Class A Hybrid Headphone Amp

by **JoeBeau** on September 17, 2013

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Why fix it if it ain't broken? Cause it's fun!

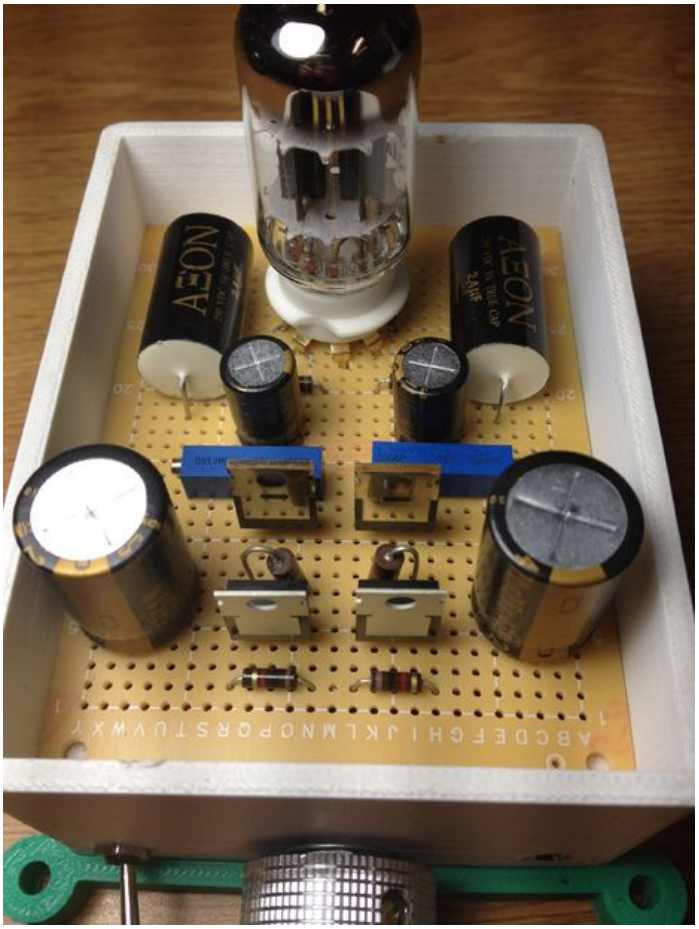
Intro: Class A Hybrid Headphone Amp

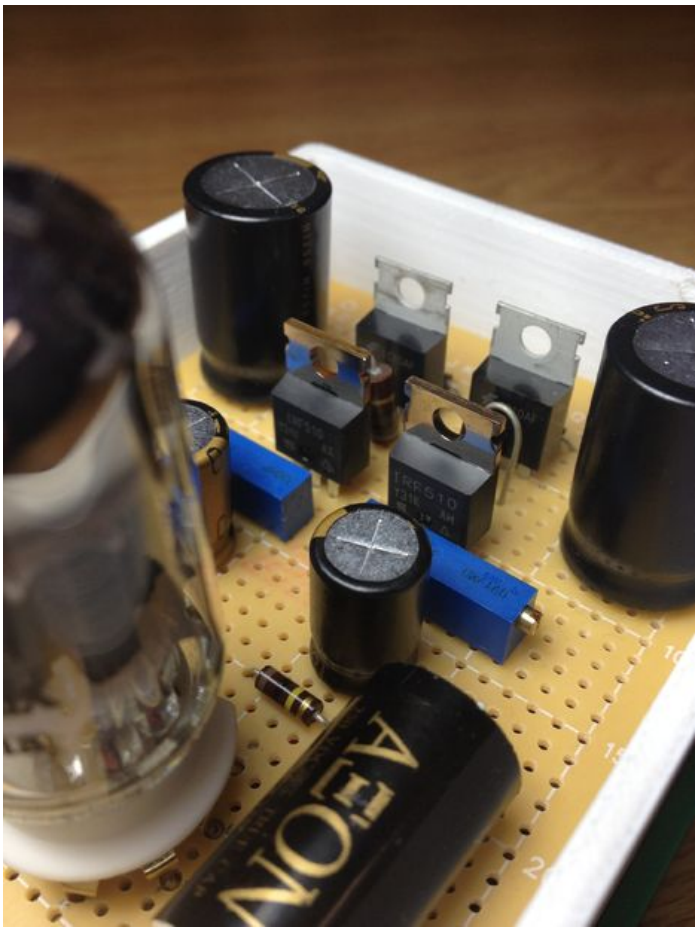
FORWARD::::::: This project was born out of a couple things. One was a need for an amp to drive some higher impedance headphones I had just bought. (The Grado SR125i headphone is great, by the way.) Also, since I have began my freshman year at Boston University, and could not resist using the Singh Imagineering Lab- a workshop only for College of Engineering students that allows you to work on pretty much anything. They also provide basic materials and components, as well as lathes, NC mills, soldering stations an electrical equipment, and a 3D printer. This is is just the tip of the ice burg though.

Another reason for the project was an assignment from another class where I had to build something for my own enjoyment and benefit, but just had t keep a running journal on how the project went. This Instructable serves as my journal. Because of this, you will notice it is written as such, with running updates on aspects of the build and a more personal touch to the process than a simple step-by-step Instructable.

So. Let's get started.

I chose a vacuum tube amplifier as opposed to sold state. The reasons to choose tubes are as follows:
-They sound better (this might be slightly subjective. But it is still true.)
-They glow
-They are just cooler
-They glow
The circuit I used was chosen for its small part count, it ability to be run at 12 volts (massively simplifying the circuit and the parts needed), it's lack of needing an output transformer, and its relative efficiency. After a little browsing on Google, I found what I thought seemed to be very viable circuit. The circuit itself is highlighted in the next step.




AEON


2A/IF

Step 1: The Circuit

The circuit I chose to use is the circuit seen here . The reason for this is as follows:
-The circuit is simple. It uses only one twin triode tube. This allows the circuit to amplify both channels (left and right) with one tube. It also uses MOSFETs as the followers for the tubes. Tube followers require the use of an output transformer- this bites severely into the efficiency and size of the circuit (and makes it more expensive)
-The circuit uses an LM317 as the constant current source. This means that less energy is dissipated through it than it would be if a resistor was used to set the current, making the circuit more efficient.
-The 12AU7 tube used uses 12.6 volts as the heater voltage, and can be operated on a plate voltage as low as 12 volts. Operating at this low of a current can affect the performance slightly. But its still effective enough for what we're doing here.

ALL CREDIT FOR THE ORIGINAL CIRCUIT GOES TO ROGERS GOMEZ AT DIYAUDIOPROJECTS.COM.
NOTE:::::: Going the link provided has much more technical information and some assembly instructions of the circuit itself, including setting bias of the tubes and such. For this reason I will turn over much of the assembly instructions to that page. It also has the files for the circuit in CAD and images for the PCB. I don't want to cut into his page views, so this Instructable is meant to be an addendum to his project and show my take, as well as provide some files to make a 3D model for the enclosure.

I modified the circuit slightly from the original on the website. The modifications include a 1000uF capacitor on the power input to reduce the chance of noise as well as .22uF capacitors on the audio input for the same reason. I also added a switchable high cut-off, since the Grados can be a little bright when listening at high volumes to certain types of music. I have to say though, I barely ever use this function. I find the sound to be great as is.

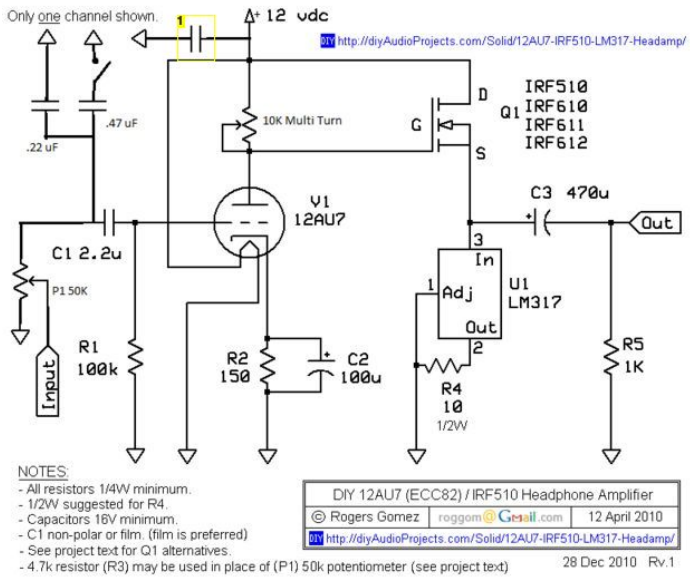


Image Notes
1. 1000 uF 35V

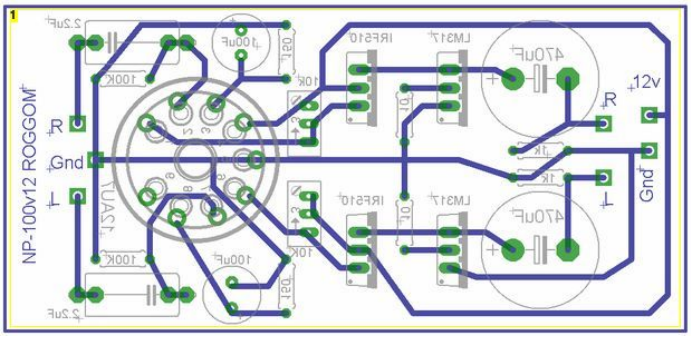


Image Notes
1. Reflected from original file in link to represent what the traces look like if looking at the final board

Step 2: Parts

There is a list of parts on the link to the original project. However, I am going to provide my modified list of parts that I used. The parts include some accessories, such as a battery and line out cable for my iPod.

When it came to ordering parts, it was apparent that I would have to order from multiple sources to track down the parts I really needed. Trying to keep a tab on all the parts, including the extra parts for the high cut and such, turned out to be a challenge. I had ordered parts for projects like this before, so I knew about the struggles I could face and the time consuming parts ordering came as no surprise. Ordering parts can be a hassle the first couple times, since there are often more than one component that will fullfill your needs, and choosing can be difficult. Sometimes the opposite happens and you cant find exactly what you need so you need to improvise. Making my way through this struggle has become second nature at this point, but to make things easier on you I have included a complete parts list.

Some of the parts I took from the Imagineering Lab to cut down on cost. These parts, however, are generic type parts that can be ordered just about anywhere.

The parts list is:

--- Part # --- Description from website and unit price

Parts Express:
2 --- 002-2.2K --- 2.2K Ohm 1/2W Flameproof Resistor 10 Pcs. $0.75
2 --- LM317T --- LM317T Variable Voltage Regulator TO-220 $2.25
1 --- 230-112 --- FiiO L10 3.5mm Dock Cable for iPod iPhone iPad 20" $8.99
1 --- 365-008 --- Grip Tools 38020 12V Automatic Battery Float Charger $14.50
1 ---140-364 --- Power-Sonic PS-1250F2 Sealed Lead Acid Battery 12V 5Ah $15.33

PartsConnexion:
1 --- ALPS-72497 --- Blue Velvet - STEREO Conductive Plastic Potentiometer, audio/log taper $19.95
2 --- ARCOL-74534 --- 10R, 1/2 Watt, 5%, Carbon Comp, Tinned Copper Leads $0.49
2--- ARCOL-75030 --- 150R, 1/4 Watt, 5%, CarbonComp, Tinned Copper Leads $0.33
2 --- ARCOL-75039 --- 1K, 1/4 Watt, 5%, CarbonComp, Tinned Copper Leads $0.33
2 --- ARCOL-75047 --- 4K7, 1/4 Watt, 5%, CarbonComp, Tinned Copper Leads $0.33
2 --- ARCOL-75063 --- 100K, 1/4 Watt, 5%, CarbonComp, Tinned Copper Leads $0.33
2 --- AXON-73720 --- 2.4uF 250V 5% TRUE CAPACITOR $1.43
1 --- SOCKET-59006 --- 9 PIN CER-PCB GZC9-B-GLD TUBE SOCK $2.95
2 --- NICHICON-72601 --- KZ 100uF 25V 10x16 $0.47
2 --- NICHICON-72610 --- KZ 470uF 25V 16x25 $0.85
1 --- TUBEEH-62013 --- 2AU7 / ECC82 Dual Triode, 9 pin, Original Box, Russia, $10.95

Radioshack:
2 --- 276-2072 --- IRF510 Mosfet $2.49
2 --- 274-246 --- 1/8" Stereo panel mount jack $2.99
1 --- 274-1582 --- DC Power jack size M $3.99
1 --- 274-1569 ---DC power plug size M $3.49

This list does not include the .22 uf (x2) mylar cap for the filter on the input or the .47 uf (x2) mylar cap for the high cut. It also includes 4.7 kohm resistors which can be used in place of the biasing potentiometers from Radioshack. I recommend using the biasing pots because the circuit operates best when biased correctly and this is not guaranteed to happen with a fixed resistance of 4.7 kohm.
Also, a note about the switches: You need a single pole switch for the power but a dual pole switch for the high cut, These are available at Radioshack, but can be ordered from any of the above place for around the same price. You might want to choose your switch depending on which you like best.
And one final note: You should purchase a knob for the volume pot. I got mine through Radioshack, but again you can get them just about anywhere so shop around and choose the one you like best.
And another final note: This is the part number for the perf board I used through Radioshack. This is the one the 3D enclosure file is sized for. It is not the exact same dimensions as the PCB file found on the original project page I have linked to. So keep this in mind when deciding the path for your project.

Step 3: Enclosure Assembly

Attached are files to allow you to print up an enclosure like I used. It is sized so the proto-board that all the components are mounted to would snap into place. Also, as you can see, the base is a separate piece. The reason for this is that I wanted the enclosure to be removable from the base in case of repair or modification in the future. The pieces are in inches, but can be scaled to metric pretty easily. The base fits tightly over the enclosure itself so that glue is not required. I ended up having to file and reshape the corners of the enclosure to match the base better due to the warped corners. Otherwise, the base would bend.

When printing the enclosure, I realized just how awesome 3D printers are. When they are working. The printer in the Imagnieering lab is a Makerbot Replicator. (the day I typed this they unboxed a 2x) It works great, minus the small issues with clogged ejectors, unlevel build plates, random glitches when slicing... but those are usually few and far between. The major problem I kept having was the piece warping while printing. The build plate temperature was adjusted, the ejector temp adjusted, infill adjusted, print speed.... Eventually I got most of the parts straight enough that it worked. The corners of the enclosure itself on the bottom were still a little warped, but they are concealed by the base, which printed straight. Overall, I am not disappointed with the final result, though relieved that it is done and I don't have to worry about printing anymore.

Some may look at the enclosure and realize there is no shielding. This is true. But i have found that the lack of shielding has not been that large of an issue. Problems only develop when a cell phone is placed next to the amp or a live power cord draped across it. But because of the battery power the circuit is very well isolated from interference. I have not had any problems with it.

If you plan on using this with a power adapter or in an environment prone to RF interference, I would recommend adding shielding to the enclosure or using a metal enclosure. In Boston it is just fine enough that I don't need the shielding, though I do find that sometimes when I place my amp near a large metal object like a fridge with the volume up all the way and no signal source connected (an unusual set of circumstances) I can pull in radio stations quite clearly. It's an interesting trick, but has not presented any problems yet.

File Downloads


amp3d2.stl (186 KB)
[NOTE: When saving, if you see .tmp as the file ext, rename it to 'amp3d2.stl']

ampbase4.stl (191 KB)
[NOTE: When saving, if you see .tmp as the file ext, rename it to 'ampbase4.stl']

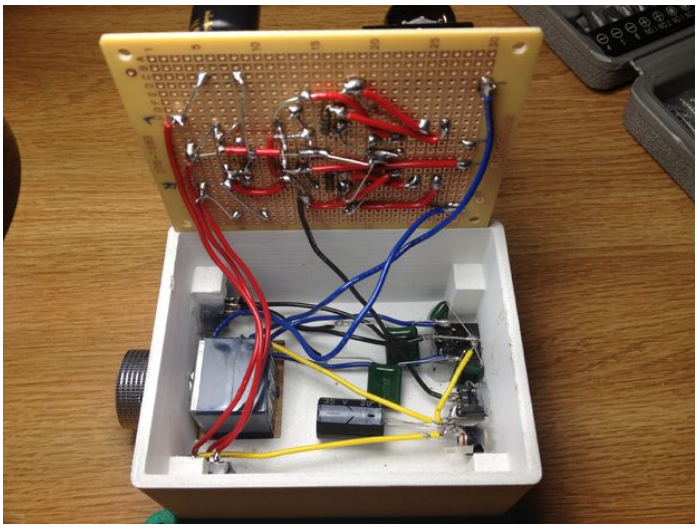
Step 4: Time To Build!

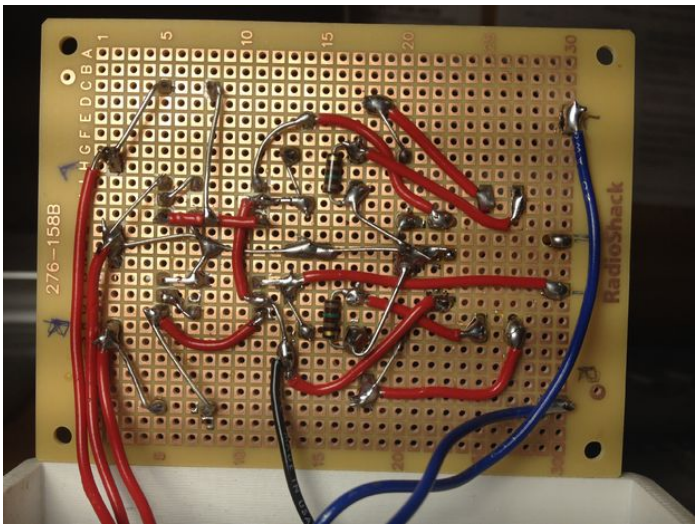
Here I am going to provide the pictures from my build, as well as tips and procedures specific to the build I did. But, I am going to turn over a lot of the build instructions to the link I referenced earlier. The reason for this is that there is no reason for me to provide the information complied by someone else and cut into their page views. I want to honor the property that is the original circuit designer's. Besides, the build guide Rogers complied is excellent.

Just some pointers specific to my project:

In reagrds to the circuit:
-SOLDER WIRES TO SWITCHES AND JACKS BEFORE INSTALLING IN THE ENCLOSURE!!!!!!!!!! The jacks and switches are meant to be glued into place to secure them. If you forget to solder your wires to the jack and have already glued it in place it can led to some awkward and difficult soldering. Save yourself some grief and think through your steps first or even make a list of steps that you will take
-The perf board (obviously) does not have traces like a PCB would. This means you have to run the traces yourself. A good way to do this is to not cut the leads off of the components when soldered in and bend them to where the connections need to be.
-When doing point to point wiring like is done here make sure there is a firm mechanical connection between electrical contacts before applying solder
-Do not overheat the components (common knowledge)
-Make sure to watch the clearance between the volume pot and the connections on the perf board above it so that everything will fit together properly.
-The holes for the pins for the tube socket will need to be enlarged. This might remove the pad entirely but you can bend the socket pins over to tough another pad.
-The capacitors for filtering and high cut are soldered to their respective jacks as opposed to the circuit board itself

In regards to the enclosure:
-ABS melts. Careful soldering
-The holes for the components might need to be filed out slightly larger in order for the components to fit

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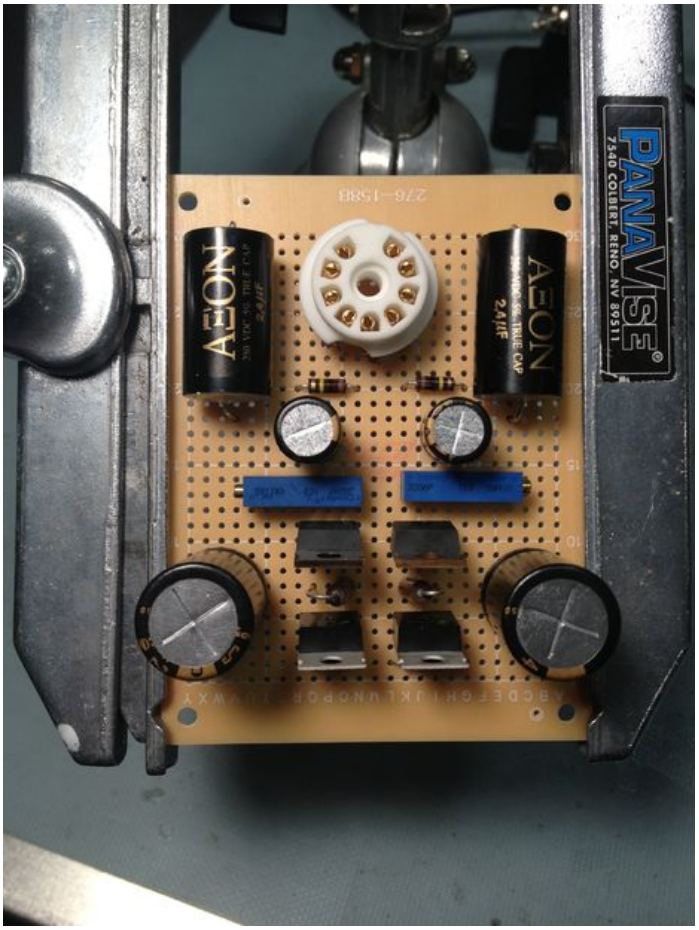
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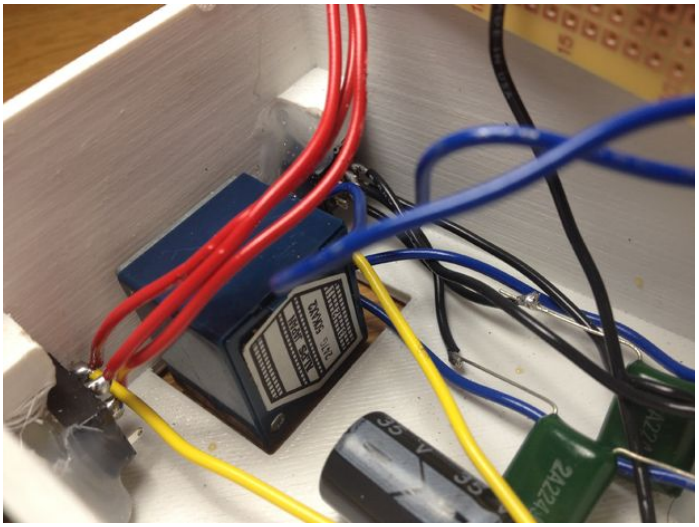
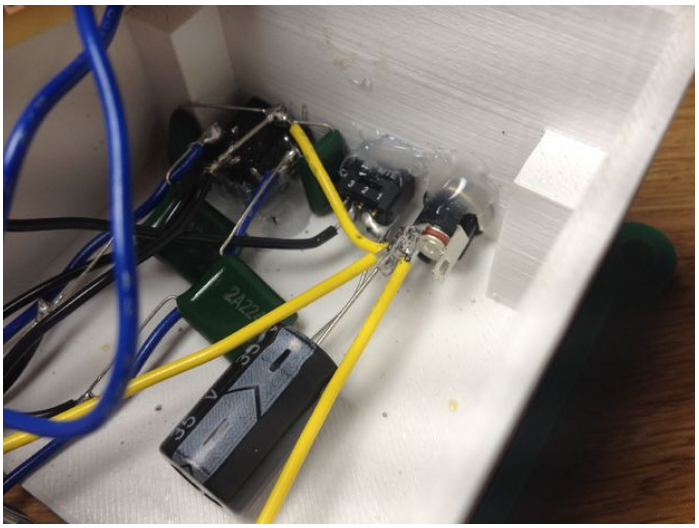
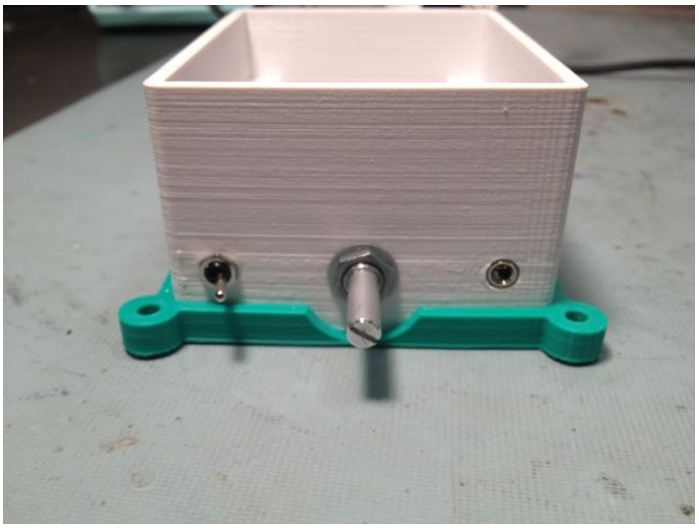
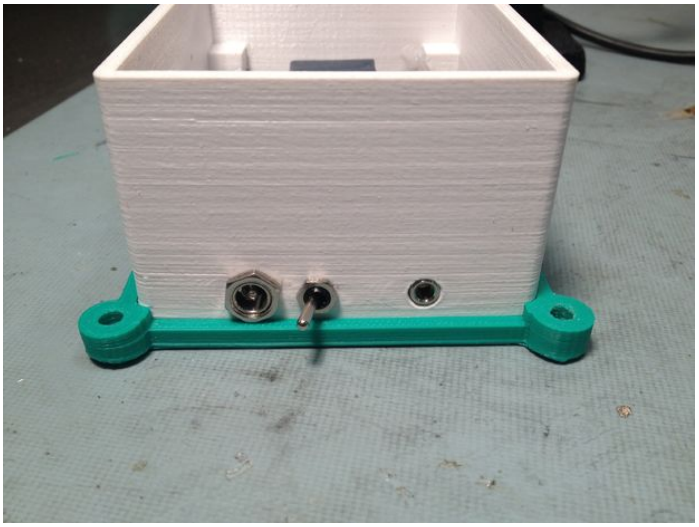
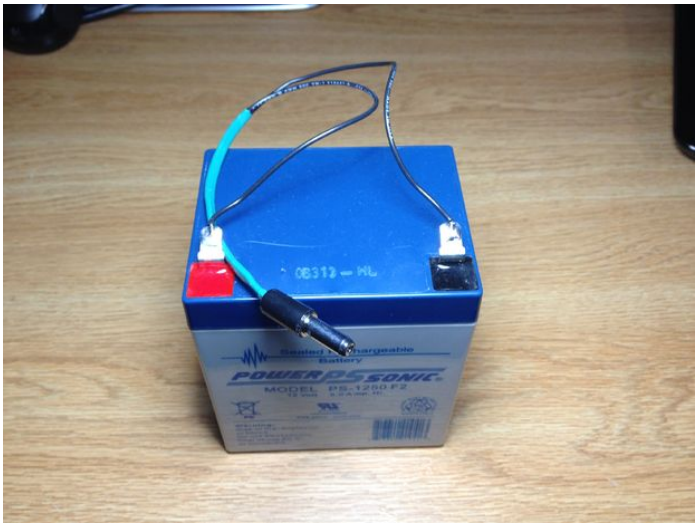










Step 5: Use It!

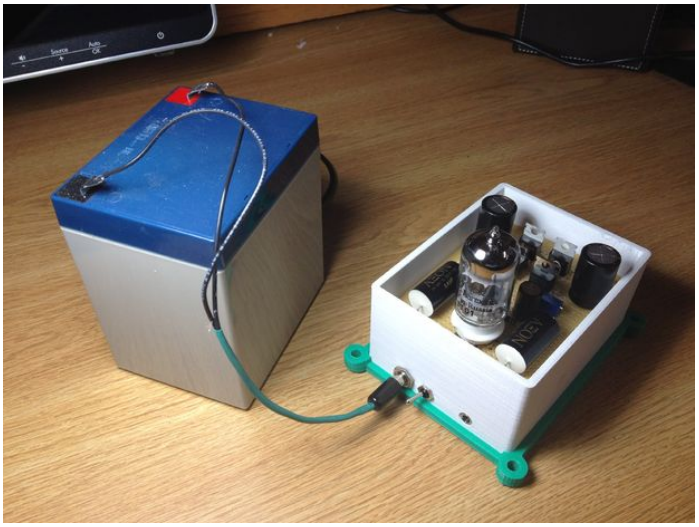
So, this amp can be used with any source that can be plugged into the 1/8" input jack. This project was intended to yield a high quality amplifier to take the place of the headphone output on my iPod. With my amp I often use a Fiio adapter pictured to hook the line output from my iPod into the amp. By bypassing the internal volume control circuit and taking the signal directly from the internal DAC the sound quality is dramatically improved. By combining this with the use of lossless file encoding (Apple's ALAC or the longtime standard FLAC) the difference is extraordinary over the normal headphone output. Taking these steps are a requirement to get the most out of a good pair of headphones.

When using the amp with some source with volume control, make sure to have the volume of the source at about half volume (assuming its output is intended for headphones)

There is no battery charge monitoring built in, so you will have to monitor battery voltage with a meter or just wait until things start sounding funny to know the battery is dead. Or, just develop a standard charging cycle of overnight every 2 days or something.

As another note, don't get thrown off by the heat of the circuit. The MOSFETs and LM317s will get hot to the touch but not dangerously so. Also, the tube needs heat to operate properly so don't panic about it either if its warm.

One other thing worth mentioning- Make sure you plug in the power supply and turn the amp on before anything else (source or headphones) are plugged in. Also, before listening it is good practice to give the tube time to warm up. This will only take a minute.



Step 6: Final Notes

Overall I found this a satisfying build. Being a budding audiophile, building your own equipment and actually having it sound great is very rewarding. While it was an expensive project for a class, it was not something that was built for the class; it was built for me to use regularly and get credit for the class at the same time. It was just a nice coincidence.

In the future this amp might see slight modifications. Namely, a power adapter at some point and an enclosure redesign. I like the simple aesthetics of the enclosure now, but would like to add some shielding so I could potentially remove the filtering caps on the signal line. I would also like to add some sort of cage around the tube to make the amplifier somewhat portable. (Portable being a relative term for something that runs off of a lead acid battery) Also, the battery would somehow be integrated into the enclosure so it would be one self contained unit.

I also found out, listening with this amp, a couple disappointing things:
-MP3 files suck
-Earbuds suck
The added clarity of using this amp over the iPod's internal amp led to me realizing how poorly MP3 files sound when it comes to low frequency reproduction and transient response. This was previously not detectable because the poor quality of the iPod amp masked the ability for a lossless file to be played 'losslessly'. Now that I have high fidelity sound hardware, the data source needs to be updated to match.
And now that I have a good source and amp, I can now easily tell the difference in clarity and accuracy between my Grados and Klipsch S4 earbuds (Which as earbuds go are very good).

Well, that concludes this journal entry/Instructable on my vacuum tube headphone amp. I hope you enjoyed it and found it informative and maybe has inspired you to take a second look into how you listen to music. There is truly a lot to be gained by improving the fidelity of your music. During the presentation of my amp to my class, my classmates were surprised at the clarity and how good the music sounded. Many of them were listening to songs that they were familiar with but to them it seemed like a whole new experience.

Related Instructables

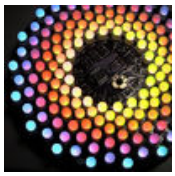
Headphone Hybrid Tube Amp (SSMH) by eh1080

Half-Life 2 Gravity Gun by eyebot117

Rubens Tube 8 foot long AMAZING by namit

555 timer based plasma speaker by Alex1M6

DIY Electron Accelerator: A Cathode Ray Tube in a Wine Bottle by Xellers



Aurora 9x18 RGB LED art by ledartist