Chapter Lab 6 Writeup

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Introduction

The goal of this Lab is to put together all the information we've amassed during the last 9 weeks of class in building a filter network with three distinct filters catered to specific types of speakers. These filters will be:

1. a low pass filter designed for use with a subwoofer
2. a bandpass filter designed for use with the speaker provided in our lab kits
3. a high pass filter designed for use with a tweeter

We then will connect this filter network to appropriate amplification for each filter, and out to the speakers. In addition, we will make the system mobile and add in a potentiometer to vary the volume, plus an LED to show when the network is receiving power.

Design

The capacitors available for use were $0.1\mu F$, $1\mu F$ and $10\mu F$. We were warned against using resistor values of less than 100Ω.

The first consideration we made was determining the frequency range which we hoped to encompass by each filter. We used cutoff frequencies of 200Hz for the low pass, 6kHz for the high pass, and 500Hz, 5kHz for the band-pass. We used the equation: $Fcutoff = 1/(2\pi * RC)$ to determine capacitor and resistor values for each filter. Our initial guesses were shown to be fairly functional when modeled in LTSpice, with the exception of the band-pass which needed slight modification to achieve an amplitude which matched the amplitude created by the other two filters. To do this, we increased the resistance in the high-pass section of the band-pass, and lowered the attached capacitor by a factor of ten. The values are as follows:

1. LOW-PASS: $200Hz = 795\mu$ seconds. We chose a 1μ capacitor and 795Ω worth of resistors.
2. HIGH-PASS: $6kHz = 27\mu$ seconds. We chose a 0.1μ capacitor and 270Ω worth of resistors.

3. BAND-PASS: For the low-end, we found $400Hz = 40\mu$ seconds. We chose a 0.1μ capacitor and 400Ω worth of resistors. For the high-end, we found $2kHz = 20\mu$ seconds. For this we chose a 0.1μ capacitor and 2000Ω worth of resistors.

Simulations and Testing

Figure 1: Schematic

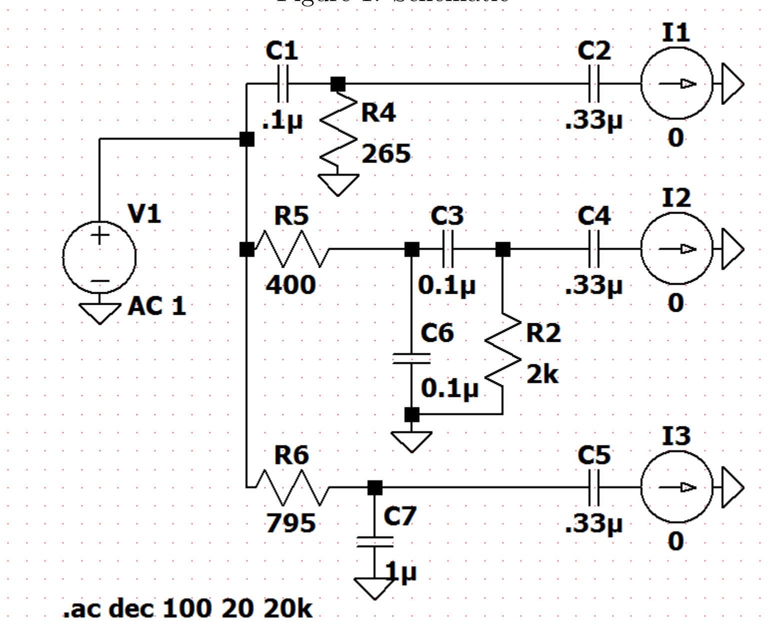


Figure 2: Simulation Results

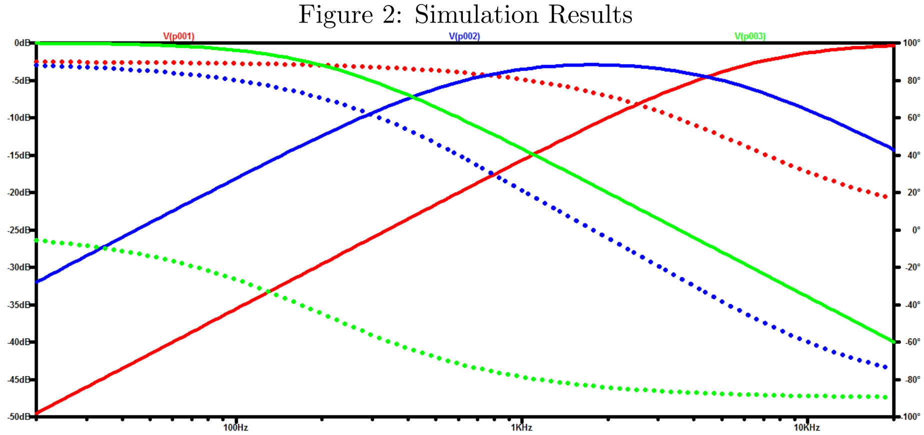
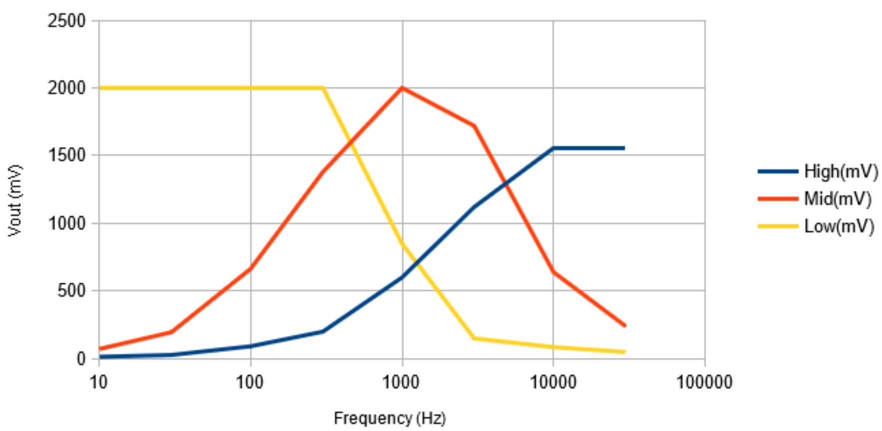


Figure 3: Data Table

Freq (Hz)	Vin(V)	High(mV)	Mid(mV)	Low(mV)
10	5	14.4	72	2000
30	5	28	196	2000
100	5	92	664	2000
300	5	200	1380	2000
1000	5	600	2000	849
3000	5	1120	1720	150
10000	5	1560	640	86
30000	5	1560	240	50

We had trouble with the osciloscope clipping at 2V, so we do not have data above 2V. To help combat this issue the function generator was set to 256mV rather than 1V.

Figure 4: Magnitude Vs Frequency



Results

We succeeded in creating a 3 stage filter network which plays music out of three different speakers. Huzzah! It was satisfying to see the final result of our effort. In conclusion, we found great success in this project, from design, to consruction, to testing. We found results which matched our expectations from design.

Thankfully, all the issues we encountered were overcome with a bit of effort. After constructing the filter network, we attempted to power it using the power supply that Simon had constructed in ECE 112, resulting in a very noisy signal. We added an inductor inline before the board and the noise was neutralized. We noticed the amps were running very hot, so we added a fan and some heat sync glue to draw off excess heat.

Conclusion

We began by setting cutoff values from speaker output values. We used these cutoff values to determine resistor and capcitor values. We then had everything we needed to construct the circuit. We made a mock-up on a breadboard to test that our design worked, which it did. We then handed over the reins to our master solder-tech, Zach, who did a marvellous job of connecting the components in a compact and organized way. With the final product fully cocnstructed, we just some final testing to make sure that everything worked as expected. If we were able to do this project again, there isn't much we would change.

Extra Credit

We added in several extra components to increase the functionality of the device including:

1. An LED to show when the device is powered
2. A fan to deal with heat created by the amps which were found to be in excess of 110 degrees.
3. An on and off switch for the signal.
4. A potentiometer installed before the filters in the signal path to control volume.
5. Powered the circuit via a 5V battery pack.