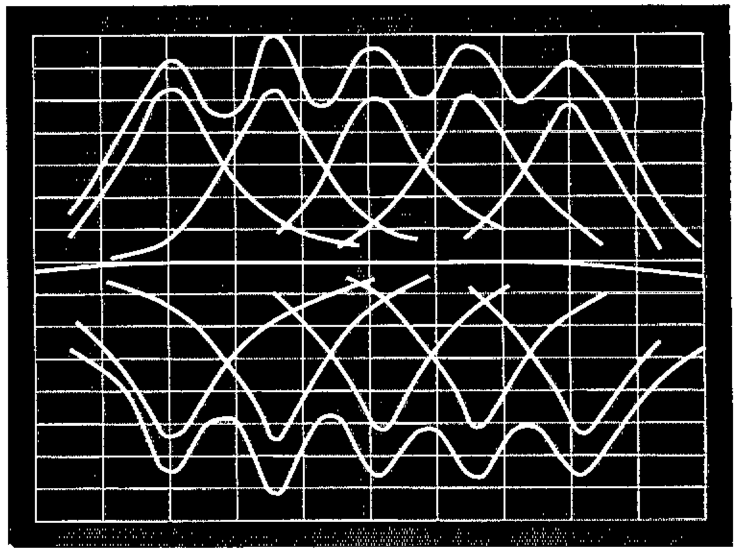
An Audio Equalizer for Communications Use



Originally designed for use at a multireceiver repeater site, this five-band equalizer may be just what you need to clarify transmit or receive audio at your station.

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Operators of multisite, voting repeater systems often encounter the problem of equalizing the different audio characteristics of remote receivers. Although my group used identical equipment for all remote receivers and their associated downlinks in our repeater system (WA4TEM), for instance, the audio characteristics of the various receivers were still different enough to be painfully apparent to repeater users—especially when the voter switched rapidly between receivers. So striking were these differences that we wondered if the voter, presented with audio input spectra that varied widely from receiver to receiver, was operating properly. We needed a means of *equalizing* the receiver outputs so that they all sounded the same.

I searched my repeater books and back copies of Amateur Radio magazines for solutions, but found none. Audio equalizers available for hi-fi systems proved unsuitable: Most of their equalization bands cover frequencies above and below the standard communications spectrum of 300 to 3000 Hz. I decided to design an equalizer to cover *only* 300 to 3000 Hz, in five bands. The solution works: After installing the equalizer, we could no longer hear any tonal differences between the receivers in our repeater system. Here's a description of the equalizer circuit, including some suggestions on how to use the equalizer for other purposes. A kit of parts is available.[1]

The Equalizer Circuit

Not wishing to reinvent the wheel, I first scanned my IC data books for equalizer ICs and application circuits. The only IC I found that fit the application is the Mitsubishi M5226P, a five-band equalizer on a chip. It can handle RMS input voltages of up to 2.3 (6.5 V P-P), has a boost/cut range of about +11 to −12 dB, and can be powered by 9 to 20 V, single supply. Just exactly what I needed! Fig 1A shows the equalizer circuit. One such circuit is necessary for each audio channel to be equalized.

Next, I calculated the values of the capacitors (C1 and C2 in Fig 1B) needed to center the equalizer's bands at 300, 1000, 1700, 2400 and 3000 Hz.[2] I sought capacitance values close to standard, available values. With capacitors of the calculated values in place, I measured the equalizer's five bands as centered at 306, 1081, 1732, 2504, and 3067 Hz—a little bit off the target frequencies, but close enough. Each band is fairly broad, as the data-sheet frequency response curves (Fig 2) indicate should be the case.

Construction

You can build the equalizer on perfboard, or on an etched PC board. (As described in Note 1, M5226P ICs, circuit boards and complete parts kits are available from me.) If you decide to build on perfboard or lay out your own PC board, consider the style of poten-

Additional Uses for the Equalizer

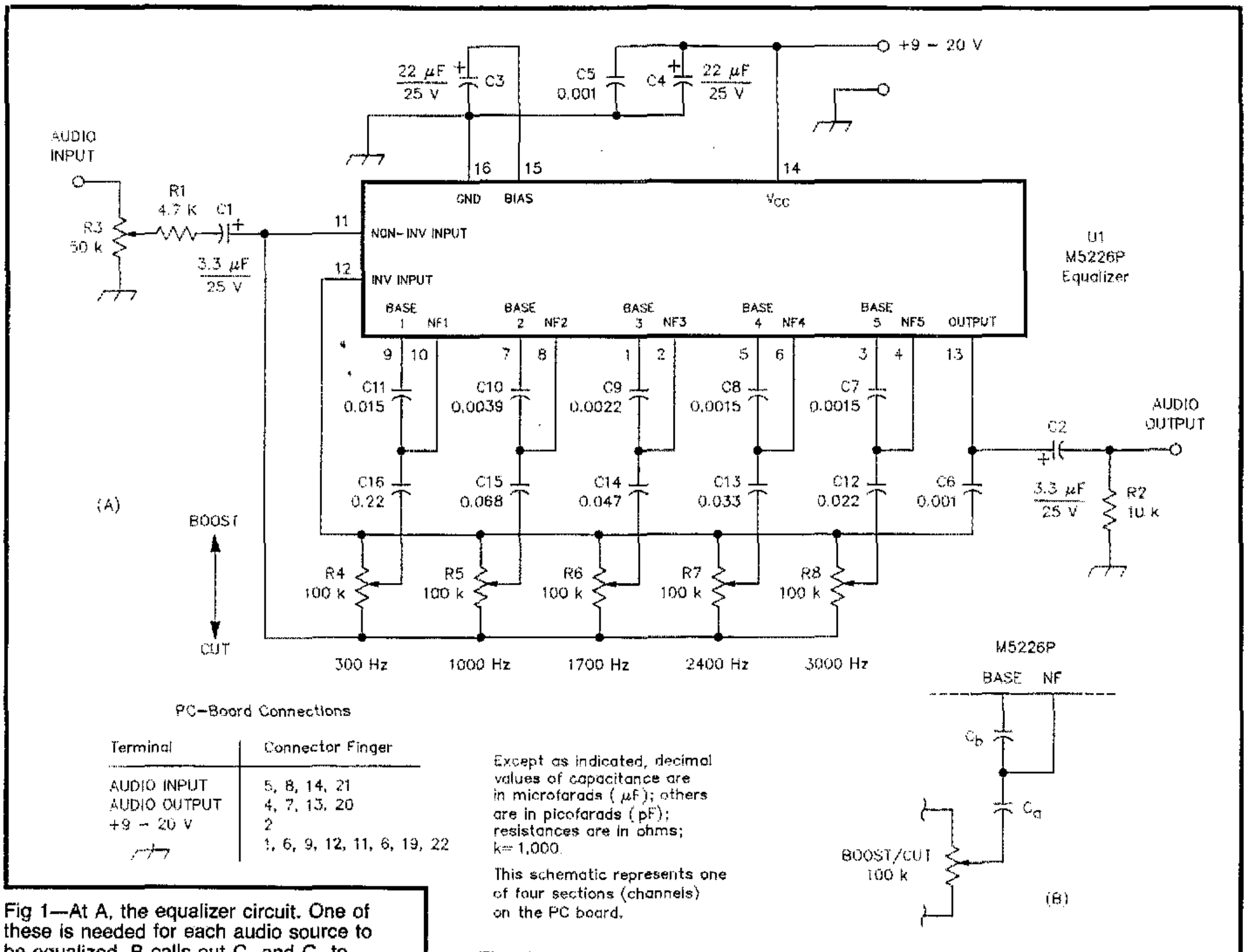
Although this article concentrates on applying the equalizer to a multisite repeater system, the circuit has many other communications uses. At a single-site repeater, for example, one equalizer channel could be used to eliminate bassy or tinny audio and tailor the system's receive-audio response to the owner's liking.

Used in conjunction with an MF/HF receiver or transceiver, the equalizer can tone down annoying heterodynes, or render noisy bands more pleasant to individual hearing tastes. You can even create a stereophonic, frequency-dependent spatial effect by feeding your receiver output to two equalizer channels, amplifying these equalizer outputs to stereo-headphone level, and adjusting the equalizers to send high frequencies to one ear and low frequencies to the other. This technique is sometimes helpful in picking out signals on crowded CW bands.

Used with transceivers and transmitters, the equalizer can be adjusted to give your favorite mike added clarity—or to help a mediocre mike sound better. Phone patches may sound better if you use the equalizer to regain some of the audio quality Ma Bell's long lines take away.

If five control bands aren't enough, by the way, you can put equalizer sections in series to construct an equalizer with as many bands as you wish; a four-channel, five-band board can easily become a two-channel, ten-band card. You can use the formulas in Note 2 to adapt the equalizer for any frequency in the audio range.—*WA4TEM*

[1]Notes appear on page 24.



PC-Board Connections

Terminal	Connector Finger
AUDIO INPUT	5, 8, 14, 21
AUDIO OUTPUT	4, 7, 13, 20
+9 – 20 V	2
(ground)	1, 6, 9, 12, 11, 6, 19, 22

Except as indicated, decimal values of capacitance are in microfarads (µF); others are in picofarads (pF); resistances are in ohms; k=1,000.

This schematic represents one of four sections (channels) on the PC board.

Fig 1—At A, the equalizer circuit. One of these is needed for each audio source to be equalized. B calls out C_a and C_b to illuminate Note 2. Fixed-value resistors are ¼-W, carbon-film units. Parts designators not called out below are intended to facilitate PC-board parts placement. Equalizer parts and parts kits are available from the author; see Note 1. The table details edge-connector pin assignments in the author's kitted PC-board version.

C6-C16—Polyester film capacitor, 5% tolerance preferred.

R3—50-kΩ, PC-mount, single-turn trimmer pot.

R4-R8—100-kΩ, PC-mount, single-turn trimmer pot.

U1—Mitsubishi M5226P audio-equalizer IC. Available from the author; see Note 1.

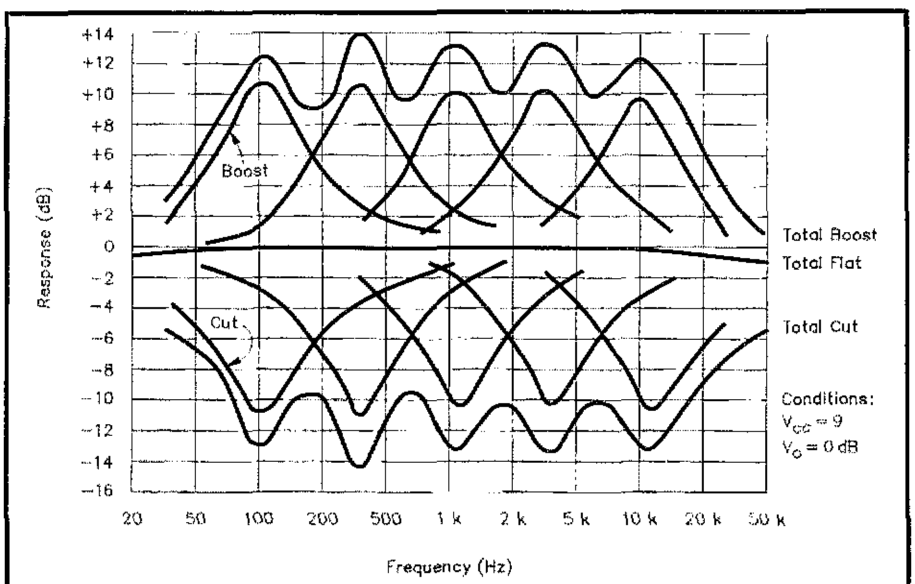


Fig 2—Typical response curves of an M5226P equalizer IC configured for hi-fi use.

tiometers you'll use for the **BOOST/CUT** and **INPUT LEVEL** controls. Since I intended the equalizer to be a set-and-forget device, I opted not to use slide **BOOST/CUT** controls. (I didn't care about "graphic" boost/cut calibration, and I didn't want the equalizer's controls to be prone to accidental bumping.) Equalizing our five-receiver repeater system called for 5 × 6 controls—five **BOOST/CUT** controls and one **INPUT LEVEL** control per equalizer—or 30 potentiometers in all. Because panel-mounting so many controls would take up a *lot* of space, I decided to use small, single-turn, PC-board-mount trimmer pots. (Don't use multiturn controls unless you want to spend your life twiddling!)

I was able to get all the components necessary for five equalizer channels on one 4½- × 6½-inch, plug-in prototyping card. The PC-board version supports *four* equalizer channels. (This matches our voter, which has four input channels. Because the WA4TEM repeater system has five receivers, I built two four-channel boards; the three unused channels allow for expansion.) However you build your equalizer, use dipped polyester-film capacitors, if possible, at C6-C12;

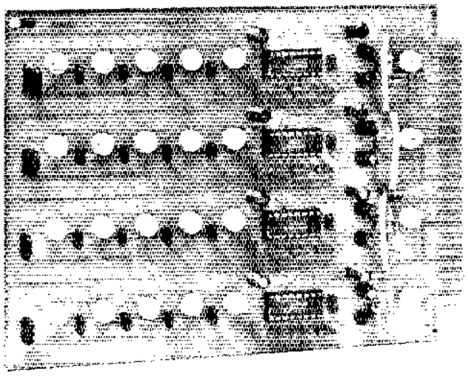


Fig 3—WA4TEM's four-channel, 300- to 3000-Hz audio equalizer just fits on a 4½- × 6½-inch PC board. PC-mount trimmer potentiometers at R3 and R4-R8 keep the space required for **INPUT LEVEL** and **BOOST/CUT** controls to a minimum.

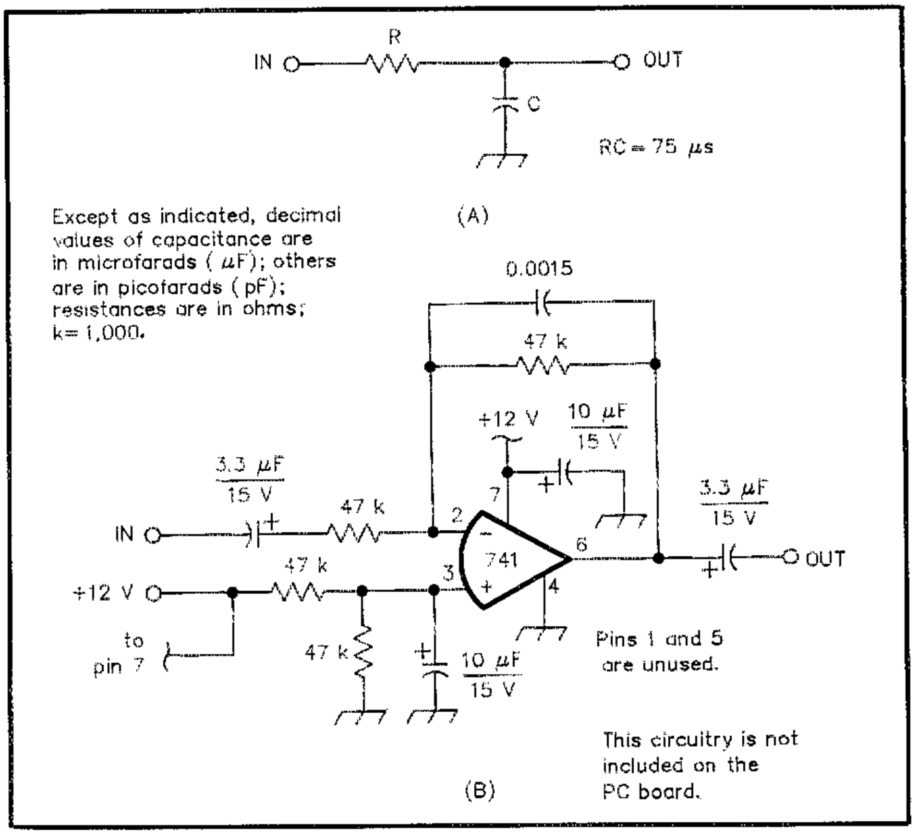


Fig 4—These passive (A) and active (B) de-emphasis circuits can be used to restore proper receive-system frequency response after system equalization. See text.

they're small and fairly temperature-stable.

Adjustments

Figuring out how to adjust the equalizer was the hardest part of the project. In our system, I installed the equalizer ahead of a Hall Electronics 4RV voter. The voter has separate equalizing capacitors on each of its input op amps; we removed these. Next, I set the equalizer's **INPUT LEVEL** and **BOOST/CUT** controls to mid-range. Then, using a deviation meter and a transmitter whose signal was full quieting into all of the system's remote receivers, I transmitted, at 5-kHz deviation, single tones at the center frequencies of the equalizer's five control bands.[3] As I transmitted each tone, I adjusted the corresponding **BOOST/CUT** controls on all five equalizer sections for the same amplitude at the **AUDIO OUTPUT** terminals of all five equalizer channels. After all **BOOST/CUT** controls were properly adjusted on all five equalizer channels, equalization was *almost* complete.

This equalization procedure assures that the entire signal path, from the transmitter input to the system's remote receivers through receiver-to-repeater links to the voter, is equalized for *a flat response* from 300 to 3000 Hz. This removes all de-emphasis from the system; proper de-emphasis must be restored.[4] The Hall voter supports the installation of a collective de-emphasis capacitor on its final output op amp; I installed a de-emphasis capacitor at that point to complete the system equalization. If necessary, you can add de-emphasis to your system; Fig 4 shows examples of suitable circuits.

Summary

The equalizer does its job well. Before we added it to our system, listeners to our repeater could hear abrupt changes in audio characteristics as the voter switched between various receivers. With the equalizer added, there are no perceptible differences in audio level or tonal characteristics between receivers—and proper voter operation is assured.

Notes

[1]Equalizer components are available from the author as follows: (1) the Mitsubishi M5226P equalizer IC, $5; (2) a drilled, plated PC board with gold-plated edge-connector fingers, $25; (3) a complete kit of parts for a four-channel, five-band, 300- to 3000-Hz equalizer, including PC board and M5226P ICs, $97. Prices include postage within the US and Canada; money orders and cashiers' checks ensure the fastest response. Contact Robin Rumbolt, 1202 Wilkinson Rd, Knoxville, TN 37923, tel 615-690-4234. The ARRL and *QST* in no way warrant this offer.

[2]Per the M5226P spec sheet, and assuming 100-kΩ **BOOST/CUT** controls, the value of equalizer capacitor C_a (see Fig 1B) for a given band center f can be found by the equation

$$C_a = \frac{1}{13{,}378\,f}$$

where

f = band-center frequency in hertz
C_a = capacitance of C_a in farads

C_b should be approximately 1/18 the value of C_a, so $C_b = 0.055 \times C_a$. Use capacitors of the nearest standard values to those you calculate. Assuming that you use 100-kΩ **BOOST/CUT** controls, you can calculate the band-center frequencies set by the standard values you choose with the formula

$$f = \frac{1}{2\pi\sqrt{C_a\,C_b} \times 8.16 \times 10^7}$$

where

f = frequency in hertz
C_a = capacitance of C_a in farads
C_b = capacitance of C_b in farads

[3]Using the deviation meter to set the transmitter audio-input level for uniform output from tone to tone eliminates the effects of audio passband variations in the transmitter.

[4]Without de-emphasis, the received audio sounds tinny. Of course, I could have "equalized in" de-emphasis by adjusting each equalizer channel to provide the appropriate audio roll-off, but it was far easier to adjust everything for a flat response at a fixed transmitter deviation and then do a collective de-emphasis with one capacitor!

Robin Rumbolt, first licensed at age 14, received his Advanced-class amateur and First-Class Radiotelephone licenses by age 17. He majored in electrical engineering in college, receiving BSEE and MSEE degrees from the University of Tennessee. Robin, now employed by Philips Consumer Electronics, has worked on various projects, including the Universal Remote Control (on which he holds three patents), HDTV and, most recently, very-large-screen TV (VIDIWALL).

Robin has been involved in many aspects of Amateur Radio: RTTY, ATV, CW DX, NCSing the Tennessee Phone Net, teaching Novice licensing classes, Navy MARS and providing code practice via repeater. He has served on the boards of five Amateur Radio organizations, and is a member of ARES, RACES and ARRL. A registered emergency communicator for a local hospital, Robin has been awarded the Communicator of the Month award by Navy MARS. WA4TEM includes equipment and antennas for almost all amateur bands from 1.8 MHz to 1.2 GHz.

Over the past 15 years, Robin has built and operated what has grown to become a five-site, voting, 2-meter repeater system. As a result of the experience gained from this work, he has written and published over a dozen repeater-related construction articles in national amateur magazines, and provided numerous article contributions to local and regional radio club bulletins.

Robin has a very patient wife and three children. Aside from ham radio, his other hobbies include computers and carpentry.