

# High Q Notch Filter



The twin "T" network is one of the few RC filter networks capable of providing an infinitely deep notch. By combining the twin "T" with an LM102 voltage follower, the usual drawbacks of the network are overcome. The Q is raised from the usual 0.3 to something greater than 50. Further, the voltage follower acts as a buffer, providing a low output resistance; and the high input resistance of the LM102 makes it possible to use large resistance values in the "T" so that only small capacitors are required, even at low frequencies. The fast response of the follower allows the notch to be used at high frequencies. Neither the depth of the notch nor the frequency of the notch are changed when the follower is added.

Figure 1 shows a twin "T" network connected to an LM102 to form a high Q, 60 Hz notch filter.

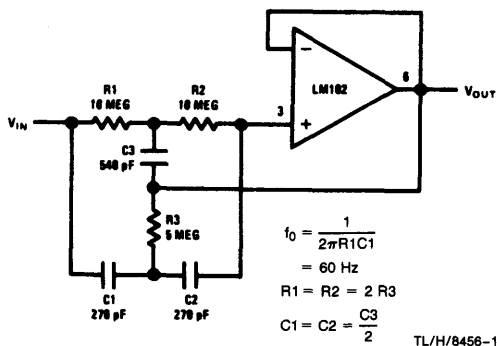


FIGURE 1. High Q Notch Filter

The junction of  $R_3$  and  $C_3$ , which is normally connected to ground, is bootstrapped to the output of the follower. Because the output of the follower is a very low impedance, neither the depth nor the frequency of the notch change; however, the Q is raised in proportion to the amount of signal fed back to  $R_3$  and  $C_3$ . Figure 2 shows the response of a normal twin "T" and the response with the follower added.

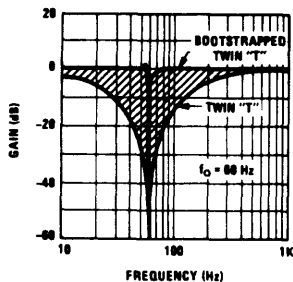


FIGURE 2. Response of High and Low Q Notch Filter

In applications where the rejected signal might deviate slightly from the null of the notch network, it is advantageous to lower the Q of the network. This insures some rejection over a wider range of input frequencies. Figure 3 shows a circuit where the Q may be varied from 0.3 to 50. A fraction of the output is fed back to  $R_3$  and  $C_3$  by a second voltage follower, and the notch Q is dependent on the amount of signal fed back. A second follower is necessary to drive the twin "T" from a low-resistance source so that the notch frequency and depth will not change with the potentiometer setting. Depending on the potentiometer setting, the circuit in Figure 3 will have a response that falls in the shaded area of Figure 2.

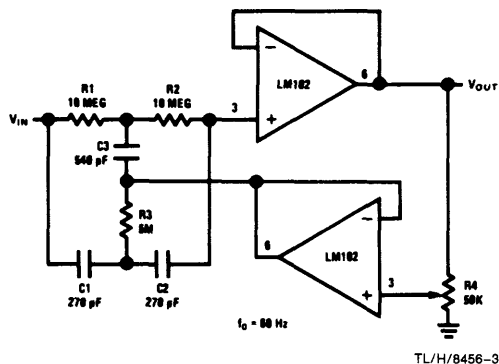


FIGURE 3. Adjustable Q Notch Filter

An interesting change in the high Q twin "T" occurs when components are not exactly matched in ratio. For example, an increase of 1 to 10 percent in the value of  $C_3$  will raise the Q, while degrading the depth of the notch. If the value of  $C_3$  is raised by 10 to 20 percent, the network provides voltage gain and acts as a tuned amplifier. A voltage gain of 400 was obtained during testing. Further increases in  $C_3$  cause the circuit to oscillate, giving a clipped sine wave output.

The circuit is easy to use and only a few items need be considered for proper operation. To minimize notch frequency shift with temperature, silver mica, or polycarbonate, capacitors should be used with precision resistors. Notch depth depends on component match, therefore, 0.1 percent resistors and 1 percent capacitors are suggested to minimize the trimming needed for a 60 dB notch. To insure stability of the LM102, the power supplies should be bypassed near the integrated circuit package with .01  $\mu\text{F}$  disc capacitors.