Experiment No. 8

Transistor Characteristics Circuit

1. OBJECTIVES

- ❖ To determine the current amplification factor (β) of a **2N 2222 A** transistor.
- ❖ To construct its **dc load line** (a representation of the combinations of the collector current and the collector-emitter voltage)

2. COMPONENTS REQUIRED

- ❖ Power supply (0-15 v).
- ❖ Digital Ammeters (0 - 200 mA, 0-200 μA).
- ❖ Bread Board.
- ❖ Connecting wires.
- ❖ 2N2222 A transistor.
- ❖ Digital Voltmeter (0 - 20V).
- ❖ Resistor 1kΩ.
- ❖ Variable Resistor.

3. THEORY

A **Bipolar Junction Transistor** or **BJT** is a three terminal device having two PN-junctions connected together in series. Each terminal is given a name to identify it and these are known as the Emitter (E), Base (B) and Collector (C). There are two basic types of bipolar transistor construction, **NPN** and **PNP**, which basically describes the physical arrangement of the P-type and N-type semiconductor materials from which they are made. Bipolar Transistors are "CURRENT" Amplifying or current regulating devices that control the amount of current flowing through them in proportion to the amount of biasing current applied to their base terminal. The principle of operation of the two transistors types NPN and PNP, is exactly the same the only difference being in the biasing (base current) and the polarity of the power supply for each type.

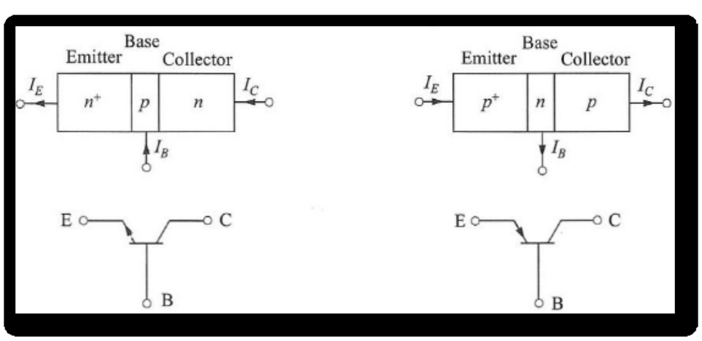


Fig. 1: The symbolic representations for both the NPN and PNP bipolar transistor.

The symbolic representations for both the NPN and PNP bipolar transistor are shown above along with the direction of conventional current flow. The direction of current flow when emitter-base junction is forward biased.

As we said, bipolar transistors have three terminals: base, emitter, and collector. Transistors characteristics are graphs of the various currents (I_B is current into the base, I_E is current out of the emitter, and I_C is current into collector) and voltages. Conservation of charge yields:

$$I_E = I_C + I_B$$

Actually the base current is usually quite small compared with the other two currents and to a good approximation $I_C = I_E$.

For the BJT, there are three regions of operation;

a. Active region: In this region, the base emitter junction is forward biased and the base-collector junction is reverse biased. This region is the normal transistor operation mode for amplification, and is characterized by the transistor current gain value, **beta**.

Current amplification factor (β) is defined as the ratio of the change in collector current to the change in base current at a constant collector-emitter voltage (V_{CE}) when the transistor is in active state.

$$\beta_{ac} = \frac{\Delta I_C}{\Delta I_B}$$

This is also known as small signal current gain and its value is very large. The ratio of $I_C$and I_B we get what is called βdc of the transistor. Hence,

$$\beta_{ac} = \frac{I_C}{I_B}$$

Since I_C increases with I_B almost linearly, the values of both βdc and βac are nearly equal.

Similarly an **α** factor is defined as the ratio between I_C to I_E. Thus;

$$\beta = \frac{I_C}{I_B} \qquad and \quad \boldsymbol{\alpha} = \frac{I_C}{I_E}$$

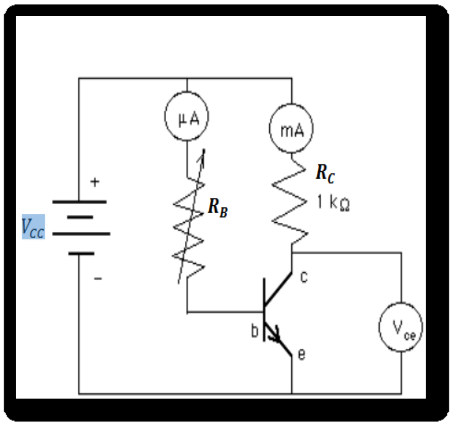
It can be easily shown that $\beta = \alpha/(1-\alpha)$ and $\alpha = \beta/(\beta+1)$.

As a rule of thumb, the larger the value of β, the higher the gain obtainable from the transistor, i.e. the better the transistor. Typical values for β ranges from about 80 to 300 or higher.

b. Cut-off region: In this region, both base-emitter and base-collector junctions are reverse biased and the transistor acts like an open switch. ($I_C = 0$)

c. Saturation region: In this region, both base emitter and base-collector junctions are forward biased and the transistor acts like a closed switch. (V_{CE}= 0)

The basic circuit diagram for studying **Current amplification factor (β)** is shown in the circuit diagram.



$V_{CC}= V_{CE}+I_C R_C$

At cutoff $I_{C(off)}= 0$

$V_{CE(off)}= V_{CC}$

At saturation $V_{CE(sat)}= 0$

$I_{Csat)}=\frac{V_{CC}}{R_C}$

Fig. 2: The basic circuit diagram for studying Current amplification factor (β).

4. PROCEDURE

- **Current amplification factor (β)**

1. Connect the circuit as shown in the circuit diagram.
2. Keep the voltage V_{CC}= 9V.
3. Vary the variable resistor $\boldsymbol{R_B}$ several times, note down base current I_B and collector current I_C.
4. Graph the collector current I_C versus the base current I_B.
5. Determine from the slope the numerical value of **β** for the above transistor.
6.

R_B	$\boldsymbol{I_B}$	$\boldsymbol{I_C}$
1 $M\Omega$		
680 kΩ		
470 kΩ		
330 kΩ		
270 kΩ		
220 kΩ		

- **Construction of Dc load line**

1. Connect the circuit as shown in the circuit diagram.
2. Keep the voltage V_{CC}= 9V.
3. Vary the variable resistor $\boldsymbol{R_B}$ several times, so that you are able to measure about five combinations of $\boldsymbol{I_C}$ and $\boldsymbol{V_{CE}}$ over the active region of the dc load line , note down the collector current I_C and the Collector-Emitter Voltage(V_{CE}) in the table below.
4. Continue to vary the variable resistor $\boldsymbol{R_B}$ untill $V_{CE(off)}$ reaches a maximum value then measure the corresponding collector current $I_{C(off)}$. Record both $V_{CE(off)}$ and $I_{C(off)}$in the table below.
5. Now vary the variable resistor $\boldsymbol{R_B}$ until V_{CE} reaches a minimum value $V_{CE(sat)}$then measure the corresponding collector current $I_{C(sat)}$. Record both $V_{CE(sat)}$ and $I_{C(sat)}$in the table below.
6. Using above equations, determine the saturation and cutoff point on the dc load line for this circuit and record theses values.
7. Graph the collector current I_C versus the Collector-Emitter Voltage(V_{CE}).
8. On the graph label the active region, the cutoff region and the saturation region.

Condition	R	$\boldsymbol{I_C}$	$\boldsymbol{V_{CE}}$
Cutoff Region	1.2 $M\Omega$		
	1.4 $M\Omega$		
	1.6 $M\Omega$		
	1.9 $M\Omega$		
	3 $M\Omega$		
	4 $M\Omega$		
	5 $M\Omega$		
	6 $M\Omega$		
	7$M\Omega$		
	8$M\Omega$		
	9$M\Omega$		
Active Region	1 $M\Omega$		
	680 KΩ		
	470 kΩ		
	330 kΩ		
	270 kΩ		
	220 kΩ		
Saturation Region	200 kΩ		
	180 kΩ		
	160 kΩ		
	150 kΩ		
	120 kΩ		
	110 kΩ		
	100 kΩ		