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Introduction:
The report for the Amplifier Design Project is provided here. The circuit's needs were built and tested using MultiSIM. The manual calculations for determining the required component values are supplied at the end of this report.

Specifications:

- **Power supply: +10*V* relative to the ground;**

- **Quiescent current drawn from the power supply: no larger than 10 *mA*;**

- **No-load voltage gain (at 1 *kHz*): |*Avo*| = 50 (± 10%);**

- **Maximum no-load output voltage swing (at 1 *kHz*): no smaller than 8 V peak to peak;**

- **Loaded voltage gain (at 1 *kHz* and with *RL* = 1 *k*Ω): no smaller than 90% of the no-load voltage gain;**

- **Maximum loaded output voltage swing (at 1 *kHz* and *RL* = 1 *k*Ω): no smaller than 4 V peak to peak;**

- **Input resistance (at 1 *kHz*): no smaller than 20 *kΩ*;**

- **Amplifier type: inverting or non-inverting;**

- **Frequency response: 20 Hz to 50 kHz (−3*dB* response);**

- **Type of transistors: BJT;**

- **Number of transistors (stages): no more than 3;**

- **Resistances permitted: values smaller than 220 *kΩ* from the E24 series;**

- **Capacitors permitted: 0. 1 *μF*, 1. 0 *μF*, 2. 2 *μF*, 4. 7 *μF*, 10 *μF*, 47 *μF*, 100 *μF*, 220 *μF*;**

- **Other components (BJTs, diodes, Zener diodes, etc.): only from your ELE404 lab kit**

Figure of Circuit Description:

Circuit Description

$\beta = 150$

$R_o = 10k\Omega$

V_E to $3V_{BE}$: $V_E = 3(0.7) = 2.1V$

$\frac{1}{2}(V_{cc} + V_E + 0.3)$

$\Rightarrow V_c = 6.2$

A good output voltage swing 8
+ BJT does not enter saturation mode we do the following

$8 = \frac{1}{2}(10 + V_E + 0.3)$

$16 = 10.3 + V_E$

$V_E = 5.7V$

- For CE amp, $R_0 = R_C$

$R_C = 01k\Omega$

Circuit

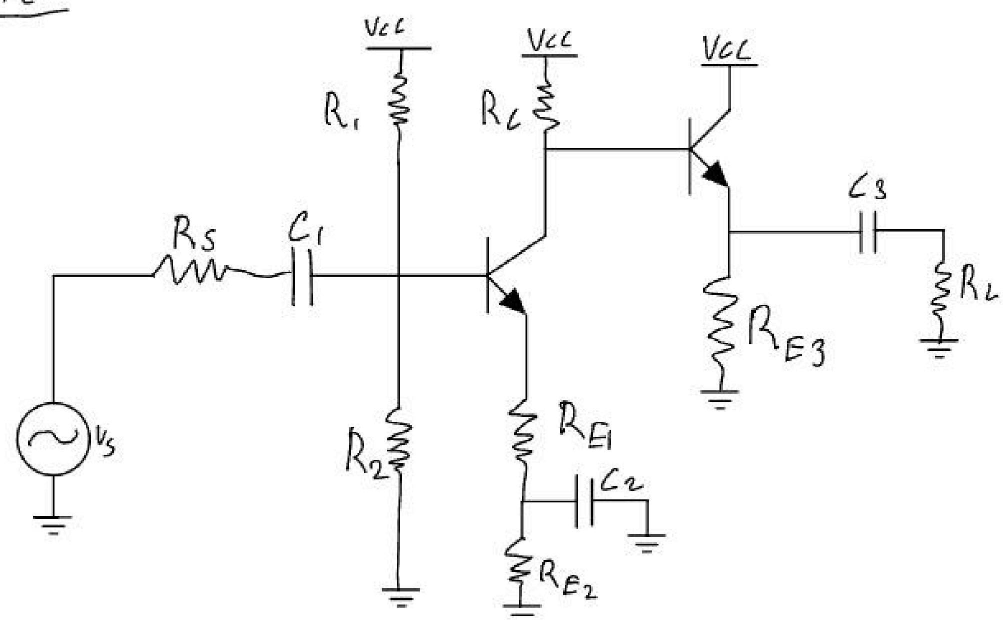


Figure of Calculations:

Calculations

$$I_C = \frac{V_{CC} - V_C}{R_C}$$

$$I_C = \frac{10V - 8V}{26\,k\Omega}$$

$$I_C = 7.7\times10^{-5}\,A$$

$$I_C = I_E = 7.7\times10^{-5}\,A$$

$$g_m = (7.7\times10^{-5}A)(0.026V)$$

$$g_m \approx 2\times10^{-6}\,mS$$

$$R_{E1} + R_{E2} = \frac{V_E}{I_E} = \frac{5.7V}{7.7\times10^{-5}A} = 74\,k\Omega$$

$$R_{E1} + R_{E2} = 74\,k\Omega$$

$$R_{E2} = 74\,k\Omega - 20\,\Omega$$

$$R_{E2} = 73.98\,k\Omega$$

$$|A_{vo}| = \left|\frac{-g_m R_C}{1 + g_m R_{E1}}\right| = 50$$

$$50(1 + (2\times10^{-6}S)R_{E1}) = (2\times10^{-6}S)(26k\Omega)$$

$$1 + (2\times10^{-6}S)R_{E1} = \frac{(2\times10^{-6}S)(26k\Omega)}{50}$$

$$R_{E1} = \frac{26\,k\Omega}{50} - \frac{1}{2\times10^{-3}S}$$

$$R_{E1} \approx 20\,\Omega$$

$$R_i > 20k\Omega$$

$$(R_1 \| R_2 \| R_i') \geq 20k\Omega$$

$$\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_i'} \geq \frac{1}{20}$$

$$R_1 \| R_2 \geq \frac{1}{\left(\frac{1}{20k\Omega} - \frac{1}{50k\Omega}\right)}$$

$$R_1 \| R_2 \geq 33.3\,k\Omega$$

$$R_1 \| R_2 = 33.3\,k\Omega$$

$$\frac{R_1 \cdot R_2}{R_1 + R_2} = 33.3\,k\Omega$$

$$r_e = \frac{26}{7.7\times10^{-5}} = 337.662.345$$

$$R_i' = \overset{100}{\beta}(r_e + R_{E1}) = 5067665\,k\Omega \approx 50\,k\Omega$$

$$V_B = V_{CC}\cdot\frac{R_2}{R_1 + R_2}$$

$$6.4 = 10\cdot\frac{R_2}{R_1 + R_2}$$

$$\frac{R_1 + R_2}{R_2} = 1.56$$

solve ① & ②

① $\frac{R_1 \cdot R_2}{R_1 + R_2} = 20k\Omega$ $\quad$ $\frac{R_1 + R_2}{R_2} = 1.56$ ② $\rightarrow R_1 = (0.56)R_2$

Sub ② → ①

$$\frac{(0.56)R_2 \cdot R_2}{(0.56)R_2 + R_2} = 33.3\,k\Omega$$

$$\frac{0.56 R_2}{(0.56 + 1)} = 33.3\,k\Omega$$

$$R_2 \approx 92.76\,k\Omega$$

Sub R_2 → ②

$$\frac{R_1 + 92.76k\Omega}{92.76k\Omega} = 1.56$$

$$R_1 = ((1.56)(92.76k\Omega)) - 92.76\,k\Omega$$

$$R_1 = 51.95\,k\Omega$$

$$R_{e3} = 26 / (26 - 1) = 1.04$$

Summary of Calculations:

These are the values used in the circuit:

C1	C2	C3
10μF	100μF	100μF

Table 1. Capacitor Values

R1	R2
$52k\Omega$	$47k\Omega$

Table 2. Resistor Values

RE1	RE2	RE3	RC
20Ω	$62k\Omega$	$1k\Omega$	$26k\Omega$

Table 3. Emitter and Collector Resistor Values

I_c	β	V_{cc}	g_m
7.7×10^{-5} A	150	10 V	2×10^{-6} mS

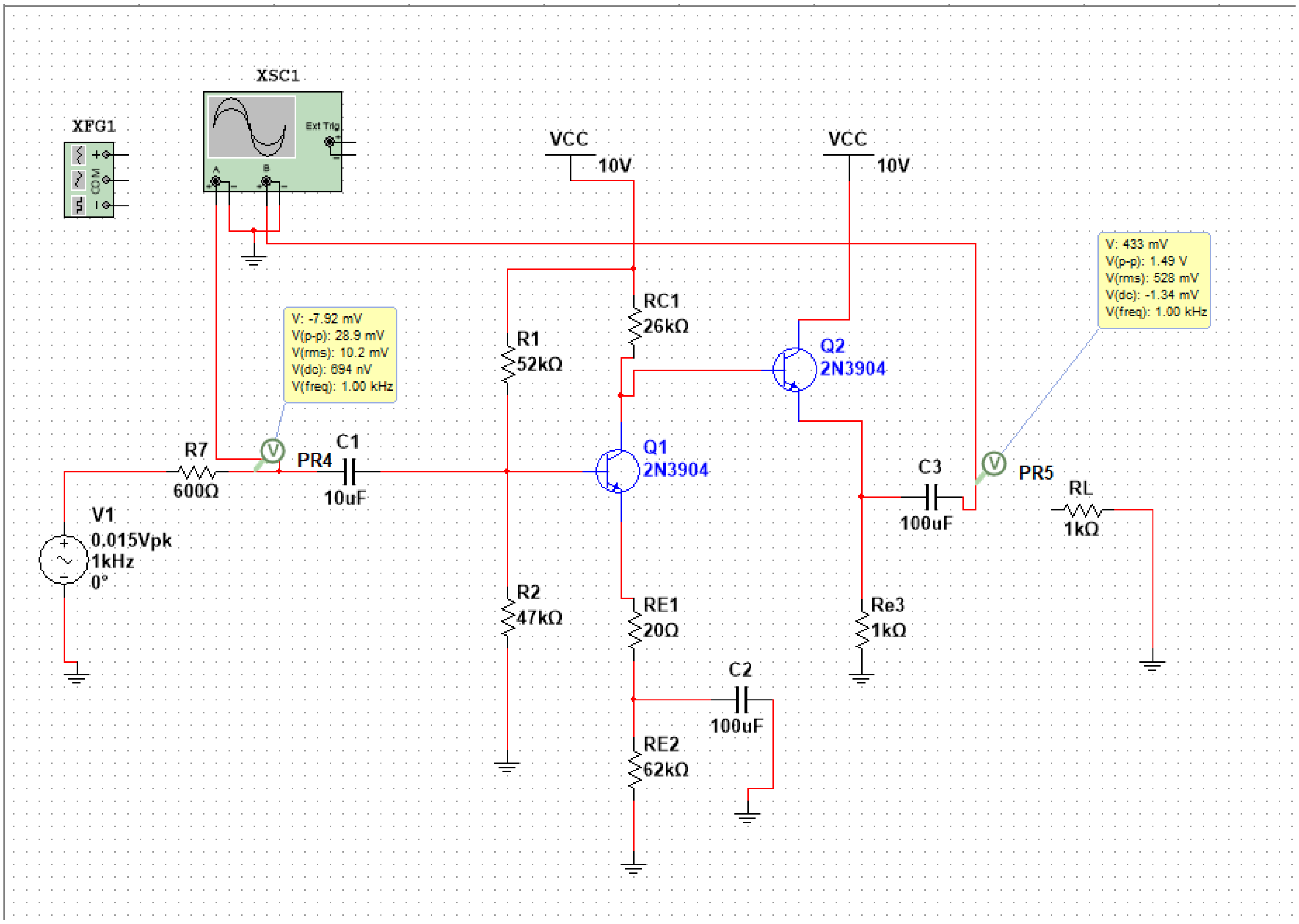
Table 4. Useful Values from Stage 1

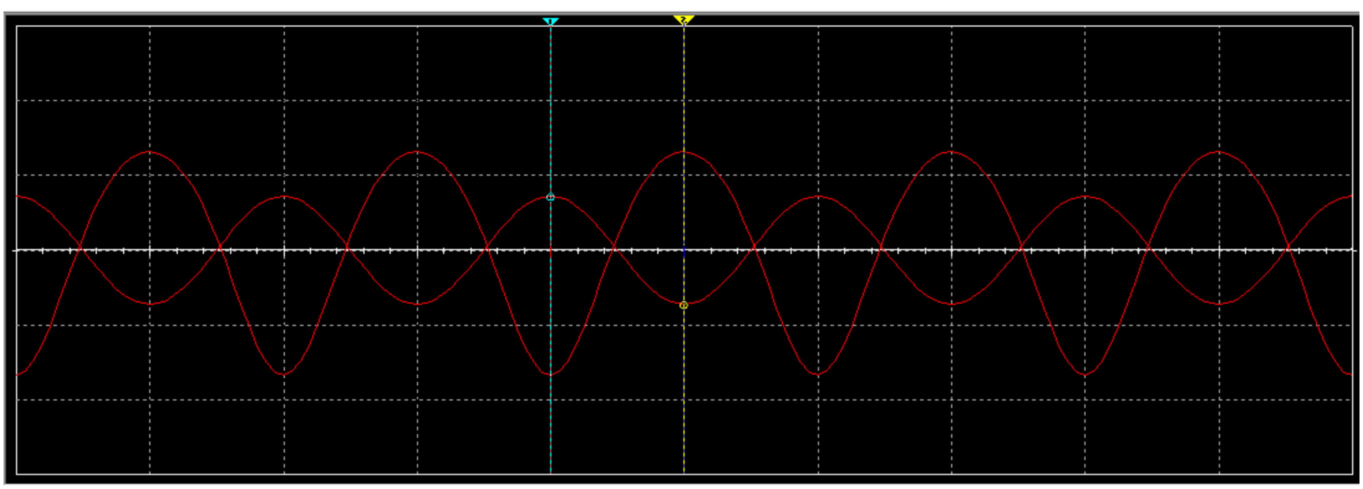
Design outline:

A two-stage amplifier was chosen to meet the project's needs. The parameters are a voltage gain of 50 and a Rin of more than 20 kOhms. The design I proposed comprises two steps. The first stage is a CE amplifier, whereas the second stage is a CC amplifier. I set the gain to 50 for the first stage. Because the CC stage is the final one, the gain will be near to unity, or approximately one. When determining overall gain, you multiply the gains from both stages. Multiplying 50 with 1 yields an increase of 50 in overall value. To begin the computations, I assumed Rc to be 26 kOhms because it worked best on multisim and was a valid resistor. Then, Vc was determined to be 8V, and these numbers were utilized to derive Ic. All resistor values were calculated based on this. Each estimated value was rounded to the closest acceptable resistor. The sole expected resistor value was $R_C = 26k\Omega$ Capacitors were all presumed. When modeling using Multisim, the capacitors had little effect on the gain. Capacitors are used to impede the AC signal and because the capacitors had no effect on the resistor calculations, any capacitor values were able to be selected to better match the specifications while simulating.

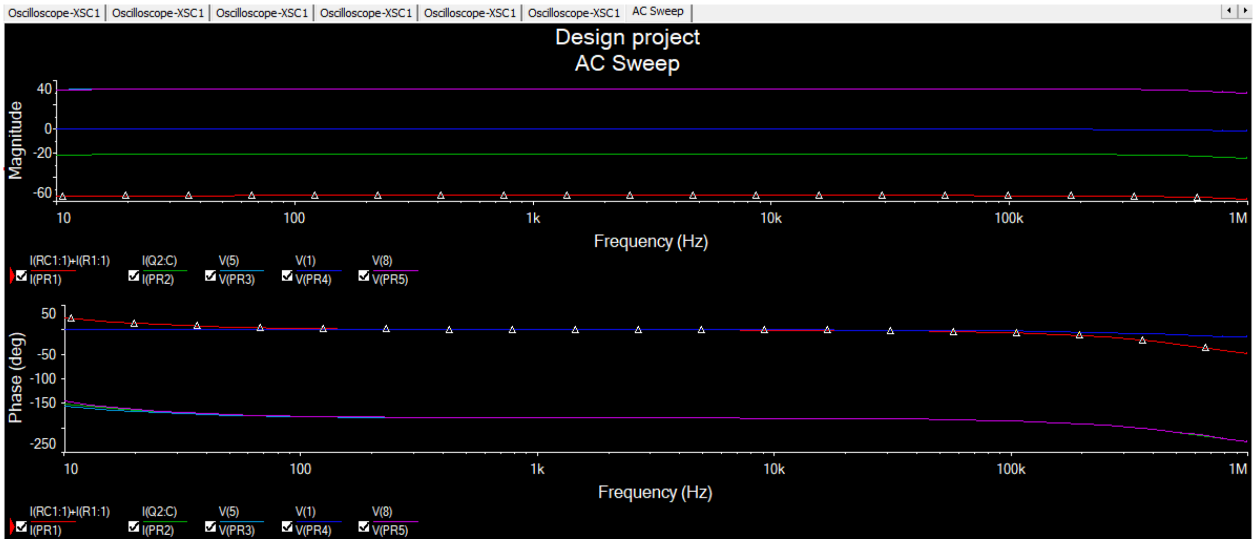
Simulations and Verifications:

Figures Without load:

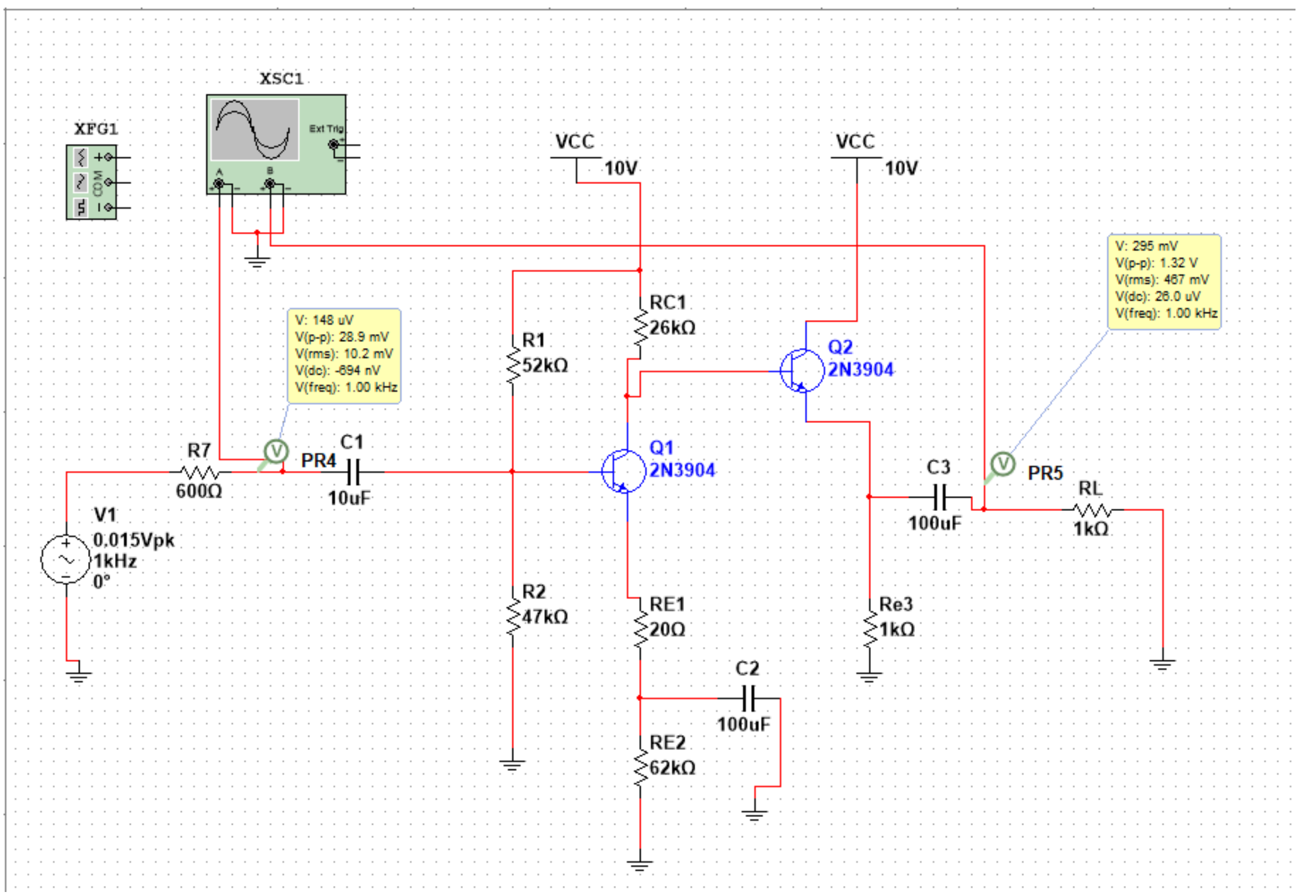


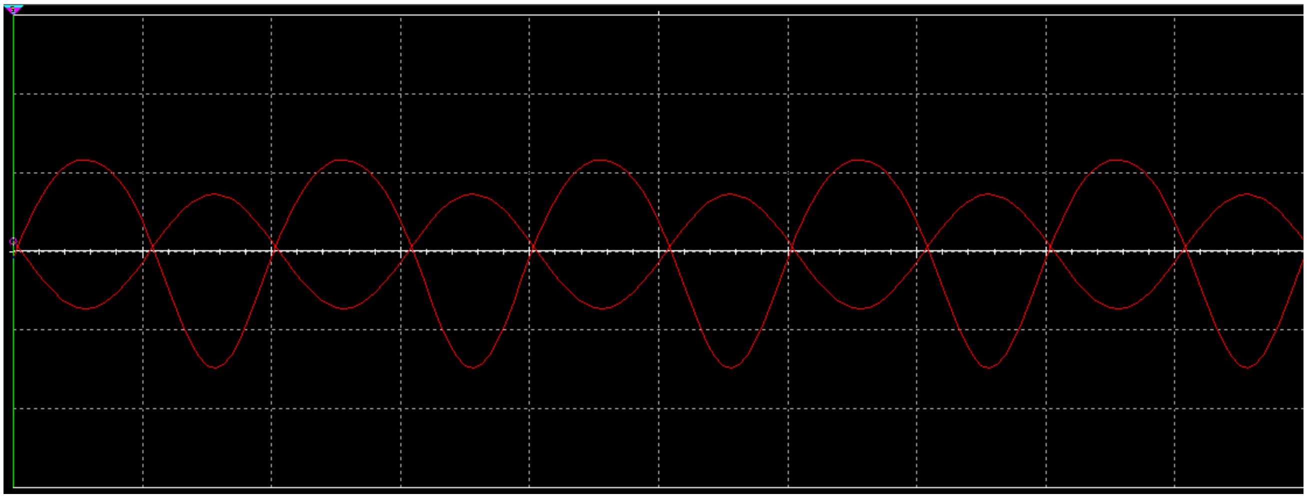


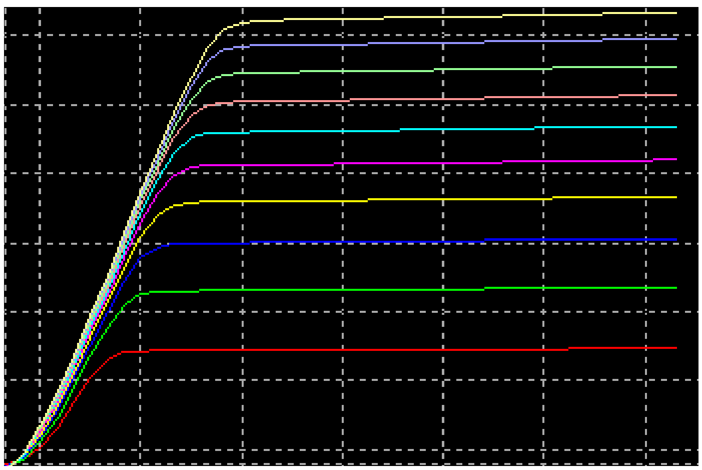
	Time	Channel_A	Channel_B
T1	669.252 ms	88.654 mV	2.988 V
T2	669.746 ms	-96.156 mV	-1.256 V
T2-T1	493.942 us	-184.810 mV	-4.244 V



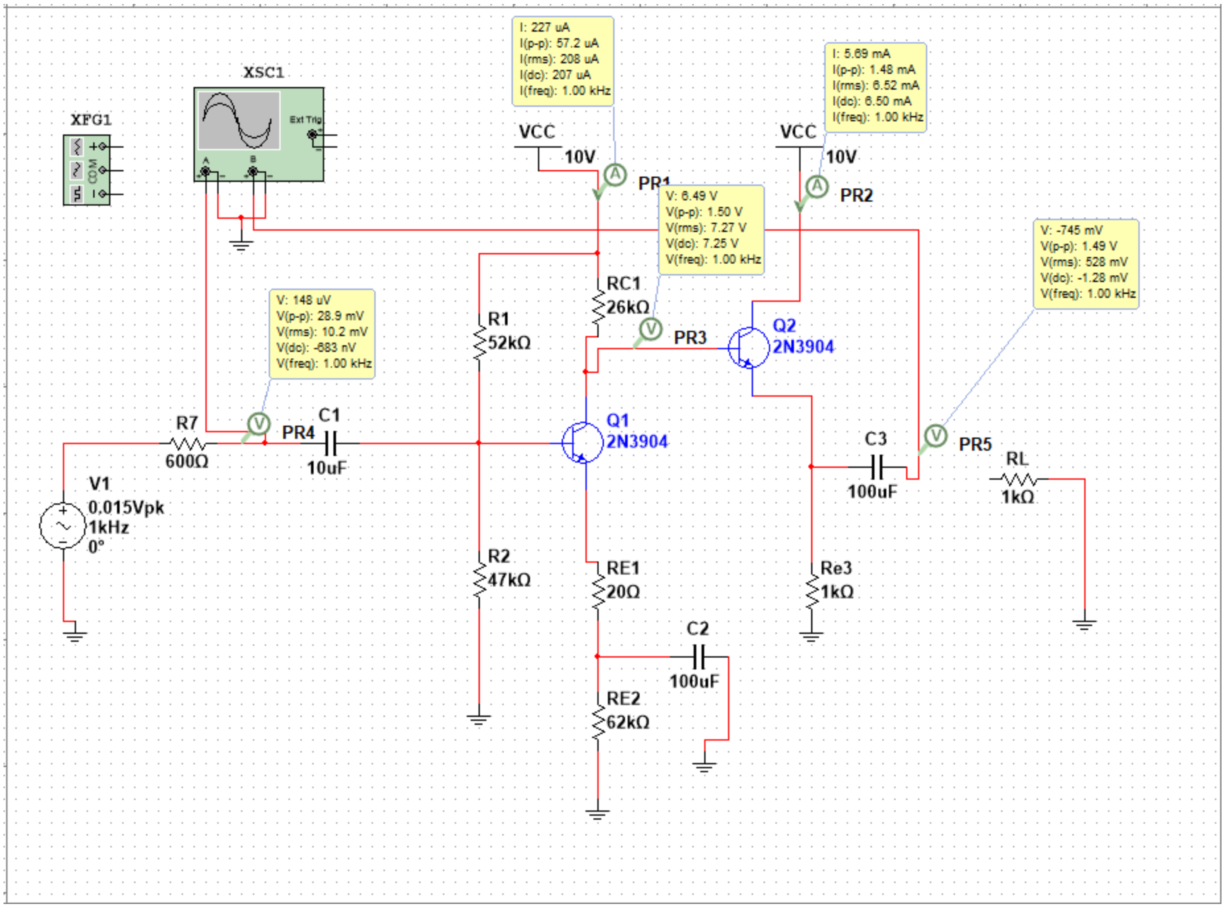
Figures With Load:







Other measurements:



$$\text{Gain without load} = \frac{1.49V}{0.0289V} \approx 51.56$$

$$\text{Gain with load} = \frac{1.32}{0.0289} \approx 45.68$$

$$\text{Input Resistant} = R1//R2//Ri = \frac{1}{\frac{1}{93}+\frac{1}{52}+\frac{1}{50}} \approx 20.01 > 20\ k\Omega$$

Conclusion:

All of the specifications were achieved except for the output voltage swing with no load. The value simulated was around 4.244V which does not meet the requirement of 8V. Also the frequency response part was not tested but it is likely that it is working as expected. In the grand scheme of the project it can be seen as a success as we have completed most of the project.