

Band-Pass Filter

A band-pass filter has a pass-band between two cutoff frequencies f_H and f_L such as $f_H > f_L$. Any input frequency outside this pass-band is attenuated.

There are two types of band-pass filters.

1. Wide band pass filter (quality factor $Q > 10$)
2. Narrow band pass filter (quality factor $Q < 10$)

$$\text{Quality factor } Q = f_c / B.W$$

A high-pass response was generated by replacing the term S in the lowpass transfer function with the transformation $1/S$. Likewise, a band-pass characteristic is generated by replacing the S term with the transformation:

$$\frac{1}{\Delta\Omega} \left(s + \frac{1}{s} \right)$$

In this case, the pass band characteristic of a low-pass filter is transformed into the upper pass band half of a band-pass filter. The upper pass band is then mirrored at the mid frequency, f_m ($\Omega=1$), into the lower pass band half.

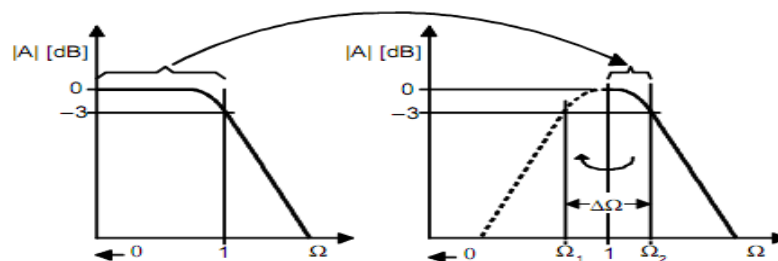


Figure 3.3

The corner frequency of the low-pass filter transforms to the lower and upper -3 dB frequencies of the band-pass, the difference between both frequencies is defined as the normalized bandwidth:

$$\Delta\Omega = \Omega_2 - \Omega_1$$

In analogy to the resonant circuits, the quality factor Q is defined as the ratio of the mid frequency (f_m) to the bandwidth (B):

$$Q = \frac{f_m}{B} = \frac{f_m}{f_2 - f_1} = \frac{1}{\Omega_2 - \Omega_1} = \frac{1}{\Delta\Omega}$$

The simplest design of a band-pass filter is the connection of a high-pass filter and a lowpass filter in series, which is commonly done in wide-band filter applications. Thus, a firstorder high-pass and a first-order low-pass provide a second-order band-pass, while a second-order high-pass and a second-order low-pass result in a fourth-order band-pass response.

In comparison to wide-band filters, narrow-band filters of higher order consist of cascaded second-order band-pass filters that use the Sallen-Key or the Multiple Feedback (MFB) topology.

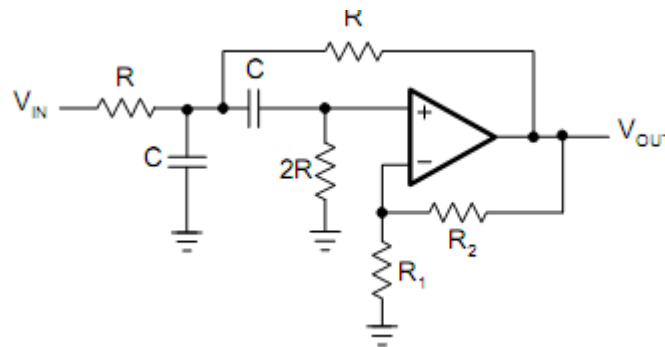


Figure 3.4

$$A(s) = \frac{A_0}{1 + s}$$

$$A(s) = \frac{A_0 \cdot \Delta\Omega \cdot s}{1 + \Delta\Omega \cdot s + s^2}$$

A wide band pass filter can be formed by simply cascading high pass and low pass sections. On the other hand multiple feedback filter is one of the narrow band –pass filter.