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May 3, 2018

Audio Amplifier Project Report

Power Supply stage(stage 3)

I used a common collector with a 2N3055 transistor due to power capabilities.
$Power\ =\ V\ *\ I$ = (938mV)*(117 mA)= 0.1097 Watts. Thus the transistors doesn't exceed 250mW and it will keep it from overheating.

- $V_{RB2} = \frac{R_{B2}}{R_{B1}+R_{B2}} V_{CC} \ \rightarrow\ \frac{3.3k\Omega}{1k\Omega+3.3k\Omega} * 5 = 3.83V$
- $V_{RE} = V_{RB2} - 0.7 \ \ \rightarrow\ 3.83 - 0..7 = 3.13\,V$
- $I_e = \frac{V_{RE}}{R_E} \approx I_C \rightarrow \frac{1V}{8} = 0.125\,A$

1st and 2nd Stage Calculations and Equations

Values Defined: $V_{cc} = 5V$; $V_0 = 0.5V$; $V_{CE,sat} = 0.5\,V$; $V_{RE} = 1V$; $V_{RC} = 2.5\,V$; $R_i = 50k\Omega;\ and\ \beta = 200$

- $V_{cc} - V_o - V_{RE} - V_{CE,sat} > V_{RC} > V_o \qquad \Rightarrow \qquad 5V - 0.5V - 1V - 0.5V > 3.0\,V > 0.5V$
- $Stage2\!: \frac{V_{RC-}0.7-V_0}{R_H} \geq \frac{V_0}{R_L} \qquad \Rightarrow \qquad R_H = 1,000\ ohms,\ and\ I\ excluded\ RL\ in\ the\ design$
- $Stage\ 2\!: I_{C2} = \frac{V_{RC}-0.7}{R_H} \qquad \Rightarrow \qquad I_{c2} = 2.3mA$
- $Stage\ 2\!:\ \frac{I_{C2}}{\beta} \leq I_{C1} \leq \frac{\beta}{R_i}\frac{1}{\frac{N}{V_{RE}+0.7}+\frac{N}{V_{CC}-V_{RE}-0.7}+\frac{A_V}{V_{RC}}} \qquad \Rightarrow \qquad 10 * \frac{540uA}{200} \leq 200uA \ \leq \frac{200}{50K\Omega} * \frac{1}{\frac{10}{1.7V}+\frac{10}{3.3V}+\frac{5}{3V}}$
- $Stage\ 1\!: I_{C1} \leq \frac{\beta}{R_i}\frac{1}{\frac{N}{V_{RE}+0.7}+\frac{N}{V_{CC}-V_{RE}-0.7}+\frac{A_V}{V_{RC}}} \qquad \Rightarrow \qquad 300uA \ \leq \frac{200}{50K\Omega} * \frac{1}{\frac{10}{1.7V}+\frac{10}{3.3V}+\frac{5}{3V}}$
- $Stage\ 2\!:\ R_c = \frac{3V}{200uA} = 15k\Omega\,;\ R_E = \frac{1V}{200uA} = 5k\Omega\,;\ R_g = \frac{15k\Omega}{5} - \frac{0.025}{200uA} = 2.8k;\ R_{B1} = \frac{200*(3.3V)}{10(200uA)} = 165k\Omega;\ R_{B2} = \frac{200(1.7V)}{10*200uA} = 85$
- $Stage\ 1\!:\ R_c = \frac{3V}{300uA} = 10k\Omega\,;\ R_E = \frac{1V}{300uA} = 3.3k\Omega\,;\ R_g = \frac{150\Omega}{5} - \frac{0.025}{300uA} = 2k\Omega;\ R_{B1} = \frac{200*(3.3V)}{10(300uA)} = 220k\Omega;\ R_{B2} = \frac{200(1.7V)}{10*300uA} = 1$

$Av\ =\ Av_1 * Av_2 * Av_3 = 5 * 5 * 1\ = 25\ gain\ NOTE\!: resistor\ values\ adjusted\ in\ measurement\ to\ to\ attain\ a\ gain\ of\ 25$

Figure A: Audio Amplifier Schematic with Interactive Points

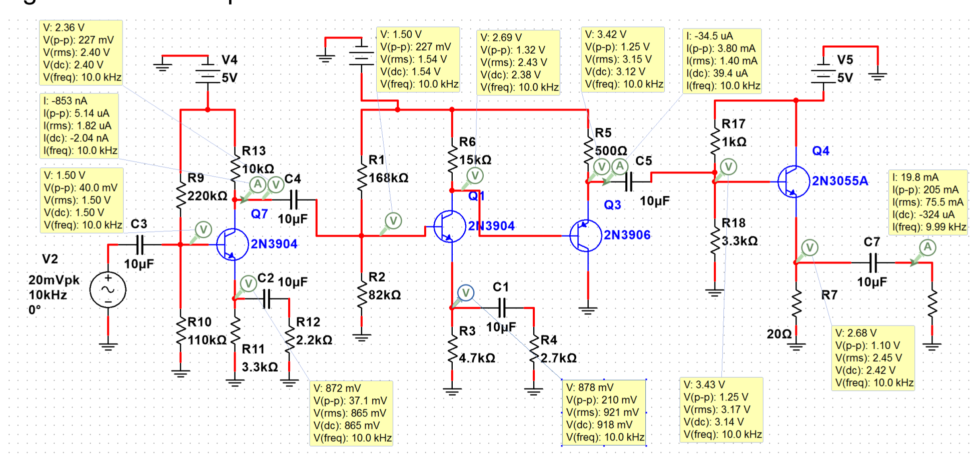

Figure 1: Stage 1 Transient Waveform with 20mV

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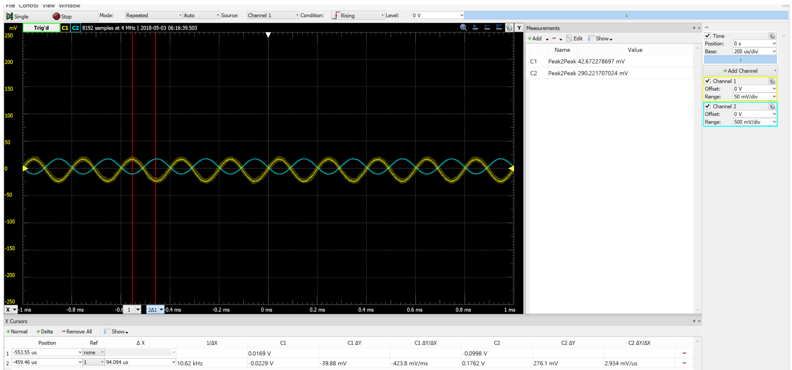

Figure 2: Stage 2 Transient Waveform with 20mV

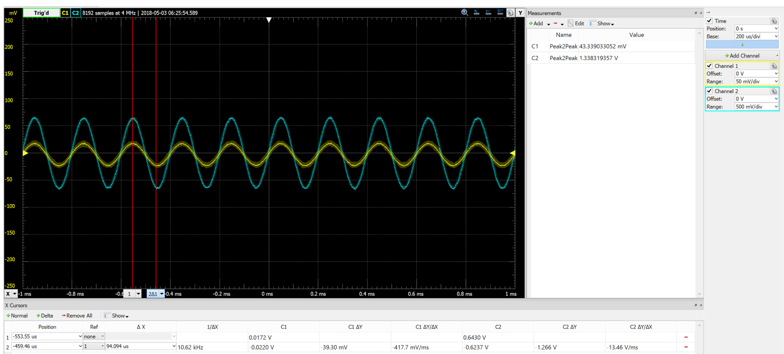

Figure 3: AC Frequency Response Stage 3

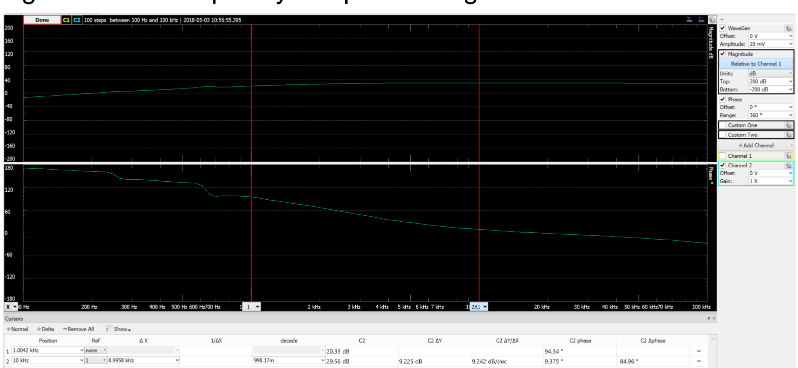

Figure 5: Transient Response Stage 3 with 10 mV

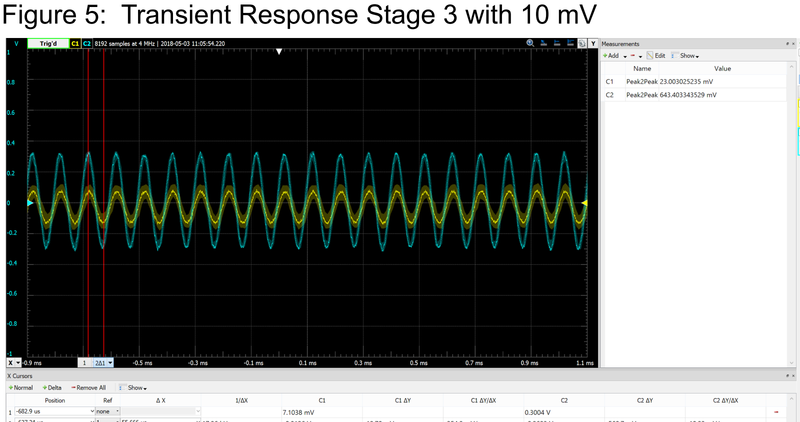

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Figure 5: Transient Response Stage 3 with 20mV

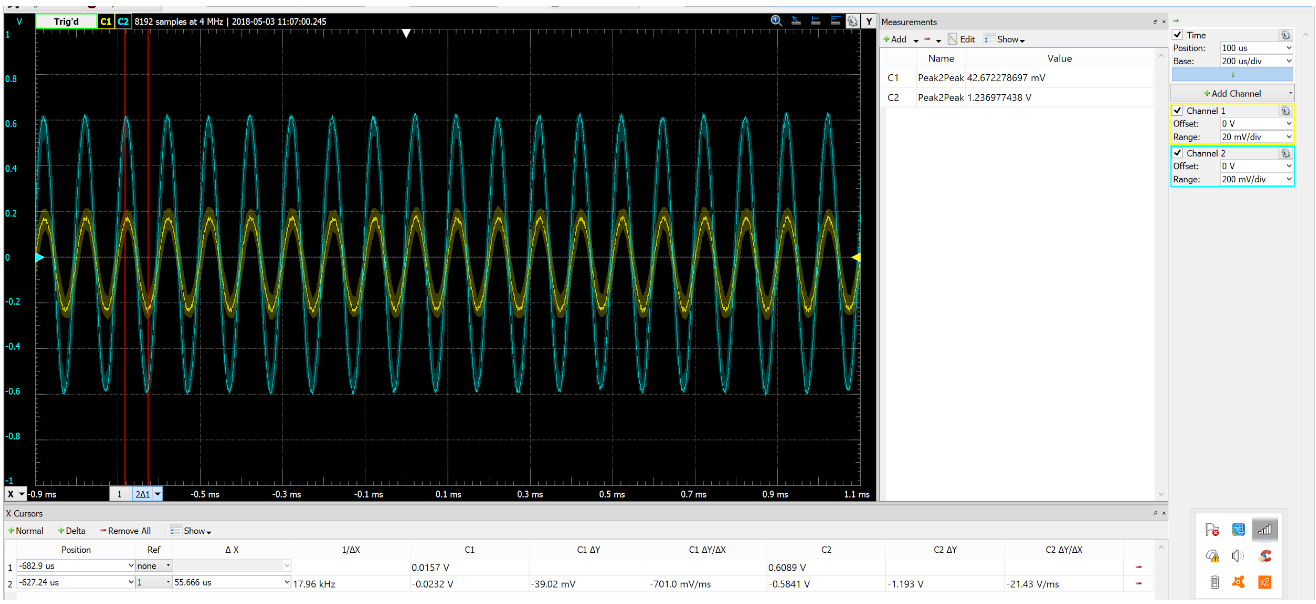

Figure 6: Transient Response Stage 3 with 30mV

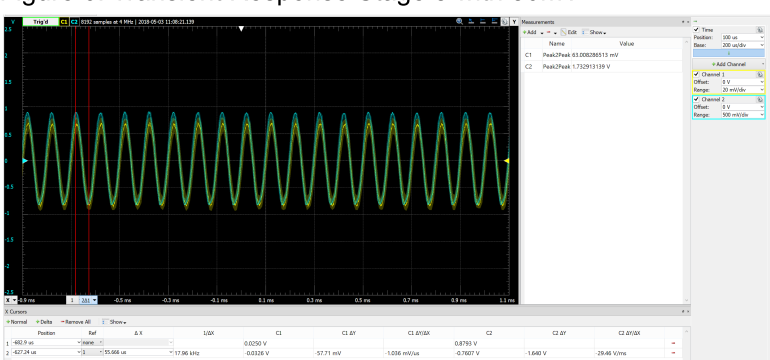

Figure 7: Transient Response Stage Stage 3 with 40mV

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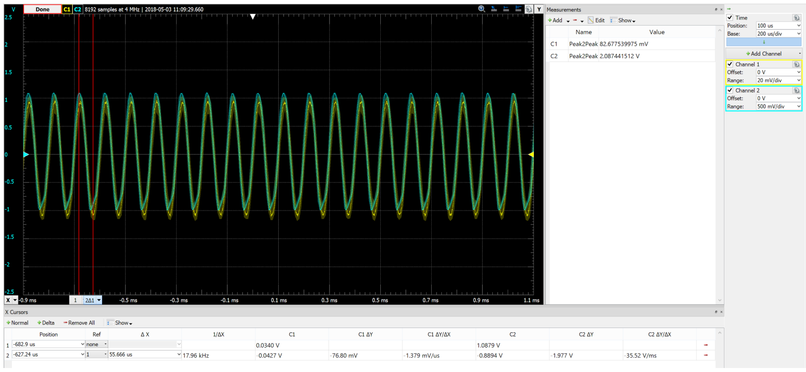

Figure 6: Total Harmonic Distortion at Stage 2

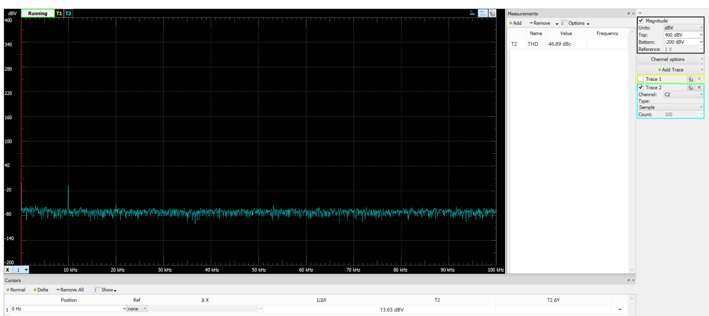

Figure 7: Total Harmonic Distortion at Stage 3

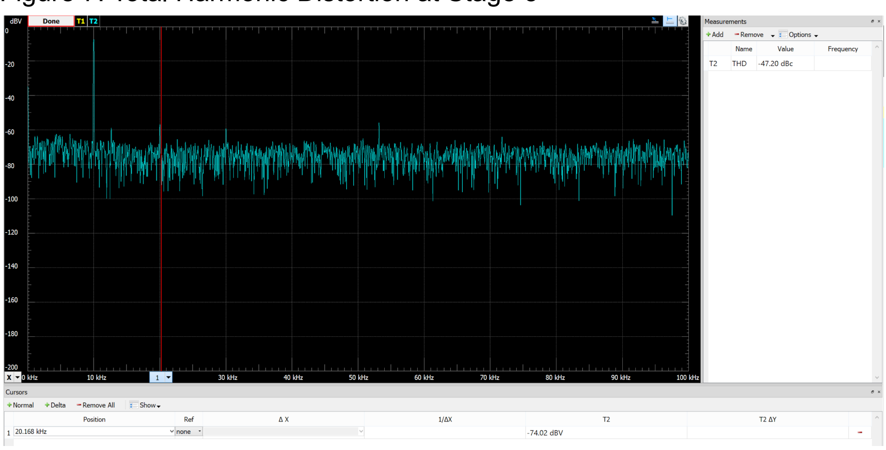

Table 1: DC Operating Points at every stage

Stage 1		Stage 2(@ pnp)		Stage 3	
Vbase	1.41V	Vbase	1.937 V	Vbase	3.365 V
Vcollector	2.242 V	Vcollector	2.623 V	Vcollector	5V

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Vemitter	878 mV	Vemitter	20mV	Vemitter	2.733 V

Discussion:

On the power amplifier, I used a 2N3055 Transistor, since the power capabilities of this transistor is greater than a 2N3904 transistor. Then I constructed a common collector with emitter follower as shown in lab 08 with Rb=825Ω and RE=20Ω in parrell with RL=8Ω. The second stage, I used lab manual 09 to construct a common emitter followed with a buffer.The gain for this stage was gain of 4.23 and with previous stage it totaled to a gain of 27.5 (AV=AV1*AV2*AV3=4*6.5*1=27.5). Therefore, the output at the second stage is approximately 1.1V.   Then, the first stage, I used a common emitter with a gain of 6.5 and the input resistance was 50k with a low total harmonic distortion. For the first two stages in my design I had to adjust the swing to 0.5 V with Vre=1 V and Vrc=3V. Then, I proceed the calculations as demonstrated in lab manual 08 and 09. I adjusted a couple resistor values(mainly Rg and Rh) to fit with my measurement circuit model. Then, a link to the video results will be attached to demonstrate my results and lab performance.

https://www.youtube.com/playlist?list=PLWMKE8Zrb39ZpDBgFhjb1N-XxiXJWxDpn