ENGE 420 Audio Amplifier

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Introduction

This experiment consisted of an application the electronic principles that were learned in ENGE 420 by building a four-stage audio amplifier. Each stage provided an important function in filtering and amplifying an audio signal to meet specific design criteria. From the initial design and testing of a four-stage audio amplifer, a PCB was designed and manufactured along with a speaker enclosure to make one complete speaker assembly with built-in amplifier.

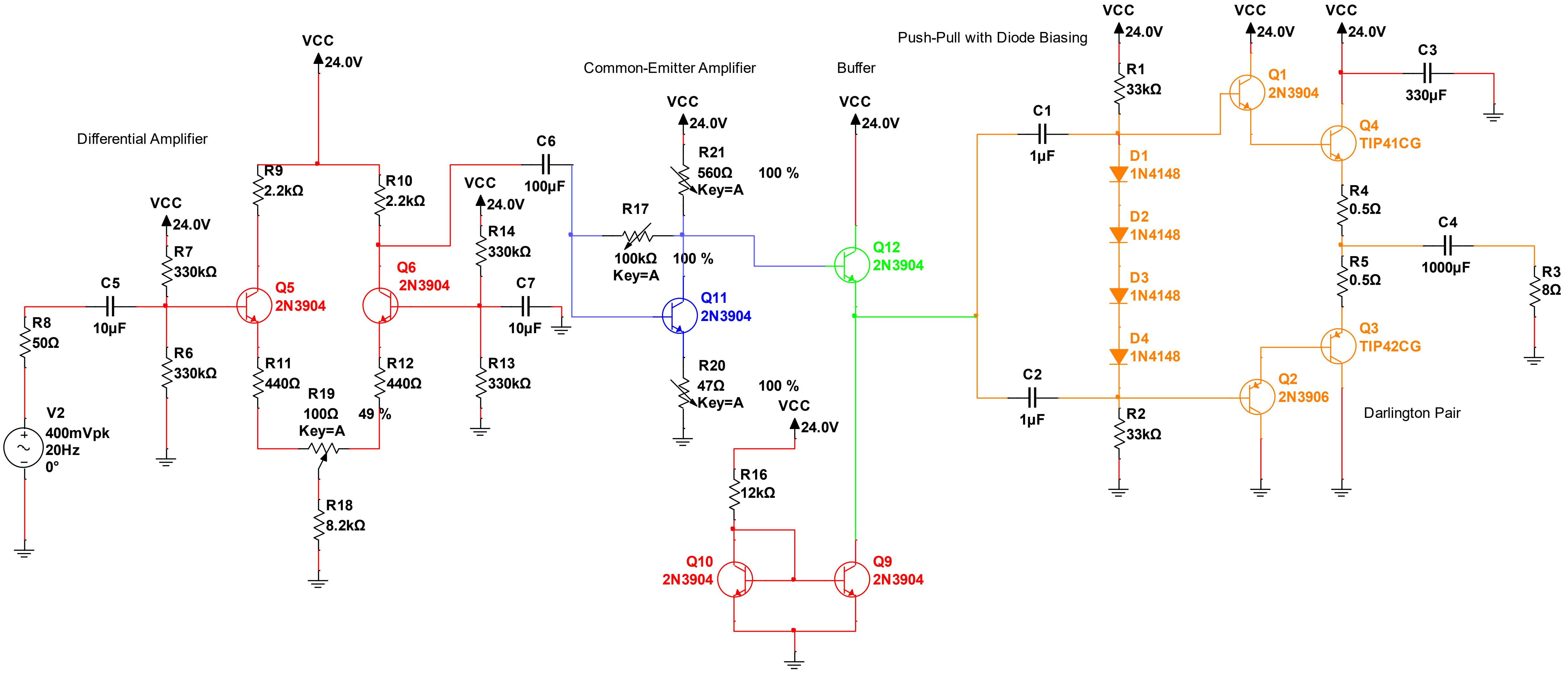
Design Constraints

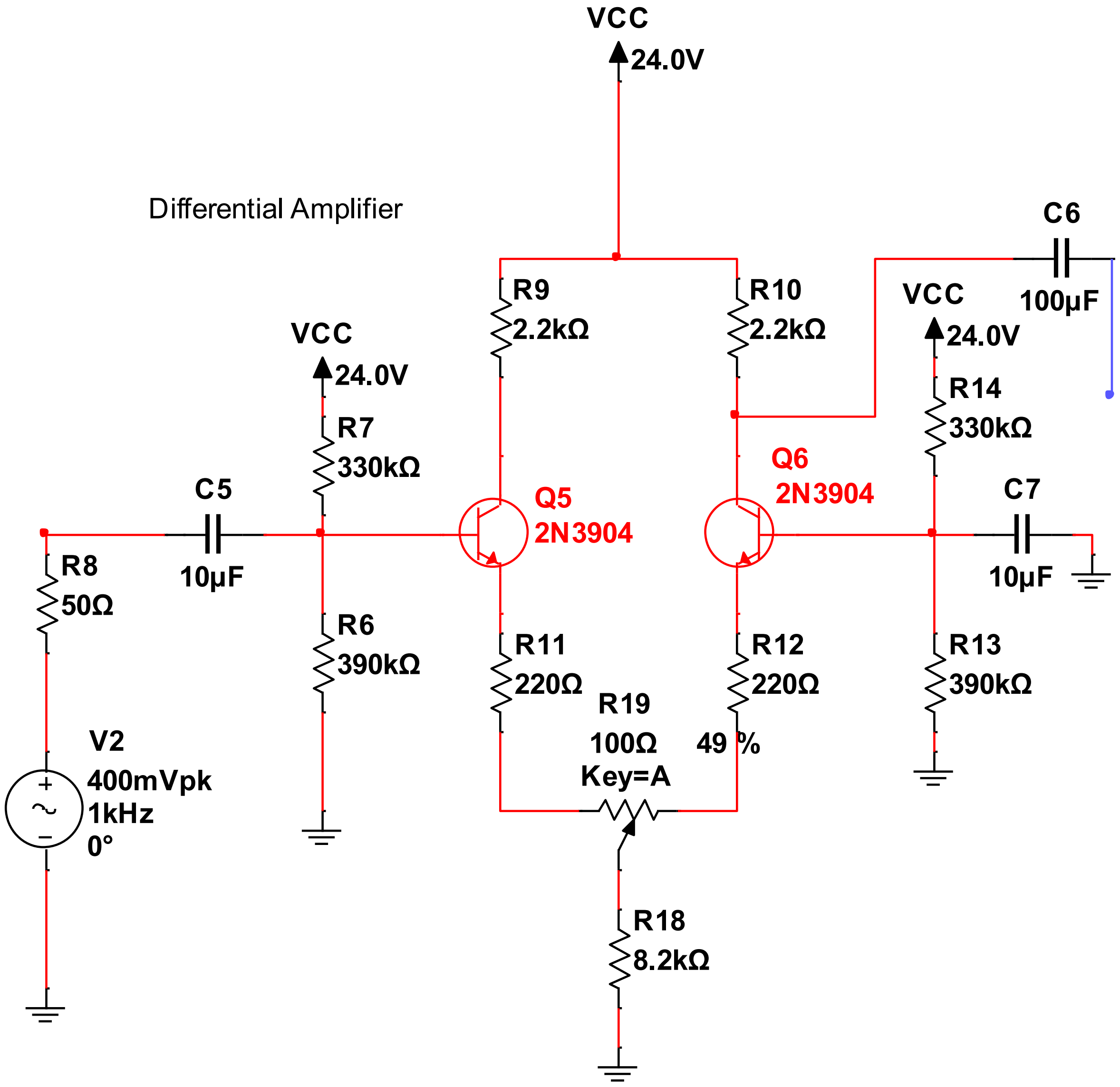
- Deliver 7.5 W to an 8Ω Load
- Frequency Response: 20 Hz – 20 kHz
- Input sensitivity: 400 mV
- Input impedance: 50 kΩ
- Utilize at least one current source
- Employ negative feedback for gain control and stability
- Must account for bias and temperature stability
- Input stage: Differential, single-ended in/out
- Output stage: Class AB, BJT push-pull configuration
- Minimize Harmonic distortion
- Minimize Capacitor Values
- Use 24 VDC, 1000 mA regulated power supply

Tradeoffs / Special Features

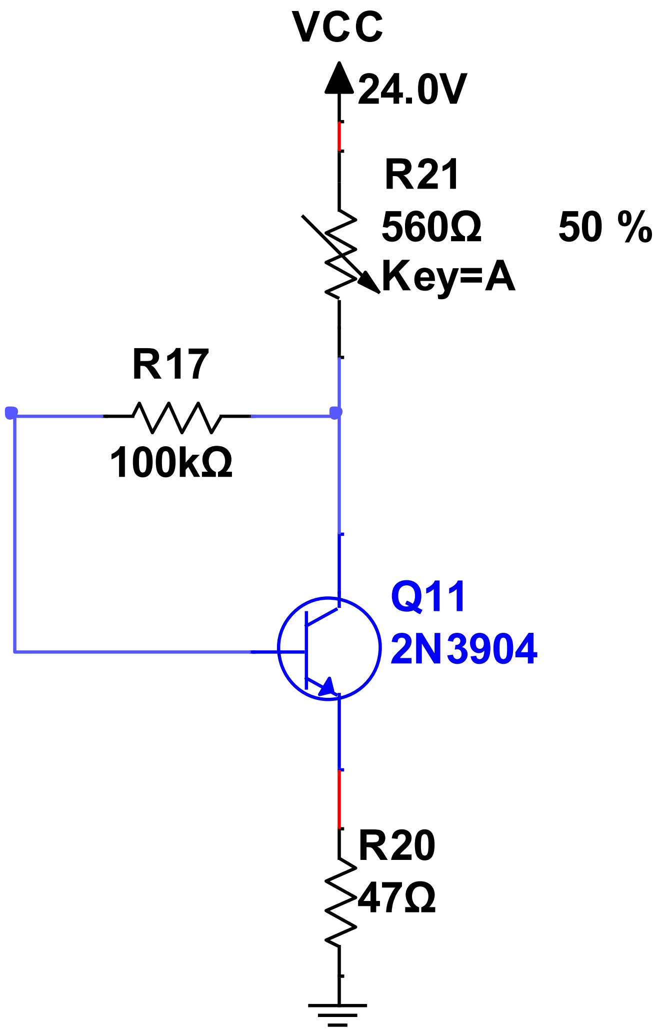
Tradeoff one : Re at push pull to reduce thermal instability
Tradeoff two: Re at CE stage to increase gain stability, reduces overall gain of system
Tradeoff three: Used resistor values > 100 k to increase input impedance for the differential stage base
Special feature: Darlington pair to increase beta of push-pull stage
Special feature: Speaker encloser is port the ¼ wavelength of a 50 Hz frequency to boost low frequency response
Special feature: Minimized capacitor by removing any capacitance between the CE and Buffer stage
Special feature: Buffer has current source at emitter
Special feature: Felt lining in audio amplifier box to minimize rattle

Final Circuit

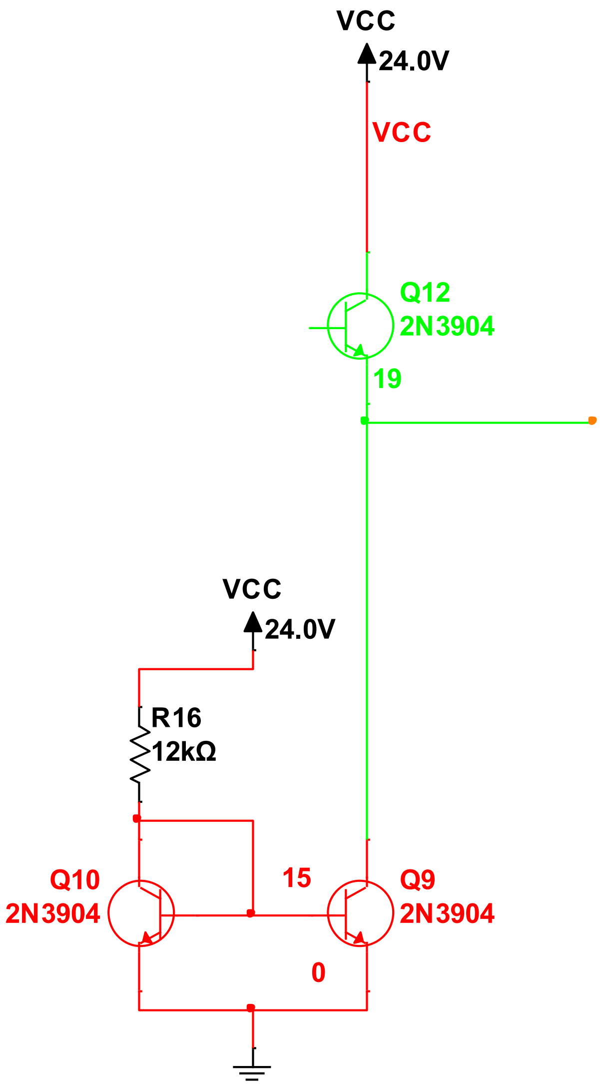


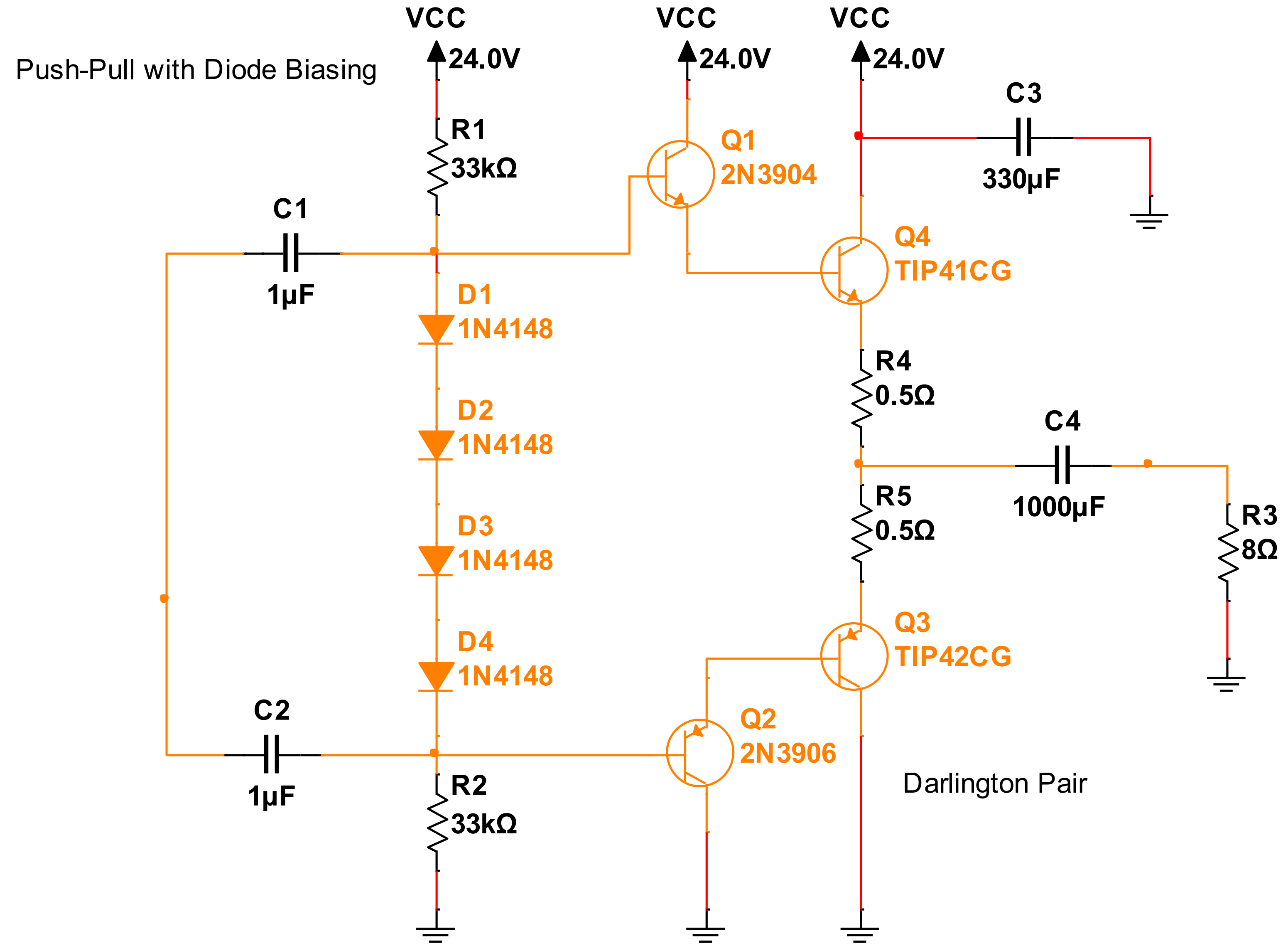

Differential Amplifier
VCC
24.0V
R9
2.2kΩ
R10
2.2kΩ
C6
100µF
VCC
24.0V
R7
330kΩ
R14
330kΩ
C5
10µF
Q5
2N3904
Q6
2N3904
C7
10µF
R8
50Ω
R6
390kΩ
R11
220Ω
R12
220Ω
R13
390kΩ
R19
100Ω
49 %
Key=A
V2
400mVpk
1kHz
0°
R18
8.2kΩ

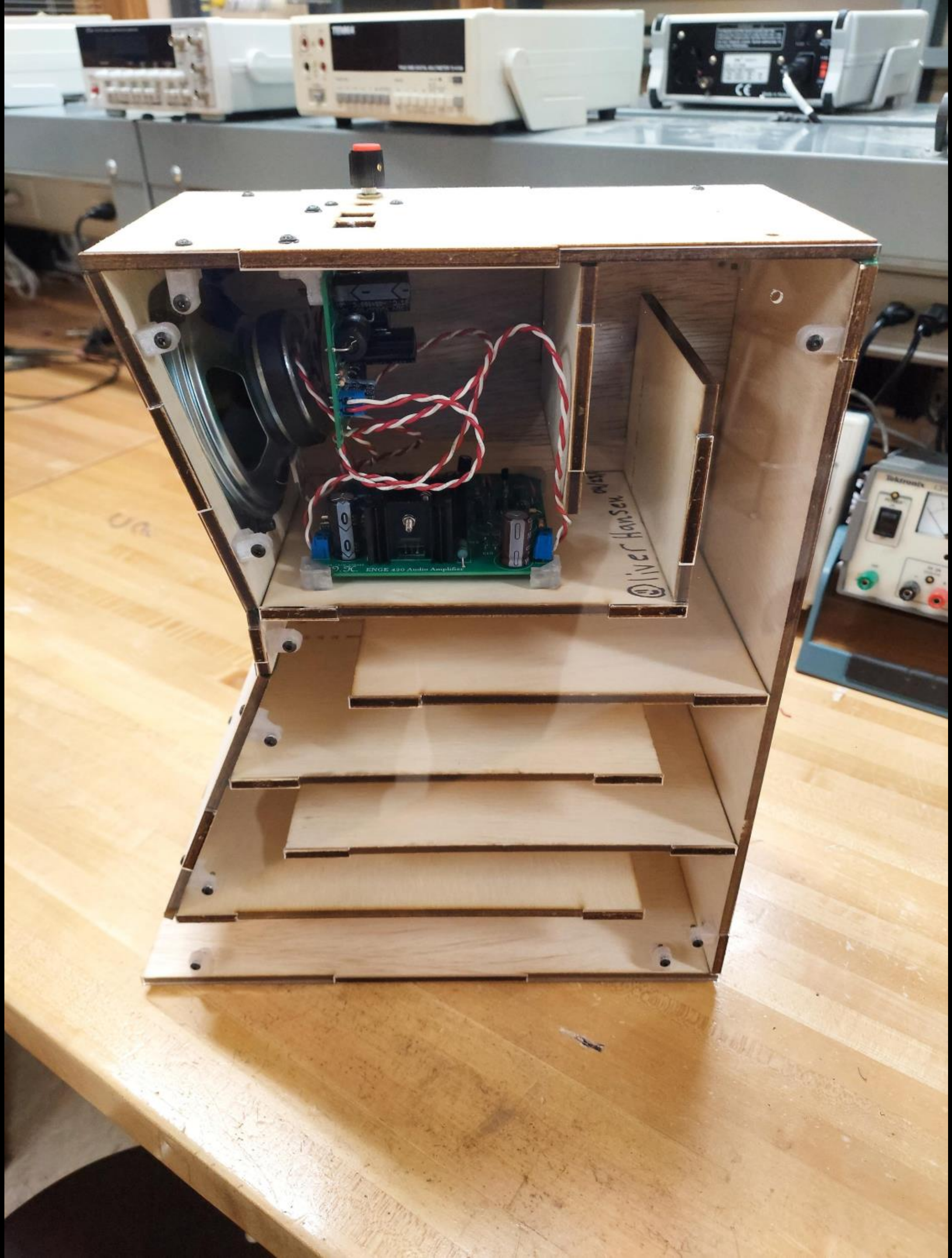
Common-Emitter Amplifier



Buffer


VCC
24.0V
VCC
Q12
2N3904
19
VCC
24.0V
R16
12kΩ
Q10
2N3904
15
Q9
2N3904
0


Push-Pull with Diode Biasing
VCC
24.0V
VCC
24.0V
VCC
24.0V
R1
33kΩ
C1
1µF
Q1
2N3904
C3
330µF
Q4
TIP41CG
D1
1N4148
D2
1N4148
D3
1N4148
D4
1N4148
R4
0.5Ω
C4
1000µF
R5
0.5Ω
R3
8Ω
Q3
TIP42CG
C2
1µF
Q2
2N3906
R2
33kΩ
Darlington Pair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04/23/25

Specifications: Experimental Data

Diff 1	Voltage (V)
C	21
B	18.62
E	17.83
BE	0.687
CE	3.06

Diff 2	Voltage (V)
C	21.21
B	18.4
E	17.81
BE	2.71
CE	3.36

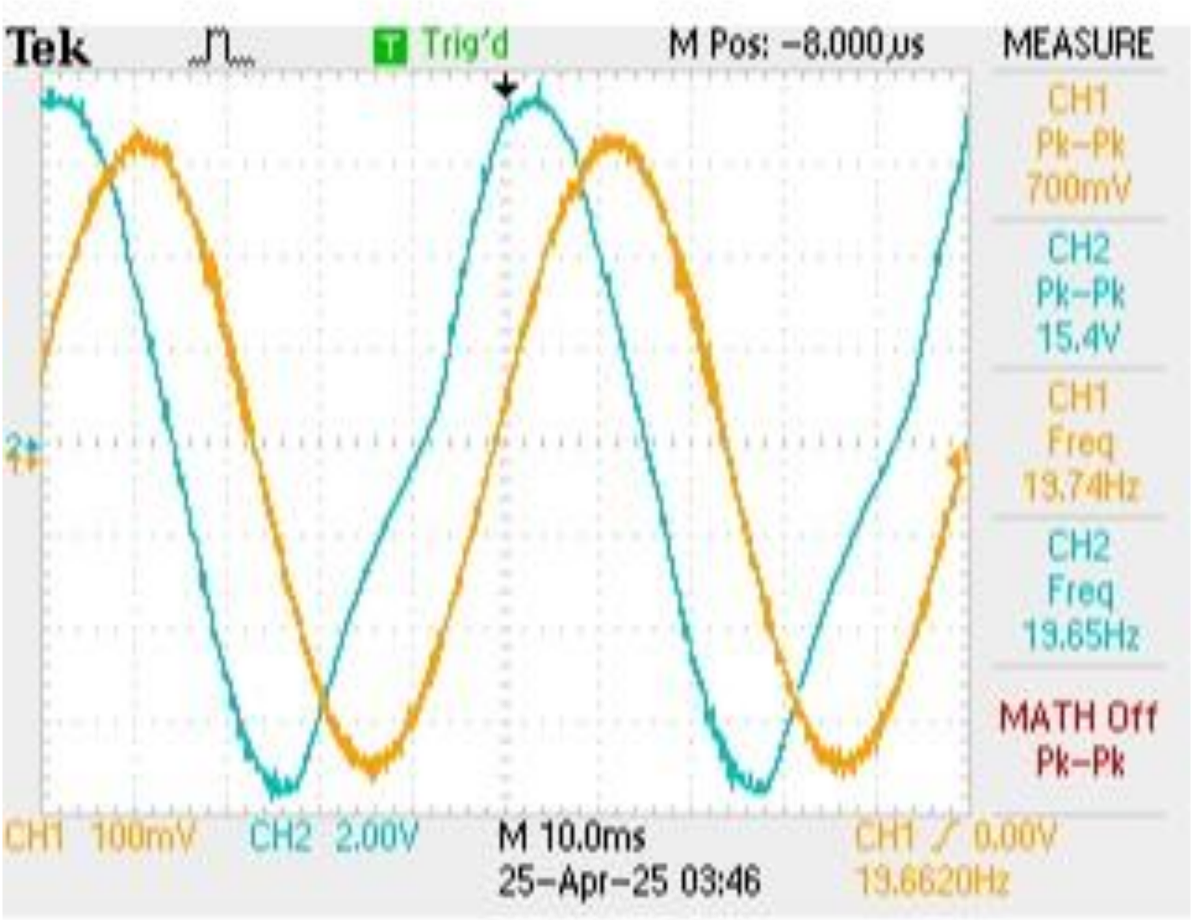
Common Emitter	Voltage (V)
C	11.78
B	1.71
E	1.06
BE	0.664
CE	10.7

Buff	Voltage (V)
C	23.91
B	11.76
E	11.08
BE	0.684
CE	12.8

Push Pull 1	Voltage (V)
C	24.36
B	13.2
E	12.13
BE	1.06
CE	13.73

Push Pull 2	Voltage (V)
C	0
B	11.01
E	12.12
BE	1.09
CE	11.57

Experimental: Low Frequency Response



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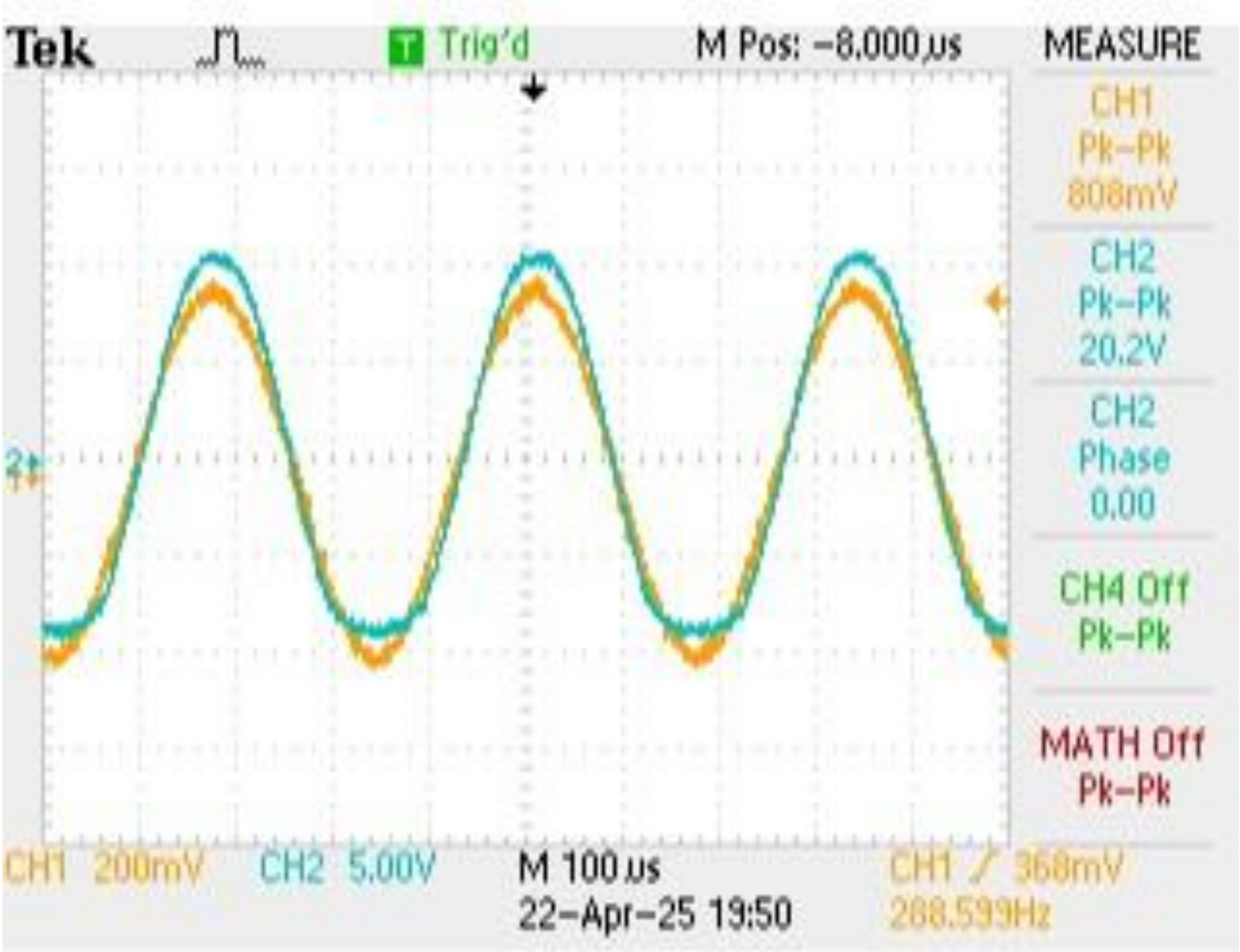
Maximum Undistorted Output

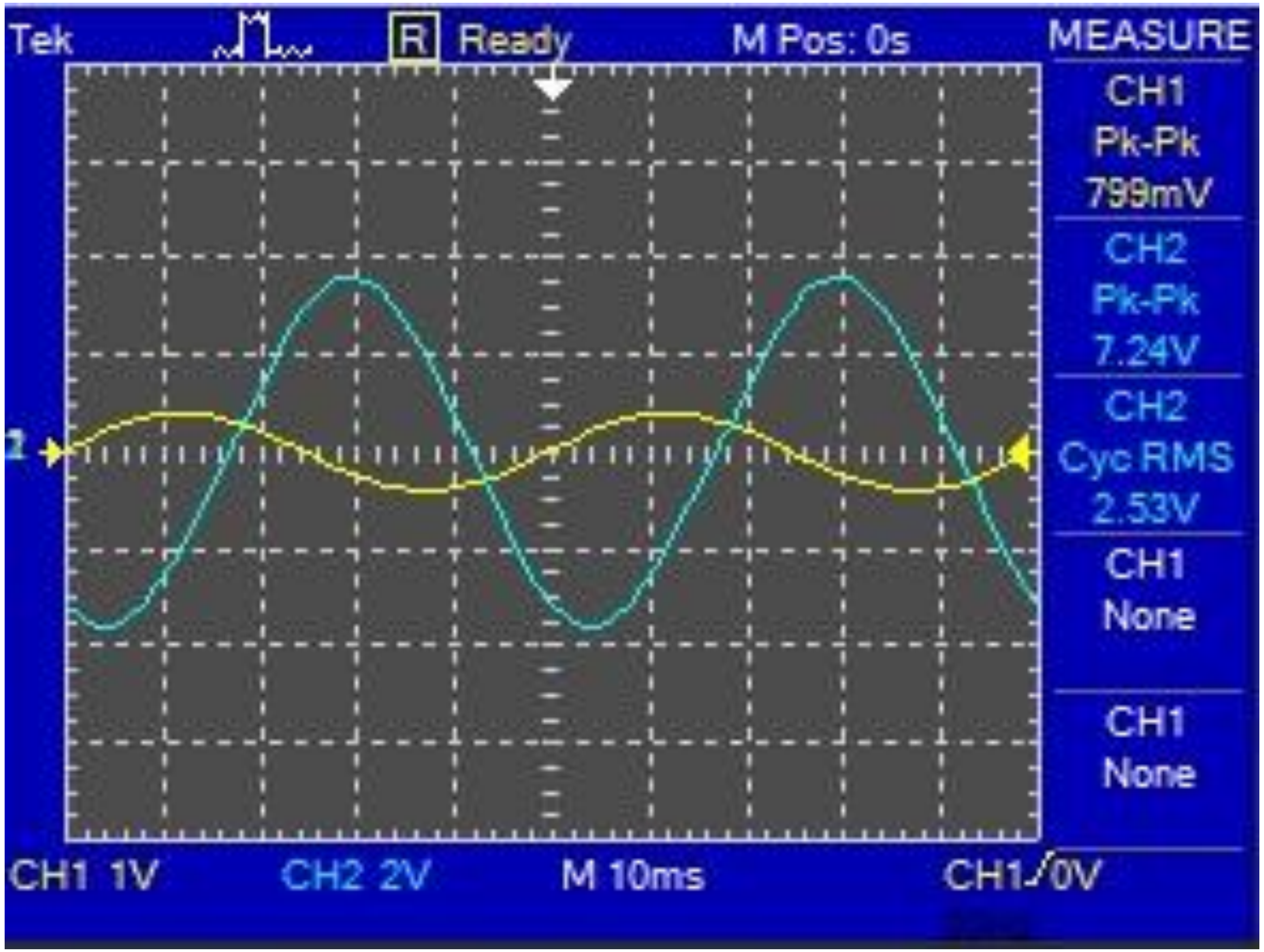


Max Undistorted Output at 3 kHz

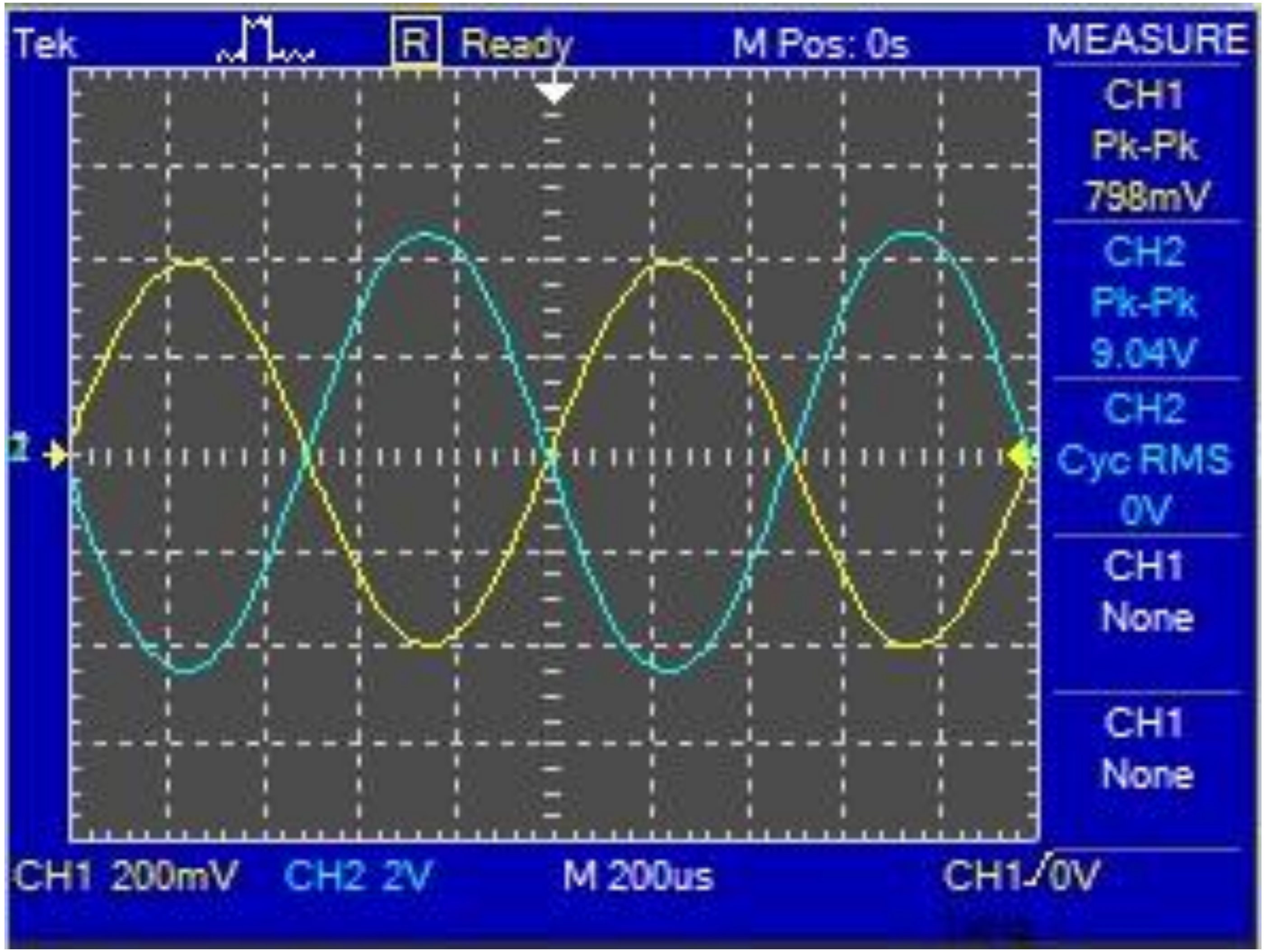
Experimental: Power Delivery

$$P_L = \frac{V_{out,rms}^2}{R_L} = \left(\frac{7.142^2}{8}\right) = 6.38 \text{ W}$$

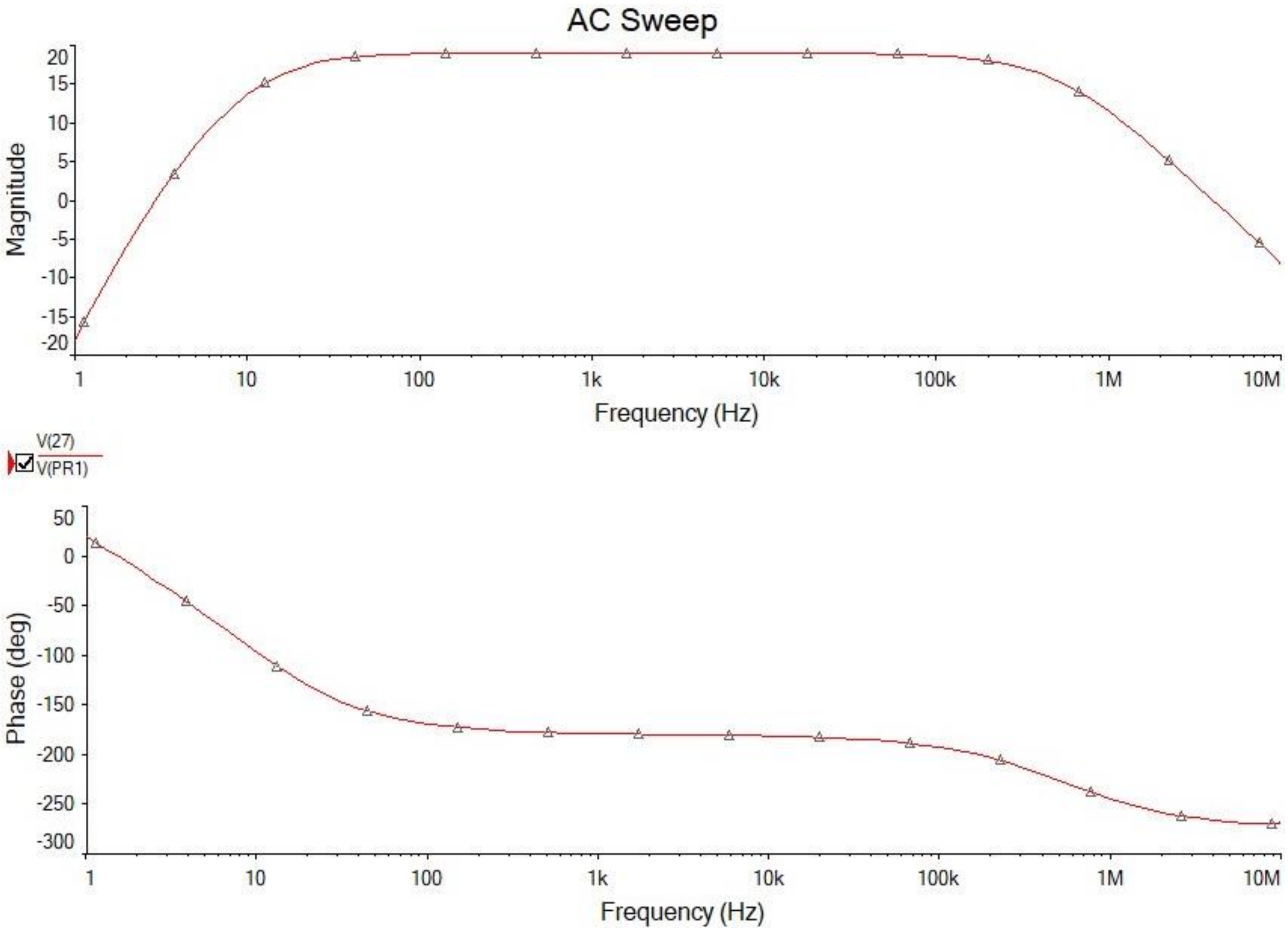
Simulated Data: Low Frequency Response



Simulated: Midband Gain



Multisim Bode Plot



Conclusions

Overall, the design and implementation of the amplifier was a success. Most of the design requirements were met or exceeded, and the overarching goal of creating a functional audio amplifier and speaker system that can produce a loud sound with a clear tone within the human range of hearing was met. Some specific criteria were not quite met, with the low frequency response and output power not quite meeting what was required. This could have been due to component tolerances not being accurate enough, errors in the design of the amplifier, transistor β values not matching, or errors in the design of the PCB. In the future, spending more time fine tuning each transistor's bias point voltages and confirming each β value would likely yield a better power output and frequency response. Increasing trace width, and annular ring sizes would also likely help.