# CMPE 460 Laboratory Exercise 7

# Op Amp and Filter Design

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Lab Section: 1
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TA: Andrew Tevebaugh
Colin Vo

Lecture Section: 1
Professor: Prof. Hussin Ketout

By submitting this report, you attest that you neither have given nor have received any assistance (including writing, collecting data, plotting figures, tables or graphs, or using previous student reports as a reference), and you further acknowledge that giving or receiving such assistance will result in a failing grade for this course.

Your Signature: ____________________________

# Lab Description

This laboratory exercise involved using an op amp as as DC inverting amplifier, DC non-inverting amplifier, AC inverting amplifier, AC non-inverting amplifier, and a summing amplifier. Each circuit was tested at different voltages where the result was both measured and calculated.
The op amp was also used to create a low pass filter, a high pass filter, and a band pass filter. The values of the required components were calculated and the circuits were tested at different frequencies. The results were measured and then graphed to show the frequency response and phase shift of each filter.

# Schematics

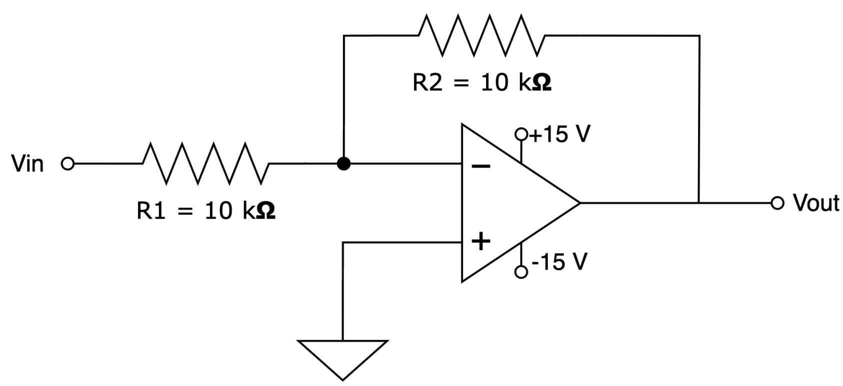


Figure 1: DC Inverting Amplifier

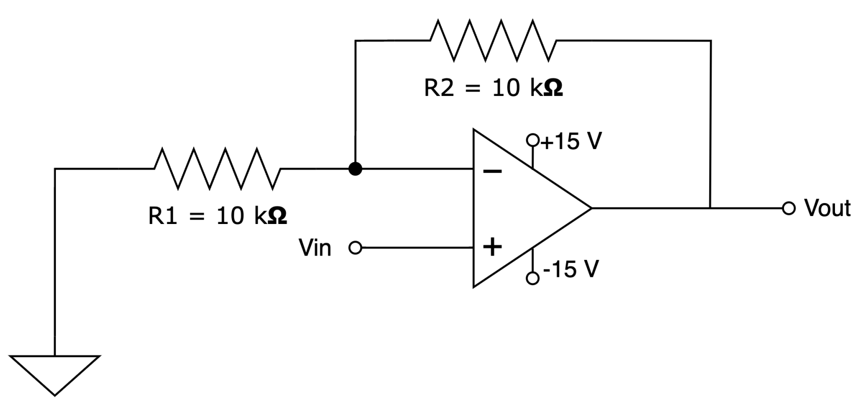


Figure 2: DC Non-Inverting Amplifier

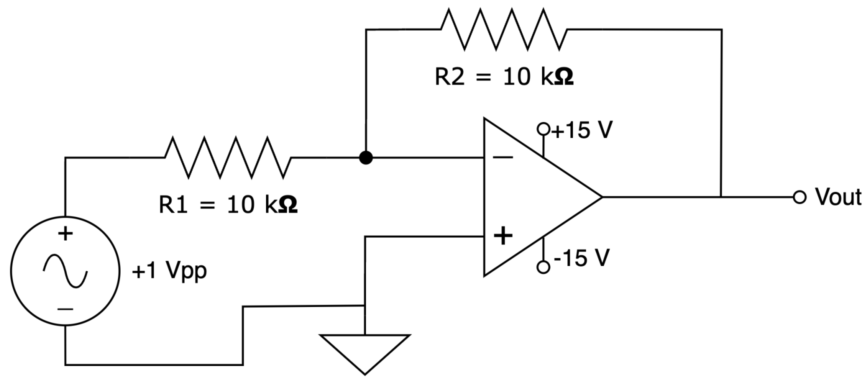


Figure 3: AC Inverting Amplifier

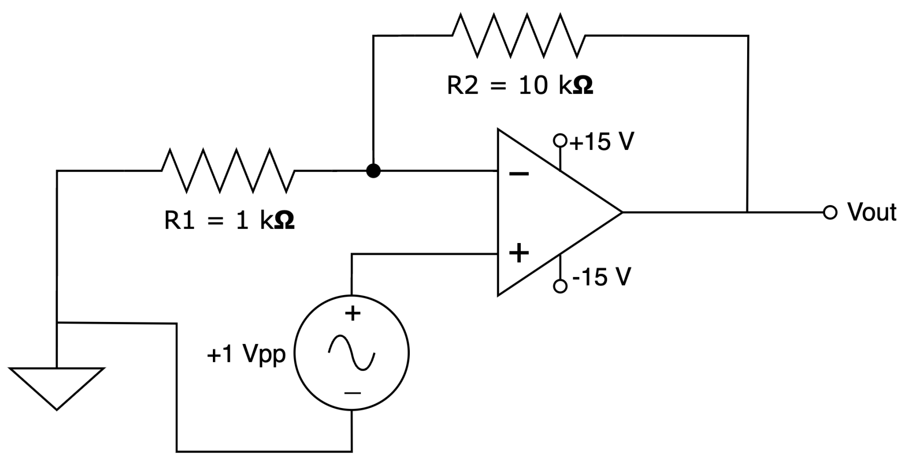


Figure 4: AC Non-Inverting Amplifier

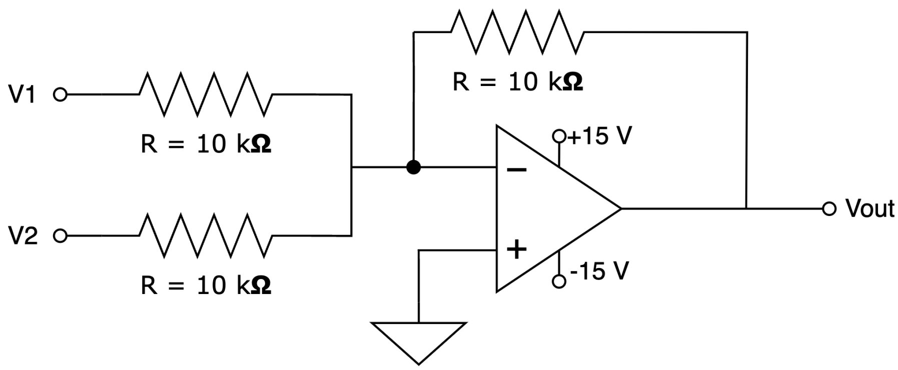


Figure 5: Summing Amplifier

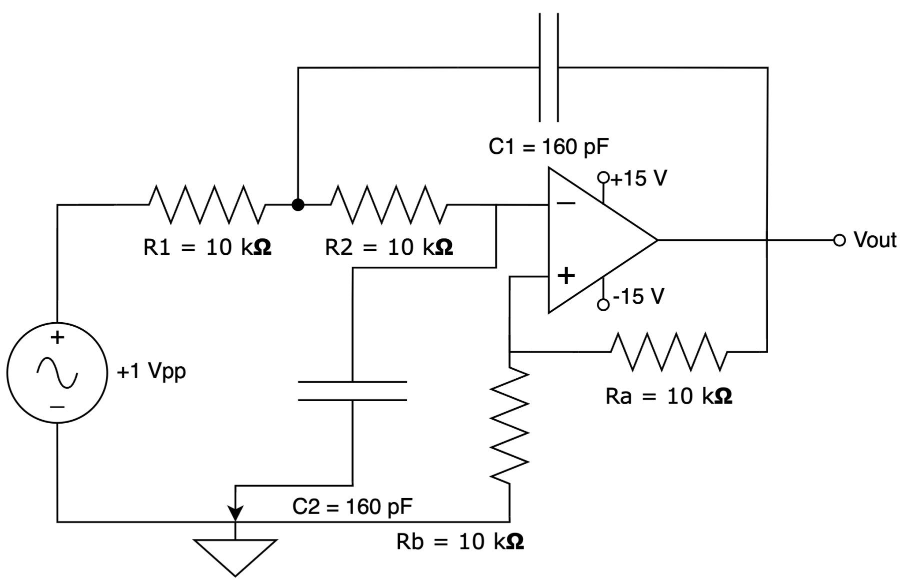


Figure 6: Low Pass Filter

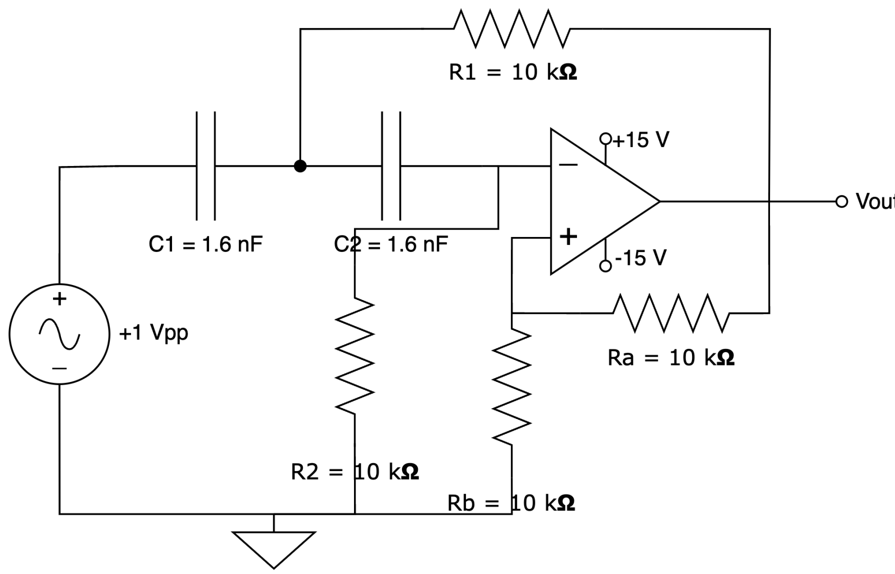


Figure 7: High Pass Filter

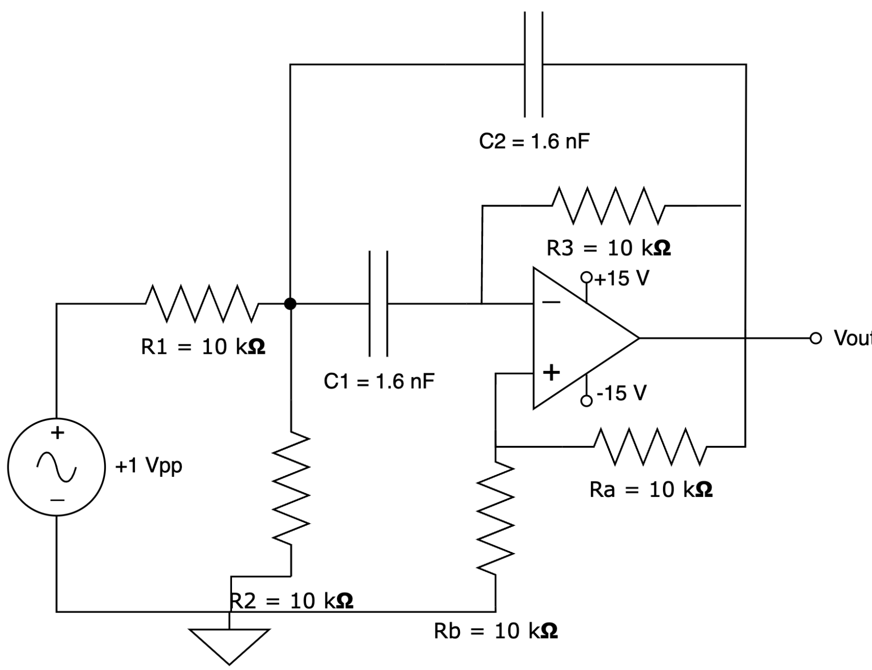


Figure 8: Band Pass Filter

# Data Tables

Table 1: Results of Part 1

| Vin (V) | Calculated Vout (V) | Measured Vout (V) |
|---|---|---|
| 0.1 | -0.2 | -0.196 |
| 1.5 | -3.0 | -2.987 |
| 2.0 | -4.0 | -3.984 |
| 2.5 | -5.0 | -4.981 |
| 3.0 | -6.0 | -5.978 |
| 4.0 | -8.0 | -7.970 |
| 5.0 | -10.0 | -9.961 |

Table 2: Results of Part 2

| Vin (V) | Calculated Vout (V) | Measured Vout (V) |
|---|---|---|
| 0.1 | 0.3 | 0.309 |
| 1.5 | 4.5 | 4.528 |
| 2.0 | 6.0 | 6.059 |
| 2.5 | 7.5 | 7.567 |
| 3.0 | 9.0 | 9.102 |
| 4.0 | 12.0 | 12.114 |
| 5.0 | 15.0 | 14.131 |

Table 3: Results of Part 3

| Vin (Vpp) | Calculated Vout (V) | Measured Vout (V) |
|---|---|---|
| 0.4 | 4.0 | 3.4 |
| 0.5 | 5.0 | 4.5 |
| 0.6 | 6.0 | 5.8 |
| 0.8 | 8.0 | 7.8 |
| 1.0 | 10.0 | 9.8 |

Table 4: Results of Part 4

| Vin (Vpp) | Calculated Vout (V) | Measured Vout (V) |
|---|---|---|
| 0.4 | 4.4 | 4.2 |
| 0.5 | 5.5 | 5.4 |
| 0.6 | 6.6 | 6.6 |
| 0.8 | 8.8 | 8.8 |
| 1.0 | 11.0 | 10.9 |

Table 5: Results of Part 5

| V1 (V) | V2 (V) | Calculated Vout (V) | Measured Vout (V) |
|---|---|---|---|
| 0 | 1 | -1 | -1 |
| 1 | 0 | -1 | -0.99 |
| 1 | 1 | -2 | -1.99 |
| -1 | 1 | 0 | 0.02 |
| 3 | 2 | -5 | -4.99 |
| -2 | 2 | 0 | 0.04 |
| 1 | -3 | 2 | 2.27 |

Table 6: Results of Part 6

| Frequency (Hz) | Gain (Vo/Vi) | Gain (dB) | Phase Angle |
|---|---|---|---|
| 100 | 2.229 | 7.000 | 5.700 |
| 500 | 2.167 | 6.700 | 5.500 |
| 5000 | 2.083 | 6.400 | 9.000 |
| 10000 | 2.083 | 6.400 | 13.500 |
| 50000 | 1.800 | 5.100 | 148.200 |
| 80000 | 1.029 | 0.200 | 175.400 |
| 100000 | 0.829 | -1.600 | 177.700 |
| 200000 | 0.314 | -10.100 | -169.000 |
| 300000 | 0.143 | -16.900 | -154.700 |
| 500000 | 0.057 | -24.900 | -123.000 |

Table 7: Results of Part 7

| Frequency (Hz) | Gain (Vo/Vi) | Gain (dB) | Phase Angle |
|---|---|---|---|
| 100 | 0.095 | -20.470 | -334.000 |
| 500 | 0.097 | -20.279 | -423.000 |
| 5000 | 0.526 | -5.575 | -140.000 |
| 10000 | 1.800 | 5.105 | 0.000 |
| 50000 | 1.811 | 5.156 | -10.000 |
| 80000 | 1.716 | 4.689 | 10.000 |
| 100000 | 1.674 | 4.473 | 20.000 |
| 200000 | 1.316 | 2.384 | 42.000 |
| 300000 | 1.032 | 0.270 | 54.000 |
| 500000 | 0.705 | -3.033 | 72.000 |

Table 8: Results of Part 8

| Frequency (Hz) | Gain (Vo/Vi) | Gain (dB) | Phase Angle |
|---|---|---|---|
| 500 | 0.047 | -26.620 | 134.000 |
| 1000 | 0.073 | -22.694 | 130.000 |
| 10000 | 0.423 | -7.466 | 120.000 |
| 20000 | 0.667 | -3.522 | 140.000 |
| 50000 | 0.937 | -0.568 | 180.000 |
| 80000 | 0.917 | -0.756 | -150.000 |
| 100000 | 0.833 | -1.584 | -140.000 |
| 200000 | 0.543 | -5.299 | -120.000 |
| 500000 | 0.270 | -11.373 | -80.000 |
| 1000000 | 0.147 | -16.673 | -50.000 |

# Filters Calculations

**Low Pass Filter**

$$R_1 = R_2 = 10k\Omega$$

$$f_c = \frac{1}{2\pi\sqrt{R_1R_2C_1C_2}} = \frac{1}{2\pi(10k\Omega)C} = 100KHz$$

$$C = C_1 = C_2 = \frac{1}{2\pi(10k\Omega)(100KHz)} = 159.15pF$$

**High Pass Filter**

$$R_1 = R_2 = 10k\Omega$$

$$f_c = \frac{1}{2\pi\sqrt{R_1R_2C_1C_2}} = \frac{1}{2\pi(10k\Omega)C} = 10KHz$$

$$C = C_1 = C_2 = \frac{1}{2\pi(10k\Omega)(10KHz)} = 1.5915nF$$

**Band Pass Filter**

$$R_1 = R_2 = R_3 = 10k\Omega$$

$$f_r = \frac{1}{2\pi\sqrt{R_1R_2R_3C_1C_2}} = \frac{1}{2\pi(10k\Omega)C} = 10KHz$$

$$C = C_1 = C_2 = \frac{1}{2\pi(10k\Omega)(10KHz)} = 1.5915nF$$

# Filters Plots

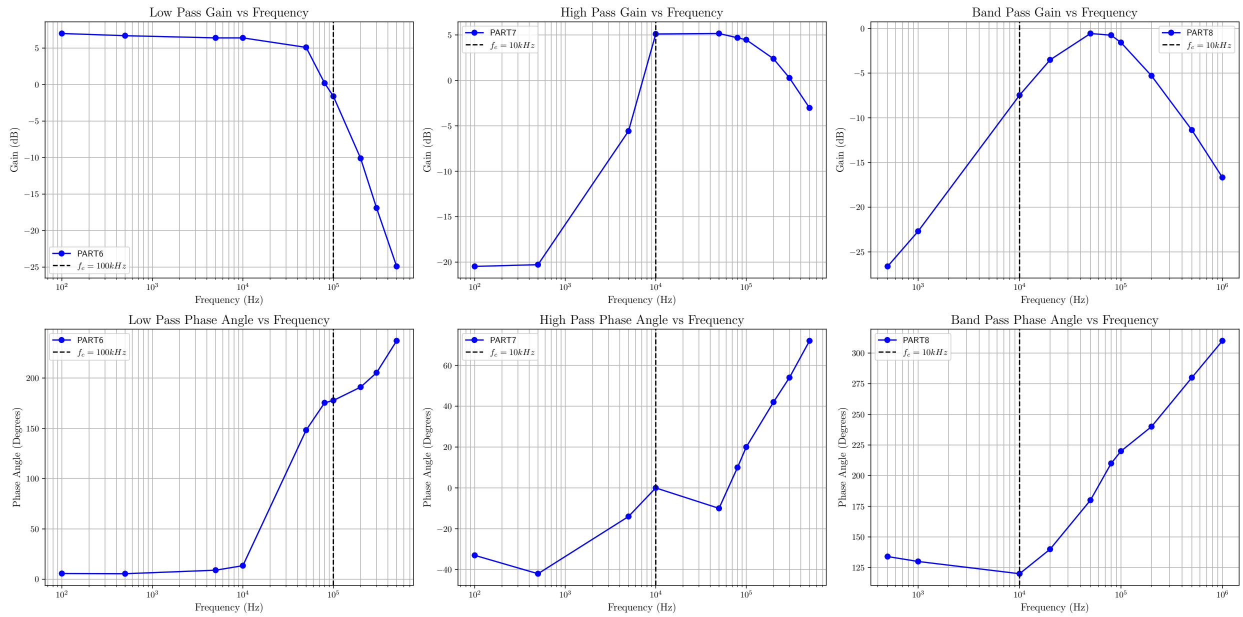


Figure 9: Filters Plots

# Questions

*Question 1.*
Answer.

*Question 2.*
Answer.

Exercise 6: Motor Control

Student's Name: Mohammed Fareed Trent Wesley Section: 1

| PreLab | | Point Value | Points Earned | Comments |
|---|---|---|---|---|
| PreLab | Motor Calculations | 10 | 10 | AJT 10/17 |
| | H-Bridge Questions | 10 | 10 | AJT 10/17 |

| Demo | | Point Value | Points Earned | Date |
|---|---|---|---|---|
| Demo | 20% Duty Cycle at 10kHz | 10 | 10 | AJT 10/25 |
| | DC Motor Functionality | 5 | 5 | MT 10/30 |
| | Stepper Motor Functionality | 5 | 5 | MT |
| | Servo Motor Functionality | 5 | 5 | MT 10/30 |
| | Simultaneous TI Car Motors-Servo Motor | 15 | 15 | AJT 11/1 |

To receive any grading credit students must earn points for both the demonstration and the report.