ACTIVE FILTER SHARPENS CW RECEPTION

Outboard op-amp circuit has a selectivity better than 100 Hz!

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ONE of the greatest assets a receiver can have is sharp selectivity, as anyone who has tried to copy CW on a crowded band can attest. Very selective receivers, using multiple conversion and ceramic or crystal filters, are priced beyond the reach of many amateurs. But, a simple outboard audio filter can change the picture. With it, an inexpensive receiver can become a razor-sharp CW rig without internal modifications.

The active filter described here can be connected to any receiver and provides a 6-dB selectivity of less than 100 Hz. That's an impressive figure for a circuit that costs less than $15.

About the Circuit. The use of audio filters to enhance CW reception is not new. However, until recently, sharply selective audio filters required impractically large inductors and capacitors. Op-amp technology has made these passive filters obsolete.

The heart of the filter is a 741 operational amplifier connected as shown in Fig. 1. The gain of the amplifier, V_o/V_i, (also called A_f), is determined by the following equation: $V_o/V_i = A_f = A_o\ (R_f/R1)$, where A_o is some fixed value. It is evident, therefore, that the larger R_f is with respect to *R1*, the greater the gain of the amplifier. We will take advantage of this property in designing the active filter.

Now, let's look at the schematic diagram of the filter, Fig. 2. In place of the fixed feedback resistor, R_f, the op amp, *IC1*, uses an R-C network, composed of *R1*, *R2*, *R3*, *C1*, *C2* and *C3*. One of the properties of the network is that at its center frequency, f_c, its impedance is a maximum. This is so because at this frequency the currents in the upper and lower arms are equal in magnitude and opposite in phase. The currents cancel each other out, so no resulting current flows through the feedback loop (which is the same as saying that R_f is infinite). The op amp's gain at f_c is very large. At other frequencies, however, this phase relationship is not a completely canceling one, so the effective R_f (and the op-amp's gain) is lower.

In other words, the gain of the op amp is very large at the center frequency, but drops off very quickly on either side. Fig. 3 shows the frequency response of *IC1*. For the values given for the filter, the center frequency is 750 Hz. If another CW note is preferred, these values will have to be changed. For example, if an f_c of 1200 Hz is desired, *R1* and *R2* are changed to 2200 ohms. *R3* would become 180 ohms. Capacitance values remain the same.

The receiver audio output is coupled to the active filter by the cable attached to *PL1*, which is plugged into the receiver's speaker jack. *R4*, a 10-ohm, 2-watt resistor absorbs most of the audio output. A fraction of the audio passes through *R5* and appears across the non-inverting input of *IC1*, and the audio component at f_c receives a great deal of amplification, as outlined above. The inverting input of *IC1* is loaded to insure stable operation. Since the output of *IC1* is not large enough to drive a speaker, another stage of audio amplification is

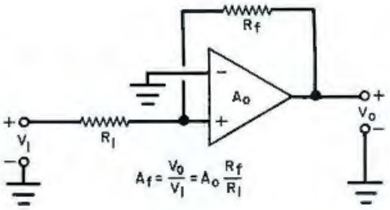

Fig. 1. Basic op amp circuit. Voltage gain depends on the amount of feedback.

included (*IC2*). A common one-watt IC audio amplifier is used for this purpose. This output level is sufficient to drive almost any communications speaker or pair of headphones, plugged into jack *J1*.

The op amp requires a bi-polar power supply. Since the audio module requires +9 volts, we decided to use a ±9-volt supply for both IC's. This can be obtained from a small full-wave zener-regulated power supply (Fig. 4). Alternatively, two 9-volt transistor batteries can be used, but you might find that they will run down rather quickly. Unless portable operation is desired, it's best to use the line-powered supply suggested.

Construction. Component layout and cabinet mounting are not critical. The circuit may be built on a pc board or a piece of perf board. Etching and drilling and component placement guides are shown in Fig. 5. An etched pre-drilled board is also available (see parts list). Be sure to use shielded cable from filter switch *S1* to the board to avoid excessive hum. Also, use an *insulated* phone jack for *J1* to avoid shorting out the power supply.

While 5% resistors and common disc capacitors are specified for the filter network (*R1*, *R2*, *R3*, *C1*, *C2*, *C3*), better results will be obtained using thin-film precision resistors and mica, glass, or polystyrene capacitors.

The active filter can be mounted either in a small utility box or, because of its small size, directly inside the receiver or speaker enclosure. One note of caution—if you are mounting the filter inside the receiver, try not to position it too close to the receiver power supply. Otherwise, you might encounter hum problems.

Using the Active Filter. While the active filter is very easy to use, it may take a little practice before you can realize its advantages. Turn on the receiver and the filter power supply, but leave filter switch, *S1*, in the FILTER OUT position. Tune around the band until you hear a CW station that you want to copy. Carefully tune the signal in until its note corresponds to the center frequency you have chosen. (It might be helpful to listen to this note on an audio signal generator a few times so that you will recognize it.) When the signal's note sounds like that of f_c, switch *S1* to the FILTER IN position. You should immediately note a drop in all QRM and most QRN. If the desired signal's level drops considerably, you have not centered it in the filter's passband. Try again! Don't touch the receiver's audio gain control once the filter is in the signal chain, because distortion might rise considerably. Instead, tune in the signal for maximum volume.

Since the passband of the active filter is so narrow, it is very difficult to tune around the band with *S1* in the FILTER IN position. Furthermore, it will not be possible to zero-beat a signal or listen to AM or SSB transmissions

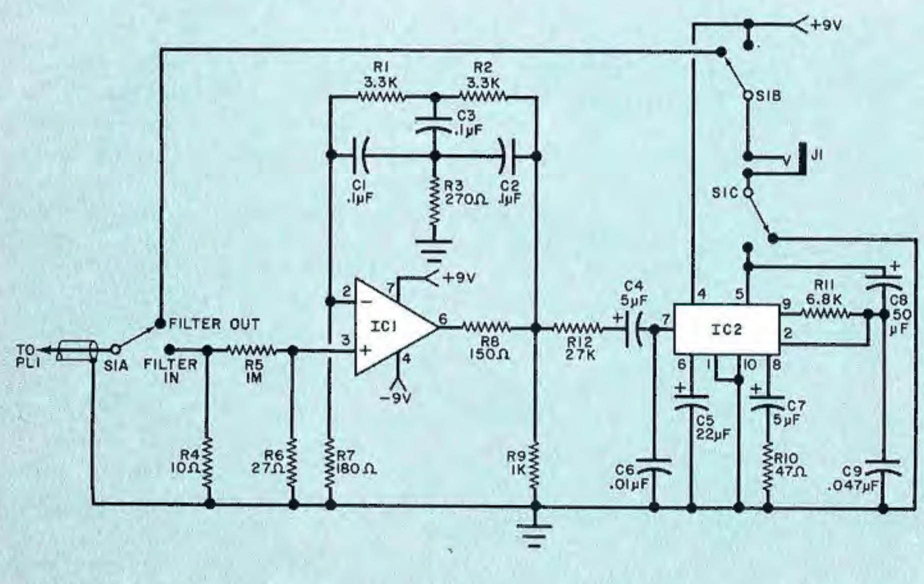

Fig. 2. Schematic for the active filter. The twin-T network determines the center frequency of the filter. When applied to any receiver, it will sharpen and improve CW reception.

PARTS LIST

C1,C2,C3—0.1-μF, 50-volt disc ceramic capacitor
C4,C7—5-μF,15-volt electrolytic capacitor
C5—22-μF, 15-volt electrolytic capacitor
C6—0.01-μF disc capacitor
C8—50-μF, 15-volt electrolytic capacitor
C9—0.047-μF, 50-volt disc ceramic capacitor
IC1—741C op amp
IC2—1-watt IC audio module (Radio Shack 276-016 or equiv.)
J1—Open-circuit insulated phone jack
PL1—Phone plug
R1,R2—3300-ohm, ½-W 5% resistor
R3—270-ohm, ½-W 5% resistor
R4—10-ohm, 2-W resistor
R5—1 megohm resistor
R6—27-ohm resistor
R7—180-ohm resistor
R8—150-ohm resistor
R9—1000-ohm resistor
R10—47-ohm resistor
R11—6800-ohm resistor
R12—27,000-ohm resistor
All resistors ½-watt, 10% unless otherwise specified.
S1—3pdt switch
Misc: Perf or pc board, shielded audio cable, utility box, wire, solder, hardware, etc. An etched, pre-drilled pc board is available from P.O. Box 15, Hawthorne, CA 90250, $3.95, postpaid.

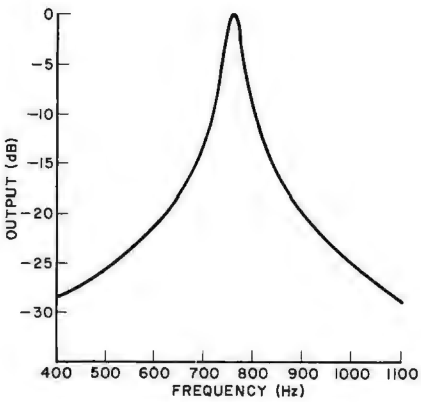

Fig. 3 Frequency response of IC1. Bandpass is less than 100 Hz.

while using the filter. However, it is possible to design a filter with a 2- or 3-kHz passband for phone use. Several filters, each with a different f_c, would have to be connected in parallel. Their outputs would then be combined by an op amp acting as a summer. Such a filter would have skirts as steep as the active filter we have described. Why not think about it? Op amps are very versatile and can make the job of sorting out signals on the crowded ham bands an easy one. QRM *can* become (for the most part) a thing of the past! ◈

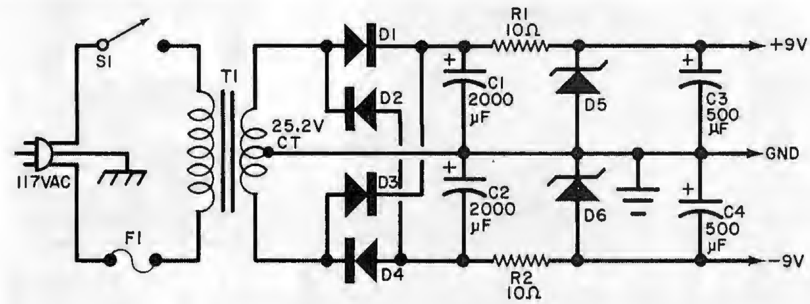

Fig. 4. Power supply for the filter. Bipolar supply features zener regulation.

PARTS LIST

C1,C2—2000-μF, 15-volt electrolytic capacitor
C3,C4—500-μF, 15-volt electrolytic capacitor
D1 to D4—1-A, 50-PIV diode (HEP R0050 or equiv.)
D5,D6—9.1-volt, 5-watt zener diode (HEP Z2513 or equiv.)
F1—¼-A fuse
R1,R2—10-ohm, 10-W resistor
S1—Spst switch
T1—25.2-volt CT transformer (Stancor P-8180 or equiv.)
Misc: Terminal strips, line cord, fuse holder, wire, solder, hardware, etc.

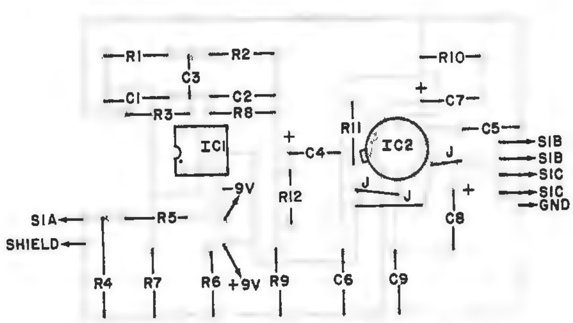

Fig. 5. Etching and drilling guide (below) and component placement for pc board (left).