



1 What is a passive filter?

Filters are a type of circuit which modifies an input to remove certain frequencies - for example removing high pitched noise from a piece of audio or separating voice and data signals on a phone line. Passive filters use only passive (unpowered) components, such as resistors, capacitors and inductors. These circuits can only reduce the strength of a signal, not amplify it.

The examples on this worksheet will be based on resistors and capacitors - these can be referred to as RC-filters.

2 Low pass filters

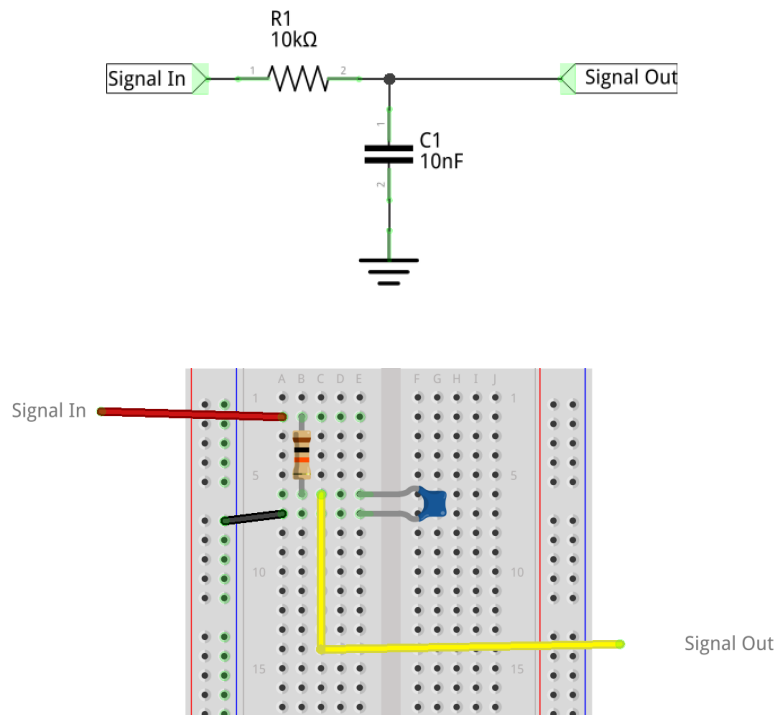


Figure 1: A low pass filter schematic (top) and example on a breadboard (bottom)

Low pass filters reduce the amplitude of high frequency components of a signal. The circuit shown in figure 1 can be considered as a potential divider, but instead of the output voltage depending on the ratio of two resistors, it depends on the voltage across the capacitor. At low frequencies, the capacitor C_1 has time to charge and the voltage at the output can rise towards the value of the input voltage, while at high frequencies the capacitor doesn't have time to charge and the voltage at the output will be lower.

The cut-off frequency f_0 of this sort of filter can be calculated as follows:

$$f_0 = \frac{1}{2\pi R_1 C_1} \quad (1)$$

The cut-off frequency marks the point at which the output power has dropped to half the original value - or $3dB$.

The response of an electronic filter is typically plotted as G vs $\log f$, with G being the gain of the filter - $\frac{V_{in}}{V_{out}}$. An example plot is shown in figure 2.

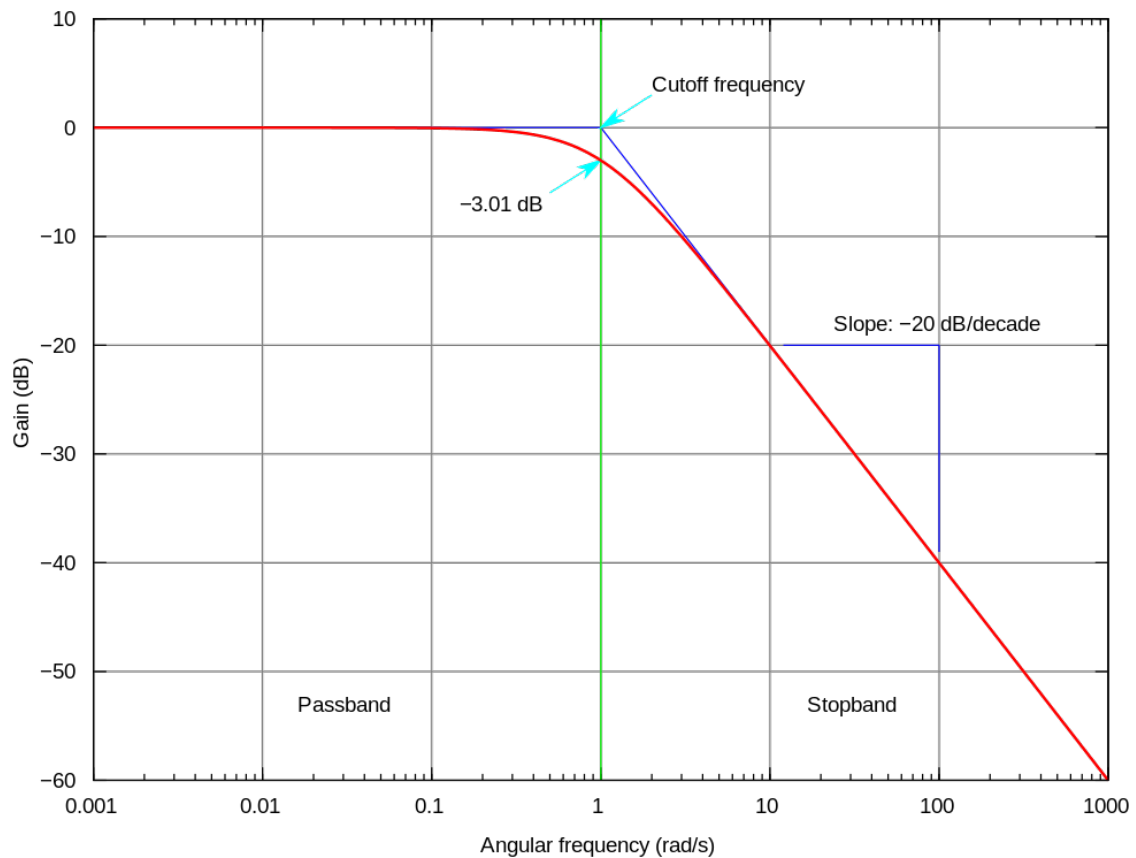


Figure 2: Example low pass filter response, taken from https://commons.wikimedia.org/wiki/File:Butterworth_response.svg

2.1 Build

Build a low pass filter with $R_1 = 10k\Omega$ and $C_1 = 10nF$

- What will the cut-off frequency be? _____

To test your circuit, use a signal generator and an oscilloscope.

Using the example breadboard layout from figure 1, connect the red "Signal In" wire to the positive output of the signal generator and the ground connector of the signal generator to the black wire.

You can then connect the probe of an oscilloscope to the yellow "Signal Out" wire and measure the output voltage. Compare the output voltage at different frequencies.

Warning: Do not exceed the input voltage for the oscilloscope!

3 High Pass Filters

A high pass filter acts in the same manner as a low pass filter, but allows high frequencies through and reduces the strength of lower frequencies.

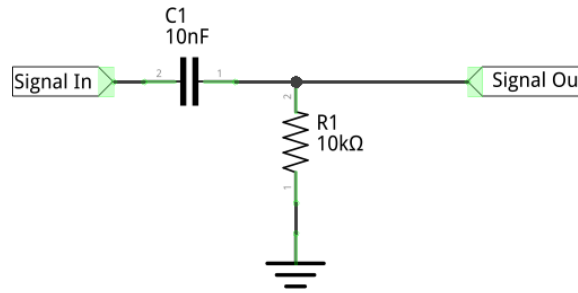


Figure 3: A high pass filter schematic

The cut-off frequency is calculated in the same way as for a low pass filter.

4 Band Pass Filters

A band pass filter acts on both high and low frequency components of a signal, allowing frequencies within a certain range to pass through. The high and low pass components can have the same cut-off frequency, or can be offset.

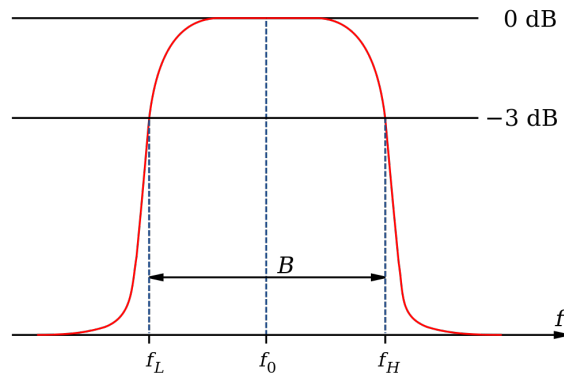


Figure 4: Example band pass filter response

The quality or Q factor of a filter represents how narrow its response is - the narrower the response of the filter, the more frequencies it removes from the input signal. The Q factor can be calculated as the ratio of the centre frequency, f_0 and the bandwidth (Δf , or B in figure 4):

$$Q = \frac{f_0}{\Delta f} \quad (2)$$