جامعة بيرزيت

BIRZEIT UNIVERSITY

Faculty of Engineering and Technology
Electrical and Computer Engineering Department
Electronics LAB (ENEE3102)
Report of Experiment #3
The Transistor Biasing and the DC Parameters

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Date:

20/9/2020

Section: #1

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Abstract:

In this experiment the supplies connections to the transistor, the characteristics of the BJT transistor for varying DC supply and the three modes the transistor could get in (active, saturation and cut-off regions) were examined.

Theory:

The Bipolar Junction Transistor (BJT) is a semiconductor, three terminal device that can amplify the signal, consists of:

1. Base.
2. Emitter.
3. Collector.

There are two types of BJTs:

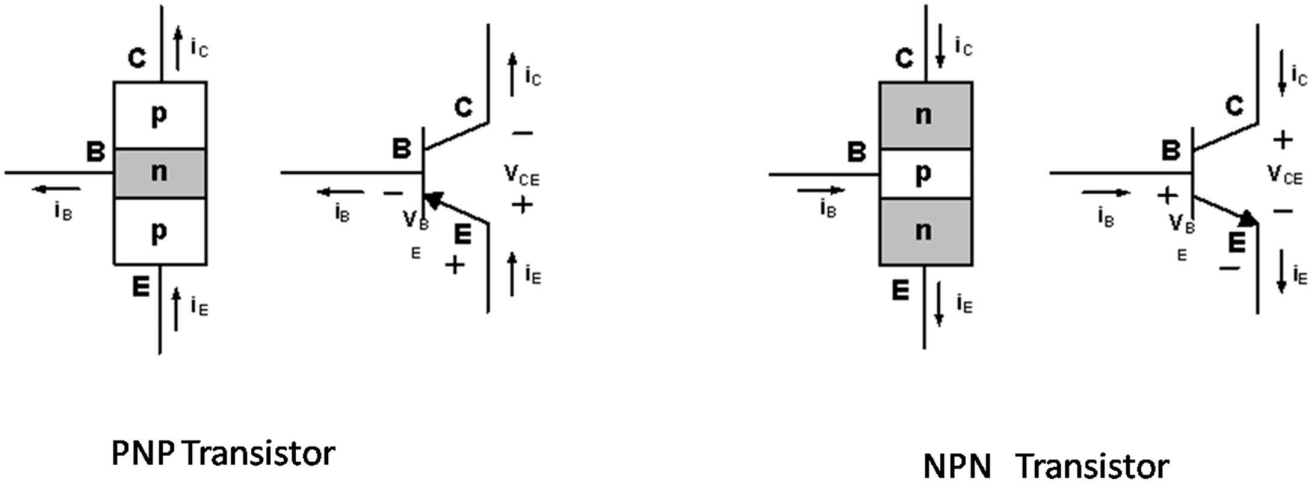


Figure 1

BJT transistor types:

1. **Active region:** The Emitter-Base junction should be forward biased, and the Collector-Base should be Reverse biased.

$$I_C = \alpha I_E$$
$$I_C = \beta I_B$$
$$I_E = (1+\beta)\, I_B$$
$$B = \frac{\alpha}{1-\alpha}$$

2. **Saturation region:** The Emitter-Base junction should be forward biased, and the Collector-Base should be forward biased.

$$V_{CE} = V_{CE,sat}$$
$$V_{BE} = 0.8V, \text{ Si, npn}$$
$$V_{BE} = -0.8V, \text{ Si, pnp}$$

3. **Cut-off region:** The Emitter-Base junction should be reverse biased, and the Collector-Base should be Reverse biased.

$$I_B = I_C = I_E = 0$$

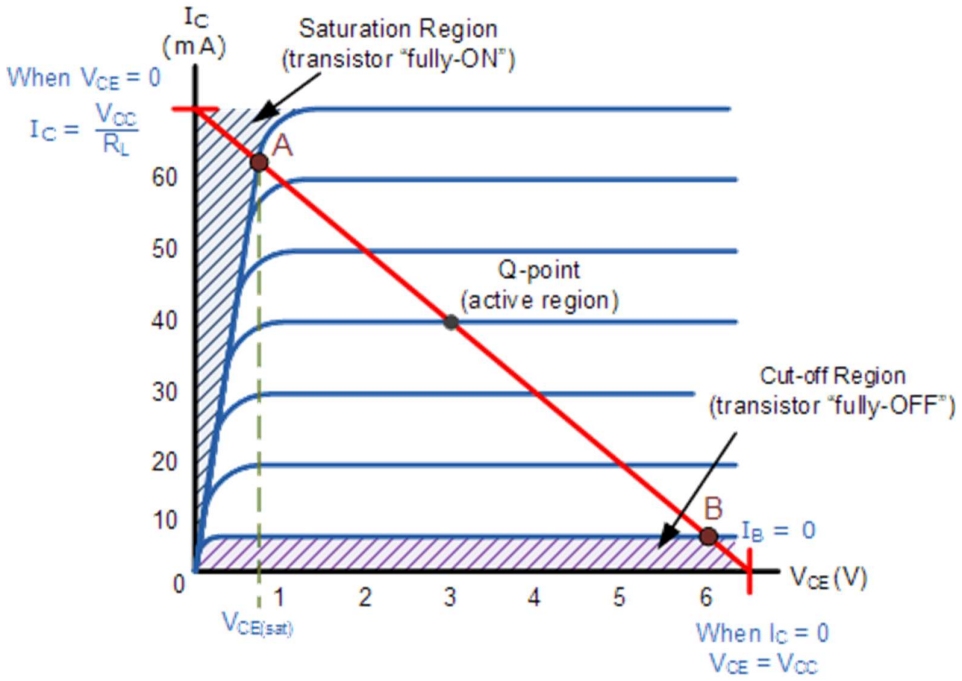


Figure 2

Usually BJT transistor works as an amplifier in the active region and as a switch in the cut-off region.

Procedure, Data and results:

I. The Transistor Biasing:

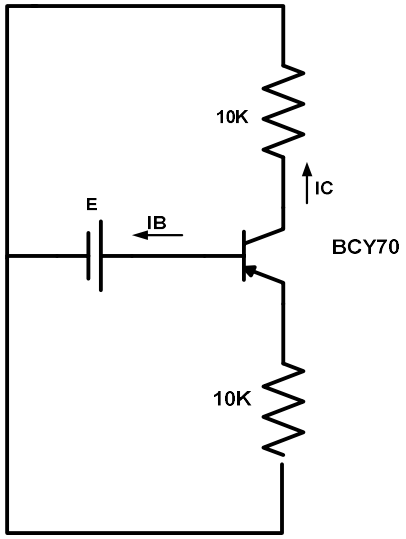


Figure (3-1)

PNP transistor:

First, the circuit above was connected, and the variable DC supply was set to 4volts, the supply makes both junctions reversed so the BJT transistor is in the cut-off region.

$$I_C = 0.01mA$$

$$I_B = 0.01mA$$

$$I_E = 0.01mA$$

then the connection of the supply was reversed so both junctions were forward biased, and the transistor was in the saturation region.

$$I_C = - 0.334A$$

$$I_B = 0.66A$$

$$I_E = 0.334A$$

NPN transistor:

The PNP transistor was replaced with NPN transistor and the variable DC supply was set to 4volts, so the transistor was in the saturation region the currents were measured:

$$I_C = 0.34A$$

$$I_B = - 0.68A$$

$$I_E = 0.333A$$

then the connection of the supply was reversed so both junctions were forward biased, and the transistor was in the reverse region, and the currents were measured:

$$I_C = 0mA$$

$$I_B = 0mA$$

$$I_E = 0mA$$

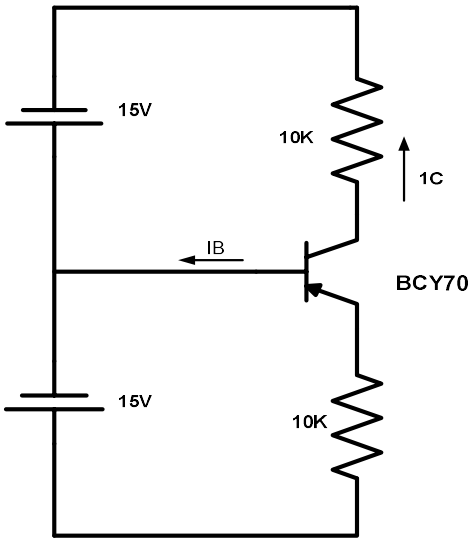


Figure (3-2)

PNP transistor:

First, the circuit above was connected, and the variable DC supplies were set to 15volts, the supplies make BE junction forward biased, and BC junction reverse biased, so the transistor is in Active region.

$I_C = 1.42mA$

$I_B = 0.12mA$

$I_E = 1.43mA$

then the connection of the supplies was reversed so BE junction reversed biased, and BC junction forward biased, so the transistor is in Reverse region.

$I_C = - 1.42mA$

$I_B = 0.031mA$

$I_E = - 1.11mA$

NPN transistor:

First, the circuit above was connected, and the variable DC supplies were set to 15volts, the supplies make BE junction reverse biased, and BC junction forward biased, so the transistor is in Reverse region.

$I_C = 1.43mA$

$I_B = 0.02mA$

$I_E = -1.23mA$

then the connection of the supplies was reversed so BE junction forward biased, and BC junction reversed biased, so the transistor is in Active region.

$I_C = -1.42mA$

$I_B = 0.012mA$

$I_E = -1.44mA$

II. The Transistor DC Parameters:

A. Input Characteristic:

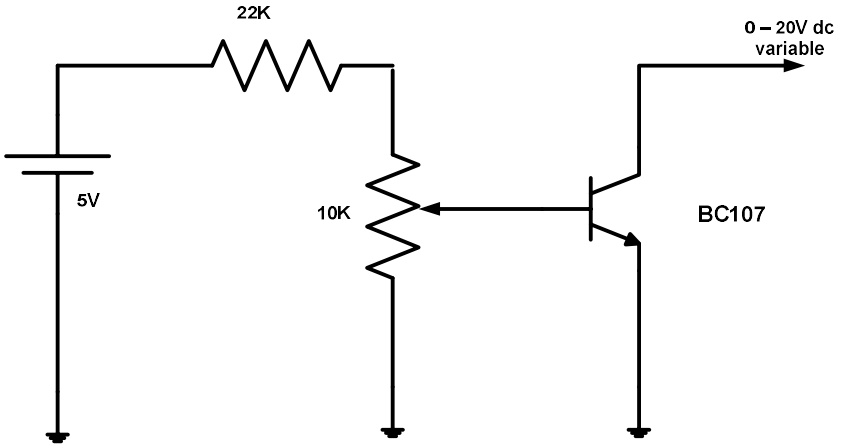
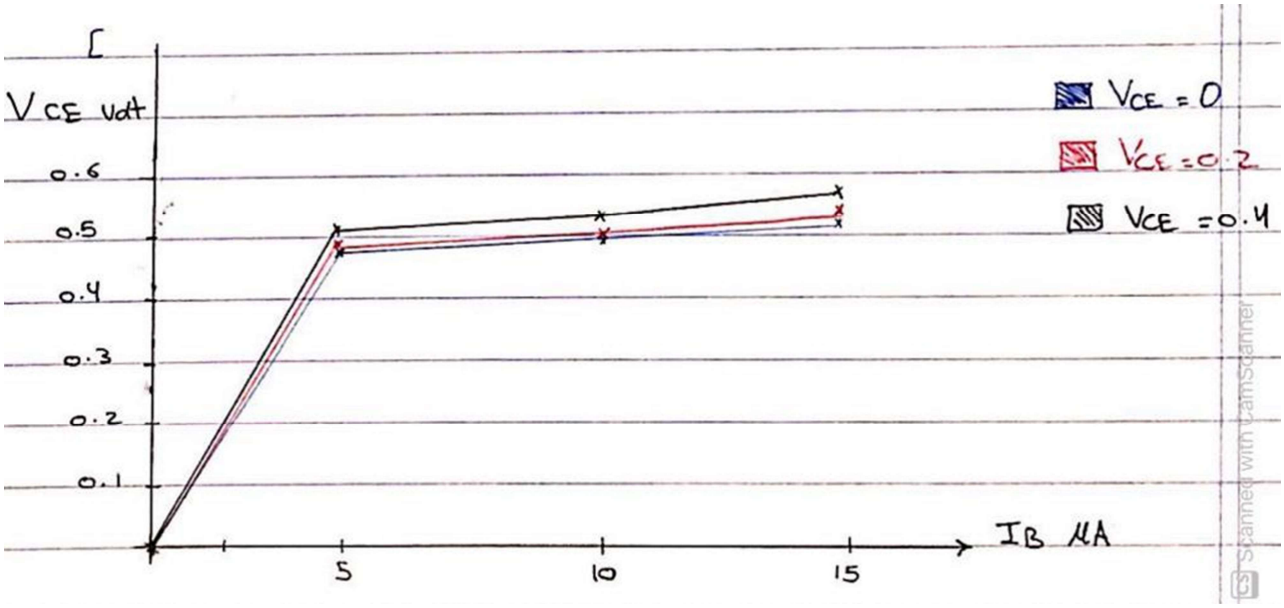


Figure (3-3)

The circuit above was connected, then the V_{CE} and I_B were set to equal 0, then the Base-Emitter voltage was measured, the potentiometer was used to adjust the value of the base current according to the table down below:

V_{CE}	I_B[uA]	V_{BE} [V]
0	0	0
	5	0.483
	10	0.492
	15	0.510
0.2	0	0
	5	0.489
	10	0.496
	15	0.513
0.4	0	0.01
	5	0.510
	10	0.523
	15	0.544

Table 1



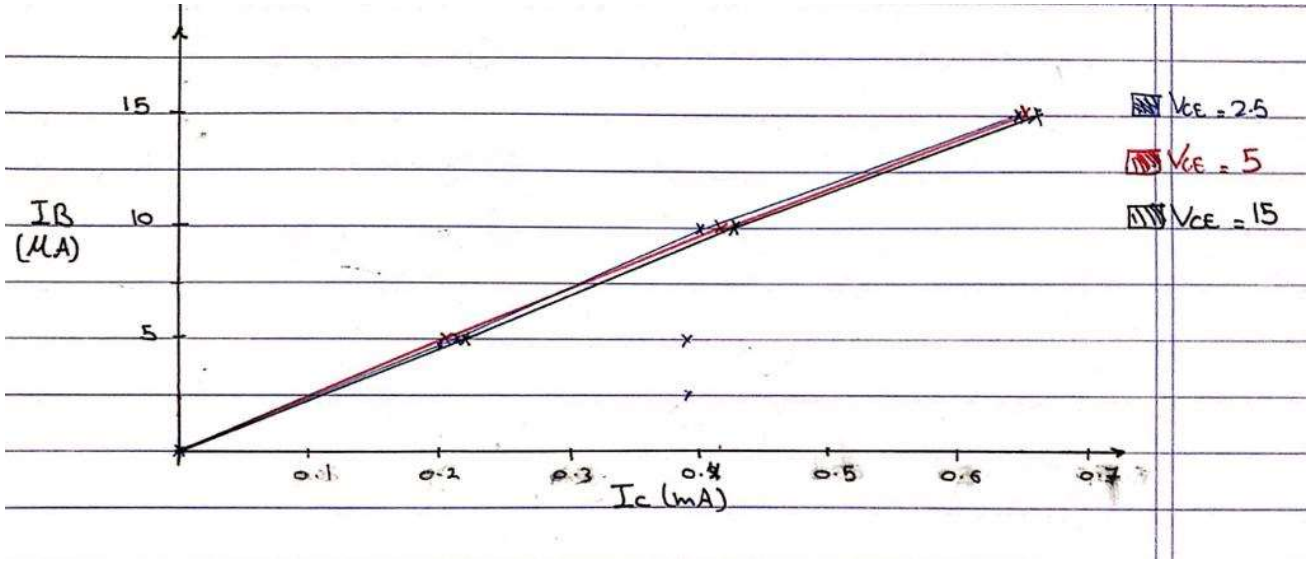
V_{BE} vs I_B

B. Forward Voltage Characteristic:

For the same circuit in figure (3-3) V_{CE} was set to 2.5volts, and the potentiometer was used to adjust the value of the base current according to the table down below:

V_{CE}	I_B[uA]	I_C [mA]
2.5	0	0
	5	0.203
	10	0.411
	15	0.645
5	0	0
	5	0.207
	10	0.415
	15	0.652
15	0	0
	5	0.214
	10	0.421
	15	0.665

Table 2



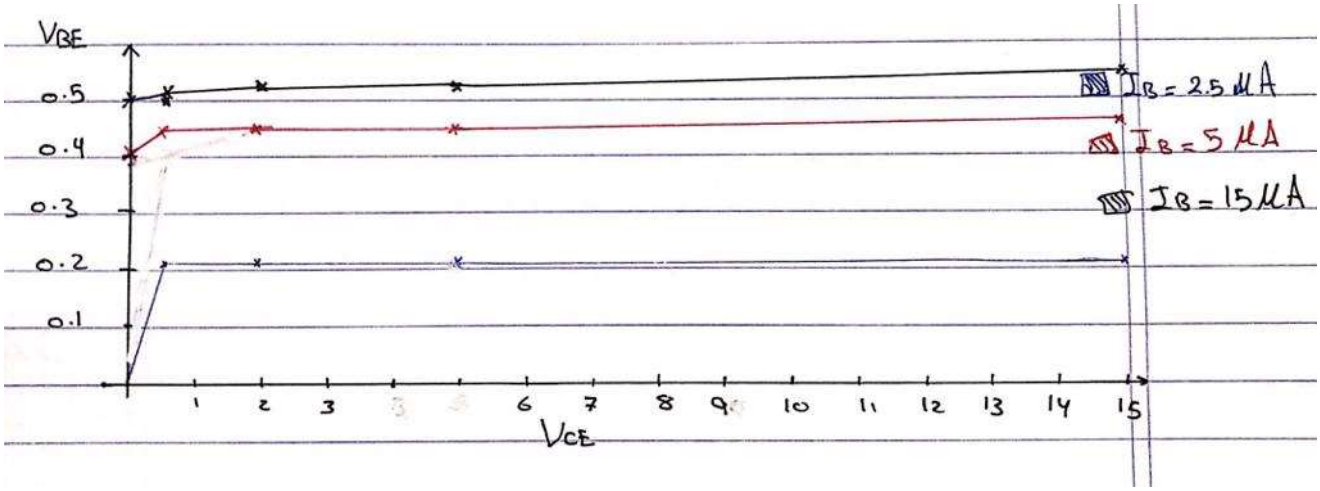
I_B vs I_C

C. Reverse Voltage Characteristics:

For the same circuit in figure (3-3) V_{BE} was measured according to the table down below:

I_B [uA]	V_{CE}[V]	V_{BE}[V]
2.5	0	0
	0.5	0.22
	2	0.223
	5	0.223
	15	0.23
5	0	0.42
	0.5	0.45
	2	0.45
	5	0.453
	15	0.46
15	0	0.50
	0.5	0.502
	2	0.509
	5	0.51
	15	0.51

Table 3



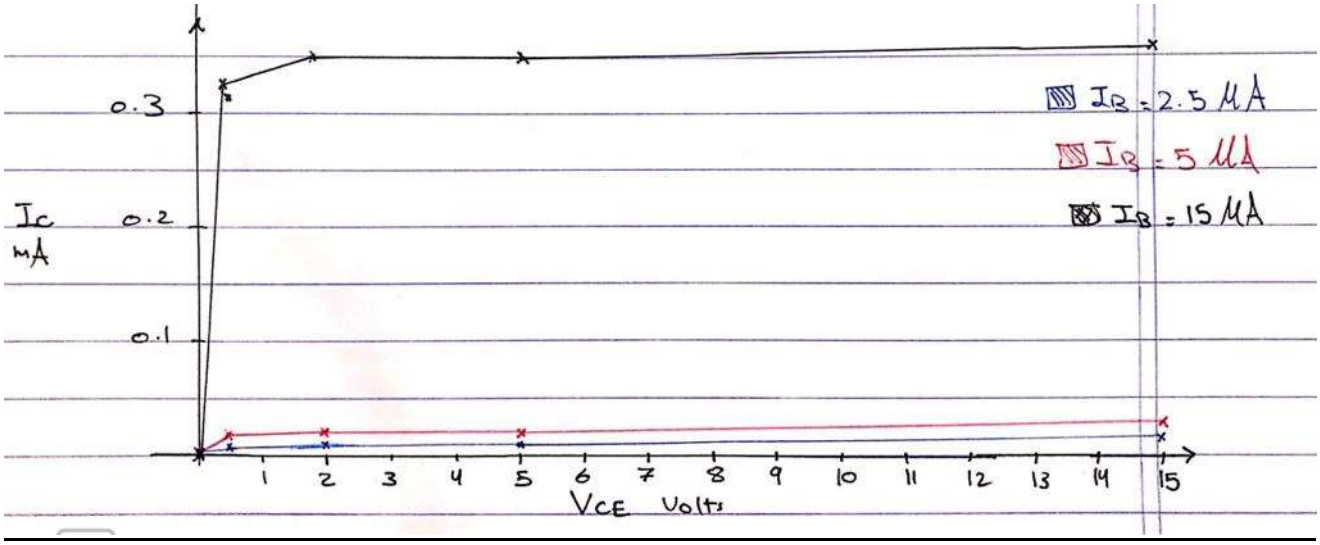
V_{BE} vs V_{CE}

D. The output Characteristic:

For the same circuit in figure (3-3) V_{BE} was measured according to the table down below:

I_B [uA]	V_{CE}[V]	I_C [mA]
2.5	0	0
	0.5	0.003
	2	0.003
	5	0.003
	15	0.004
5	0	0.020
	0.5	0.023
	2	0.024
	5	0.024
	15	0.025
15	0	0.00
	0.5	0.33
	2	0.35
	5	0.35
	15	0.36

Table 4



Questions:

- $H_{IE} = (\Delta V_{BE}/\Delta I_B)$ |vce=0.----------> input characteristic

  $H_{IE} = \frac{0.510-0.483}{15-10} = 5.4k\ ohm$

- $H_{RE} = (\Delta V_{BE}/\Delta V_{CE})$ | ib=0. ----------> reverse characteristic

  $H_{RE} = \frac{0.23-\ .22}{15-0.5} = 0.0006$

- $H_{OE} = (\Delta I_C/\Delta V_{CE})$ | ib=0. ----------> output characteristic

  $H_{OE} = \frac{(0.004-0.003)*10^{-3}}{15-0.5} = 0.6 * 10\text{^} - 7$

- $H_{FE} = (\Delta I_B/I_C)$ | vce=0. ----------> forward current transfer characteristic.

  $H_{FE} = \frac{(15-5)*10^{-6}}{(0.645\quad .203)*10^{-3}}$ = 0.0226

Conclusion:

Finally, after comparing our measured values with the theoretical values taken from pspice simulation, they were very close to each other, and the small difference was due to some systematic errors.

This experiment was very helpful in getting to know BJT transistor and it's operating principle, types and structure.

References:

1. https://www.electrical4u.com/bipolar-junction-transistor-or-bjt-n-p-n-or-p-n-p-transistor/
2. Electronics Lab ENEE3102 Lab Manual
3. Microelectronic_Circuits_6th_Edition