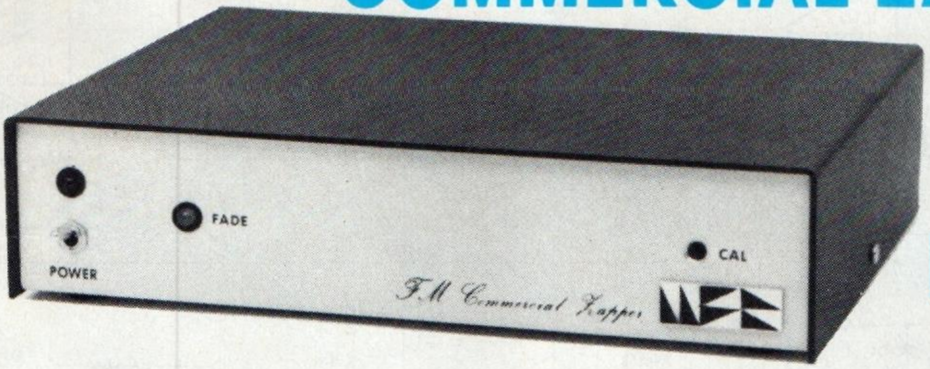
COMMERCIAL ZAPPER FOR YOUR RADIO



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Bothered by commercial interruptions on FM? Kill 'em with this zapper.

MANY SMALL OFFICES USE FM EASY-LISTENING stations to supply background music. Often, the commercials broadcast by those stations are unobjectionably loud. If you'd like to restore peace and quiet to your office, just connect our commercial killer in your receiver's tape-monitor loop. The circuit automatically senses large changes in volume and reduces output accordingly. In addition, it's easy to build, and inexpensive.

How it works

The commercial killer monitors the incoming signal and reduces output according to how much the input resembles a commercial (we'll discuss how it makes its decision in a moment). In reducing output, the commercial killer takes account of the past few seconds of signal in determining how much to reduce output. Doing so reduces the number of errors and creates a smoother overall effect as it fades out of commercials and fades into music. It is less objectionable to miss the first few seconds of music than to hear the first few seconds of a commercial, so the commercial killer has different attack and decay times.

Whether a signal is "commercial-like" is determined by the rate of large volume transitions. Because music (especially that on "light" stations) is typically composed of a number of instruments playing more or less continuously, the volume (or envelope) stays fairly constant over a short period of time. In a typical commercial, however, the instantaneous volume changes rapidly over time as the announcer pauses between words, and as various additional sound sources are mixed in and out.

Music with much dynamic range (rock and roll, for example) has a high rate of large volume transitions, so the commercial killer probably will trigger erroneously with that type of music.

Figure 1 shows a block diagram of the commercial killer. A summing amplifier adds the left- and right-channel inputs. The summing amp has adjustable gain so that you can find the optimum signal level for the station you use the commercial killer with.

Next comes an envelope detector, which produces a waveform that represents the instantaneous volume of the signal. A comparator (with hysteresis) produces a transition whenever the output of the envelope detector goes either above or below pre-set thresholds. The output of the comparator is conditioned via the transition converter, which produces a pulse of fixed width and amplitude for each transition of the comparator. Those pulses feed a "leaky integrator," whose output determines the gain of the left and right VCA's (*V*oltage *C*ontrolled *A*mplifiers). The output of the leaky integrator is a DC voltage whose value depends on the pulse rate from the transition converter.

The VCA's are what actually reduce the output signals during commercials. An LED connected to the VCA's provides a visible indication of the amount of volume reduction taking place.

Figure 2 shows the schematic of the circuit. Diodes D5–D8 form a bridge rectifier that feeds Zener diode D9, which provides a regulated single-ended 16-volt supply for the circuit. Because a single-ended supply is used, a reference voltage (V_{REF}) is generated via the voltage divider composed of R36 and R37 and transistor Q3. That reference voltage is used to bias the op-amps precisely.

Op-amps IC1-a and IC1-b function as buffers that drive both the summing amp (IC2-a) and the VCA's (IC1-c and IC1-d). The outputs of IC1-a and IC1-b are, of course, biased to the reference voltage. To achieve maximum dynamic range, a positive envelope detector follows the

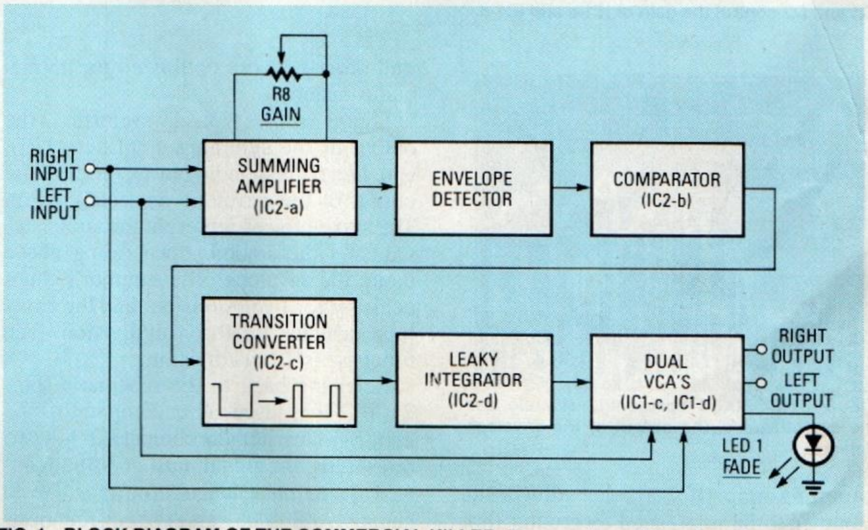

FIG. 1—BLOCK DIAGRAM OF THE COMMERCIAL KILLER: The envelope of the signal is used to vary the pulse rate from IC2-c. The pulses are integrated; the resulting signal controls the gains of a pair of VCA's.

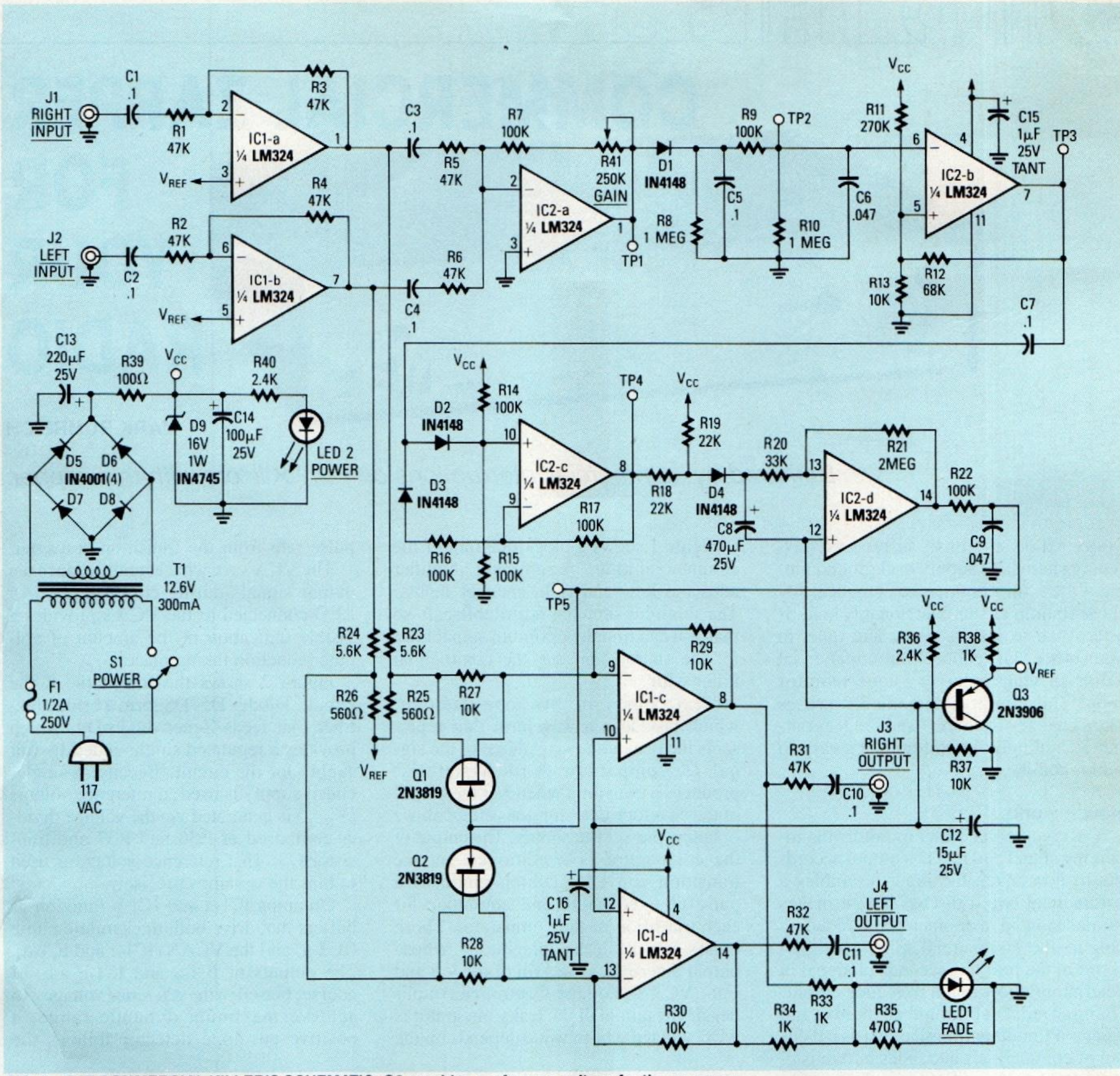

FIG. 2—THE COMMERCIAL KILLER'S SCHEMATIC: Q3 provides a reference voltage for the op-amps; Q1 and Q2 control the gain of IC1-c and IC1-d.

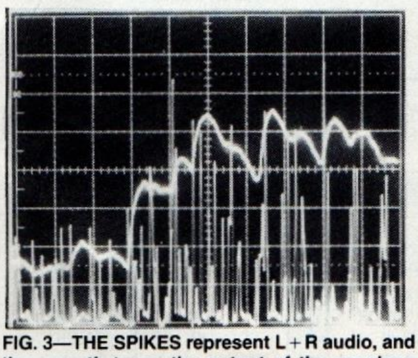

FIG. 3—THE SPIKES represent L + R audio, and the smooth trace, the output of the envelope detector.

summing amp (IC2-a); that allows the summer to be referenced to ground (not V_{REF}). The envelope detector has a second-order network optimized for normal audio material.

Figure 3 shows typical waveforms at the output of the summing amplifier (TP1), and the corresponding waveform at the output of the envelope dectector (TP2). The spiked traces represent the audio signal, and the smooth trace riding above them, the envelope. The summer's channel is set for 1 volt/division, and the envelope detector for 0.5 volt/division. The timebase is 20 ms/division.

Referring back to the schematic (Fig. 2), IC2-b is used as a comparator. As mentioned earlier, the comparator has two thresholds; the signal must cross both before the output changes from positive to negative (or vice-versa). The equations describing the lower and upper threshold voltages (V_{LO} and V_{HI}, respectively) as functions of the supply voltage and bias resistors are as follows:

$$A = (R12 \times R13) / (R12 + R13)$$

$$V_{LO} = (A \cdot V_{CC}) / (A + R11)$$

$$B = (R11 \times R12) / (R11 + R12)$$

$$V_{HI} = (R13 \cdot V_{CC}) / (R13 + B)$$

In this case, $V_{LO} \approx 0.5$ volts and $V_{HI} \approx 2.48$ volts.

Figure 4 shows the envelope-detector's output (TP2) at 0.5 volts/division and the comparator's output (TP3) at 2 volts/division (both at 20 ms/division). The square waveform in the center of the photo is the comparator's output; the other waveform is the envelope detector's output. Notice that the comparator does not respond to

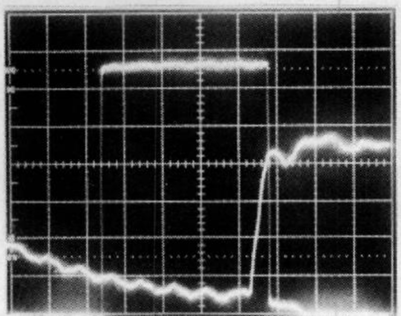

FIG. 4—THE SQUARE WAVEFORM represents the output of the comparator; the other waveform is the output of the envelope detector.

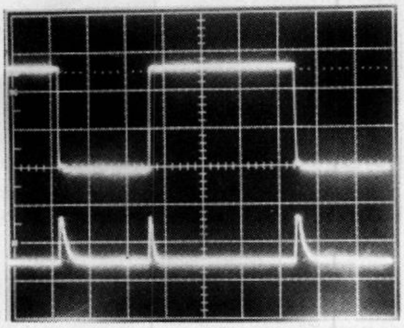

FIG. 5—THE COMPARATOR'S OUTPUT is shown in the upper trace; the output of the transition converter is shown in the lower trace. Every time the comparator changes state, another pulse is generated.

the minor transitions in the early part of the waveform; the comparator's output changes state only after both thresholds have been crossed.

Because the inverting input of the comparator is used for threshold detection, the output is inverted with respect to the input. The comparator responds to specifically designed threshold levels, so it is important that the output of the summing amp provide that level. We'll show how to make the adjustment later.

Figure 5 shows a typical output of the transition converter (TP4) along with the corresponding input from the hysteresis comparator, in the upper and lower traces, respectively. The transition-converter waveform is shown at 5 volts/division, with the bottom graticule at 0 volts; the timebase is 100 ms/division. Notice that the baseline is approximately eight volts ($V_{CC}/2$); that is due to the bias at the non-inverting input of IC2-c.

The leaky integrator (IC2-d) produces a DC voltage that depends on the pulse rate from the transition converter. When no pulses are present, diode D4 is reverse-biased, and the output of IC2-d will be equal to the voltage present at its non-inverting input, V_{REF}. When pulses arrive, diode D4 is forward-biased, so the voltage across capacitor C8 increases. The output of IC2-d then decreases by a factor of about 60 (R21/R20). When the pulse rate is high, the output voltage will be between six and nine volts, thereby providing minimum gain from the VCA's. But when the pulse rate is low, capacitor C8 will discharge through resistor R20 to V_{REF}, thereby restoring the gain op-amp to maximum.

The trick about the VCA circuits is that a matched pair of N-channel JFET's act as voltage-controlled input resistors. When gate-to-source voltage (V_{GS}) is near 0 volts, the FET acts as a small resistor, and gain is maximum—about 5 dB with respect to the output of the buffer stages (IC1-a and IC1-b).

However, when V_{GS} is less than -3 volts, the FET acts as a large resistor, so the gain of the op-amp is minimized—it provides about 20 dB of attenuation. In order to provide good left/right matching, the two FET's should have similar voltage and current characteristics, especially at drain-to-source voltages of 0.6 volts.

PARTS LIST

All resistors are ¼-watt, 5% unless otherwise noted.
R1–R6, R31, R32—47,000 ohms
R7, R9, R14–R17, R22—100,000 ohms
R8, R10—1 megohm
R11—270,000 ohms
R12—68,000 ohms
R13, R27–R30, R37—10,000 ohms
R18, R19—22,000 ohms
R20—33,000 ohms
R21—2 megohms
R23, R24—5600 ohms
R25, R26—560 ohms
R33, R34, R38—1000 ohms
R35—470 ohms
R36, R40—2400 ohms
R39—100 ohms
R41—250,000 ohms, trimmer potentiometer

Capacitors
C1–C5, C7, C10, C11—0.1 µF, ceramic disc
C6, C9—0.047 µF, ceramic disc
C8—470 µF, 25 volts, electrolytic
C12—15 µF, 25 volts, electrolytic
C13—220 µF, 25 volts, electrolytic
C14—100 µF, 25 volts, electrolytic
C15, C16—1 µF, 25 volts, tantalum

Semiconductors
IC1, IC2—LM324 quad op-amp
D1–D4—1N4148 signal diode
D5–D8—1N4001 rectifier diode
D9—Zener diode, 16 volt, 1 watt (1N4745 or similar)
LED1, LED2—standard
Q1, Q2—2N3819 N-channel JFET
Q3—2N3906 (or similar)

Other components
J1–J4—Chassis-mount RCA connectors
F1—Fuse, 0.5 amp, 125 volts AC
S1—SPST, 1 amp, 125 volts AC
T1—Transformer, 12.6 volts, 300 mA (Radio Shack 273-1385 or similar)

NOTE: The following are available from MFR Engineering, 5333 N. Guilford, Indianapolis, IN 46220: Etched drilled circuit board, $11; matche (Q1 and Q2) $2.50. All prices postpaid. Indiana residents must add applicable sales tax.

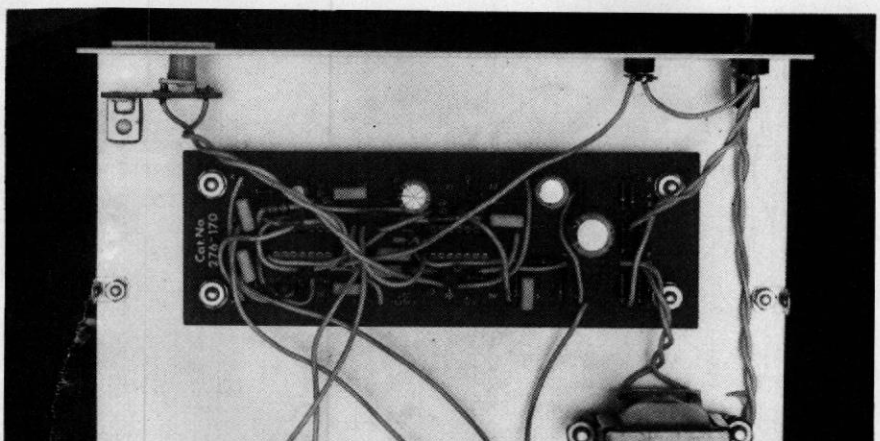

FIG. 6—THE AUTHOR'S PROTOTYPE was built on a piece of perfboard using point-to-point wiring. Keep your lead lengths short, and be careful with the 117-volt primary circuit.

Construction hints

Figure 6 shows the author's prototype, which was built on a piece of prototype board. The author used two LM324 quad op-amps, because they're inexpensive and easy to obtain. However, slightly better frequency response and signal-to-noise ratio may be obtained by replacing the op-amps with low-noise JFET op-amps (TL074's, for example). Whichever op-amps you use, make sure that the buffer amps (IC1-a–IC1-d) are not in the same physical package as the processing amps (IC2-a–IC2-d). Also, be sure to connect a good decoupling capacitor, near the IC, from the V_{CC} pin to ground.

Alignment and troubleshooting

To align the commercial killer, adjust the detector-gain potentiometer (R41) to

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maximize the number of comparator transitions during commercials. Begin by connecting the commercial killer to the stereo receiver's tape-monitor loop. Set the receiver to FM and select the tape-monitor mode. Because the audio level may vary from station to station, tune to the station of greatest intended use. And remember, the commercial killer works best with easy-listening formats. During commercials, adjust R41 to maximize attenuation by watching the FADE LED. Slight readjustment may be necessary to provide the fewest zapping errors without performance degradation.

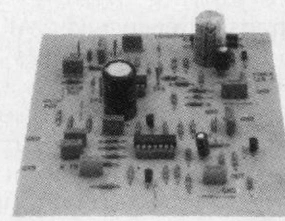

FIG. 7—THE COMMERCIAL ZAPPER circuit is shown here assembled on a PC board.

If the commercial killer fails to work, make sure that the power supply is providing the correct voltage, and that V_{REF} is about 13.5 volts.

If the voltages are correct, then verify that you can obtain waveforms like those shown in Fig. 3–Fig. 5. If the peak signal level at the inverting input of IC2-b cannot be adjusted (via R41) to exceed 2.5 volts, the signal level out of the receiver may be unusually low, so the value of R41 may need to be increased.

If the rate of transitions at TP4 is low during music and high during commercials (but attenuation is not proportional to the rate of transitions), verify the following.

- When there is no signal present, the voltage at TP5 should be within 0.2 volts of the voltage at the non-inverting input of IC1-c.
- During a commercial, the voltage at TP5 should be at least three volts less than the voltage at the non-inverting input of A7.

If the first condition is not met, there will be attenuation during music. Diode D4 should be reverse-biased with no signal present. If it is not, and if the voltage at TP4 is about eight volts, it may be necessary to reduce R18.

If the second condition is not met, there will be insufficient attenuation during commercials. If TP4 is approximately eight volts with no signal present, it may be necessary to decrease R19 or R20.

Last, if fading occurs, but the LED does not light, it may be connected to the circuit backwards. **R-E**