



Vacuum Tube Amplifier

Team #1

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UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN



Introduction

- Less than 1% of people plays music at real stereo system
 - Most people have high quality musics files, but lacks high quality audio system to make it sound truly alive.
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Objective

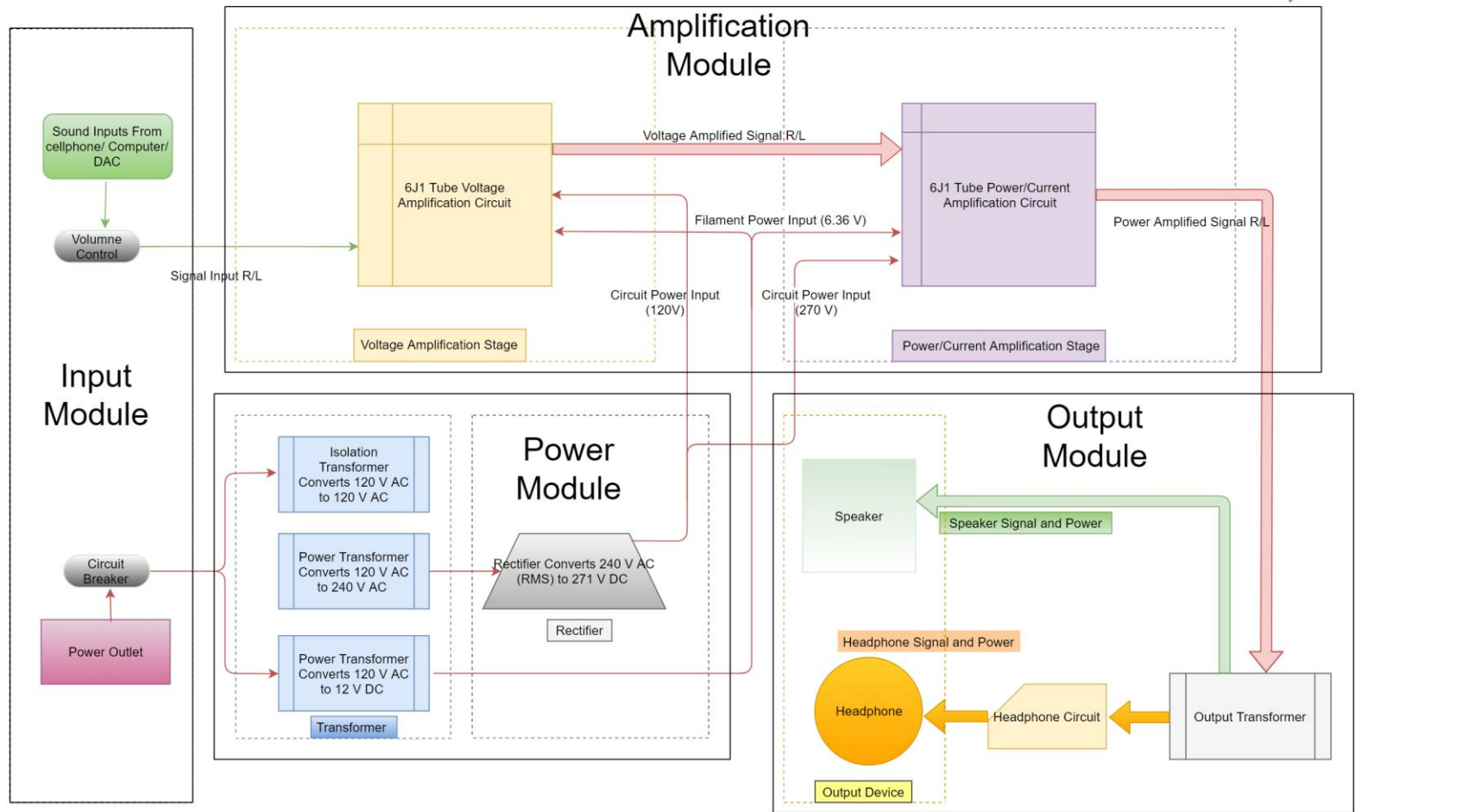
- Low cost vacuum tube amplifier
 - Versatilities –being able to drive both headphones and speakers
 - Intended for beginners in high fidelity music
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Features

- Integrated pre-amp stage and power-amp stage
 - Compatible with 3.5 mm input and RCA input
 - Up to 4.2W of output power per channel
 - Two-port output, can power both headphones or speakers
 - Tubes can be replaced for future upgrade
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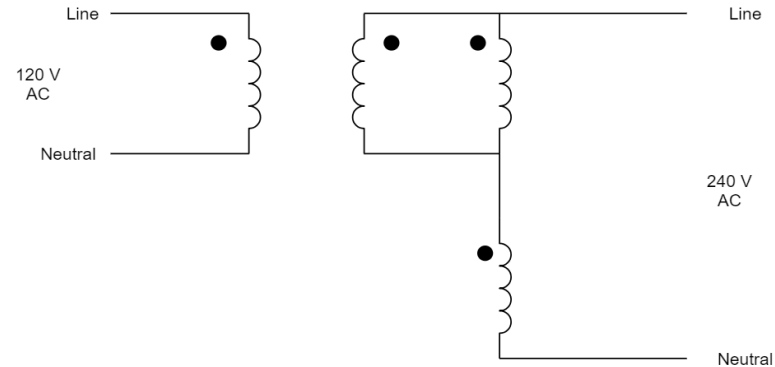
System Overview

- Power Modules
 - Transformers
 - Bridge Rectifier
 - RC Filter
 - Input Modules
 - 3.5 mm & RCA Jacks
 - Volume Control
 - Output Stage
 - Output Stage
 - Headphone Module
 - Amplification Modules
 - Voltage Amp Stage
 - Power Amp Stage
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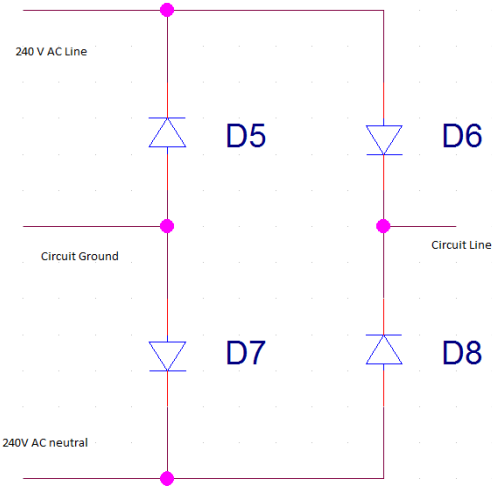


Transformers

- Dual-transformer system
- One isolation transformer reduces high frequency noise
- One transformer steps up voltage

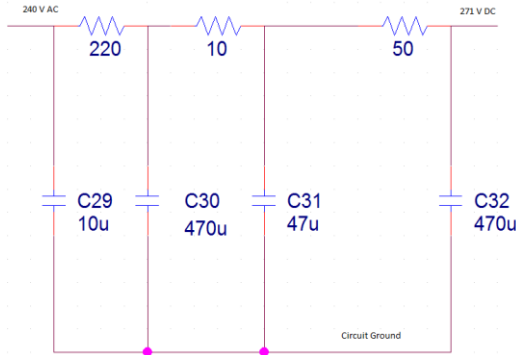


Bridge Rectifier



- High current rating diode to make sure fast charging of capacitor will not damage the rectifier
 - Flip the negative cycle of AC voltage to positive side
 - Provide full-wave rectification
 - Circuit ground is connected to earth ground to eliminate floating voltages
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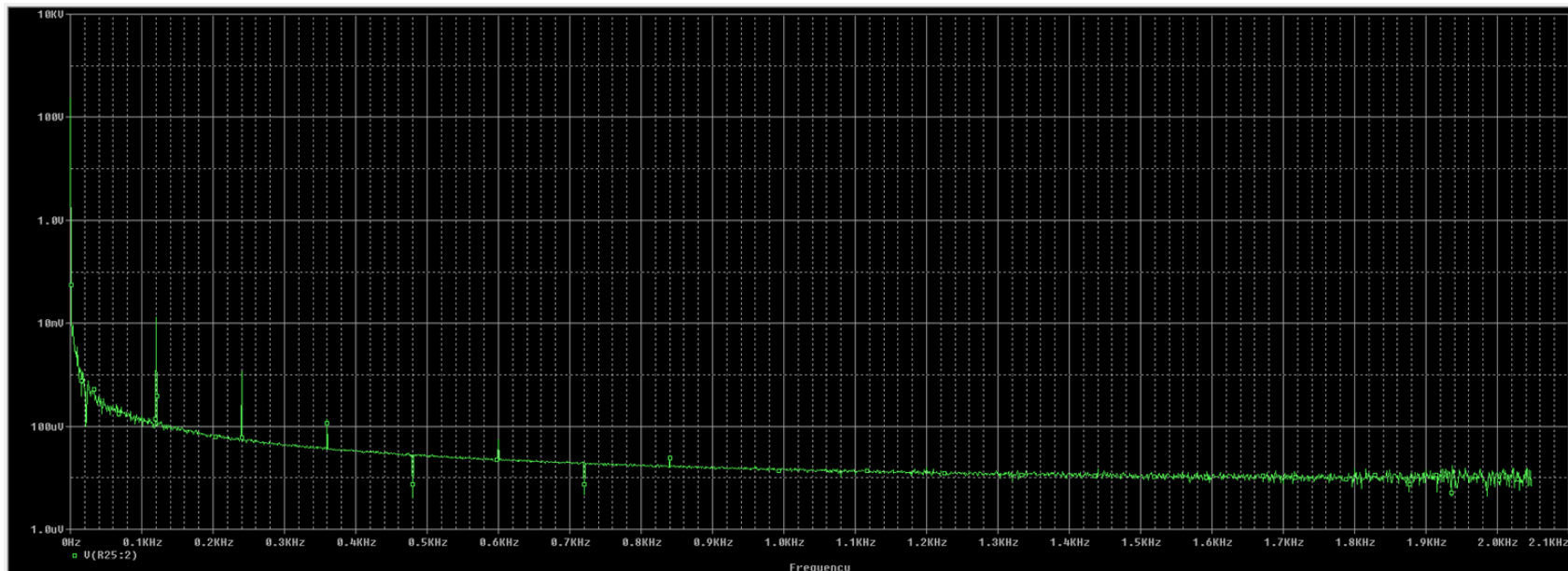
RC Filter



- Eliminates low and high frequency component through rectifier
 - Large capacitor to minimize the ripple voltage
 - Provides high voltage DC power to the tubes
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Power Module Requirement and Verification

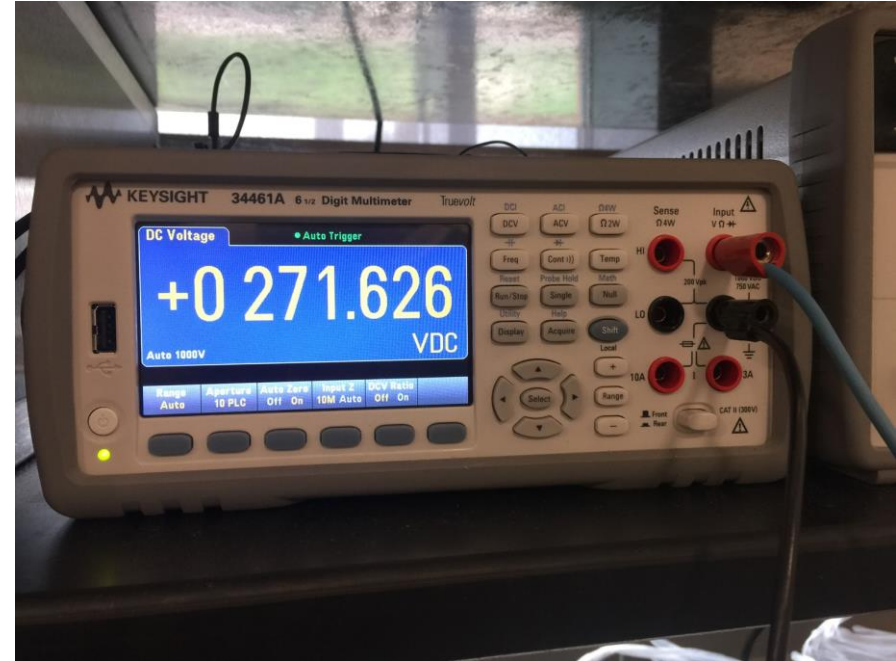
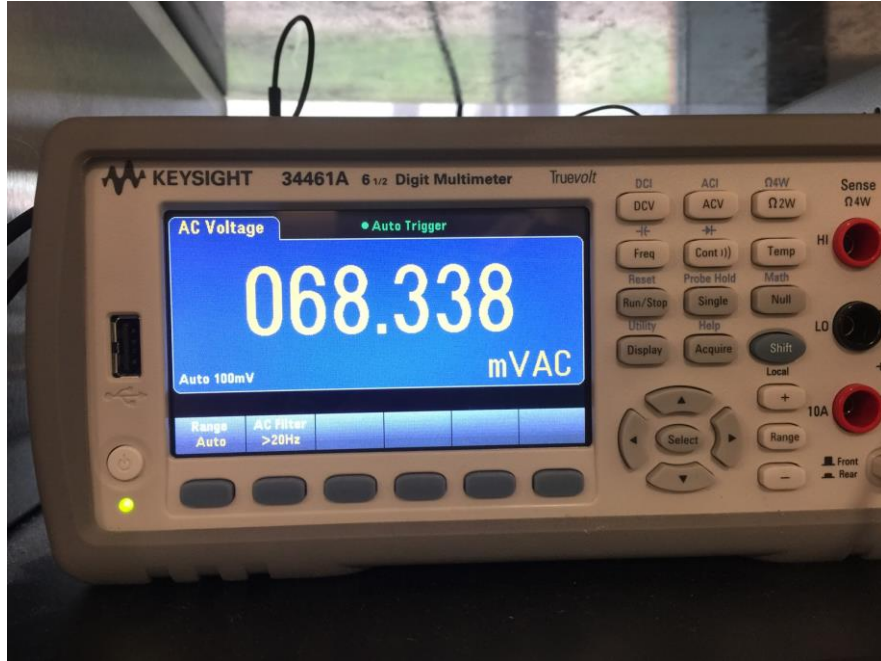
- Output voltage in steady state would be within 240 - 280 V
- Output Ripple in steady state should be less than 100 mV



Simulation result

Highest spike is at -80dB

Power Module Requirement and Verification

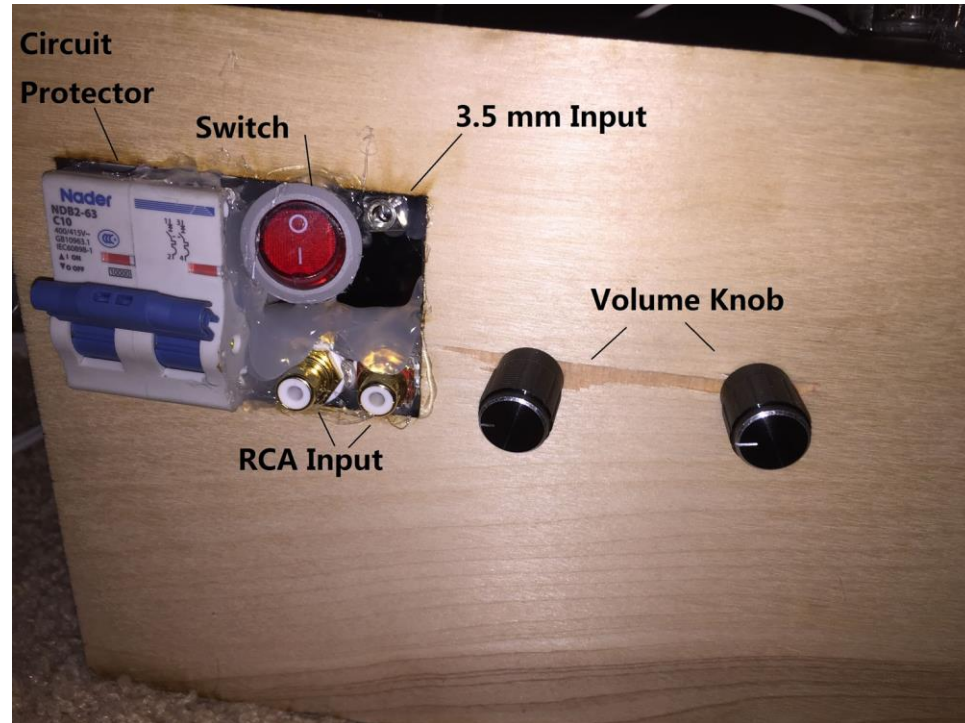


Vripple = 0.025%

3.5 mm & RCA Jacks

- 3.5 mm is compatible to AUX cable, which can be used to connect portable device such as iPhone, MP3, etc.
 - RCA is used to connect to desktop device such as desktop DACs and Blu Ray players
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3.5 mm & RCA Jacks

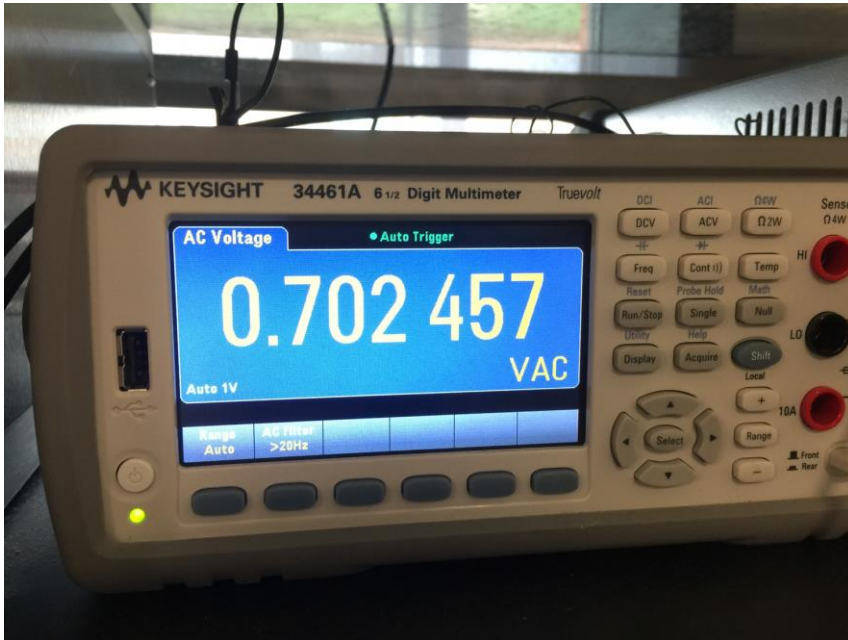


Volume Control

- Single channel adjusting knob to balance 2 channels
 - High quality potentiometers to approach 100% efficiency
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Input Module Requirement and Verification

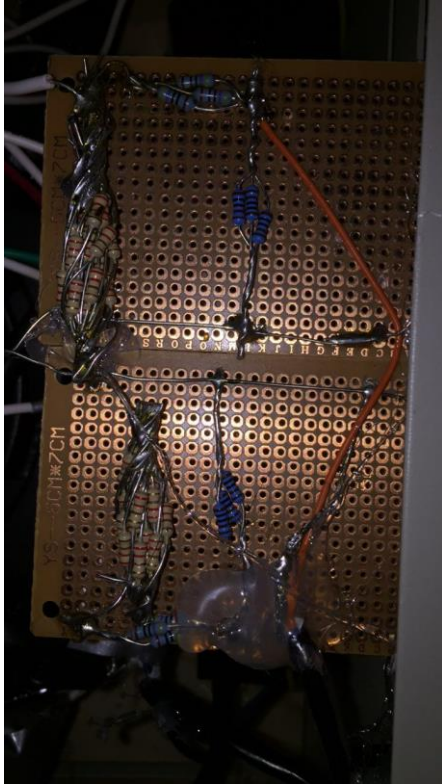
- Impedance of 3.5mm and rca jacks are less than 0.5 ohms
- When Volume control is turned to maximum, the output node voltage is greater than 99%
- When Volume control is turned to minimum, the output voltage is less than 0.001 V.



Test using 2V peak to peak sinusoidal waveform.
efficiency = 99.3% at both channel

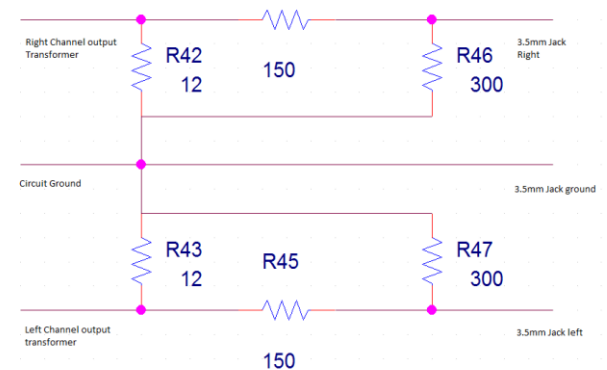
Output transformer

- Less winding on the secondary side to reduce voltage
 - High primary resistance to maximize power transfer
 - Provide 8 ohm and 4 ohm impedance matching to speakers and headphone circuit module
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Headphone module

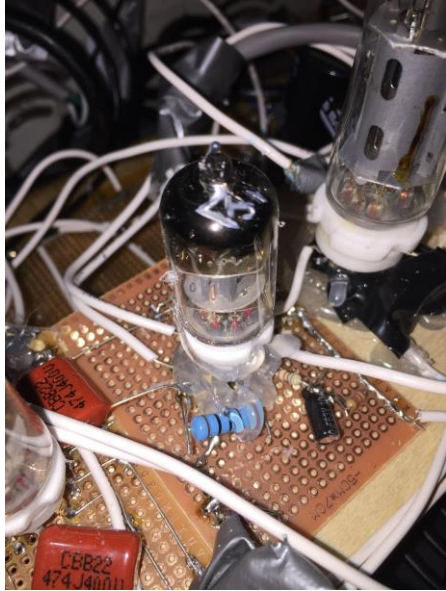
- Reduce power transferred due to less power rating for headphones
- Universal impedance matching to headphones with impedance range 16-600 ohms



Output stage Requirement and Verification

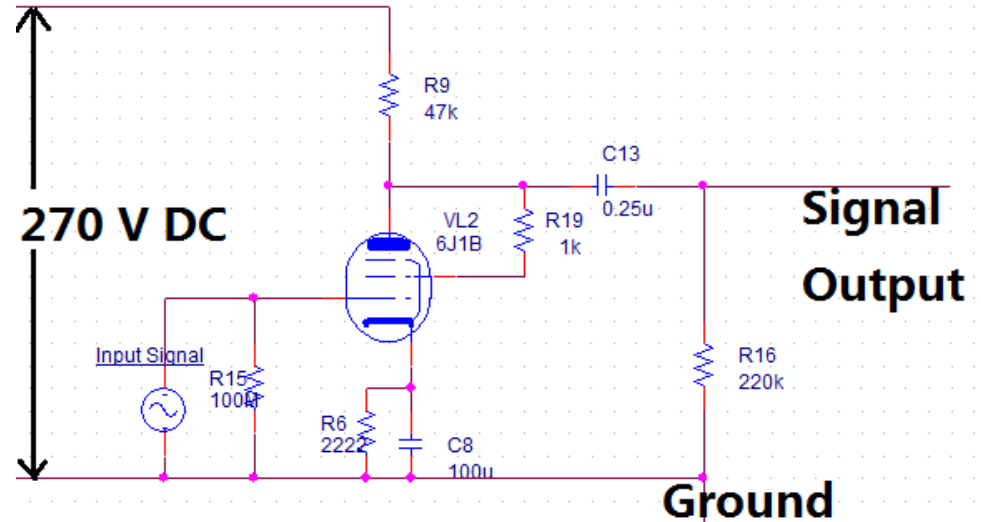
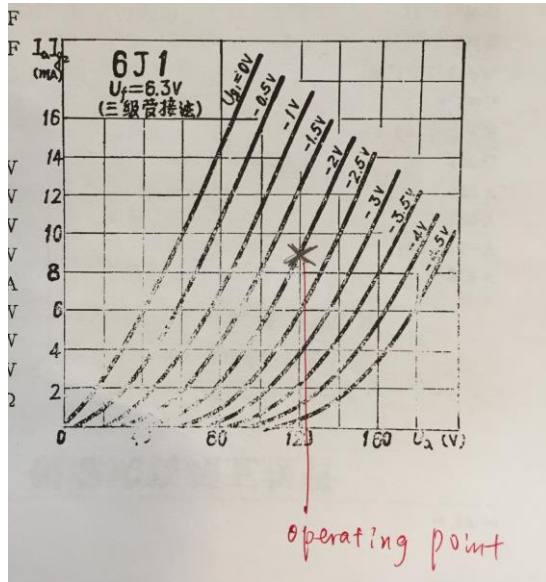
- Mismatched impedances of all components such as resistors, speakers and transformers are within 3%
- Power transmitted from the output transformer is 4.2 W maximum

First stage Amplification



- 6J1 pentode tube in triode connection to provide voltage amplification
 - Excellent tube with wide frequency response
 - Low cost, light weight, power-efficient
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First stage Amplification

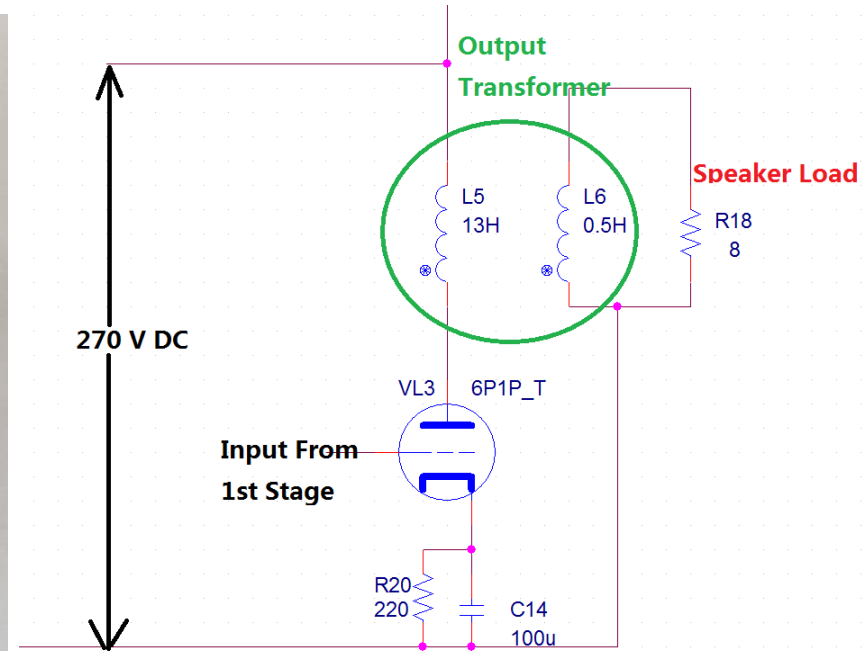
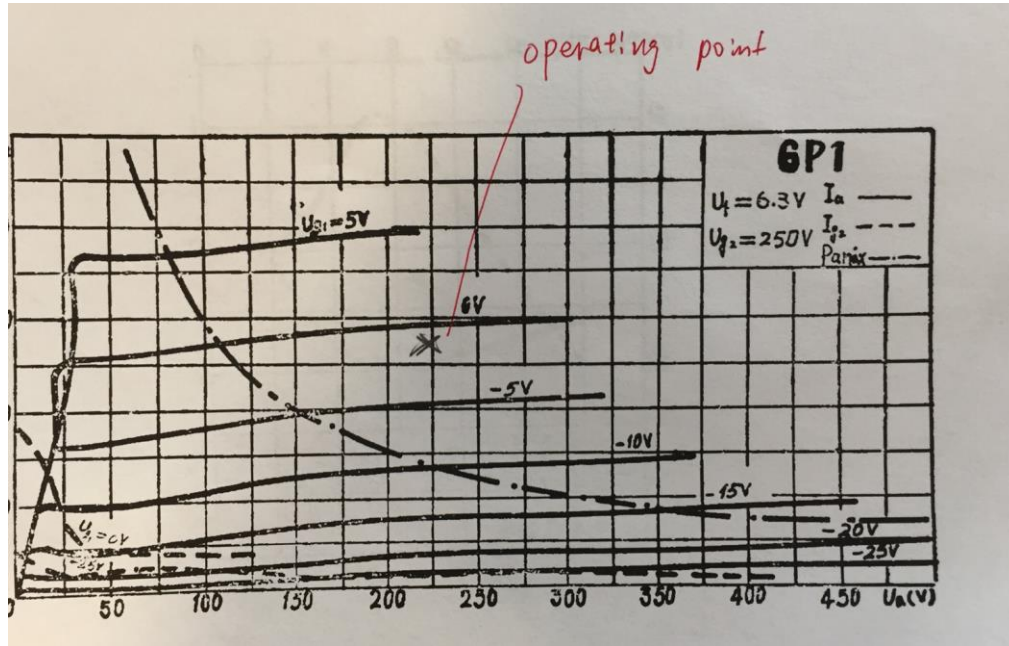


Second stage Amplification



- 6P1 beaming tetrode tube in triode connection to provide power amplification
 - Excellent power tube if used within audio frequency range
 - Can output 4.2 W maximum based on our operating point
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Second stage Amplification



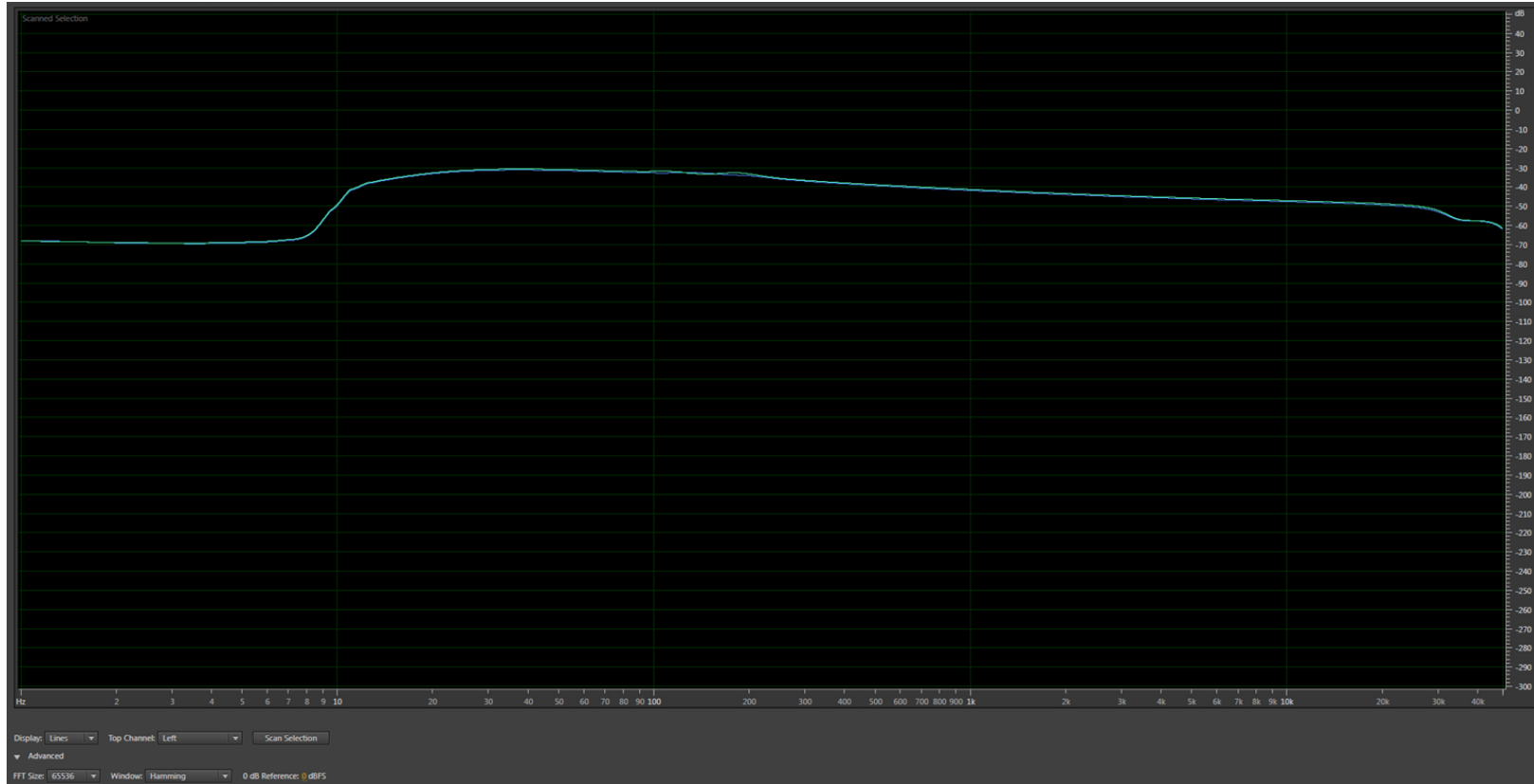
Amplification Modules Requirement and Verification

- In the first stage, the theoretical calculation gave us a gain of 17.8, the actual gain is 19
- Frequency response of the overall amplification is flat at 20-20kHz
- Total Harmonic Distortion in the left and right channel is within 1%

Amplification Modules Requirement and Verification

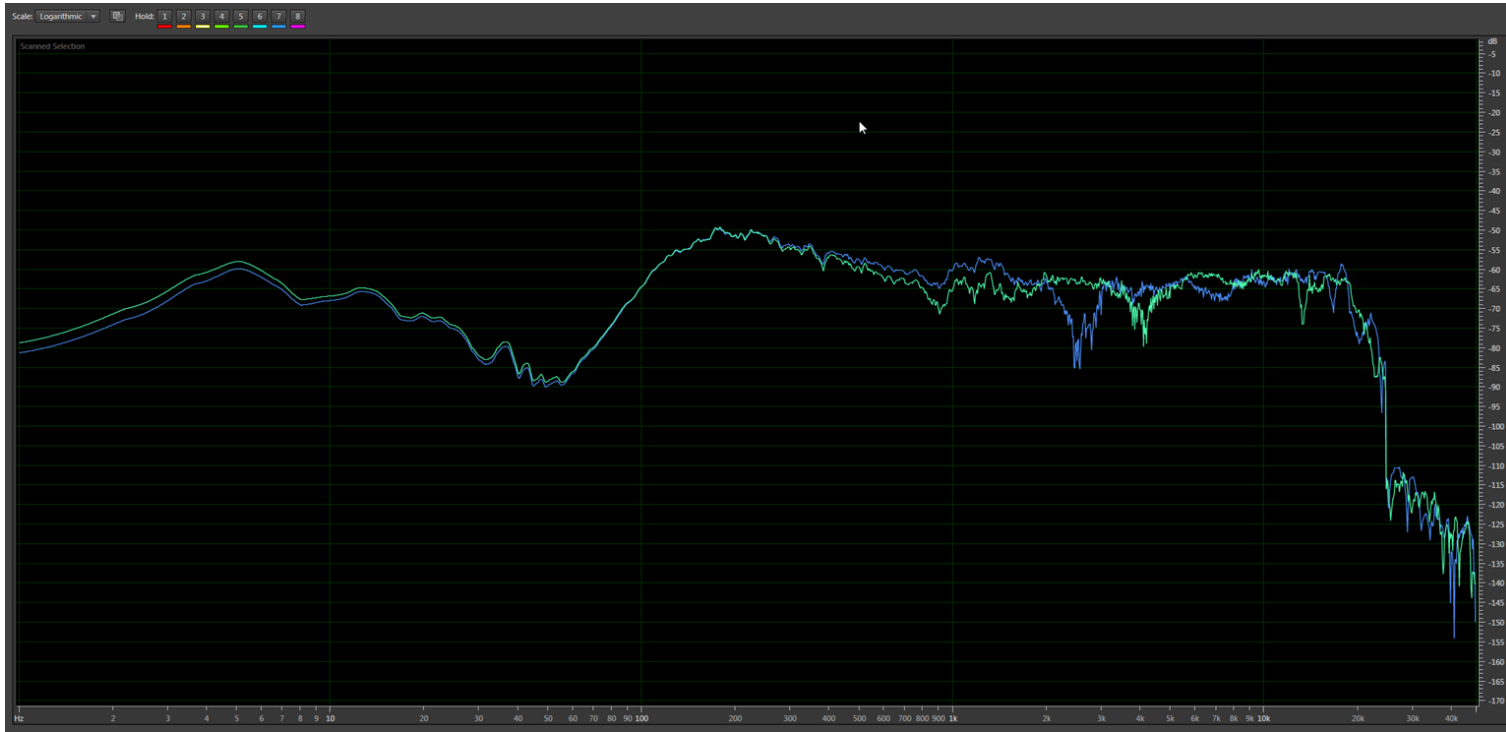
Overall measurements - Frequency response

Frequency
Response
of amplifier
itself



Amplification Modules Requirement and Verification

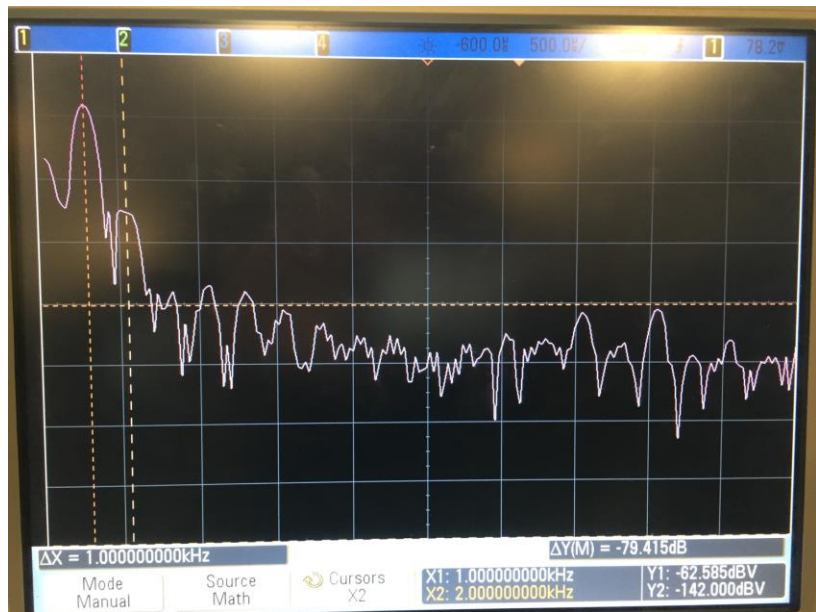
Overall measurements - Frequency response



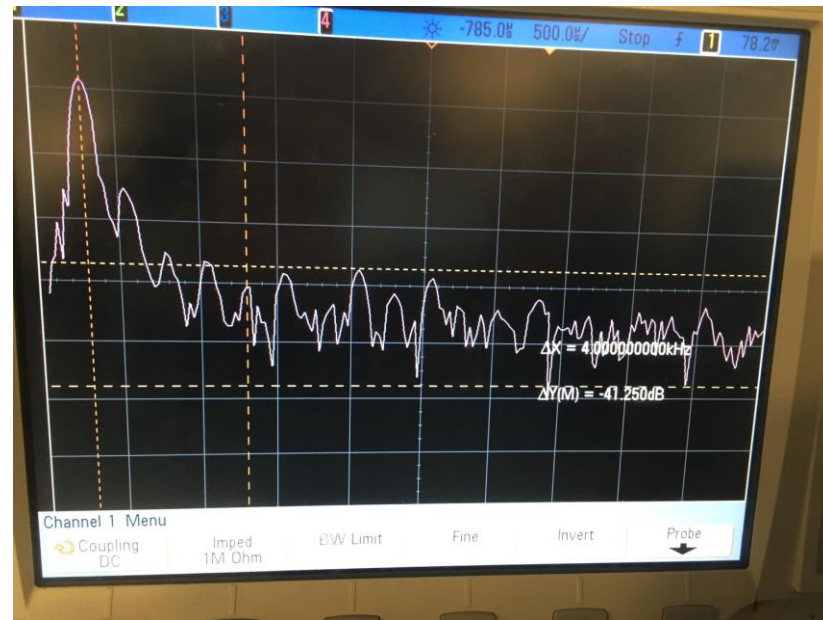
Frequency
Response
with
Speakers

Amplification Modules Requirement and Verification

Overall measurements - Frequency response



Right Channel THD \approx 0.08 % at 1kHz and 1W



Left Channel THD \approx 0.073 % at 1kHz and 1W

Future Work

- Add additional Voltage Amplification stages to further increase power
 - Use tube rectifiers instead of diodes
 - Use multiple winding transformers to reduce overall size and cost
 - Use high quality connecting wires and components to improve signal to noise ratio and frequency response
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Conclusion

- We have successfully built our vacuum tube amplifier
 - We have successfully controlled the budget lower than \$ 100
 - All the measurements meet all of our requirements
 - The sound quality is better than our expectation
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You are still awake...

Questions?