CMPE 460 Laboratory Exercise 7

Op Amp and Filter Design

Mohammed Fareed
Trent Wesley
Performed: November 1, 2023
Submitted: November 8, 2023

Lab Section: 1
Instructor: Prof. Hussin Ketout
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

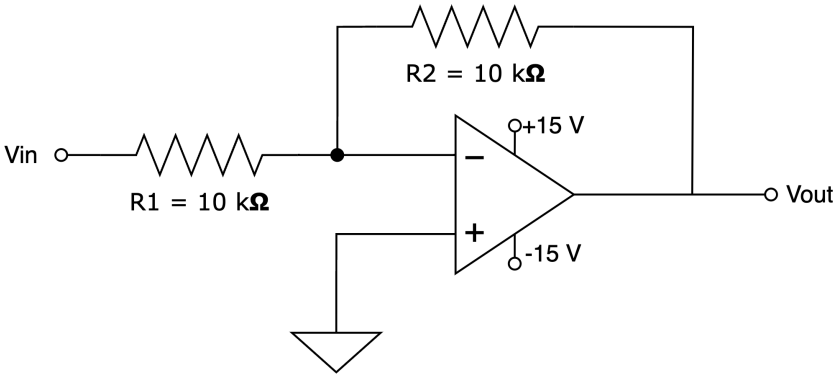

Figure 1: DC Inverting Amplifier

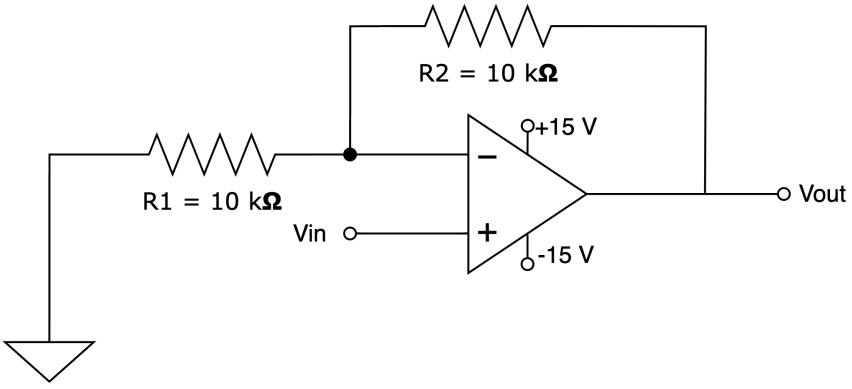

Figure 2: DC Non-Inverting Amplifier

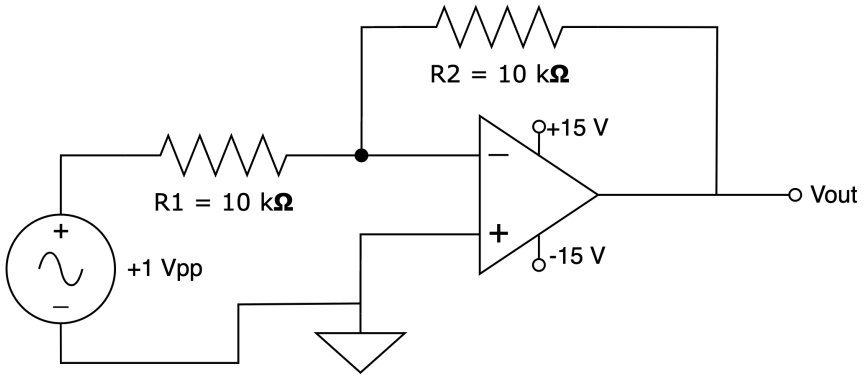

Figure 3: AC Inverting Amplifier

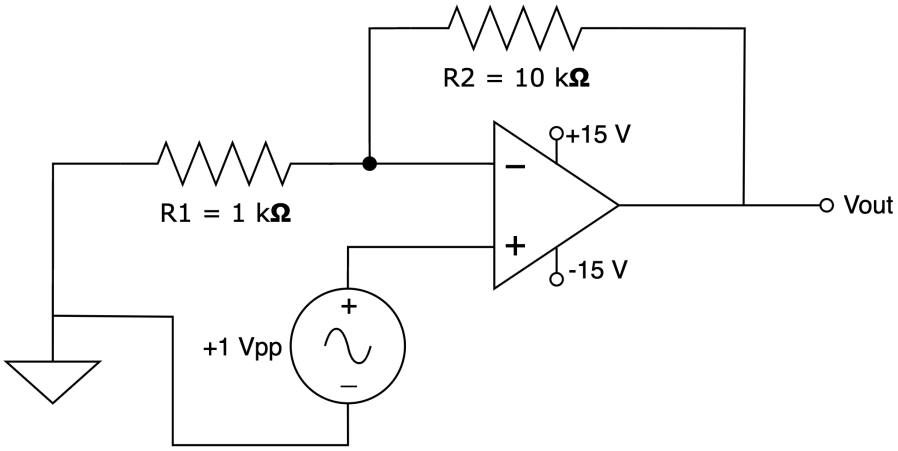

Figure 4: AC Non-Inverting Amplifier

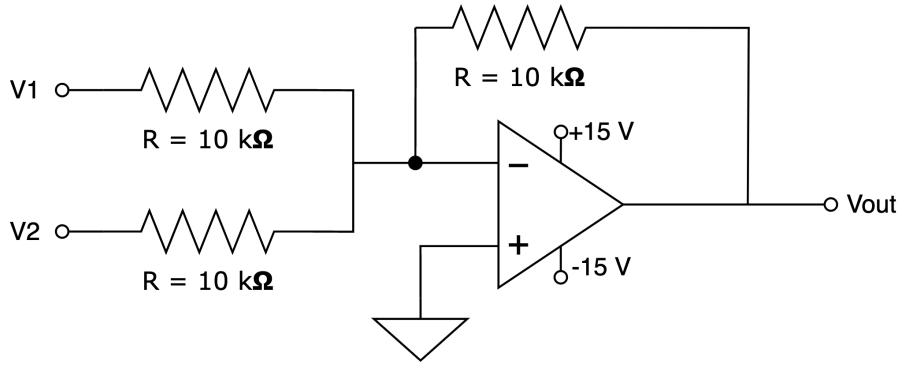

Figure 5: Summing Amplifier

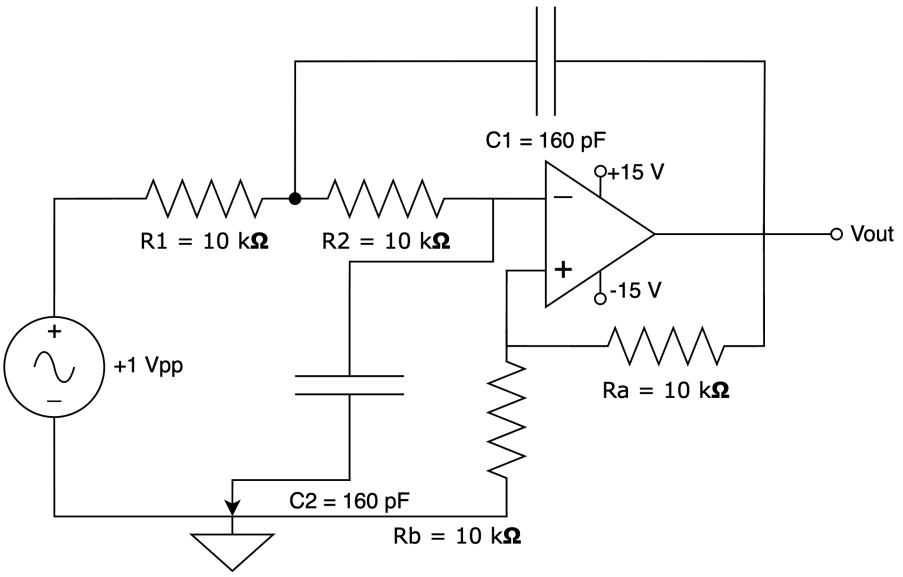

Figure 6: Low Pass Filter

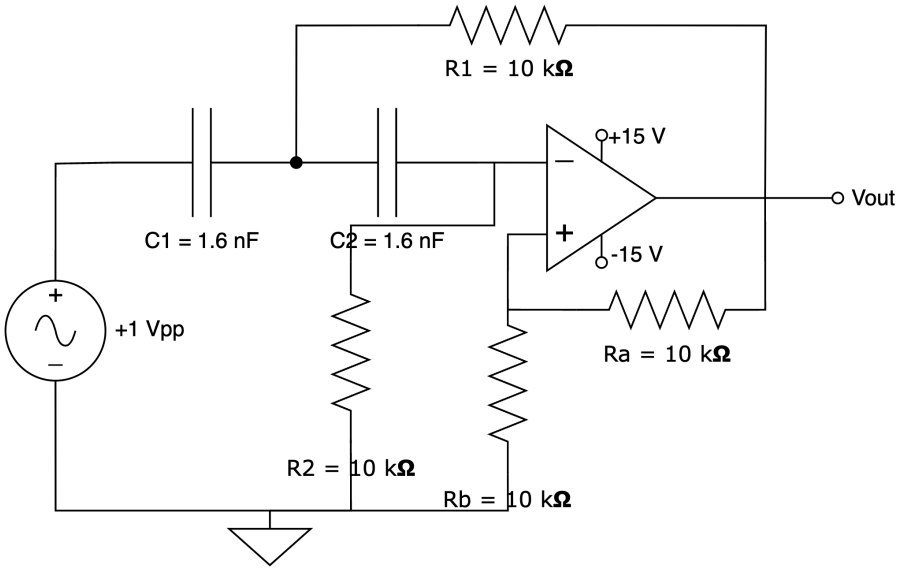

Figure 7: High Pass Filter

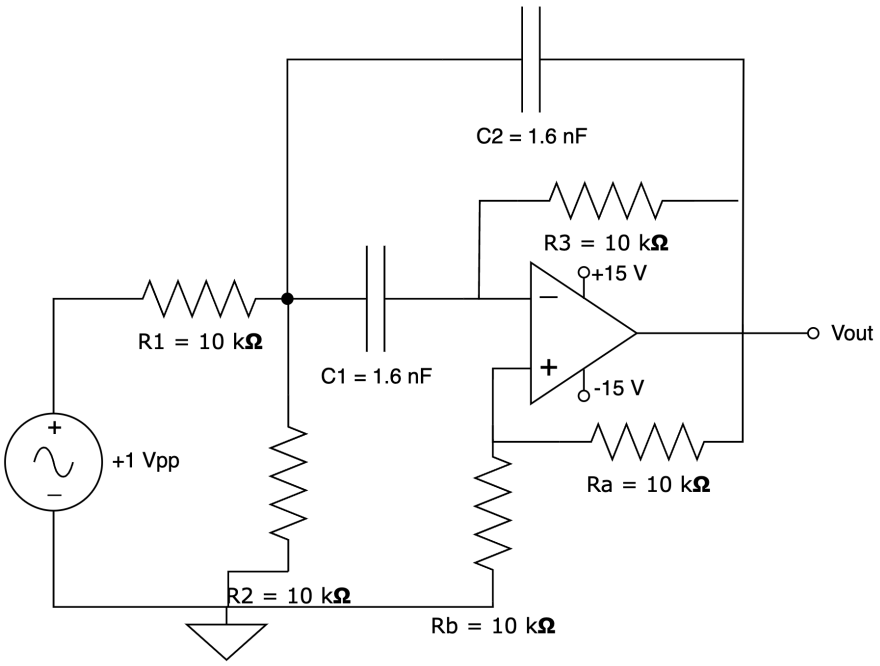

Figure 8: Band Pass Filter

Data Tables

Table 1: DC Inverting Amplifier

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: DC Non-Inverting Amplifier

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: AC Inverting Amplifier

Vin (Vpp)	Calculated Vout (Vpp)	Measured Vout (Vpp)
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: AC Non-Inverting Amplifier

Vin (Vpp)	Calculated Vout (Vpp)	Measured Vout (Vpp)
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: Summing Amplifier

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: Low Pass Filter

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: High Pass Filter

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: Band Pass Filter

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

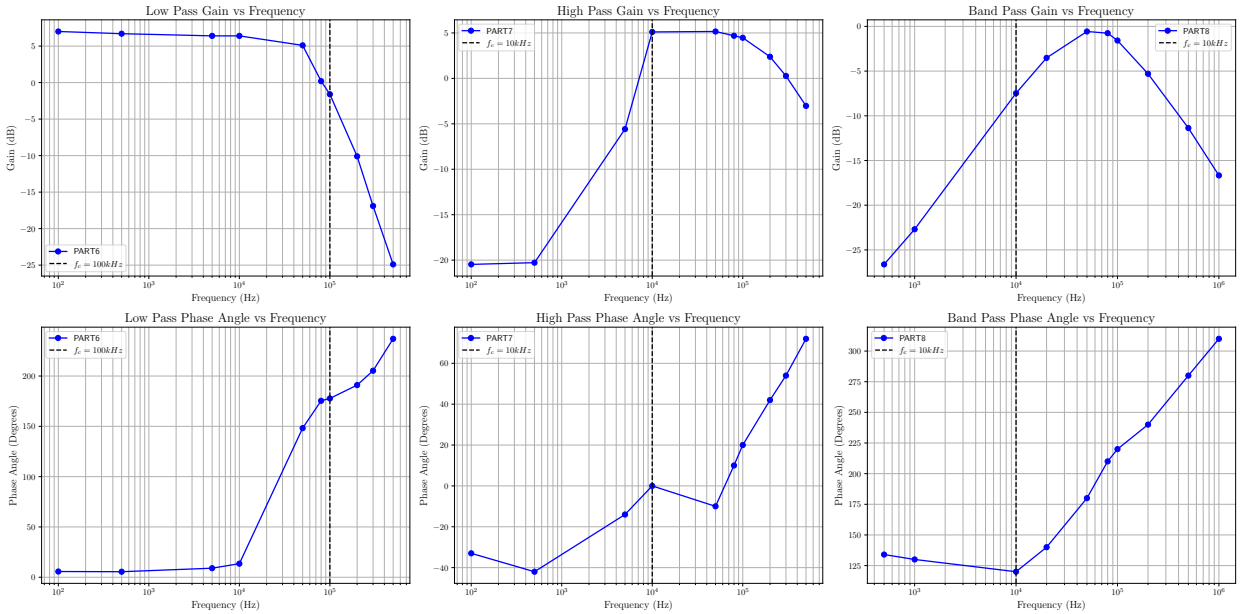

Figure 9: Filters Plots

Questions

Part 3: *Repeat step 2 for the following frequencies: 10 Hz, 100 Hz and 10 KHz. What conclusions can be drawn about voltage gain and phase shift?*
The voltage gain is x10 and the phase is shifted by pi.

Exercise 7: Op amp and Filter Design

Student's Name: Trent Wesley Mohammed Fareed Section: L1

Demo		Point Value	Points Earned	Date
Demo	Inverting op amp (DC & AC)	10	10	11/3 CV
	Non-Inverting op amp (DC & AC)	10	10	
	Summing Amplifier	10	10	CV 11/6
	second order Butterworth low pass filter	10	10	AT 11/7
	second order Butterworth high pass filter	10	10	AT 11/8
	Band pass Infinite Gain (MFB) Filter	10	10	

Report	Point Value	Points Earned	Comments
Exercise Description	5		
Circuit Schematics/Wiring diagrams	10		
Calculated and measured values	5	10	
Magnitude and phase plot with f_c identified	10		