**BAND PASS FILTERS**

**Band Pass Filter**

A band-pass filter is a circuit which is designed to pass signals only in a certain band of frequencies while attenuating all signals outside this band. The parameters of importance in a bandpass filter are the high and low cut-off frequencies \( f_H \) and \( f_L \), the bandwidth (BW), the centre frequency \( f_c \), centre-frequency gain, and the selectivity or \( Q \).

There are basically two types of bandpass filters viz wide bandpass and narrow bandpass filters. Unfortunately, there is no set dividing line between the two. However, a bandpass filter is defined as a wide bandpass if its figure of merit or quality factor \( Q \) is less than 10 while the bandpass filters with \( Q > 10 \) are called the narrow bandpass filters. Thus \( Q \) is a measure of selectivity, meaning the higher the value of \( Q \) the more selective is the filter, or the narrower is the bandwidth (BW). The relationship between \( Q \), 3-db bandwidth, and the centre frequency \( f_c \) is given by an equation

For a wide bandpass filter the centre frequency can be defined as where \( f_H \) and \( f_L \) are respectively the high and low cut-off frequencies in Hz. In a narrow bandpass filter, the output voltage peaks at the centre frequency \( f_c \).

**Wide Bandpass Filter**

![Circuit Diagram](www.CircuitsToday.com)
A wide bandpass filter can be formed by simply cascading high-pass and low-pass sections and is generally the choice for simplicity of design and performance though such a circuit can be realized by a number of possible circuits. To form a ± 20 db/decade bandpass filter, a first-order high-pass and a first-order low-pass sections are cascaded; for a ± 40 db/decade bandpass filter, second-order high-pass filter and a second-order low-pass filter are connected in series, and so on. It means that, the order of the bandpass filter is governed by the order of the high-pass and low-pass filters it consists of.

A ± 20 db/decade wide bandpass filter composed of a first-order high-pass filter and a first-order low-pass filter, is illustrated in fig. (a). Its frequency response is illustrated in fig. (b).

Narrow Bandpass Filter.
A narrow bandpass filter employing multiple feedback is depicted in figure. This filter employs only one op-amp, as shown in the figure. In comparison to all the filters discussed so far, this filter has some unique features that are given below.

1. **It has two feedback paths, and this is the reason that it is called a multiple-feedback filter.**
2. **The op-amp is used in the inverting mode.**

The frequency response of a narrow bandpass filter is shown in fig(b).

Generally, the narrow bandpass filter is designed for specific values of centre frequency \( f_c \) and Q or \( f_c \) and BW. The circuit components are determined from the following relationships. For simplification of design calculations each of \( C_1 \) and \( C_2 \) may be taken equal to \( C \).

\[
\begin{align*}
R_1 &= \frac{Q}{2\pi f_c} CA_f \\
R_2 &= \frac{Q}{2\pi f_c} C(2Q^2 - A_f) \\
\text{and } R_3 &= \frac{Q}{\pi f_c} C
\end{align*}
\]

where \( A_f \) is the gain at centre frequency and is given as

\[
A_f = \frac{R_3}{2R_1}
\]

The gain \( A_f \) however must satisfy the condition \( A_f < 2Q^2 \).

The centre frequency \( f_c \) of the multiple feedback filter can be changed to a new frequency \( f_c' \) without changing, the gain or bandwidth. This is achieved simply by changing \( R_2 \) to \( R_2' \) so that

\[
R_2' = R_2 \left(\frac{f_c}{f_c'}\right)^2
\]