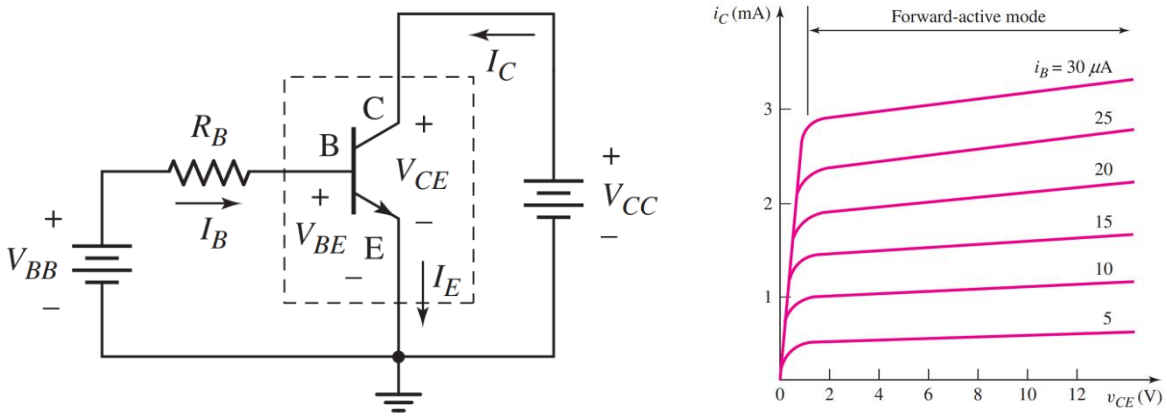
# LAB 5: CURRENT-VOLTAGE CHARACTERISTIC OF BIPOLAR JUNCTION TRANSISTOR (BJT)

## 1. Goals

- Understand the working principle of a BJT.
- Verify the current-voltage (V-A) characteristic of a BJT.
- Build up a switch circuit by using a BJT.

## 2. Exercises

**Exercise 1.** Investigate the current-voltage characteristic of a BJT (*2N2222*) in a Common-Emitter amplifier circuit as shown in Figure 1.




(a) (b)

*Figure 1. Common-Emitter amplifier circuit (a) and V-A characteristic of the BJT (b)*

**Requirements:**

- Implement the circuit in Figure 1 with a resistor ($R_B$ = 94 kΩ) and a transistor *2N2222*. Use a DC power supply to provide $V_{BB}$ (input voltage) = 3V, $V_{CC}$ = 10V.
- Use a multimeter to measure the base current ($I_B$) and the collector current ($I_C$) of the transistor. Compute the *common emitter current gain*, $\beta = \frac{I_C}{I_B}$ of the transistor.
- Keep $V_{BB}$ = 3V so that $I_B$ is unchanged, and then gradually reduce $V_{CC}$ from 9V to 0V (e.g., 9V, 8V, …, 1V, 0.9V, ..., 0.1V, 0V). For each value of $V_{CC}$, use a multimeter to measure $I_C$. Record the measured data.
- Repeat the above procedure with $V_{BB}$ = 5V, $V_{BB}$ = 4V, $V_{BB}$ = 2V, and $V_{BB}$ = 1V, respectively.
- Based on the measured data, plot the current-voltage characteristic of the transistor for each value of $I_B$ (see Figure 1(b)). Write your comments on the current-voltage characteristic. Comment on the increase of $I_C$ with respect to the increase of $V_{CC}$ (note: $V_{CC}$ = $V_{CE}$).

**Exercise 2.** Figure 2 shows a switch circuit. When there is no current flowing through the *Base* (i.e., $V_{IN}$ = 0 and the transistor is in the cut-off mode), the *Collector* and *Emitter* are electrically isolated (i.e., like switching OFF), resulting in the LED OFF (because the circuit is open). When there is a small current flowing through the *Base* by increasing $V_{IN}$ ($V_{IN}$ > $V_{BE}$ (on), the *Collector* and *Emitter* are electrically connected (i.e., like switching ON), resulting in the LED ON (because the circuit is closed).

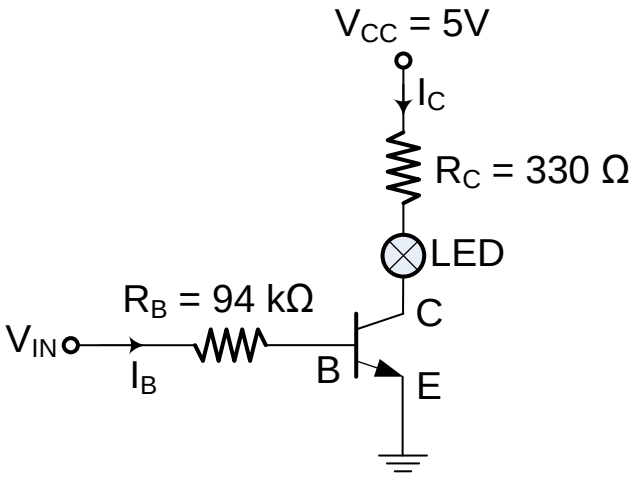



*Figure 2. Switch circuit using a BJT.*

**Requirements:**

- Implement the switch circuit in Figure 2 with $R_B$ = 94 kΩ and $R_C$ = 330 Ω. Use a DC power supply to provide the input voltage $V_{IN}$ in the range of 0-10V (i.e., $V_{IN}$ = 0–10V) and $V_{CC}$ = 5V.
- Observe the status of the LED when $V_{IN}$ = 0V and when $V_{IN}$ > 0V. Comment on the observation.
- Gradually increase $V_{IN}$ from 0V to 10V and observe the brightness of the LED. Comment on the results.
- Use a multimeter to measure $I_C$ (the current flows through $R_C$ and the LED) with $V_{IN}$ = 1V, $V_{IN}$ = 3V, $V_{IN}$ = 5V, $V_{IN}$ = 7V, and $V_{IN}$ = 9V, respectively. Record and explain the measured data.

**Components and devices needed for the lab:**

| Components and Devices | Description | Amount |
|---|---|---|
| BJT | 2N2222, 50V-1A | 1 |
| Resistor | 330 Ω / 47 or 50 kΩ | 1/2 |
| DC power supply | Aditeg, 0-12V | 1 |
| Breadboard | | 1 |
| Wire | | few |
| Multimeter | | 1 |


| 2N2222A | |
|---|---|
| 1 | Emitter |
| 2 | Base |
| 3 | Collector |

**Exercise 1: I-V**

| $V_{BB}$ (V) | $V_{CC}$ (V) | $I_C$ (mA) |
|---|---|---|
| 5 | 9 | |
| | 8 | |
| | 7 | |
| | 6 | |
| | 5 | |
| | 4 | |
| | 3 | |
| | 2 | |
| | 1 | |
| | 0,5 | |
| | 0 | |
| 4 | 9 | |
| | 8 | |
| | 7 | |
| | 6 | |
| | 5 | |
| | 4 | |
| | 3 | |
| | 2 | |
| | 1 | |
| | 0,5 | |
| | 0 | |
| 3 | 9 | |
| | 8 | |
| | 7 | |
| | 6 | |
| | 5 | |
| | 4 | |
| | 3 | |
| | 2 | |
| | 1 | |
| | 0,5 | |
| | 0 | |
| 2 | 9 | |
| | 8 | |
| | 7 | |
| | 6 | |
| | 5 | |
| | 4 | |
| | 3 | |
| | 2 | |
| | 1 | |
| | 0,5 | |
| | 0 | |
| 1 | 9 | |
| | 8 | |
| | 7 | |
| | 6 | |
| | 5 | |
| | 4 | |
| | 3 | |
| | 2 | |
| | 1 | |
| | 0,5 | |
| | 0 | |

**Exercise 2**

**LED observation**

| $V_{CC}$ (V) | $V_{IN}$(V) | LED observation |
|---|---|---|
| 5 | 0 | |
| | 1 | |
| | 2 | |
| | 3 | |
| | 4 | |
| | 5 | |
| | 6 | |
| | 7 | |
| | 8 | |
| | 9 | |

**$I_C$ Values**

| $V_{CC}$ (V) | $V_{IN}$(V) | $I_C$ (mA) |
|---|---|---|
| 5 | 1 | |
| | 3 | |
| | 5 | |
| | 7 | |
| | 9 | |