DIY Headphone Amplifier and Speaker Kit Building

By: Dong San Choi

Motivation

I wanted to build/make things that I could keep after I was finished with them. Looking through previous student projects, building a pair of speakers interested me the most. For the headphone amplifier, there was an opportunity with IEEE workshop to build a cMoy headphone amplifier.

Speaker Building

Research on the Net

After much searching on the internet on DIY speakers, starting from scratch takes a lot of effort. When making your own speaker cabinets, the dimensions and shape are highly important and will also depend on what kind of drivers are being used. The cabinets are usually made of MDF (medium density fiberboard). Clean, straight cuts are needed to build good speaker cabinets without any air holes/leaks, which is really hard to do by hand (and really dusty/messy). CNC (computer numeric controlled) cut MDFs are recommended. There are other considerations needed like internal bracing of the drivers and baffle design (if using a baffle). Even after everything is made, paint and finish need to be taken into consideration. All in all, it may indeed be cheaper to make speakers from scratch, but there needs to be a lot of effort and time that needs to be put into it. Based on how much time and effort I could put into this project during the semester, I decided to buy a speaker kit from Parts-Express. Even then, there were many choices to pick from. I wanted to be sure to have a pair of speakers and that would also be

good quality for the price. There was a really cheap speaker pair with a transmission line design for $188 based on the TriTrix MTM design, but it came unpainted . The speaker pair I decided to buy was the Dayton Audio RS621 Speaker Kit with curved speaker cabinets for $378 based on Parts Express DIY Project Showcase "The Encore" project. The curvature on the speaker cabinet makes it extremely rigid and reduced diffractions.

Figure 1. Dayton Audio RS621 Speaker Kit

Building

The assembly of the speaker kit was not difficult at all, but some of the directions were quite unclear. I made a few mistakes of my own as well, but I'll go through some of the process in order. First, putting in the binding posts was intimidating. The instructions say that it needs to be "knocked" into place with a hammer. The binding post size was at least two millimeters larger in diameter than the hole it was supposed to go into, however, after hitting it somewhat light/firm enough, the binding posts did indeed "knock" into place. Next the instructions say to wire the crossovers and install then inside the cabinet. However, if you do this, it becomes much more difficult to install the damping material deep into the cabinets because the crossovers may get in the way. So I went with installing the damping material first behind the internal bracing.

They had to be cut into proper size and I used hot glue to install them in place. Then the crossovers were screwed into place so that the damping material could be cut to fit around them. Some things I had to consider while installing crossovers. First, all the wires needed to be connected (this is when I noticed that I was missing one wire connecting the crossover to the tweeter). Second, the instructions recommend that the low-pass filter (crossover) for the woofer be screwed onto the internal brace of the cabinet, but if the crossover is installed too low or high it may interfere with the installation of the drivers. The drivers will not fit into place if the crossover is in the way! So be sure to check this before completely installing the crossovers. After that it was pretty much smooth sailing. Screw everything back in and test it out. I did not have a power amp of my own so I used the 50W power amp in class to power the speakers. They sounded great. It lacks punch in the bass, or overall bass in fact, but the use of the speakers would be fine with the addition of a subwoofer.

Measurements

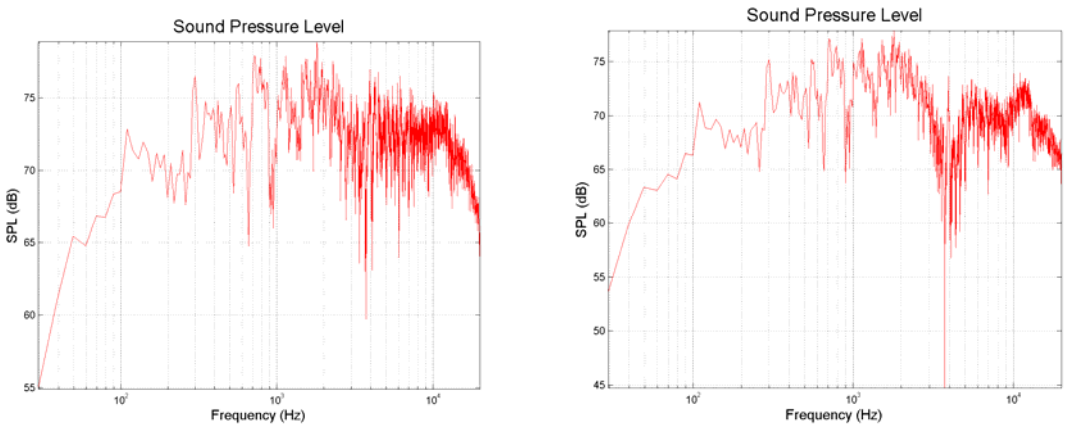

Figure 2. SPL of both speakers individually measured in lab[1]

It is easy to see how the SPL drops significantly below 100Hz, meaning there is a lack of bass.

[1] This is not a smooth frequency response as one may expect because of the room resonances of the lab this was measured in.

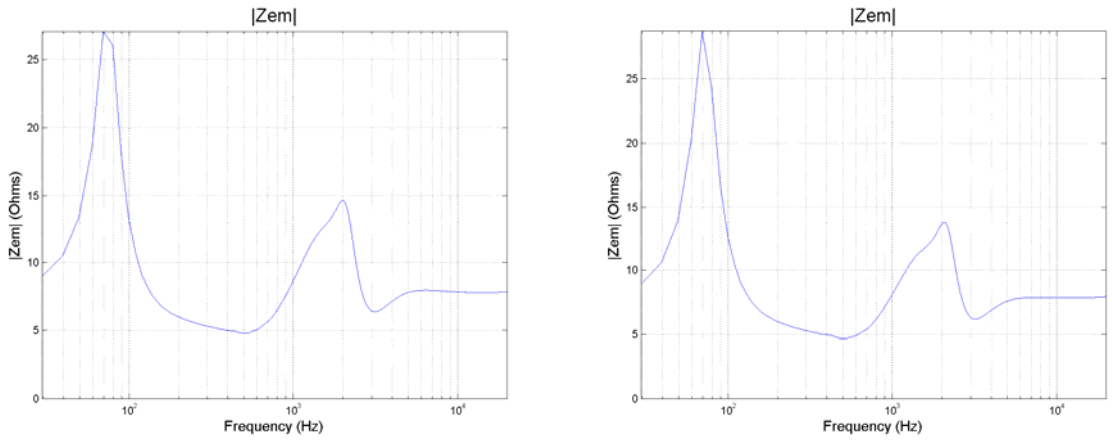

Figure 3. Impedance of both speakers individually

Both the SPL and impedance of the speakers are similar but somewhat off the given graph.

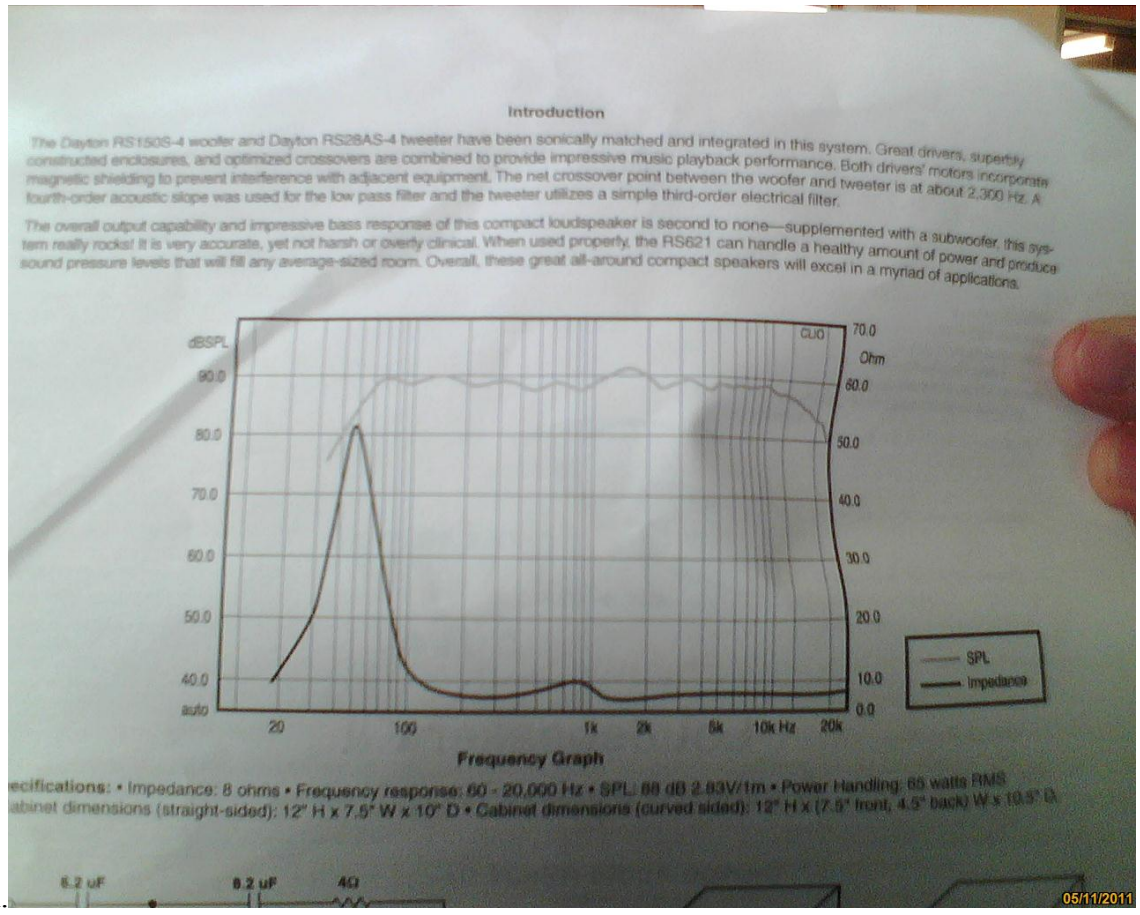

Figure 4. SPL and impedance graph given in the instructions manual

Headphone Amplifer

I did not make this in this class, but I did want to. John Alsterda, the TA, said that it would be too easy (and it indeed was). Luckily, there was a workshop hosted by IEEE where they were making the same cMoy headphone amplifier that I wanted to build. During the two-hour workshop, the cMoyBB v2.03 was put together with simple soldering. The "BB" stand for bass boost. However, everyone's bass boost toggle on their cMoyBB was not working. We could not debug during the workshop due to time, but I wanted to fix it. So with the help of classmate Daniel Klingler, the source of the problem was the capacitors used in the bass boost.

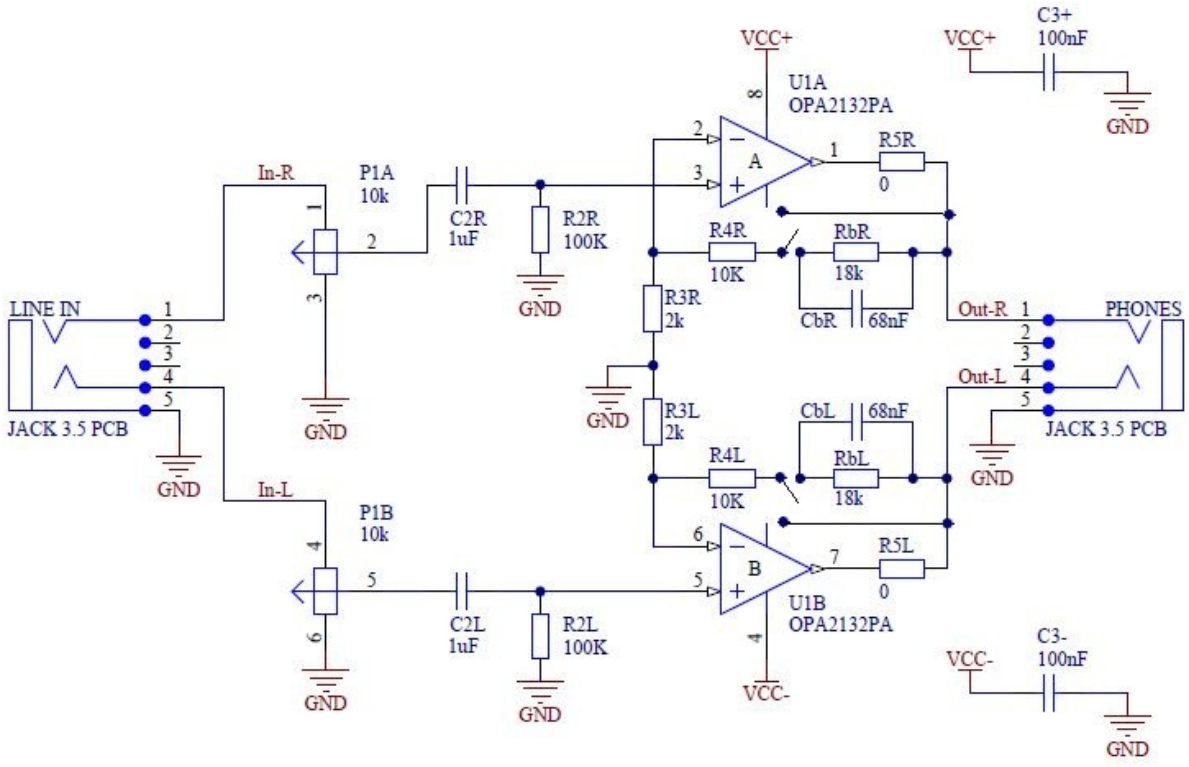

Figure 5. Schematic of a modified cMoy taken from http://diy4fun.blogspot.com/2010/03/cmoy-for-altoids-box.html with a switch edited into the schematic

The capacitors used during the workshop were actually 680nF, not 68nF. The cut off frequency for the low-pass filter can be calculated as $f_c = 1/(2piR_bC_b)$. $R_b = 24k\Omega$ and $C_b = 680nF$ at the workshop, which results in $f_c = 9.75Hz$, and so when the bass boost was toggled on, there could be no perceived difference since only the frequencies below f_c were being boosted. With the correct $C_b = 68.0nF$, $f_c = 97.5Hz$, which was around where one would want it for proper bass boost. One hint that the capacitors were wrong was the size of them. Then looking up the data sheet for those specific capacitors, it was obvious that the capacitor value was not the one we wanted. The bass boost toggle now makes a significant difference. I added a DC adapter (which was not included during the workshop) because I wanted to use it for long-time use with a laptop audio input, which would not be ideal with a 9V battery that would only last ~20-30 hours.

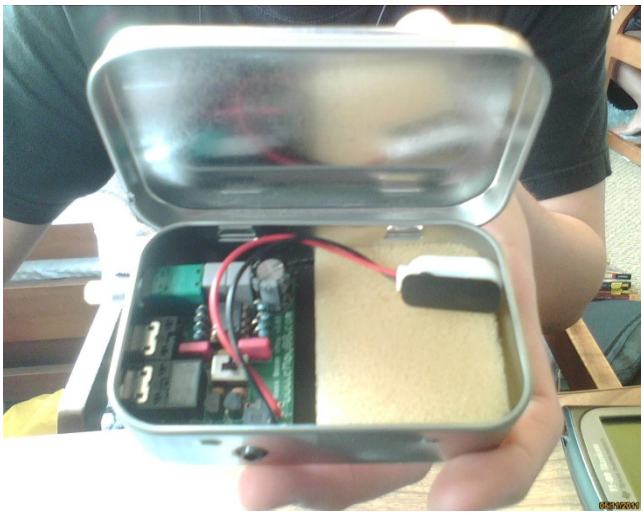

Figure 6. Finished cMoyBB v2.03

Special Thanks

Thank you Professor Steven Errede and John Alsterda for the support and help.

Thank you Daniel Klingler for helping me debug the cMoy.

Thank you Parts Express and JDS labs for the speaker kit and the cMoy DIY projects.