EE 230 Lab Lab 3 report

Report: **Second-order filters**

Lab work done by _____Tejas Agarwal_____

and _____Sean Gordon_____

Lab work date:

Report submission date:

Lab Section: E

Graded by _____

Score _____

Introduction

This lab focuses on second order filters of various types, proposing several designs for experimentation to reinforce the relationship between frequency and output. The lab goes over several types of active and inactive filters, requiring graphs of the output.

A. Active low-pass filters

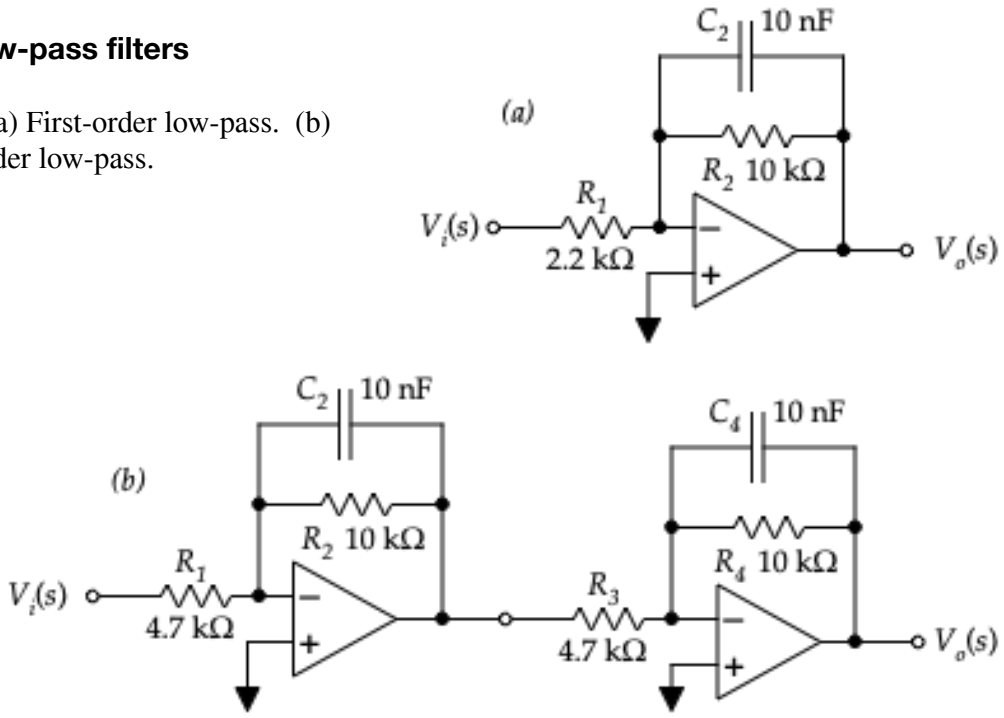


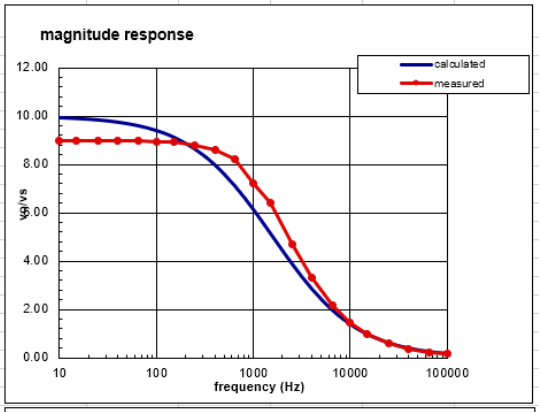
Figure 1. (a) First-order low-pass. (b) Second-order low-pass.

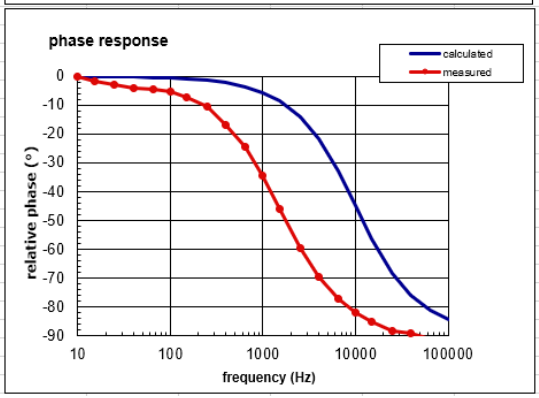
Include the calculations for expected f_c and G_o *for the first-order circuit and* f_o, Q_P, *and* G_o *for the second-order circuit. Comment on how well the calculations and measurements matched.*

f_c = 1591.6 Hz G_o = -4.54
f_o = 1591.6 Hz G_o = 20.66 Q_p = .5

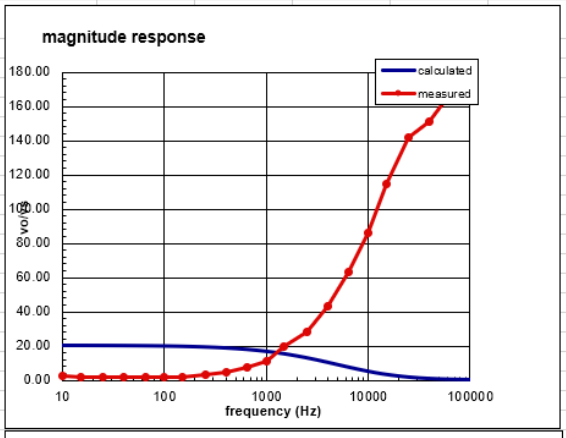
Figures: *Insert plots of the magnitudes versus frequency (both curves in one Bode plot) and phase angle versus frequency (also both curves on one set of axes).*

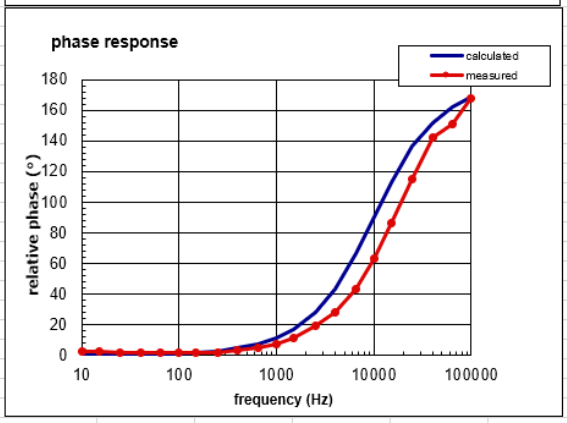
frequency (Hz)	Vo	measured magnitude	predicted magnitude	measured phase	predicted phase
10	2.24	8.96	9.937560466	0	-0.05729576
15	2.24	8.96	9.906632191	-1.7	-0.0859436
25	2.24	8.96	9.84534961	-2.9	-0.14323915
40	2.24	8.96	9.754834274	-4	-0.2291819
65	2.24	8.96	9.607618108	-4.5	-0.37241732
100	2.23	8.92	9.408826026	-5.5	-0.5729387
150	2.23	8.92	9.138698005	-7.5	-0.85937224
250	2.2	8.8	8.642447518	-10.5	-1.43209618
400	2.15	8.6	7.991513573	-17	-2.29061004
650	2.05	8.2	7.100220093	-24.5	-3.71899397
1000	1.8	7.2	6.141304549	-34.5	-5.71059314
1500	1.6	6.4	5.148063993	-46	-8.53076561
2500	1.18	4.72	3.889845296	-59.5	-14.0362435
4000	0.825	3.3	2.84634778	-69.5	-21.8014095
6500	0.538	2.152	1.966927897	-77	-33.0238676
10000	0.361	1.444	1.373025617	-82	-45
15000	0.245	0.98	0.959253045	-85	-56.3099325
25000	0.149	0.596	0.598516997	-88.5	-68.1985905
40000	0.094	0.376	0.382661731	-89	-75.9637565
65000	0.058	0.232	0.239001712	-91	-81.2538377
100000	0.038	0.152	0.156661596	-93	-84.2894069





frequency (Hz)	predicted magnitude	Vo	measured magnitude	predicted phase	measured phase
10	20.61989661	2.26	9.04	0.11459152	2.56
15	20.59931273	2.26	9.04	0.17188721	2.5
25	20.55823734	2.26	9.04	0.2864783	2.1
40	20.49685424	2.26	9.04	0.45836379	2
65	20.39515827	2.26	9.04	0.74483464	2
100	20.2540506	2.26	9.04	1.1458774	1.8
150	20.0549948	2.26	9.04	1.71874449	1.8
250	19.66558669	2.26	9.04	2.86419237	1.7
400	19.10240109	2.26	9.04	4.58122009	3.3
650	18.21610088	2.26	9.04	7.43798795	4.8
1000	17.07533638	2.26	9.04	11.4211863	7.3
1500	15.62280304	2.25	9	17.0615312	11
2500	13.22314049	2.21	8.84	28.0724869	19.6
4000	10.54140664	2.14	8.56	43.602819	28.4
6500	7.589038391	1.96	7.84	66.0477351	43
10000	5.165289255	1.66	6.64	90	63.1
15000	3.305785123	1.24	4.96	112.619865	86.1
25000	1.686625063	0.697	2.788	136.397181	115
40000	0.826446281	0.34	1.36	151.927513	142
65000	0.367309458	0.147	0.588	162.507675	151
100000	0.170753364	0.062	0.248	168.578814	168





B. *RLC* 2nd-order filters

Include the calculations for f_o, Q_P, and G_o for the circuits. *Comment on how well the calculations and measurements matched.*

Figure 2. Low-pass.

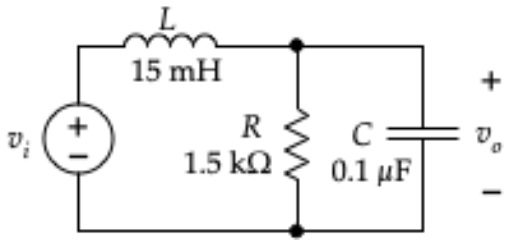


Figure 3. High-pass

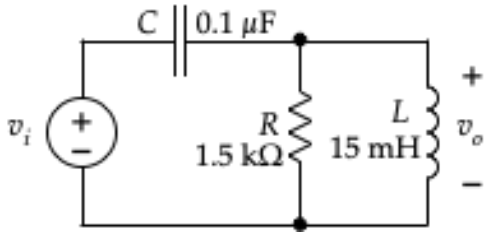
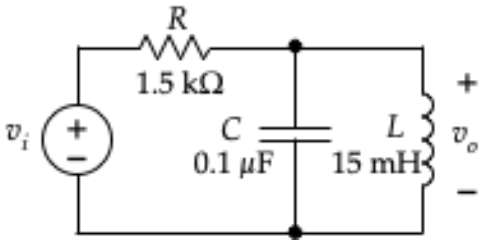


Figure 4. Band-pass

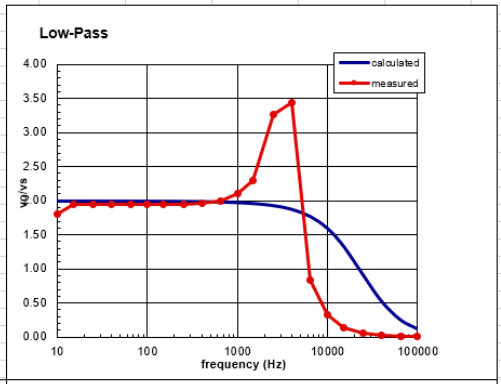


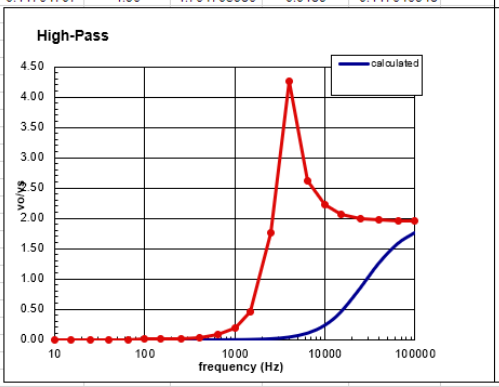
For all Circuits:

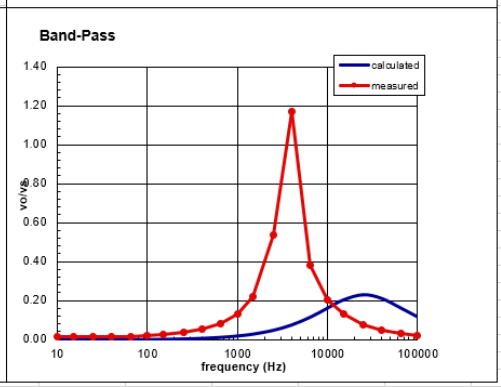
$f_o = 4109\ Hz$ $Q_p = 3.87$ $G = 1$

Figures. *Insert measured Bode plots for each of the three circuits.*

frequency (Hz)	Low-Pass Magnitude	Low-Pass Predicted	High-Pass Magnitude	High-Pass Predicted	Band-Pass Magnitude	Band-Pass Predicted
10	1.8	1.99979972	0.000323	2.9997E-07	0.015	0.00019998
15	1.94	1.99969937	0.000385	6.74899E-07	0.0152	0.000299955
25	1.94	1.99949825	0.000558	1.87453E-06	0.0152	0.000499874
40	1.94	1.99919552	0.000873	4.79807E-06	0.016	0.000799677
65	1.94	1.99868819	0.00151	1.26667E-05	0.0171	0.001299146
100	1.94	1.99797206	0.00265	2.99696E-05	0.0196	0.00199797
150	1.94	1.9969372	0.00284	6.73966E-05	0.0241	0.002995403
250	1.95	1.99482593	0.0118	0.000187015	0.0347	0.00498706
400	1.96	1.99155581	0.0286	0.000477973	0.0524	0.007966215
650	2	1.98583357	0.0751	0.001258522	0.0841	0.012907905
1000	2.1	1.97726151	0.183	0.002965892	0.133	0.019772595
1500	2.3	1.96391313	0.45	0.006628207	0.218	0.029458667
2500	3.27	1.93353479	1.76	0.018126889	0.539	0.048338321
4000	3.44	1.87969932	4.26	0.045112784	1.17	0.075187898
6500	0.837	1.7724605	2.62	0.112329684	0.383	0.115209817
10000	0.323	1.60000013	2.22	0.240000019	0.206	0.159999853
15000	0.14	1.34453795	2.07	0.453781558	0.129	0.201680491
25000	0.05	0.91428582	2	0.857142955	0.0755	0.228571226
40000	0.019	0.52631584	1.97	1.263158028	0.047	0.210526127
65000	0.0073	0.25039126	1.96	1.586854589	0.029	0.162754154
100000	0.003	0.11764707	1.96	1.764705986	0.0189	0.117646948







C. Active Bi-quads

Include the calculations for f_o, Q_P, and G_o *for each circuit. Comment on how well the calculations and measurements matched.*

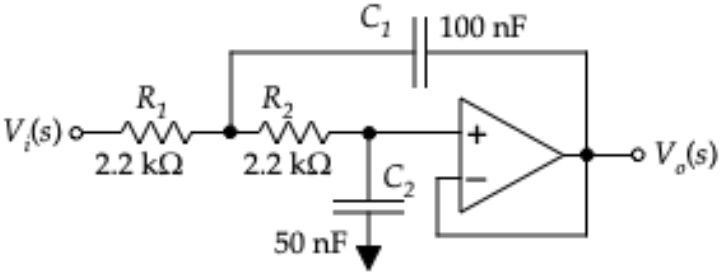


Figure 5. Sallen-Key low-pass.
Note that you can make a 50 nF capacitor using two 100-nF caps in series.

f_o = 723.4 Hz Q_p = .5 G = 1

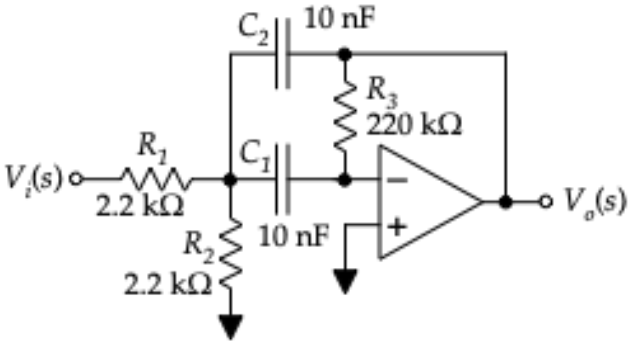


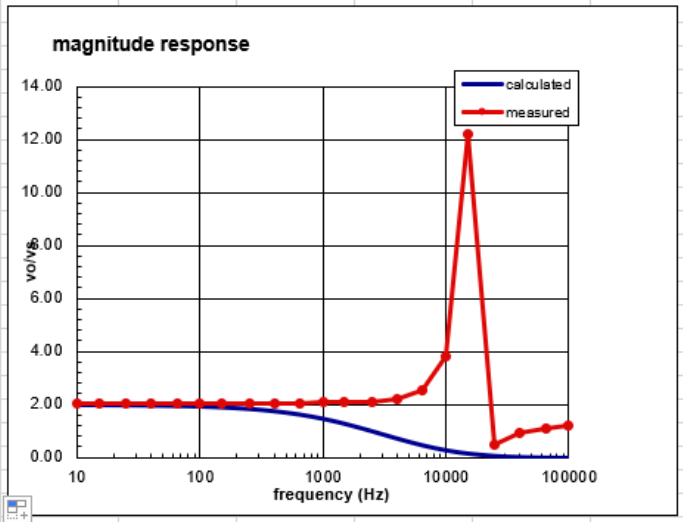
Figure 6. Delyiannis-Friend band-pass.

f_o = 102.3 Hz Q_p = .07 G = .5

Figures. *Insert the measured Bode plots for each circuit.*

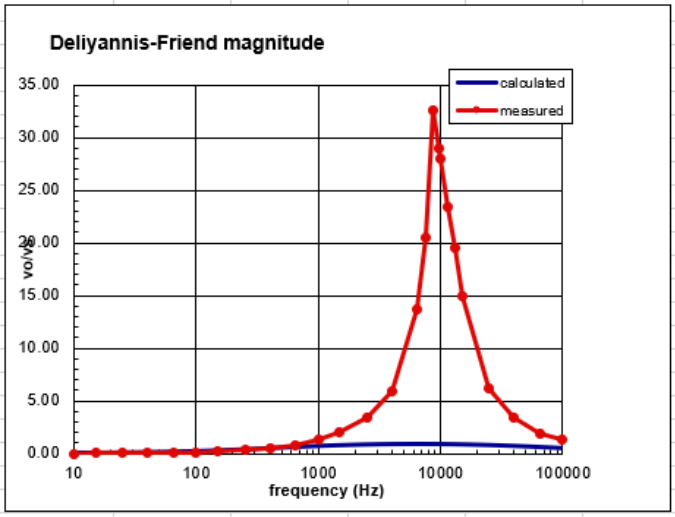
Sallen-Key:

frequency (Hz)	Sallen-Key Vo	Sallen-Key Magnitude	Sallen-Key Predicted
10	0.513	2.052	1.9934169
15	0.513	2.052	1.99013798
25	0.513	2.052	1.98360526
40	0.513	2.052	1.97386851
65	0.513	2.052	1.95780492
100	0.513	2.052	1.93565497
150	0.513	2.052	1.90468121
250	0.513	2.052	1.84499721
400	0.514	2.056	1.76076183
650	0.515	2.06	1.6330204
1000	0.516	2.064	1.47688682
1500	0.519	2.076	1.29078071
2500	0.527	2.108	1.01201782
4000	0.546	2.184	0.73877078
6500	0.634	2.536	0.47990984
10000	0.95	3.8	0.29761909
15000	3.05	12.2	0.1755156
25000	0.121	0.484	0.08205129
40000	0.23	0.92	0.0377929
65000	0.273	1.092	0.01603914
100000	0.301	1.204	0.00724638



Deliyannis-Friend:

frequency (Hz)	Deliyannis-Friend Vo	Deliyannis-Friend Magnitude	Deliyannis-Friend Predicted
10	0.00475	0.019	0.02152173
15	0.0058	0.0232	0.03193541
25	0.0087	0.0348	0.05210478
40	0.0133	0.0532	0.0808141
65	0.021	0.084	0.12494186
100	0.0321	0.1284	0.17996762
150	0.048	0.192	0.24740512
250	0.08	0.32	0.35324054
400	0.127	0.508	0.46495109
650	0.206	0.824	0.5825975
1000	0.324	1.296	0.67771541
1500	0.492	1.968	0.75214524
2500	0.848	3.392	0.82013039
4000	1.49	5.96	0.85643093
6500	3.41	13.64	0.86848513
7500	5.11	20.44	0.86722283
8750	8.15	32.6	0.8634101
9700	7.23	28.92	0.85943105
10000	7	28	0.85803423
11500	5.84	23.36	0.85032147
13000	4.89	19.56	0.84177553
15000	3.73	14.92	0.82966679
25000	1.55	6.2	0.76735255
40000	0.863	3.452	0.68429231
65000	0.481	1.924	0.57736947
100000	0.328	1.312	0.47291482



D. Psuedo-inductor circuit

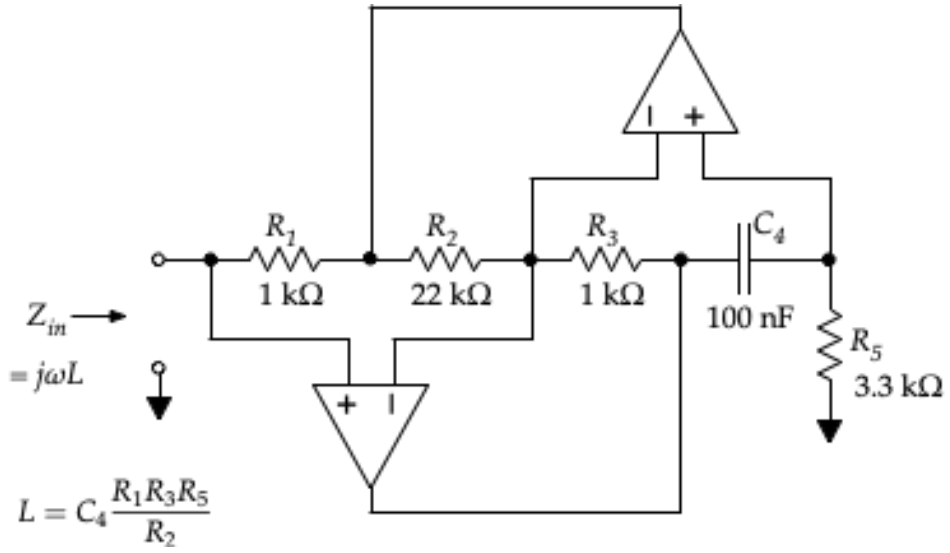


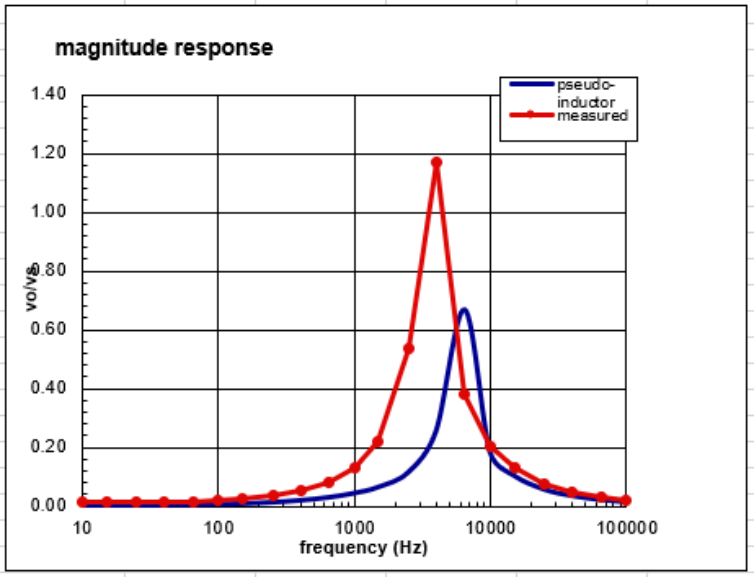
Figure 7. Inductor simulation circuit.

Include the calculation for expected inductance.

$L = \frac{R_1 R_3 R_5 C}{R_2} = .015\ H$

Figures. *Insert Bode plots of the the RLC bandpass circuit (measured in part B) and the bandpass circuit using the psuedo-inductor measured here. Put both curves on one set of axes.*

	A	B	C
1	frequency (Hz)	Band-Pass Magnitude	Band-Pass Pseudo-Inductor
2	10	0.015	0.01108
3	15	0.0152	0.00972
4	25	0.0152	0.01056
5	40	0.016	0.01228
6	65	0.0171	0.01692
7	100	0.0196	0.02368
8	150	0.0241	0.03332
9	250	0.0347	0.0516
10	400	0.0524	0.0772
11	650	0.0841	0.1184
12	1000	0.133	0.1756
13	1500	0.218	0.258
14	2500	0.539	0.46
15	4000	1.17	1.02
16	6500	0.383	2.684
17	10000	0.206	0.736
18	15000	0.129	0.416
19	25000	0.0755	0.2276
20	40000	0.047	0.14
21	65000	0.029	0.0868
22	100000	0.0189	0.0568
23			



Conclusion

This lab focused on the relationship between frequency and output for several different types of filters. The lab went over several specific filter designs, as well as just general passive and active second order filters.