LOW PASS FILTER

An Active Low Pass Filter Circuit is a passive RC low pass filter section but uses an operational amplifier as its active device for voltage amplification and gain

LOW PASS FILTER USES OP-AMPS FOR VOLTAGE GAIN

Active filters such as the **Active Low Pass Filter** circuit, are RC filter circuits that use along with some resistors and capacitors, an operational amplifier (op-amp) as the their main amplifying device to provide voltage gain as well as greater control and filter performance in the low frequency passband.

Basic first-order passive RC filter circuits, such as a low pass or a high pass filter, can be constructed using just a single resistor in series with a non-polarized capacitor connected across a sinusoidal input signal.

The main disadvantage of passive RC filters is that the amplitude of the output signal is less than that of the input signal. That is, their gain can never be greater than 1 (unity), and that load impedance affects the filters characteristics.

With passive filter circuits containing multiple stages, this loss in signal amplitude called “Attenuation” can become quiet severe. One way of restoring or controlling this loss of signal is by using amplification through the use of Filters.

As their name implies, Filters contain active components such as operational amplifiers, transistors or FET’s within their circuit design. They draw their power from an external power source and use it to boost or amplify the output signal.

Filter amplification can also be used to either shape or alter the frequency response of the filter circuit by producing a more selective output response, making the output bandwidth of the filter more narrower or even wider. Then the main difference between a "passive filter" and an "active filter" is amplification.

An active filter generally uses an operational amplifier (op-amp) within its design and in the Operational Amplifier tutorial we saw that an Op-amp has a high input impedance, a low output impedance and a voltage gain determined by the resistor network within its feedback loop.

Unlike a **passive high pass filter** which has in theory an infinite high frequency response, the maximum frequency response of an active filter is limited to the Gain/Bandwidth product (or open loop gain) of the operational amplifier being used.

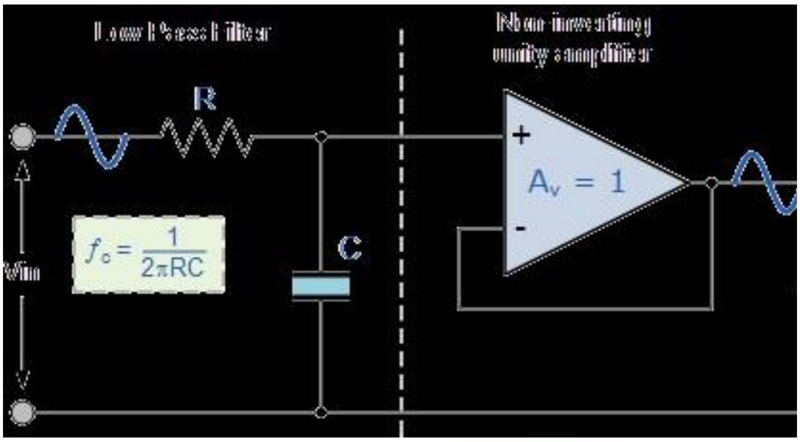
Still, active filters are generally much easier to design than passive filters. They produce good performance characteristics, very good accuracy with a steep roll-off and low noise when used with a good circuit design.

The Low Pass Filter

The most common and easily understood active filter is the **Low Pass Filter**. Its principle of operation and frequency response is exactly the same as those for the previously seen passive filter. The only difference this time is that it uses an op-amp for amplification and gain control.

The simplest form of an *active low pass filter* is to connect either an inverting or non-inverting operating amplifier configuration to the basic RC low-pass filter circuit as shown.

First Order Low Pass Filter



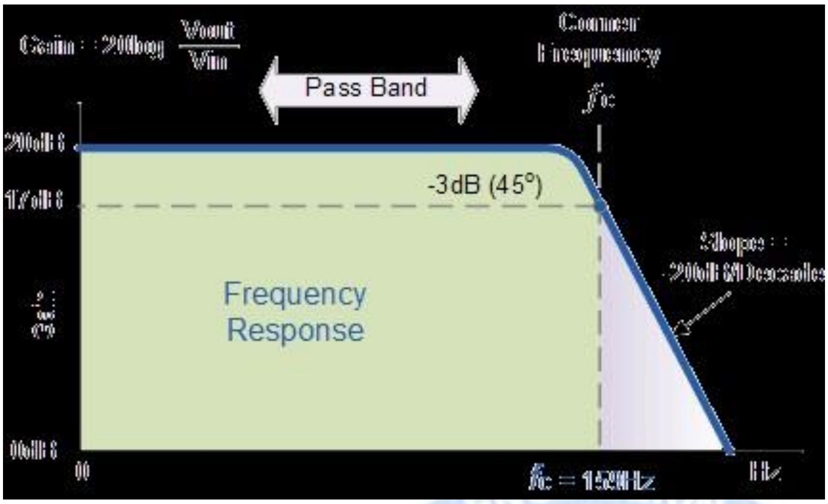
This 1st-order low pass active filter, consists simply of a passive RC filter stage providing a low frequency path to the input of a non-inverting operational amplifier.

The operational amplifier is configured as a voltage-follower (Buffer) giving it a DC gain of one. That is: Av = +1 or unity gain. Unlike the previous passive RC filter which has a DC gain of less than unity.

The advantage of this configuration is that the op-amps high input impedance prevents excessive loading on the filters output while its low output impedance prevents the filters cut-off frequency point from being affected by changes in the impedance of the load.

While this configuration provides good stability to the filter, its main disadvantage is that it has no voltage gain greater than one. However, although the voltage gain is unity the power gain is very high as its output impedance is much lower than its input impedance. If a voltage gain greater than one is required we can use the following filter circuit.

Frequency Response Curve



If the external impedance connected to the input of the filter circuit changes, this impedance change would also affect the corner frequency of the filter (components connected together in series or parallel).

One way of avoiding any external influence is to place the capacitor in parallel with the feedback resistor R2 effectively removing it from the input but still maintaining the filters characteristics.

However, the value of the capacitor will change slightly from being 100nF to 110nF to take account of the 9k1Ω resistor. But the formula used to calculate the cut-off corner frequency is the same as that used for the RC passive low pass filter.

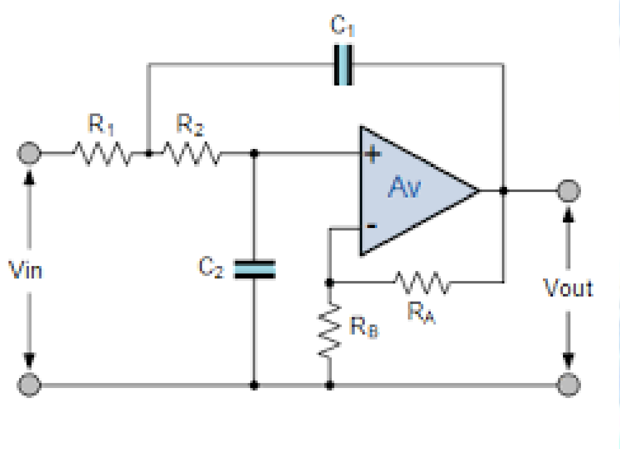
$$fc = \frac{1}{2\pi C R_2} \ Hertz$$

Second-order Low Pass Active Filter

As with the passive filter, a first-order low-pass active filter can be converted into a second-order low pass filter simply by using an additional RC network in the input path.

The frequency response of the second-order low pass filter is identical to that of the first-order type except that the stop band roll-off will be twice the first-order filters at 40dB/decade (12dB/octave). Therefore, the design steps required of the second-order active low pass filter are the same.

Second-order Low Pass Filter Circuit



When cascading together filter circuits to form higher-order filters, the overall gain of the filter is equal to the product of each stage. For example, the gain of one stage may be 10 and the gain of the second stage may be 32 and the gain of a third stage may be 100. Then the overall gain will be 32,000, (10 x 32 x 100).