

Object : To study the characteristic curves of a PNP or NPN junction transistor in the common emitter (CE) mode configuration and determination of current gain.

Apparatus Required : PNP or NPN junction transistor, two batteries, two rheostats, a voltmeter, a millivoltmeter, a microammeter, connecting wires.

Description of the Apparatus : The electric circuit for the PNP transistor in the CE mode is shown in Fig. 46.

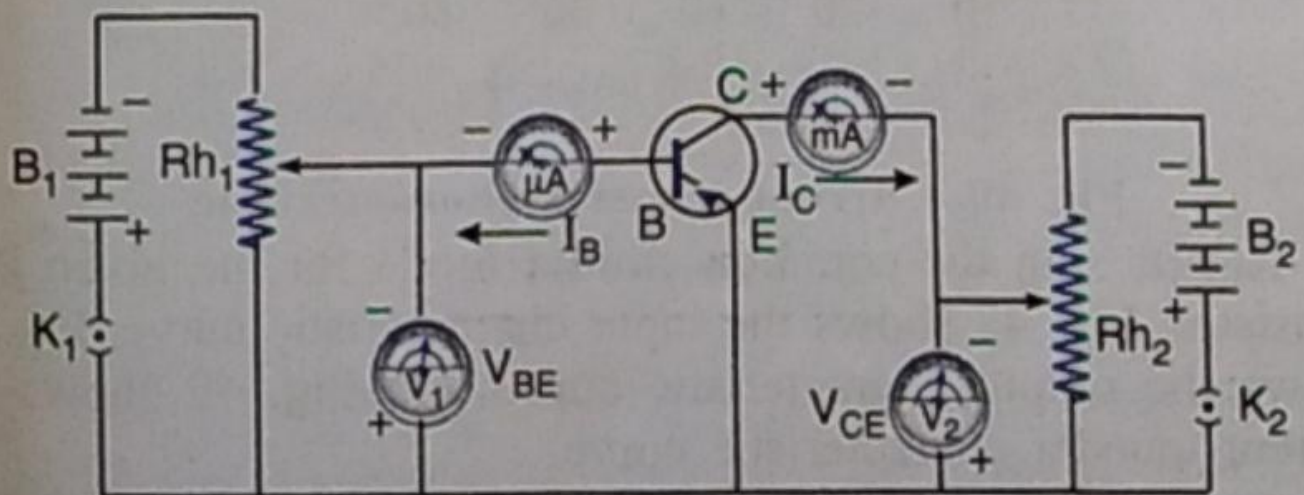


Fig. 46

The base-emitter junction is in the forward bias and the collector-emitter junction is in the reverse bias. A voltage V_{BE} is applied between the base B and the emitter E by means of a potential divider of battery B_1 from a rheostat Rh_1 . The value

of base-emitter voltage V_{BE} is read by a voltmeter V_1 and the base current I_B is read by the microammeter μA . A voltage V_{CE} is applied between the collector and the emitter by means of a potential divider of battery B_2 through the rheostat Rh_2 . The collector emitter voltage V_{CE} is read by the voltmeter V_2 and the collector current I_C is read by the milliammeter mA .

Note that for the NPN transistor, the terminals of the battery B_1 and B_2 are reversed.

Theory : In this experiment we draw the following three characteristic curves :

(1) **Input characteristic curve :** For this, graphs are plotted for the base-current I_B versus base-emitter voltage V_{BE} for different constant collector-emitter voltage V_{CE} (Fig. 47). This is called the input characteristic curve.

(2) **Output characteristic curve :** For this, graphs are plotted for the collector-current I_C versus collector-emitter voltage V_{CE} for the different constant base current I_B (Fig. 48). This is called the output characteristic curve.

(3) **Current transfer characteristic curve :** For this, a graph is plotted for the collector-current I_C against the base-current I_B at a constant collector-emitter voltage V_{CE} (Fig. 49). This is called the current transfer characteristic curve. The slope of this graph is called the current gain β in the common emitter mode. Hence current gain $\beta = \left(\frac{\Delta I_C}{\Delta I_B} \right)_{V_{CE}}$

Formula Used : Current gain in the common-emitter mode

$$\beta = \left(\frac{\Delta I_C}{\Delta I_B} \right)_{V_{CE}} = \text{slope of } I_C\text{-}I_B \text{ characteristic curve.}$$

where ΔI_C and ΔI_B are the variation in collector current and base current respectively at a constant collector-emitter voltage V_{CE} .

Procedure : First complete the electric circuit as shown in Fig. 46. Then the experiment is performed in the following three steps :

(1) **To draw the Input characteristic curve :** (i) Adjust the collector-emitter voltage V_{CE} as zero volt with the help of rheostat Rh_2 and keep it constant.

(ii) Now increase gradually the base-emitter voltage V_{BE} in steps of 0.2 or 0.1 volt with the help of rheostat Rh_1 and note the base current I_B from the microammeter μA corresponding to each base-emitter voltage V_{BE} .

(iii) Plot a graph by taking the base-emitter voltage V_{BE} on X-axis and the base current I_B on Y-axis (Fig. 47).

(iv) Repeat the above experiment for constant collector-emitter voltage V_{CE} at 2 volt, 4 volt and 6 volt.

(2) **To draw the output characteristic curve :** (i) Adjust the base current I_B at 20 μA with the help of rheostat Rh_1 by reading in microammeter μA and keep it constant.

(ii) Now the collector-emitter reverse voltage V_{CE} is gradually decreased from zero in steps of 1 V with the help of rheostat Rh_2 and note the collector current I_C from the milliammeter mA corresponding to each collector-emitter voltage V_{CE} .

(iii) Then a graph is plotted by taking the collector current I_C on Y-axis and collector-emitter voltage V_{CE} on X-axis (Fig. 48).

(iv) The above experiment is repeated for constant base current I_B at 40 μA , 60 μA and 80 μA .

(3) To draw the current transfer characteristic curve :

(i) Adjust the collector-emitter voltage V_{CE} at 2 V with the help of rheostat Rh_2 and keep it constant.

(ii) Now gradually increase the base current I_B from zero in steps of $10 \mu A$ with the help of rheostat Rh_1 and note the collector current I_C from the milliammeter for each value of I_B . This is done till the collector current becomes 4 mA.

(iii) Then a graph is plotted by taking the collector current I_C on Y-axis and base current I_B on X-axis (Fig. 49).

Observations :

(1) For the input characteristic curve (I_B - V_B characteristics) :

S.No.	Base-emitter voltage V_{BE} (in volt)	Base current I_B (in μA) when			
		Collector-emitter voltage $V_{CE} = 0 V$	Collector-emitter voltage $V_{CE} = 2 V$	Collector-emitter voltage $V_{CE} = 4 V$	Collector-emitter voltage $V_{CE} = 6 V$
1.	0.2				
2.	0.3				
3.	0.4				
4.	0.5				
5.	0.6				
6.	0.7				

(2) For the output characteristic curve (I_C - V_C characteristics) :

S.No.	Collector-emitter voltage V_{CE} (in volt)	Collector current I_C (in mA) when			
		Base current $I_B = 20 \mu A$	Base current $I_B = 40 \mu A$	Base current $I_B = 60 \mu A$	Base current $I_B = 80 \mu A$
1.					
2.					
3.					
4.					
5.					
6.					

(3) For the current transfer characteristic curve (I_C - I_B characteristic) :

Collector-emitter voltage $V_{CE} = - 2$ volt

S.No.	Base current I_B (in μA)	Collector current I_C (in mA)
1.		
2.		
3.		
4.		
5.		
6.		

Calculations : From the observation Table 1, a graph is plotted for I_B versus V_{BE} at different collector-emitter voltages V_{CE} (Fig. 47).

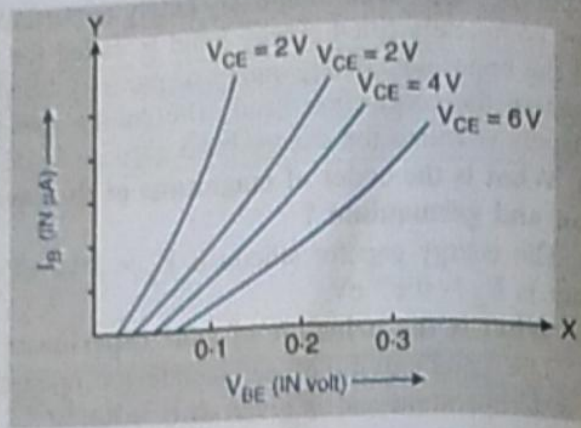


Fig. 47. Input characteristic

From the observation Table 2, a graph is plotted for I_C versus V_{CE} at different base current I_B (Fig. 48).

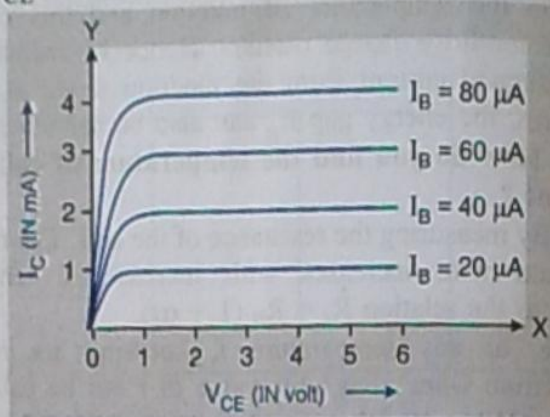


Fig. 48. Output characteristic

From the observation Table 3, a graph is plotted for the collector current I_C versus base current I_B (Fig. 49).

The slope of the graph $s = \frac{ab}{cd} = \dots$

Current gain in common emitter mode

$$\beta = \frac{\Delta I_C}{\Delta I_B}$$

= slope s of I_C - I_B curve

=

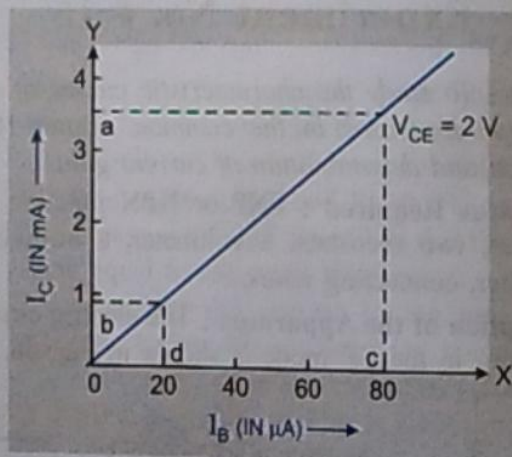


Fig. 49. Current transfer characteristic

Result : In the common emitter mode for the given PNP transistor, Fig. 47 shows the input characteristic curve, Fig. 48 shows the output characteristic curve and Fig. 49 shows the current transfer characteristic curve.

Current gain in common emitter mode $\beta = \dots\dots\dots$

Precautions : (1) The emitter-base junction is kept in forward bias while the collector-emitter junction is kept in reverse bias.

(2) A high potential should not be applied at the base or collector.