Sinusoidal Steady State Filters

Experiment 1, 2, & 3

Justin Fortner

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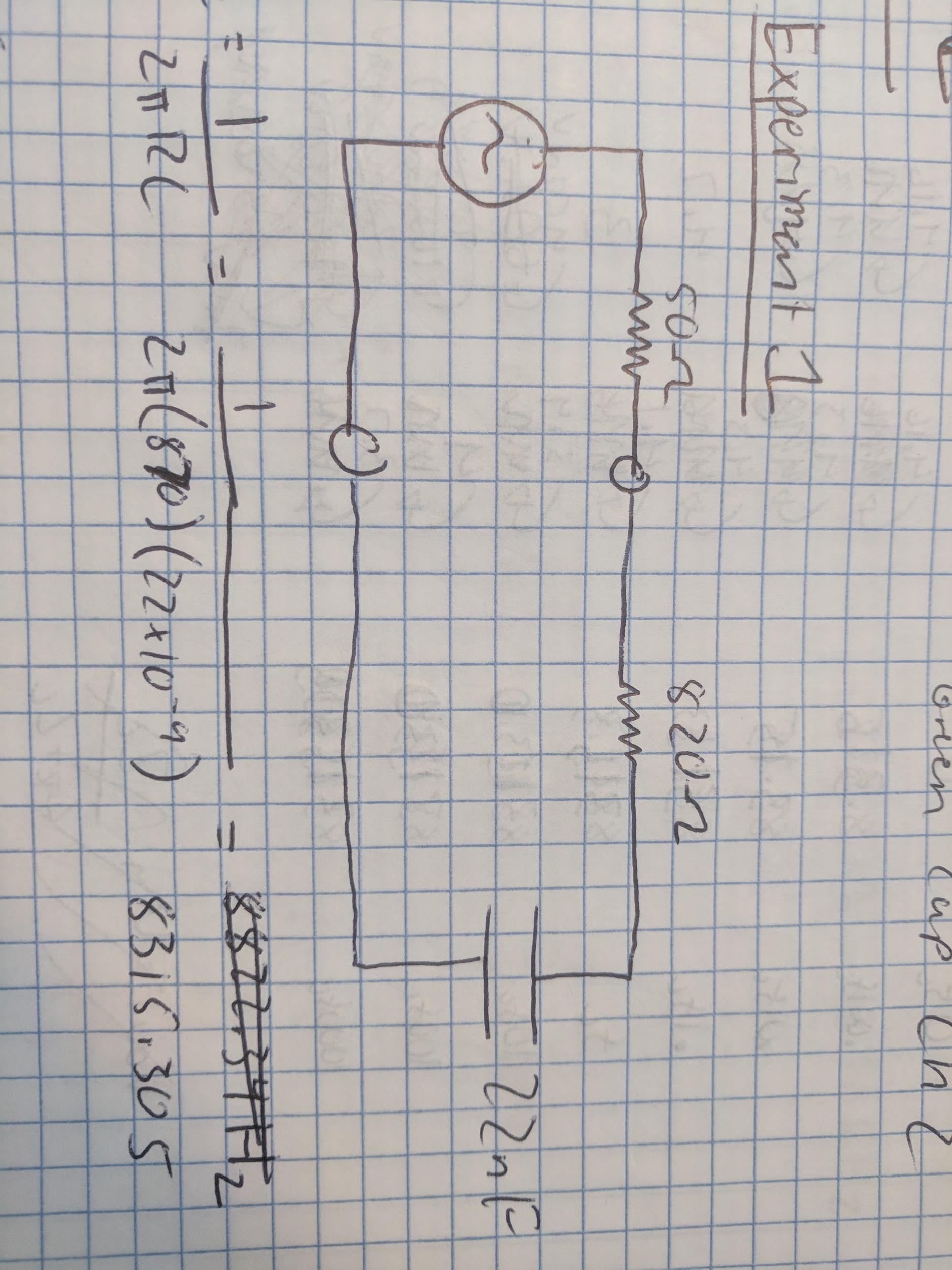
Section 04 Wednesday 12:20-2:20 (Tuwin)

**Introduction**

The purpose of lab 4 was to allow students to investigate the frequency domain characteristics of low and high pass filters. Three circuits will be observed in this lab, low pass RC, high pass RC and an inverting low pass op amp. For each experiment we must use the oscilloscope with probes set to measure at 10x in order to decrease loading effects of the probe itself. Using the oscilloscope we must take enough measurements in order to construct the bode and phase plots.

**Low Pass RC Filter**

The circuit in **Figure 1** must be replicated in order to continue on in the experiment.



**Figure 1**

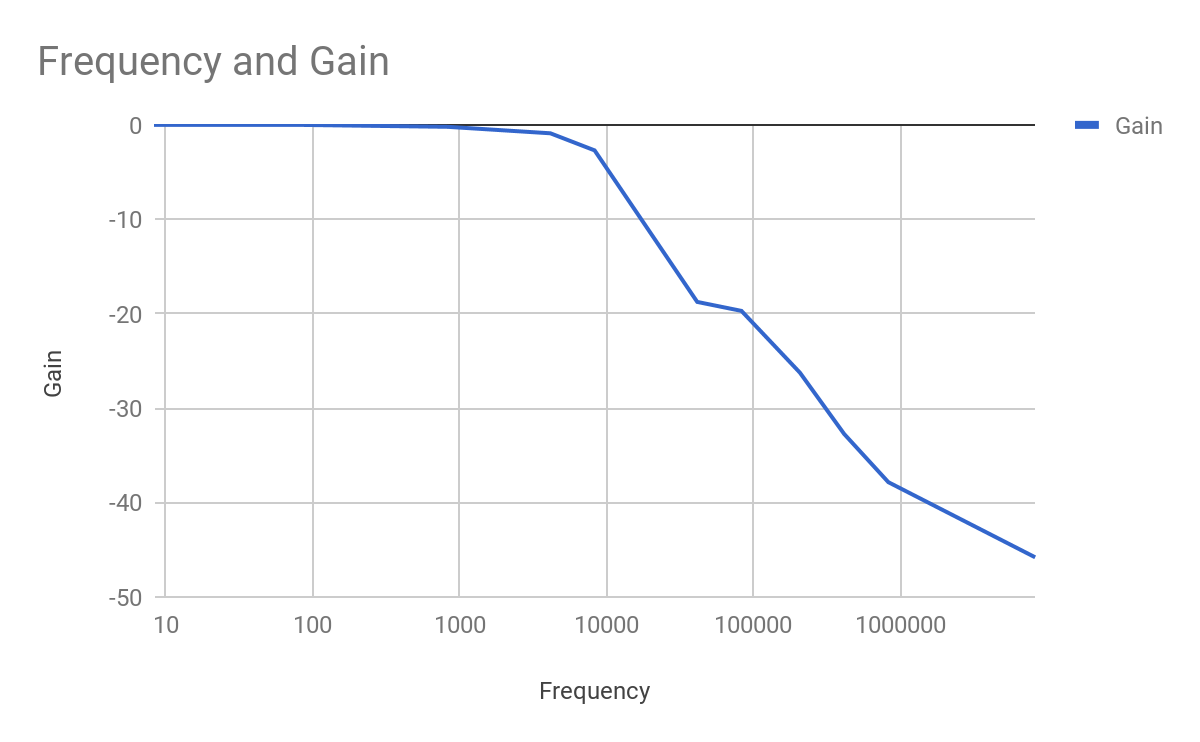
Low Pass RC Filter Circuit Schematic for Lab 4, Experiment 1

In order to complete this circuit I used a 820 Ohm resistor and a 22 nF capacitor. In addition to the 820 Ohm resistor in the circuit, the wave generator has an internal resistance of 50 Ohms that must be taken into account when making calculations. The first calculation we must make is the corner frequency. The corner frequency is calculated using the equation . For this circuit the corner frequency is 8315.305 Hz. The phase shift at this frequency is calculated using the equation was found to be Additional variations of the corner frequencies and their corresponding phase shifts can be seen in **Figure 2** below.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | (Hz) | (V) | (V) | Phase  (Expected) | Phase  (Experiment) | % Difference |
| 0 | 0 | 0 | 0 | - | - | 0% |
|  | 8.315305 | 4.16 | 4.16 | - | - | 3.6% |
|  | 83.15305 | 4.3 | 4.3 | - | - | 11.4% |
|  | 831.5305 | 4.3 | 4.2 | - | - | 4.55% |
|  | 4157.652 | 4.1 | 3.7 | - | - | 6.85% |
|  | 8315.305 | 4.1 | 3 | - | - | 2.1% |
|  | 41576.52 | 3.9 | .45 | - | - | .39% |
|  | 83153.05 | 3.9 | .4 | - | - | .34% |
|  | 207882.6 | 3.9 | .19 | - | - | .55% |
|  | 415765.2 | 3.9 | .09 | - | - | .07% |
|  | 831530.5 | 3.7 | .05 | - | - | .42% |
|  | 8315305 | 3.7 | .02 | - | - | .06% |

**Figure 2**

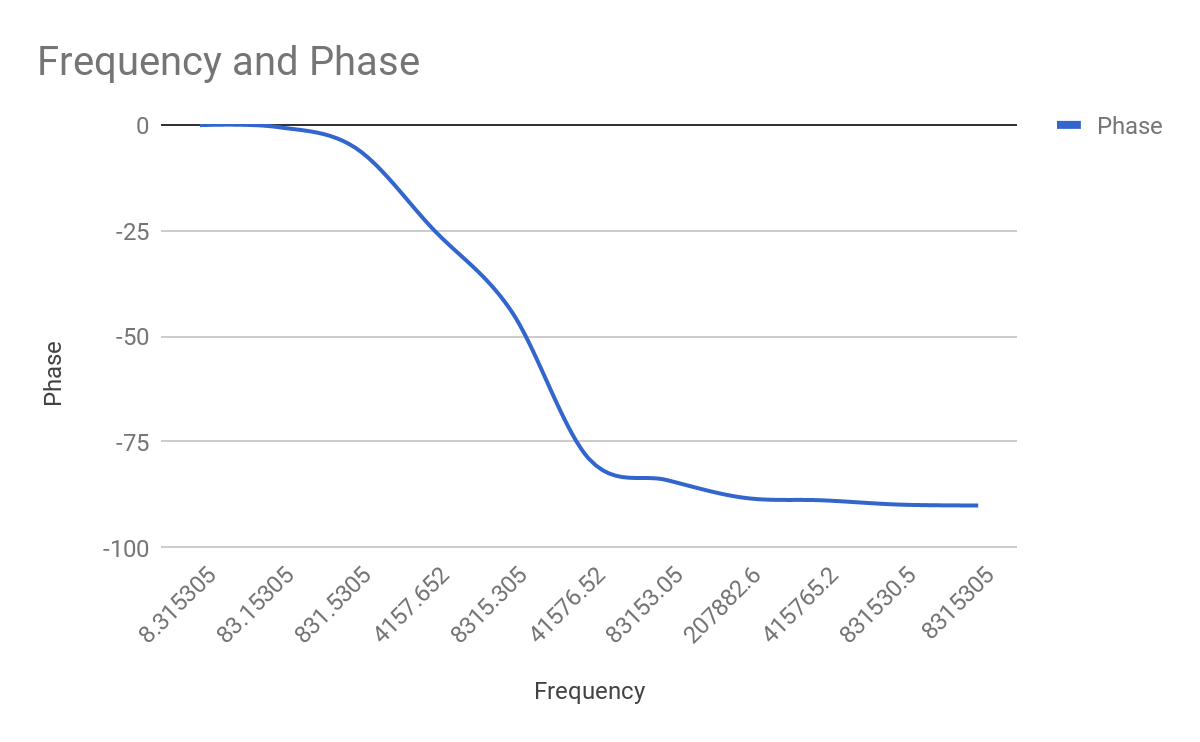
Low Pass RC Filter Circuit Frequencies and Phase Shifts, Experiment 1

The resulting bode plot from the information in **Figure 2** can be seen below in **Figure 3**. 

**Figure 3**

Low Pass RC Filter Circuit Bode Plot, Experiment 1

The bode plot shows that as the frequency increases the gain will decrease from 0 into the negatives. The resulting phase plot from the information in **Figure 2** can be seen below in **Figure 4**.



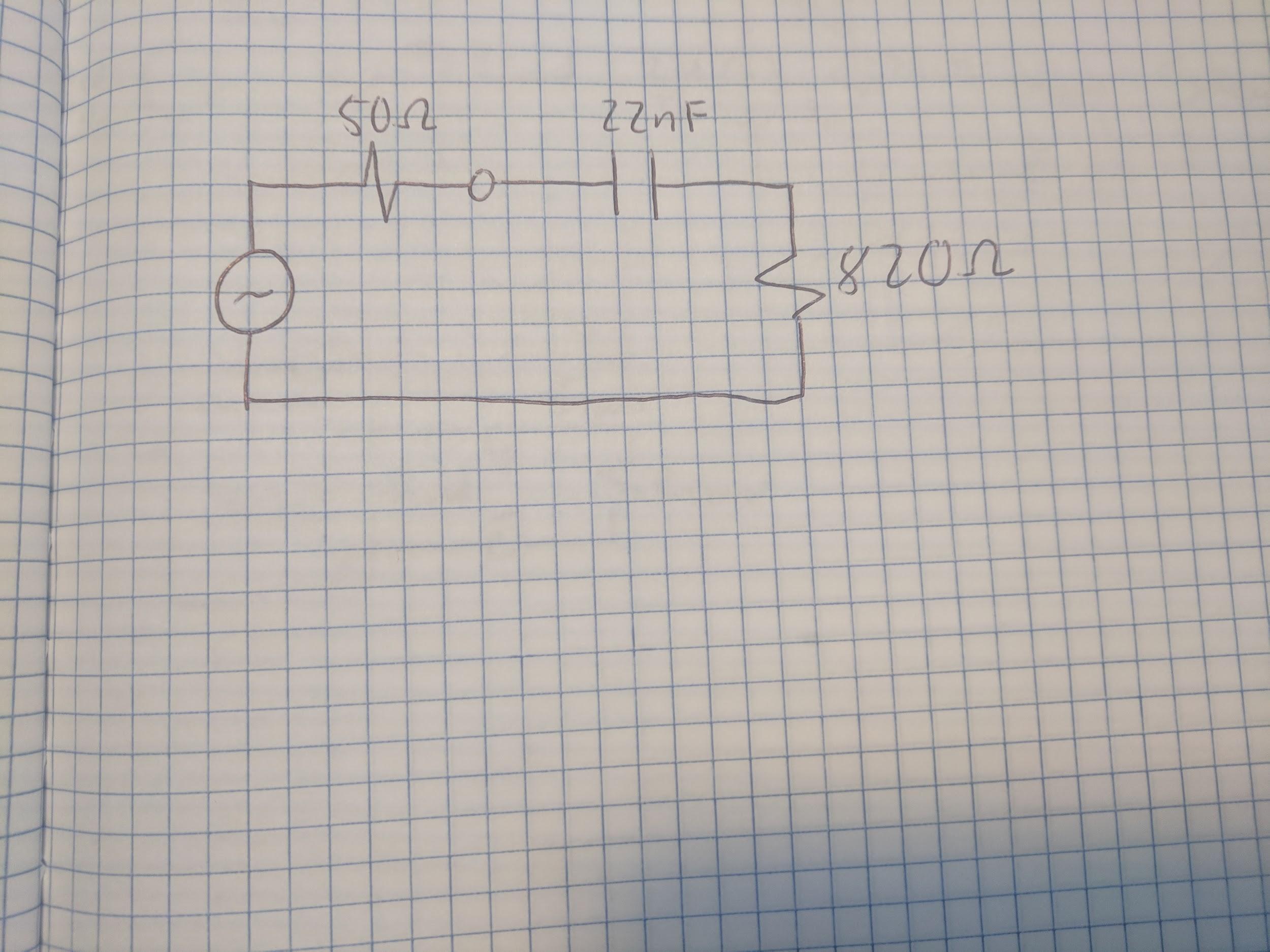
**Figure 4**

Low Pass RC Filter Circuit Phase Plot, Experiment 1

The phase plot shows that the phase angle at the corner frequency is The phase angle is always negative and has the steepest slope between and . The phase angle starts at and approaches .

**High Pass RC Filter**

The circuit in **Figure 5** must be replicated in order to continue on in the experiment.



**Figure 5**

Low Pass RC Filter Circuit Schematic for Lab 4, Experiment 2

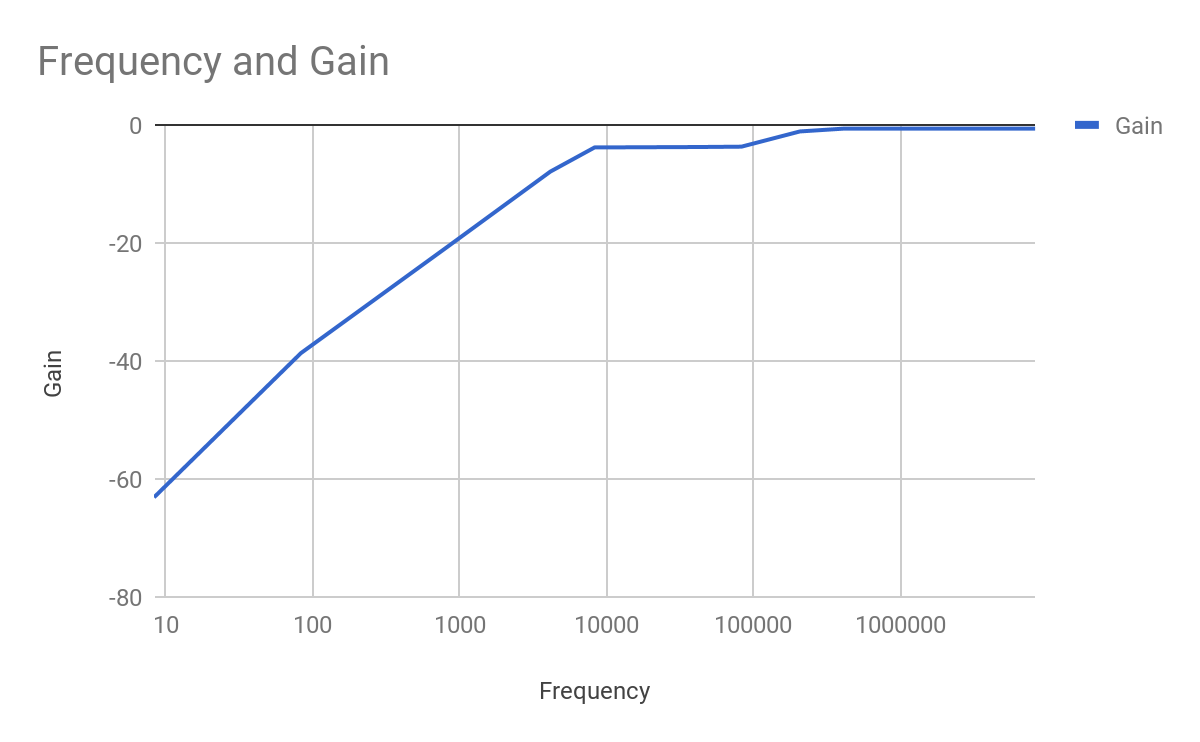
In order to complete this circuit I used a 820 Ohm resistor and a 22 nF capacitor. In addition to the 820 Ohm resistor in the circuit, the wave generator has an internal resistance of 50 Ohms that must be taken into account when making calculations. The first calculation we must make is the corner frequency. The corner frequency is calculated using the equation . For this circuit the corner frequency is 8315.305 Hz. The phase shift at this frequency is calculated using the equation was found to be Additional variations of the corner frequencies and their corresponding phase shifts can be seen in **Figure 6** below.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | (Hz) | (V) | (V) | Phase  (Expected) | Phase  (Experiment) | % Difference |
| 0 | 0 | 0 | 0 |  |  | 0% |
|  | 8.315305 | 4.3 | .003 |  |  | .91% |
|  | 83.15305 | 4.3 | .05 |  |  | .39% |
|  | 831.5305 | 4.3 | .4 |  |  | 1.24% |
|  | 4157.652 | 4.1 | 1.73 |  |  | .34% |
|  | 8315.305 | 4.1 | 2.77 |  |  | 2.06% |
|  | 41576.52 | 4 | 2.79 |  |  | 5.75% |
|  | 83153.05 | 4 | 2.81 |  |  | 1.16% |
|  | 207882.6 | 4 | 3.78 |  |  | 4.97% |
|  | 415765.2 | 4 | 4 |  |  | 3.38% |
|  | 831530.5 | 4 | 4 |  |  | 6.2% |
|  | 8315305 | 4 | 4 |  |  | 5% |

**Figure 6**

Low Pass RC Filter Circuit Frequencies and Phase Shifts, Experiment 2

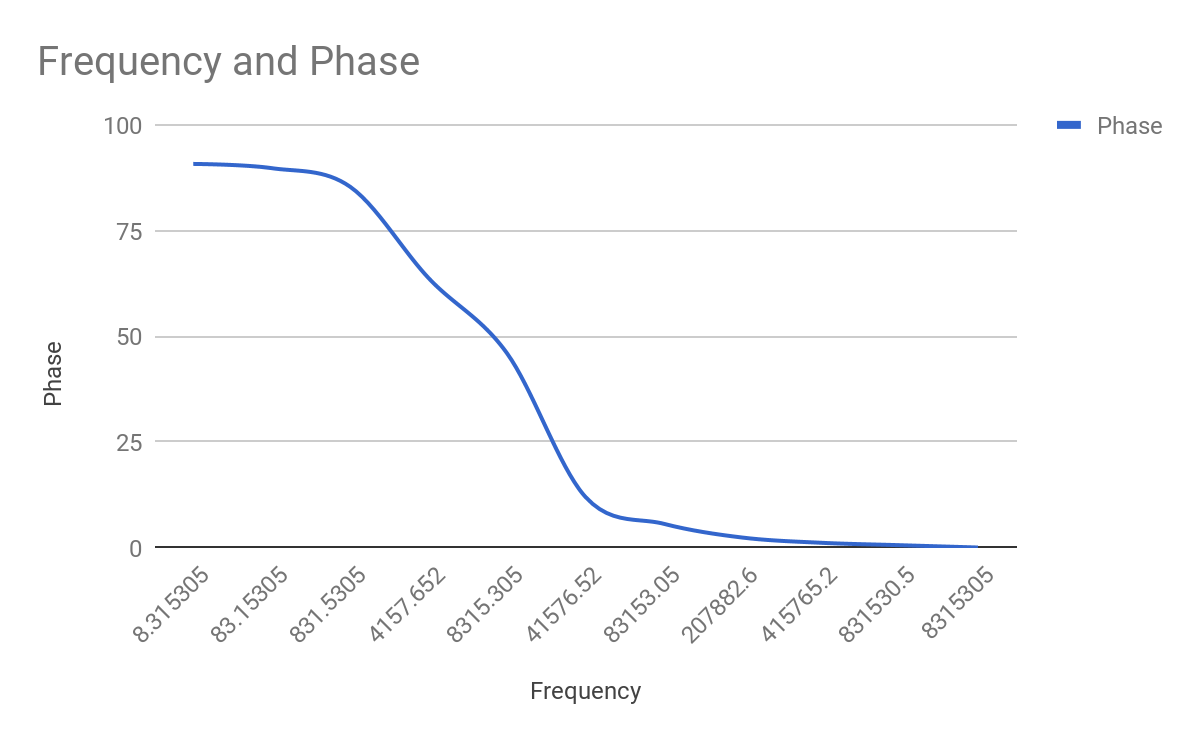
The resulting bode plot from the information in **Figure 6** can be seen below in **Figure 7**.



**Figure 7**

Low Pass RC Filter Circuit Bode Plot, Experiment 2

The bode plot shows that as the frequency increases the gain will increase from the negatives towards 0. The resulting phase plot from the information in **Figure 6** can be seen below in **Figure 8**.



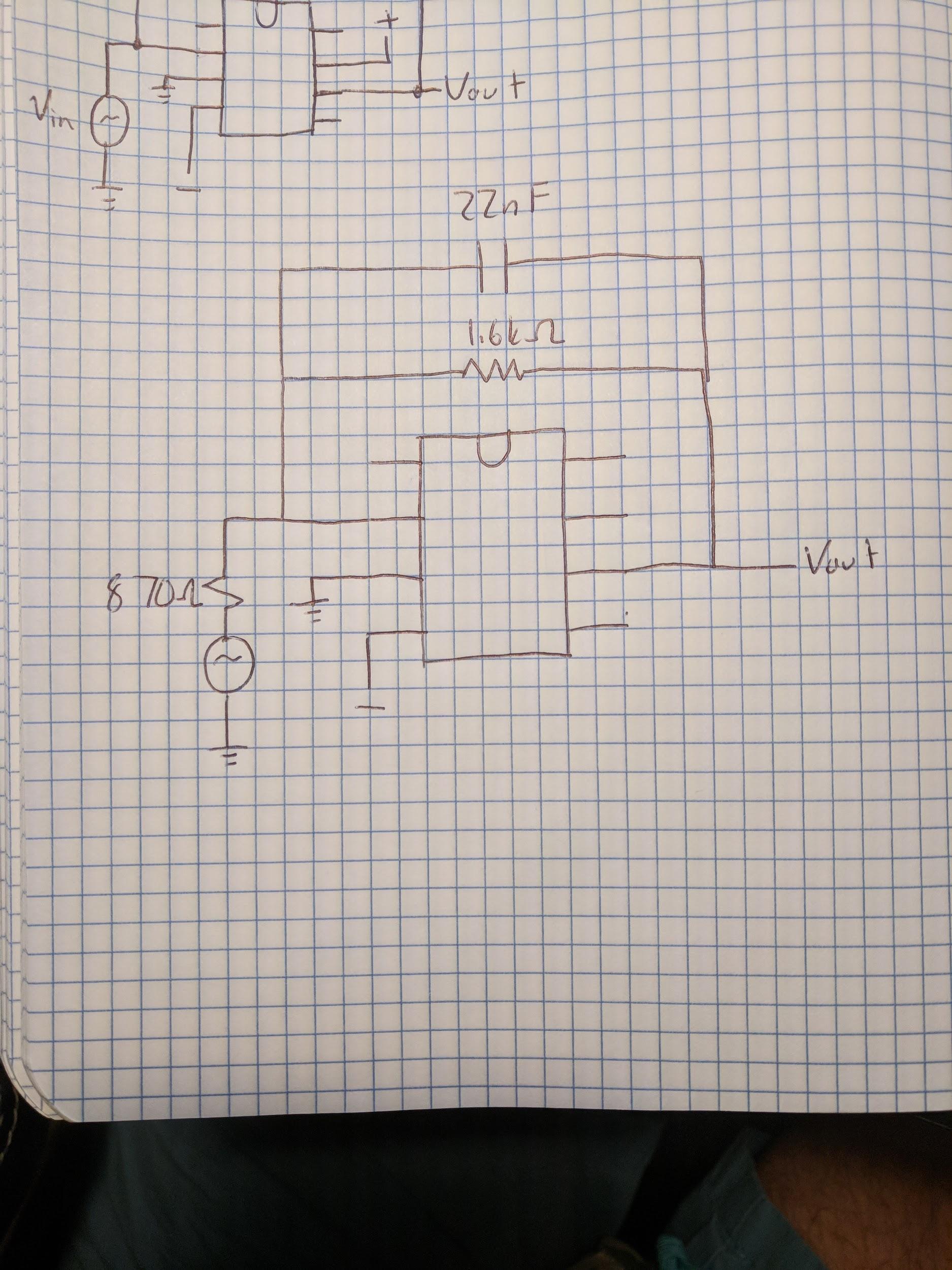
**Figure 8**

Low Pass RC Filter Circuit Phase Plot, Experiment 2

The phase plot shows that the phase angle at the corner frequency is The phase angle is always positive and has the steepest slope between and . The phase angle starts at and approaches .

**Inverting Low Pass Op Amp Filter**

The circuit in **Figure 9** must be replicated in order to continue on in the experiment.



**Figure 9**

Inverting Low Pass Op Amp Filter Circuit Schematic for Lab 4, Experiment 3

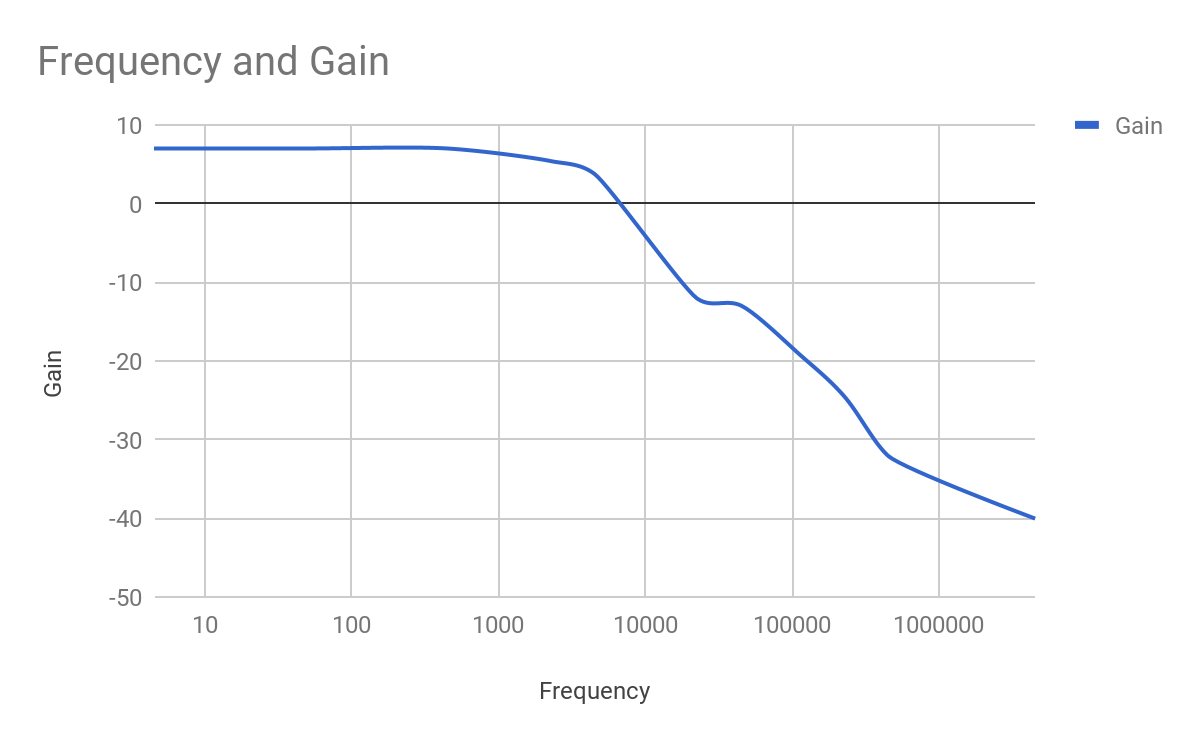
In order to complete this circuit I used a 820 Ohm resistor and a 22 nF capacitor. In addition to the 820 Ohm resistor in the circuit, the wave generator has an internal resistance of 50 Ohms that must be taken into account when making calculations. A 1.6 KOhm resistor is used in parallel with a 22 nF capacitor. The first calculation we must make is the corner frequency. The corner frequency is calculated using the equation . For this circuit the corner frequency is 4521.447 Hz. The phase shift at this frequency is calculated using the equation was found to be . However because this is an inverting circuit there is a phase shift. This making the phase shift at the corner frequency Additional variations of the corner frequencies and their corresponding phase shifts can be seen in **Figure 10** below.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | (Hz) | (mV) | (mV) | Phase  (Expected) | Phase  (Experiment) | % Difference |
| 0 | 0 | 0 | 0 |  |  | 0% |
|  | 4.521447 | 201 | 450 |  |  | .03% |
|  | 45.21447 | 201 | 450 |  |  | .32% |
|  | 452.1447 | 201 | 450 |  |  | .17% |
|  | 2260.723 | 201 | 375 |  |  | 1.14% |
|  | 4521.447 | 201 | 310 |  |  | 1.48% |
|  | 22607.23 | 201 | 50 |  |  | 1.49% |
|  | 45214.47 | 201 | 45 |  |  | 1.46% |
|  | 113036.1 | 201 | 22 |  |  | .31% |
|  | 226072.3 | 201 | 12 |  |  | .18% |
|  | 452144.7 | 201 | 5 |  |  | .38% |
|  | 4521447 | 201 | 2 |  |  | .05% |

**Figure 9**

Inverting Low Pass Op Amp Filter Circuit Frequencies and Phase Shifts, Experiment 3

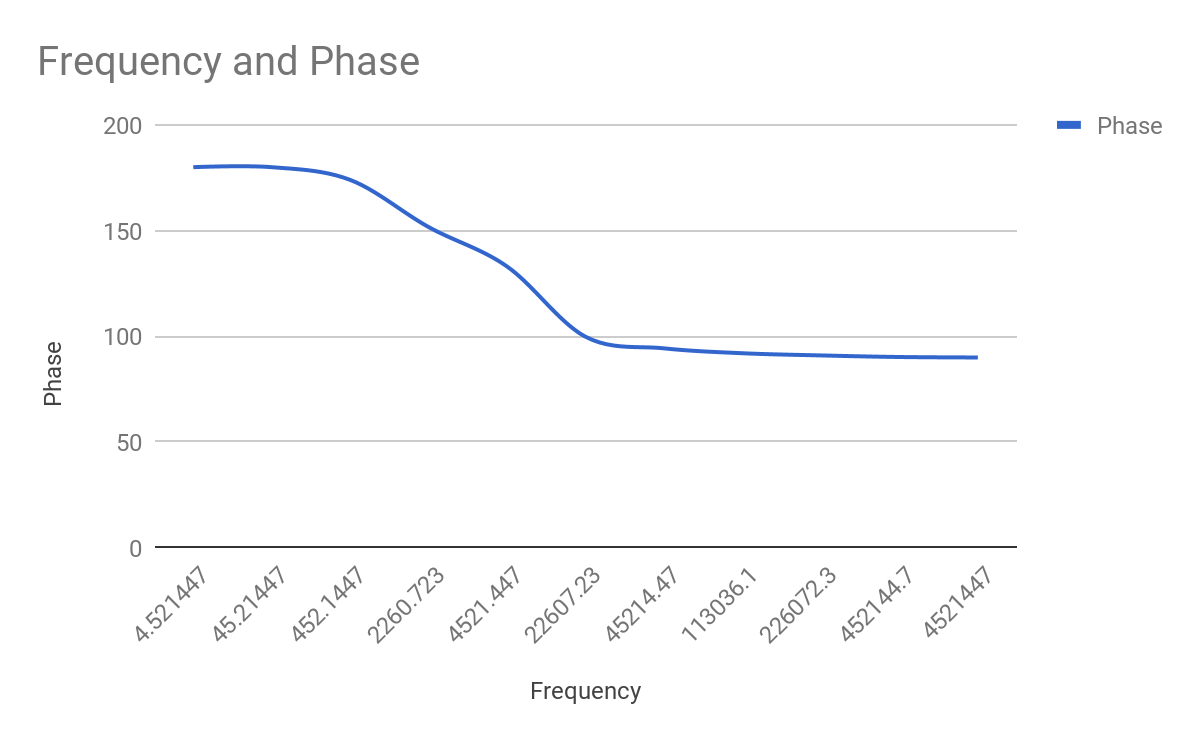
The resulting bode plot from the information in **Figure 9** can be seen below in **Figure 10**.



**Figure 10**

Inverting Low Pass Op Amp Filter Circuit Bode Plot, Experiment 3

The bode plot shows that as the frequency increases the gain will decrease from roughly 10 towards the negatives. The resulting phase plot from the information in **Figure 9** can be seen below in **Figure 11**.



**Figure 11**

Inverting Low Pass Op Amp Filter Circuit Phase Plot, Experiment 3

The phase plot shows that the phase angle at the corner frequency is The phase angle is always positive and has the steepest slope between and . The phase angle starts at and approaches .

**Conclusion**

I had a fairly successful lab in lab 4. I successfully observed characteristics of all three circuits through their respective bode and phase plots.

Experiment 1 focuses on a passive RC low pass filter. The bode plot shows that as the frequency increases the gain will decrease from 0 into the negatives. The phase plot shows that the phase angle at the corner frequency is The phase angle is always negative and has the steepest slope between and . The phase angle starts at and approaches .

Experiment 2 focuses on a passive RC high pass filter. The bode plot shows that as the frequency increases the gain will increase from the negatives towards 0. The phase plot shows that the phase angle at the corner frequency is The phase angle is always positive and has the steepest slope between and . The phase angle starts at and approaches .

Experiment 3 focuses on a inverted active RC Op Amp low pass filter. The bode plot shows that as the frequency increases the gain will decrease from roughly 10 towards the negatives. The phase plot shows that the phase angle at the corner frequency is The phase angle is always positive and has the steepest slope between and . The phase angle starts at and approaches .

This was a great lab, I accomplished and learned a lot about bode and phase plots as well as decibel and decibel notation.