## Introduction

The filter described here has an easily adjustable center frequency, symmetrical skirts and an attenuation (gain) of -40(+40)dB at an octave either side of the center frequency ($f_C$). The filter Q ($Q = f_C/BW3dB \cong 250$) does not vary significantly when the center frequency is changed, thus, the shape of the skirts is essentially independent of the pot setting. This feature yields filters that can be adjusted over a much wider frequency range than "T" type filters, the only other type of filter with such a deep notch or narrow bandpass. Now one filter type is useful in many designs. The calculation of the center frequency for the circuits shown in Figure 1 and Figure 2 is given in Equation 1 and Equation 2.

$$f_C = \frac{1}{2\pi C \sqrt{3R_1R_2}} \qquad \text{(EQ. 1)}$$

Where $R_1 = R_{1A} + \alpha R_P$

$R_2 = R_{2A} + (1-\alpha)R_P$

$$R_3 = 6(R_1 + R_2) \qquad \text{(EQ. 2)}$$

A basic theorem of feedback circuits is that a function generator included in a negative feedback loop computes the inverse function at the output. This approach has been used to change an excellent bandreject filter into an excellent bandpass filter. The schematic of the bandreject filter, which is passive and comprised of C, $R_1$, $R_2$ and $R_3$ is shown in Figure 1. The bandpass filter, which includes the passive network in the feedback loop, is shown in Figure 2. The bandpass filter has the advantage of high input impedance and low output impedance because of the location of the op amp. With the values shown the center frequency is adjustable from 55kHz to 550kHz producing a decade of frequency adjustment. The Intersil HA-2841 op amp is chosen as the amplifier because it has good DC characteristics and has the high gain bandwidth required to achieve the bandpass gain without distorting the filter response. $R_1$ should be split into $R_{1A}$ and $R_{1B}$ to prevent $R_1$ from becoming zero, and the split may be selected to obtain maximum resolution over the desired center frequency range.

A PSPICE™ plot of the circuit using the SPICE Model for the HA-2841 is shown in Figure 3. The plots are the logarithmic transfer function of both the filters (in dB). Notice that the bandreject filter transfer function, represented by the diamonds, is the mirror image of the bandpass transfer function, represented by the squares. These transfer functions change very little when they are adjusted to 550kHz center frequency. Bench test results show some deviation from the PSPICE™ simulations because of component tolerances and layout capacitances, but generally they correlate well with the simulations. The transfer functions change radically and tend to degenerate at high frequencies if low gain bandwidth op amps are used.
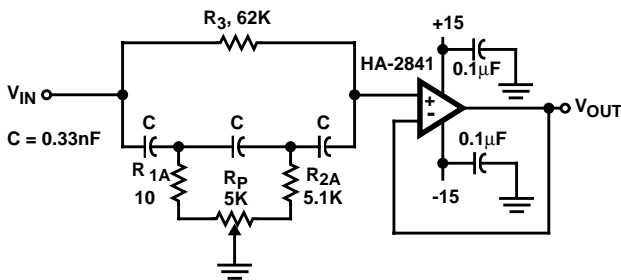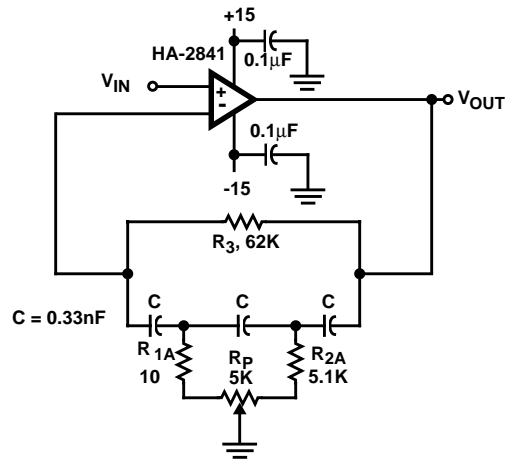


FIGURE 1. ADJUSTABLE BANDREJECT FILTER
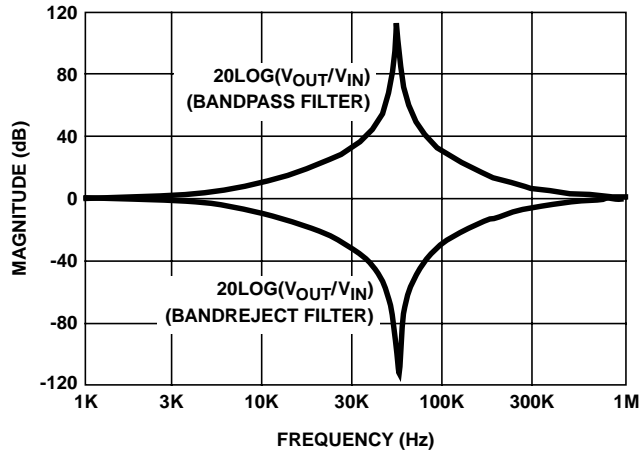


FIGURE 2. ADJUSTABLE BANDPASS FILTER

**FIGURE 3. PSPICE PLOT OF FILTERS TRANSFER FUNCTION**

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