Filter Design Experimental Results

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1 Design Specifications

My design specifications were as follows:

1. Passband $f = 600\,\text{Hz}$
2. Do not deviate by more than $\pm 3\,\text{dB}$ from 20 dB gain in the passband
3. Attenuate frequencies higher than $9.5\,\text{kHz}$ by more than 15 dB

2 Final Filter Design

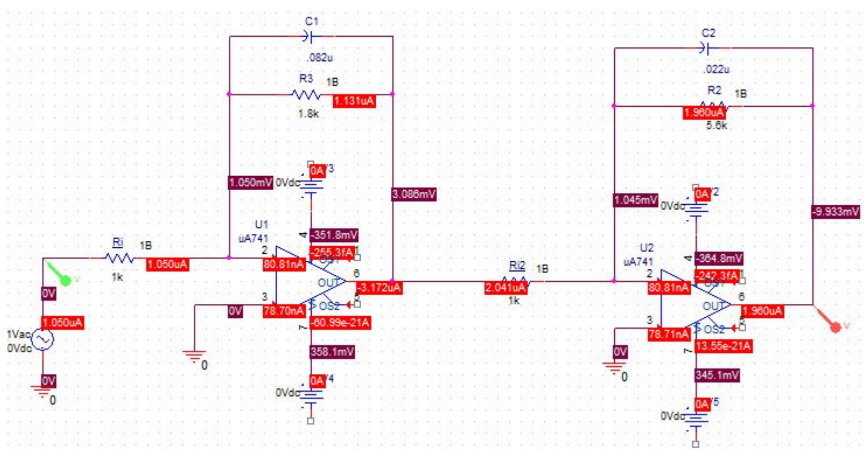

Figure 1: Final circuit diagram with components marked

3 Data

	Experimental				Theoretical	
Frequency (Hz)	V_O(V)	V_i(V)	H(s)	Phase (°)	H(s)	Phase (°)
400	8.180	.952	8.59	-40	8.9998	-38
500	7.643	.952	8.03	-48	8.4896	-47
600	7.095	.952	7.45	-57	7.9403	-55
700	6.548	.952	6.88	-64	7.3773	-62
800	6.026	.952	6.33	-71	6.8202	-69
900	5.548	.952	5.83	-77	6.2833	-75
1000	5.085	.952	5.34	-83	5.7758	-81
1500	3.330	.952	3.50	-104	3.7756	-104
2000	2.276	.952	2.39	-117	2.5449	-119
2500	1.630	.951	1.71	-129	1.7939	-130
3000	1.231	.951	1.29	-136	1.3185	-137
3500	.916	.950	.964	-141	1.0041	-143
4000	.725	.950	.763	-145	.7875	-147
4500	.588	.950	.619	-149	.6328	-151
5000	.4761	.949	.502	-153	.5189	-154
5500	.3998	.948	.422	-156	.4327	-156
6000	.3387	.949	.357	-159	.3662	-158
6300	.3092	.948	.326	-160	.3333	-159
6700	.2757	.951	.290	-161	.2958	-160
7000	.2532	.949	.267	-161	.2717	-161
7300	.2341	.949	.247	-163	.2504	-162
7700	.2111	.949	.222	-161	.2256	-163
8000	.1966	.949	.207	-165	.2094	-164
8300	.1831	.950	.193	-163	.1948	-165
8700	.1673	.950	.176	-162	.1776	-165
9000	.1565	.950	.165	-163	.1662	-166
9300	.1478	.950	.156	-164	.1558	-166
9700	.1366	.950	.144	-163	.1434	-167
10000	.1320	.950	.139	-166	.1350	-167
10500	.1212	.950	.128	-167	.1226	-168
11000	.1111	.949	.117	-167	.1119	-168
11500	.1039	.950	.109	-167	.1024	-169
12000	.0963	.950	.101	-169	.0942	-170
12500	.0893	.950	.0940	-169	.0868	-170
13000	.0847	.950	.0892	-172	.0803	-170
13500	.0790	.950	.0831	-168	.0745	-171
14000	.0740	.951	.0778	-173	.0694	-171
14500	.0712	.951	.0749	-170	.0647	-171
15000	.0630	.951	.0662	-173	.0605	-171
15500	.0600	.950	.0632	-174	.0567	-171
16000	.0560	.952	.0588	-170	.0532	-172

4 Plots

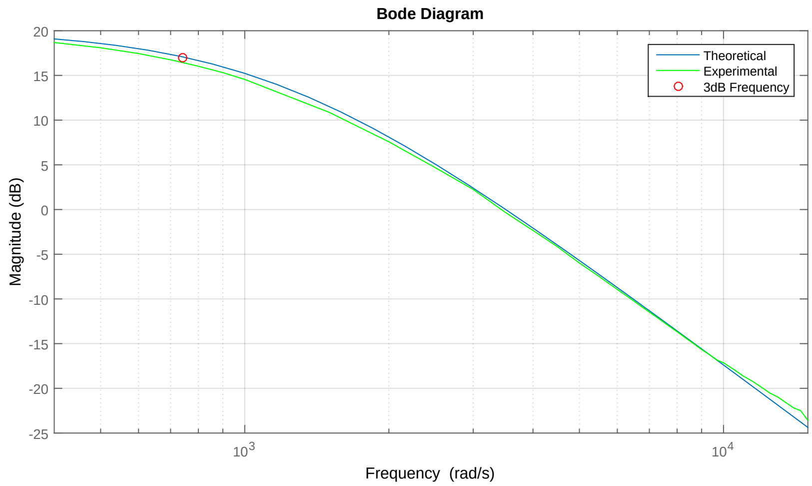

Figure 2: Theoretical & experimental bode magnitude plots

5 Discussion

It's worth noting that some of my circuit component values were not readily available in the lab, so I used combinations to achieve values that were as close as possible to the circuit designed. The values that were changed are:

$$R_{f1} = 1.803\,\mathrm{k}\Omega \tag{1}$$
$$R_{f2} = 5.5\,\mathrm{k}\Omega$$

However, even with these altered values, the experimental filter still met the specifications, as shown by calculating the magnitude in the pass band and stop band.

$$20\log 7.45 \approx 17.443\,\mathrm{dB}$$
$$20\log .156 \approx -16.138\,\mathrm{dB}$$

These values are well within the design specifications. Frequencies in the pass band (600Hz and below) produce magnitudes above 17dB (within 3dB of 20dB), and frequencies above 9500kHz produce magnitudes below -15dB. As shown in the bode plot comparison, the experimental data collected correlated closely with the theooretical data predicted in the original filter design report.

6 Conclusion

This project provided a concrete link between the extensive theoretical work we've done in class with filter analysis and the actual circuits being described by transfer functions. The small margin of error between the experimental and theoretical results strengthens the grounding our theoretical work has in reality. The filter was built successfully (despite slight component changes) and sufficiently met the design specifications. This experiment provided a tangible real-world basis for the theoretical filter discussions we've had so far.

7 Matlab

```
K = 10.08;
w1 = 1052;
w2 = 1291;
wo = sqrt(w1*w2);
beta = w1+w2;
transferf = tf(K*wo^2,[1 beta wo^2]);
f = 400:100:1000;
f = [f 1500:500:6000];
f = [f 6300 6700 7000 7300 7700 8000 8300 8700 9000 9300 9700 10000];
f = [f 10500:500:16000];
f = f';
[mags, phases] = bode(transferf, f);
figure;
bodemag(transferf);
hold on;
v0 = [8.18 7.643 7.095 ...etc];
vin = [0.952 0.952 0.952 ...etc];
exptf = v0./vin;
exptf = 20*log10(exptf);
mg = squeeze(mags);
mg = 20*log10(mg);
f3db = bandwidth(transferf);
plot(f, exptf, 'g-', f3db, 17, 'ro');
```