Laboratory Report

Laboratory Exercise No.:	4	**Date Performed:**	February 22, 2025
Laboratory Exercise Title:	Bipolar Junction Transistor (BJT) Characteristics		
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Part I

A **transistor** is a semiconductor device that is used to conduct and insulate current or voltage. It acts as a switch and an amplifier. It is one of the key components in most of the electronic devices that we have currently. Developed in the year 1947 by three American physicists, John Bardeen, Walter Brattain and William Shockley, the transistor is considered one of the most important inventions in the history of science.

It is composed of three semiconductor layers of material which helps to make a connection to an external circuit and carry the current. A voltage or current at one terminal controls the current between the other two. The three terminals are as follows: Base, Collector, and Emitter. The base activates the transistor, the collector is the positive lead, and the emitter is the negative lead.

Figure 1: 2N2222A (NPN BJT Transistor)

A transistor mainly has two types: Bipolar Junction Transistor (BJT) and Field Effect Transistor (FET) but in this activity, we will delve deeper into the Bipolar Junction Transistor. It has two types: PNP and NPN Transistor. A PNP Transistor is a type of BJT that introduces or places one n-type material between two p-type materials. In this arrangement, the gadget will control the flow of current. A PNP transistor consists of two crystal diodes connected in series. The diodes' right and left sides are referred to as the collector-base diode and the emitter-base diode. A NPN Transistor is used to turn weak signals into strong signals. In an NPN transistor, electrons migrate from the emitter to the collector region, causing current to flow through the transistor. This transistor is utilized extensively in the circuit.

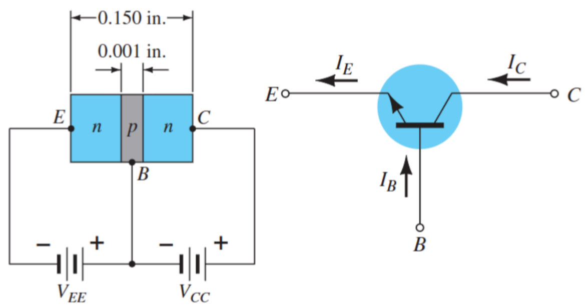

Figure 2: NPN Transistor and Schematic Symbol

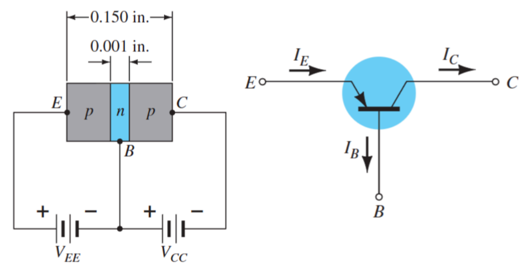

Figure 2.1: PNP Transistor and Schematic Symbol

It has three (3) configurations: common-base, common-emitter, and common-collector, as seen in Figure 3. Each configuration has unique qualities that will be used for its intended application. Each arrangement is obtained through suitable transistor biasing. Figure 3 also depicts the proper biasing of the BJT in each arrangement.

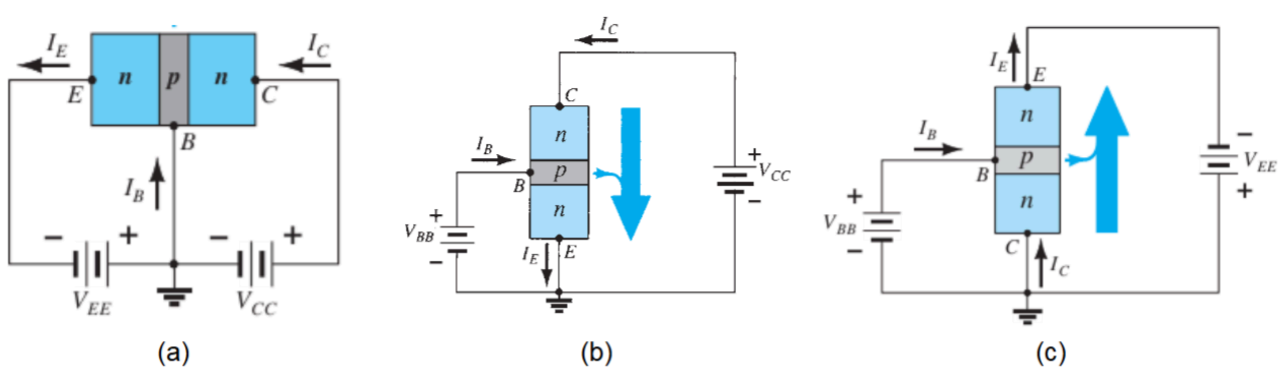

Fig. 3 Common-Base (a), Common-Emitter (b) and Common-Collector (c)

Part IIa: Common-Base Configuration

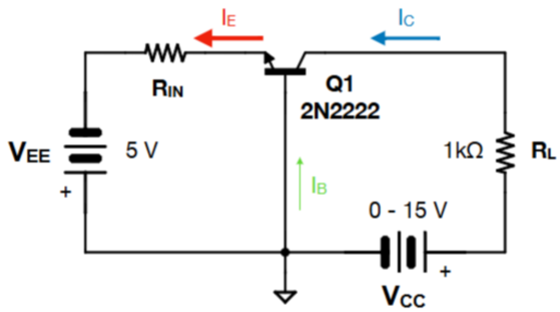

Figure 4.1: Common-Base Circuit

Table 1 - Output Currents (Ic) for Common-Base Configuration Data

V_{CB}	I_C @ I_E = 7 mA	I_C @ I_E = 6 mA	I_C @ I_E = 5 mA	I_C @ I_E = 4mA
0.1V	5.11 mA	6.29 mA	5.23 mA	4.265 mA
0.2V	5.143 mA	6.31 mA	5.232 mA	4.267 mA
0.3V	5.144 mA	6.32 mA	5.233 mA	4.268 mA
0.4V	5.144 mA	6.325 mA	5.235 mA	4.271 mA
0.5V	5.144 mA	6.33 mA	5.237 mA	4.271 mA
0.6V	5.147 mA	6.331 mA	5.238 mA	4.272 mA
0.7V	5.148 mA	6.334 mA	5.239 mA	4.273 mA
0.8V	5.149 mA	6.336 mA	5.241 mA	4.275 mA
0.9V	5.161 mA	6.337 mA	5.242 mA	4.276 mA
1.0V	5.161 mA	6.337 mA	5.246 mA	4.278 mA
2.0V	5.166 mA	6.341 mA	5.247 mA	4.279 mA
3.0V	5.169 mA	6.346 mA	5.248 mA	4.28 mA
4.0V	5.17 mA	6.350 mA	5.251 mA	4.285 mA
5.0V	5.173 mA	6.353 mA	5.252 mA	4.287 mA
6.0V	5.175 mA	6.354 mA	5.253 mA	4.284 mA
7.0V	5.180 mA	6.356 mA	5.254 mA	4.281 mA

Graph:

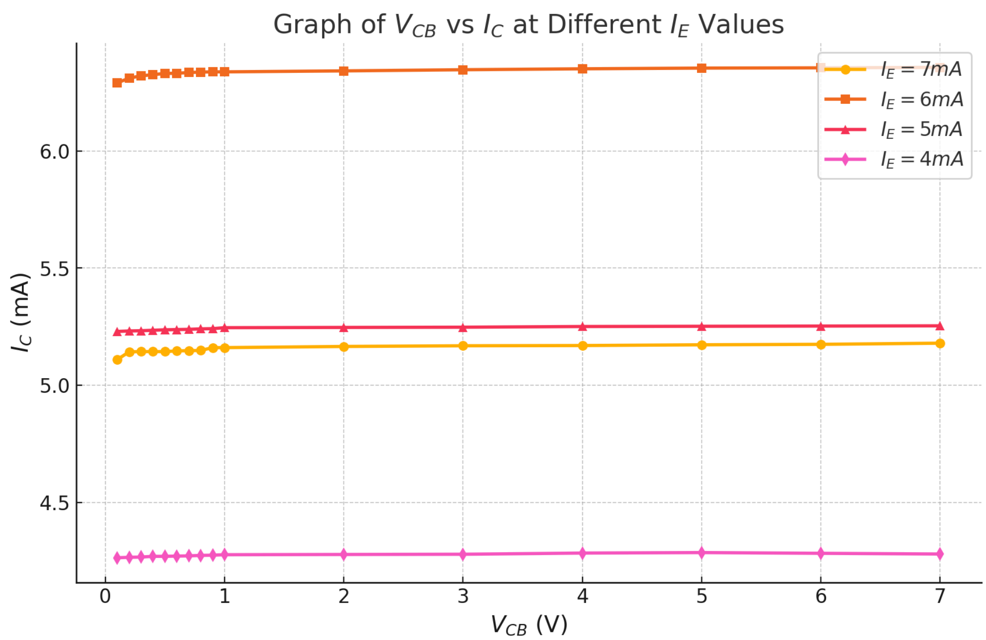

Figure 4.2: Graphical Analysis (Common-Base)

Part IIb: Common-Emitter Configuration

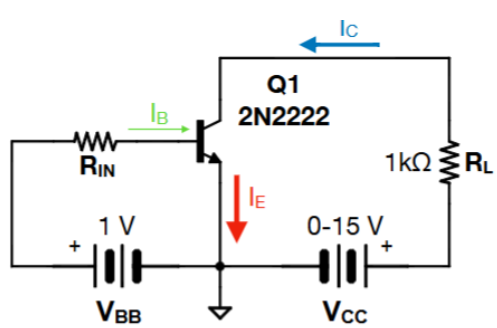

Figure 5.1: Common-Emitter Circuit

Table 2 - Output Currents (Ic) for Common-Emitter Configuration Data

V_{CE}	I_C @ I_B = 50 uA	I_C @ I_E = 70 uA	I_C @ I_E = 90 uA
0.1V	2.921 mA	2.72 mA	3.571 mA
0.2V	5.010 mA	6.840 mA	6.952 mA
0.3V	5.209 mA	6.248 mA	7.248 mA
0.4V	5.243 mA	6.293 mA	7.303 mA

0.5V	5.261 mA	6.308 mA	7.321 mA
0.6V	5.276 mA	6.325 mA	7.330 mA
0.7V	5.279 mA	6.337 mA	7.341 mA
0.8V	5.302 mA	6.351 mA	7.356 mA
0.9V	5.325 mA	6.367 mA	7.370 mA
1.0V	5.332 mA	6.362 mA	7.384 mA
2.0V	5.378 mA	6.392 mA	7.432 mA
3.0V	5.46 mA	6.475 mA	7.496 mA
4.0V	5.567 mA	6.563 mA	7.563 mA
5.0V	5.580 mA	6.621 mA	7.665 mA
6.0V	5.700 mA	6.744 mA	7.715 mA
7.0V	5.806 mA	6.754 mA	7.812 mA

Graph:

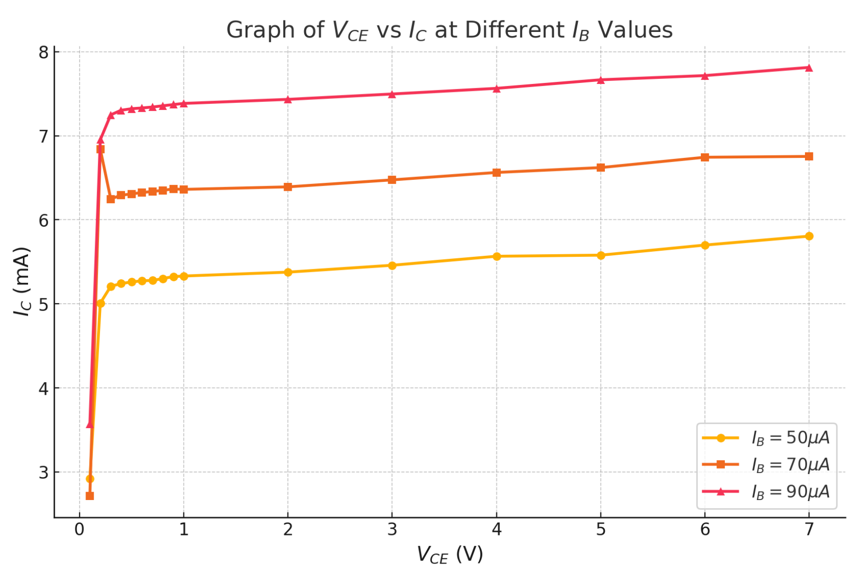

Figure 5.2: Graphical Analysis (Common-Emitter)

Part IIc: Common-Collector Configuration

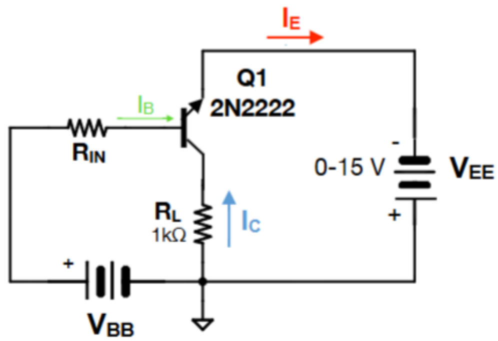

Figure 6.1: Common-Collector Circuit

Table 3 - Output Currents (Ic) for Common-Collector Configuration Data

V_{CE}	I_C @ I_B **= 50 uA**	I_C @ I_E **= 70 uA**	I_C @ I_E **= 90 uA**
0.1V	4.5 mA	6.2 mA	8.01 mA
0.2V	5.8 mA	7.9 mA	9.9 mA
0.3V	7.6 mA	10.5 mA	13.3 mA
0.4V	9.593 mA	13.432 mA	17.251 mA
0.5V	9.612 mA	13.454 mA	17.275 mA
0.6V	9.624 mA	13.473 mA	17.291 mA
0.7V	9.648 mA	13.49 mA	17.319 mA
0.8V	9.663 mA	13.511 mA	17.337 mA
0.9V	9.681 mA	13.527 mA	17.363 mA
1.0V	9.699 mA	13.546 mA	17.381 mA
2.0V	9.731 mA	13.577 mA	17.419 mA
3.0V	9.765 mA	13.613 mA	17.456 mA
4.0V	9.796 mA	13.651 mA	17.496 mA
5.0V	9.83 mA	13.687 mA	17.534 mA
6.0V	9.865 mA	13.722 mA	17.574 mA
7.0V	9.896 mA	13.761 mA	17.611 mA

Graph:

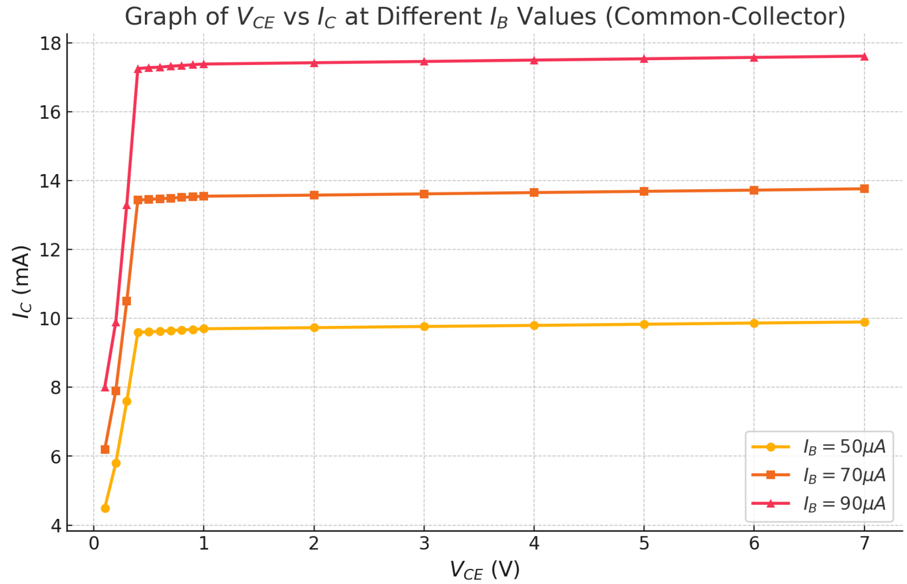

Figure 6.2: Graphical Analysis (Common-Collector)

Part IV

Observe the data in Table 1 (Common-Base output currents), what can you conclude on the output current (I_C) versus the input current (I_E) in terms of current gain (α)?

- The data in Table 1 shows that the collector current (I_C) is slightly less than the emitter current (I_E). This aligns with the theoretical concept that the current gain (α) in a common-base configuration is always slightly less than 1. Since $\boldsymbol{\alpha} = \frac{I_C}{I_E}$, the readings stay reasonably consistent, indicating that the circuit has a stable current relationship. This indicates that a common-base amplifier has a large voltage gain but does not considerably increase current.

Observe the data in Table 2 (Common-Emitter output currents), what can you conclude on the output current (I_C) versus the input current (I_B) in terms of current gain (β)?

- The data in Table 2 indicates that the collector current (I_C) is significantly larger than the base current (I_B**)**, confirming that the common-emitter configuration provides a high current gain (β). Since $\boldsymbol{\beta} = \frac{I_C}{I_B}$, a small increase in I_B results in a large increase in I_C, making this configuration highly effective for signal amplification. This is why common-emitter amplifiers are widely used in audio and signal processing applications.

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Observe the data in gathered in Part IIc (Common-Collector output currents), what can you conclude on the output current (I_C) versus the input current (I_B) in terms of gain (A_i)?

- In the common-collector design, the emitter current (*IE*) is higher than the base current (IB), indicating significant current gain. However, the voltage gain is near to one, indicating that the output voltage closely tracks the input voltage. This demonstrates that the common-collector arrangement is primarily utilized as an impedance matching buffer, not for voltage amplification.

From all the data gathered, what can you say about the characteristics of the different BJT configurations?

- Each transistor configuration serves a specific purpose. The **common-base configuration** offers high voltage gain but low current gain, making it useful for high-frequency applications. The **common-emitter configuration** provides both high current and voltage gain, making it the most commonly used amplifier circuit. The **common-collector configuration** primarily provides current gain while maintaining a stable voltage, making it ideal for impedance matching and buffering applications.

What is the current application of the transistor in the configurations performed in this exercise?

- The common-base arrangement is widely employed in radio frequency (RF) amplifiers and high-speed circuits due to its strong voltage gain and stability at high frequencies. The common-emitter architecture is frequently used in audio amplifiers and signal processing circuits because it may deliver high current and voltage gain, making it suitable for amplification. In contrast, the common-collector topology is generally utilized as a voltage buffer in circuits with high input impedance and low output impedance, such as power supply and impedance-matching applications.

References

[1] **BYJU'S**, "Transistor," *BYJU'S*, [Online]. Available: https://byjus.com/jee/transistor/#parts-of-transistor. [Accessed: 04-Mar-2025].

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[3] **Electronics Tutorials**, "Diode Characteristics," *Electronics Tutorials*, [Online]. Available: https://www.electronics-tutorials.ws/diode/diode_7.html. [Accessed: 04-Mar-2025].