FILTERS

Subject Name: Electrical Fundamentals

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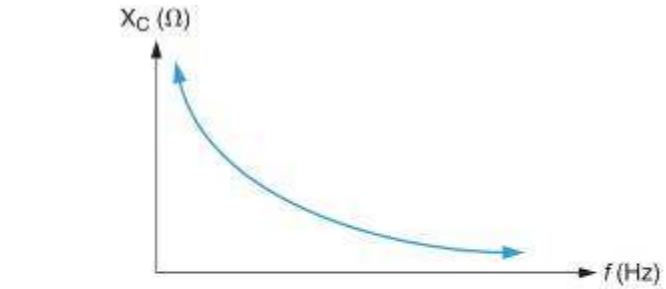
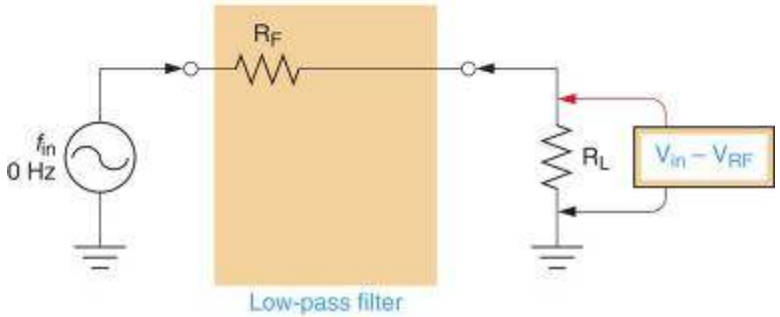
LOW PASS FILTER (LPF)

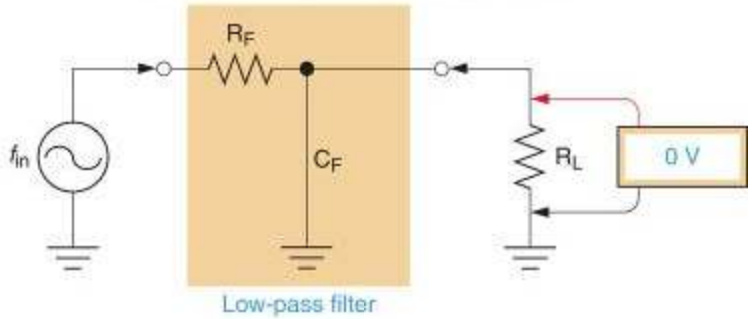
low-pass filter (LPF) is a filter that passes signals with a frequenc
lower than a selected cutoff frequency and attenuates signals witl
frequencies higher than the cutoff frequency. The exact frequenc
response of the filter depends on the filter design. The filter i
sometimes called a high-cut filter, or treble-cut filter in audi
applications. A low-pass filter is the complement of a high-pass filter.



(a) Capacitive reactance vs. frequency

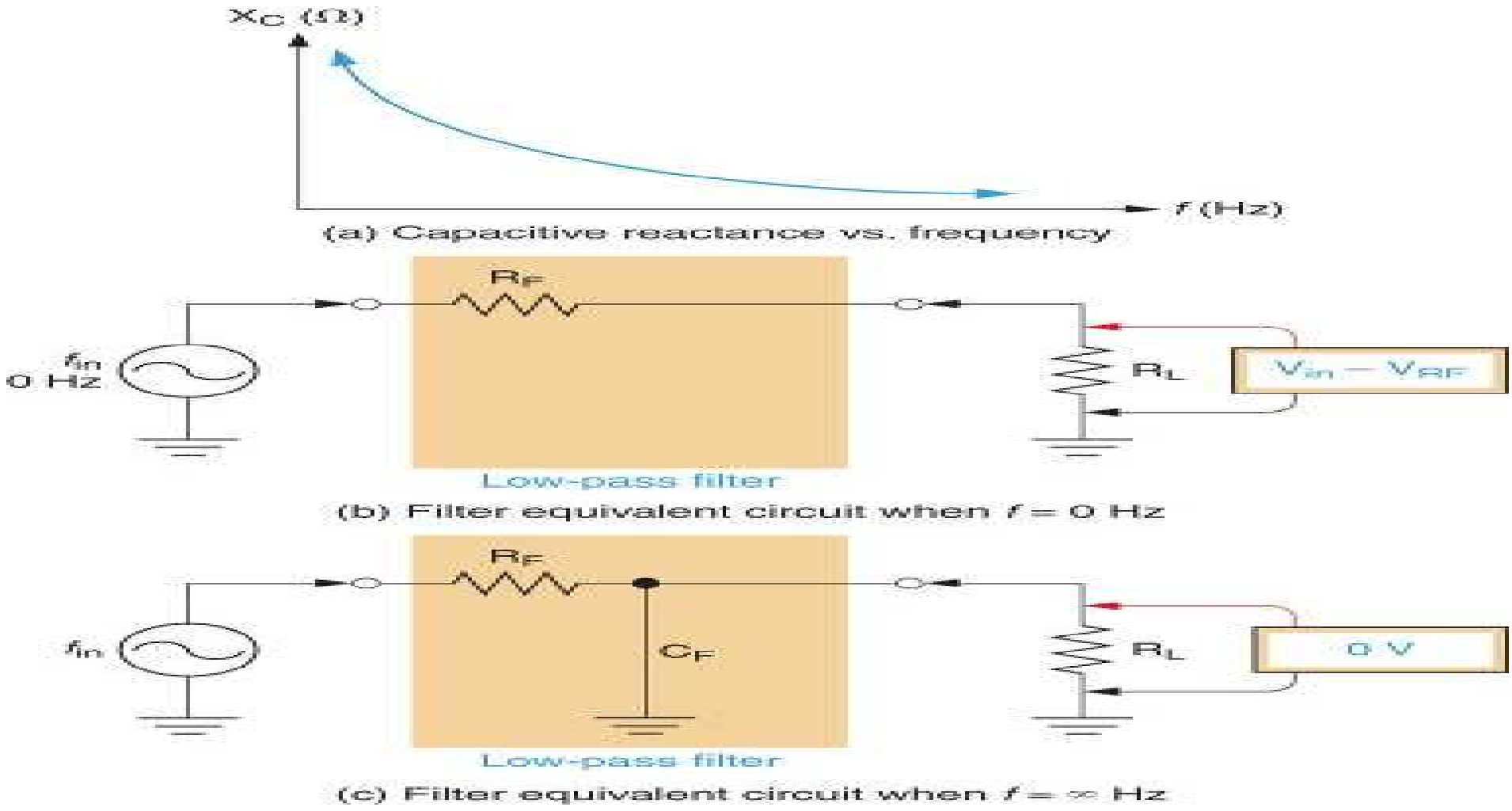


(b) Filter equivalent circuit when $f = 0$ Hz

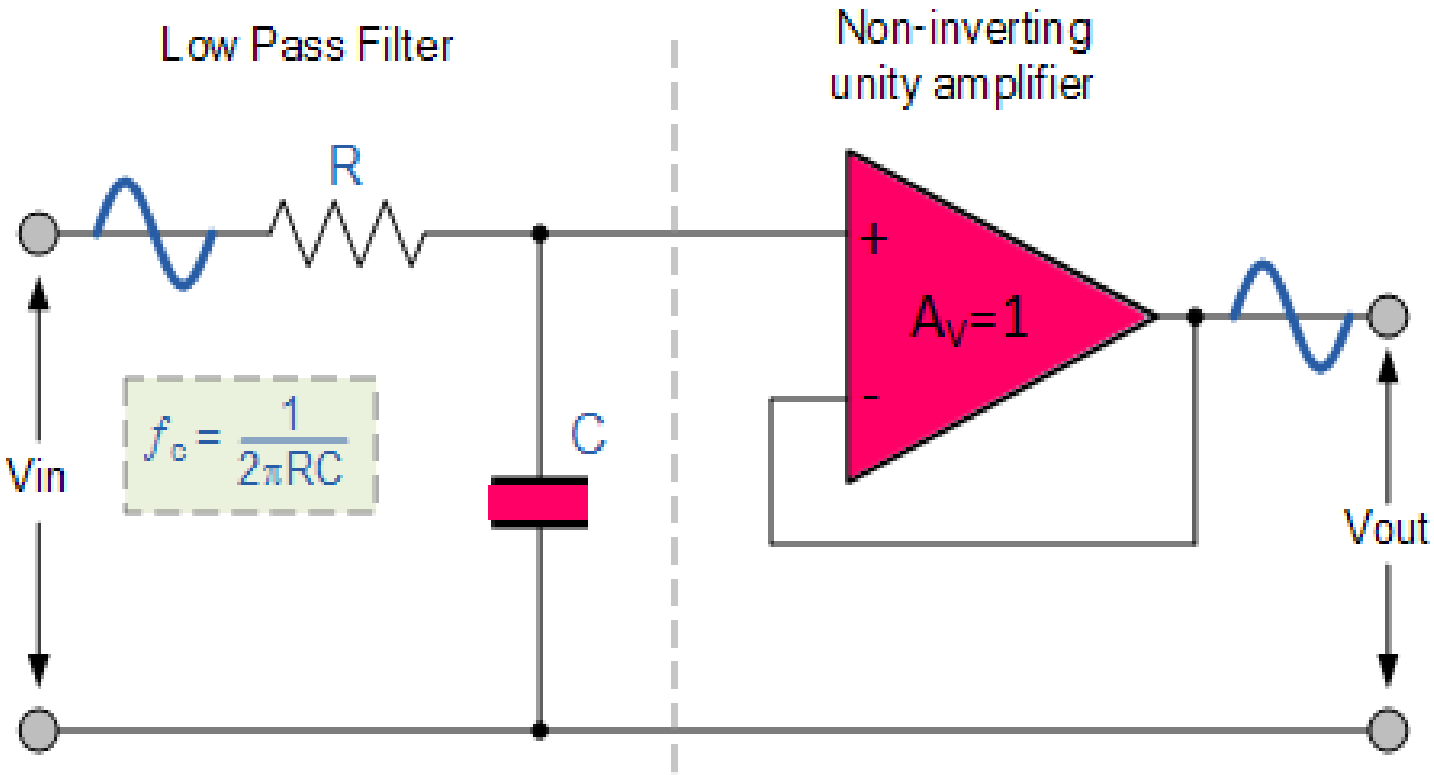


(c) Filter equivalent circuit when $f = \infty$ Hz

EFFECT OF LOW PASS FILTER

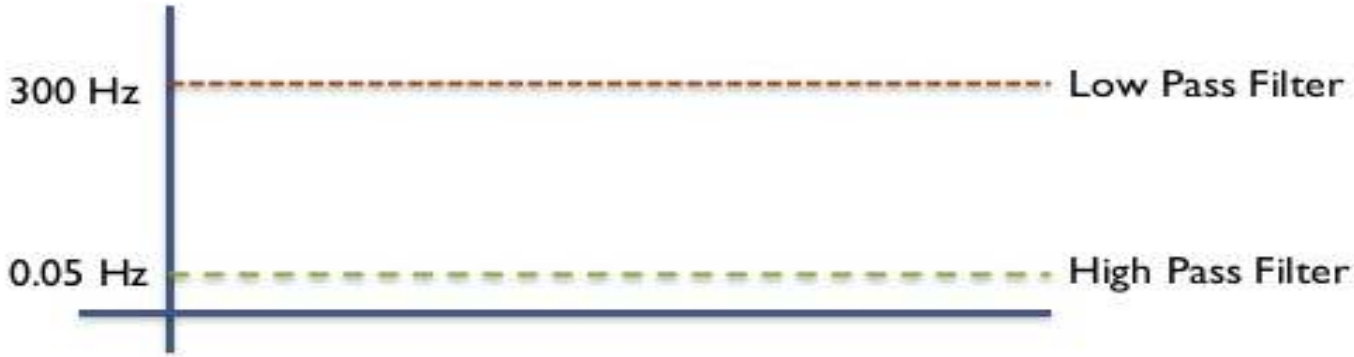


APPLICATION OF LOW PASS FILTER

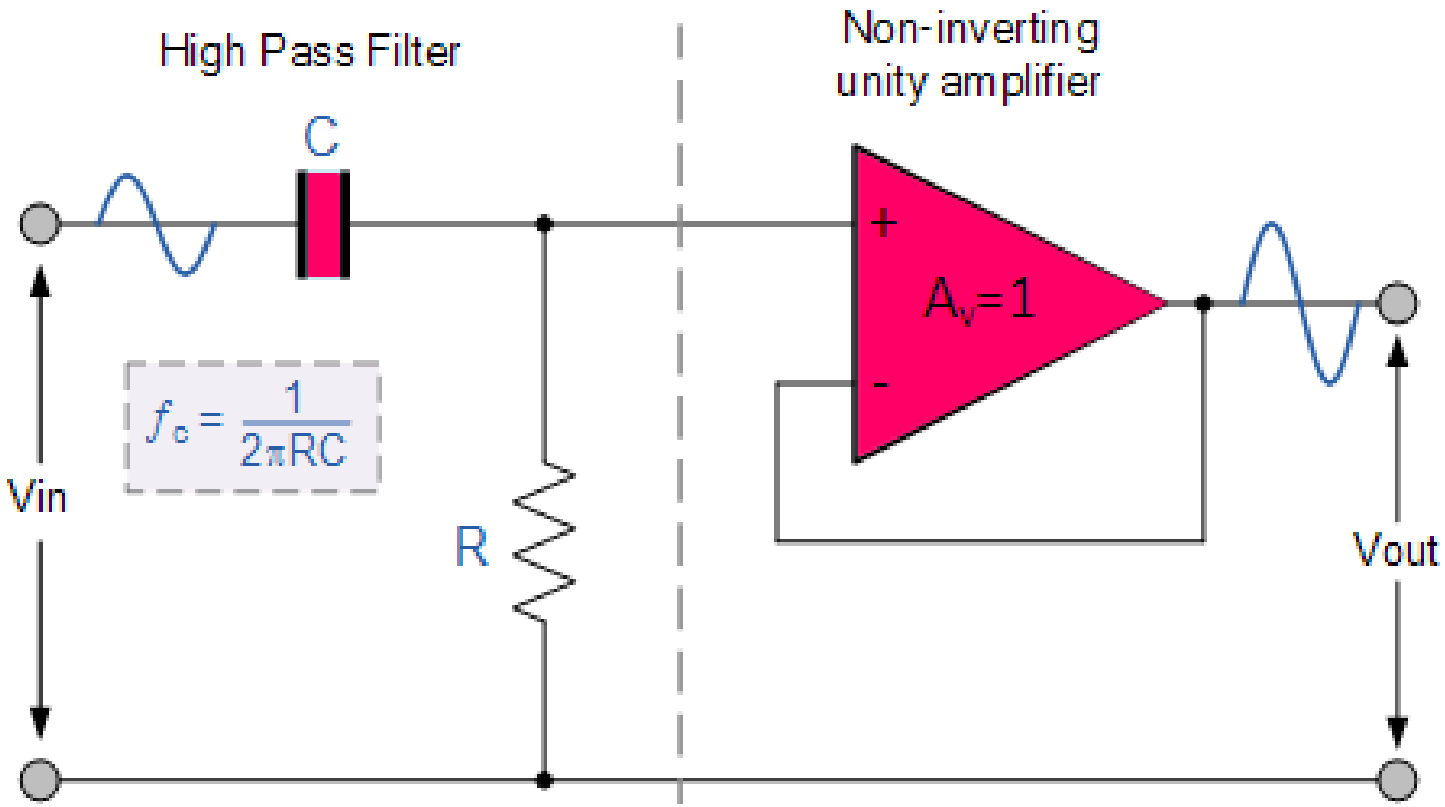


Application of Filters

Signal Type	High Pass Filter	Low Pass Filter
Surface ECG	0.5Hz	100Hz
Intracardiac Bipolar	30Hz	300Hz
Intracardiac Unipolar	1-2Hz	300Hz
Unfiltered Unipolar	0.1Hz (or no high pass)	300Hz



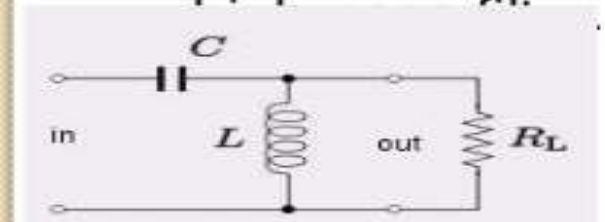
HIGH PASS FILTER



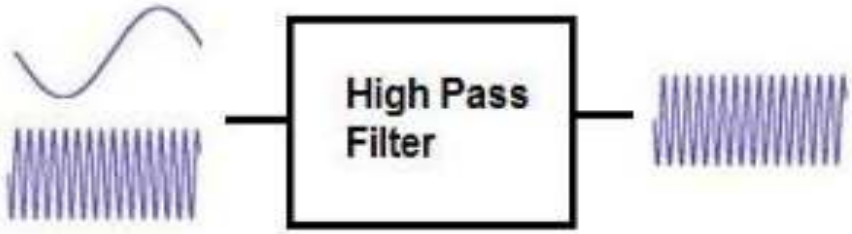
HIGH PASS FILTER

High-pass filter

- A high pass filter is a filter which passes high-frequency signals and blocks, or impedes, low-frequency signals.
- In other words, high-frequency signals go through much easier and low-frequency signals have a much harder getting through, which is why it's a



RLC circuit as a high-pass filter



Active High Pass Filter

Active High Pass Filter as its name implies, attenuates low frequencies and passes high frequency signals.

The basic operation of an **Active High Pass Filter** (HPF) is same as that of a passive high pass filter circuit, however the active high pass filter circuit has an operational amplifier or op-amp included in its design to provide amplification and gain control.

The simplest form of an *active high pass filter* is designed by connecting a standard inverting or non-inverting operational amplifier to the basic RC high pass passive filter circuit as shown below .

It consists of a passive filter section followed by a non-inverting operational amplifier.
The frequency response of the circuit is the same as that of the passive filter, except that the amplitude of the signal is increased by the gain of the amplifier.
for a non-inverting amplifier the magnitude of the voltage gain is given as a function of the feedback resistor (R2) divided by its corresponding input resistor (R1) i.e. 1 + R2/R1, the same as for the active low pass filter circuit.
Hence, the gain for an Active High Pass Filter is given as :

Where:
A_F = Pass band Gain of the filter= (1 + R2/R1)
f = the Frequency of the Input Signal in Hz
fc = the Cut-off Frequency in Hz

The operation of a high pass active filter can be verified from the frequency gain equatio
bove as:

. At very low frequencies, $f < fc$

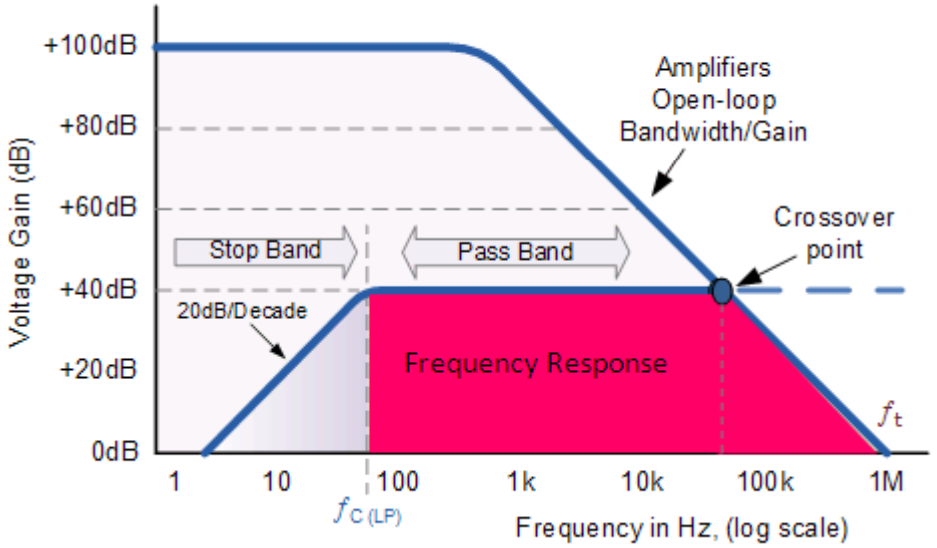
. At the cut-off frequency, $f = fc$

. At very high frequencies, $f > fc$

Therefore, the **Active High Pass Filter** has a gain A_F that increases from 0 Hz t
he low cutoff frequency point, f_C at 20dB/decade as the frequency increases.

At f_C the gain is $0.707A_F$ and after f_C all frequencies are pass band frequencies s
he filter has a constant gain A_F with the highest frequency being determined by th
losed loop bandwidth of the op-amp

Frequency response curve



The maximum pass band frequency response of an active HPF i limited by the open-loop characteristics or bandwidth of th operational amplifier being used.

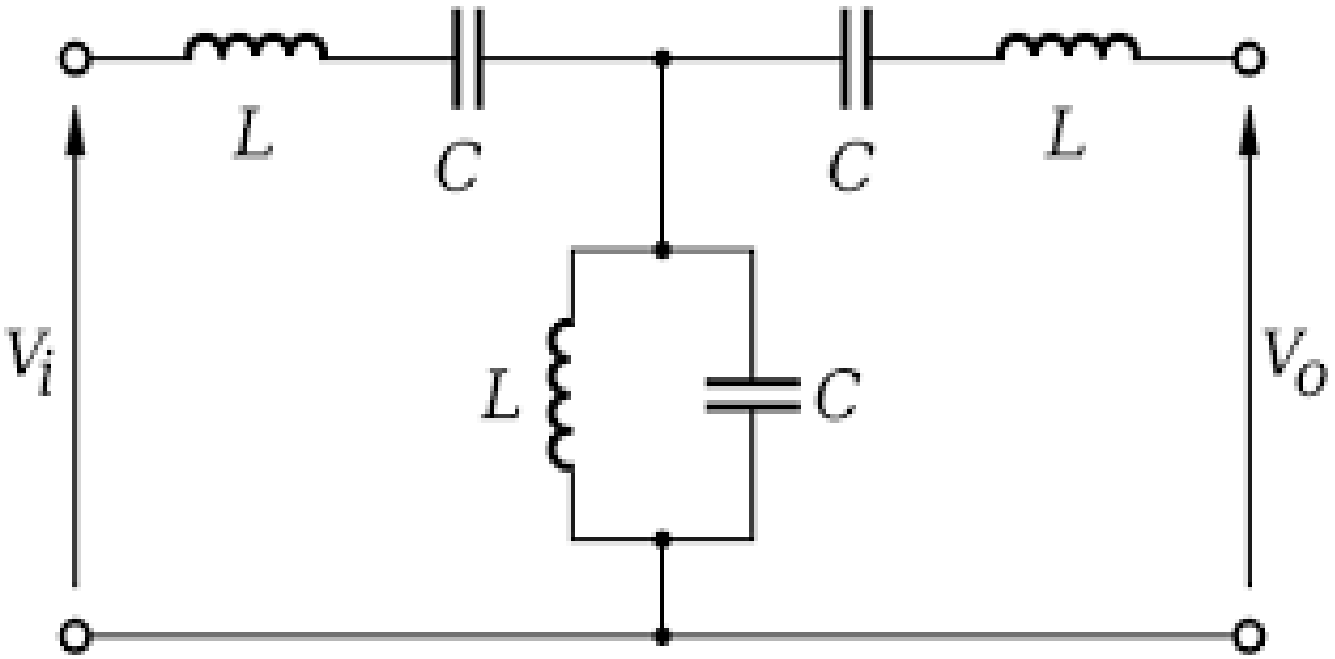
In our Operational amplifier tutorial we saw that the maximun frequency response of an op-amp is limited to the Gain/Bandwidt product or open loop voltage gain (A_V) of the operational amplifie being used giving it a bandwidth limitation, where the closed loo response of the op amp intersects the open loop response.

What is Band Pass Filter?

The **definition of the band pass filter is** a circuit which permits the signals to flow among two particular frequencies, although divides these signals at other frequencies. These filters are available in different types; some of the BPF-**band pass filter design** can be done with an external power as well as active components such as integrated circuits, transistors, which are named as an **active band pass filter**. Similarly, some of the filters use any kind of power source as well as passive components like capacitors and inductors, which are named as a passive band pass filter.

The best example of a **band pass filter circuit** is the RLC circuit that i
shown below. This filter can also be designed by uniting an LPF and
HPF. In BPF, Bandpass illustrates a kind of filter otherwise procedure
of filtering. It is to be differentiated from passband that refers to the
real section of the influenced spectrum. An idyllic bandpass filte
doesn't have gain and attenuation, so it is totally level passband. Tha
will totally attenuate every one of frequencies exterior the passband.

Band pass filter circuit



Different Types of Band Pass Filters

The categorization of the bandpass filter can be done in two type such as wide bandpass filter as well as **narrow band pass filter**.

Band Pass Filter Applications

The applications of bandpass filters include the following.

These filters are extensively applicable to wireless transmitters & receivers.

This filter can be used to optimize the S/N ratio (signal-to-noise) as well as th compassion of a receiver.

The main purpose of the filter in the transmitter is to limit the BW of the outpu signal to the selected band for the communication.

BPFs are also widely used in optics such as **LIDARS,** lasers, etc.

The best application of this filter is audio signal processing, wherever a specifi range of sound frequencies is necessary though removing the rest.

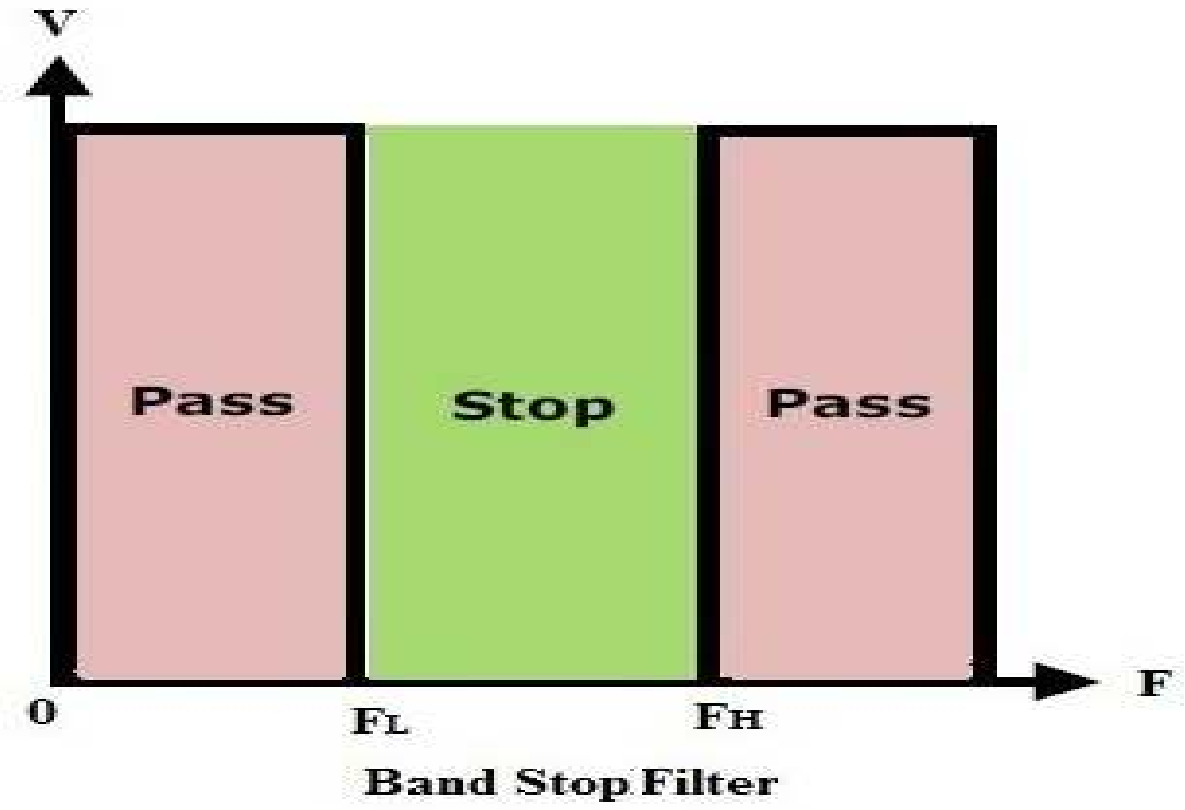
These filters are applicable in sonar, instruments, medical, and **Seismolog** applications

These filters involve **communication systems** for choosing a particular signal fron a variety of signals

Band stop filter

The band stop filter is formed by the combination of low pass and high pass filters with a parallel connection instead of cascading connection. The name itself indicates that it will stop a particular band of frequencies. Since it eliminates frequencies, it is also called a band elimination filter or band reject filter or notch filter. We know that unlike high pass and low pass filters, band pass and band stop filters have two cut-off frequencies. It will pass above and below a particular range of frequencies whose cut off frequencies are predetermined depending upon the value of the components used in the circuit design. Any frequencies in between these two cut-off frequencies are attenuated. It has two pass bands and one stop band. The ideal characteristics of the Band pass filter are as shown below:

Band stop filter



Band Stop Filter

Where f_L indicates the cut off frequency of the low pass filter

f_H is the cut off frequency of the high pass filter.

The center frequencies $fc = \sqrt{(f_L \times f_H)}$

The characteristics of a band stop filter are exactly opposite of the band pass filter characteristics.

When the input signal is given, the low frequencies are passed through the low pass filter in the band stop circuit and the high frequencies are passed through the high pass filter in the circuit. This is shown in below block diagram.

In practical, due to the capacitor switching mechanism in the high pass and low pass filter the output characteristics are not same as that of in the ideal filter. The pass band gain must be equal to low pass filter and high pass filter. The frequency response of band stop filter is shown below and green line indicates the practical response in the below figure.