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EE 316-08
Electric Circuits & Electronics Design Lab

Lab 5: Basic Filters and Frequency Response

By: Nolan Anderson

Lab Date: 02/24/2021

Lab Due: 02/24/2021

1. Introduction:

This laboratory studies and demonstrates the characteristics of low and high pass filters. We will analyze the gain and phase angle of said filters by introducing varying frequencies at the input of the circuit. We will first cover the theory behind these filters and then simulate them in Multisim.

2. Theoretical Analysis:

2.1 Low Pass Filters:

Low pass filters (LPF) simply allow low frequencies and block high frequencies in the circuit. Looking at figure 1, we can see the equation for the gain of a low pass filter and the phase angle formula can be seen in figure 2. A LPF can be seen in Figure 3. Next I will do the hand calculations necessary to find the gain and phase angle of the LPF, see table 1 and figures 4 and 5. Section 3 will show the filter in a simulation.

$$\left|\frac{V_c}{E}\right| = \frac{1}{\sqrt{(1+(2\pi f RC)^2)}}$$

$$\tan(\phi) = -2\pi f RC$$

Figure 1: LPF Gain

Figure 2: LPF Phase Angle

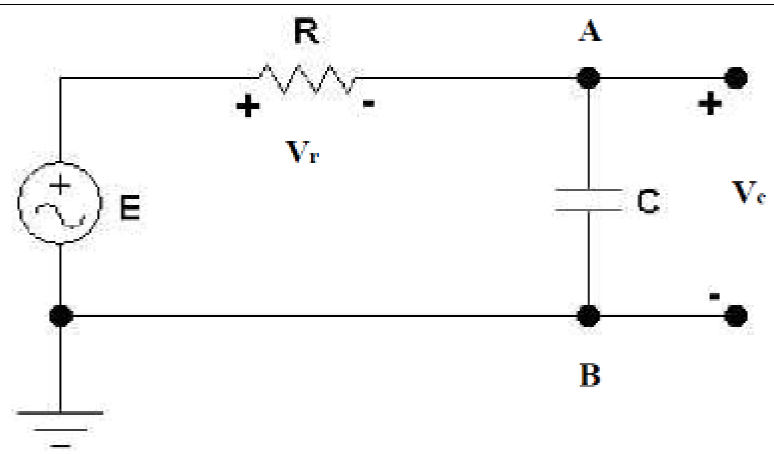


Figure 3: LPF Theoretical Circuit

f (Hz)	Gain (dB)	Phase Angle (Degree)
25	-0.11	8.93
50	-0.41	17.44
75	-0.87	25.23

100	-1.45	32.14
150	-2.76	43.3
200	-4.11	51.49
300	-6.58	62.05
500	-10.36	72.34
600	-11.82	75.14
700	-13.08	77.19
800	-14.19	78.75
900	-15.18	79.97
1000	-16.07	80.96

Table 1: LPF Hand Calculation results.

$$\left|\frac{V_c}{E}\right| = \frac{1}{\sqrt{(1+(2\pi f RC)^2)}}$$

$$\tan(\phi) = -2\pi f RC$$

Figure 4: LPF Gain vs Frequency

Figure 5: LPF Phase Angle vs Frequency

2.2 High Pass Filters:

High pass filters (HPF) simply allow high frequencies and block low frequencies in the circuit. Looking at figure 6, we can see the equation for the gain of a HPF and the phase angle formula can be seen in figure 7. Lastly, a HPF can be seen in Figure 8. Next I will do the hand calculations necessary to find the gain and phase angle of the HPF, see table 2 and figures 9 and 10. Section 3 will show the filter in a simulation.

$$\left|\frac{V_c}{E}\right| = \frac{1}{\sqrt{(1+(2\pi f RC)^2)}}$$

$$\tan(\phi) = -2\pi f RC$$

Figure 6: HPF Gain

Figure 7: HPF Phase Angle

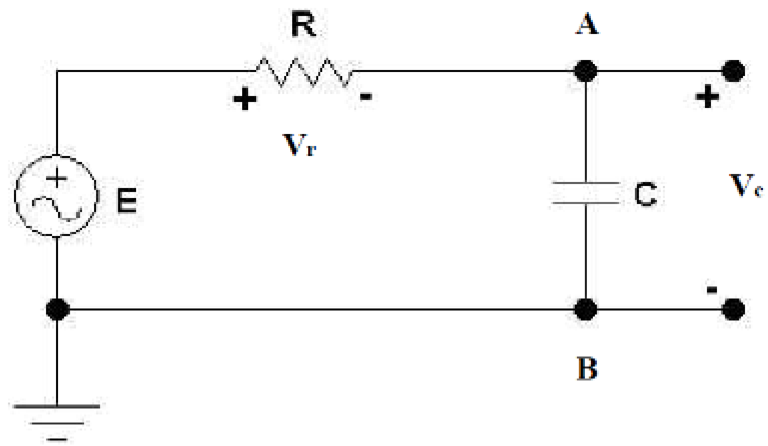


Figure 8: LPF Theoretical Circuit

f (Hz)	Gain (dB)	Phase Angle (Degree)
25	-16.18	81.07
50	-10.47	72.56
75	-7.41	64.77
100	-5.48	57.86
150	-3.28	46.7
200	-2.13	38.51
300	-1.08	27.95
500	-0.42	17.66
600	-0.3	14.86
700	-0.22	12.81
800	-0.17	11.25
900	-0.13	10.03
1000	-0.11	9.04

Table 2: HPF Hand Calculation results.

$$\left|\frac{V_c}{E}\right| = \frac{1}{\sqrt{(1+(2\pi f RC)^2)}}$$

$$\tan(\phi) = -2\pi f RC$$

Figure 9: HPF Gain vs Frequency

Figure 10: HPF Phase Angle vs Frequency

3. Simulations:

3.1 Low pass filter simulated

This section will simulate a low pass filter in Multisim. To make this report more concise, I will not show the bode plotters from Multisim as this was provided in Prelab 5.
Let R = 1kΩ, C = 1 μF, varying frequency, V_{IN} = 4Vpp sinusoidal

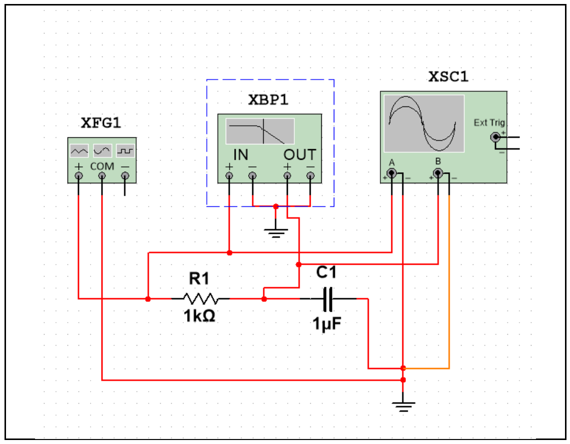


Figure 11: Low Pass Filter in Multisim

f (Hz)	Gain (dB)	Phase Angle (Degree)
25	0.158651	9
50	-0.32627	17
75	-0.83987	25
100	-1.57562	32
150	-3.03537	44
200	-4.45033	52
300	-6.72919	65
500	-10.6056	71
600	-11.7654	75
700	-12.7498	77
800	-13.8601	79
900	-14.688	80
1000	-15.6031	81

Table 3: Low Pass Filter Simulation Results

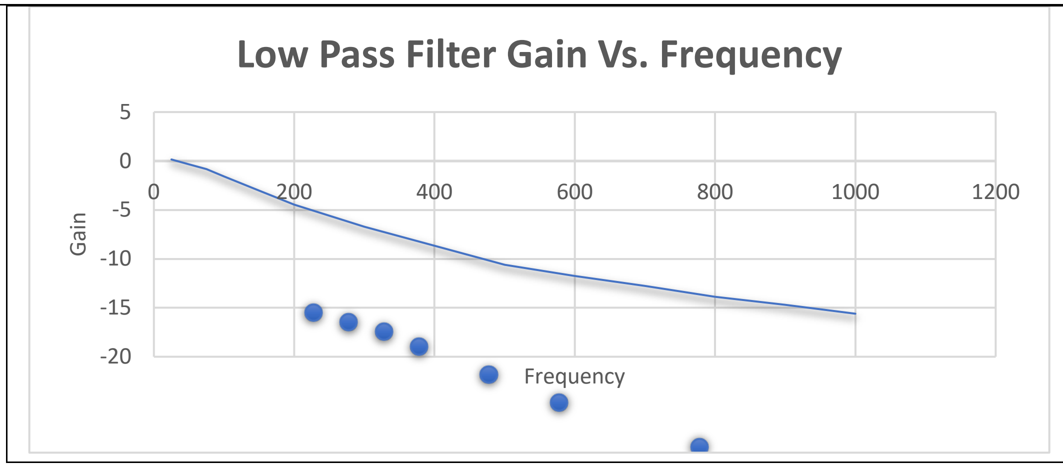


Figure 12: Low Pass Filter Gain vs Frequency

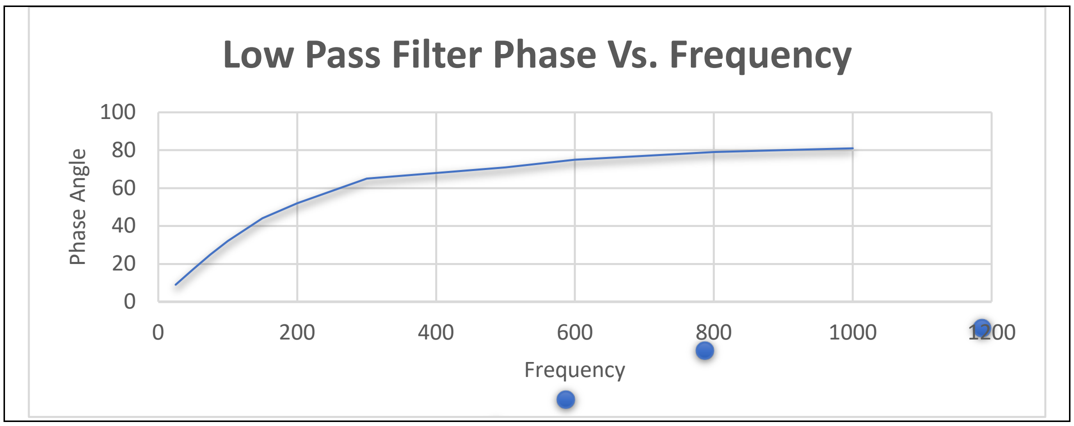


Figure 13: Low Pass Filter Phase vs. Frequency

3.2 High pass filter simulated

This section will simulate a HPF Multisim. To make this report more concise, I will not show the bode plotters from Multisim as this was provided in Prelab 5.

Let R = 1kΩ, C = 1 μF, varying frequency, V_{IN} = 4Vpp sinusoidal

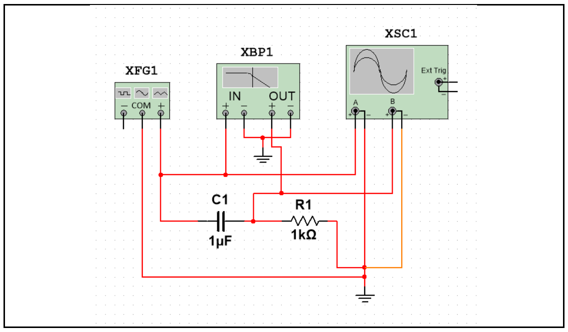


Figure 14: Low Pass Filter in Multisim

f (Hz)	Gain (dB)	Phase Angle (Degree)
25	-13.8601	81
50	-9.11292	72
75	-6.64277	65
100	-4.79099	58
150	-2.8112	46
200	-1.96827	38
300	-1.19996	28
500	-0.49412	18
600	-0.49412	15
700	-0.49412	14
800	-0.32627	11
900	-0.24355	10
1000	-0.1616	9

Table 3: Low Pass Filter Simulation Results

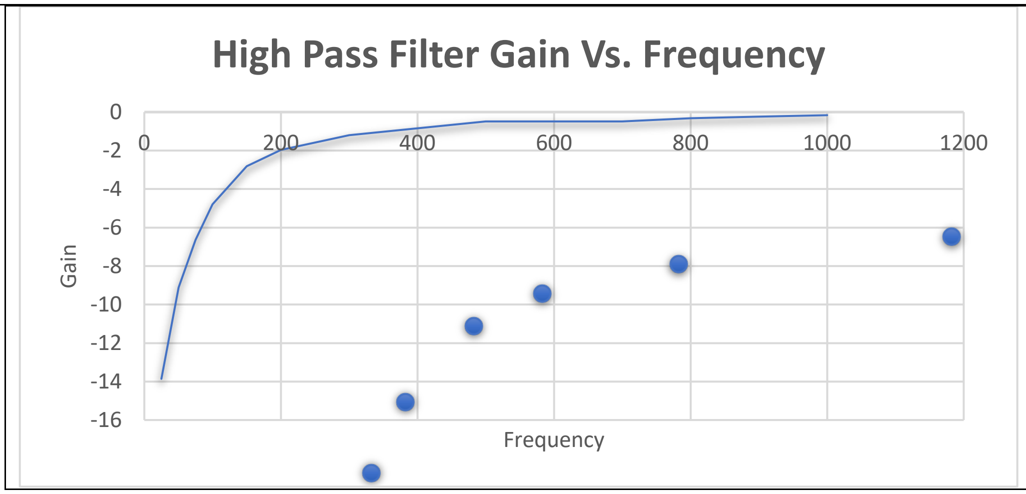


Figure 15: High Pass Filter Gain vs Frequency

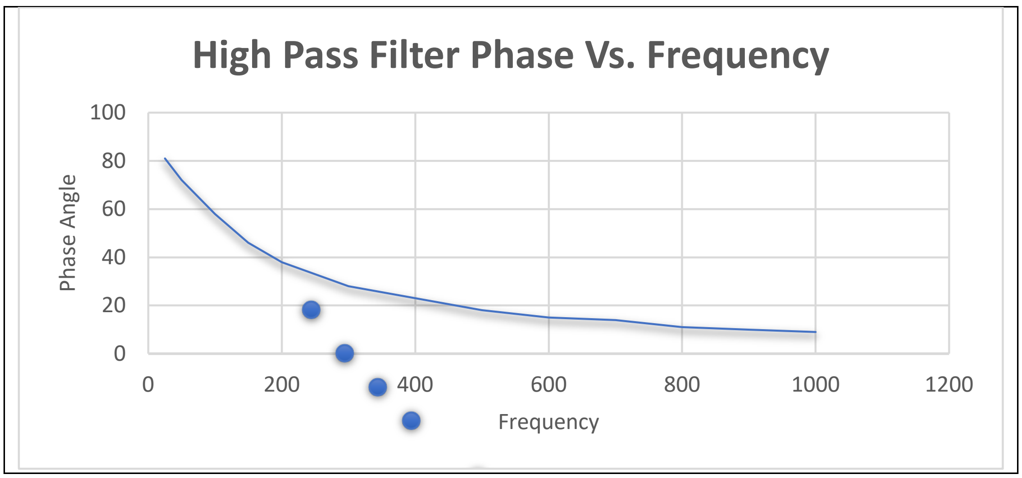
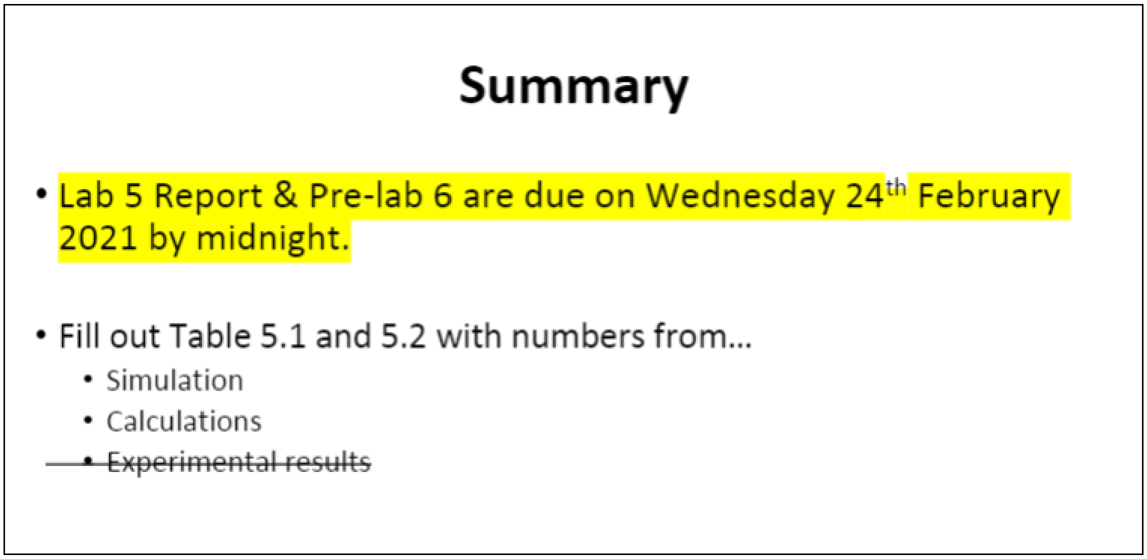


Figure 16: High Pass Filter Phase vs. Frequency

~~4. Experimental:~~

We were not instructed to provide experimental results for this lab, see the following screenshot.



5. Results and Discussion:

Comparing the simulations and theoretical results we can see that the laboratory performed as expected. LPF's and HPF's are a very useful technology for implementing different circuits.

6. Conclusion:

This lab was a much-needed introduction and review of low pass filters. It was very helpful to see the different results match the simulations and theoretical values. Lastly, having a filter implemented in Multisim is helpful as I can refer to it to test different values in the future.