8.2.3 Bandpass network function The complex-conjugate-pole-pair bandpass transfer function is

$$H(s) = \frac{H_o \alpha \omega_o s}{s^2 + \alpha \omega_o s + \omega_o^2}$$

where

$$\alpha = \frac{1}{Q} \qquad \text{and} \qquad Q = \frac{\omega_o}{\omega_2 - \omega_1} = \frac{f_o}{f_2 - f_1}$$

and where f_2 and f_1 are the frequencies where the magnitude response is -3 dB from H_o, the passband gain which occurs at $\omega_o = 2\pi f_o$. The sinusoidal steady-state transfer function may be written in the form

$$H(j\omega) = \frac{H_o}{1 + jQ(\omega/\omega_o - \omega_o/\omega)}$$

Thus, the magnitude, phase, and delay functions are

$$G(\omega) = \left[\frac{H_o^2}{1 + Q^2(\omega/\omega_o - \omega_o/\omega)^2}\right]^{1/2} = \left[\frac{H_o^2 \alpha^2 \omega_o^2 \omega^2}{\omega^4 + \omega^2 \omega_o^2(\alpha^2 - 2) + \omega_o^4}\right]^{1/2}$$

$$\phi(\omega) = \frac{\pi}{2} - \arctan\left(\frac{2Q\omega}{\omega_o} + \sqrt{4Q^2 - 1}\right) - \arctan\left(2Q\frac{\omega}{\omega_o} - \sqrt{4Q^2 - 1}\right)$$

$$\tau(\omega) = \frac{2Q\cos^2\phi}{\omega_o} + \frac{\sin 2\phi}{2\omega}$$

Bandpass 1. There are several configurations of the five elements which may be used to realize a bandpass function. One of the more practical configurations is the one shown in Fig. 8.5. The voltage transfer function is

$$\frac{E_o}{E_1}(s) = \frac{-s(1/R_1C_4)}{s^2 + s(1/R_5)(1/C_3 + 1/C_4) + (1/R_5C_3C_4)(1/R_1 + 1/R_2)}$$

In terms of our bandpass network function

$$H_o = \frac{1}{(R_1/R_5)(1 + C_4/C_3)}$$

$$\omega_o = \left[\frac{1}{R_5C_3C_4}\left(\frac{1}{R_1} + \frac{1}{R_2}\right)\right]^{1/2}$$

$$\frac{1}{Q} = \alpha = \sqrt{\frac{1}{R_5(1/R_1 + 1/R_2)}}\left[\sqrt{\frac{C_3}{C_4}} + \sqrt{\frac{C_4}{C_3}}\right]$$

$$\phi = \pi + \phi_{BP}$$

$$\tau = \tau_{BP}$$

Tuning this filter appears rather formidable. In practice $R_1 \gg R_2$ and so R_2 can be used to trim the Q. Then, to adjust the center frequency, R_2 and R_5 can be simultaneously adjusted by the same percentage with negligible effect on the Q.

From Operational Amplifiers, Graham, Toby, Huelsman