Cover Page

EE 316-08

Electric Circuits & Electronics Design Lab

**Lab 5: Basic Filters and Frequency Response**

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**Lab Date: 02/24/2021**

**Lab Due: 02/24/2021**

**1. Introduction:**

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| 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:**

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| 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.   |  | | --- | |  |   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.   |  | | --- | |  |   Figure 4: LPF Gain vs Frequency Figure 5: LPF Phase Angle vs Frequency |

**2.2 High Pass Filters:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| 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.   |  | | --- | |  |   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.   |  | | --- | |  |   Figure 9: HPF Gain vs Frequency Figure 10: HPF Phase Angle vs Frequency |

**3. Simulations:**

**3.1 Low pass filter simulated**

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| 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, VIN = 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**

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| 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, VIN = 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.

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**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.