Wien bridge and op amp select notch filter's bandwidth

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The band over which a notch filter provides rejection of unwanted frequencies can be selected with this circuit, which uses a Wien bridge plus an operational amplifier with fixed gain. Such a circuit represents one of the simplest configurations for easily adjusting the selectivity of the filter, which has a notch depth of nearly 60 decibels, independent of component precision.

Circuit operation is most easily described with the transfer function shown in the figure, which is:

$$\frac{V_o}{V_i} = \frac{1-R^2C^2\omega^2}{1-R^2C^2\omega^2+j3(1-k)RC\omega} = \frac{1-x^2}{1-x^2+j3(1-k)x} \quad (1)$$

where $x = \omega/\omega_c = f/f_c = RC\omega$, ω is the frequency of interest, f_c is the center frequency of the notch filter, and k is the percentage of the output voltage from A_1 that is introduced at the noninverting input of A_2. This transfer function has a transmission zero at $f_c = 1/2\pi RC$, which is the center frequency of the notch.

The amount of phase shift provided by the Wien bridge (A_1 and the RC components), from Eq. 1, is:

$$\tan\phi = [-3(1-k)x]/(1-x^2) \quad (2)$$

The width of the rejected band at the −3-dB points can be easily expressed with respect to k by setting $\phi = 45°$, so that Eq. 2 becomes:

$$|\tan\phi| = 1 = [3(1-k)x]/(1-x^2)$$

or:

$$k = (x^2+3x+1)/3x, \text{ for } x<1 \quad (3)$$

where $x = f_r/f_c$ and f_r is defined as the difference in frequency as measured at the −3-dB points. Thus, for example, if $f_c = 10$ kilohertz and the desired $x = 0.9$ (or $f_r = 9$ kHz), then k must be set at 0.93.

It will be noted that although the transfer function for the popular twin-T variety of notch filter (not shown) is almost identical to that in Eq. 1 (the constant 3 is replaced by the number 4), in practice, the twin-T is not very easily adjusted. This is because a greater number of components must be trimmed, and more careful adjustments made, to achieve the desired degree of selectivity and notch depth required. □

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Selectable stopper. Notch filter, which operates at up to 200 kHz, uses modified Wien bridge to select bandwidth over which frequencies are rejected. RC components determine filter's center frequency. P_1 selects notch bandwidth. Notch depth is fixed at about 60 dB.