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The Magical Audio Filter

A variable-frequency notch filter plus a peaking circuit will do wonders for your reception. And this project will almost build itself.

Audio filtering is a well-known process for improving receiver selectivity and many articles have been written on the subject. Because I have been in the process of building a direct-conversion receiver, I have been most interested in the subject. However, in order to further improve the receiver, I wanted more than the usual passband type of filter. Since one of the receiver modes is CW, I wanted a notch filter with a variable frequency and a variable-frequency peaking circuit. The notch filter could also be used on SSB reception to reject heterodynes from AM stations. Some of the requirements that I wanted for the notch filter were:

- a high Q (so the bandwidth at the 3-dB point of the notch frequency was approximately 200 Hz with a rejection of greater than 20 dB)
- the capability of shifting the notch frequency from 500 to 3 kHz
- a minimum number of parts.

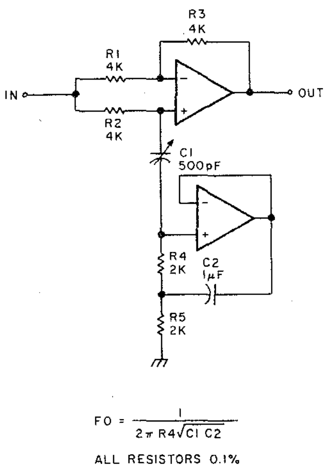

Fig. 1. Original circuit.

The Frequency-Notching Circuit

Most articles I'd seen on this subject showed at least three or four operational amplifiers plus a multitude of resistors and capacitors and therefore did not satisfy my third requirement.

One day, I accidentally ran across a number of circuits in a *National Semiconductor Linear Applications Manual.*[1] The circuit that interested me the most was the one providing variable frequency-notching using a variable capacitor. This circuit was constructed on a proto board and performed quite well, but the frequency range was limited by the maximum value of the capacitor. The basic circuit is shown in Fig. 1. The major drawback of this circuit was the large physical size of the capacitor as compared with the rest of the circuit.

Looking at the formula for the notch frequency (Fig. 1), one can see that the frequency is a function of R4, C1, and C2. The frequency varies directly as R4 and by the square root of C1 and

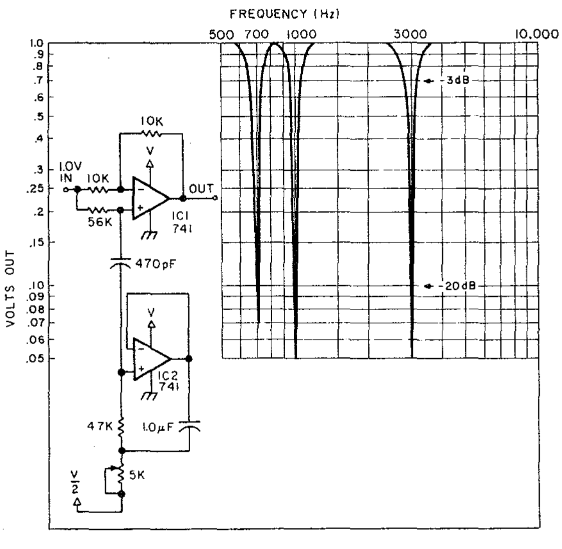

Fig. 2. Notch circuit.

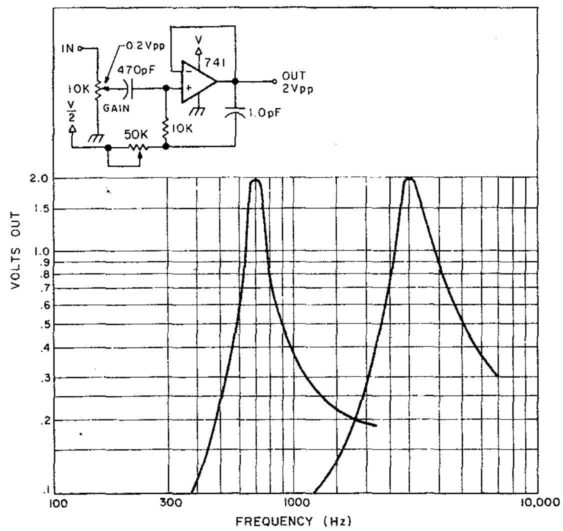

Fig. 3. Peaking circuit.

C2. Thus, if the resistor is doubled in value, the frequency doubles. Doubling the capacitors only gives 1.4 times the change. I decided to build the circuit with R4 variable and again results were very good. The frequency-range requirements were met and the rejection was greater than 20 dB. It did have one problem that was also experienced with the variable-capacitor circuit. In order to achieve maximum rejection at the high end vs. the low end, R3 had to be varied. Experimenting further, I found that if R5 were varied and R3 and R4 were properly chosen, only one control was necessary. Almost equal rejection could then be achieved across the whole range. A typical response is shown in Fig. 2.

The Peaking Circuit

Since the above circuit was rather novel (there is no signal inversion from input to output at the off null point), I started to look at voltages at various points with an oscilloscope. To my amazement, I found that when the output was going to null on IC1, the output was peaking on IC2. Eureka!—Here was the second circuit I was looking for. To accomplish peaking, only IC2 was needed. This circuit was constructed and the results are shown in Fig. 3. R_{in} is necessary to prevent saturation of the amplifier. The gain of this stage is about 10—therefore the input must be less than 0.5 volts. The power supply used was plus and minus 8 volts to be equivalent to the supply to be used in the final construction.

It will be noticed that there is an additional resistor that can be switched in or out in the final circuit. When the resistor is in, the peak is broadened and the circuit can be used on AM or SSB to modify the speech characteristics of the transmitted signal being received. It can reduce the low frequencies and accentuate the frequencies that transmit the spectrum that contains the most intelligence. It also reduces higher frequencies, thereby reducing background noise.

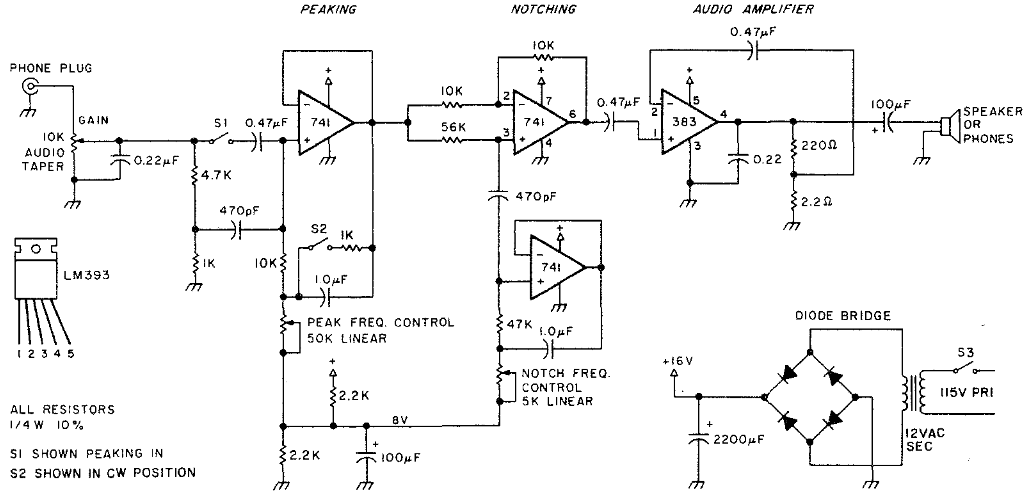

Fig. 4.

Combination Notch and Peaking Circuit

Fig. 4 shows the final circuit combining the two circuits. The circuit was constructed on a perfboard using wire-wrap sockets. The perfboard is mounted in a Radio Shack box with 1-inch spacers. Both the LM383 and the transformer are mounted to the box. One note of caution—the 0.22-uF capacitor on the output to ground on the LM383 should be mounted on the device terminals. The input cable, the output jack, and the 115-V-ac input all come in on one end of the box and the potentiometers mount on top.

For some reason, not many articles ever use perfboards and wire-wrap sockets. PC boards should be used for rf work, but the perfboard does very well for audio frequencies. The nice thing about wire-wrap circuits is that if you make a mistake, it can be corrected or modified easily. The following are some hints on building with a perfboard and wire-wrap sockets.

Parts List

Quantity	Part	R. S. part#
3	LM741	276-007
1	LM383	276-703
1	Phone plug	274-1536
1	Phone jack	274-252
1	50k linear pot	271-1716
1	10k audio taper pot	271-1723
1	5k linear pot	271-1714
2	470-pF capacitors	272-125
3	1.0-uF capacitors	272-996
2	100-uF capacitors	272-1016
2	0.22-uF capacitors	272-1070
1	2200-uF capacitor	272-1020
1	12-V-ac transformer	273-1505
3	8-pin DIP w-w sockets	276-1988
1	SPST switch pwr	275-602
2	SPST switches	271-612
1	Chassis box	270-238
1	Line cord	278-1255
3	Knobs	Your choice
1	Perfboard	276-1395
1 pkg	Push-in terminals	270-1392
1	Wire-wrap tool	276-1570
3	10k ¼-W resistors	
2	2.2k ¼-W resistors	
1	56k ¼-W resistor	
1	47k ¼-W resistor	
1	4.7k ¼-W resistor	
2	1k ¼-W resistors	
1	220-Ohm ¼-W resistor	
1	2.2-Ohm ¼-W resistor	
1	Bridge rectifier	276-1151
	Wire-wrap wire	Your choice of colors
	Misc. hardware	

1. Make a Xerox® copy of the schematic; every time you put in a wire, mark it down. This is especially helpful should you put the project away and come back to it later.

2. Using a marking pen on the wire side of the board, indicate which pin is #1 for the IC sockets. Remember that the numbering on the wire side is opposite to that on top.

3. I use model-airplane cement to hold the IC sockets in place. If you want to reuse the perfboard, this type of glue allows the socket to be easily removed.

Clean the board with acetone when the sockets are removed.

4. It is also helpful to use different colors of wire for different parts of the circuitry.

5. Push-in teminals (Radio Shack #270-1392) are used to mount the resistors and capacitors. The wire-wrap wires are soldered to these terminals on the wire side of the board. (A special tool is available to insert these terminals but is not available from Radio Shack. Long-nose pliers can be used but are nowhere near as satisfactory as the tool.)

6. Mount the components when the push-in terminals are in place so as not to lose track of which terminal goes with which component.

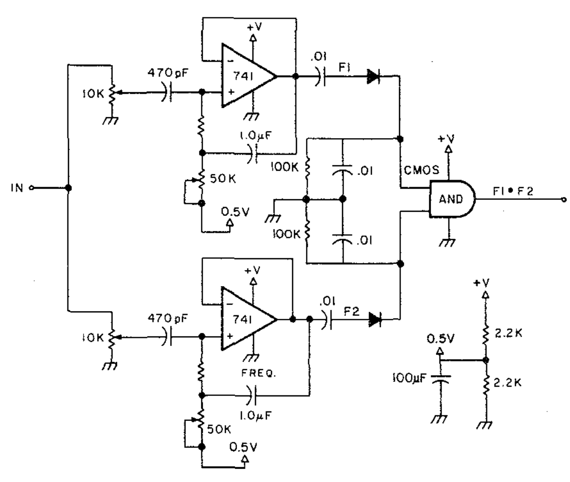

Fig. 5. Another application for peaking-circuit decoder.

7. Wire-wrapping is done with a manual tool to conveniently allow interchanging of wire colors. If you have never used a wire-wrap tool, the operation is very simple. In learning, the best way is to measure the distance between the two points to be wired and add 1¼ inch if wire-wrap to wire-wrap, add 7/8 inch for wire-wrap to teminal, and add ½ inch for terminal to terminal. For good measure, add on about ½ inch so the wire will not be too tight. Strip both ends 5/8 inch for wire-wrapping and ¼ inch for terminals. Stripping is done with a special tool provided with the wire-wrap tool. The bare wire is inserted into the end of the wire-wrap tool with the wire entering the smallest hole on the end of the tool. Place the tool over the terminal post to be wrapped and rotate the tool in a clockwise direction for about ten turns. The connection is now made. If you make a mistake, a tool is available to rotate in the opposite direction to remove the wire.

Circuit Operation

When the project is finished, the input cable can be plugged into the phone jack of any receiver and the output to either a speaker or headphones. Set S1, the peaking-circuit switch, to OUT. Tune in a CW signal and adjust the signal frequency to give about an 800-Hz tone. Throw S1 to IN and turn the peaking control to a point where the maximum audio is heard. The first thing you will notice with the peaking switch in is the reduction in noise. As you approach the peaking point, the signal will increase greatly in volume. Of course, if some other frequency suits you better than 800 Hz, that is the listener's choice.

The next thing to check is the notch filter. With the 800-Hz signal coming in, adjust the notch control to a point where the signal drops in volume. On some CW signals with key clicks and thumps, the 800-Hz signal will drop out but the clicks and thumps will still be there. I have found that it is easier to remove a heterodyne with the peaking circuit out; then bring in the peaking circuit, producing an even greater reduction in the interfering signal. When the notch circuit is not used, the pot should be set to the low-frequency end.

Frequency-Selection Circuit

Another circuit is shown in Fig. 5. Although I have not tried this circuit, it could be of interest. I have tried LM567s in frequency-selective circuits, but noise spikes seem to get through, creating an unwanted output signal. A case in point is my garage-door opener. This unit had a vibrating-reed type of frequency detector and I replaced it with a pair of LM567s. Every once in awhile the door will open without a command due to noise. After I finish this project, reworking the opener will be my next project.

Conclusion

The peaking/notching circuit should be a worthwhile addition to any receiver for a parts cost of about $35 excluding the wire-wrap tool and wire that can be used on many other projects. It is a simple but effective way to gain a bit more selectivity that should improve any old receiver and maybe some of the newer ones.

A list of parts is given with all but one being available from Radio Shack. Of course, most hams will have many of these parts available in their junk boxes, bringing the overall cost down. ■

References

1. *National Semiconductor Linear Applications Manual*, January, 1972, page AN 31-14.