Lab 9:
BJT Amplifier Design

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ECEN 325 Section 514

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Calculation

Choose $V_{RE} = 1.3V$ $\hat{V_o} = 1.1V$ $|V_{CE,SAT}| = 0.3V$

$5 - 1.1 - 1.3 - 0.3 \geq V_{RC} \geq 1.1 \Rightarrow 2.3 \geq V_{RC} \geq 1.1$

$\Rightarrow V_{RC} = 2.3V$

$$\frac{2.3 - 0.7 - 1.1}{R_H} \geq \frac{1.1}{100} \Rightarrow R_H \leq 45.45 \Rightarrow R_H = 33\Omega$$

$$I_{C2} = \frac{2.3 - 0.7}{33} = 48mA$$

Choose $N = 20$, $\beta = 300$, $R_i = 1.5K\Omega$

$$20 \cdot \frac{48m}{350} \leq I_{C1} \leq \frac{300}{1500} \cdot \frac{1}{\frac{20}{1.3+0.7} + \frac{20}{5-1.3-0.7} + \frac{20}{2.3}}$$

$$\Rightarrow 2.74mA \leq I_{C1} \leq 7.9mA \Rightarrow I_{C1} = 4.2mA$$

$$R_C = \frac{2.3}{4.2m} = 547\Omega \qquad R_E = \frac{1.3}{4.2m} = 309\Omega$$

$$R_G = \frac{547}{20} - \frac{25}{4.2} = 21\Omega$$

$$R_{B1} = \frac{300(5 - 1.3 - 0.7)}{20 \cdot 4.2m} = 10.7K\Omega$$

$$R_{B2} = \frac{300(1.3 + 0.7)}{20 \cdot 4.2m} = 7.1K\Omega$$

Simulation

(I redo the simulation, since the simulation in pre-lab was wrong)

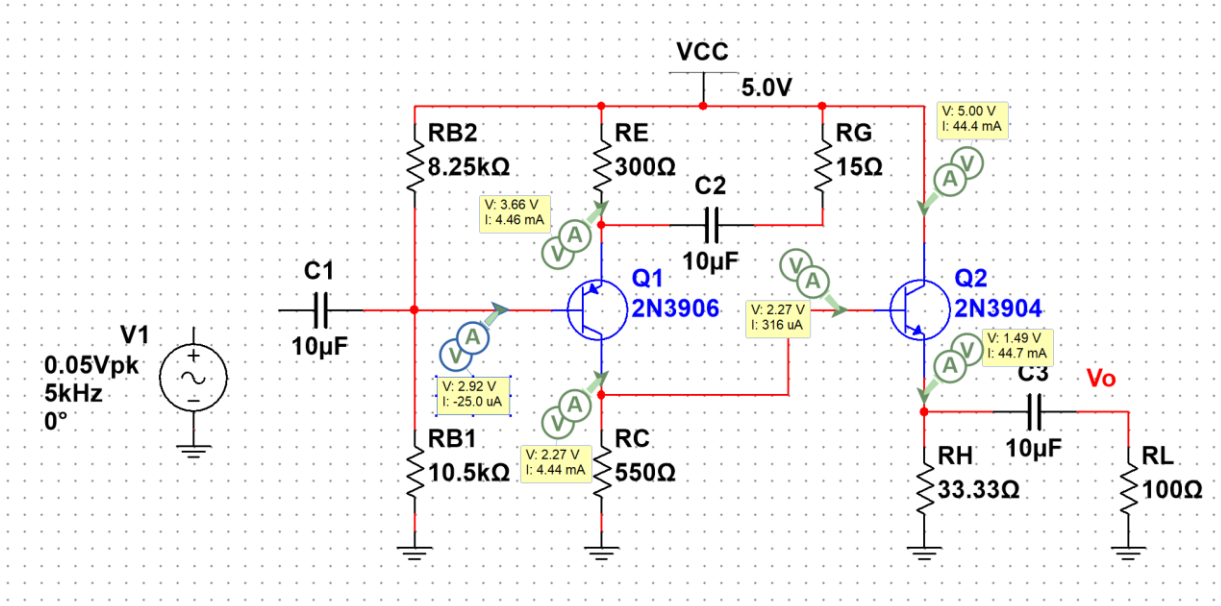

Figure 1: DC solutions

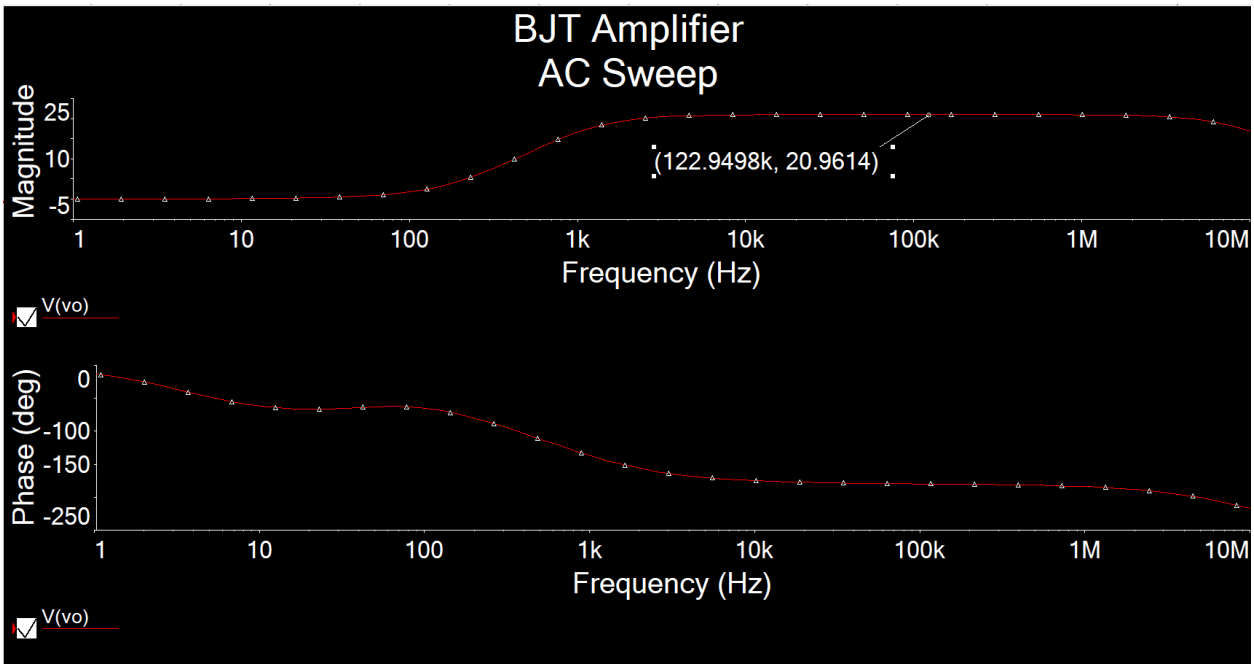

Figure 2-1: AC Simulation of Av

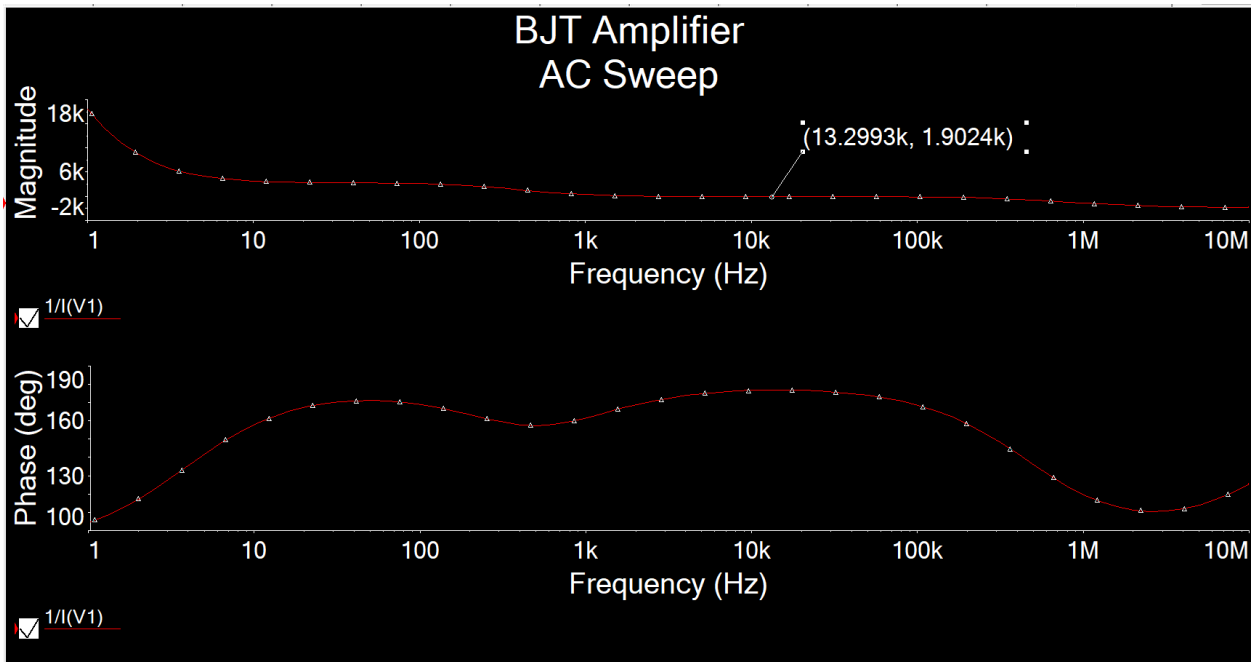

Figure 2-2: AC Simulation of Ri

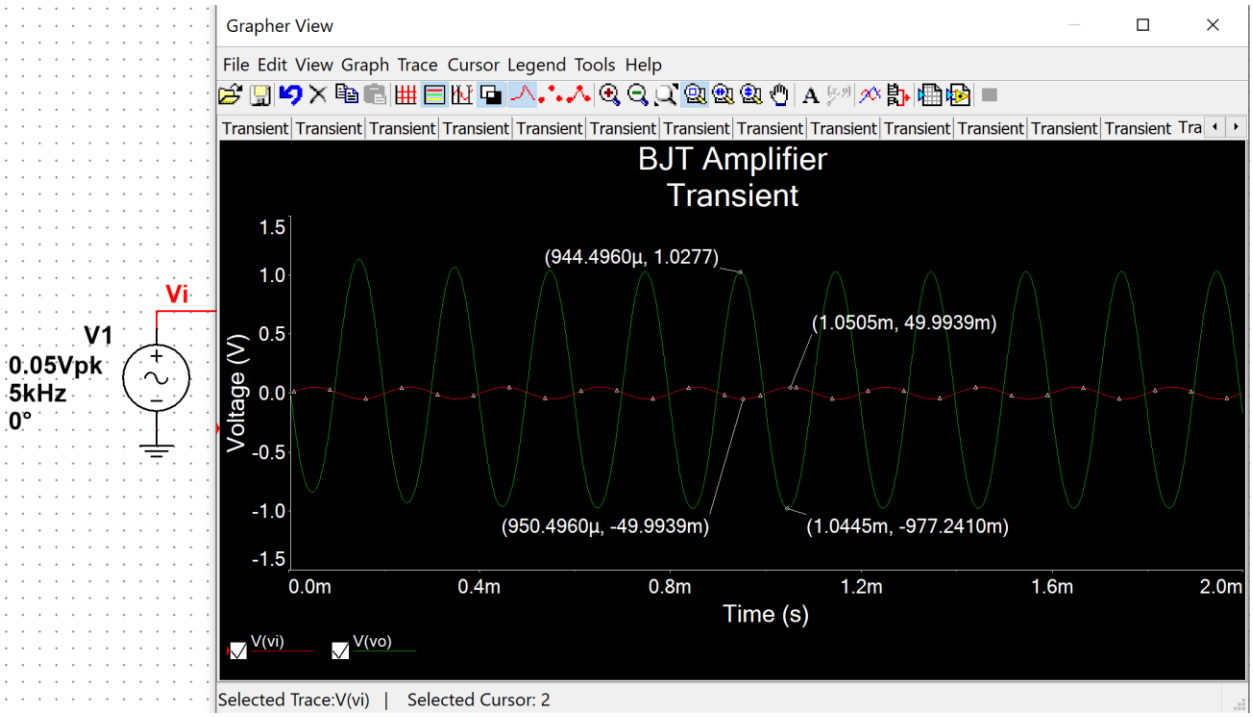

Figure 3: Time-domain waveform

$$A_V = \frac{1.03 - (-0.977)}{0.05 - (-0.05)} = \mathbf{20.07} \approx \mathbf{20}$$

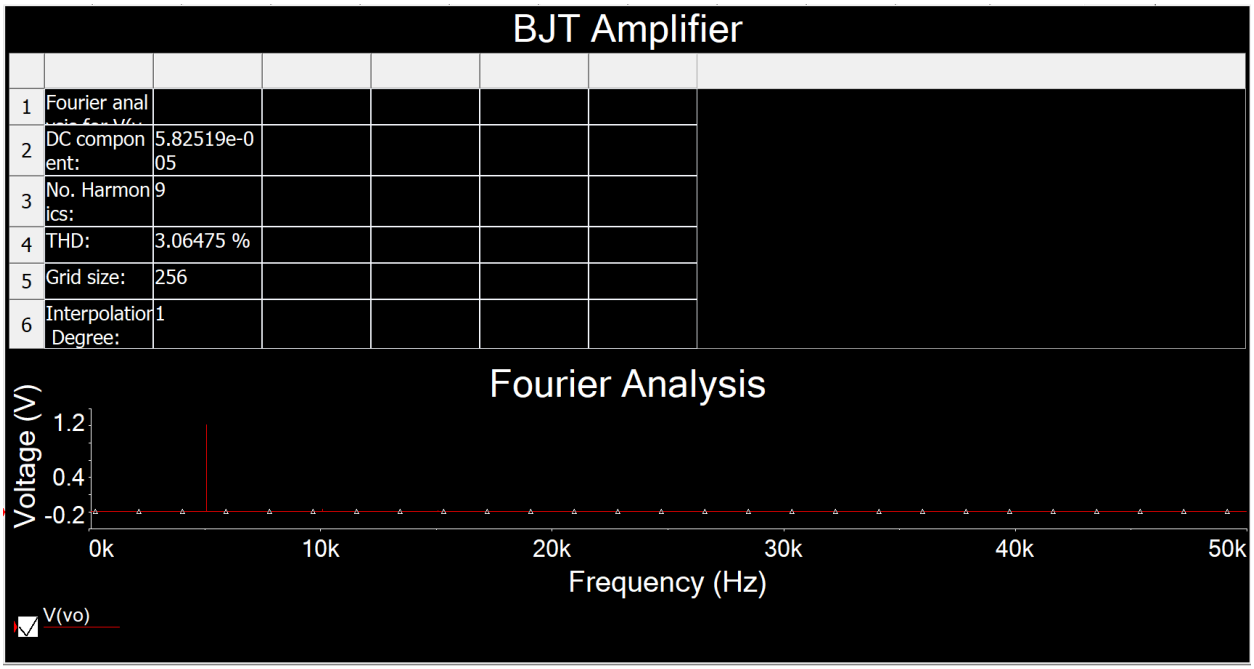

Figure 4: THD

THD = 3.06% which is less than 5%

Measurement

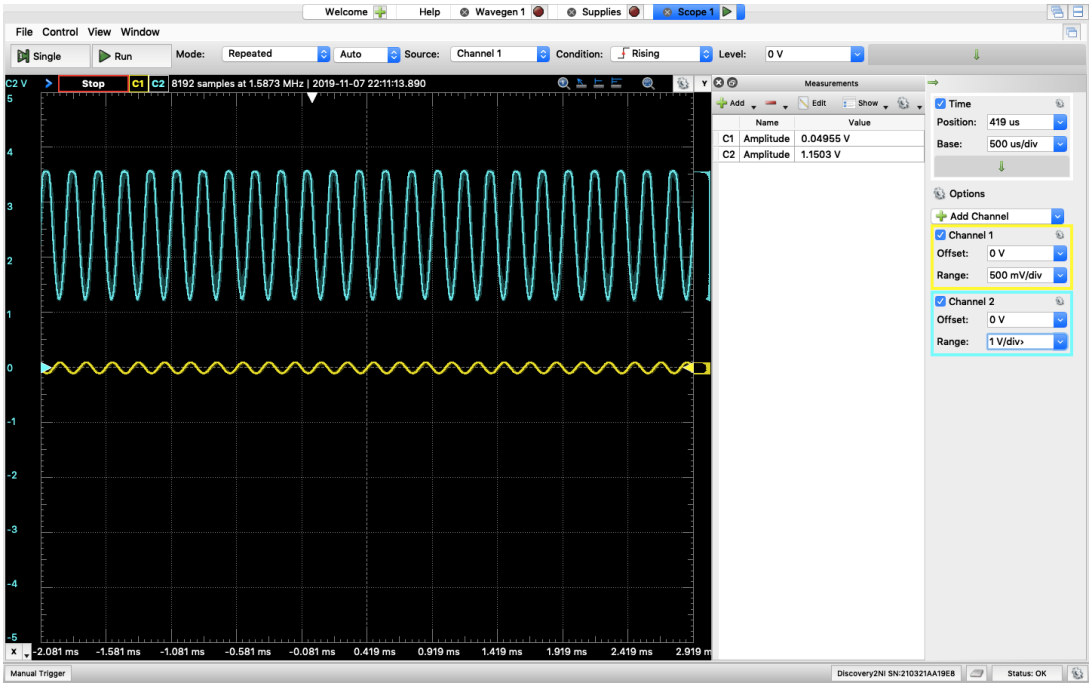

Figure 5: Stage 1 Gain

(I change R_G from 15Ω to 3.33Ω since 15Ω didn't give me gain of 20)

$$A_V = \frac{1.1503}{0.04955} = \mathbf{23.21}$$

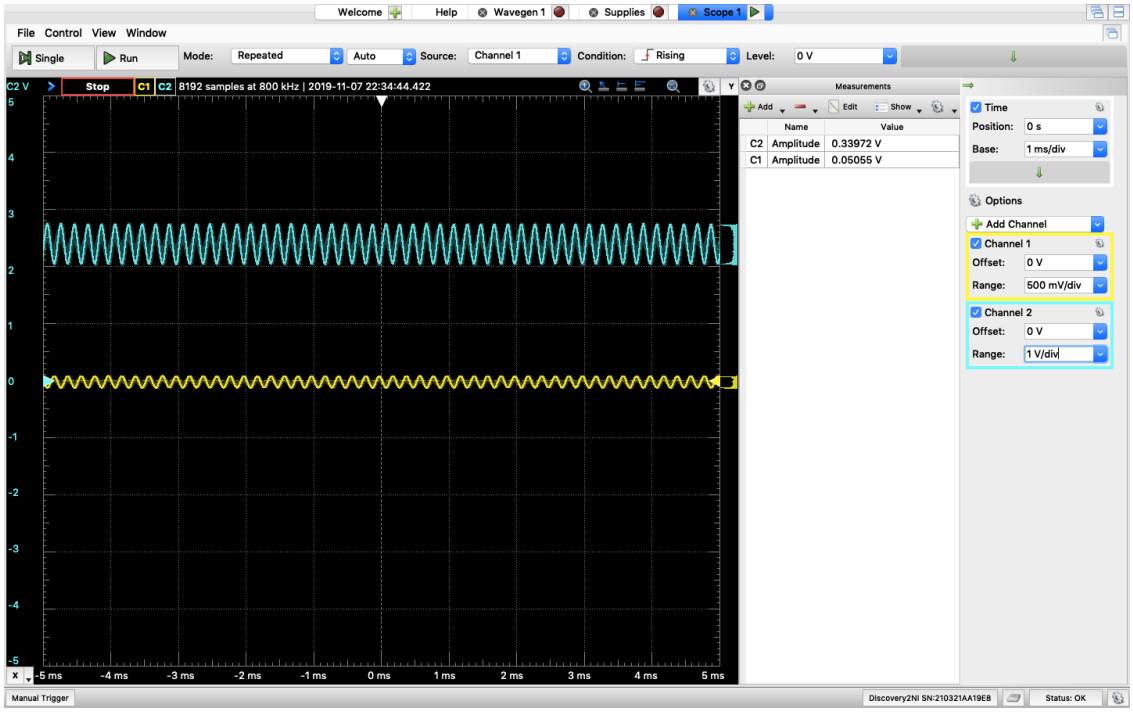

Figure 6: Stage 2 Gain

$$A_V = \frac{0.33972}{0.05055} = 6.72$$

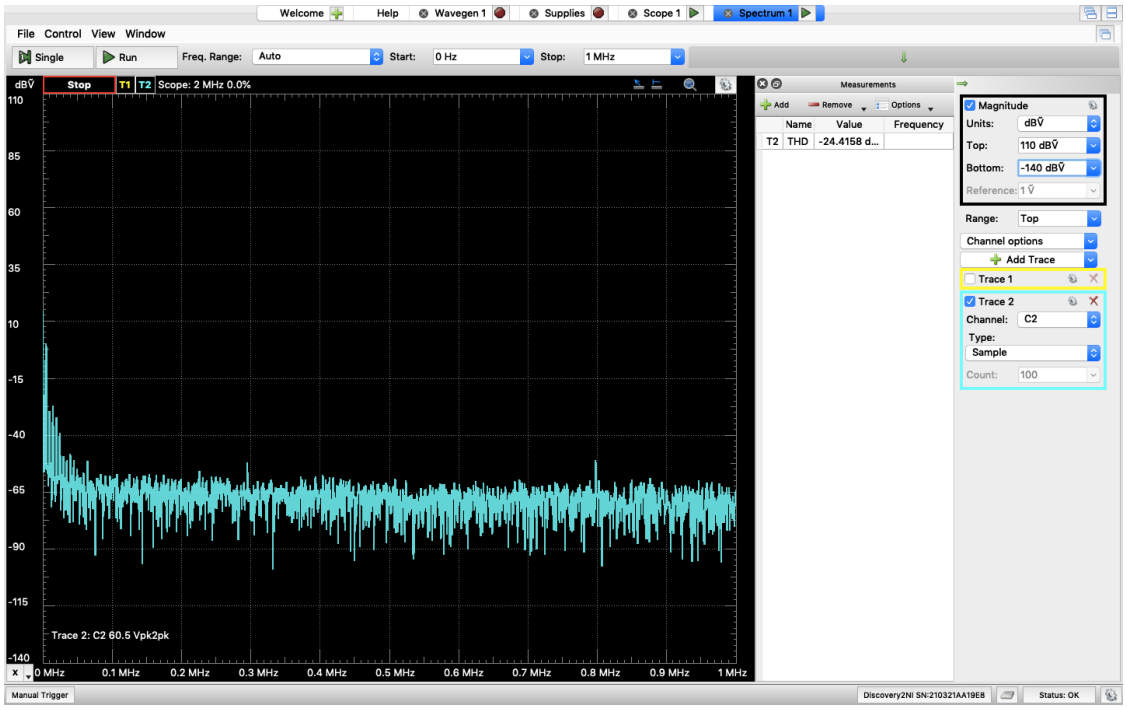

Figure 7: THD at Stage 1

THD = -24.4158dB = 0.06015 = 6%

Table

	Calculation	Simulation
V_{RE}	1.3V	1.34V
V_{RC}	2.3V	2.27V
I_{C1}	4.2mA	4.44mA
I_{C2}	48mA	44.4mA

Comment

The measurement part is not correct for several reasons. First, the Analog Discovery 2 can only handle up to 250mW. To make stage 2 have gain of 20, the circuit needs to be modified to reduce the power consumption at stage 1. Second, the breadboard, resistors, transistors, and capacitors in the real world are not ideal. So that why not everything work as simulation.