Build the Tone Processor

Eliminate interfering signals with this versatile switched capacitor audio filter.

by Kazuo Niwa JA1AYO

The tone processor described here uses the National Semiconductor MF4, a four-stage Butterworth low-pass filter. As Figure 1 shows, unlike conventional audio filters, the capacitor filter cutoff $\mathbf{f_c}$ can be changed by varying the clock frequency $\mathbf{f_c lk}$. There are two varieties of MF4 switched capacitor filters, the MF4-100 and the MF4-50. The MF4-100 is shown in Figure 1. For the MF4-50, the relationship between the cutoff frequency and the clock frequency is $\mathbf{f_c = f_c lk/50}$. Referring to Figure 1, the input impedance Zin is 3 megohm for a $\mathbf{f_c}$ of 3 kHz and 20 megohm for a $\mathbf{f_c}$ of 500 Hz. The SCF has an ideal filter gain of around about 1. Attenuation for a four-stage filter is 24 dB per octave.

The MF4-100, an 8-pin DIP package is used in this tone processor. The cutoff frequency $\mathbf{f_c}$ varies from 500—3000 Hz and $\mathbf{f_c lk}$ varies over a range 100 times greater between 50—300 kHz. Two MF-4s are used in series to create an eight-stage low-pass filter in order to achieve greater attenuation.

Once power supply connections are made, a frequency counter can be connected to terminal TP as shown in Figure 2 to measure the clock frequency $\mathbf{f_c lk}$ without affecting the oscillator frequency. As variable resistor VR is adjusted, the cutoff frequency $\mathbf{f_c}$ and clock frequency

Photo A. Remove interference with this versatile switched capacitance audio filter.

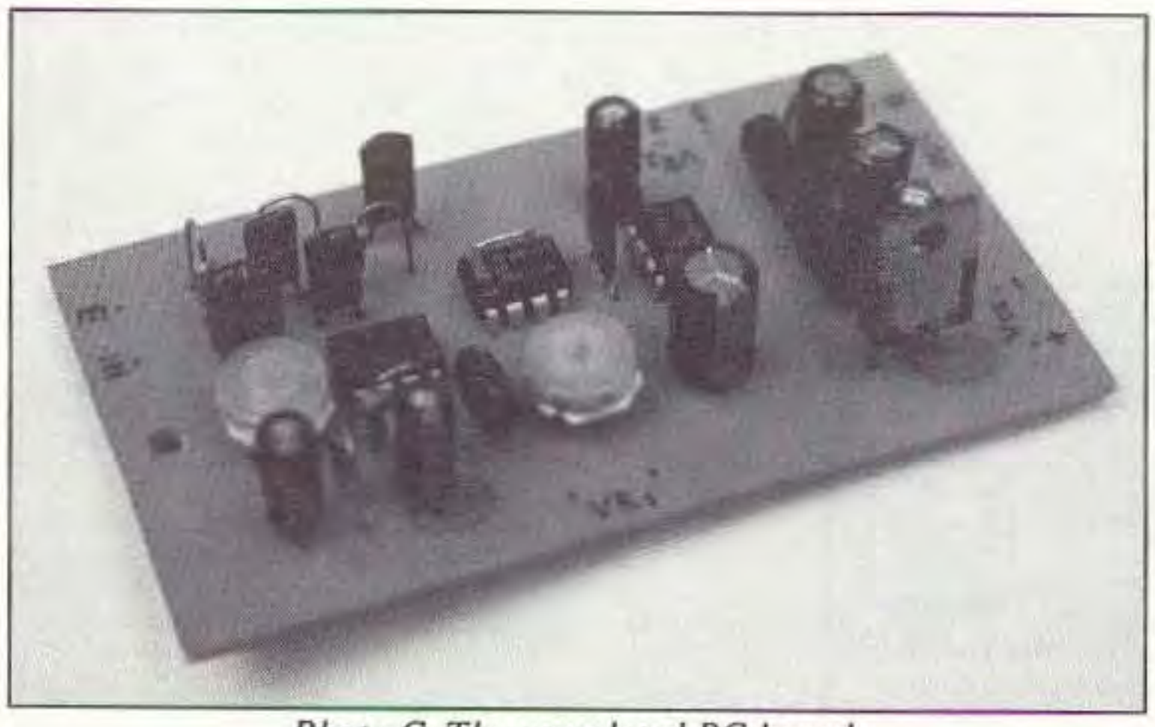


Photo C. The completed PC board.

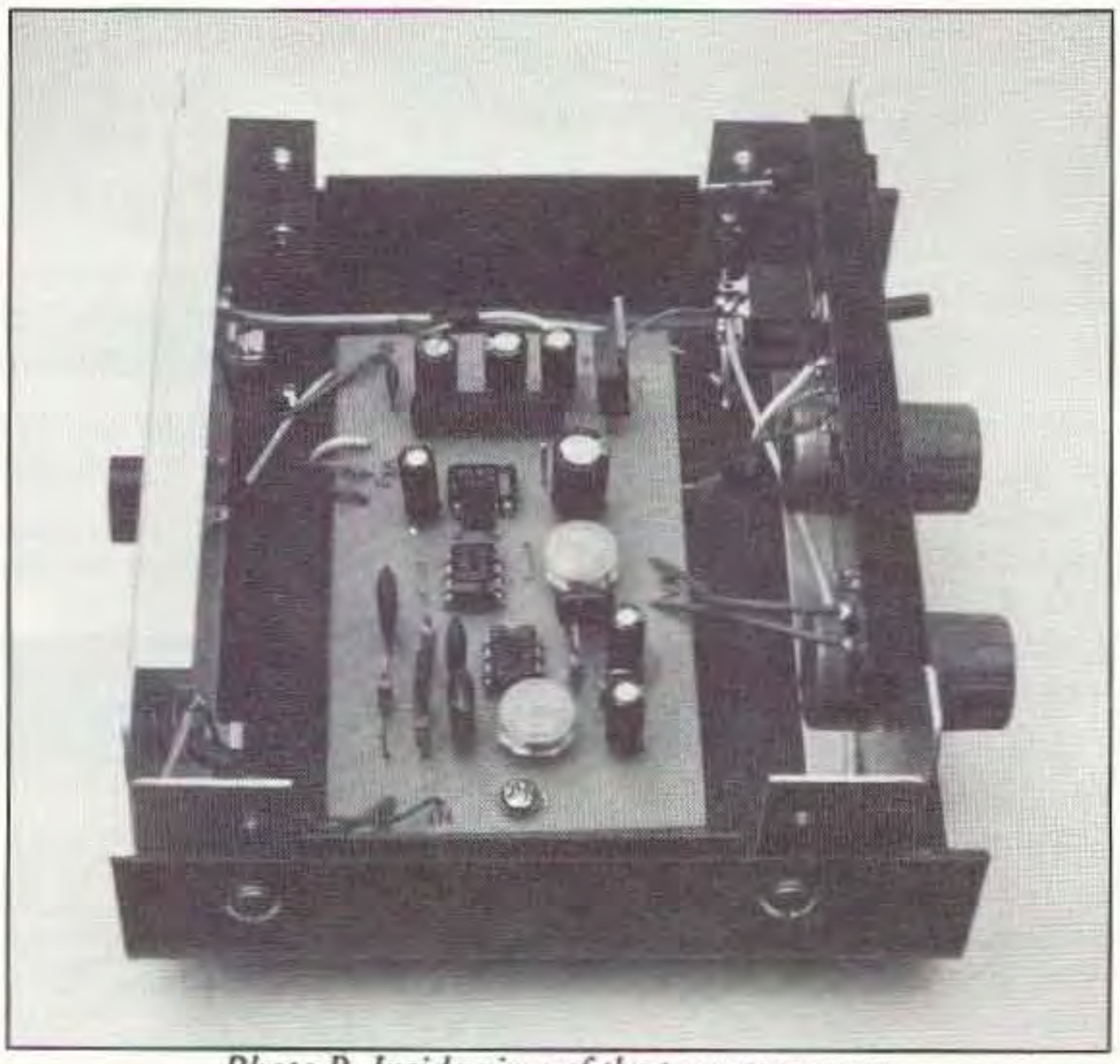


Photo B. Inside view of the tone processor.

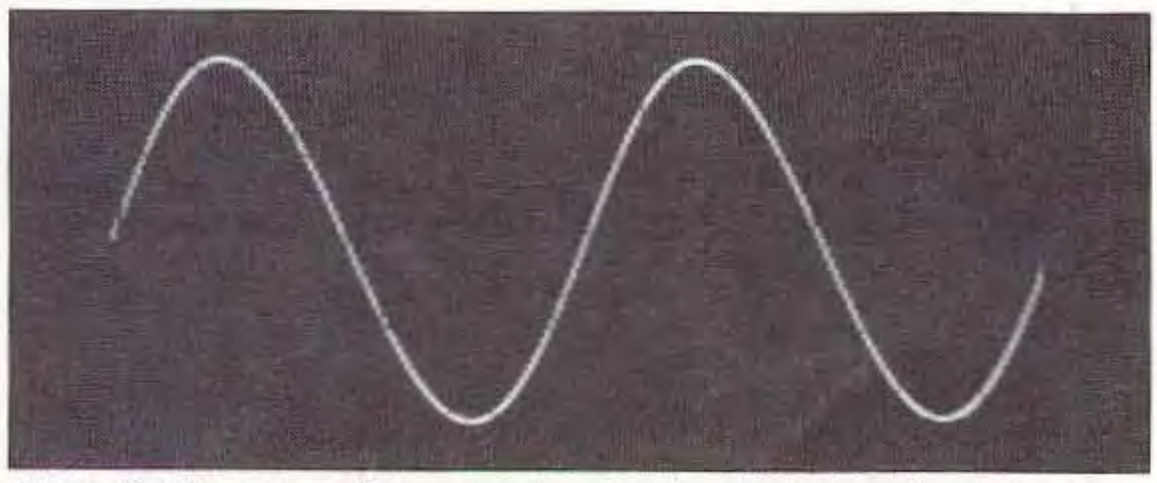


Photo D. Chopping of the waveform by the clock signals can be observed.

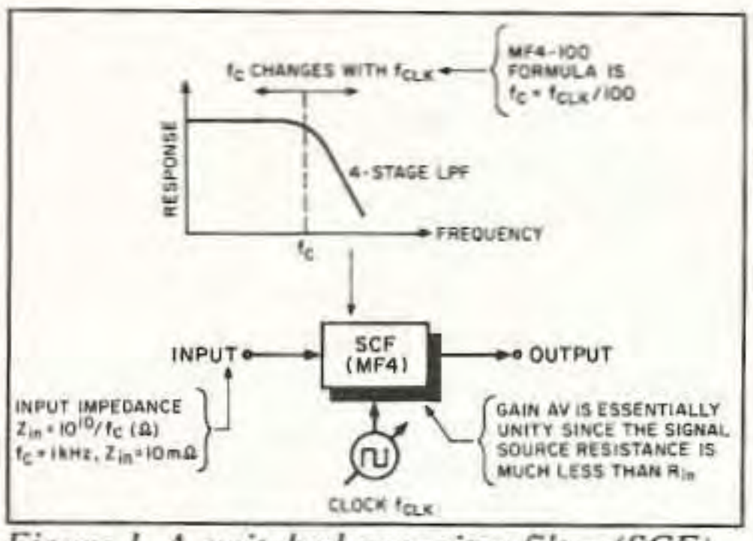


Figure 1. A switched capacitor filter (SCF) can be made using the MF4-100.

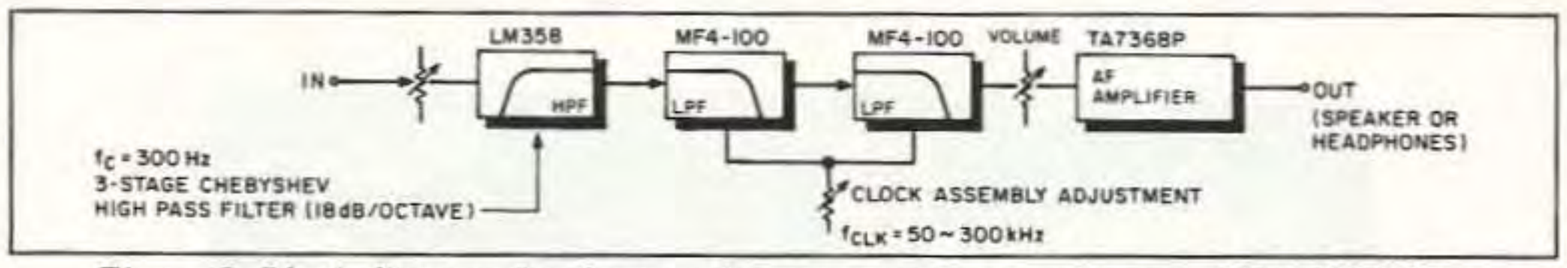


Figure 3. Block diagram for the complete tone processor using two MF4-100 SCFs.

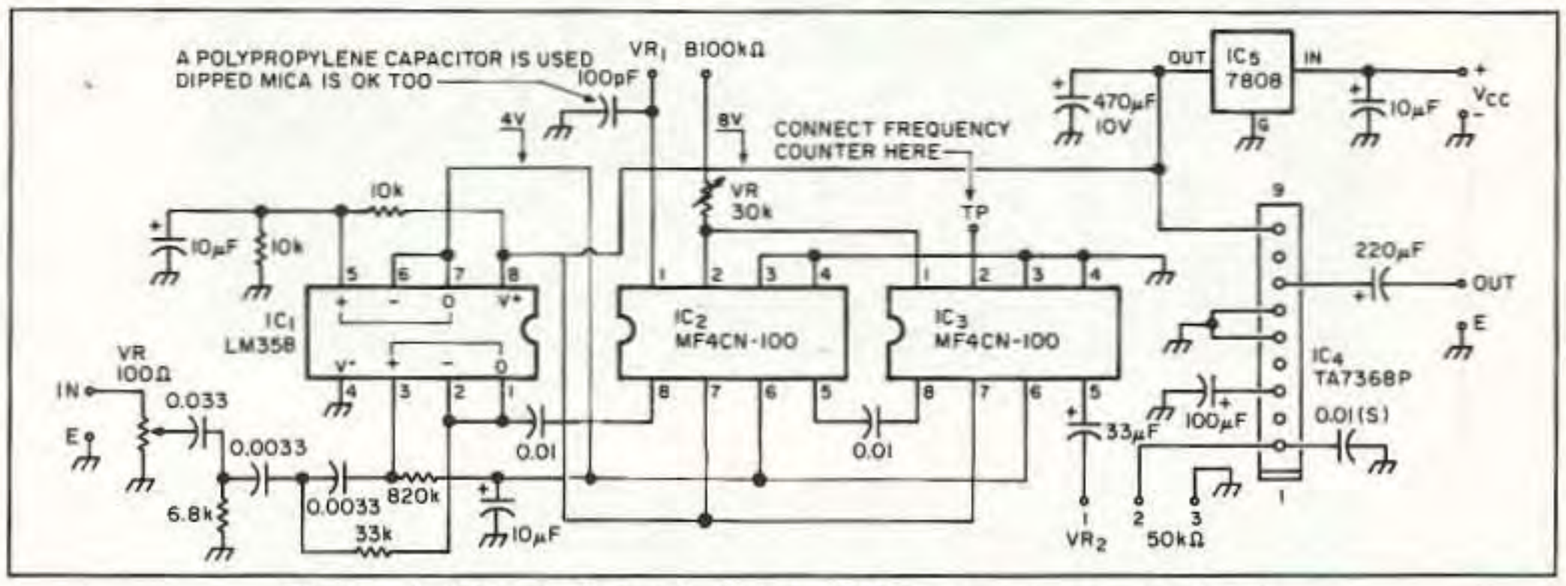


Figure 4. Circuit diagram for the SCF tone processor circuit.

$f_c$lk for an 24 dB/octave four-stage low-pass filter and a 48 dB per octave low-pass filter vary as shown in Figure 2b. This tone processor is very effective in removing unwanted noise from SSB signals.

Circuit Description

The final version of the tone processor, shown in Figure 3 and Figure 4, is designed chiefly for improving SSB reception, so low-pass filters (using the SCF ICs) as well as high-pass filters are used to provide audio balance. An LM358 op amp Chebyshev active filter with f_c fixed at 300 Hz has three stages and 18 dB/octave attenuation. An audio amplifier follows the high-pass and low-pass filters to drive a speaker.

The circuit shown in Figure 4 should be connected to a 12-volt power supply. An 8-volt three-terminal voltage regulator is used to ensure that the voltage supplied to the MF4s holds steady to ensure clock frequency **$f_c$lk** stability. IC1, a LM358, shown in Figure 5, is composed to two op amps: One is a three-stage Chebyshev high-pass filter; the other provides a 1/2 Vcc output which is used by the MF4s.

The high-pass filter uses fixed RC passive type components to set the clock frequency, but the two MF4s of the eight-stage low-pass filter use variable resistors to change the low-pass filter clock frequency.

The National Semiconductor ICs are available through Digi-Key Corporation (800-344-4539) and other sources. The

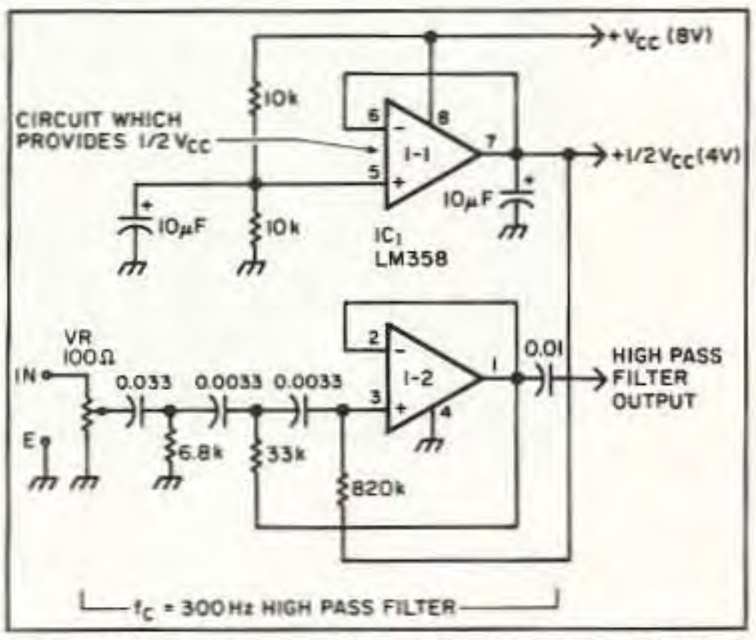


Figure 5. 3-stage Chebyshev high-pass filter and 1/2 Vcc circuit.

Toshiba TA7368 audio amplifier IC is available from MCM Electronics, 858 E. Congress Park Dr., Centerville, OH 45459-4072; Telephone: (800) 543-4330 or (513) 434-0031.

Printed circuit patterns for the circuit boards and the circuit layout are shown in Figure 6. Place a pin in the circuit board hole marked test point (TP). Photo A shows the completed tone processor in its case. The frequency characteristics of the tone processor where the cutoff frequency fc is set to 2 kHz are shown in Figure 7. The upper and lower slopes of the curve illustrate the difference in the characteristics of the low-pass Butterworth filter and the high-pass Chebyshev filter. The circuit board can be put in a project box, as shown in Photos A and B, with two rotary variable resistors on the front panel to control the cutoff frequency of the low-pass filter and the volume, as well as an on/off switch.

Operation

Put the tone processor between a transceiver and external speaker. If the tone processor is OFF, then the speaker line simply runs through the tone processor unaffected. Use insulated wire on the

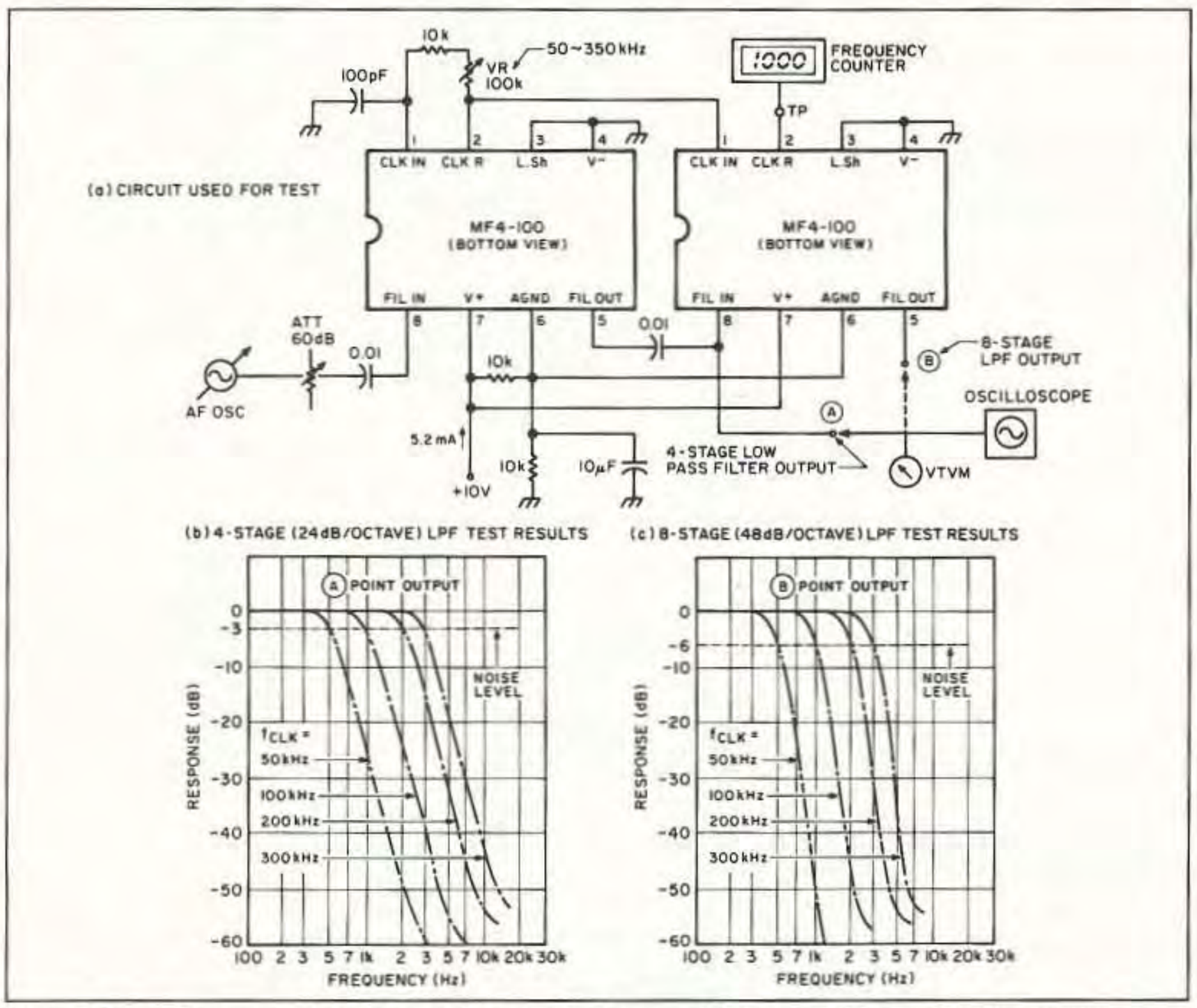
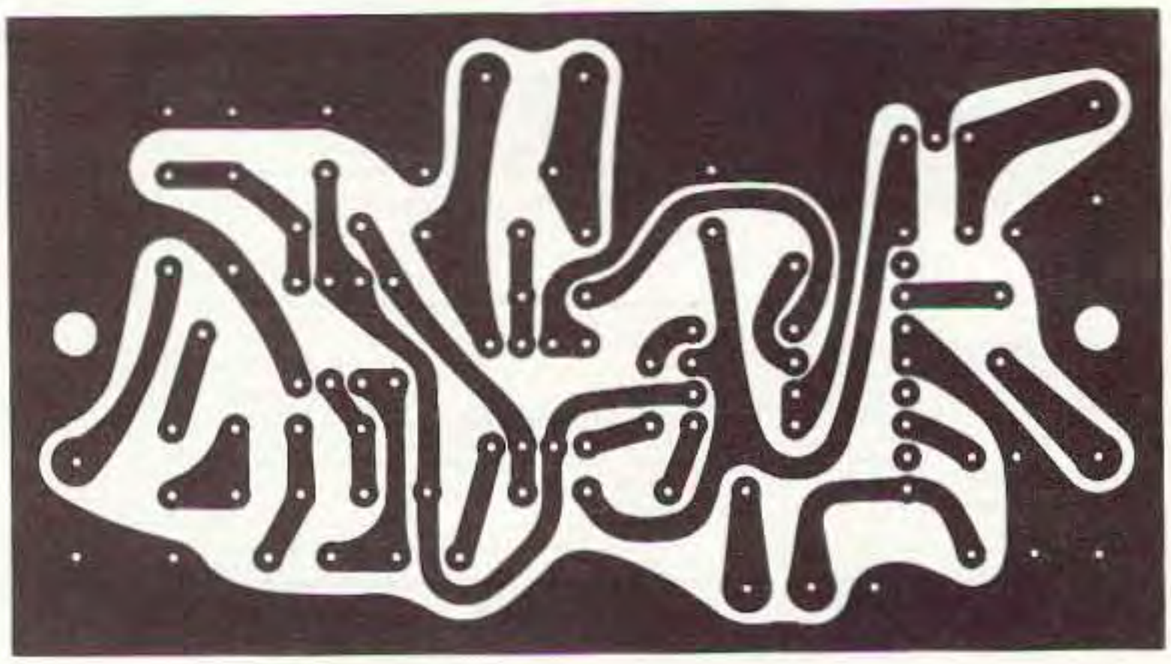
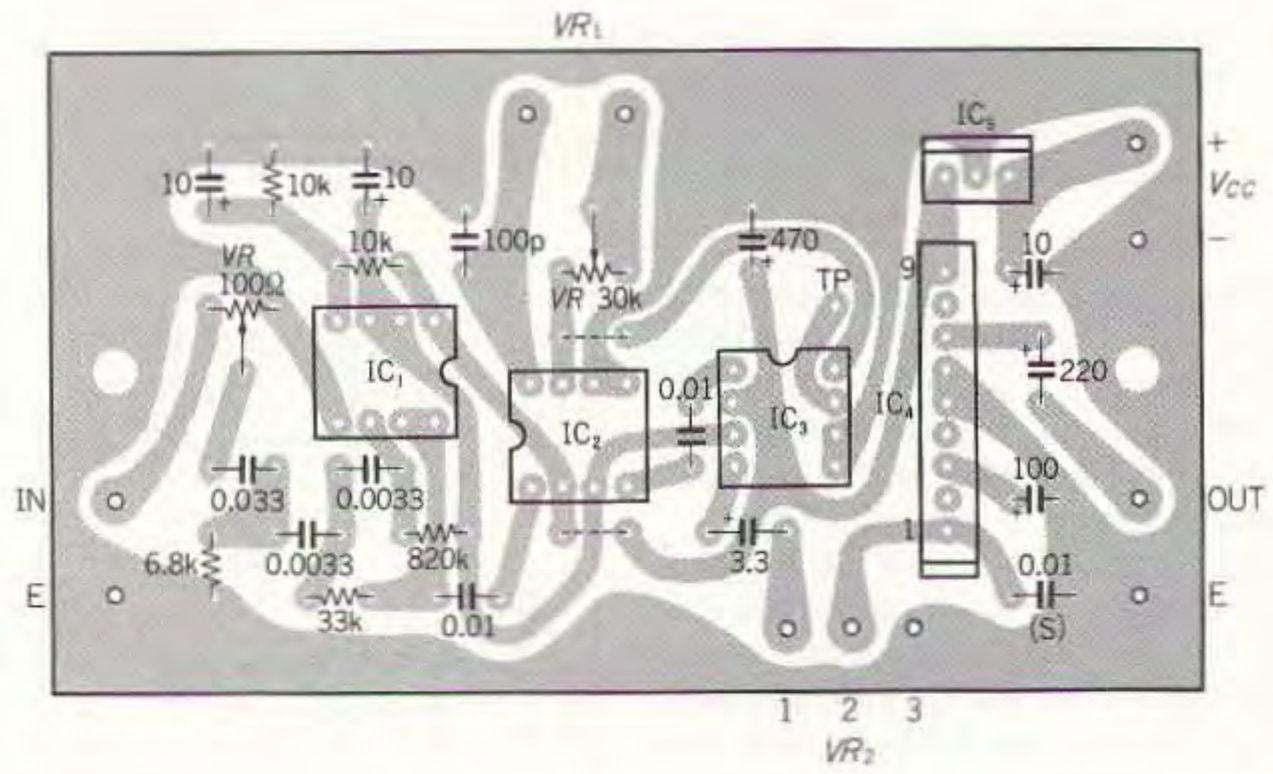


Figure 2 (a). Prototype 4-stage and 8-stage Butterworth low-pass filters. (b). Frequency response for the 4-stage filter. (c). Frequency response for the 8-stage filter.





run from VR1 to avoid frequency changes—putting your finger near that wire is enough to shift the clock frequency. The frequency markings on the cutoff frequency control as crowded in the upper range are shown in Photo A. This problem could be solved by a D curve variable resistor, but they are hard to get.

While listening to 40 meter SSB with the tone processor, much unwanted noise could be eliminated by adjusting VR1. For SSB a cutoff frequency of about 1000 Hz proved to be the best for reducing noise; below that frequency, intelligibility suffers. The tone processor generally improves readability 4 signals to readability . 73

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Figure 6 (a). PC board foil pattern.
(b). Parts placement. Please note that this parts placement diagram is shown as viewed from the foil side of the PC board, the components mount on the opposite side of the foil pattern.

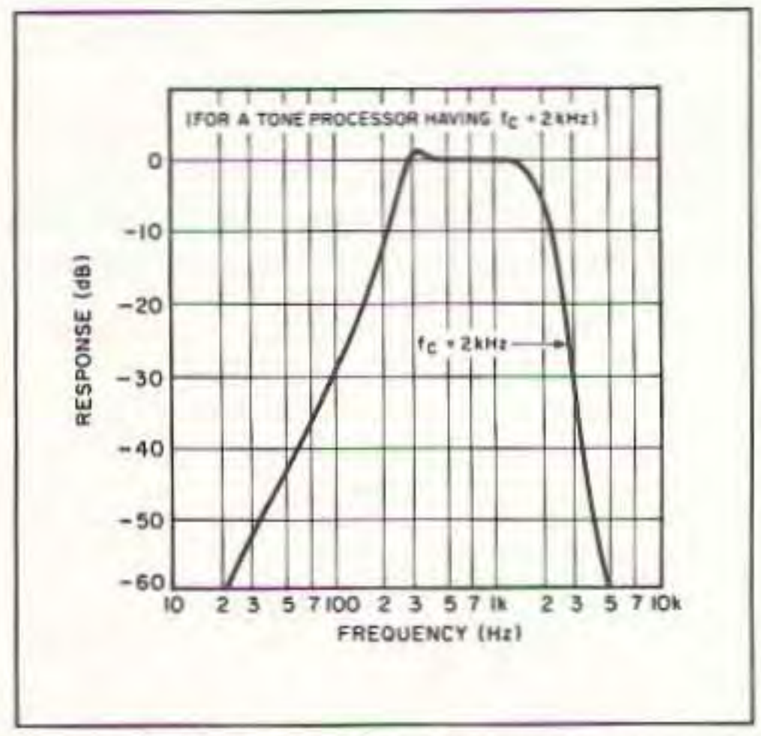

Figure 7. Tone processor frequency response characteristics.

PARTS LIST

IC1	LM358 op amp
IC2,IC3	MF4CN-100 SCF IC
IC4	TA7368 audio amplifier (see Note 2 for source)
IC5	7808 8-volt voltage regulator
1	100 pF capacitor (polypropylene or dipped mica)
1	0.0033 µF mylar capacitor
1	0.01 µF mylar capacitor
1	0.033 µF mylar capacitor
1	0.01 µF ceramic capacitor
1	3.3 µF electrolytic
3	10 µF electrolytic
1	100 µF electrolytic
1	220 µF electrolytic
1	470 µF electrolytic
1	6.8k resistor
2	10k resistor
1	33k resistor
1	820k resistor
1	100k potentiometer
1	30k potentiometer

Note 1: An etched and drilled PC board is available for $4.50 + $1.50 postage from FAR Circuits, 18N640 Field Court, Dundee IL 60118.

Note 2: The Toshiba TA7368 audio amplifier IC is available from MCM Electronics, 858 E. Congress Park Dr., Centerville OH 45459-4072. Telephone: (800) 543-4330 or (513) 434-0031.

Note 3: All other parts should be available from Digi-Key Corporation at (800) 344-4539 or Mouser Electronics at (800) 346-6873.

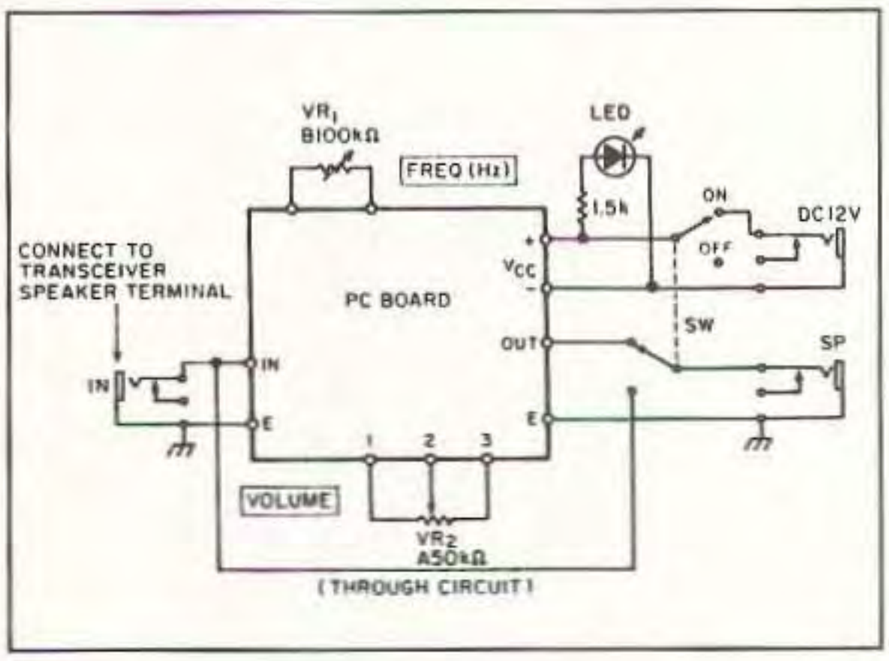

Figure 8. Hook up the tone processor between your rig's speaker output and your speaker as shown. It can be removed from the circuit with the switch.