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PHY366 Lab Report
Practical(s): 4 & 5   Registration No.: 11912610   Section: G2903

Aim

To study the low-pass, high-pass, band-pass and band-reject active filters.

Methods

We simulate our operational amplifier circuit on the MultiSim platform. In this section, we quickly summarize the circuit schematics and in Results and Discussion, we discuss the frequency response received and how that compares with expectations.

For simplicity, in both high and low-pass filters, we have consistently used $R = 1k\Omega$ and $C = 1\mu F$. This configuration corresponds to a cutoff frequency of $f_c = 159.2$ Hz.

Low Pass Filter

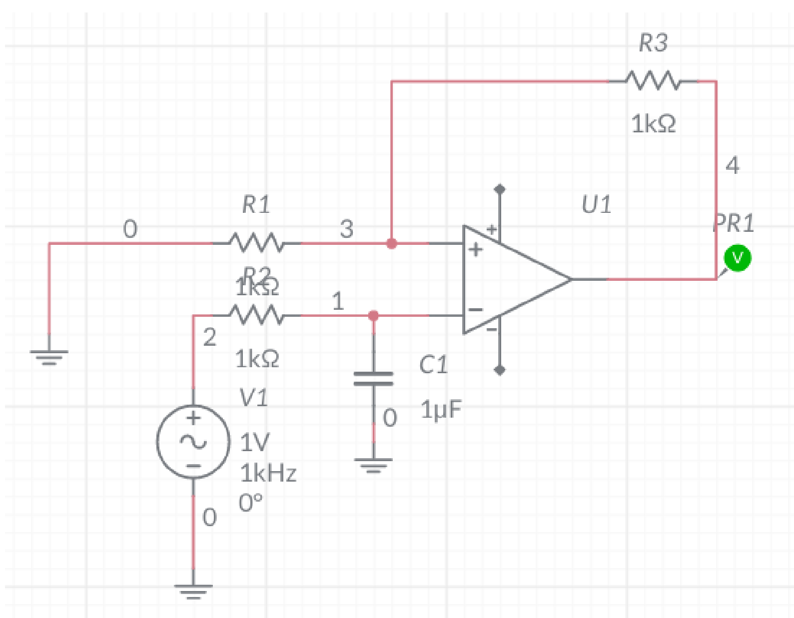


Figure 1: Low-pass filter circuit

High Pass Filter

The high-pass filter circuit illustrated in Figure 2 is available publicly at https://www.multisim.com/content/krAnsJD3FhLvUGbCkkjTk8/low-pass-filter/open/.

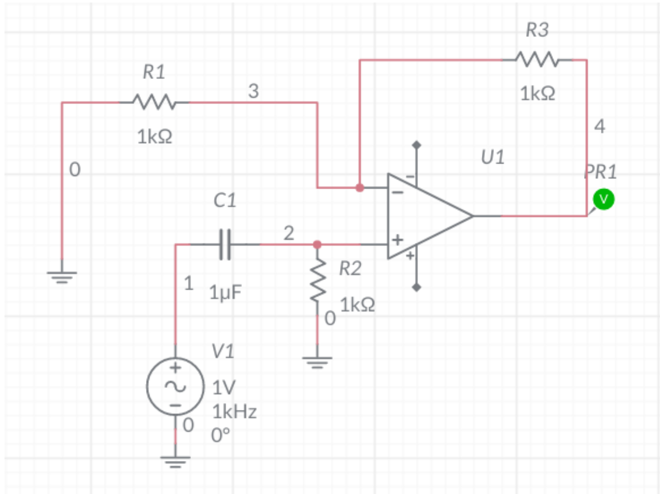
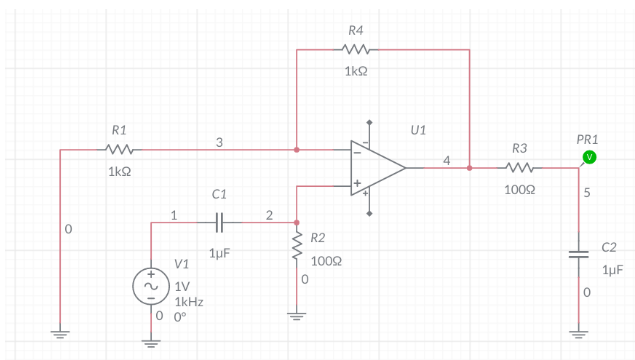


Figure 2: High pass filter circuit

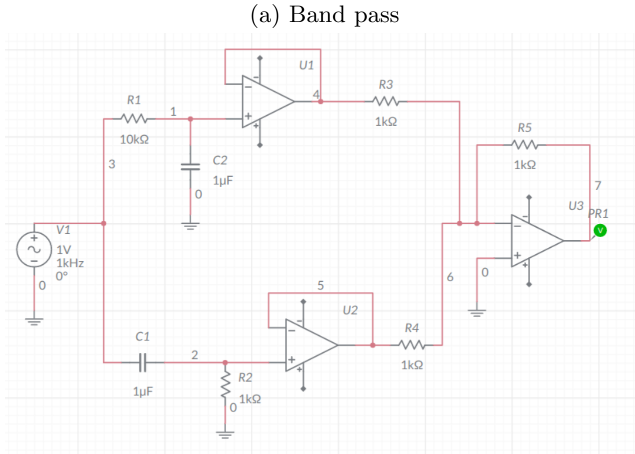
Band Pass Filter

We configured the filter such that the maxima occurs at 1.59 kHz (as opposed to 159.2 Hz in previous cases). Circuit available at https://www.multisim.com/content/GL9t3YLGo2bemhTcSeW6Qn/band-pass-filter/open/.

Band Reject Filter



(a) Band pass

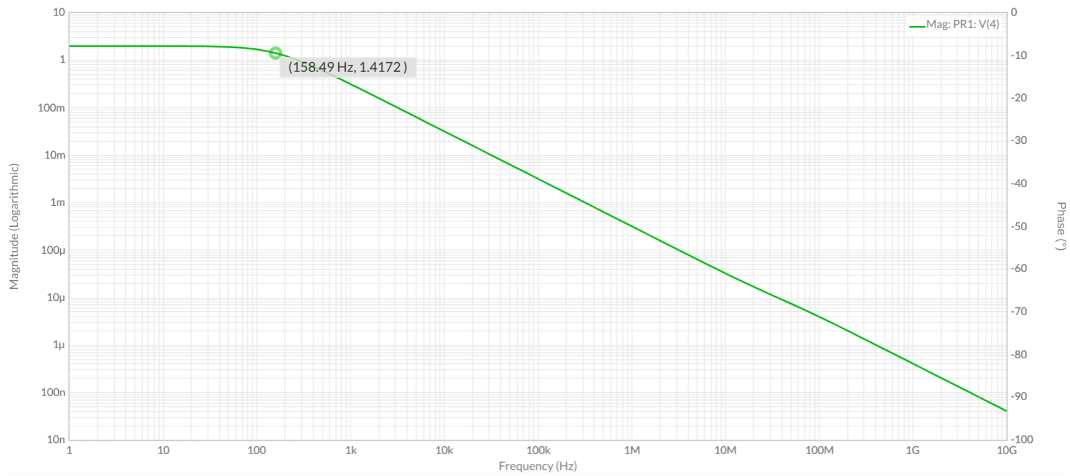


(b) Band reject

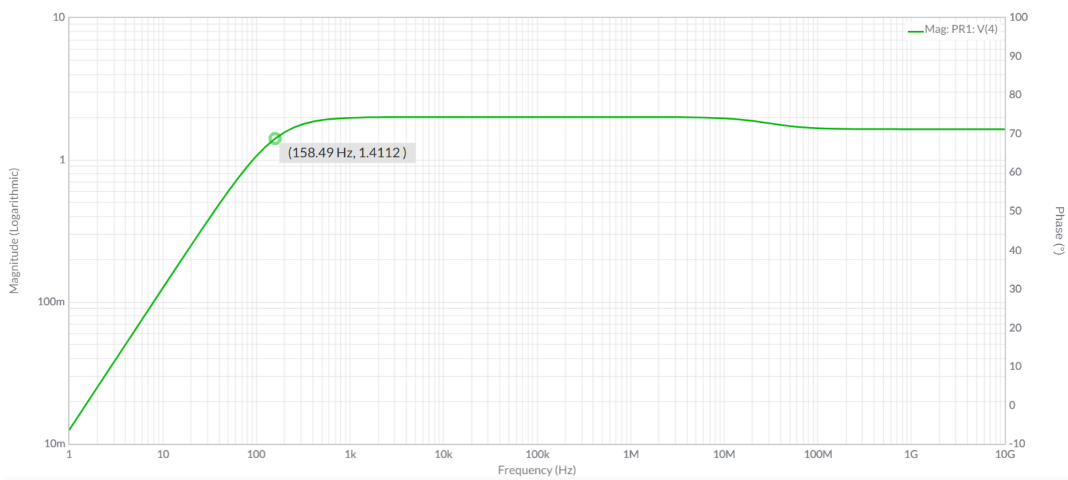
Figure 3: Band pass and reject filters

Results and Discussion

We show the frequency response profile we obtained for the high and low pass filters in Figure 4. The important features of these circuits can be understood based on the following fashion:



(a) Low-pass filter frequency response



(b) High-pass filter frequency response

Figure 4: Frequency response of high- and low-pass filter circuits.

We expect a low pass filter to allow lower frequencies unimpeded while higher ones get attenuated. The characteristic frequency beyond which the attenuation starts to become significant is the *cutoff frequency*. For a low-pass filter circuit

$$V_o = \frac{V_{in}}{\sqrt{\left(\frac{f}{f_{cl}} + 1\right)^2}}$$

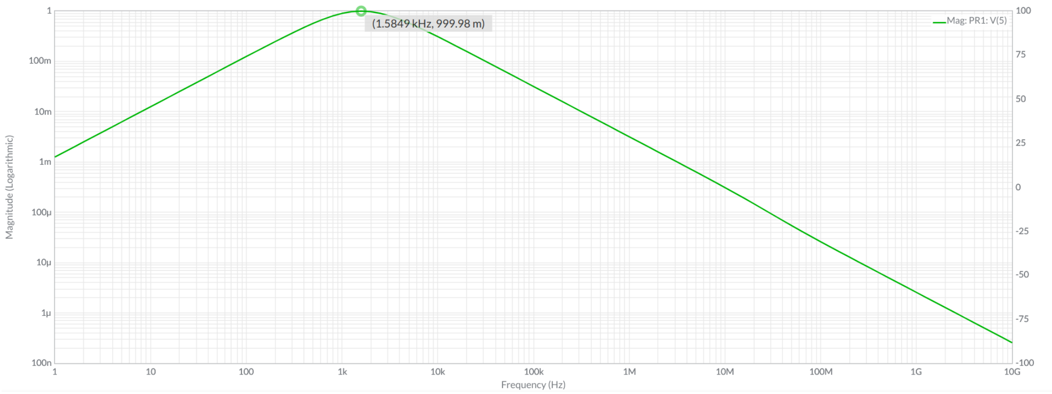
where the cutoff frequency

$$f_{cl} = \frac{1}{2\pi RC}$$

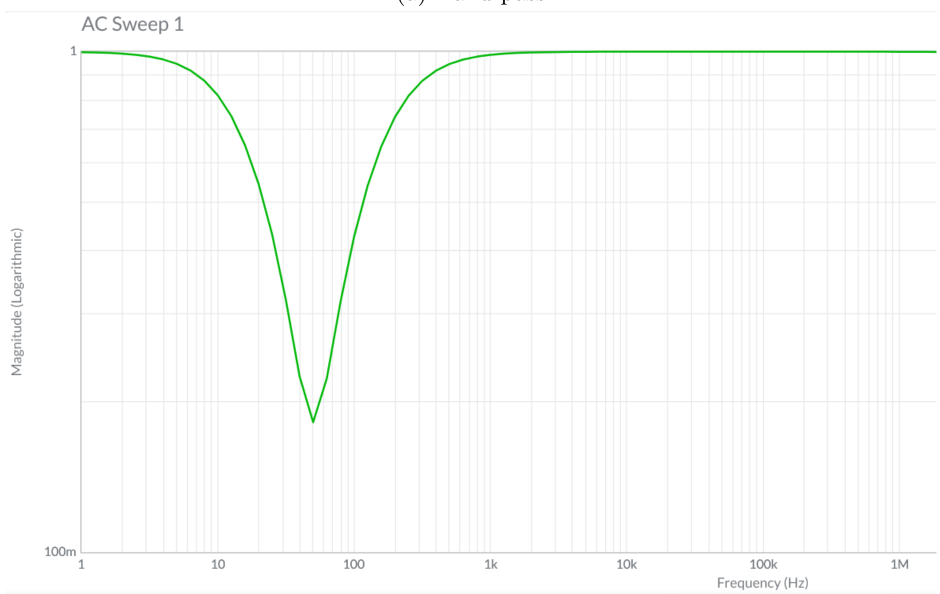
for a high pass-filter on the other hand.

$$V_o = \frac{V_{in}}{\sqrt{\left(1 + \frac{f_{ch}}{f}\right)^2}}$$

The cutoff frequency for the configuration $R = 1k\Omega$ and $C = 1\mu$F turns out to be $f_c = 159.2$Hz for both high and low pass configurations. At this frequency, we expect our amplitude to drop to $1\sqrt{2} \simeq 0.707$ times.



(a) Band pass



(b) Band reject

Figure 5: Frequency dependence for the band pass and band-reject filter

It it indeed evident in Figure 4 that at roughly the cutoff frequency, the voltage drops to $0.707 \times 2 \simeq 1.414$ V.

We show the frequency dependence of the output for the band pass and band-reject filters in Figure 5.

The maxima of the bandpass filter is expected at $f_{max} = \sqrt{f_{ch} f_{cl}}$. Since the cutoff $f_{ch} = f_{cl} = 1.59$ kHz. The result is as expected in Figure 5