Lab 5: BJT Amplifier

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ECE 311-03
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1 Introduction

The purpose of this lab was to successfully construct a BJT amplifier and compare the theoretical results with the results obtained in lab.

2 Theory

Transistors can be considered the bread and butter of an amplifier. Specifically, Bipolar Junction Transistors are used to amplify analog signals because of their high gain. In order to use a BJT as an amplifier, it must operate in the active region. Depending on the values chosen for resistors R_B and R_C and supply voltages V_{CC} and V_{BB}, the value of I_C and V_{CE} will have certain values. When there is a sinusoidal AC voltage added to V_{BB}, this causes the values of I_C and V_{CE} to change with respect to time. Thus, this changes the fixed Q point from applying only V_{BB} to the circuit. When this input signal is applied, the operating point will move from its original position. Since $I_B\beta = I_C$, small changes in I_B result in large changes in I_C, thus amplifying the output signal. This is due to the change in voltage drop across R_C.

3 Procedure

The equipment used in the lab was:

- Breadboard
- DC Power Supply
- Function Generator
- Oscilloscope
- $47\mu F$ and $220\mu F$ Capacitors
- $1k\Omega$, $2k\Omega$, $5k\Omega$, $10k\Omega$ Resistors
- 2N3904 NPN BJT Chip
- Wire
- Multimeter

This lab was performed in two phases, that of DC analysis, and that of AC analysis. The DC analysis portion will be described first.

The schematic used to construct the physical circuit is shown below in Figure 1.

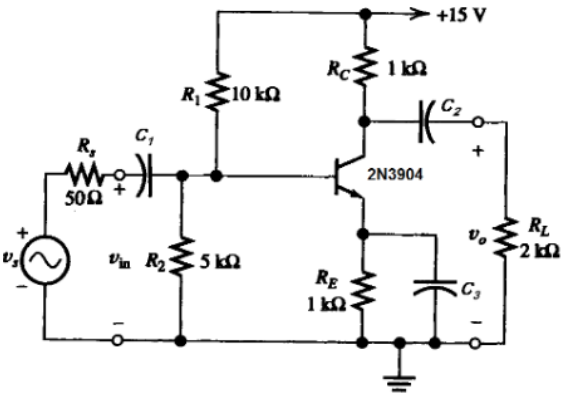

Figure 1: BJT Amplifier Schematic

To successfully perform DC analysis, it is necessary to open circuit each capacitor. This is because under DC conditions, capacitors become open circuits. Figure 2 shows the physical circuit constructed in lab. To test the voltage gain along with the values of V_{CC}, V_B, V_E, V_C and V_{out}, it was necessary to

physically remove the capacitors and set the AC input to zero. Using a multimeter, each value could then successfully be obtained and the results were recorded.

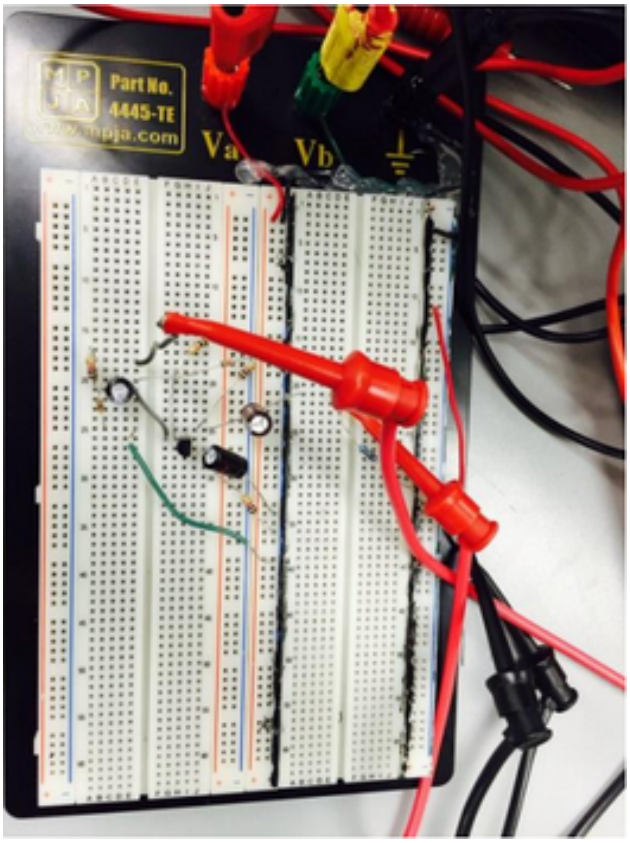

Figure 2: Constructed BJT Amplifier Circuit

AC analysis portion of the lab was then performed. This involved returning the capacitors to their original configuration, and applying an AC sinusoidal voltage of $V_{pp} = 200mV$ with a frequency of $1Khz$. Because this voltage is very large, it was necessary to build a voltage divider circuit to reduce the input voltage. This circuit is shown in Figure 3. This configuration was necessary because the circuit will saturate if a voltage as high as $200mV$ is applied as the input voltage V_{in}.

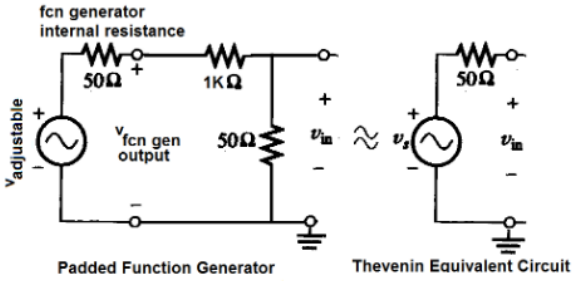

Figure 3: Input Voltage Divider

Using the oscilloscope, the input signal V_{in} and the output signal V_{out} were displayed and recorded. This was used in the calculation of the gain of our amplifier, also known in the engineering world as $A = \frac{V_{out}}{V_{in}}$.

4 Interpretation

The results of the DC analysis performed as described in Section 3 are shown in Table 1. It is quite clear that the theoretical results calculated before hand are close to the experimental results obtained during lab, thus justifying the validity of the results acquired.

Voltage	**Theoretical Value**	**Experimental Value**
V_B	4.96V	5.05V
V_C	10.76V	10.8V
V_E	4.26V	4.4V
V_{CE}	6.50V	6.57V

Table 1: Results of DC Analysis

Upon inspection of the results obtained during AC analysis, it is clear that the circuit successfully amplified the input voltage. Figure 4 shows V_{in} and V_{out} compared to each other, with the amplitude of $V_{in} = 196mV$ and the amplitude of $V_{out} = 568mV$ resulting in a gain $A = \frac{V_{out}}{V_{in}} \approx -2.90$. This gain can also be calculated by recording the slope value of the Lissajous figure shown in Figure 5. Upon further inspection of Figure 5, it can also be observed that both signals are in phase, which is further confirmation that the results obtained are indeed as theoretically expected.

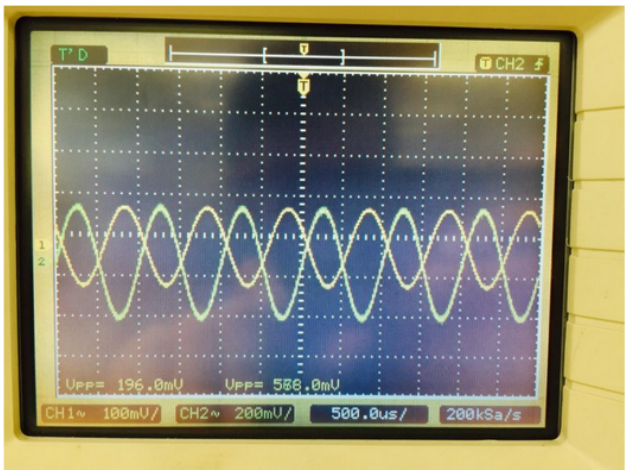

Figure 4: V_{in} and V_{out} of BJT Amplifier Circuit

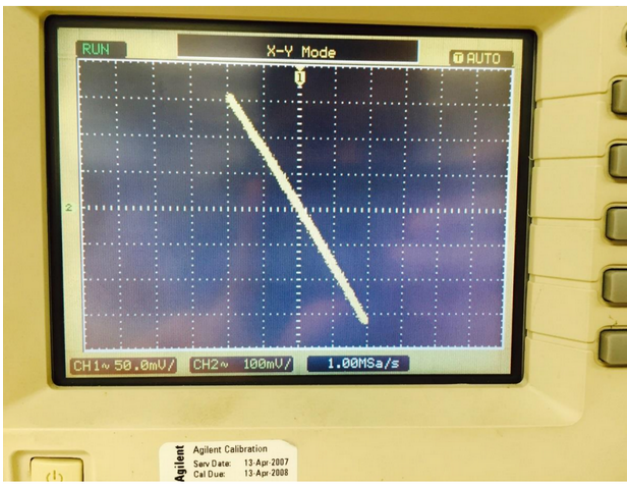

Figure 5: Lissajous Figure of Figure 4

5 Conclusion

Overall this lab was a success. After fully understanding how a BJT amplifier works, the construction and implementation of the circuit was performed with ease, resulting in a fully functional signal amplifier using a transistor. The theoretical results were also used to confirm the experimental results obtained, mathematically proving that this lab was a true victory.