Faculty of Science

Department of Physics

Laboratory Report Cover Page

Course Number	ELE404
Course Title	Electronic Circuits I
Semester/Year	04/2024
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Report Title	Design Project

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Introduction

This is a design project focused on creating a transistor amplifier that is multistage and inverting. The results of this lab will aid in analyzing and testing this amplifier. This will be accomplished through the software MultiSim.

Objectives

Build an amplifier with the listed requirements

- 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 kΩ): no smaller than 90% of the no-load voltage gain;
- Maximum loaded output voltage swing (at 1 kHz and RL = 1 kΩ): 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 (−3dB 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.

Circuit Under Test

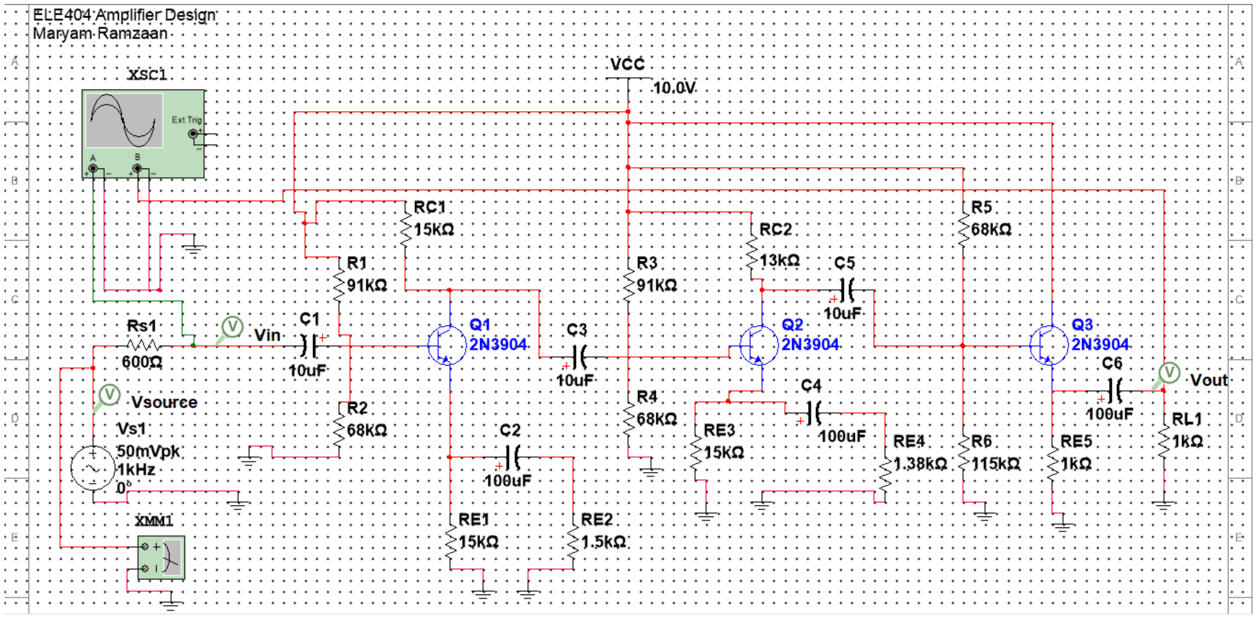

Figure 1: Amplifier circuit simulation created by cascading two CE amplifiers with a CC amplifier

Graphs

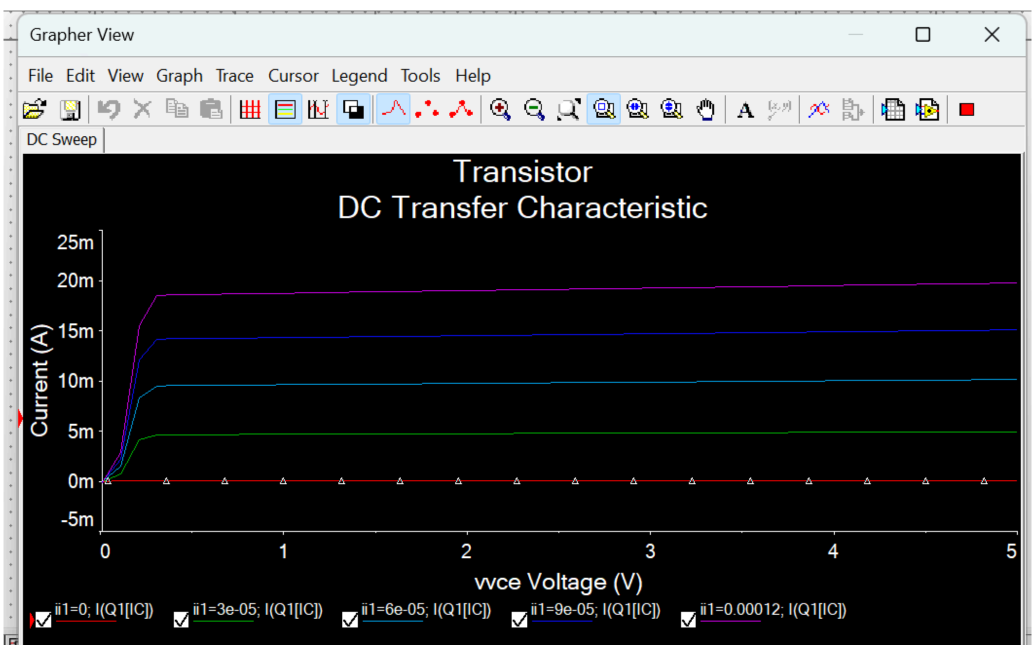

Figure 2: characteristic graph of the 2N3904 BJT

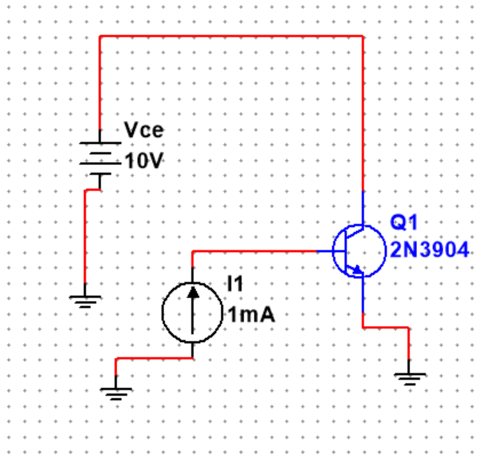

Figure 1b: The circuit used to create Figure 1a.

Justifications

Calculation Process

To design an amplifier that meets the stated objectives, it was assumed that a circuit with two common emitter BJTs and a common collector would be suitable. A voltage source of 50m Vpk with a frequency of 1kHz was used to power the circuit, as well as a Vcc value of 10V. Three NPN Bipolar junction transistors were used as well as six capacitors to separate each of the three transistors followed by a load resistor R_L which was removed at certain points of this project to determine whether its presence would create changes among other measurements in the circuit. Furthermore, the chosen load line was 5V for the operation point, and 4.25 for the corresponding CE Voltage for this project although it is not shown and done manually.

As for the calculations, the voltage gain was considered first to fulfill the requirement for $A_{vo} \leq 50$. Since A_{vo}=$A_{vo1} \times A_{vo2} \times A_{vo3}$, and since the third amplifier is a common collector one, its A_{vo}= 1 because voltage gains of the CC amplifier are close to unity, and since the rest of the BJTs were CE, it made sense to assume $A_{vo1} = A_{vo2}$. Two numbers with a product of 50 is about $\sqrt{50} = \pm\ 7.1$. Throughout the calculation, it was recognized that both no-voltage gains needed to be -7.1, and that would yield a non-inverting amplifier as the product would be a positive A_{vo} of $50\frac{V}{V}$. Apart from making calculations simpler, the CC amplifier would not be impacted by the removal and addition of the load resistor, making the circuit stable.

To determine the values of $R_{ES} and\ R_6$, the third amplifier, or stage 3 was considered. Since the values of the resistors could only be those found in the ELE404 lab kit, it was assumed that R_5

had a value of $68k\Omega$. To find R_{E3}, the second stage was considered, and Kirchoffs voltage law and R_{c2} and R_{E4} at the transistor, Q2. Lastly, the capacitor values were calculated for best and worst cases, as well as the quiescent current. All capacitors that were positioned before the BJT, was given the value of 10 μF, and the capacitors parallel to the R_e in each of the three stages were 100 μF.

Experimental Results

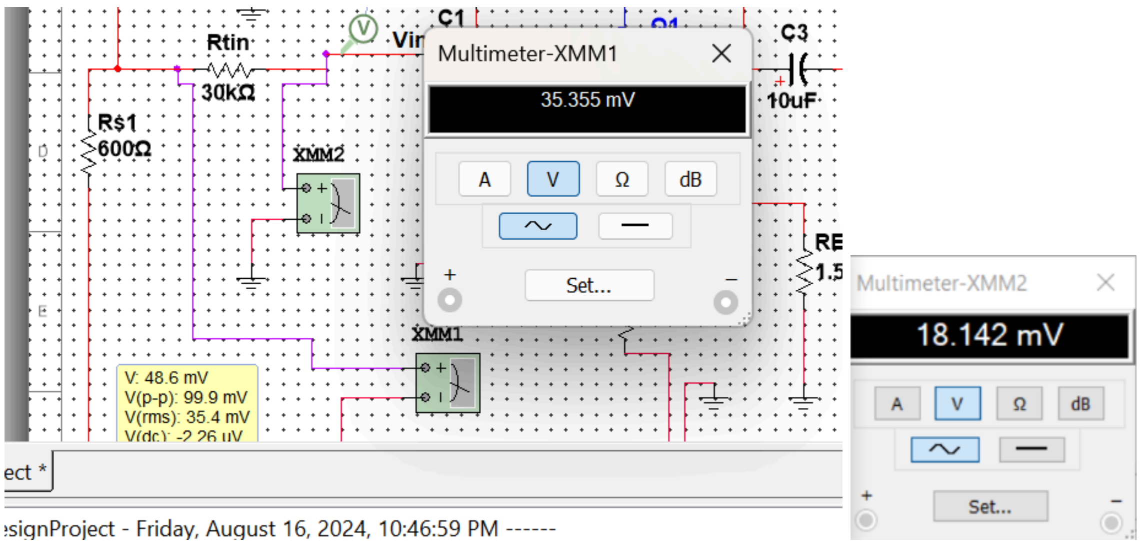

Figure : the multimeter placed before the Rtin resistor provides the Vt value while the one after provides the Vi

Using the information from Figure above, a new Rtin can be calculated with the following formula:

$$R_i = R_{t,in}\left(\frac{v_i}{v_t - v_i}\right)$$

$R_{i1,\ calculated}$ [kΩ]	R_{in} [kΩ]	V_t [V]	V_i [V]	$R_{i1,measured}$ [kΩ]
38.96	30	35.02	18.14	32.251

The percentage error between the calculated and the measured input resistance is as follows:

$$e\% \;=\; \frac{calculated\ value - measured\ value}{measured\ valued} \times 100$$

$$= \frac{38.96 - 32.251}{32.251} \times 100$$

$$e\% = 20.8\%$$

The percentage error is about 20% and this could be the result of managing significant digits in calculations or general miscalculations. However, the percentage is well under 50% so it is acceptable and valid for this experiment.

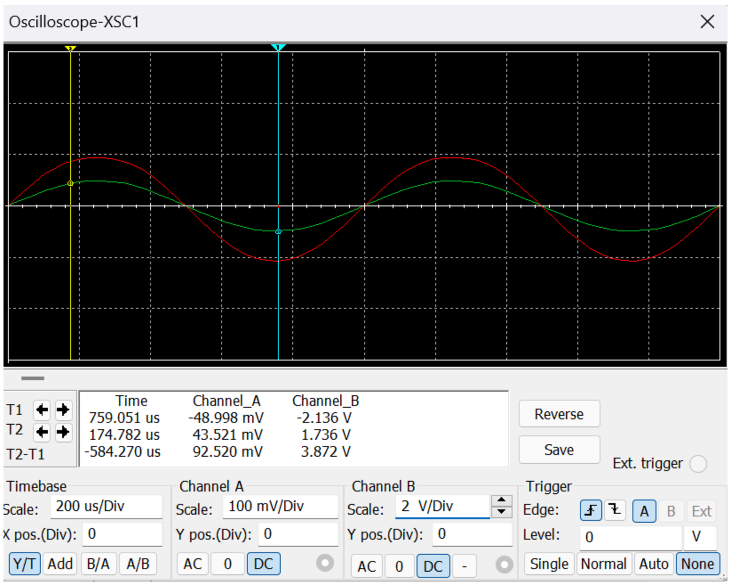

Figure 1a: input and output graph for $R_L = 1k\Omega$

$V_{I,PP}$ [mV]	$V_{O,PP}$ [mV]
92.520	3.872

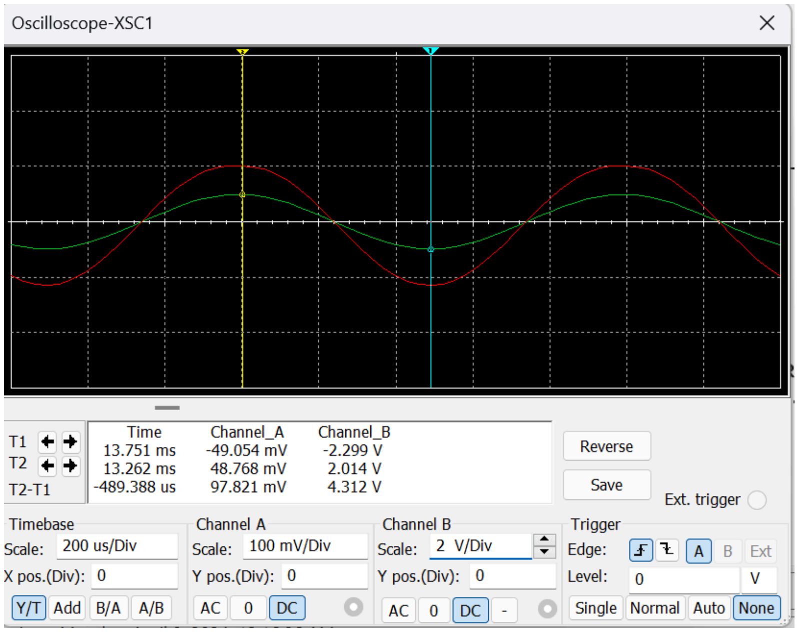

Figure 1b: input and output graph for $R_L = \infty$

$V_{I,PP}$ [mV]	$V_{O,PP}$ [V]
97.821	4.312

Conclusion

According to the results of the project, the majority of the requirements were met. If I could improve this experiment, I would need to make some changes in my choice of amplifiers and the resistors to ensure that there was voltage swing of 8V, and perhaps try different methods of calculations to increase the precision of my calculations to the results percentage.