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Ecen 325 Project

Objective:

The purpose of this project was to design a multistage amplifier that could drive a speaker with a load impedance of 16 Ω with a 10 mVpk input. The amplifier needed to satisfy the following specifications:

Gain	= 50V/V
Overall Distortion	< -34 dB
Input impedance	> 200 kΩ
Input Signal	<= 10mVpk

Design:

In order to achieve the specifications, we chose to design a 3 stage amplifier. The first stage was used to satisfy the input impedance requirement and create a gain of approximately -5 V/V. The second gain was mostly used to create a greater gain, approximately -10 V/V, because the input impedance was already satisfied by the first stage. Since the first two stages needed to create a high gain, the common emitter configuration was used for both. Lastly, the third stage was designed as a common collector to create a unit gain and amplify the current so the speaker could be used because the load resistance in the common emitters before would have been too low.

In order to get the resistor values, we started from the end and designed a common collector. For this stage, we wanted it to have a total input impedance of about 1 kΩ in order to achieve good linearity and a unit gain because the gains would be satisfied from the first two stages. For this stage, the input impedance was calculated to be about 1909 Ω and the gain was .959.

For the second stage, we used the input impedance from the third stage for our load resistor value. We then used the graphical approach to calculate the resistor values for the rest of the circuit and made the following assumptions.

Vcc	10V
beta	255
Vbepk	5 mV
Zin	15 kΩ

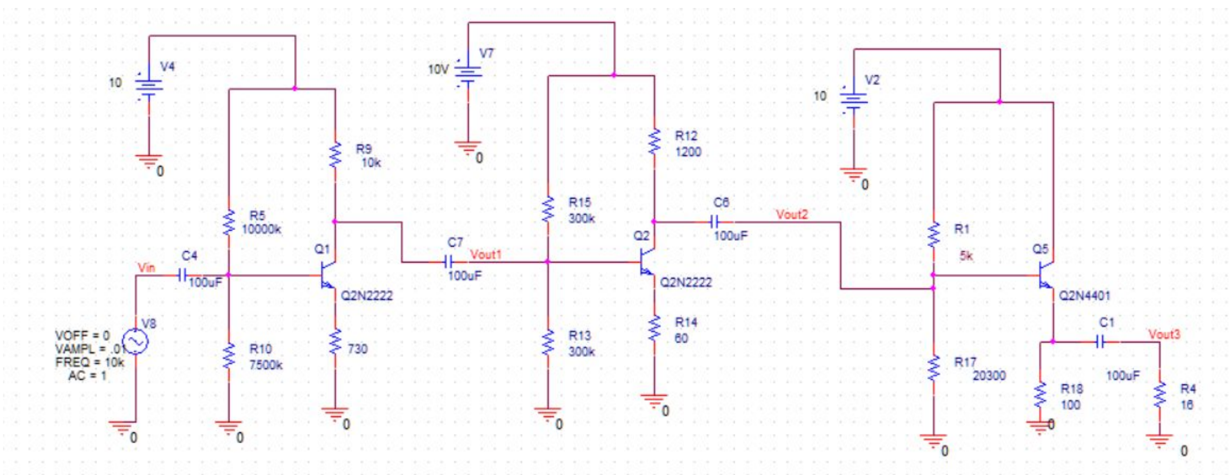
Vipk	.5 V
Av	-10 V/V

We then got values for all of the resistors and then adjusted them accordingly in order to get the appropriate gain. The actual impedance ended up being about 15083 Ω and a gain of -9.908 V/V.

Lastly, we designed the first stage with the same approach as before and assumed the following. This stage had a gain of about -5.33 V/V and an impedance of 235.3 kΩ.

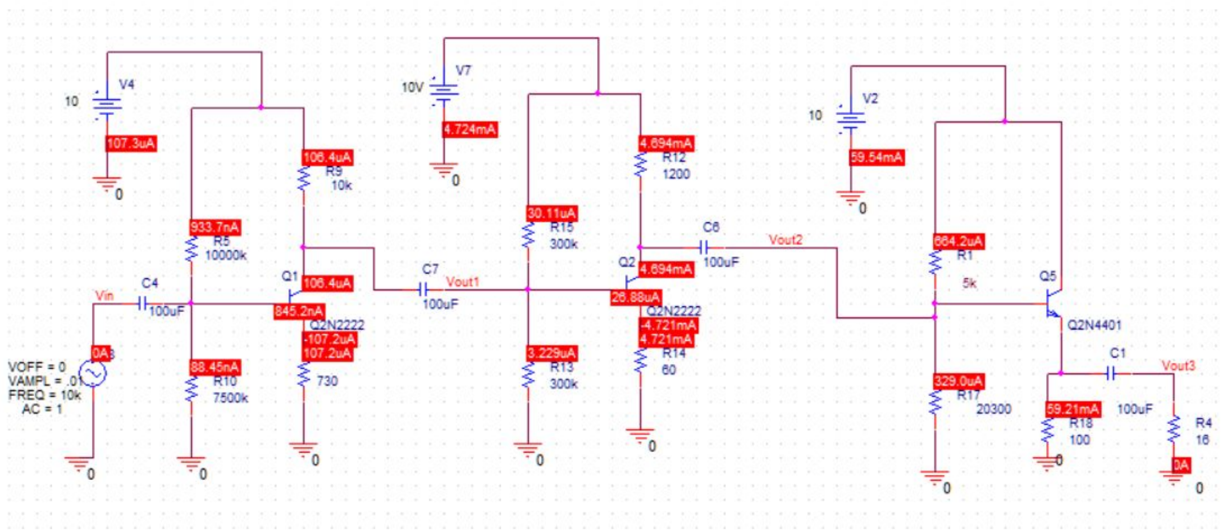
Vcc	10V
beta	255
Vbepk	5 mV
Zin	200 kΩ
Vipk	.1 V
Av	-5 V/V

For each of these designs we had to consider three major things in order to maintain good linearity. The first consideration was that the AC voltage in the collector should not exceed Vcc on the positive signal swing in order to avoid clipping. The second was that the AC voltage from the collector to emitter must always be greater than 500 mV in order to keep the transistor operating in the linear region. The last consideration was that the AC voltage from the base to emitter must be less than or equal to 5 mV in order to keep distortion low. We also found that the power dissipation in the transistor was 238, which is less than 250 mV and thus the 2222 transistor was sufficient for our design.

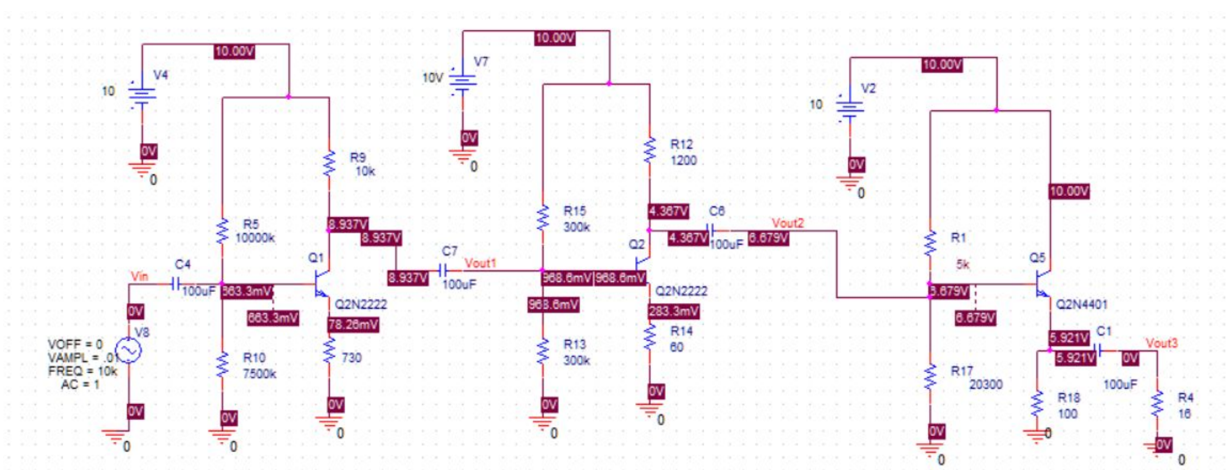


PSPICE Results:

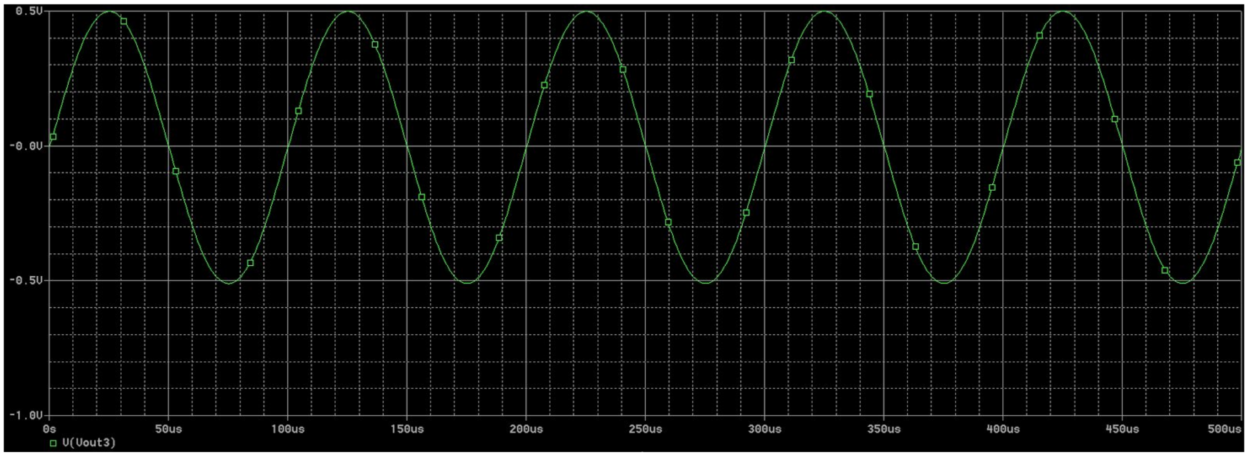
Current Bias Points



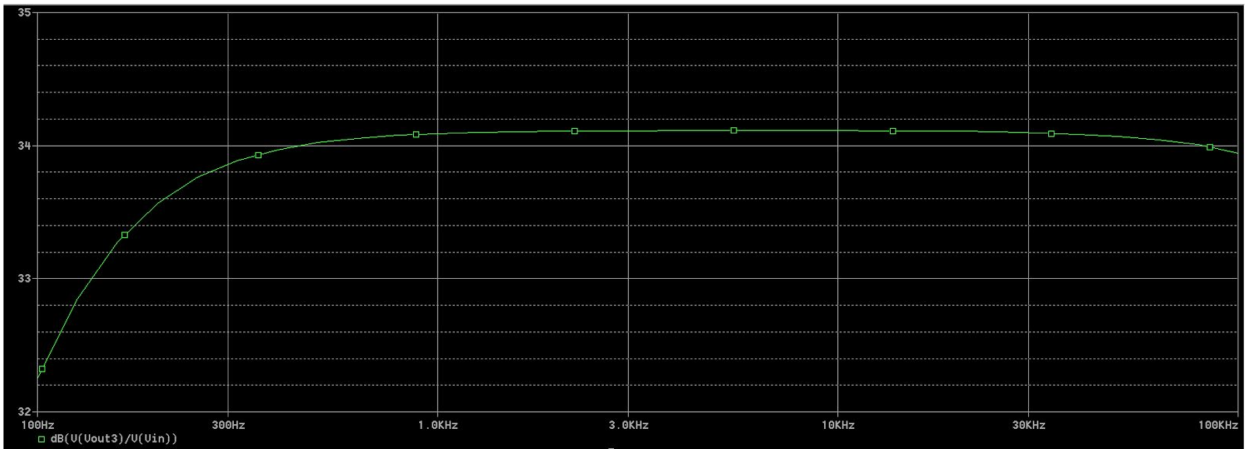
Voltage Bias Points



Transient Response



Magnitude Bode Plot



Harmonic Distortion

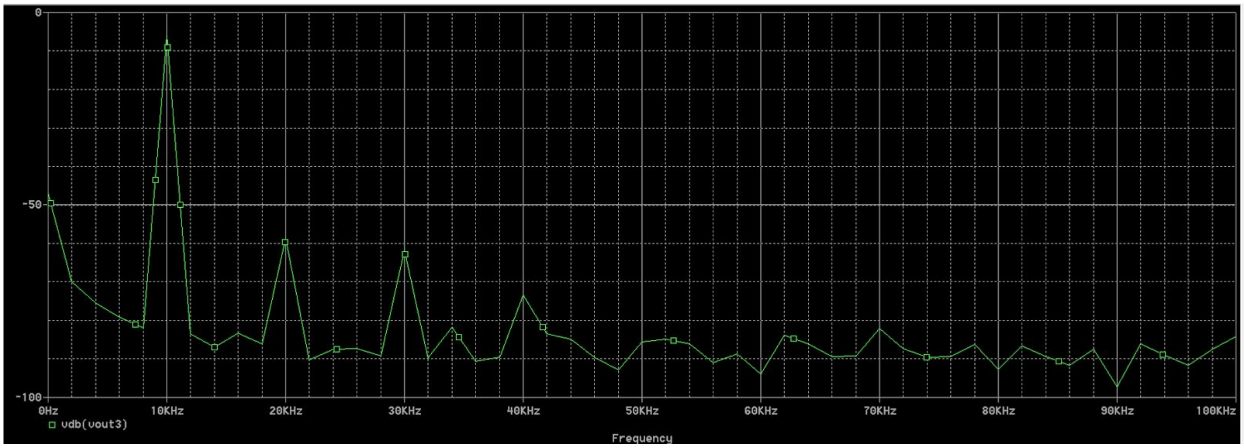
FOURIER COMPONENTS OF TRANSIENT RESPONSE V(VOUT3)

DC COMPONENT = -4.1157E-03

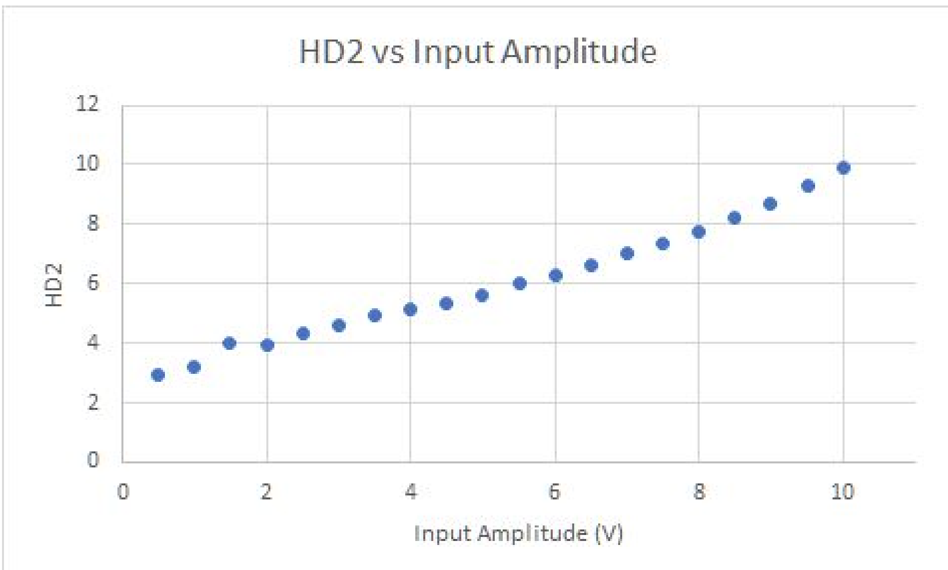
HARMONIC NO	FREQUENCY (HZ)	FOURIER COMPONENT	NORMALIZED COMPONENT	PHASE (DEG)	NORMALIZED PHASE (DEG)
1	1.0000E+04	5.0557E-01	1.0000E+00	-7.8120E-01	0.0000E+00
2	2.0000E+04	1.1979E-03	2.3693E-03	7.8348E+01	7.9911E+01
3	3.0000E+04	8.0597E-04	1.5942E-03	-3.6439E-01	1.9792E+00
4	4.0000E+04	1.9143E-04	3.7865E-04	6.1025E+01	6.4150E+01
5	5.0000E+04	1.7717E-05	3.5045E-05	1.1261E+02	1.1651E+02

TOTAL HARMONIC DISTORTION = 2.8809E-01 PERCENT

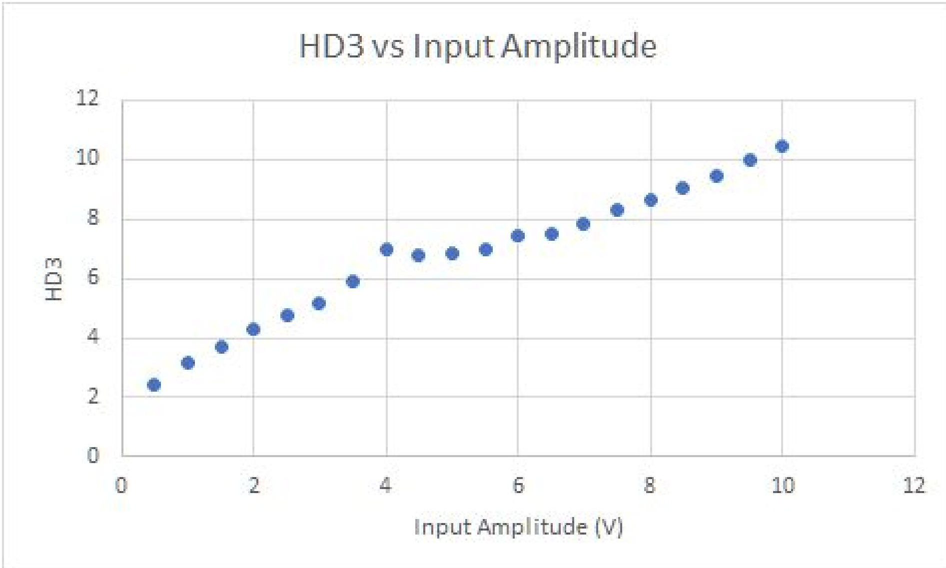
Fourier Analysis at 10mW input


0
-50
-100
0Hz
10KHz
20KHz
30KHz
40KHz
50KHz
60KHz
70KHz
80KHz
90KHz
100KHz
vdb(vout3)
Frequency

HD2


HD2 vs Input Amplitude
12
10
8
6
4
2
0
HD2
0
2
4
6
8
10
Input Amplitude (V)

HD3



Our calculated operating point values differed from the simulated values slightly.

Conclusion:

In summary, we had to design an amplifier that could produce a high gain, have good linearity, and drive a 16 ohm speaker. This taught us a lot about the design considerations and how to satisfy them using a graphical approach. We also learned how to build the circuits in lab and various debugging methods and how to take into account some of the real world factors needed to produce said amplifier.