's most negative voltage swing, corresponding to 100% amplitude modulation. Potentiometers *R7* and *R13* and fixed resistors *R5* and *R11* source variable currents (remember, the CA3080E is a current-sensitive device) to pin 3 of each IC for nulling purposes.

Outputs of the variable-gain amplifiers are resistively loaded by *R9* and *R15* and buffered by *IC1A* and *IC4B*, which are unity-gain noninverting voltage followers. If the outputs of the operational transconductance amplifiers

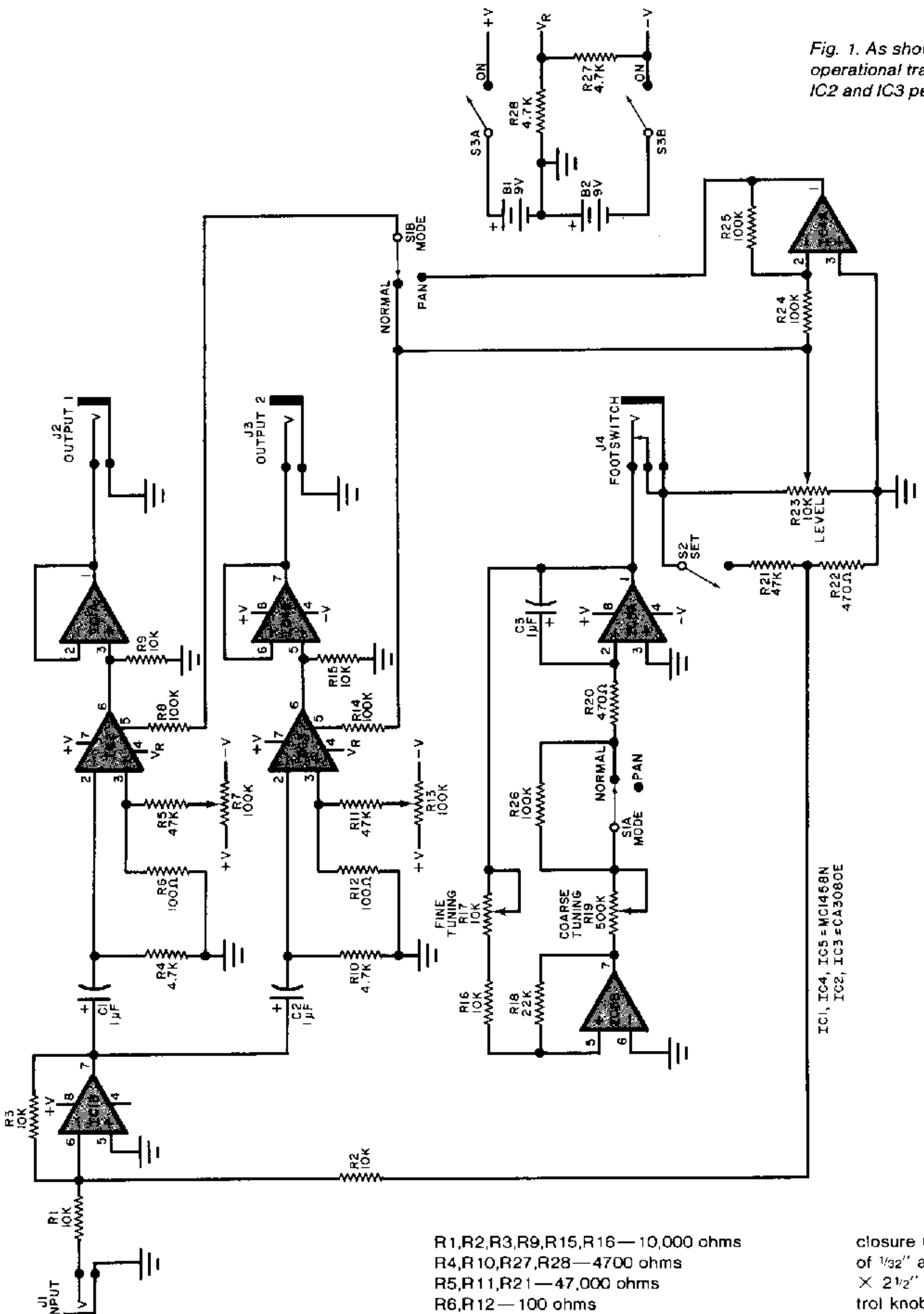


Fig. 1. As shown in schematic diagram, operational transconductance amplifiers IC2 and IC3 perform signal processing.

PARTS LIST

B1,B2—9-volt transistor battery
C1,C2,C3—1-µF, 25-volt electrolytic
IC1,IC4,IC5—MC1458N dual op amp
IC2,IC3—CA3080E operational transconductance amplifier
J1,J2,J3—phone jack
J4—closed-circuit, insulated phone jack
The following are ¼-watt, 10% tolerance fixed carbon-composition resistors unless otherwise specified.
R1,R2,R3,R9,R15,R16—10,000 ohms
R4,R10,R27,R28—4700 ohms
R5,R11,R21—47,000 ohms
R6,R12—100 ohms
R8,R14,R24,R25,R26—100,000 ohms
R18—22,000 ohms
R20,R22—470 ohms
R7,R13—100,000-ohm, pc-mount, linear-taper trimmer potentiometer
R17,R23—10,000-ohm, linear-taper potentiometer
R19—500,000-ohm, audio-taper potentiometer
S1—Dpdt switch
S2—Spst switch
S3—Dpst switch
Misc.—Printed circuit board, suitable enclosure (can be fabricated from a sheet of 1/32" aluminum and two pieces of 5½" × 2½" × ¾" mahogany or pine), control knobs, battery clips, battery holder, phenolic stock, machine and self-tapping hardware, hookup wire, solder, etc.

Note—The following are available from BNB Kits, R.D. No. 1, Box 241H, Tennent Road, Englishtown, NJ 07726: Kit of parts consisting of etched and drilled printed circuit board and all components except case, No. UNI-E, for $34.95; Etched and drilled pc board only, No. UNI-PC, for $10.95. Prices include postage and handling for USA and Canada orders. New Jersey residents, add 5% sales tax.

were not buffered, the input impedances of the two channels of amplification which are driven by the UniMod could load down the outputs of the CA3080Es. If those input impedances were too low, there would be insufficient drive signal available. The buffers eliminate this problem by terminating the variable-gain amplifiers with fixed, relatively high-impedance loads. Also, they act as voltage sources with low output impedances, making it unlikely that *any* instrument amplifier will load them down.

The modulating-signal generator comprises both sections of IC5, an MC1458N dual operational amplifier. One half of *IC5* is used as an integrator (*IC5A*) and the other half as a comparator (*IC5B*). When the output of *IC5B* goes from −V to +V, the positive-going voltage step is integrated by *IC5A* into a ramp with a positive slope. The output of the integrator is fed back to the non-inverting input of the comparator via *R16* and *R17*. When the ramp attains an amplitude equal to the voltage between pin 7 of *IC5A* and ground times the quantity $-(R16 + R17)/R18$, the comparator output switches from +V to −V. Note that *R17* in the expression just given is the effective resistance of the potentiometer, which of course depends on the setting of its control shaft.

The negative-going voltage step generated when the comparator output changes states is integrated by *IC5A* into a ramp with a negative slope. This ramp voltage continues to become more negative until the signal fed back to the comparator reaches that stage's trigger level. At this point, the process begins all over again.

The resulting sequence of positive and negative ramp voltages is actually a triangle wave which is tapped at the output of *IC5A*. The slope of the ramps and hence the frequency of the triangle wave depend on the amount of current supplied to integrator capacitor *C3* via *R19*, *R20* and *R26*. Potentiometer *R19* functions as a coarse frequency control, allowing adjustment over the full range of the generator. Fine frequency adjustment (over slightly more than one octave) is performed by varying the setting of potentiometer *R17*.

Fixed resistors *R20* and *R26* set the upper frequency limits of the triangle-wave generator. When *S1* is in its PAN position, *R26* limits the maximum output frequency to approximately 30 Hz. This resistor is bypassed when the switch is in its NORMAL position, in which case the upper frequency limit (about 1000 Hz) is determined by *R20*.

The triangle wave which appears at the output of *IC5A* is passed through jack *J4* if either no footswitch is connected to the jack or a footswitch is connected to it and is closed. From the jack, the signal flows to LEVEL control *R23* and to SET switch *S2*. Closing that switch connects voltage divider *R21R22* to the output of the triangle generator. That fraction of the output voltage which appears across *R22* is applied to input summer *IC1B* via *R2*. The triangle waveform is then amplified and delivered to the output jacks for monitoring purposes.

Potentiometer R23 passes a portion of the triangle generator output to the control input of *IC3* through *R14*, to the NORMAL position of *S1B*, and to the input of inverting buffer *IC4A*. If MODE switch *S1* is in its NORMAL position, the same modulating signal is applied to the control inputs of both operational transconductance amplifiers via *R14* and *R8*. Note that *IC4A* is an inverting, unity-gain amplifier whose output waveform is 180° out of phase with respect to its input waveform. If MODE switch *S1* is placed in its PAN position, the modulating triangle wave applied to the control input of *IC2* is out of phase with respect to that applied to *IC3*. This results in an automatic panning effect—as the gain of *IC2* increases and reaches its maximum value, the gain of *IC3* decreases to its minimum value, and vice versa.

If a footswitch is connected to the circuit via *J4* and the switch is open, the modulation function is defeated. Triangle waves from *IC5B* cannot reach *S2* and *R23*. Resistor *R14* is grounded via *R23*, and *R8* is grounded in the same way if *S1* is in its NORMAL position. If the switch has selected the PAN mode, *R8* is grounded via the output of *IC5B*, which is at ground potential. Because the value of *R14* is 100,000 ohms, the resistance added by *R23* is negligible (regardless of its setting) and both operational transconductance amplifiers operate at essentially maximum gain.

The integrated circuits employed in this project require a bipolar (positive and negative voltage, referenced to ground) power supply. For simplicity and ease of set-up under live performance conditions, two 9-volt transistor batteries are used to power the project. They are connected to the rest of the circuit via dpst power switch *S3*. For longest battery life, alkaline cells should be used for *B1* and *B2*.

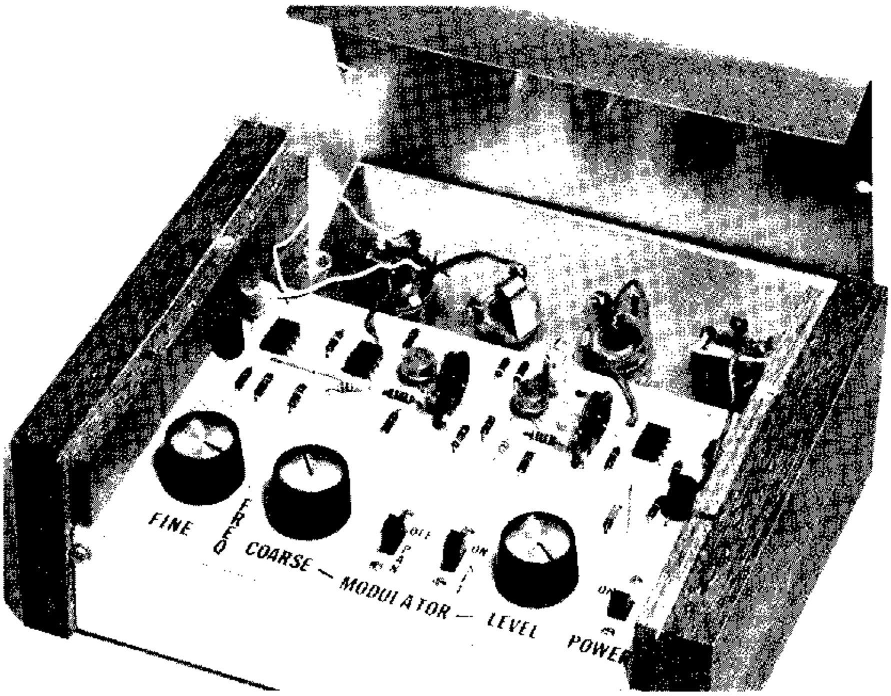


Photo of author's prototype shows how pc board extends under control panel to hold switches and potentiometers.

Construction. Any assembly technique is acceptable, but the author recommends the use of a printed circuit board. Shown in Figs. 2 and 3 are the etching and drilling and parts placement guides for the project's pc board. This board will not only accommodate the usual components installed on a pc board, but also the potentiometers and switches as well. At the builder's option, the latter components can be mounted

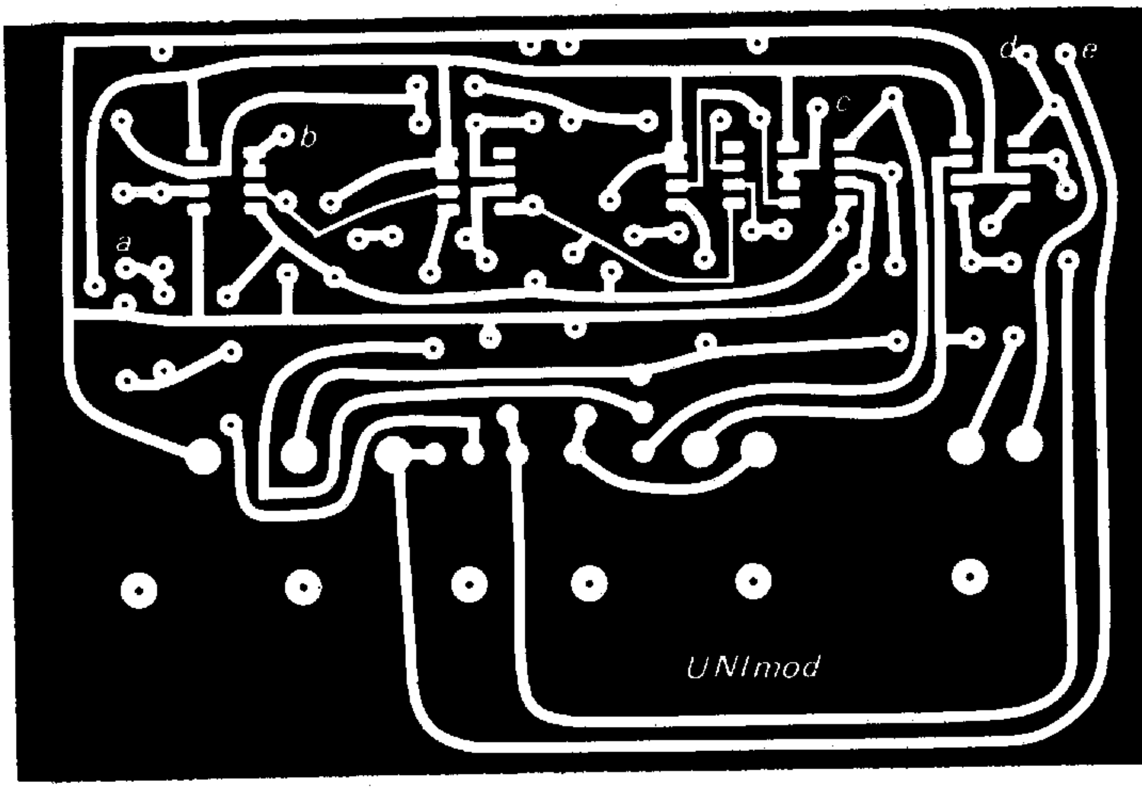


Fig. 2. Full-size etching and drilling guide for the printed circuit board for the UniMod.

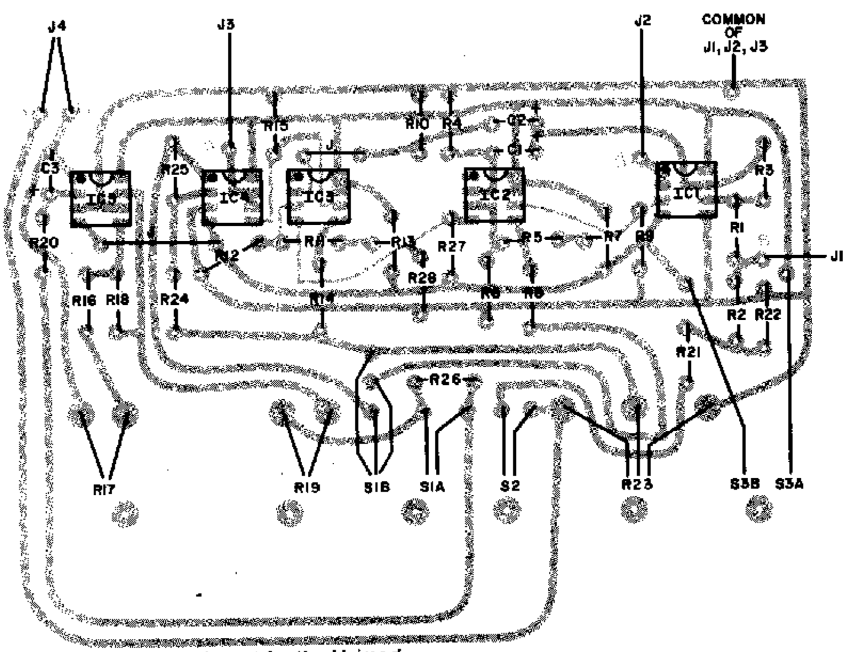


Fig. 3. Component layout for the Unimod. At bottom are markers for locations of various control switches and potentiometers.

on the project's enclosure instead.

When mounting semiconductors and electrolytic capacitors on the printed circuit board, pay close attention to pin basing and polarity. The use of IC sockets or Molex Soldercons is recommended. Don't apply too much heat or solder when making connections, and avoid cold solder joints and solder bridges across adjacent foils. Be sure to inspect the board carefully after all components have been mounted.

In line with the author's idea of mounting all switches and controls on the circuit board, the etching and drilling guide provides markers for locations of these components. Three large (3/8-inch or 9.5 mm) holes will accept standard-size potentiometers. Three rectangular holes to accommodate switches can be drilled and then squared off with a small file. Alternatively, miniature toggle switches which require 1/4-inch (6.4-mm) holes can be used, in which case filing is unnecessary. The author also suggests that all unlettered pads to which wires are to be attached (as well as those for *R26*, which he specifies as mounted on the foil side of the board) not be drilled. Component and wire leads to these undrilled pads should be "tack" soldered. However, if you are mounting switches and jacks off the board, all pc pads should be drilled.

Interconnect the printed circuit board and wires and jacks with suitable lengths of hookup wire. Then select an enclosure for the project and mount the printed circuit board in it using pc standoffs. Switches and jacks should be mounted on the enclosure, and a bracket to retain the batteries attached to it. Unlike the other three jacks, the shell of *J4* is not grounded. Therefore, if this jack is mounted on a metallic panel along with *J1* through *J3*, an insulated jack will have to be used. Alternatively, an uninsulated jack can be employed if insulating washers are used and the hole in which the jack is mounted is drilled oversize. The insulating washers can be fabricated by drilling ³⁄₈-inch (9.5-mm) holes in two pieces of phenolic stock ½-inch (1.3-cm) square.

Alignment. Connect a patch cord between output jack *J2* and the input of your power amplifier. Set the various controls and switches as follows: *R17*, FINE TUNING fully counterclockwise (for maximum frequency); *R19*, COARSE TUNING fully counterclockwise (for maximum frequency); *R23*, LEVEL fully clockwise (for maximum modulation); *S1*, MODE in its NORMAL position; *S2*, SET so that it is open; *S3*, POWER to its ON position. Then apply power to the amplifier and set its gain control at some convenient level.

You should hear a high-pitched tone through the speaker connected to the output of the amplifier. Adjust trimmer potentiometer *R7* to null out the tone. It might not be possible to eliminate the tone completely, but the correct setting of *R7* is that which results in minimum feedthrough of the tone with no signal source connected to input jack *J1*. Repeat this procedure for the other output channel by connecting the patch cord running to the amplifier to output jack *J3* and adjusting trimmer *R13* for minimum tone feedthrough.

Next, close switch *S2*. You should hear the tone that was just nulled. Rotate COARSE TUNING *R19* clockwise, noting that the pitch of the output signal decreases. Similarly, rotate FINE TUNING control *R17* counterclockwise, noting a decrease in pitch. Rotate LEVEL control *R23*, increasing the volume of the tone from minimum to maximum as the control is rotated clockwise. Connect a normally open footswitch or pushbutton switch to jack *J4*. The tone will only be heard when the footswitch is depressed. This completes initial alignment and checkout. Return *S2* to its open position and you're ready to begin experimenting with the UniMod.

Use. The three principal sound effects that the UniMod can provide are automatic panning, tremolo, and amplitude modulation by an adjustable tone (similar to the effect produced by driving one input of a balanced modulator with the output of an oscillator). Let's examine each in turn.

Automatic panning requires two channels of amplification and two speaker cabinets. One amplifier's input should be patched to jack *J2*, the other amplifier's input to *J3*. For maximum effect, the speaker cabinets should be at least six feet (two meters) apart. Connect your musical instrument to input jack *J1* and place MODE switch *S1* in its PAN position. Depending on the settings of the TUNING and LEVEL controls, the sound will bounce back and forth between the two speakers at a given rate and to a certain degree. Increasing the frequency of the modulating triangle wave will cause the signal to "ping pong" faster. Adjusting the LEVEL control for more amplitude of the modulating signal will enhance the intensity of the "ping pong" effect, causing one operational transconductance amplifier to exhibit more gain at the same time that the other exhibits less gain.

Only one channel of amplification and one speaker cabinet are required for tremolo operation, but two can be used. For single-channel operation, follow the auto pan instructions just given but patch the input of a single amplifier to either output jack (*J2* or *J3*). Place *S1* in its PAN position and adjust the controls for the desired effect. If two channels are to be used, interconnect them and the UniMod as previously described but place *S1* in its NORMAL position, adjusting *R17* and *R19* for a modulating signal frequency of between 2 and 30 Hz. Again, the intensity of the effect is governed by the setting of *R23*.

"Balanced modulator" effects can be obtained with either one or two channels of amplification. For dual-channel operation, all controls are set as for dual-channel tremolo except that the COARSE and FINE TUNING controls should be adjusted to generate a modulating frequency in the audible range. When this is done, the input signal will be modulated by an audible signal, producing sum-and-difference modulation products. Many interesting effects such as gong and chime sounds can be generated in this manner. If only one amplifier is used, place *S1* in its NORMAL position, take output signals from either *J2* or *J3*, and adjust the LEVEL and TUNING controls for the desired effect.

Practice with the various modes of UniMod operation to get an appreciation of what this versatile little sound effects box can do. Experiment with the various controls, making notations of the various combinations of settings that particularly interest you. Finally, remember that the UniMod is battery powered. Use alkaline cells for maximum useful life and be sure to open power switch *S3* when UniMod is not being used. ◇