Design and Construction of Vacuum Tube Amplifiers

DIY Audio Projects
Bruce Heran

I frequently get questions about the design and building of vacuum tube (valve) audio equipment. So I thought I would scribble down some of the tips and ideas that I have found useful. This list is certainly not complete, nor a comprehensive guide. There are numerous special circumstances that don't fit the information. I hope that it is of use to individuals that are either new to DIY valve audio or may help refresh others with things that they may have forgotten.

Initial Concerns

1. First and most important, remember safety. Nearly all vacuum tube amplifiers contain circuits with dangerous voltages. If you don't know what you are doing, don't do it! Mistakes can be fatal.

2. Figure out what you are building and why. What purpose will the equipment serve? Will it be your main system, a secondary one, or just something for fun?

3. Select your parts well. If you use cheap parts, generally the end project will reflect that choice. At the same time don't waste money on parts that don't matter. Don't get stuck on someone else's choice. Ask them why it is best. If you are sufficiently knowledgeable, use parts you like. Avoid getting trapped into thinking that tube equipment must be all tubes. I greatly prefer high performance solid state rectifiers over tube ones of similar capacity. I also use solid state constant current sources and regulators. Use the type of component that best fits your needs and personal preferences.

4. Determine what tube types will do the job. How much gain, power output, impedance, equalization?

5. Is there already a design / circuit that does what you want that you can use?

6. Can you get the parts needed? Some parts are proprietary or discontinued and may be near impossible to get.

7. Do not try to run components above their ratings. Sooner or later they will probably fail.

8. For power tubes, I recommend not exceeding 80% of the maximum dissipation. This will also help extend the life of the tube.

9. If a circuit requires matching of gain or output, it is better to include a way to do that. In my experience “matched” tubes are not always equal. Plus with aging they don’t generally stay matched forever.

10. Select power transformers that can deliver at least 1.5 times the current you need.

11. Consider heat buildup under the chassis. A classic case often overlooked is that solid state rectifiers (diodes) have a voltage drop of 0.7 volts. This times the current, for example 1 ampere will result in the generation of 0.7 watts of heat per rectifier. A bridge then would generate 2.8 watts. Heat is the enemy of things like capacitors.

OK, let’s build it now ...

Design / Build Concerns

1. Keep anything with AC voltages away from signal carrying parts or wires. The further the better. I like to keep a minimum distance of 2 inches. Don’t get weird and go to huge extremes.

2. Where power (DC or AC) conductors must cross signal wires or parts, do so at right angles with as much separation as is reasonable.

3. Keep all wiring close to the chassis (particularly the corners) if the chassis is metal.

4. Segregate power supply circuitry from signal circuitry. Especially transformers.

5. Put power transformers on the opposite side of a metal chassis as the active circuitry.

6. Do not ground the inputs or outputs to the chassis. This will nearly always will cause a ground loop.

7. Use a “Star” or “Buss” grounding system.

8. It is best to have a single connection between the power supply ground (B-) and the signal ground.

9. If your electrical code permits (or insists) the metal chassis (if used) and all exposed metal parts should connect to the AC mains ground (not the neutral).

10. Fuse the AC input. It is a good idea to fuse the B+ inside the project as well.

11. If your electrical code permits, connect the signal, and power supply grounds to the chassis at a single point through a X2 type capacitor and resistor. This is a great help in keeping noise low. Do not use a standard capacitor. Typical values are 0.1 uF to 0.22uF at 250 volts AC for the X2 rated capacitor. The resistor is usually between 100 and 150 ohms and is a half watt to one watt preferably a flameproof version.

12. Keep capacitors, particularly signal carrying ones close to the chassis if it is metal. Keep them away from filter capacitors and transformers.

13. Keep component leads as short as possible.

14. I like to use a consistent wiring color code for tube audio circuits, especially in prototypes. It makes it a lot easier to troubleshoot when something doesn't work like expected. Be consistent in the color codes as it will pay off if you do several projects.

Additional Considerations

1. Take your time in the design and layout planning phase. A poor design or poor layout will seriously degrade the end device. I spend more time in design and layout than in building by a factor of 10 or more.

2. Take your time in building the project. Poor construction technique has ruined lots of projects.

3. I like to use DC on tube heaters. The less AC running around in a chassis the better (quieter). If you must use AC on the heaters, be sure to tightly twist the wires together. Use bypass capacitors (often called a snubber) on the heaters. I usually put one on each tube right at the socket.

4. I like to use a IEC AC receptacle. The types I prefer to use have EMI/RFI line filters and sometimes the fuse all in one neat package.

5. Include a power indicator light. LEDs are great for this. Since tube equipment takes some time to warm up and even then it is not always obvious it is turned on an indicator is quite handy.

6. Build the project with the thought in mind that you may want to modify or service it later. Test points are handy to verification proper operation.

7. Check the wiring carefully when you are finished the building process.

8. I like to use a ground fault protected outlet (GFCI) when first powering up a new project. Getting zapped by your project is no fun.

9. Check all voltages when you are convinced the project is functioning.

10. If all is not working properly, seek help. Both individuals and diy audio discussion forums are quite valuable in the resolution of problems.

11. Relax and enjoy with satisfaction the project you built yourself.

Source: http://www.co-bw.com/DIY_Design_and_Construct_Tube_Amp.htm