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MMI 506 Audio Electronics II

(Trendy Audio Electronics 2)

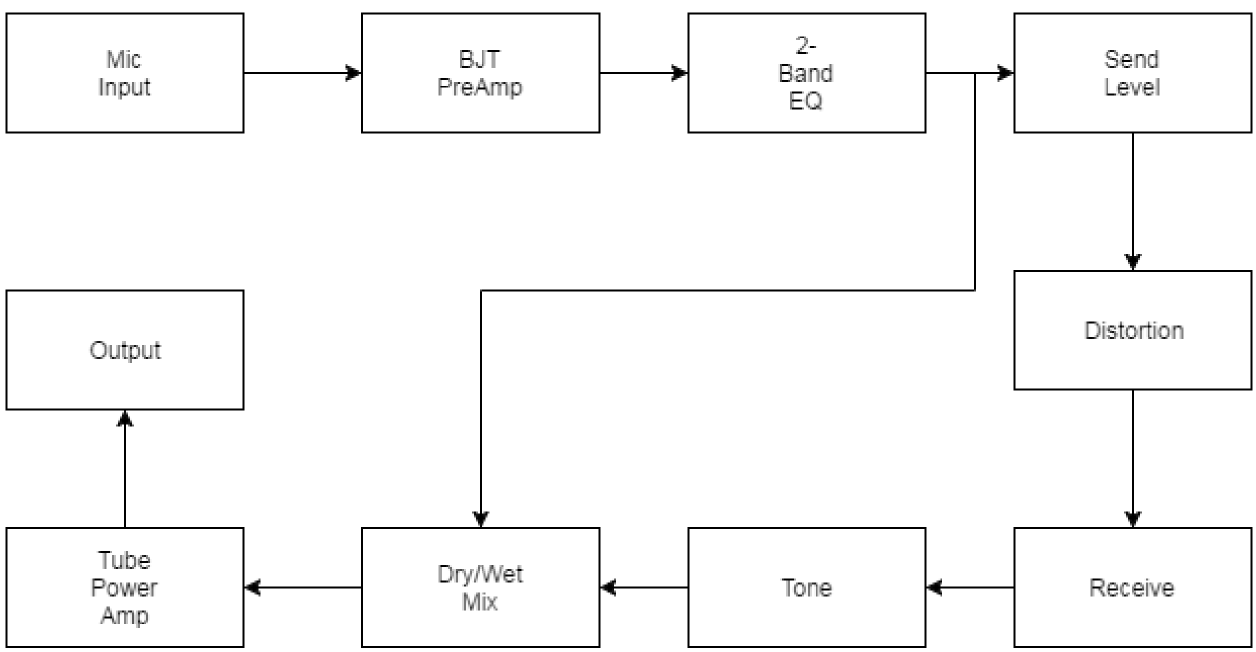
Will Pirkle

Final Project

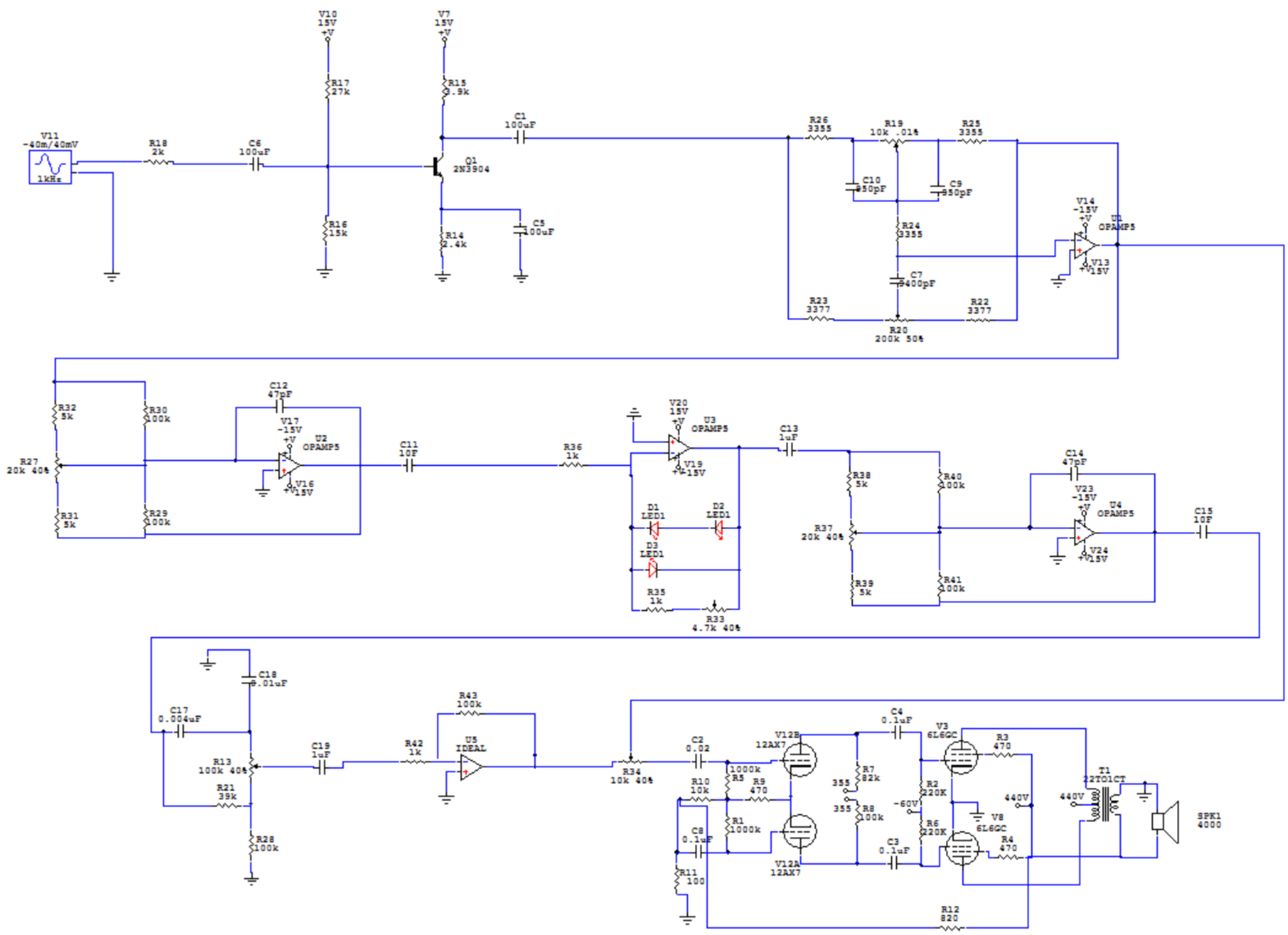
Introduction and Design/Idea:

The purpose of this project was to design a device that contains a tube, a solid state device, and a BJT. While not currently the most practical in circuit design because of their size and cost, tubes are still very much staple components in the world of high-end audio design. The tone shaping and unique distortion caused by tubes set them apart from a standard device.

Transistors are versatile devices. They are used as amplifiers, in output bias circuits, and as gain control devices. There are many similarities between tube and transistor circuits. Their wide range of uses led me to design a mic preamp and effects loop. The mic input goes into a BJT preamp, a 2-Band EQ, send, distortion, receive, tone control, dry/wet mix, and finally through a power amplifier. This can be seen in the flow chart below:

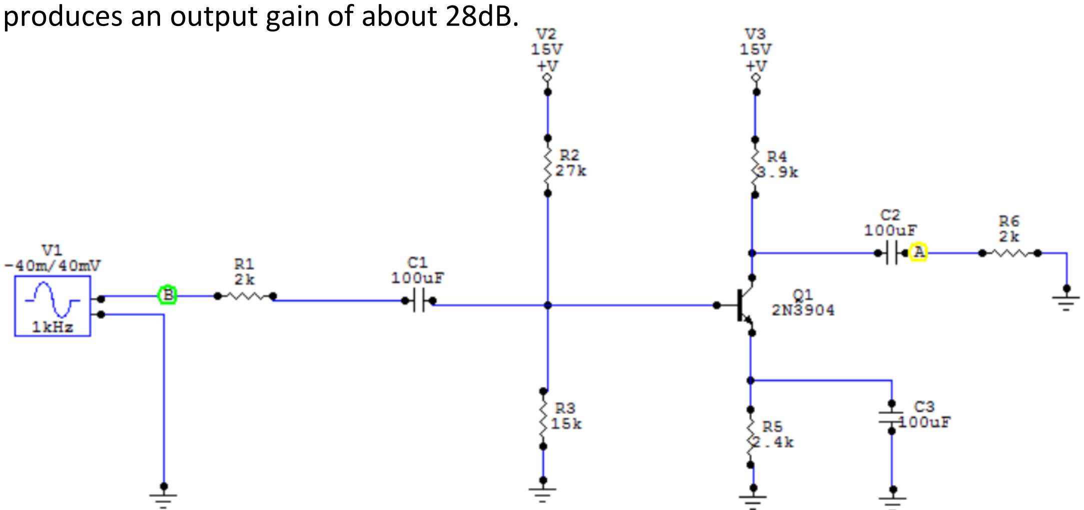


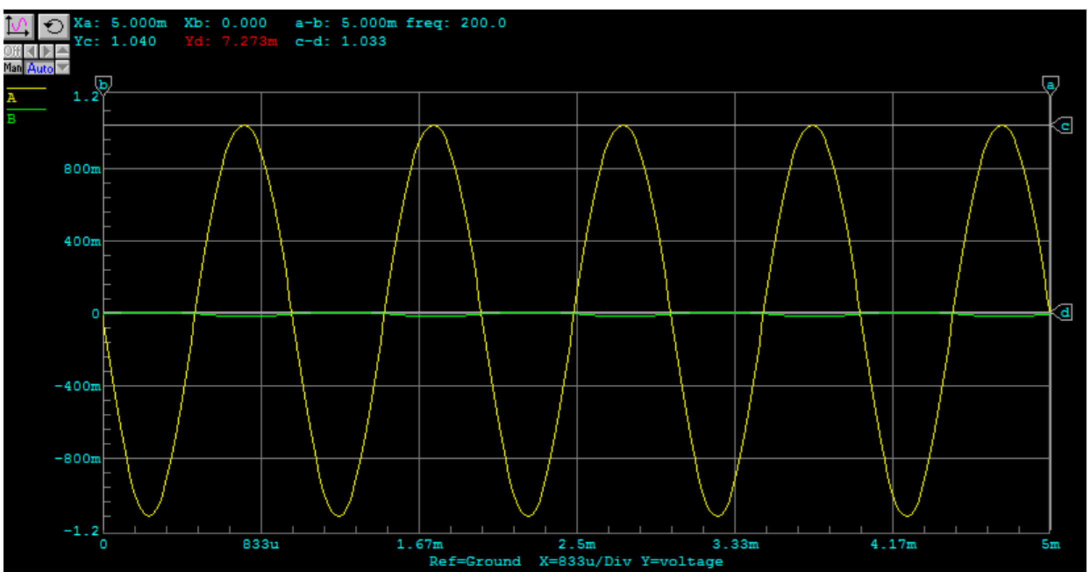
The entire circuit is shown below. Coupling capacitors were added in between each sub-circuit to block DC voltages that appear at the input and output pins of op-amps. In addition, there should also be bypass caps on every op-amp to provide a path to ground for AC signals that are superimposed on the power supplies, but to save space, these were omitted. The student version of CircuitMaker would not allow me to simulate the entire circuit, so I simulated each sub-circuit instead.

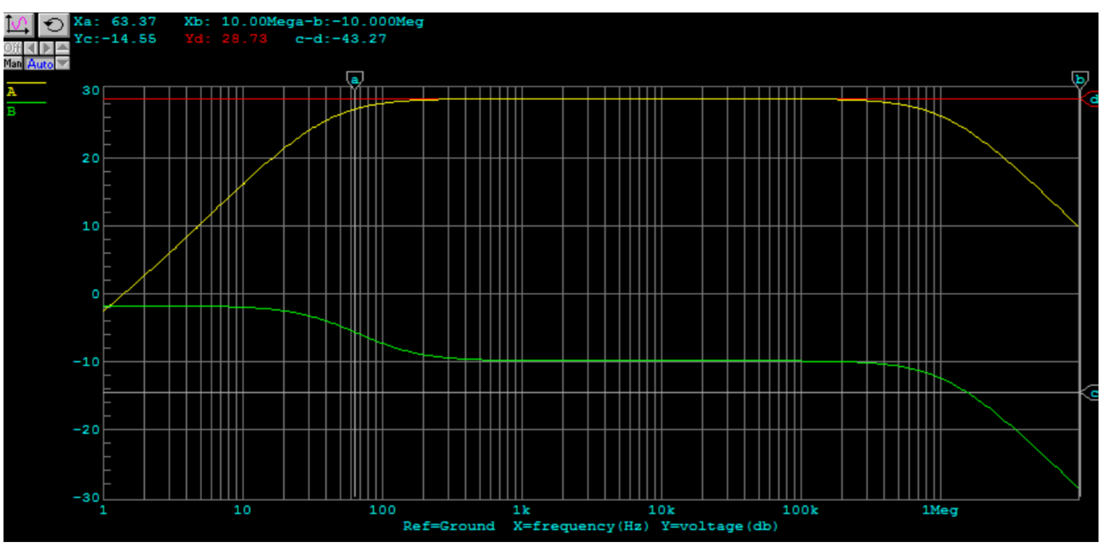


Preamp:

I decided to use a simple BJT circuit for my preamp. The transistor (2N3904) is an NPN and because there is a small input current to the base, there is a large collector-to-emitter current. The BJT is biased with the voltage divider. The transistor reverses the phase of the input and it produces an output gain of about 28dB.

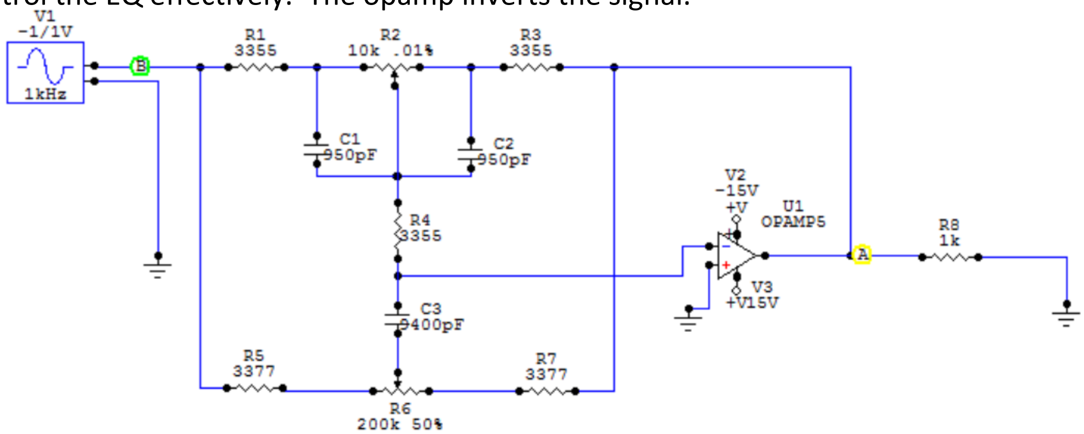


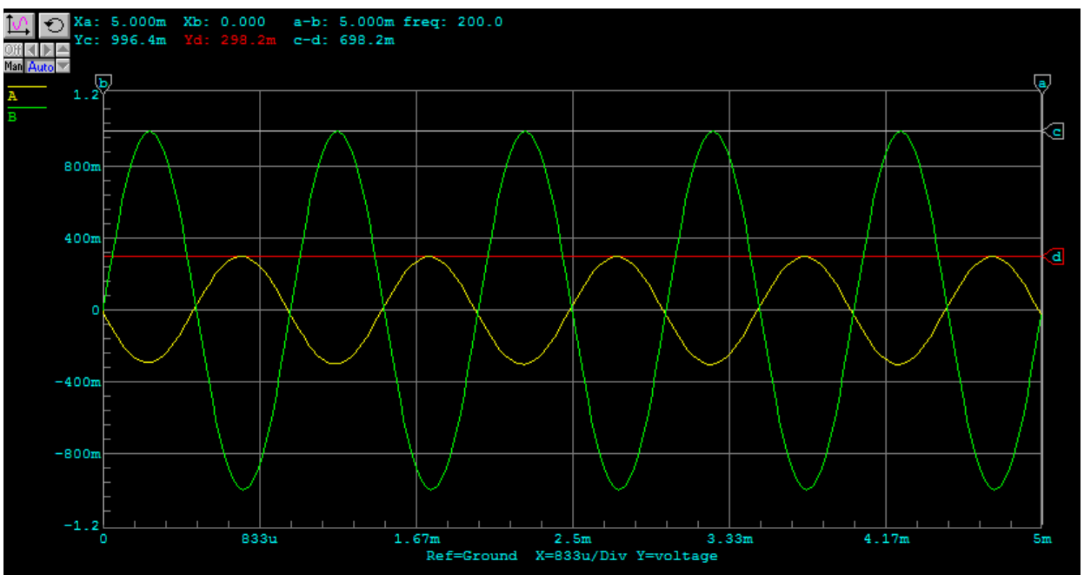


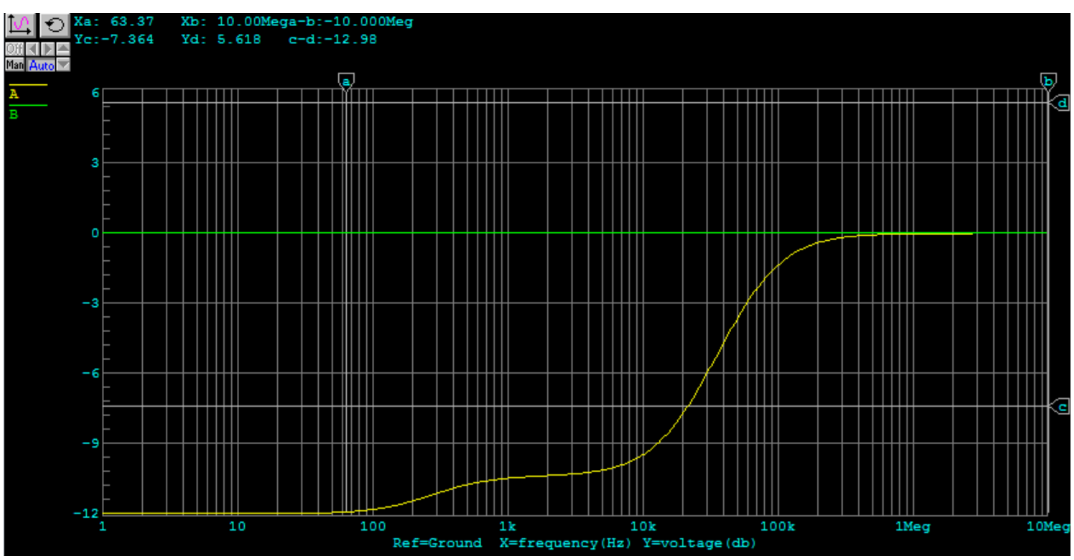


2-Band EQ:

I used the Baxandall shelving filter for my 2-band EQ. The top half of the circuit controls the bass and the bottom controls the treble. I chose my low shelving frequency to be 50Hz and the high shelving frequency to be 5kHz. Using these frequencies and Baxandall's design equations, I got the values for R1, R3, R4, R5, and R7. R2 and R6 need to be large potentiometers, in order to control the EQ effectively. The opamp inverts the signal.

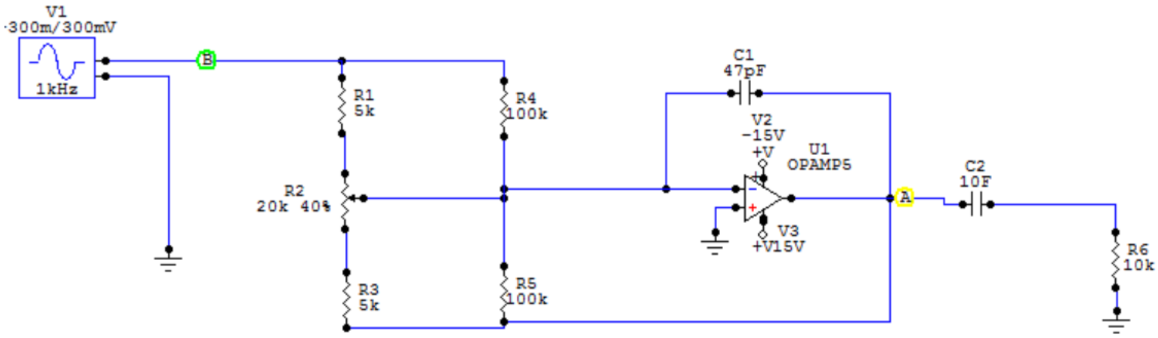


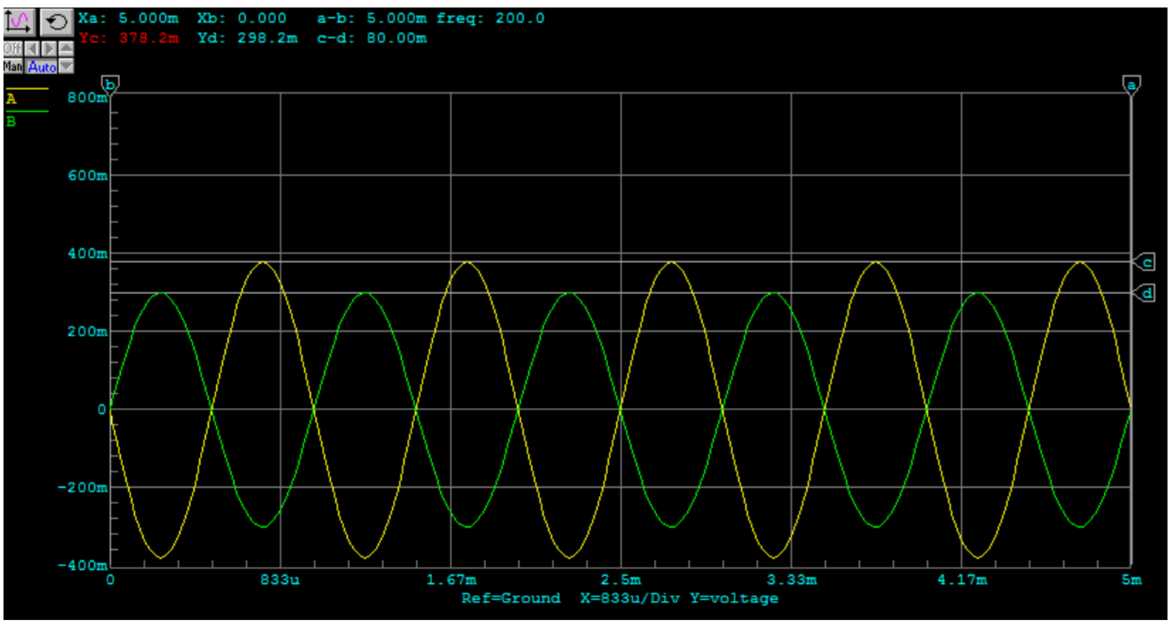


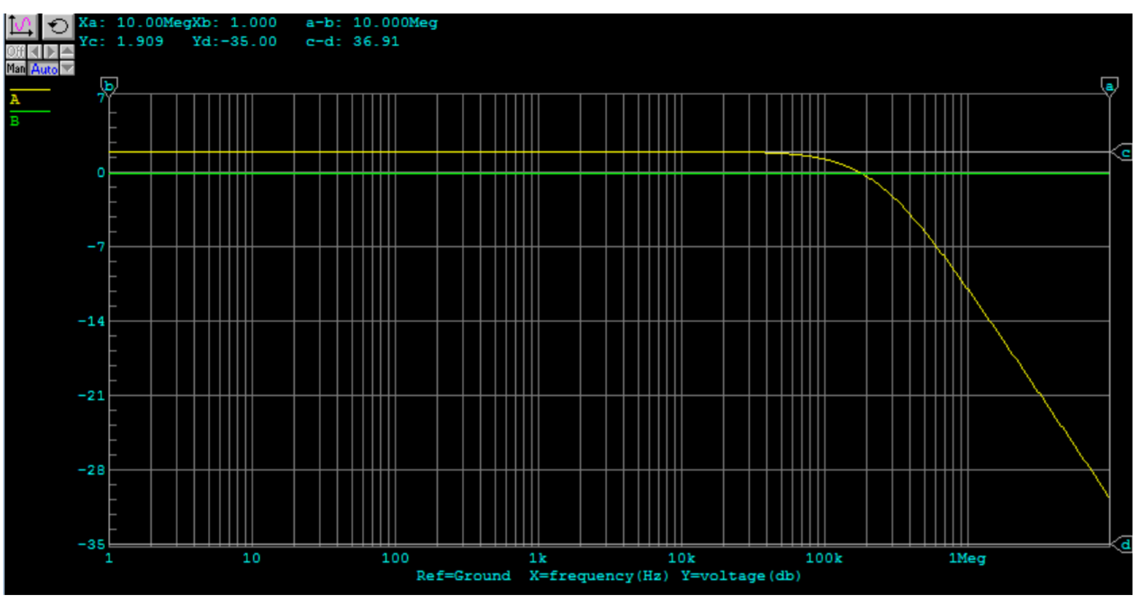


Send/Receive:

The send and receive circuits are the same. I used the design that was in the Rane MLM65 Mic and Line Mixer. The function is to either raise or lower the signal by up to 12dB, depending on how the potentiometer is set. Mine is set so the signal is raised 2dB. In addition, the circuit inverts the signal because of the op-amp. When the signal goes through the send, it get inverted and then when it goes through the receive later on, it is put back in phase.



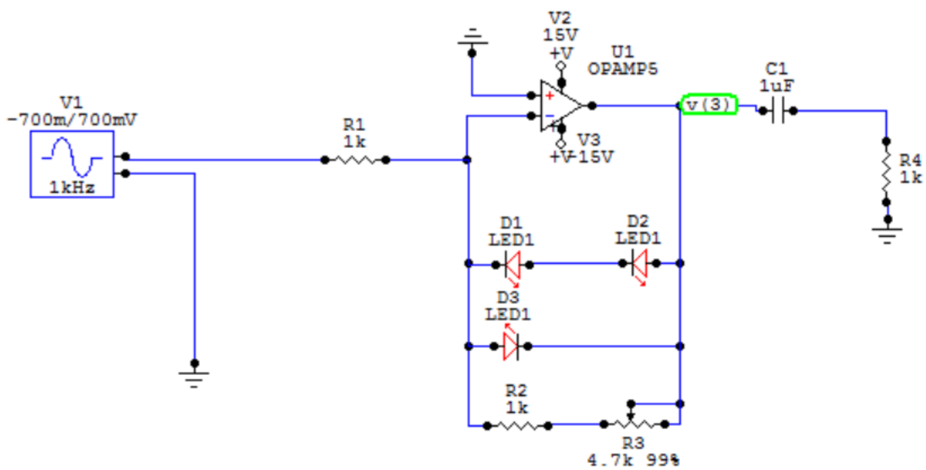


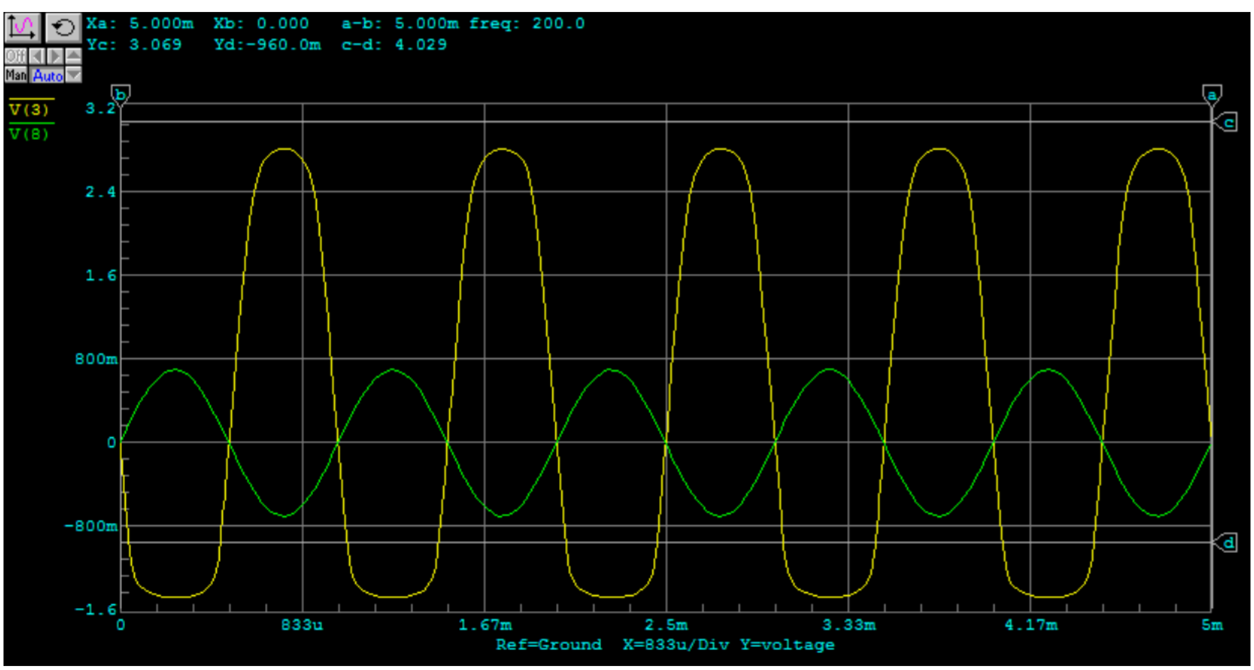


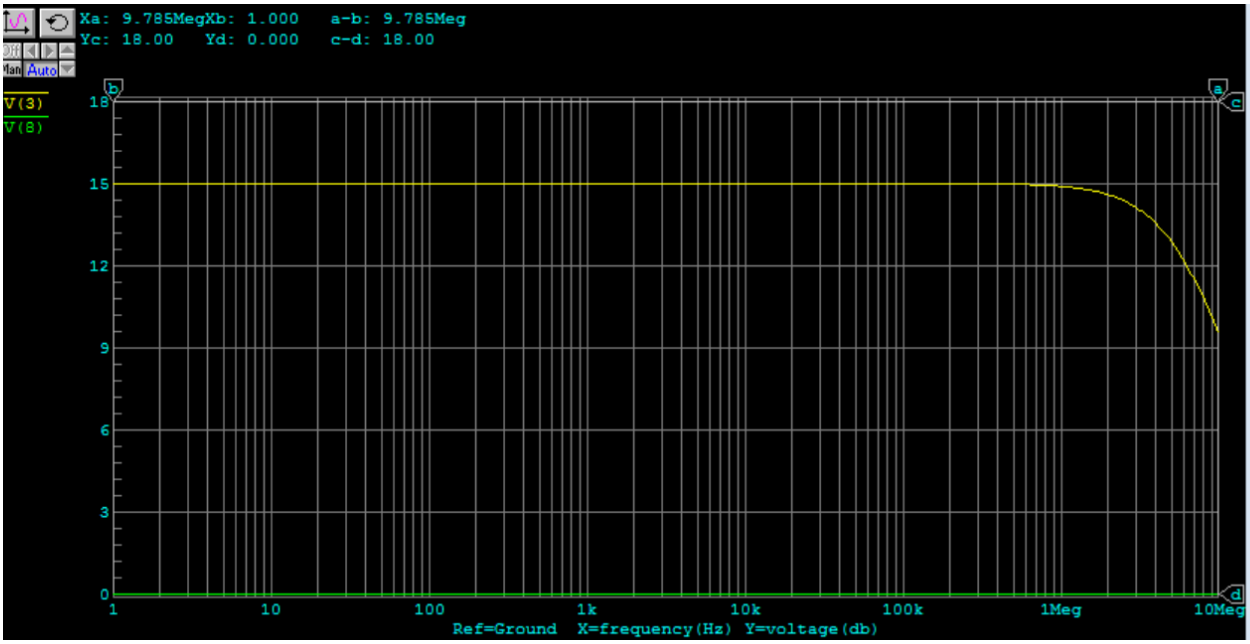
Distortion:

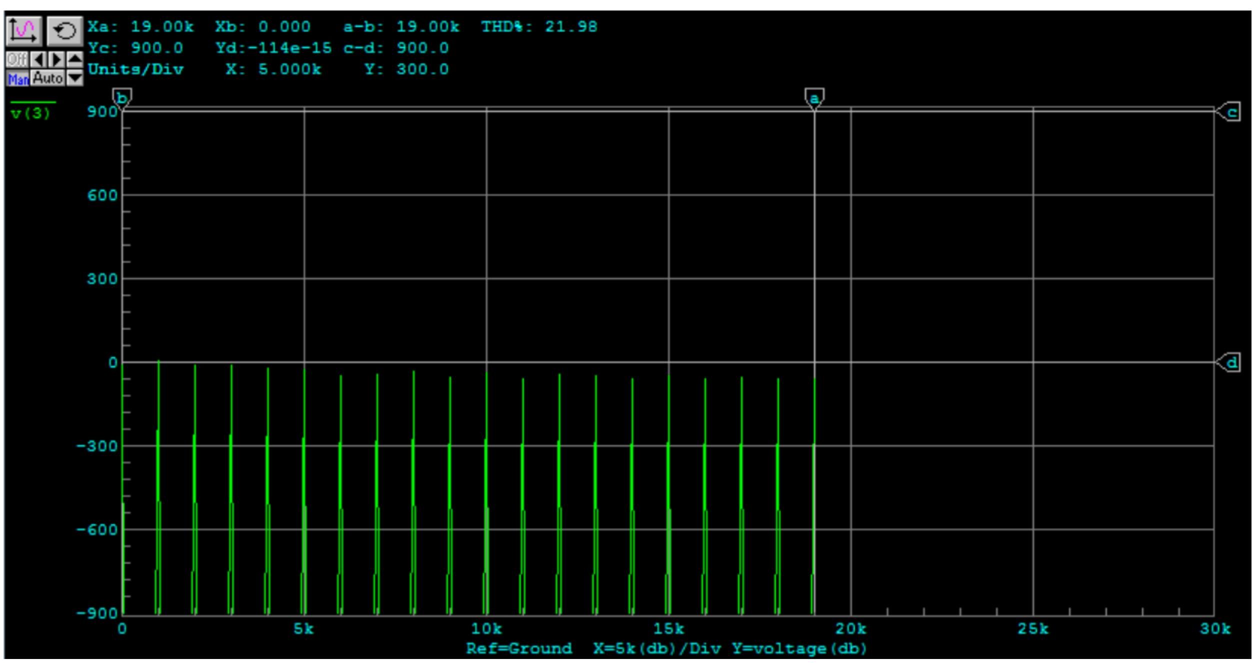
I chose to make an asymmetrical distortion circuit. This was done by placing two diodes that would clip the negative halves of the signal at 1.4V and the positive halves at 0.7V. Also, I used LEDs instead of ideal diodes. Doing this created a softer, more rounded distortion. The THD was

*It is important to note that for every sub-circuit simulation, the input signal values are the same as the previous sub-circuits' output. That was not the case for the distortion sub-circuit, because I wanted to show a more extreme output than the theoretical one with the input value of the send circuit.



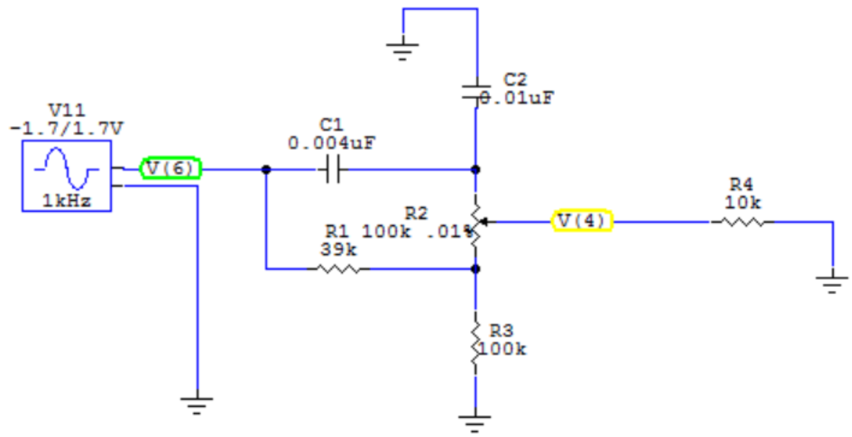


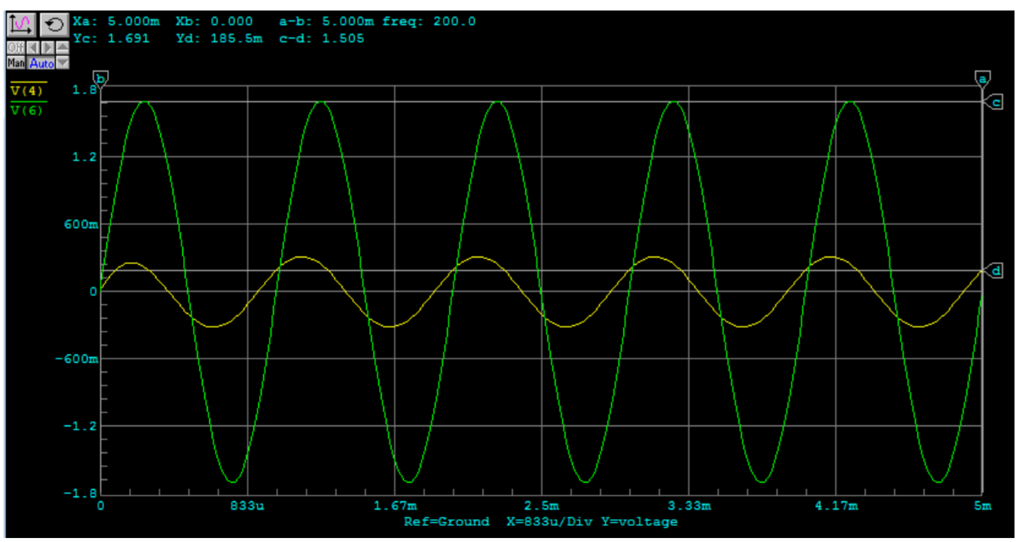

Xa: 9.785MegXb: 1.000 a-b: 9.785Meg
Yc: 18.00 Yd: 0.000 c-d: 18.00
V(3)
V(8)
18
15
12
9
6
3
0
1
10
100
1k
10k
100k
1Meg
10Meg
Ref=Ground X=frequency(Hz) Y=voltage(db)

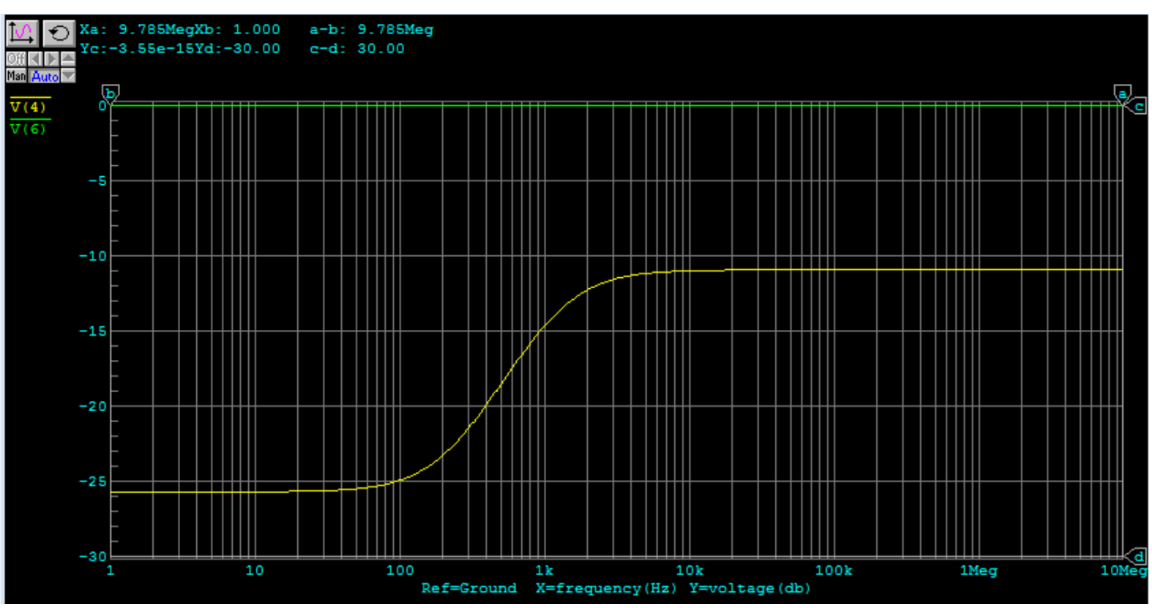

Xa: 19.00k Xb: 0.000 a-b: 19.00k THD%: 21.98
Yc: 900.0 Yd:-114e-15 c-d: 900.0
Units/Div X: 5.000k Y: 300.0
v(3)
900
600
300
0
-300
-600
-900
0
5k
10k
15k
20k
25k
30k
Ref=Ground X=5k(db)/Div Y=voltage(db)

Tone Control:

I used Electro-Harmonix "Big Muff" Tone Control in my circuit. I chose to replicate this particular tone control because it is simple. If the theoretical EQ knob is turned one way, the treble is boosted and if it is turned the other way, the bass is boosted. At maximum treble position, a high shelving filter is produced and at maximum bass boost, a low pass filter in formed.





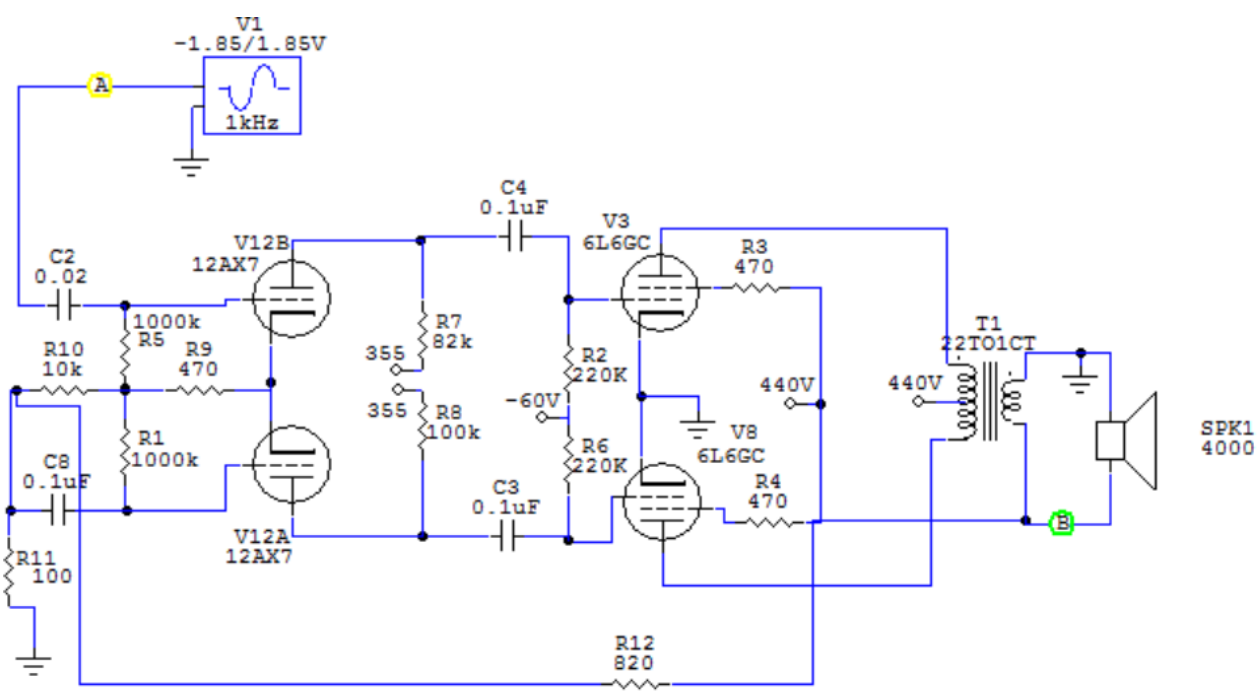


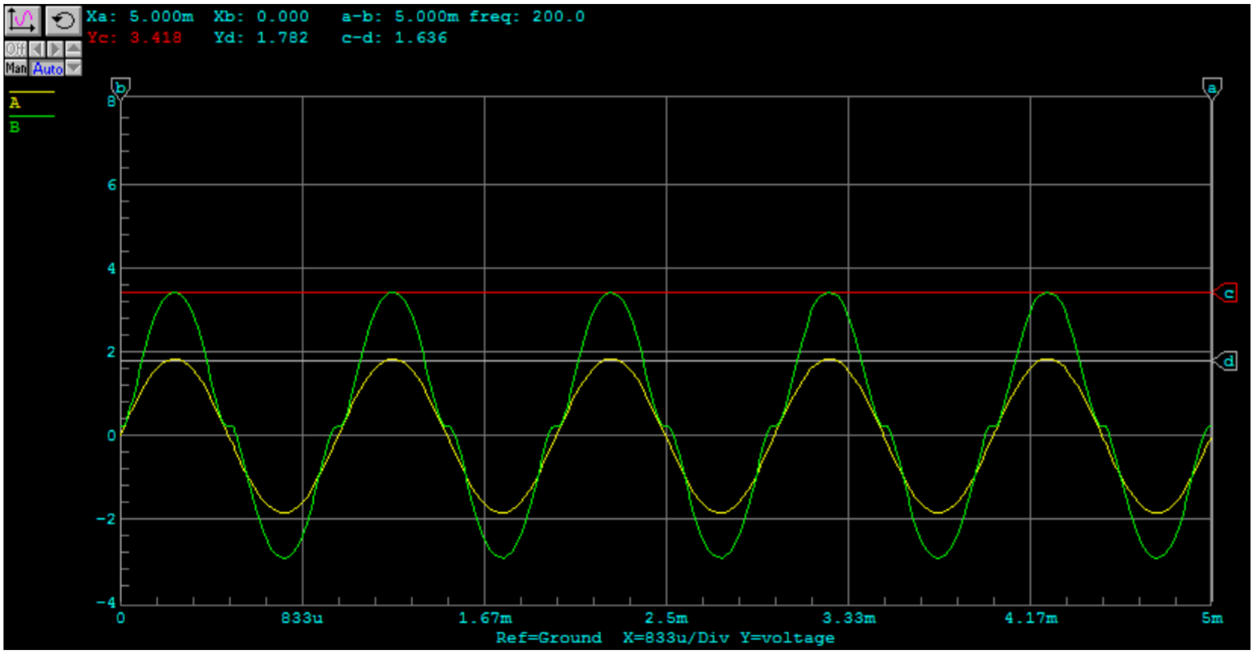
Tube Power Amp:

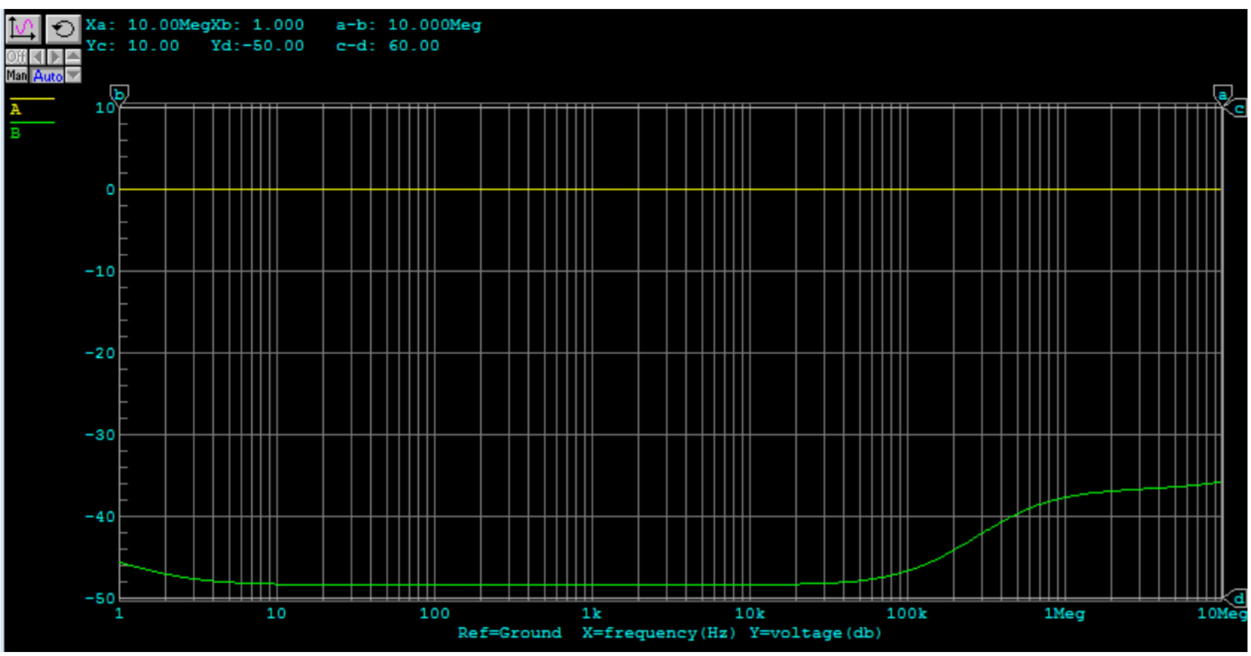
The power amplifier was created with an AB push-pull circuit. This amp can be broken up into two parts. The first section is a phase splitter, which is necessary to create the balanced signal that's required for a push-pull amplifier. This works by feeding the voltage swing that is created at the cathode of the first tube into the cathode of the second tube. This will put the outputs of the two 12AX7 tubes out of phase with each other. The out of phase signals are then fed into the power amplification stage of the circuit. This stage contains two 6L6GC tubes that are operating in pentode mode. Both tubes apply enough current and voltage gain to the signal, making the signal suitable enough to send to speakers.

Class AB power amplifiers work because each tube will only conducts for a little over half of the time. Each tube is responsible for amplifying its half of the signal. While one is conducting the positive half of the signal, the other tube will only be conducting a small amount. When the voltage switches to a negative value, the tubes switch jobs and the latter tube will conducts the negative half of the signal. Because both tubes are always slightly conducting, there is less crossover distortion in the output than in a typical class B amplifier output. However, there is still some crossover distortion.

The wet and dry signals are mixed before the power amp stage. This was done simply with a potentiometer. In addition, I added an amplifier with a gain of 100 so the power amp would function properly. I tried simulating with the output value from the tone control circuit (around 300mV) and because the input voltage was so small, the circuit was not functioning properly with my component values.




Xa: 5.000m Xb: 0.000 a-b: 5.000m freq: 200.0
Yc: 3.418 Yd: 1.782 c-d: 1.636
A
B
Ref=Ground X=833u/Div Y=voltage


Xa: 10.00MegXb: 1.000 a-b: 10.000Meg
Yc: 10.00 Yd:-50.00 c-d: 60.00
A
B
Ref=Ground X=frequency(Hz) Y=voltage(db)