Filters

What Is a Filter?

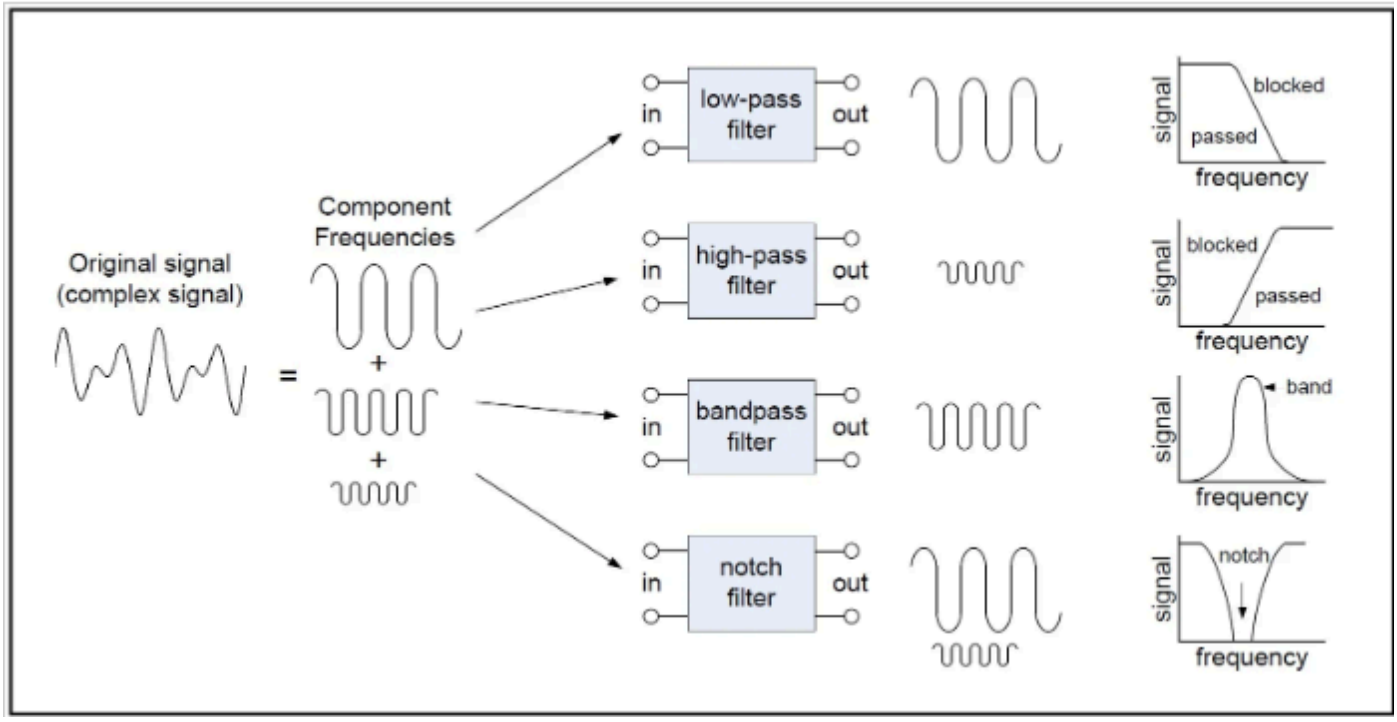
A filter is a circuit capable of passing (or amplifying) certain frequencies while attenuating other frequencies. Thus, a filter can extract important frequencies from signals that also contain undesirable or irrelevant frequencies.

In the field of electronics, there are many practical applications for filters. Examples include:

- **Radio communications**: Filters enable radio receivers to only "see" the desired signal while rejecting all other signals (assuming that the other signals have different frequency content).
- **DC power supplies**: Filters are used to eliminate undesired high frequencies (i.e., noise) that are present on AC input lines. Additionally, filters are used on a power supply's output to reduce ripple.
- **Audio electronics:** A crossover network is a network of filters used to channel low-frequency audio to woofers, mid-range frequencies to midrange speakers, and high-frequency sounds to tweeters.
- **Analog-to-digital conversion**: Filters are placed in front of an ADC input to minimize **aliasing (https://www.allaboutcircuits.com/technical-articles/understanding-analog-to-digital-converters-deciphering-resolution-and-sampl/)** .

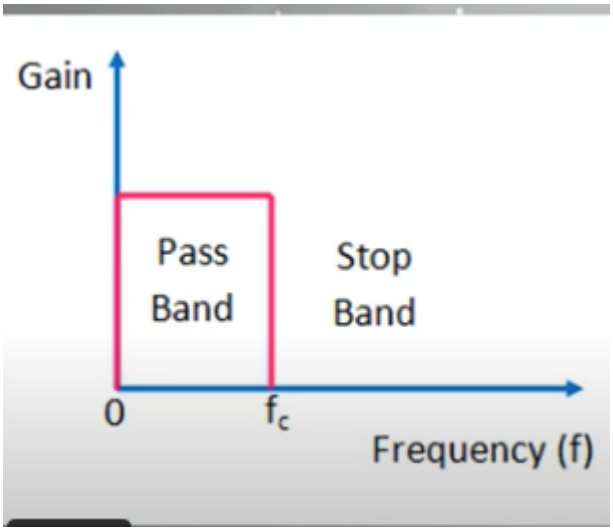
Four Major Types of Filters

The four primary types of filters include the **low-pass filter (https://www.allaboutcircuits.com/textbook/alternating-current/chpt-8/low-pass-filters/)** , the **high-pass filter (https://www.allaboutcircuits.com/textbook/alternating-current/chpt-8/high-pass-filters/)** , the **band-pass filter (https://www.allaboutcircuits.com/textbook/alternating-current/chpt-8/band-pass-filters/)** , and the notch filter (or the band-reject or **band-stop filter (https://www.allaboutcircuits.com/textbook/alternating-current/chpt-8/band-stop-filters/)**).



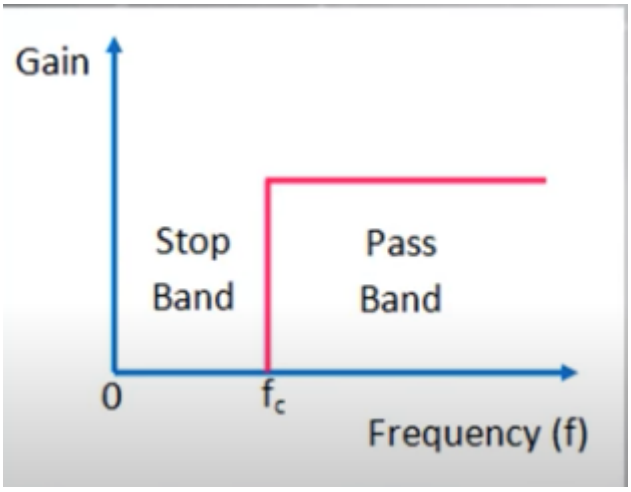
Low-Pass Filters

The voltage gain ie the ratio of output voltage to input voltage is constant over a frequency range from 0 to cutoff frequency fc



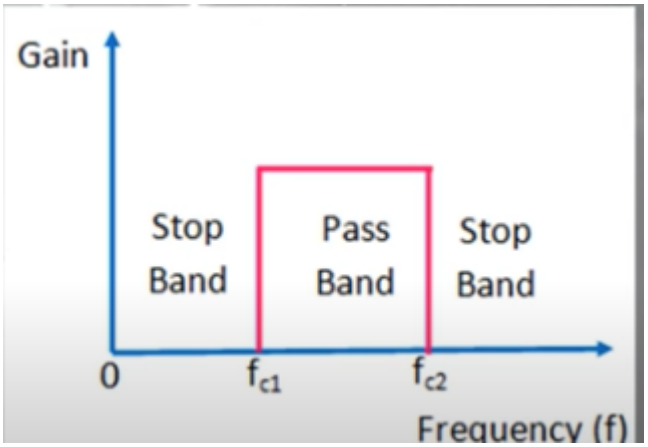
High pass filters

Has a zero-gain starting from 0 to to a frequency fc, called the cut off frequency, and above this frequency, the gain is constant.



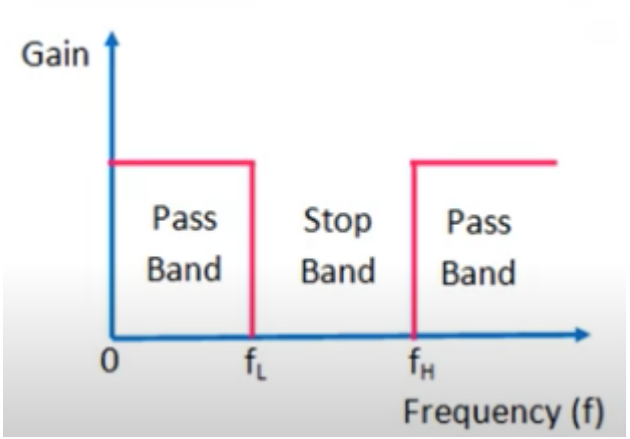
Ideal Band pass filter

When the filter circuit passes signals that are above one cutoff frequency and below a second cutoff frequency, Bandwidth is equal to fc2 - fc1.



Ideal Band Stop Filter

It has a band stop between two cut off frequencies fc2 and fc1 and two pass bands 0 <f <fc1 and fc2 < f. This is also called band elimination or notch filter



Passive and Active Filters

Filters can be placed in one of two categories: *passive* or *active*.

Passive filters include only passive components—**resistors** (https://www.allaboutcircuits.com/textbook/direct-current/chpt-2/resistors/) , **capacitors** (https://www.allaboutcircuits.com/textbook/direct-current/chpt-13/practical-considerations-capacitors/) , and **inductors** (https://www.allaboutcircuits.com/textbook/direct-current/chpt-15/inductors-and-calculus/) . In contrast, **active filters** (https://www.allaboutcircuits.com/technical-articles/inductor-out-op-amp-in-an-introduction-to-second-order-active-filters/) use active components, such as **op-amps** (https://www.allaboutcircuits.com/textbook/semiconductors/chpt-8/op-amp-practical-considerations/) , in addition to resistors and capacitors, but not inductors.

Passive filters are most responsive to a frequency range from roughly 100 Hz to 300 MHz. The limitation on the lower end results from the fact that the inductance or capacitance would have to be quite large at low frequencies. The upper-frequency limit is due to the effect of parasitic capacitances and inductances. Careful design practices can extend the use of passive circuits well into the gigahertz range.

Active filters are capable of dealing with very low frequencies (approaching 0 Hz), and they can provide voltage gain (passive filters cannot). Active filters can be used to design high-order filters without the use of inductors; this is important because inductors are problematic in the context of integrated-circuit manufacturing techniques. However, active filters are less suitable for very high-frequency applications because of amplifier bandwidth limitations. Radio-frequency circuits must often utilize passive filters.

Links

https://www.youtube.com/watch?v=8IdCYjax5VI