

Solid-State vs. Hybrid Tube Headphone

Amplifier

Jack Blandin

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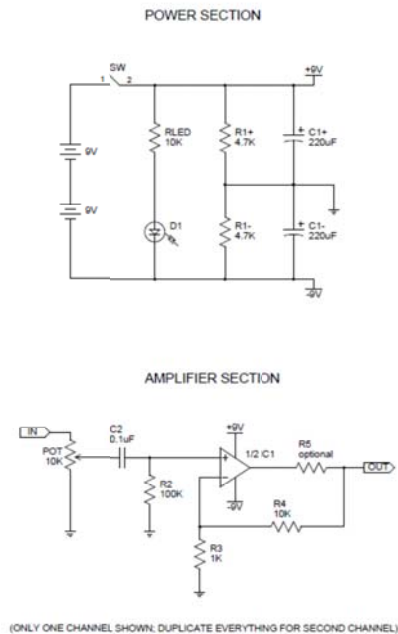
A Choosing a Project

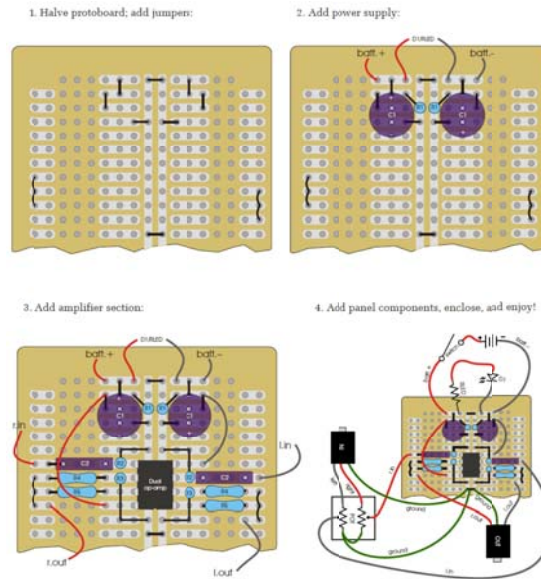
Originally, for my project, I wanted to make a pair of noise canceling headphones from scratch. However, after some research, I realized that this would be too difficult for a newbie in DIY electronics projects like me. I discovered, however, that a headphone amplifier was something I could build. After some online reading on how others faired at building this amplifier, it seemed that I would finish it in a short period of time (and could not have been more wrong), so I decided to add another pocket headphone amplifier to my project, a hybrid tube headphone amp. I am not much of a musician, or an audiophile, so I admit that initially I didn't have the slightest idea what the difference was between a transistor amplifier and a tube amplifier. Once I discovered that the difference was a hot debate between music lovers, I became much more interested. I read lots of forums and discussion posts about people's views on this topic, and learned that most people did not have a clear or exact way to describe the difference. So I decided to investigate and make it the thesis of my project.

B Building the CMOY Transistor Amp

I used the Tangentsoft.net website for the instructions on how to build this amplifier. The site is extremely useful and even includes the product numbers for the individual circuit components for several different online stores. I ordered most of my supplies from Mouser Electronics. I also invested in a Weller pencil soldering iron since I plan on building more things for fun.

The schematic was provided on the Tangentsoft website. A graphic of the components attached to the circuit board was also available.

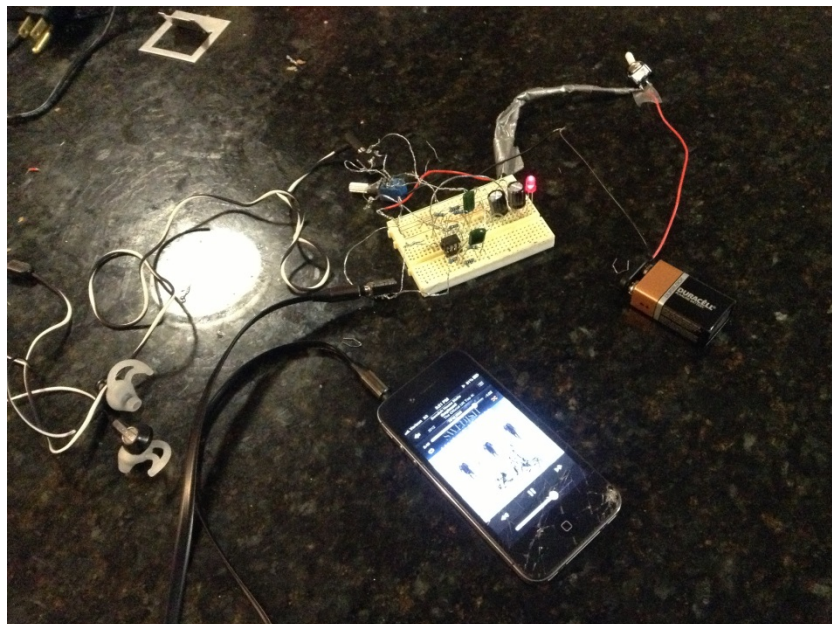
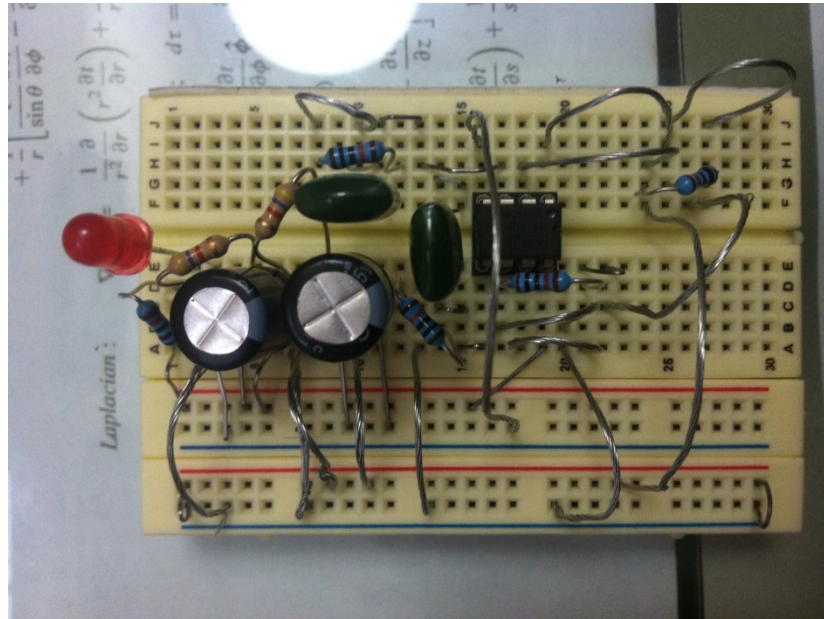




It took me a few tries before I finally got the hang of soldering. Watching online videos can only teach you so much. Soldering the circuit components to the board was fairly easy, although not as easy as some people made it seem. Physics 212 is the closest thing to an electronic circuit class as I have taken, so I only had a rough understanding of what was going on in the circuit. However, when it came time to wire the components to the inputs and the potentiometer, I was absolutely lost. Looking back, I laugh at myself at how clueless I was, since after a couple of months of building and tweaking these amps I eventually understood the functions of each component, and how to wire them to the others.

When I first finished wiring everything together, but before I put it in the enclosure, I tested the amp with headphones and my iphone. As you would expect, it didn't work. I checked and rechecked all my soldering joints, and that everything was in its correct place, and it still would not work. I thought that I may have fried some of the copper strips on the circuit board, so I decided to try to recreate this circuit on a

breadboard and see if that worked. I've never designed a circuit before, so this took me about 3 hours to do. A lot of that time was making jumper wires (out of staples and anything I could find that fit in the breadboard sockets). The circuit was hideously ugly, but it worked.



After a lot of frustrated testing and adjusting, I realized that I had forgotten to wire the op-amp to the power supply. Once I did that, the amplifier worked perfectly so I stuffed it in the Hammond enclosure. This case was perfect since it has a place designated for a 9V battery with contacts that are easy to wire.



C Building the Hybrid Tube Amp

While researching the hybrid tube headphone amplifier, I found a kit for just \$25 that contained everything except an enclosure and the 12AU7 tube. The main reason I decided to go with this kit was because it came with a PCB and I did not want to go through designing my own circuit board. The only instructions the kit provided was the schematic, but since it had a pcb, there really isn't much else to say. I had little trouble

putting this one together since I had recently but the CMOY, and it worked when I plugged it in with a 12 power supply. The power supply I purchased was the cheapest one I could find so there is a lot of static but I plan to look for a better one when I have the time.

I ran into some trouble when I tried to put the circuit into the enclosure that I bought separately. The inside of the enclosure had rounded corners, and the input/output Jacks were on the corners of the pcb so it wouldn't fit as it was. The only way I could solve this was to put the pcb in the center of the enclosure and then attach wires to the prongs of each component which would connect them to the pcb. This was very annoying because the wires kept detaching from one component while I was trying to secure another. My enclosure is made from aluminum so drilling a 3/4 in. hole for the tube socket was a little difficult with a drill bit. Once completed, I was very happy with its appearance:



The light comes from an LED glued in the small hole in the middle of the tube socket.

C Comparing the Amplifiers

Before performing any tests, I did some research on the fundamental differences between a solid-state and tube amplifier. When operated in a linear (unclipped) mode, tube amps sound the same as solid-state amplifiers, as long as their frequency response and group delay characteristics are well matched and their distortion levels sufficiently low. The audible difference occurs only when they are clipped.

A vacuum tube can only move a limited number of electrons in an amount of time, dependent on its size, temperature, and metals. Usually, the fall-off in amplification with increasing output results in “soft clipping” and mostly even harmonics. Solid state amps, on the other hand, are basically a mirror. What goes in, comes out, or very close to it. This results in “hard clipping” and mostly odd harmonics.

Initially, I wanted to perform several tests on the amplifiers in order to examine the difference between them. However, it took me much longer to complete the building process, so I only had time to compare images of their linear and clipped waveforms.

Figure 1: CMOY (solid-state) linear waveform

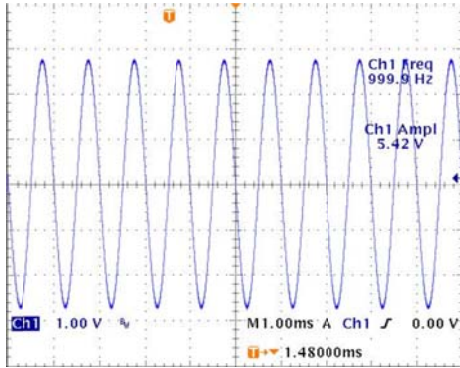


Figure 2: CMOY (solid-state) clipped waveform

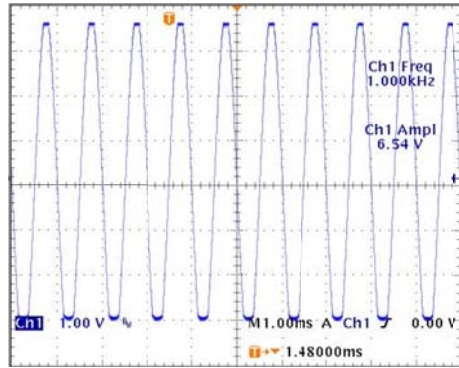


Figure 3: Hybrid Tube linear waveform

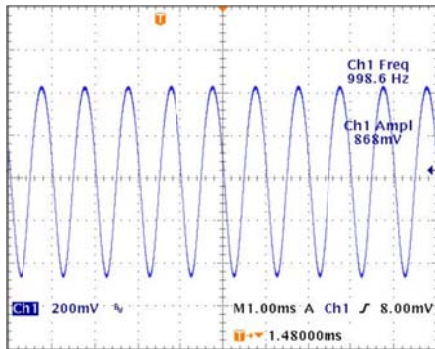
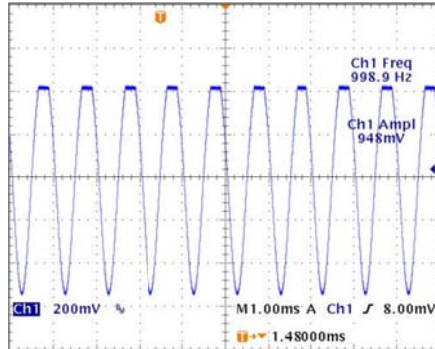


Figure 4: Hybrid Tube clipped waveform



The hybrid tube amplifier clipping is not as soft as I would have liked, but there is at least a clear difference from the clipping of the solid-state amplifier. Once I find a better power supply, I will be able to hear if there is any difference between the two.

D Conclusion

As I previously stated, I would have liked to perform more measurements on the amplifiers. Specifically, I wanted to examine the harmonic content of each. Also, I thought about trying out different op-amps in both and looking for any differences in the harmonic content. That way, I could see how much the op-amp was influencing the signal of the hybrid tube amp. Overall, I am very happy with how this project went. Despite all my frustration, I ended up with two working headphone amplifiers, experience with building circuits, and possibly a new hobby.