ECE 2101L Section 8

Electrical Circuit Analysis II Lab

LAB 13

Four Pole Low Pass Filter

12/07/2023

ABSTRACT

A four-pole low-pass filter will have its voltages examined through a load resistor to understand the filter's effect to various input frequencies. On the other hand, a state variable filter is a type of multiple feedback filter that can produce all three filter responses, low pass, high pass and band pass simultaneously.

Table of Contents

Page

Abstract…………………………………………………………………2

List of Figures……………………………………………………………..5

List of Tables……………………………………………………………4

I. Objectives……………………………………………………………...8

II. Lab……………………………………………………………………8

III. Conclusion Part 1……………………………………………………...13

IV. Conclusion Part 2……………………………………………………...17

V. Post Lab……………………………………………………………..14

LIST OF TABLES

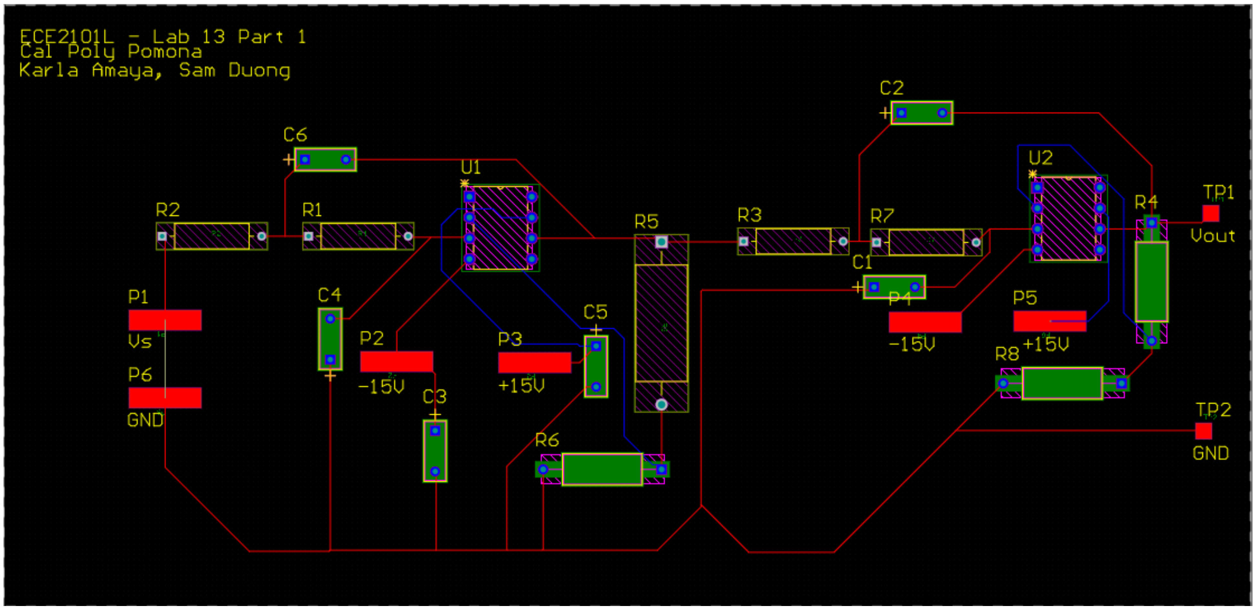
Table 1……………………………………………...9
Table 2……………………………………………...9

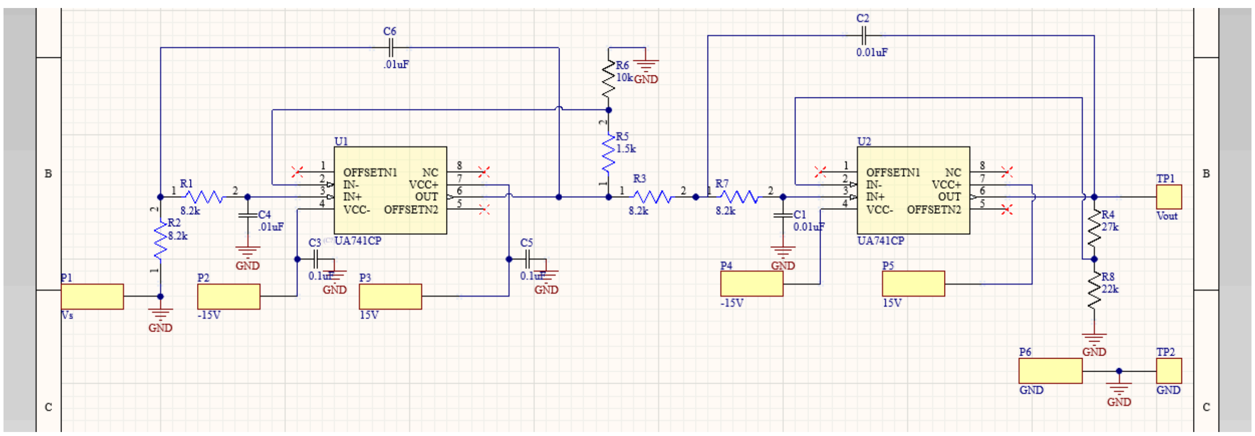
LIST OF FIGURES

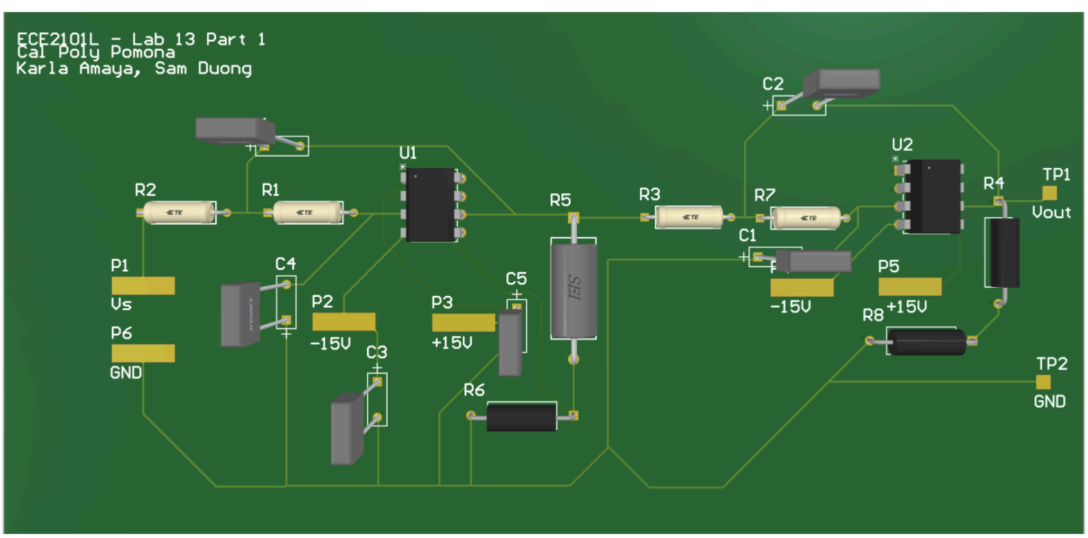
Figure 1…………………………………………….8
Figure 2…………………………………………….9
Figure 3……………………………………………..10
Figure 4……………………………………………..11
Figure 5……………………………………………..12

Schematic + PCB

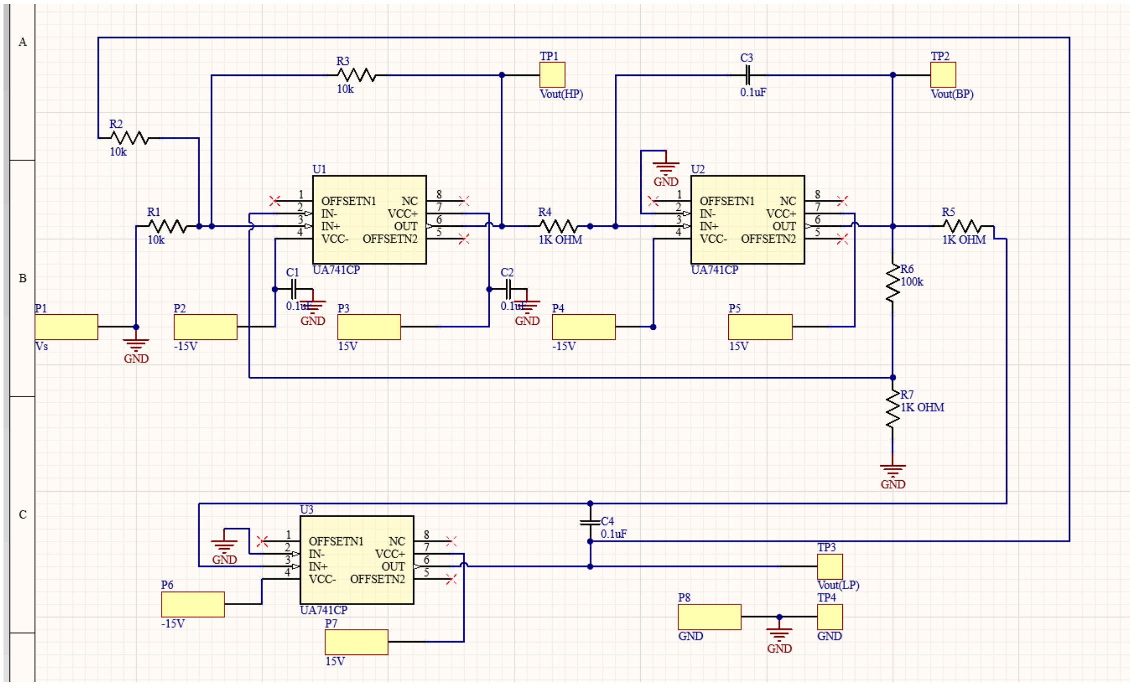
Part 1:

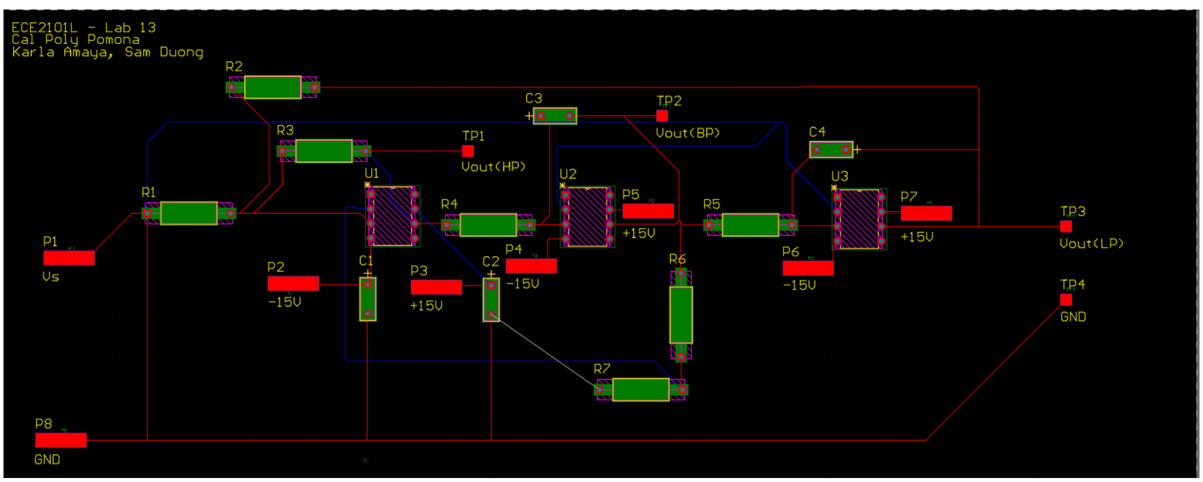


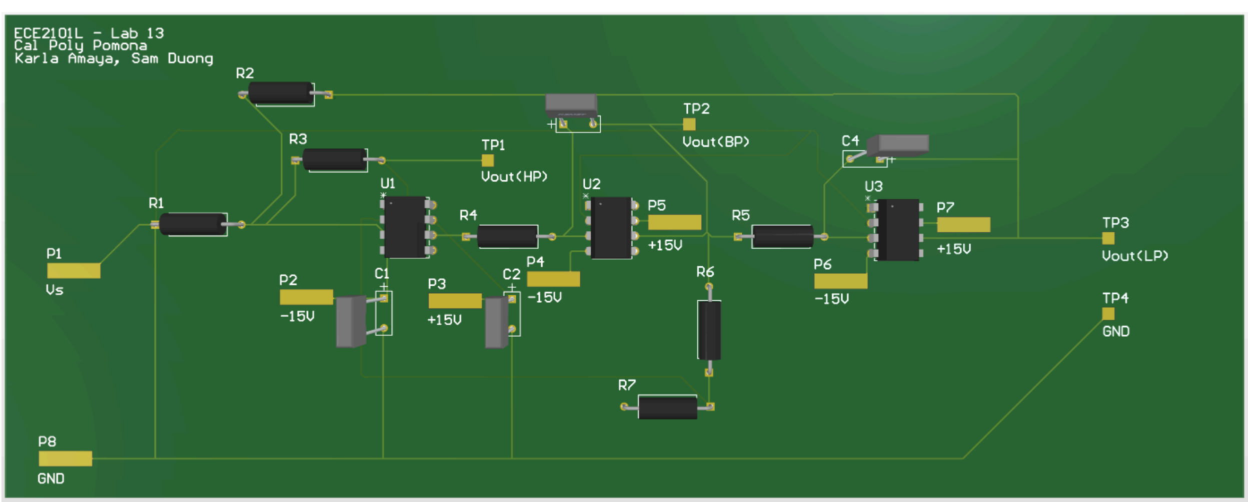




Part 2:


A
B
C
R3
10k
TP1
Vout(HP)
C3
0.1uF
TP2
Vout(BP)
R2
10k
U1
U2
GND
OFFSETN1
NC
IN-
VCC+
IN+
OUT
VCC-
OFFSETN2
UA741CP
R1
10k
R4
1K OHM
R5
1K OHM
R6
100k
C1
C2
P1
Vs
P2
-15V
P3
15V
P4
-15V
P5
15V
R7
1K OHM
U3
C4
0.1uF
TP3
Vout(LP)
TP4
P6
-15V
P7
15V
P8
GND


ECE2101L - Lab 13
Cal Poly Pomona
Karla Amaya, Sam Duong
R2
C3
TP2
Vout(BP)
R3
TP1
Vout(HP)
C4
U1
U2
U3
R1
R4
P5
+15V
R5
P7
+15V
TP3
Vout(LP)
P1
Vs
P2
-15V
C1
P3
+15V
C2
P4
-15V
R6
P6
-15V
TP4
GND
R7
P8
GND


ECE2101L - Lab 13
Cal Poly Pomona
Karla Amaya, Sam Duong
R2
TP2
Vout(BP)
R3
TP1
Vout(HP)
C4
U1
U2
U3
R1
R4
P5
+15V
R5
P7
+15V
TP3
Vout(LP)
P1
Vs
P2
-15V
C1
P3
+15V
C2
P4
-15V
R6
P6
-15V
TP4
GND
R7
P8
GND

Lab

Key Objectives:
1-Build and test a Butter worth low pass active filter for a specific frequency and order.
2-Simulate the circuit
3-Design a PCB for the circuit.

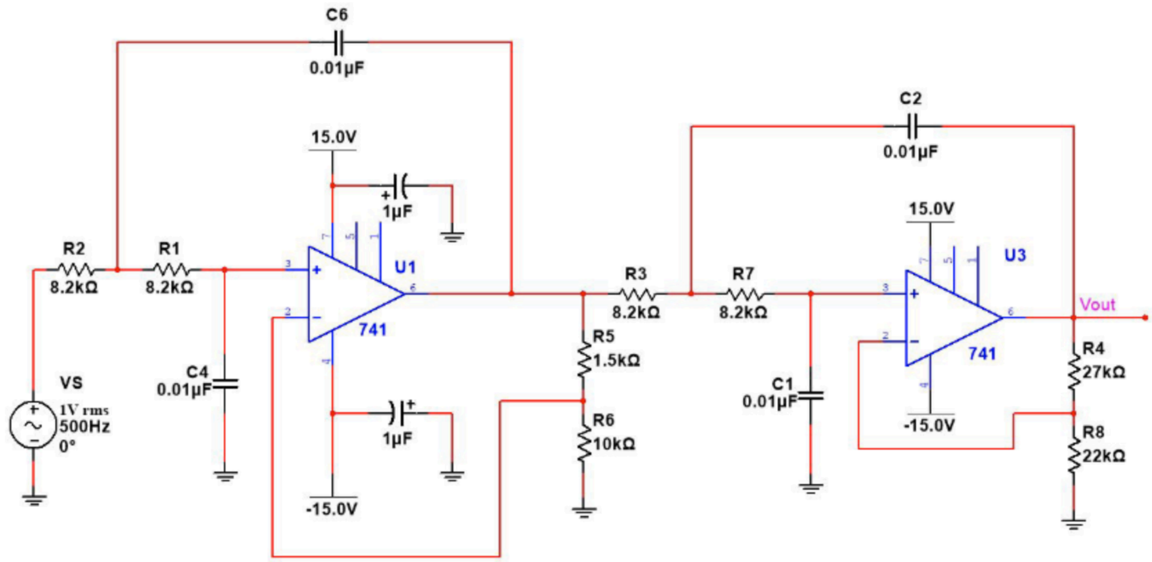


Figure 1

Materials Required:

1. Four 0.01 µF, four 1.0 µF
2. one 1.5 kΩ, four 8.2 kΩ, two 10 kΩ, one 22 kΩ, one 27 kΩ
3. Two LM741 C op-amps
4. Breadboard and all other connecting test leads, alligator clip leads, and etc.
5. Function Generator
6. Oscilloscope
7. Power Supply

Table 1

Component	Listed Value	Measured values A1	B1	A2	B2
R_{A1},R_{B1},R_{A2},R_{B2}	8.2 kΩ	8.19kΩ	8.16kΩ	8.19kΩ	8.19kΩ
C_{A1},C_{A2},C_{B1},C_{B2}	0.01 µF	0.01µF	0.01µF	0.01µF	0.01µF
R_{i1}	10 kΩ	9.89 kΩ			
R_{f1}	1.5 kΩ	1.49 kΩ			

Ri2	22 kΩ	21.65 kΩ			
Rf2	27 kΩ	27.25 kΩ			

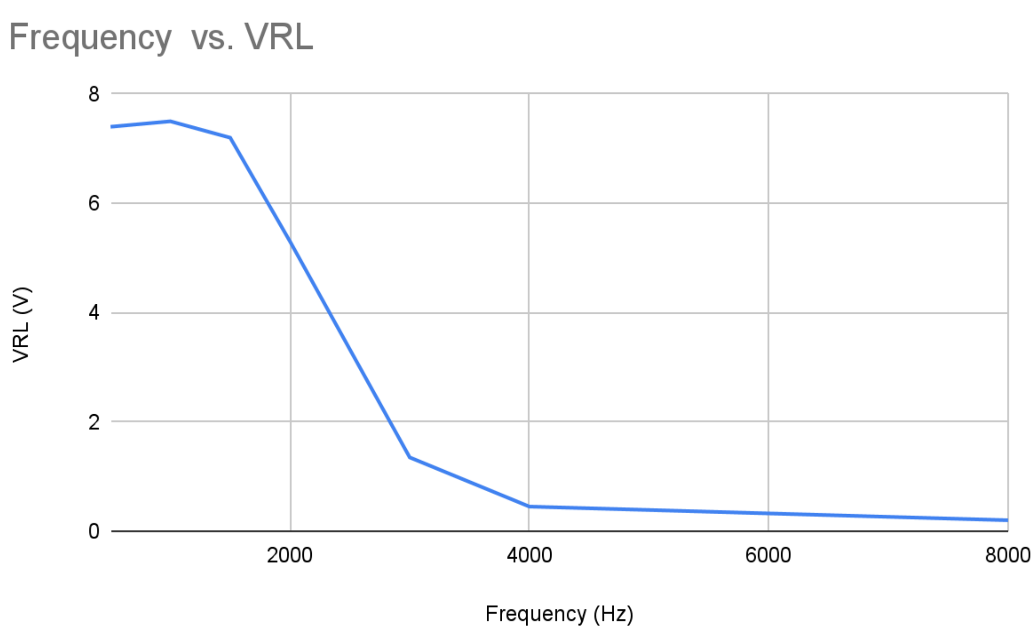
Table 2

Frequency	V_{RL}
500 Hz	7.4V
1000 Hz	7.5V
1500 Hz	7.2V
2000 Hz	5.3V
3000 Hz	1.35V
4000 Hz	450mV
8000 Hz	20mV

<u>Graphs of Findings:</u>

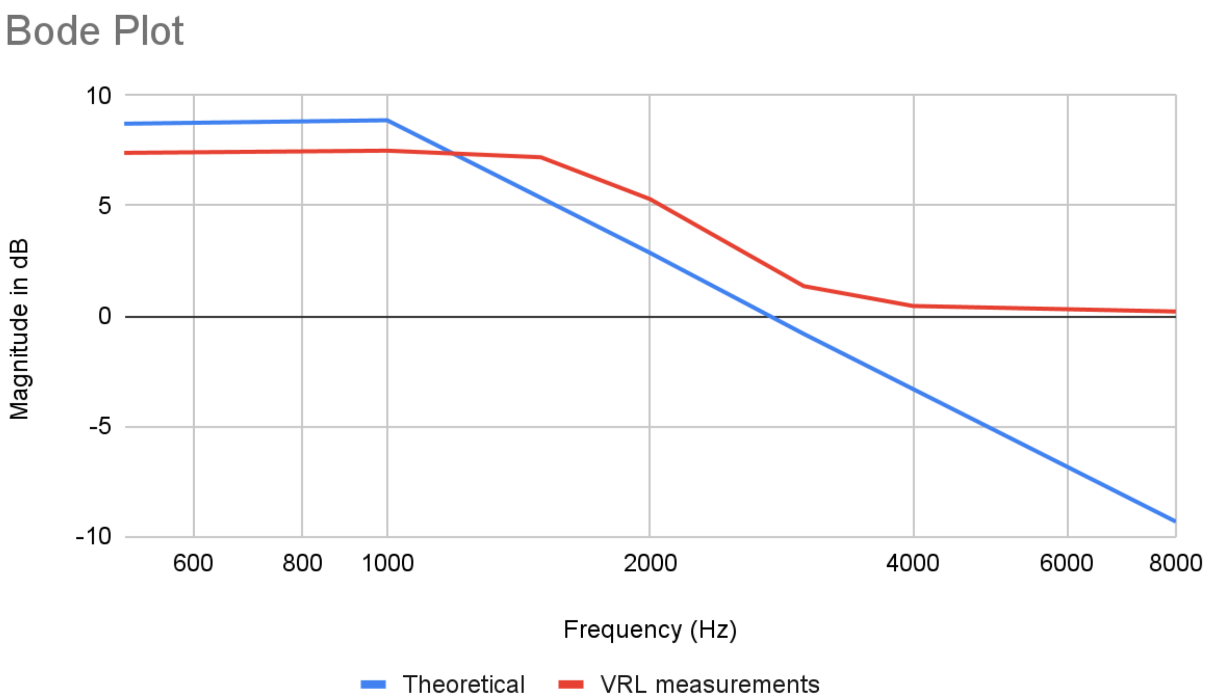
Plot 1:

Figure 2



Plot 2:

Figure 3



<u>Analysis:</u>

- The cutoff frequency for the filter appears to be ~1300 Hz as shown by the drop in voltage on the graph.
- The measured voltage gain is 7.4 V
- The voltage gain should be 7.4 V, our data is correct.
- At 20,000 Hz we would predict that the voltage would be very close to 0 V.
- The actual roll off rate of this filter is 86.334 dB/Decade.

Part 2- State Variable Filter (Simulation)

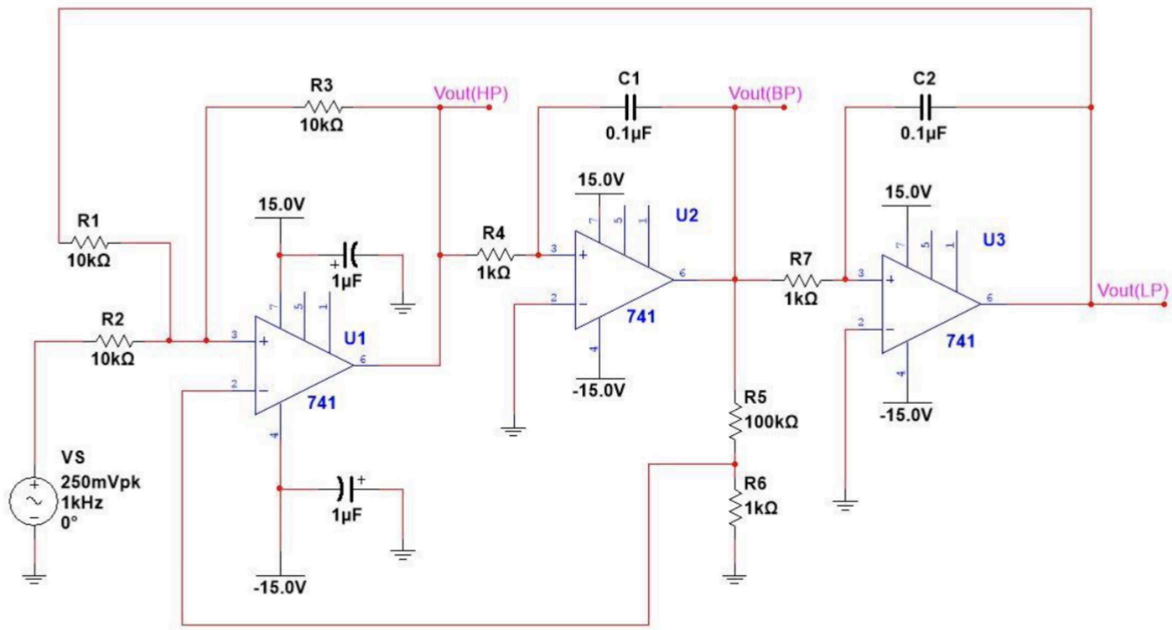


Figure 4

Theoretical and Measured Values

Quantity	Computed	Measured
Center Frequency, f0	1591.55 Hz	1586 Hz
Vpp (Center)		16.772 V
Upper cutoff, fcu		1610 Hz
Lower cutoff, fc1		1563 Hz
Bandwidth, BW	47.27	47 Hz
Q	33.66	33.72

<u>Voltages at varying frequencies:</u>

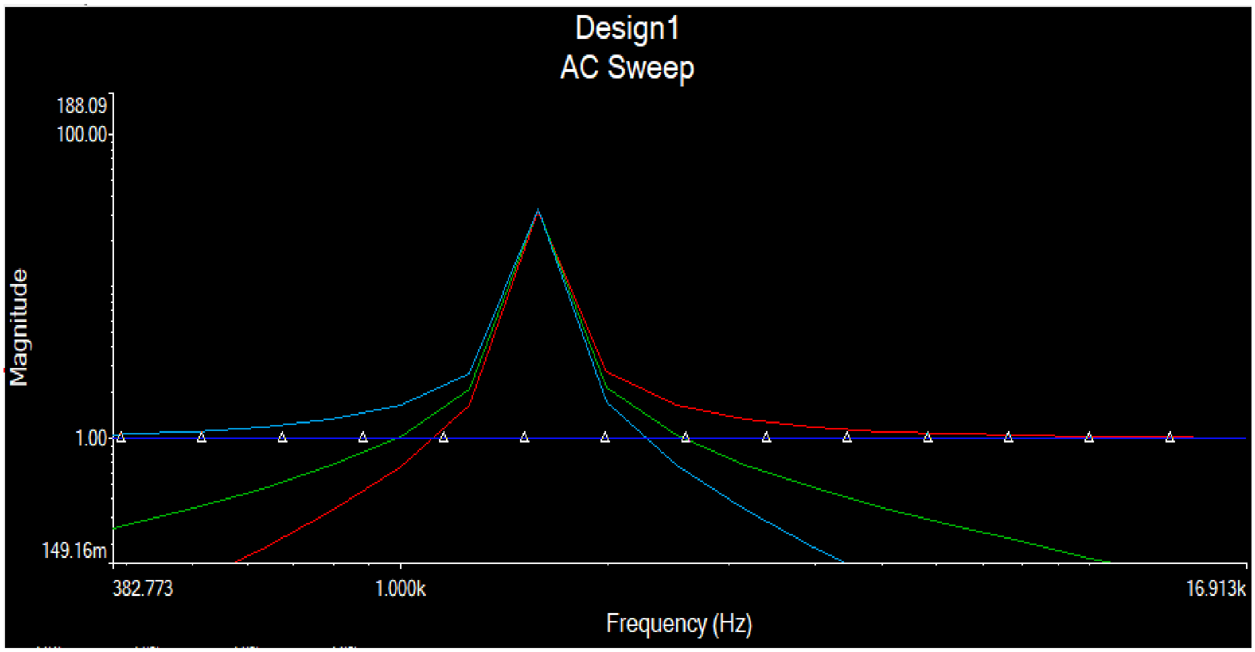


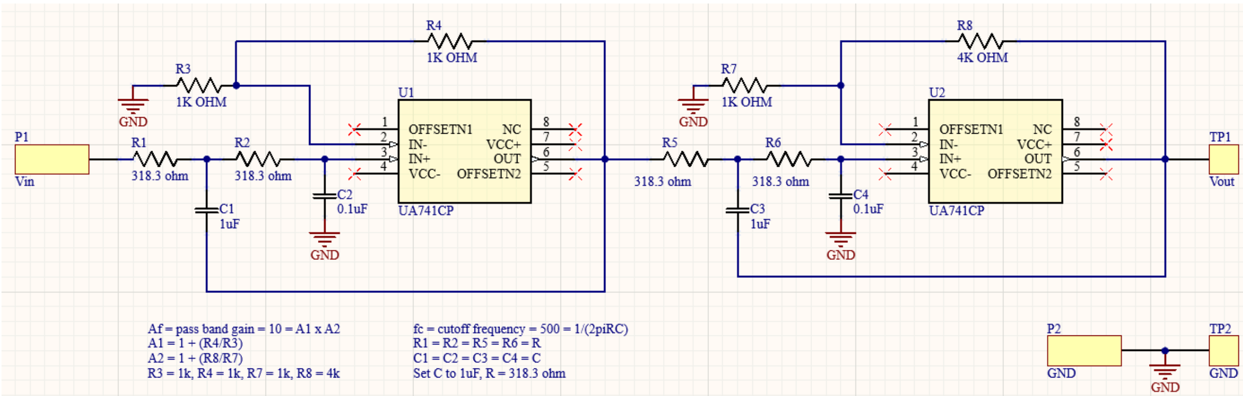
Figure 5

Conclusion:

For this lab, we got to study the response of a four pole low pass filter. We did so by creating this filter with two op-amps and a Load Resistor from which we could study voltage changes. When examining the voltage across the load resistor at various frequencies, we found that the filter we created mimicked that of an actual low pass filter when it came to its frequency response. For part two of the lab, we constructed a state-variable band-pass filter. With this filter, the center frequency was found by tuning the input frequency until the bandpass output was at its highest voltage. For our experiment, this came out to 1586 Hz which is extremely close to the calculated 1591 Hz. In addition to yielding the expected center frequency, the gain and bandwidth of our experimental filter came out to be nearly identical to what our theoretical values were. The cause for such accuracy would be due to the fact that our circuit was created through a simulation rather than in physical life. Finding the center frequency and bandwidth of this filter allowed us to understand this filter's functionality in comparison to our prior lab's butterworth filter.

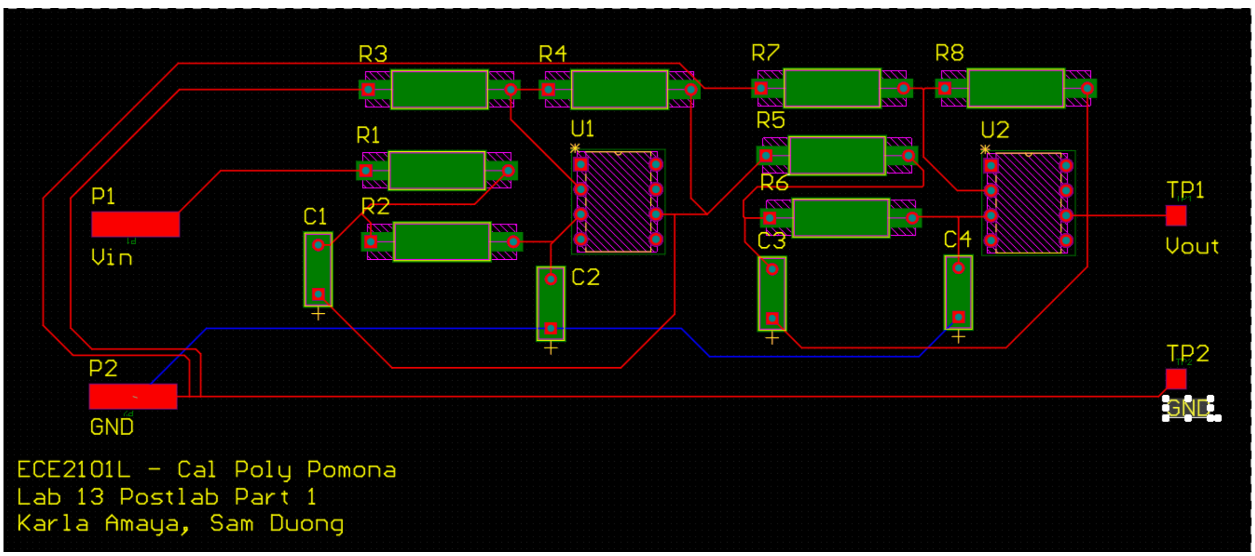
Postlab:

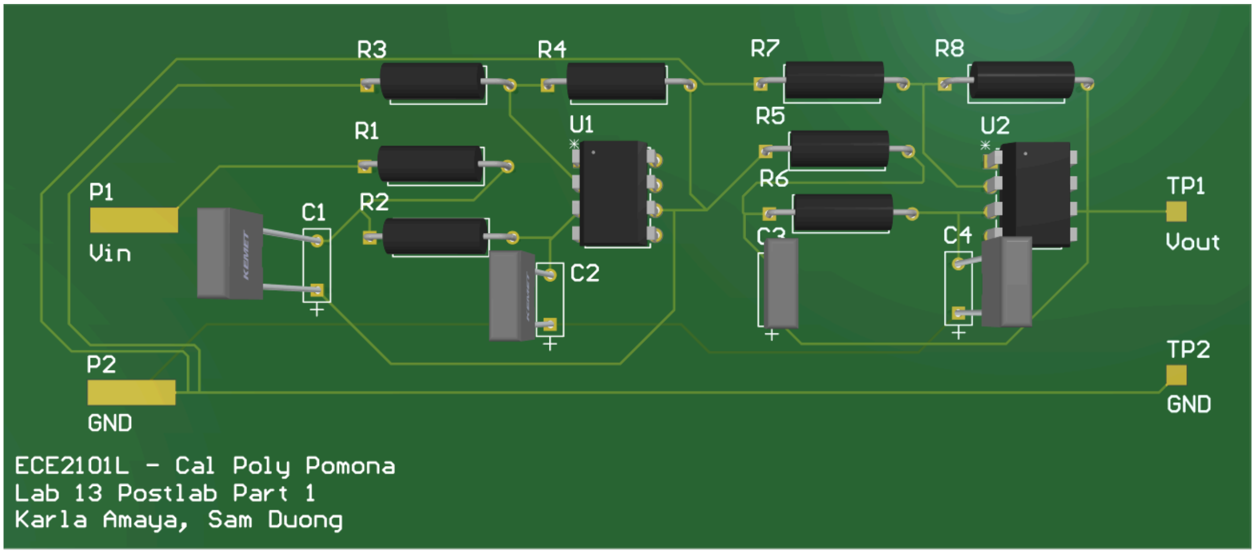
1)

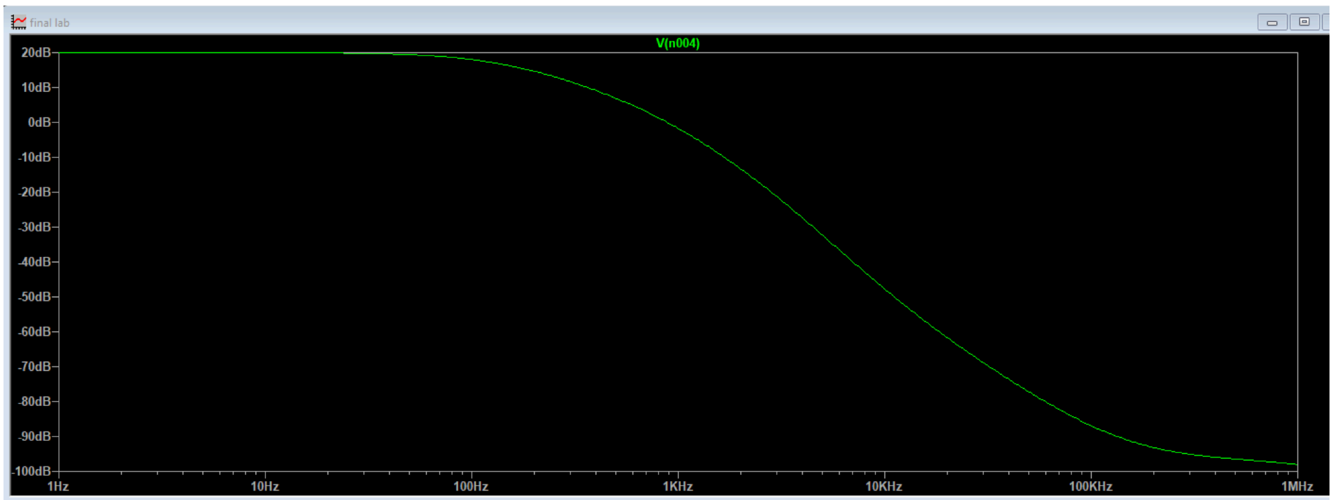


Af = pass band gain = 10 = A1 x A2
A1 = 1 + (R4/R3)
A2 = 1 + (R8/R7)
R3 = 1k, R4 = 1k, R7 = 1k, R8 = 4k

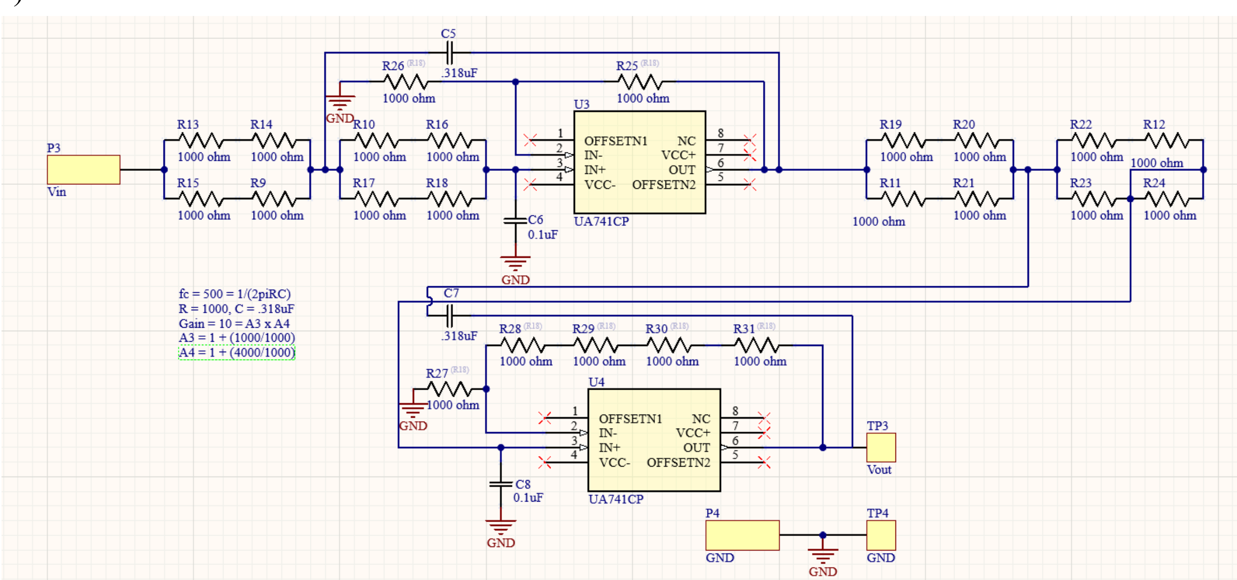
fc = cutoff frequency = 500 = 1/(2piRC)
R1 = R2 = R5 = R6 = R
C1 = C2 = C3 = C4 = C
Set C to 1uF, R = 318.3 ohm



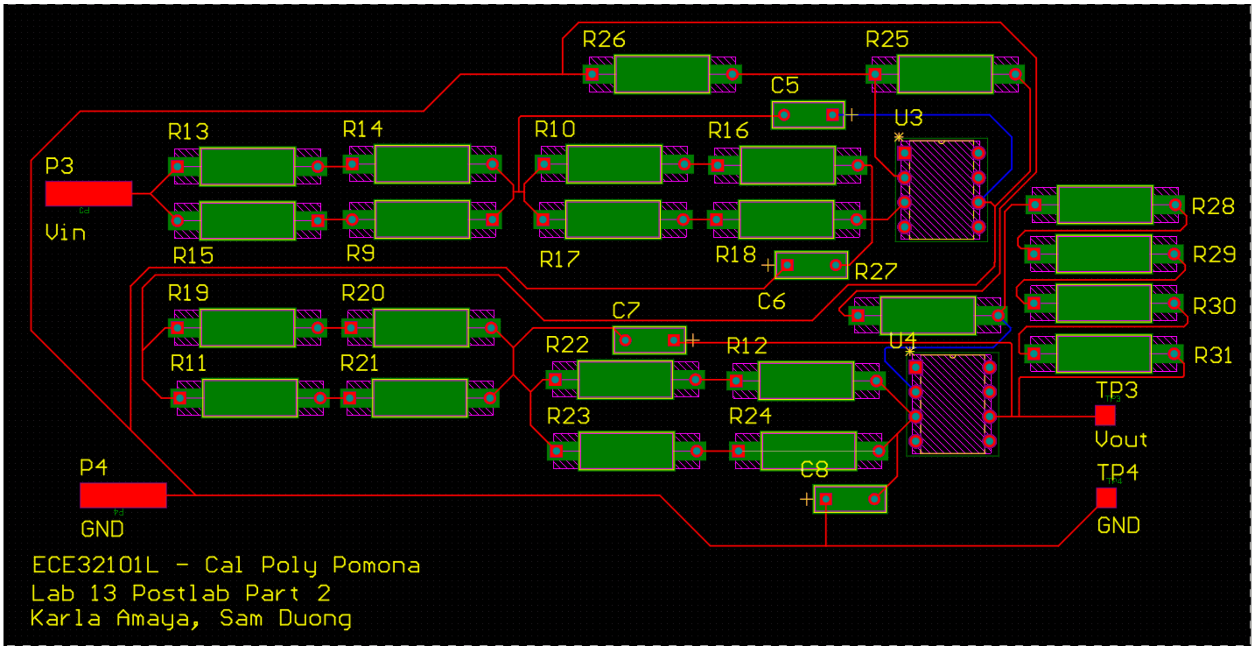

R3
R4
R7
R8
R1
U1
R5
U2
R6
P1
Vin
C1
R2
C2
C3
C4
TP1
Vout
P2
GND
TP2
GND
ECE2101L - Cal Poly Pomona
Lab 13 Postlab Part 1
Karla Amaya, Sam Duong

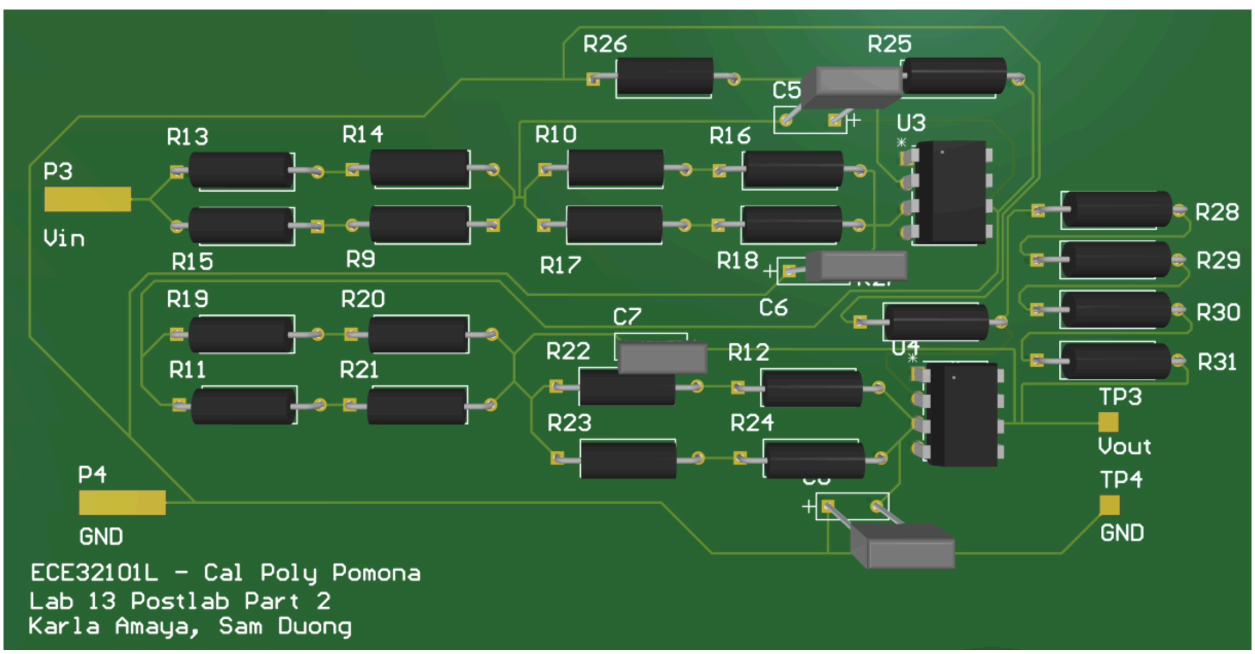

final lab
V(n004)
20dB
10dB
0dB
-10dB
-20dB
-30dB
-40dB
-50dB
-60dB
-70dB
-80dB
-90dB
-100dB
1Hz
10Hz
100Hz
1KHz
10KHz
100KHz
1MHz

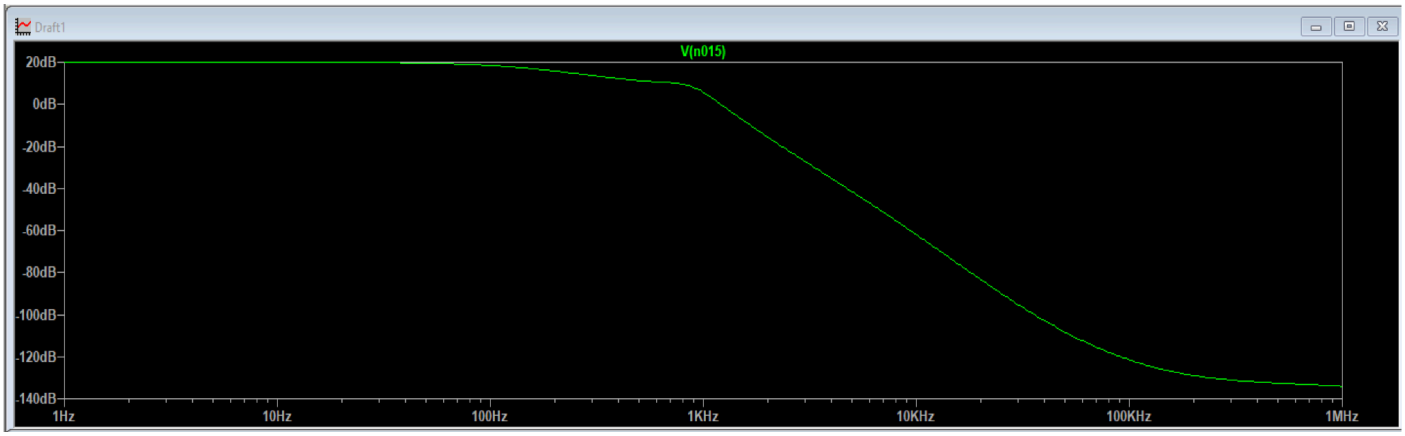
2)


C5
.318uF
R26
1000 ohm
R25
1000 ohm
U3
P3
Vin
R13
R14
R15
R9
R10
R16
R17
R18
1000 ohm
GND
OFFSETN1
NC
IN-
VCC+
IN+
OUT
VCC-
OFFSETN2
UA741CP
C6
0.1uF
GND
R19
R20
R22
R12
R11
R21
R23
R24
1000 ohm
fc = 500 = 1/(2piRC)
R = 1000, C = .318uF
Gain = 10 = A3 x A4
A3 = 1 + (1000/1000)
A4 = 1 + (4000/1000)
C7
.318uF
R28
R29
R30
R31
1000 ohm
R27
1000 ohm
GND
U4
OFFSETN1
NC
IN-
VCC+
IN+
OUT
VCC-
OFFSETN2
UA741CP
C8
0.1uF
GND
TP3
Vout
P4
GND
TP4
GND
GND

fc = 500 = 1/(2piRC)
R = 1000, C = .318uF
Gain = 10 = A3 x A4
A3 = 1 + (1000/1000)
A4 = 1 + (4000/1000)







Conclusion:

For this lab, we got to study the response of a four pole low pass filter. We did so by creating this filter with two op-amps and a Load Resistor from which we could study voltage changes. When examining the voltage across the load resistor at various frequencies, we found that the filter we created mimicked that of an actual low pass filter when it came to its frequency response. For part two of the lab, we constructed a state-variable band-pass filter. With this filter, the center frequency was found by tuning the input frequency until the bandpass output was at its highest voltage. For our experiment, this came out to 1586 Hz which is extremely close to the calculated 1591 Hz. In addition to yielding the expected center frequency, the gain and bandwidth of our experimental filter came out to be nearly identical to what our theoretical values were. The cause for such accuracy would be due to the fact that our circuit was created through a simulation rather than in physical life. Finding the center frequency and bandwidth of this filter allowed us to understand this filter's functionality in comparison to our prior lab's butterworth filter.