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### 300B Single Ended Class-A Amplifier



## **Abstract**

I always wanted to have a hi-fi quality amplifier for my headphones, especially one of the real-deal tube amp ones. I decided to go with a pair of 300B single ended amplifiers, which have one separate block for one channel. They are one of the vintage amplifiers, which were predominant in before 1980's. I found the schematic for these amplifiers on the Internet, and bought the parts from several web stores for high-end audio parts. I drew a layout for the amp to optimize the circuits and design of the amps. I spent a lot of time punching and drilling holes on the chasses. While I and professor Errede were building them, we realized the schematic is faulty in some ways. Professor helped a lot modifying the schematic and we finally get it to work fine. Still there is some irreducible hum but it can be solved later on with some parts changed.

## **Introduction**

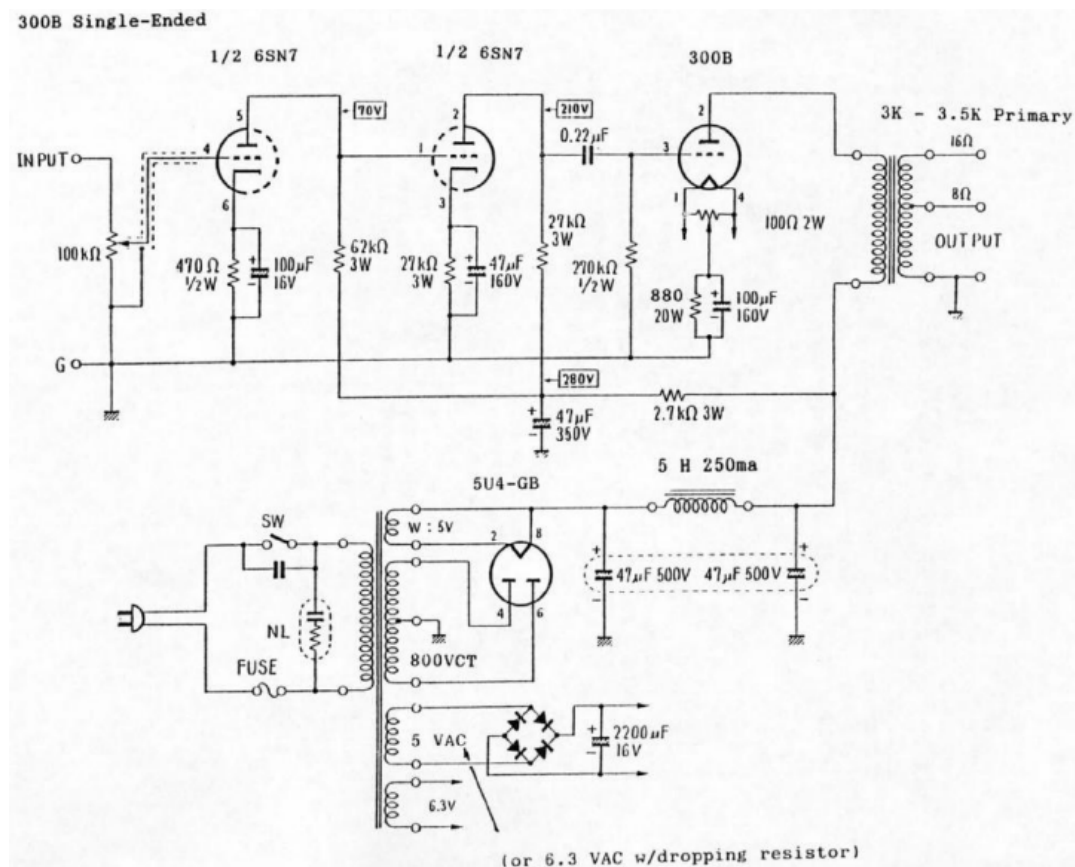
I have been really into the audio gears and headphones since about 5 years ago. I have been raising up my budget since that time to get high quality audio gears. During that time, I have experienced several headphones and audio gears and I ended up staying with AKG-K1000 headphones. These are quite different headphones from other dynamic driver type conventional headphones. It requires much higher power than other headphones. So in my ears it just sounded not good with any headphone amplifiers driving them. So I read the reviews for these phones and found they are really good matching with 300B tube amplifiers. However, they are too expensive for my budget, so I decided to build that on my own when I have chance, and this Physics of Music class was the perfect chance. Therefore, my goal was building a 300B tube power amplifier that is specially designed for my headphones.

First of all before building amplifiers, I needed schematics for them. Professor

suggested me a push-pull type 300B amplifier. However, I wanted a pair of single-ended type amplifiers instead, because of its sweeter midband and less dry sound. Many high-end 300B amplifier makers choose the single-ended type and I wanted know why.

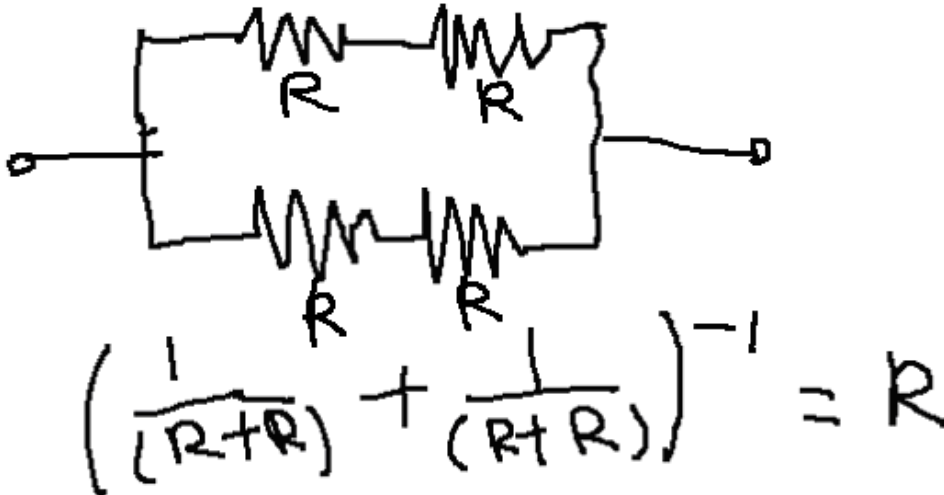
## Procedure

The very first thing I needed to have was the schematics. I found the schematics on Goggle.

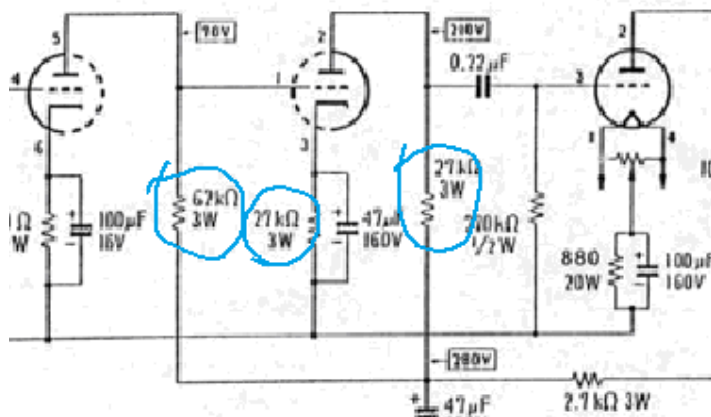


I decided to go with this schematic. This one seemed like the most common type of 300B single ended amplifiers, and many other same type amplifiers' schematics looked quite similar, so I thought it was safe way not to get a faulty schematic so that I do not have to risk a lot of money for making a faulty amplifier.

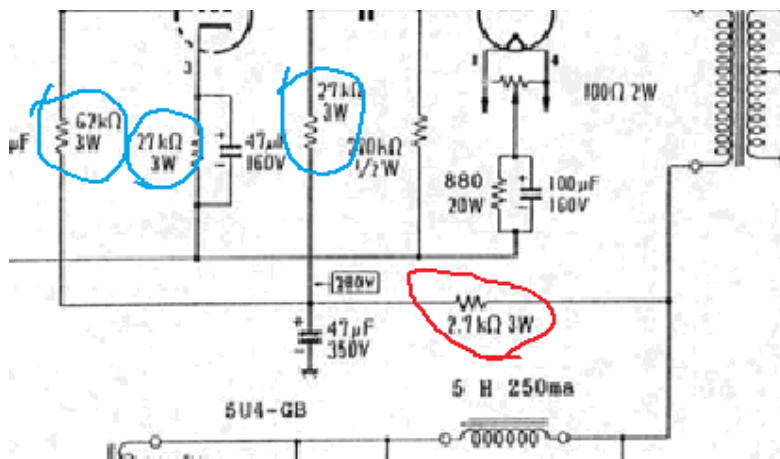
And I started to buy the parts for my project. However, as always, there was a problem. Some of the resistors did not have exactly same wattage and resistance rating, so I paralleled them like this to raise only wattage while keeping resistance.



This will raise the wattage of the resistors by four while keeping the resistance. Some of them, such as 3 watt resistor on the schematic, I could not find the resistor with its power rating as high as them, so this was the way I could get it around. Actually, some of them below (indicated by blue circles) were actually calculated to be not requiring not that high wattage, since their voltage drops are approximately 70 volts, and the power dissipated by that resistor is:  $V^2/R$ , so 2 watt resistor can be substitute for them without burning the resistors.



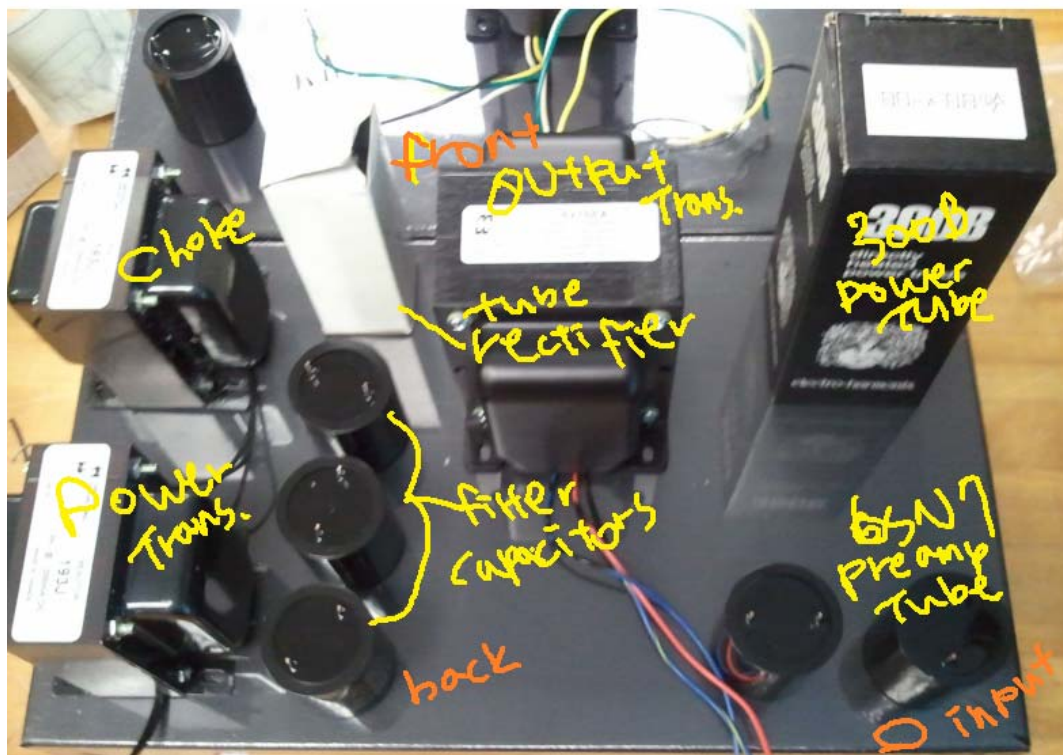
I mostly used the Japanese-made Riken resistors, and Audio Note UK resistors if Riken resistors were not available. When calculating the power dissipation on resistor, professor and I found a problem on the resistor indicated by red circle.



Because it is indicated that the resistor have about 200V drop between it, and 2.7k ohm and 3 watt resistor just seemed not making sense, since the calculation  $P=V^2/R$  says that using 2.7k ohm requires about 15 watt power dissipation. It seemed like it is a typo of 27k ohm. Therefore I ordered 27k ohm resistors. Then I bought the output and power transformers and choke. They are all made by Hammond. The parts' names were 278X, 1627SEA, and 193J respectively.

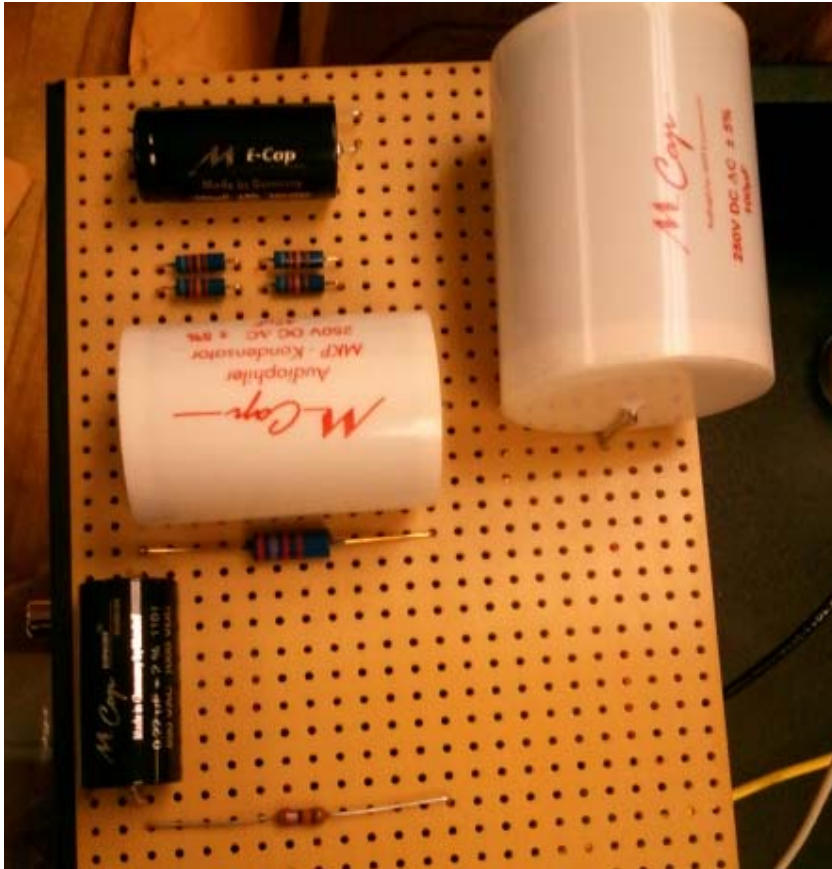
Then I needed the chasses for them. I did not want them to be too packed, but not to have too much space left. Finally, I got 17x10x3 inch chasses by Hammond as well.

After every part came in, I tried to optimize the layout of the amplifier to make it as much free as from the radiation from its sources, such as filter capacitor, transformers, and others. The picture is what the amp was intended to be designed.

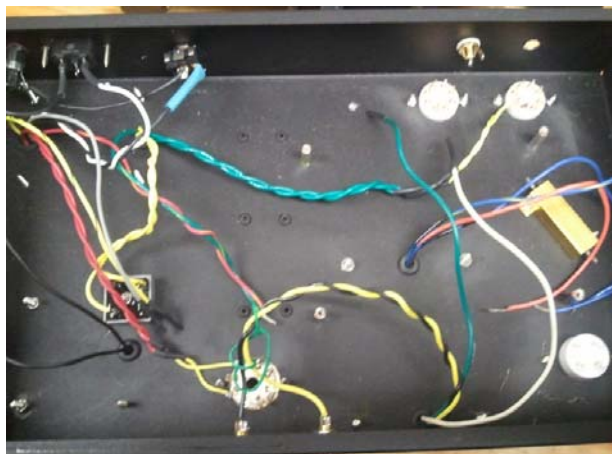


The side with 300B is the front. The point of this layout is to set the output transformer 90 degree from the power transformer and choke so that it has no interference from their radiation. And I put 6sn7 tubes as far away as I can from the transformers, since it is the most sensitive parts in the circuit. For output and input, it is a power amplifier's convention that both input and out is located at both back of the chase, but I put the output to be on the front so that it will be more convenient to connect the headphones. Then I actually started to build the amplifiers. Actually one of the biggest challenges I met was drilling all the necessary holes with various sizes. It could have saved almost half of the entire time working on these amplifiers if I bought chasses that already have holes for them. Anyway, after done with the drilling, I started to build the board for it.





Making the audio boards was simple, since there are not many components for it. The picture above is the initial layout for the circuit board, but I had few modifications later. Still, it is really similar to the final design. And the picture below is the parts other than



the board.

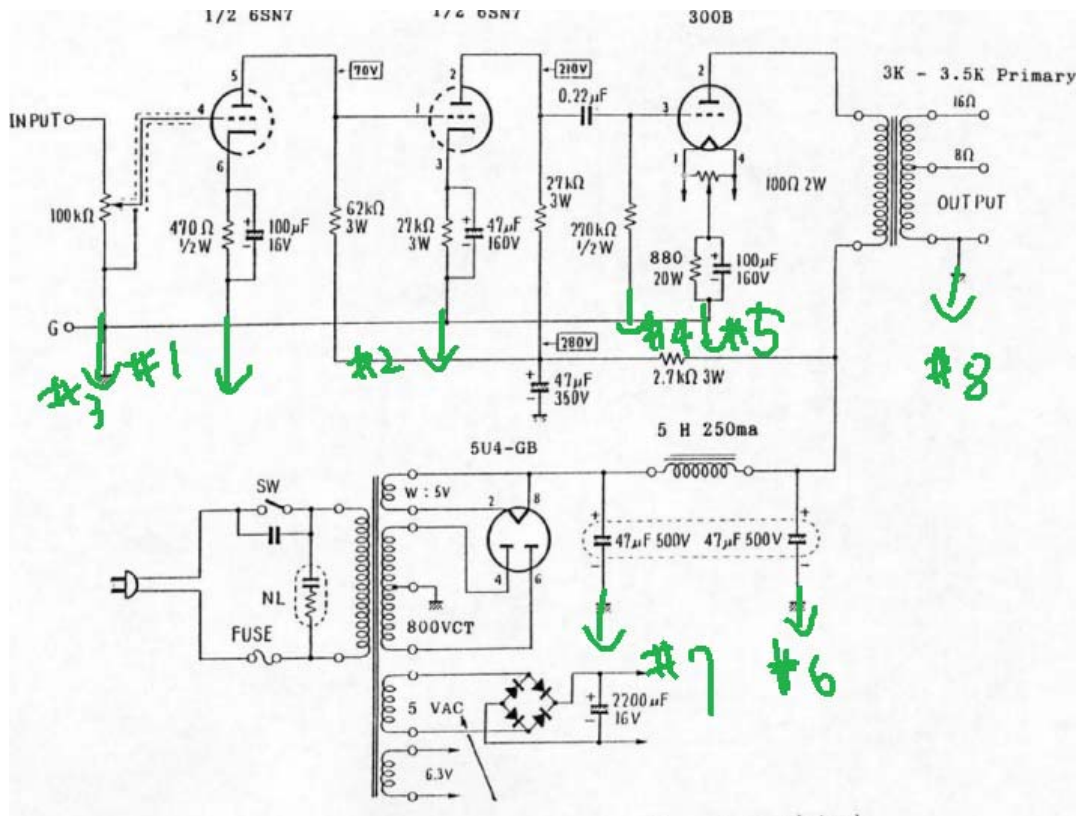
I cut and hit shrunk every unnecessary wire so that it won't cause the problem when it hits the chaise. It is crucial that every wire that has AC current flowing should be twisted together so that they cancel their electric field each other. Otherwise, other audio parts will catch the signal and causing 60hz-humming noise.



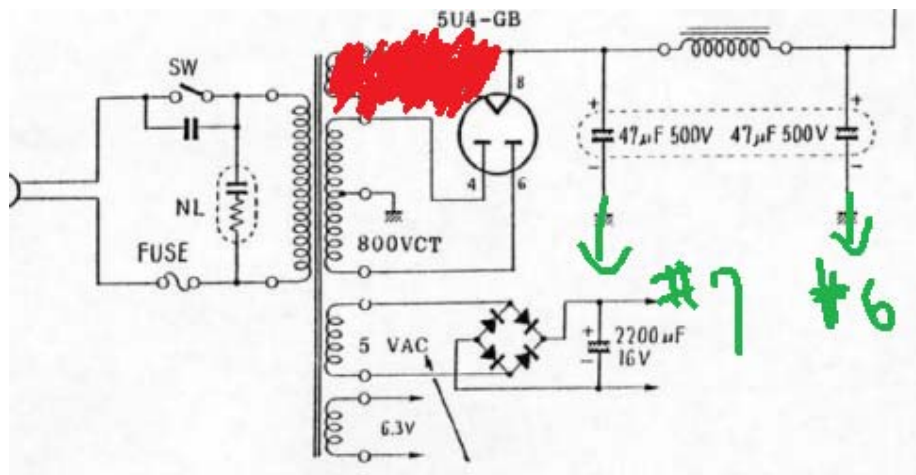
After both of the audio boards and the chasses are complete, they were put together and wired up. I used coax cable for long signal path and input-to-potentiometer signal path, since they are vulnerable to the radiation from the other parts and become sources of 60-cycle hum. Otherwise, I used 22 AWG Belden wire that was provided by the lab.

For grounding, I used what professor introduced me, which is star grounding.





#1,2, and 3 were connected together, and #4 and 5 were connected together. Otherwise, they are separately coming from different wires, and then they were put altogether in one grounding spot.



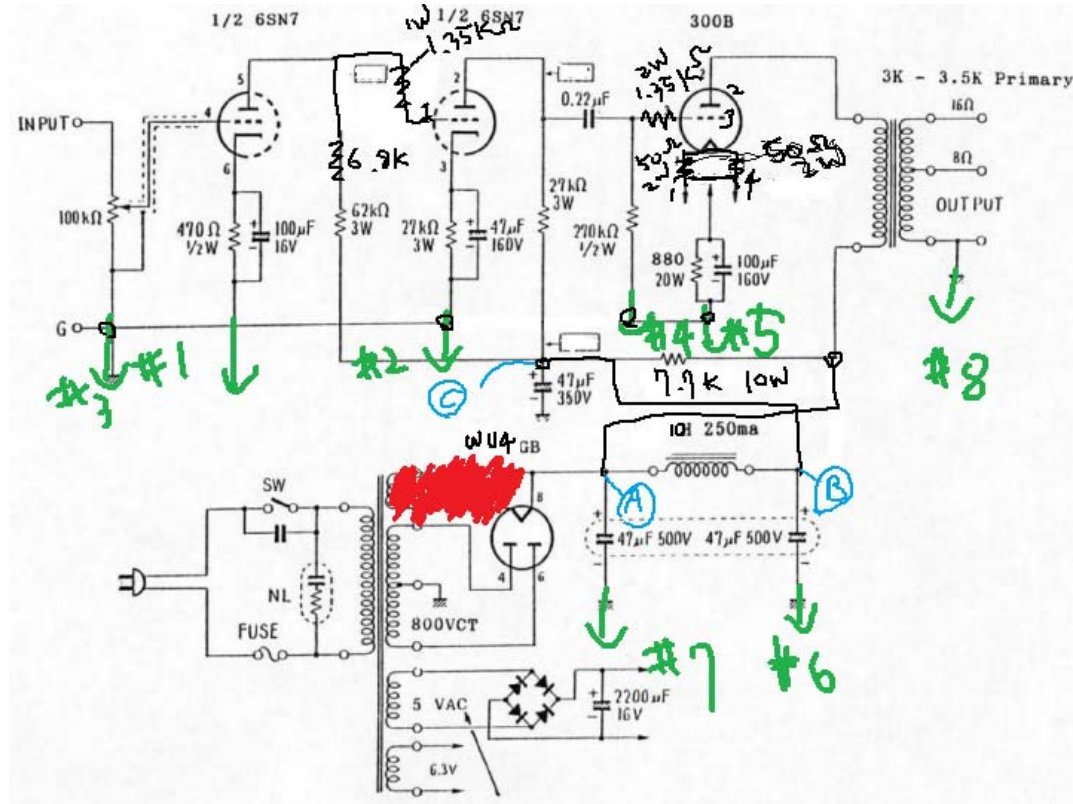
and then I used WU4GB solid state rectifier that mimics 5U4GB tube rectifier, and eliminated the wires that goes to the tube rectifier, since the WU4GB does not require

them. (The read region)

## Result and Conclusion

After done with wiring up, I powered them and checked the sound, and unfortunately it was not audible quality sound produced from the amp. After several trials to debug, professor and I looked at the other schematics and modified the original schematic, trying not to be too different from the original schematic. The schematic we consulted was from Angela 300B SE project.

So this was the final schematic.



Big difference is that we put 1.35k ohm resistor between their grid of each 6SN7 and 300B tubes. Additionally, I skipped the choke to the power transformer because it sounded better. After done with them, we measured the voltage at each A, B, and C in sky blue, pin of the tubes, and the solid-state bridge rectifier.

Amp #1 (left channel)

Line voltage = 119V

Main voltage = 406x2V

5V out Voltage = 5.08V

6.3V out Voltage = 6.55V

Solid state bridge rectifier = 4.29V

V(A) = 488V

V(B) = 487V

V© = 420V

	Grid	Cathode	Plate
V1A(6sn7) =	0.00	2.232	95.6 (V)
V1B(6sn7)=	95.6	104.0	316.3
V2=	0.23	65.9	481

Amp #2 (right channel)

Line voltage = 119V

Main voltage = 404x2V

5V out Voltage = 5.05V

6.3V out Voltage = 6.49V

Solid state bridge rectifier = 4.28V

V(A) = 482V

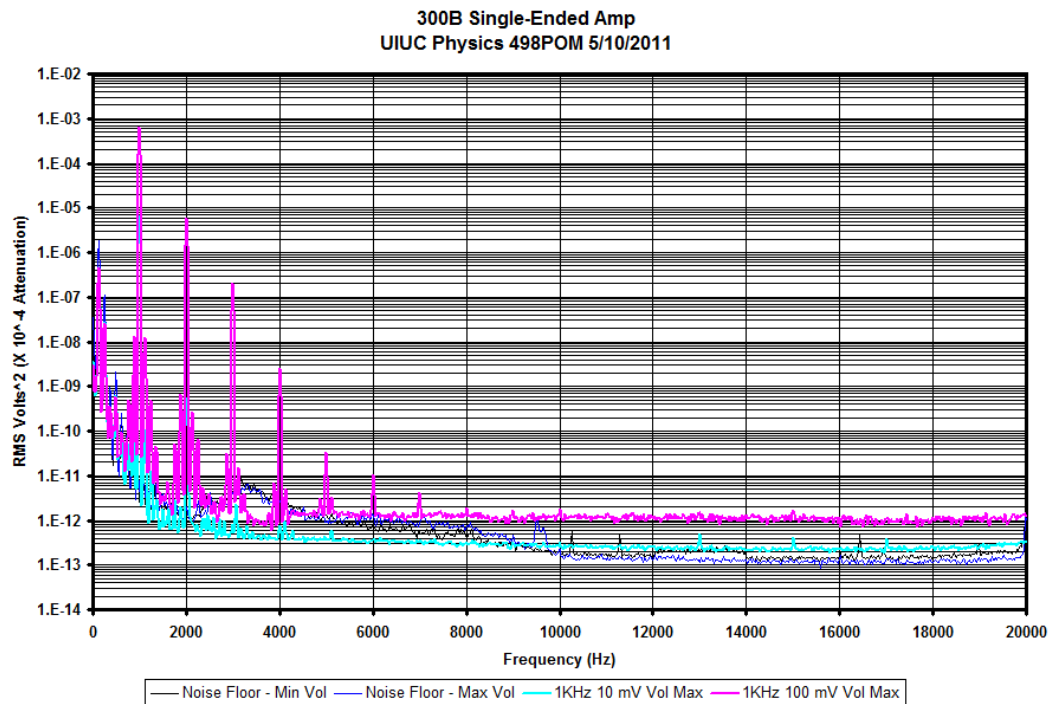
$$V(B) = 481V$$

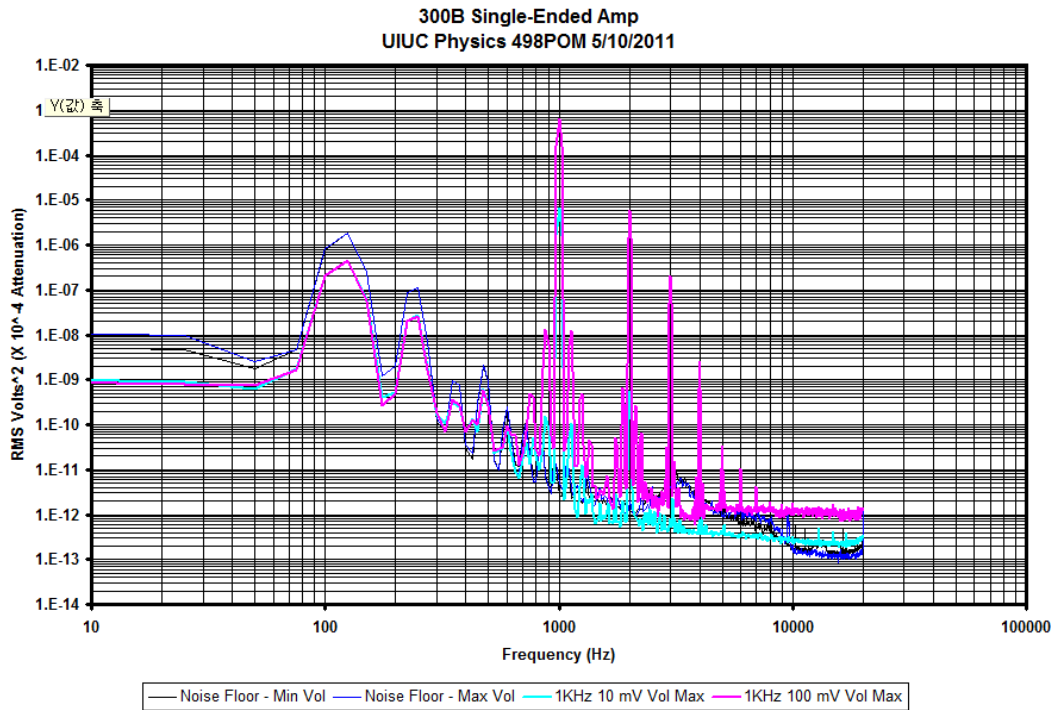
$$V(C) = 417V$$

	Grid	Cathode	Plate
V1A(6sn7) =	0.00	2.250	92.1 (V)
V1B(6sn7)=	92.1	101.7	322.0
V2=	0.20	67.3	476

Then we measured the  $V_{rms}$  clipping to be 6.5V at 8ohm, so the power dissipation of the amplifier would be  $P = V^2/R = 5.3$  watts. Doubling it makes the actual amplifier's power output, which is 10.6 watts per channel.

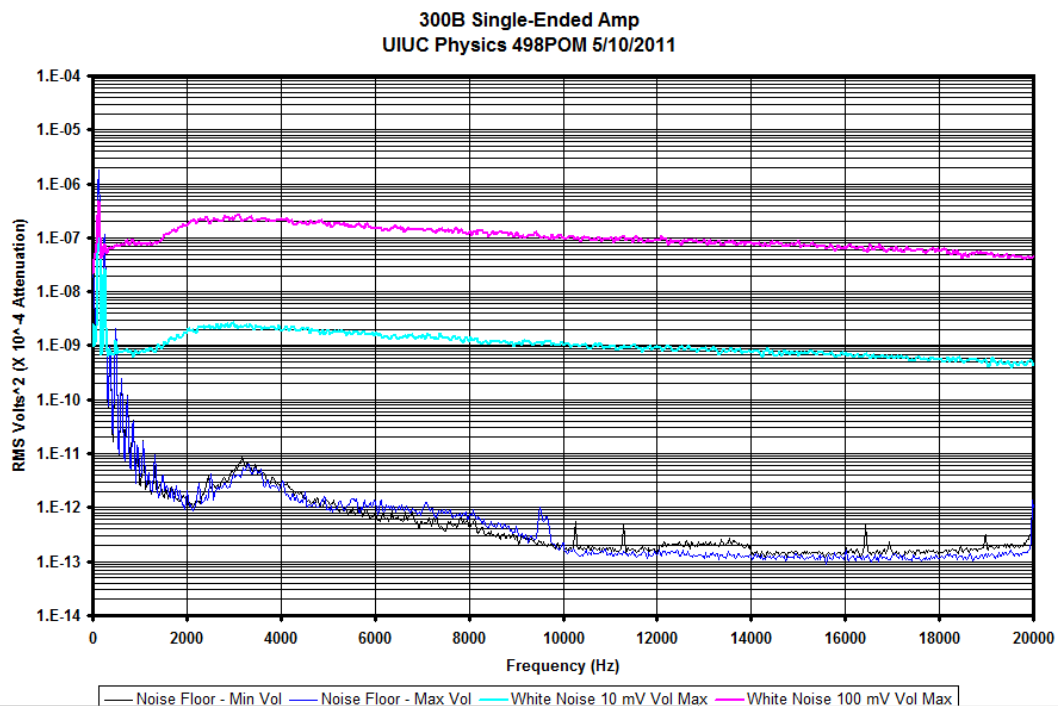
And then we measured the specification of the amp. First, the graph is for the harmonic distortion in linear scale.

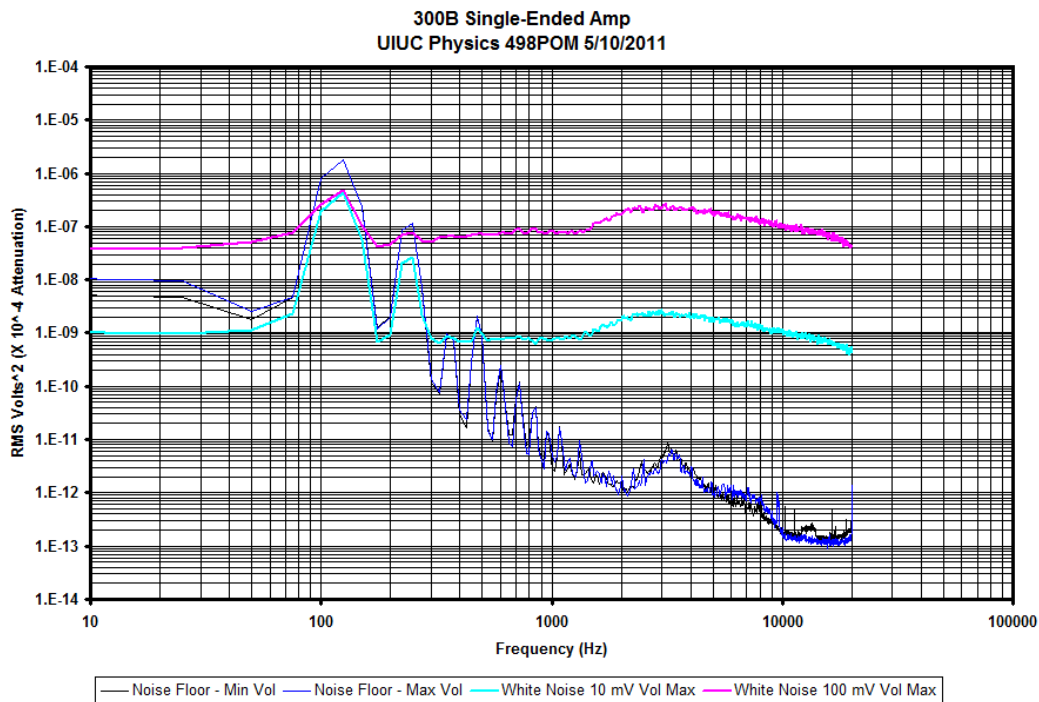




This graph above is in logarithmic scale.

The percentage total harmonic distortion for them was 0.008271% at 10mV, and 0.943136% at 100mV, which are satisfactory.





The graphs above are the frequency response in linear scale and logarithmic scale respectively. In linear scale, it seemed to have no cusp or harsh curve overall in audible range, 20hz-20000hz, which is also good.

However, there was an audible hum. We measured the ripple voltage on the tube, and each channel there were 8.6mV of ripple voltage resided in the 300B power tube. It seems irreducible unless I use different method of heating the tubes than directly AC-current heating. The next goal is try to reduce the hum as much as I can. There were several ways to modify the 300B SE amp to reduce the ripple voltage such as using DC filament supply for 300B tubes, or try other types of 300B tubes. This will take some time and I will take my time trying the various ways.

After all, when I connect this to my headphones, they sound just wonderful if there is no hum. Compared to my \$1000 6AS7 tube headphone amplifier, my 300B amp sounds much superior by hundreds of miles. Much lower bass extension, much juicier midband,



and much wider soundstage with more dynamic and resolution. This amplifier brings my entire audio system into another league. I would like to thank Professor Errede and John for all of their help. I learned a lot from building these amplifiers. Every small detail on each part constructs a beauty of the audio amplifiers.

