EXPERIMENT

Static characteristics of Bipolar Junction Transistor (Common Emitter Configuration)

1 Objectives

To study the input and output characteristics of an NPN transistor in Common Emitter mode and determine transistor parameters.

2 Circuit components/equipment

1. Transistor (BC 547 or equivalent)
2. Resistors (2 Nos.)
3. Multimeters (3 Nos.)
4. DC power supply
5. Connecting wires
6. Breadboard.

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 control 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 transistor 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. The symbols for both the NPN and PNP bipolar transistor are shown above along with the direction of conventional current flow. The direction of the arrow in the symbol shows current flow between the base and emitter terminal, pointing from the positive P- type region to the negative N-type region, exactly the same as for the standard diode symbol. For normal operation, the emitter-base junction is forward-biased and the collector-base junction is reverse-biased.

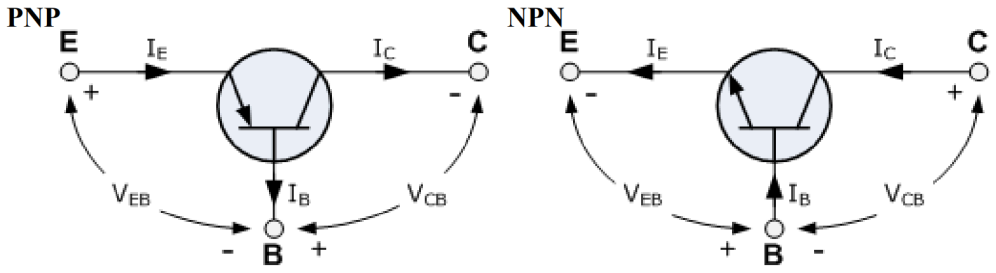

Figure 1: Schematic diagrams of PNP and NPN transistors.

Transistor configurations

There are three possible configurations possible when a transistor is connected in a circuit:

1. Common base
2. Common emitter
3. Common collector.

We will be focusing on the common emitter configurations in this experiment. The behavior of a transistor can be represented by DC current-voltage (I-V) curves, called the static characteristic curves of the device. The three important characteristics of a transistor are:

1. Input characteristics
2. Output characteristics
3. Transfer Characteristics.

These characteristics give information about various transistor parameters, e.g. input and output dynamic resistance, current amplification factors, etc.

Common Emitter Transistor Characteristics

In a common emitter configuration, emitter is common to both input and output as shown in its circuit diagram (Figure 1).

1. **Input Characteristics:** The variation of the base current IB with the base-emitter voltage V_{BE} keeping the collector-emitter voltage V_{CE} fixed, gives the input characteristic in CE mode.

   Input Dynamic Resistance (r_i)**:** This is defined as the ratio of change in base emitter voltage (ΔV_{BE}) to the resulting change in base current (ΔI_B) at constant

collector-emitter voltage (V_{CE}). This is dynamic and it can be seen from the input characteristic, its value varies with the operating current in the transistor:

$$r_i = \left|\frac{\Delta V_{BE}}{\Delta I_B}\right|_{V_{CE}}$$

The value of r_i can be anything from a few hundred to a few thousand ohms.

2. **Output Characteristics:** The variation of the collector current IC with the collector- emitter voltage V_{CE} is called the output characteristic. The plot of I_C versus V_{CE} for different fixed values of I_B gives one output characteristic. Since the collector current changes with the base current, there will be different output characteristics corresponding to different values of I_B.

   Output Dynamic Resistance (r_o)**:** This is defined as the ratio of change in collector- emitter voltage ΔV_{CE} to the change in collector current ΔI_C at a constant base current I_B.

$$r_o = \left|\frac{\Delta V_{CE}}{\Delta I_C}\right|_{I_B}$$

3. **Transfer Characteristics:** The transfer characteristics are plotted between the input and output currents (I_B versus I_C), keeping a constant collector-emitter voltage (V_{CE}). Both I_B and I_C increase proportionately.

4. **Current amplification factor** (β)**:** This 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.

$$\beta_{ac} = \left|\frac{\Delta I_C}{\Delta I_B}\right|_{V_{CE}}$$

   This is also known as small signal current gain and its value is very large. The ratio of I_C and I_B gives us what is called β_{dc} of the transistor. Hence,

$$\beta_{dc} = \left|\frac{\Delta I_C}{\Delta I_B}\right|_{V_{CE}}$$

   Since I_C increases with I_B almost linearly, the values of both β_{ac} and β_{dc} are nearly equal.

4 Circuit diagram

The circuit diagram is shown in Figure 2.

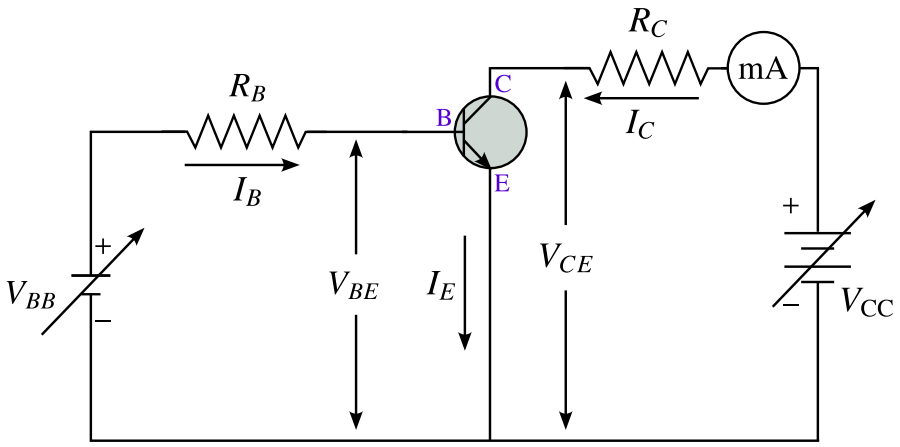

Figure 2: NPN transistor in CE configuration.

5 Procedure

Input characteristics

1. Note down the code of the transistor.

2. Identify different terminals (E, B and C) and the type (PNP/NPN) of the transistors. For any specific information refer to the datasheet of the transistors.

3. Now configure the CE circuit using the NPN transistor as per the circuit diagram. Use $R_B = 100$ kΩ and $R_C = 1$ kΩ.

4. For input characteristics, first fix the voltage V_{CE} by adjusting V_{CC} to the minimum possible position. Now vary the voltage V_{BB} slowly (say, in steps of 0.2 V) and measure current I_B and voltage V_{BE} using a multimeter. If V_{CE} varies during measurement, bring it back to the set value.

5. Repeat the above step for another value of V_{CE} say, 2 V.

6. Plot the graph I_B vs. V_{BE}.

Output characteristics

1. First fix $I_B = 0$, i.e. $V_{R_B} = 0$. Vary the collector voltage V_{CC} in steps of say 1 V and measure V_{CE} and the corresponding I_C using multimeters.

2. Repeat the above step for at least 5 different values of I_B by adjusting V_{BB}. You may need to adjust V_{BB} continuously during measurement in order to maintain a constant I_B.

3. Plot the graph I_C vs. V_{CE}.

Table 1: Input characteristics.

Sl. No.	V_{CE} = _____ V	
	V_{BE} (V)	I_B (μA)
1		
2		
...		
10		

4. To plot transfer characteristics, select a suitable voltage V_{CE} well within the active region of the output characteristics, which you have tabulated already (no need to take further data). Plot a graph between I_C and the corresponding I_B at the chosen voltage V_{CE}.

6 Observations

Transistor code: _____ , R_B = _____ , R_C = _____

Table 2: Output characteristics.

Sl. No.	$I_{B_1} = 0$		I_{B_2} =		I_{B_3} =		I_{B_4} =		I_{B_5} =	
	V_{CE} (V)	I_C (mA)	V_{CE} (V)	I_C (mA)	V_{CE} (V)	I_C (mA)	V_{CE} (V)	I_C (mA)	V_{CE} (V)	I_C (mA)
1										
2										
...										
10										

Table 3: Transfer characteristics. V_{CE} = _____ V.

Sl. No.	I_B (μA)	I_C (μA)
1		
2		
3		
4		
5		

7 Graphs

Plot the input, output and transfer characteristics for each configuration.

1. **Input characteristics:** Plot $V_{BE} \sim I_B$, for different VCE and determine the input dynamic resistance in each case at suitable operating points.
2. **Output characteristics:** Plot $V_{CE} \sim I_C$, for different IB and determine the output dynamic resistance in each case at suitable operating points in the active region.
3. **Transfer characteristics:** Plot $I_B \sim I_C$, for a fixed V_{CE} and determine β_{ac}.

8 Calculation

1. **Small-signal current gain:** $\beta_{ac} = \Delta I_C / \Delta I_B$ with the V_{CE} at a constant voltage.
2. **Dynamic input resistance:** It is given by $\Delta V_{BE} / \Delta I_B$ at constant V_{CE}
3. **Dynamic output resistance:** It is given as $\Delta V_{CE} / \Delta I_C$ at constant I_B

9 Results

10 Precautions