Chapter-1

Bipolar Junction Transistor (BJT)

1.1 Introduction:

Bipolar Junction Transistor (BJT) was invented in 1947 by John Bardeen, Walter Brattain and William Shockley at Bell Laboratory in America. This invention revolutionized the electronic Industry. BJTs can be used as amplifiers, switches or in oscillators. The term bipolar reflects the fact that holes and electrons participate in the injection process into the oppositely polarized material.

This chapter introduces the construction, working and V-I characteristics of transistors. Also it introduces different circuit configurations of transistor circuits along with the discussion of its parameters.

1.2 Structure of transistor:-

- BJT (bipolar junction transistor) is constructed with three doped semiconductor regions separated by two pn junctions.
- These three layers/regions are named as emitter, base & collector.
    - Emitter- It's function is to emit majority charge carriers in the middle region. Emitter is heavily doped.
    - Base- It's function is to pass the charge carriers to collector. It is lightly doped and its thickness is very small.
    - Collector- It's function is to collect the charge carriers. It is moderately doped and its thickness is comparatively large.
- Transistor consists of two pn-junctions:
    1. emitter-base junction (EB junction)
    2. collector-base junction (CB junction)
- If P-type material is sandwiched between two N-regions then it is called as NPN transistor
- if N-type material is sandwiched between two P-regions, then it is called as PNP transistor.

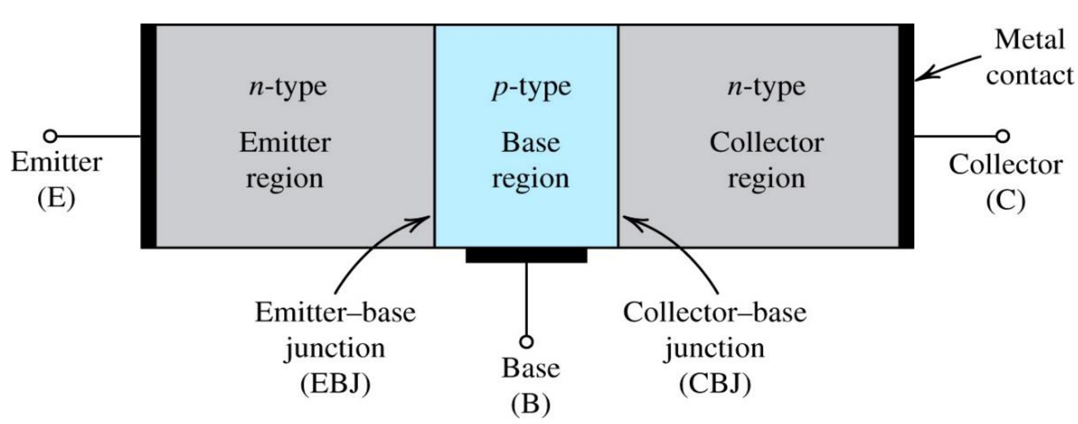
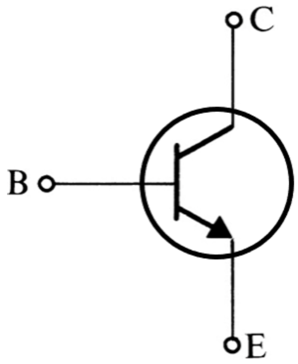


Fig 1.1: Simplified structure of *npn* transistor



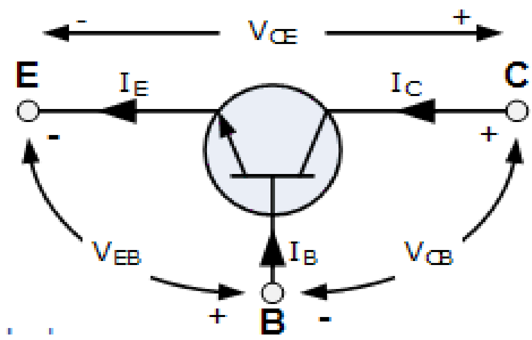


Fig 1. 2: Symbol of *npn* transistor **Fig 1.3: current components in *npn* transistor**

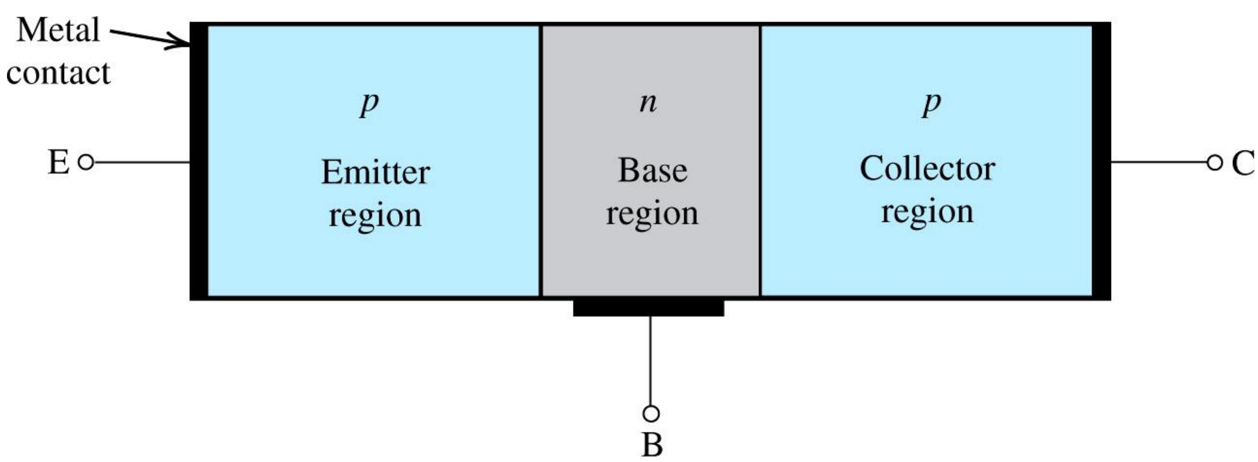
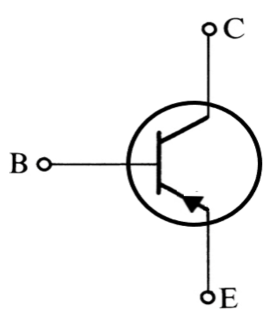


Figure 1.4: Simplified structure of *pnp* transistor



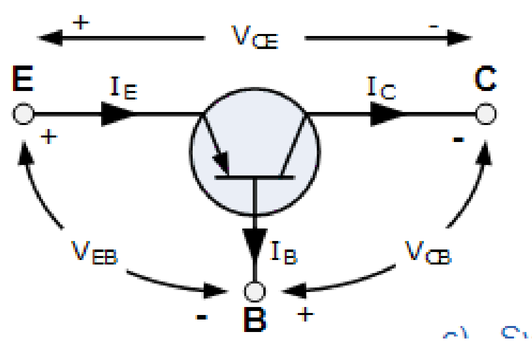


Fig 1.5: Symbol of *pnp* transistor **Fig 1.6: current components in *pnp* transistor**

1.3 Biasing of a Transistor:-

There are 3-ways of transistor biasing.

1) **EB junction is forward biased an CB junction is reverse biased**

   - small change in input current causes large change in output current. Thus Transistor acts as an amplifier.

2) **EB junction is forward biased an CB junction is forward biased**

   -large current flows through both the junctions.

   -But both the current are independent of each other & there is no controlling action.

   -In this case transistor is in ON state and is said to be in the saturation state.

   -Thus transistor is equivalent to a closed-circuit switch.

3) **EB junction is reverse biased an CB junction is reverse biased**

   -only reverse saturation current flows through the junctions.

   -Thus ideally transistor does not conduct and is said to be in the cut-off state or in the OFF state.

   -Thus transistor is equivalent to an open-circuit switch.

1.4 WORKING OF NPN TRANSISTOR –

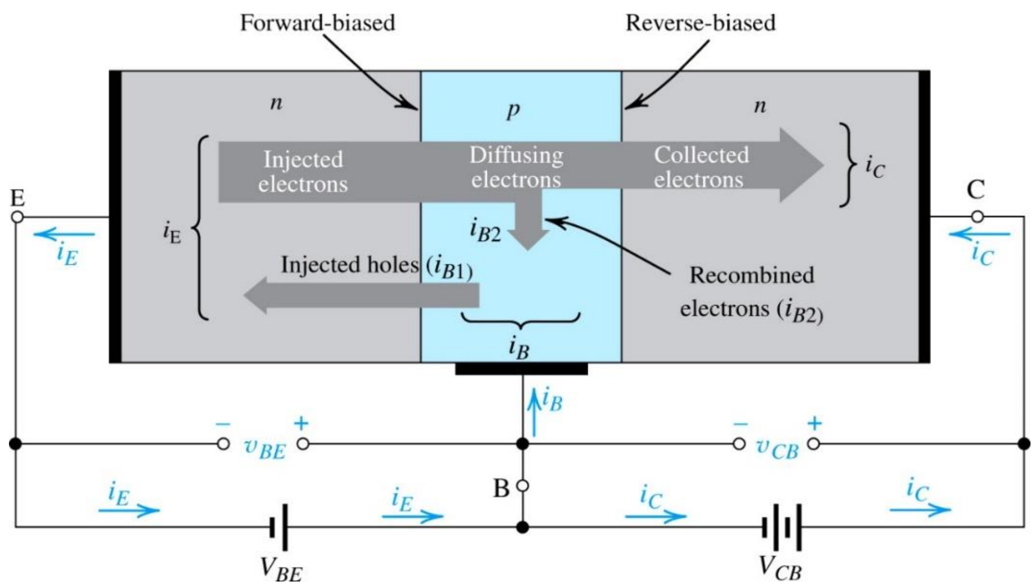


Fig 1.7

The figure 1.7 shows the NPN transistor with forward bias to emitter base junction and reverse bias to collector-base junction. The forward bias causes the electrons in the n-type emitter to flow towards the base. This constitutes the emitter current I_E. As these electrons flow through the p-type base, they tend to combine with holes. As the base is lightly doped and very thin, therefore, only a few electrons (less than 2 %) combine with holes to constitute base current I_B. The remainder (more than 98%) cross over into the collector region to constitute collector current I_C. In this way, almost the entire emitter current flows in the collector circuit. It is clear that emitter current is the sum of collector and base currents

$$\text{i.e.} \quad I_E = I_B + I_C \quad ....(1.1)$$

1.5 WORKING OF PNP TRANSISTOR –

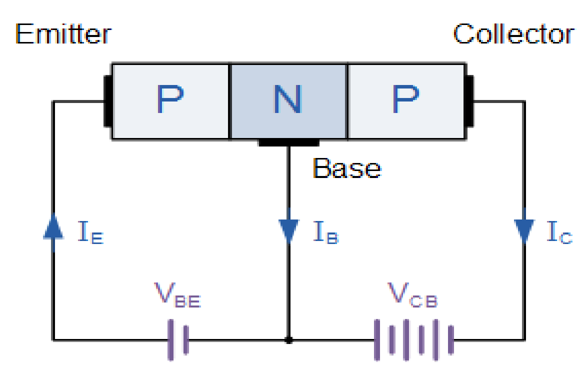


Fig 1.8

Figure 8 shows the basic connection of a *PNP* transistor. The forward bias causes the holes in the p-type emitter to flow towards the base. This constitutes the emitter current I_E. As these holes cross into n-type base, they tend to combine with the electrons. As the base in lightly doped and very thin, therefore, only a few holes (less than 2%) combine with the electrons. The remainder more than 98% cross into the collector region to constitute collector current Ic. In this way, almost the entire emitter current flows in the collector circuit. It may be noted that current conduction within PNP transistor is by holes. However, in the external connecting wires, the current is still by electrons.

1.6 Transistor Configurations:-

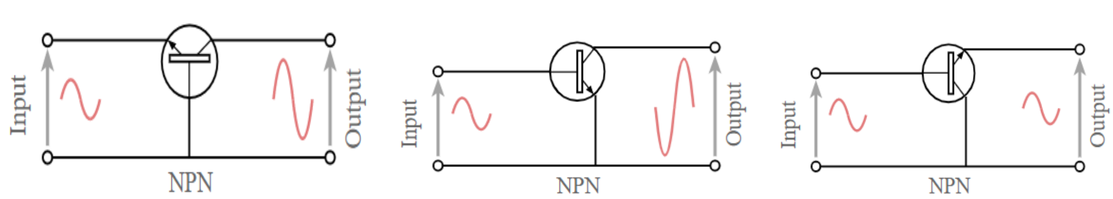
Depending on the method of connections, there are three transistor configurations

1) Common Base (CB) configuration: Base terminal is common to input and output as shown in fig 1.9(a). This transistor configuration provides low input impedance while offering high output impedance. Although the voltage gain is high, the current gain is low and the overall power gain is also low when compared to the other transistor configurations. The other salient feature of this configuration is that the input and output are in phase.

   This transistor configuration is probably the least used, but it does provide advantages that the base which is common to input and output is grounded and this has advantages in reducing unwanted feedback between output and input for various RF circuit design applications. This occurs because the base, which is the electrode physically between the emitter and collector is grounded, thereby providing a barrier between the two.

2) Common Emitter (CE) configuration: Emitter terminal is common to input and output as shown in fig 1.9(b). This transistor configuration is probably the most widely used. The circuit provides a medium input and output impedance levels. Both current and voltage gain can be described as medium, but the output is the inverse of the input, i.e. 180° phase change. Typically used as a voltage amplifier.
3) Common Collector (CC) configuration: Collector terminal is common to input and output as shown in fig 1.9(c). This configuration is also known as the emitter follower because the emitter voltage follows that of the base. This configuration offers a high input impedance and a low output impedance. The voltage gain is unity, although current gain is high. The input and output signals are in phase.

   In view of these characteristics, the emitter follower configuration is widely used as a buffer circuit providing a high input impedance to prevent loading of the previous stage, and a low output impedance to drive following stages.



(a) (b) (c)

Fig 1.9 Transistor configurations

Comparison between CB, CE & CC configurations: -

Parameter	CB-Configuration	CE-Configuration	CC-Configuration
Current gain	Very low(≈1)	High	High
Voltage gain	High	High	Low (≈1)
Input dynamic Resistance (ri)	Very low	medium	Very high
Output dynamic resistance (ro)	High	Medium	Low
Leakage current	Very small (5μA for Ge, 1μA for si)	Very large (500μA for Ge, 20μA for si)	Very large (500μA for Ge 20μA for si)
Application	Constant Current Source (Current Buffer)	Voltage or current Amplifier	Voltage Buffer Amplifier

1.7 IMPORTANCE OF TRANSISTOR ACTION

The input circuit (i.e. emitter-base junction) has low resistance because of forward bias whereas output circuit (i.e. collector-base junction) has high resistance due to reverse bias. As we have seen, the input emitter current almost entirely flows in the collector circuit. Therefore, a transistor transfers the input signal current from a law-resistance circuit to a high-resistance circuit. This is the key factor responsible for the amplifying capability of the transistor.

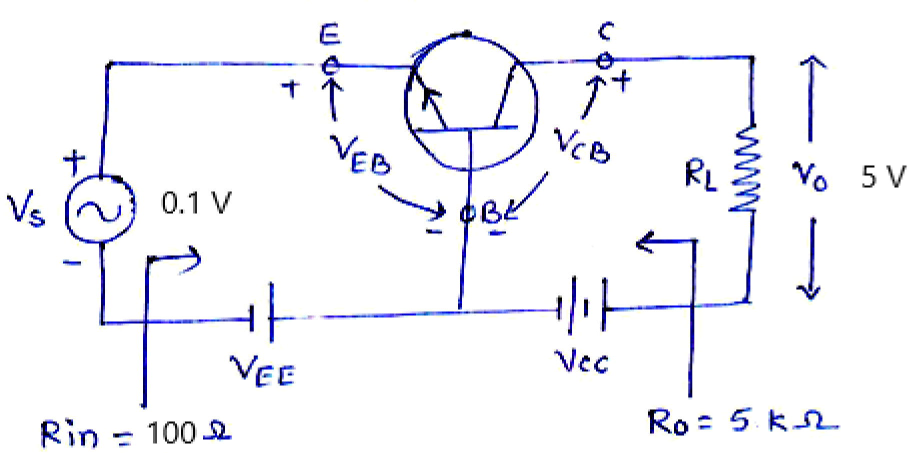


Fig 1.10

Suppose in a common base circuit, there is a load resistance RC = 5 kΩ. Suppose the change of 0.1 V in the signal voltage produces a change of 1 mA in emitter current. The same change of current takes place in collector current i.e., 1 mA. This collector current through RC produces a voltage = 5V. Thus a change of 0.1 V in the input signal has produced a change of 5V in the output signal. So the transistor has raised the voltage from 0.1 V to 5V. Thus voltage amplification in this case is 50.

1.8 Transistor Characteristics:

1.8.1 Common Base Configuration:-

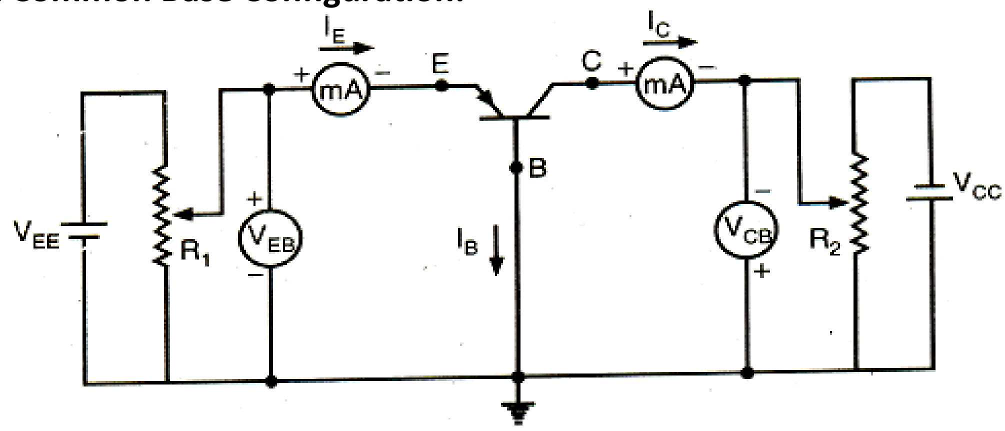


Fig 1.11

Fig. 1.11 shows the circuit arrangement for determining the characteristics of transistor in common base configuration.

a) Input characteristics

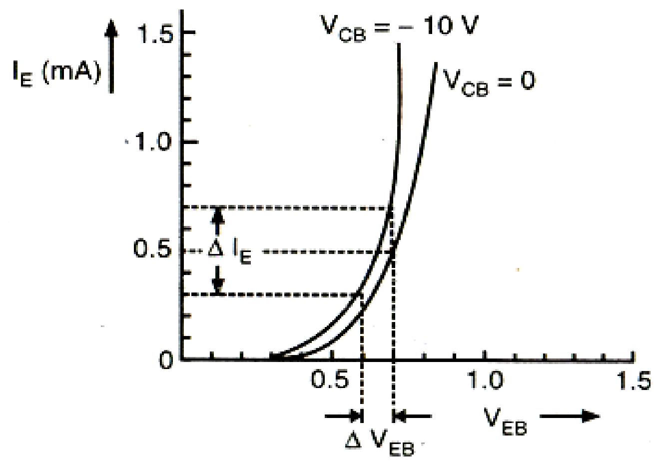


Fig 1.12

The graph between input voltage (V_{EB}) and input current (I_E) at constant output Voltage (V_{CB}) is called as input characteristics. From the circuit diagram, it is seen that the emitter base junction is forward biased; hence the input characteristic is similar to that of forward biased PN junction diode as shown in fig.1.12. As collector voltage increases the curve shift towards the left side this is because more emitter current flows for the same value of V_{EB}

The dynamic input resistance is given by

$$r_i = \left.\frac{\Delta V_{EB}}{\Delta I_E}\right|_{V_{CB}=\text{ constant}}$$

b) Output characteristics:-

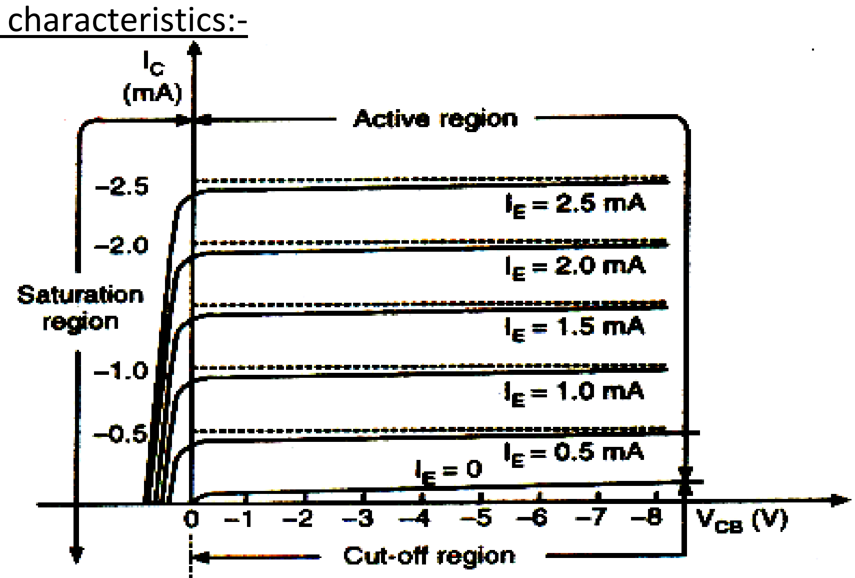


Fig 1.13

The graph between output voltage (V_{CB}) and output current (I_C) at constant input current (I_E) is called as output characteristics from the fig 1.13. It is seen that the curves are divided into 3 regions, namely i) active region ii) Cut-off region iii) saturation region

Active region In active region emitter junction is forward biased and collector junction is reverse biased thus the transistor operates in normal mode the collector current is nearly equal to emitter current ($I_C=I_E$) if I_E is kept constant then I_C also remains constant i.e. I_C is independent of collector voltage (V_{CB}) but depends only on IE hence the curves are almost flat

The dynamic output resistance is given by

$$r_o = \left.\frac{\Delta V_{CE}}{\Delta I_c}\right|_{I_E = \text{constant}}$$

Cut-off region The region below the curve IE=0 is known as cut-off region In this both the junctions are reverse biased and only the reverse saturation current flows through the circuit as shown in fig2.8 the transistor is in cut-off state and acts as an open switch

Saturation region In this both the junctions are forward biased, therefore current increases exponentially as shown in fig. 1.13. Large current flows through transistor and it acts as a closed switch.

1.8.2 Common Emitter Configuration:-

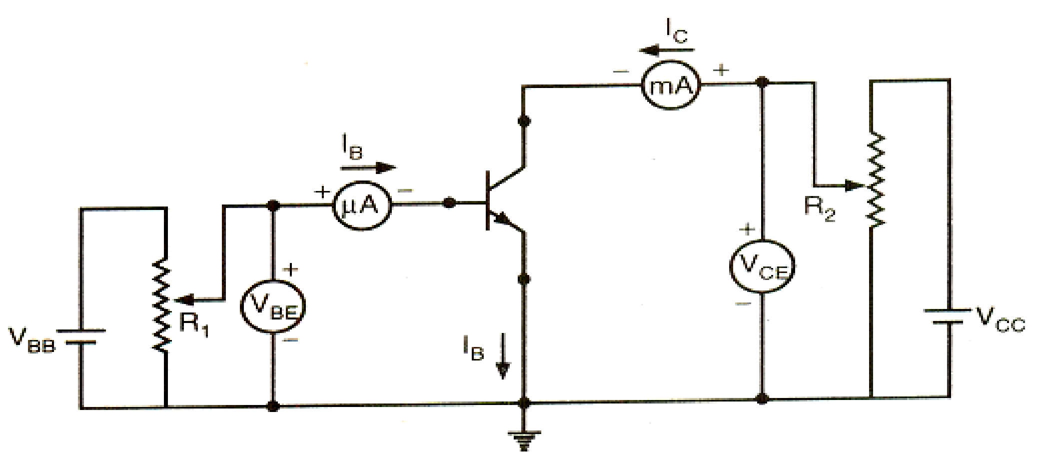


Fig 1.14

Fig 1.14 shows the circuit arrangement for determining the characteristic of transistor in CE configuration.

a) Input Characteristics

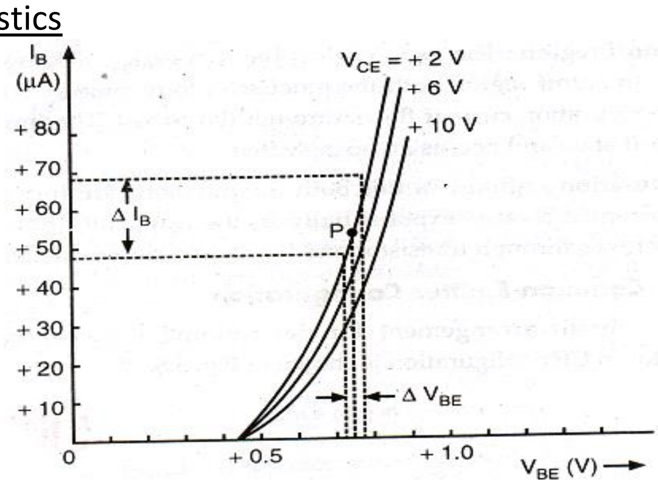


Fig 1.15

The graph between input voltage (V_{BE}) and input current (I_B) at constant output Voltage (V_{CE}) is called as input characteristics. From the circuit diagram in fig. 1.14, it is seen that the emitter base junction is forward biased. Hence current IE increases exponentially with input voltage V_{BE} as shown in fig. 1.15. As collector voltage increases the curve shift towards the right side this is because less base current flows for the same value of V_{BE}.

The dynamic input resistance is given by

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

b) Output characteristics:-

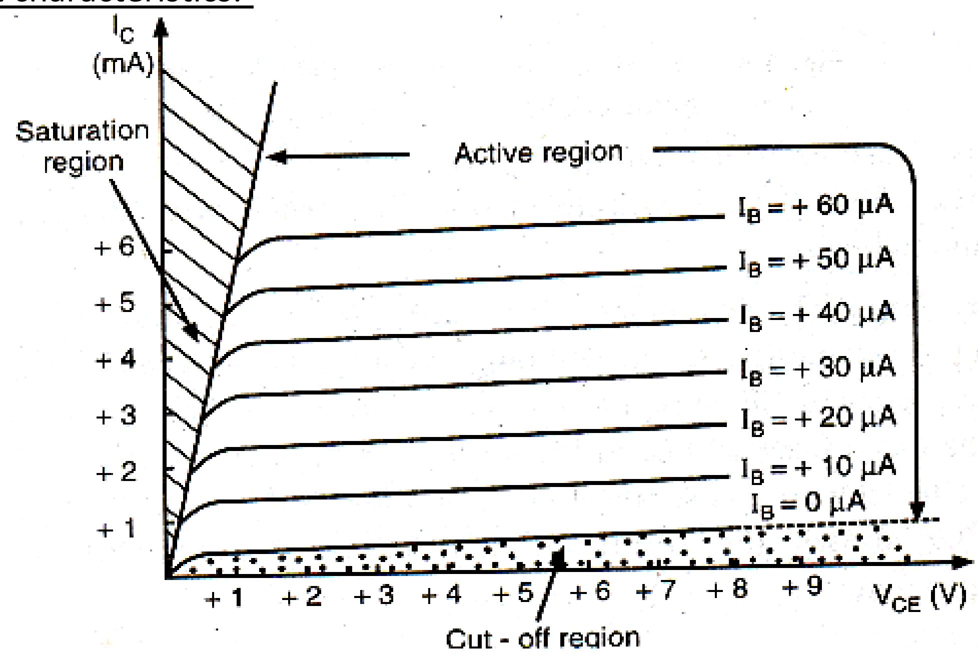


Fig 1.16

The graph between output voltage (V_{CE}) and output current (I_C) at constant input current (I_B) is called as output characteristics. From the graph in fig. 1.16, it is seen that the curves are divided into 3 regions namely i) active region ii) Cut-off region iii) saturation region

Active region:

In active region emitter junction is forward biased and collector junction is reverse biased thus the transistor operates in normal mode. As collector voltage increases, the width of depletion layer increases this decrease the effective base width because of this the recombination's in the base region and hence, the base current decreases slightly this will increase the collector current. Thus, for given base current as collector voltage increases collector current also increases and the output curves are inclined as shown in graph of fig.1.16.

The dynamic output resistance is given by,

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

Cut-off region:

The region below the curve I_B=0 in fig.1.16 is known as cut-off region. In this region both the junctions are reverse biased and only the leakage current flows through the transistor, the transistor is in cut-off state and acts as an open switch.

Saturation region:

In this region both the junctions are forward biased large current flows through the transistor & transistor acts as a close switch.

1.9 Current gain of transistor:-

1.9.1 In CB configuration:-

a) D.C current gain:- The ratio of collector current (I_C) to emitter current (I_E) is called as dc current gain, denoted by α_{dc}.

$$\alpha_{dc} = \frac{I_C}{I_E}$$

The value of α_{dc} is nearly equal to 1 but it is always less than 1 it never becomes greater than or equal to 1.

b) A.C current gain:- The ratio of change in collector current to change in emitter current at constant V_{CB} is called as ac current gain , denoted by α_{ac}.

$$\alpha_{ac} = \left.\frac{\Delta I_C}{\Delta I_E}\right|_{V_{CB} = \text{constant}}$$

The value of α_{ac} is nearly equal to 1

1.9.2 In CE configuration:-

a)D.C current gain:-

The ratio of collector current (I_C) to base current (I_B) is called as dc current gain, denoted by β_{dc}.

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

b)A.C current gain:- The ratio of change in collector current to change in base current at constant V_{CE} is called as ac current gain , denoted by β_{ac}.

$$\beta_{ac} = \left.\frac{\Delta I_C}{\Delta I_E}\right|_{V_{CE} = \text{constant}}$$

1.9.3 In CC configuration:

a) D.C current gain:- The ratio of emitter current (I_E) to base current (I_B) is called as dc current gain, denoted by γ_{dc}

$$\gamma_{dc} = \frac{I_E}{I_B} = \frac{I_B + I_C}{I_B} = 1 + \frac{I_C}{I_B} = 1 + \beta$$

1.9.4 Relation between α_{dc} and β_{dc} :

Since $I_E = I_B + I_C$

Dividing both sides by I_C , we get

$$\frac{I_E}{I_C} = \frac{I_B}{I_C} + 1$$

But $\frac{I_E}{I_C} = \frac{1}{\alpha_{dc}}$ and $\frac{I_B}{I_C} = \frac{1}{\beta_{dc}}$

i.e $\frac{1}{\alpha_{dc}} = \frac{1}{\beta_{dc}} + 1$

$$\therefore \quad \frac{1}{\alpha_{dc}} = \frac{1 + \beta_{dc}}{\beta_{dc}}$$

$$\boxed{\alpha_{dc} = \frac{\beta_{dc}}{1 + \beta_{dc}}}$$

Simly, $\frac{1}{\alpha_{dc}} = \frac{1}{\beta dc} + 1$

$\frac{1}{\beta dc} = \frac{1}{\alpha_{dc}} - 1$

$$\boxed{\beta dc = \frac{\alpha_{dc}}{1 - \alpha_{dc}}}$$

Relation between αac and βac

$$\alpha ac = \frac{\beta ac}{1+ \beta ac} \quad \& \quad \beta ac = \frac{\alpha ac}{1- \alpha ac}$$

1.10 **<u>Collector cut-off currents: -</u>**

1.10.1 In CB-configuration – (I_{CBO})

If emitter terminal is open (I_E=0) then only reverse saturation current I_{CO} flows through the collector circuit. This current is called as collector cut-off current, denoted by I_{CBO} or I_{CO}. This current is very very small, because it is due to minority charge carriers. This current is temperature dependent. As temperature increases, I_{CBO} increases. It doubles for every 10°C rise in temperature.

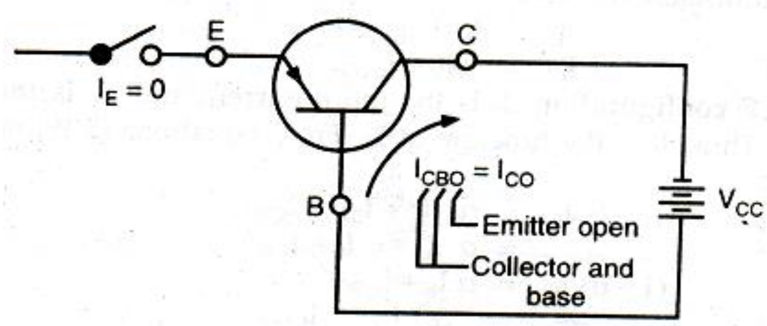


Fig 1.17

Thus the total collector current is given by, **$I_C = \alpha I_E + I_{CBO}$**

1.10.2 In CE-configuration: -(I_{CEO})

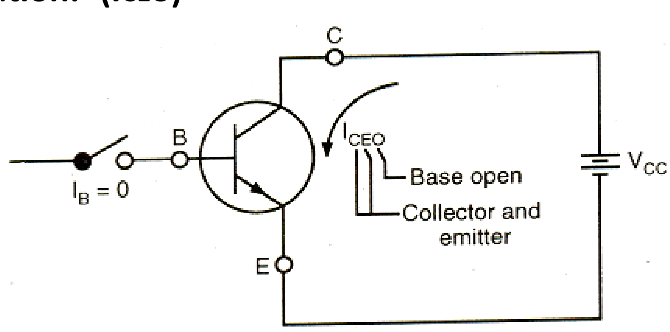


Fig 1.18

If base terminal is open (I_B=0), then some leakage current flows through collector circuit. This current is called as collector cut-off current denoted by I_{CEO}.

Thus the total collector current is given by, **$I_C = \beta I_B + I_{CEO}$**

1.10.3 Relation between I_{CBO} and I_{CEO}: -

Since $I_E = I_C + I_B$ ________(1.2)

and $I_C = \alpha I_E + I_{CBO}$ __________(1.3)

$I_C = \beta I_B + I_{CEO}$ __________(1.4)

From eqns.(2.2)&(2.3)

$I_C = \alpha(I_C + I_B) + I_{CBO}$

$= \alpha I_C + \alpha I_B + I_{CBO}$

$(1-\alpha)I_C = \alpha I_B + I_{CBO}$

$$I_C = \left(\frac{\alpha}{1-\alpha}\right) I_B + \frac{I_{CBO}}{1-\alpha}$$

$$I_C = \beta I_B + \frac{I_{CBO}}{1-\alpha}$$ _________(1.4)... [Since $\beta = \alpha/1-\alpha$]

Comparing eqns.(1.4) & (1.5) we get

$$\boxed{I_{CEO} = \frac{I_{CBO}}{1-\alpha}}$$

$$I_{CEO} = \frac{I_{CBO}}{1-\frac{\beta}{1+\beta}} = \frac{\frac{I_{CBO}}{(1+\beta)-\beta}}{1+\beta} = \frac{I_{CBO}(1+\beta)}{1+\beta-\beta}$$

$I_{CEO} = (1+\beta)\, I_{CBO}$ _________(1.6)

I_{CEO} is also temperature dependent. The change in I_{CEO} with temperature is $(1+\beta)$ times the change in I_{CBO}.

Thus the total collector current can also be represented as,

$\boxed{I_C = \beta I_B + (1+\beta)\, I_{CBO}}$ __________**(1.7)**

Equations to remember:

1. $I_E = I_C + I_B$
2. $\alpha_{dc} = \frac{I_C}{I_E}$
3. $\beta_{dc} = \frac{I_C}{I_B}$
4. $\alpha_{dc} = \frac{\beta_{dc}}{1+\beta_{dc}}$
5. $\beta_{dc} = \frac{\alpha_{dc}}{1-\alpha_{dc}}$
6. $I_C = \alpha I_E + I_{CBO}$
7. $I_C = \beta I_B + I_{CEO}$

8. $I_{CEO} = \dfrac{I_{CBO}}{1-\alpha}$

9. $I_{CEO} = (1+\beta)\, I_{CBO}$

10. $\boxed{I_C = \beta I_B + (1+\beta)\, I_{CBO}}$

Ex:(1) If the base current in a transistor is 20μA, when the emitter current is 6.4mA, what are the values of α & β ?

Sol: - I_B =20 μA= 20 x 10^{-3}mA and I_E= 6.4 mA

Since $I_E = I_B + I_C$

$6.4 = 20 \times 10^{-3} + I_C$

$(6.4-20 \times 10^{-3})\text{ mA} = I_C$

$(6.4 - 0.02)\text{ mA} = I_C$

$I_C = 6.38\text{ mA}$

Then $\alpha_{dc} = \dfrac{I_C}{I_E} = \dfrac{6.38}{6.4} = 0.997$

$\beta_{dc} = \dfrac{I_C}{I_B} = \dfrac{6.38\text{mA}}{20 \times 10^{-3}\text{mA}} = \mathbf{319}$

Ex: (2) A certain transistor has α= 0.92 & collector leakage current I_{CBO} = 50 μA. Calculate the total collector current (Given I_E = 1 mA)

Sol^n:- α= 0.92 , I_{CBO} = 50 μA = 0.05 mA, IE = 1mA
Since total collector currents is,

$I_C = \alpha I_E + I_{CBO}$

$= 0.92 \times 1\text{mA} + 0.05\text{mA}$

$\mathbf{I_C = 0.97mA}$

Ex: (3) Calculate I_E in a transistor for which β = 100 & I_B = 20μA.

Sol^n:- Given β = 100, I_B = 20μA

Sine $\beta = I_C / I_B$

$I_C = \beta . I_B$

$= 100 \times 20\mu A = 2000\mu A = 2mA$

Again $I_E = I_B + I_C$

$= 20\mu A + 2000\mu A$

$= 2020\ \mu A$

$\mathbf{I_E = 2.02\ mA}$

Ex: (4) A transistor has I_{CBO} = 50nA & α = 0.995. Find I_{CEO}.

Sol^n:- Given: α = 0.995, I_{CBO}=50nA = 50 x 10^{-9} A

Since, I_{CEO} = I_{CBO} /1-α

$$= \frac{50\times10^{-9}}{1-0.995} = \frac{50\times10^{-9}}{0.005} = 10{,}000\times10^{-9}$$

$= 10\times10^{-6}$A = 10μA

Ex: (5) In CB amplifier I_C = 10mA & I_E =11mA.What is the value of α? Also calculate β of a transistor

Sol^n:- Given: I_C = 10mA, I_E =11mA

$$\alpha = \frac{IC}{IE} = \frac{10}{11} = 0.9$$

$I_B = I_E - I_C$

$$\beta = \frac{IC}{IB} = \frac{10}{1} = 10$$

Ex: (6) The D.C. current gain of a transistor in CB configuration is 0.98. Find the D.C. current gain in CE configuration. What will be the collector current? (ΔI_B =200μA = 200 x 10^{-6}A)

Sol^n:- Given : α = 0.98, ΔI_B =200μA = 200 x 10^{-6}A

Since $$\beta = \frac{\alpha}{1-\alpha} = \frac{0.98}{1-0.98} = \frac{0.98}{0.021-\alpha} = \frac{98}{2} = 49$$

Since $$\beta = \frac{\Delta IC}{\Delta IB}$$

ΔIC = β X IB

= 49 x 200 x 10^{-6}A

= 9800 x 10^{-6}A

ΔIC = 9.8mA

Ex: (7) In common base connection, the emitter current is 1mA. If the emitter is open, the collector current is 50 x 10^{-6}A. Find the total current through collector if α = 0.93.

Sol^n:- Given: I_E= 1mA= 1x 10^{-3}A, I_{CBO} = 50 x 10^{-6}A, α = 0.93

Since $I_C = \alpha I_E + I_{CBO}$

= 0.93 x 1x10^{-3} + 50 x 10^{-6}A

= 10^{-3}(0.93 + 50 x 10^{-3})

=10^{-3}(0.93 + 0.05)

= 0.98 x 10^{-3}

IC= 0.98 mA

Ex:(8) Calculate IE in a transistor for which $\beta = 50$ and $I_B = 20\ \mu A$.

Sol[n]:- since $\beta = I_c / I_B$

$I_c = \beta \times I_B$

$= 50 \times 20\ \mu A = 1000\ \mu A$

Since $I_E = I_B + I_C$

$= 20\ \mu A + 1000\ \mu A$

$= 1020\ \mu A$

1.11 The operating point & DC load Line: -

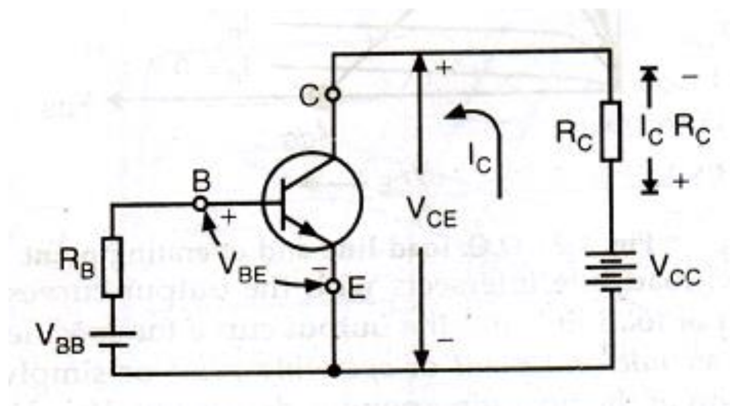


Fig 1.19

Consider a CE amplifier circuit without any a.c. input signal. This condition is called 'quiescent condition'. The battery VCC sends current Ic through the load resistance RC & the transistor.

Applying Kirchhoff's voltage law to the collector circuit, we get

$V_{CC} = I_c\ R_c + V_{CE}$ --------(1.8)

Rearranging and solving for Ic,

$$I_c = \left(-\frac{1}{R_c}\right) V_{ce} + \frac{V_{cc}}{R_c} \qquad \text{---------(1.9)}$$

This eqn. is similar to y = mx +c which is the equation of straight line. Thus plotting eqn.(1.9) on the transistor output characteristic we get a straight line, whose slope is ($-\frac{1}{R_c}$) & intercept on the Ic axis is (Vcc / Rc). The slop of this line depends on the d.c. load resistance Rc hence this line is called as d.c. load line.

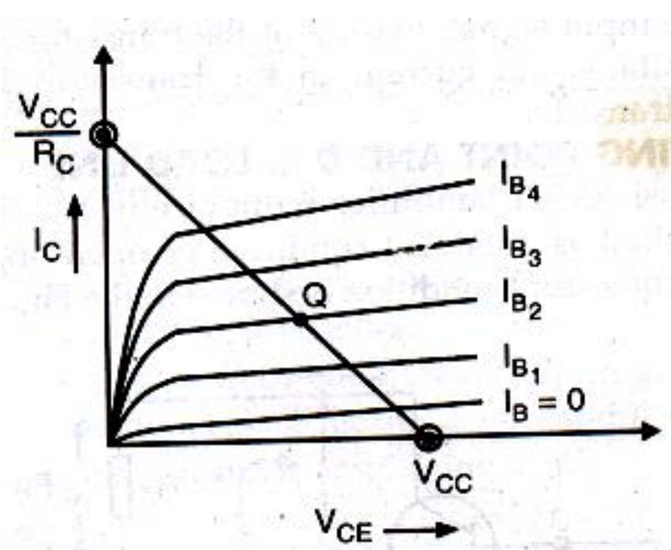


Fig 1.20

From eqn.(1.9) we have

(i) When VcE = 0, Ic = Vcc/Rc
(ii) When Ic = 0, VcE = Vcc

Joining these two points gives the dc load line as shown in graph.
The dc load line intersects the output curves. The point of intersection of load line for specified base current IB is called as 'quiescent point' or 'operating point' or 'Q-point'. The exact location of Q-point is decided by Vcc, Rc, RB, VBE and VBB. For given values of Vcc & Rc, the Q-point depends upon the base current IB, which is calculated as follows –

Applying Kirchhoff's voltage law to the base circuit, we get,

VBB = IB. RB + VBE

$$I_B = \frac{V_{BB} - V_{BE}}{R_B} = \frac{V_{BB}}{R_B}$$

since VBE is small (VBE is 0.7 v for Si & 0.3 v for Ge)

1.12 Analysis of Amplifier using d.c. load line :-

Consider a CE amplifier circuit as shown in fig (1.21). A transistor can amplify ac signals only after its dc operating point is suitably fixed. Generally the operating point is selected at the centre of the load line.

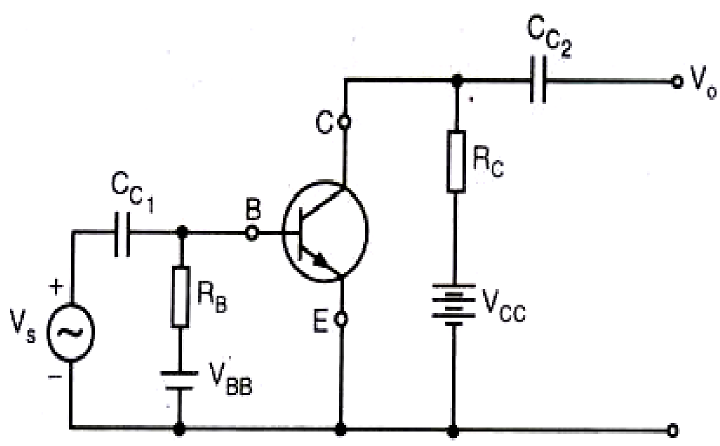


Fig 1.21

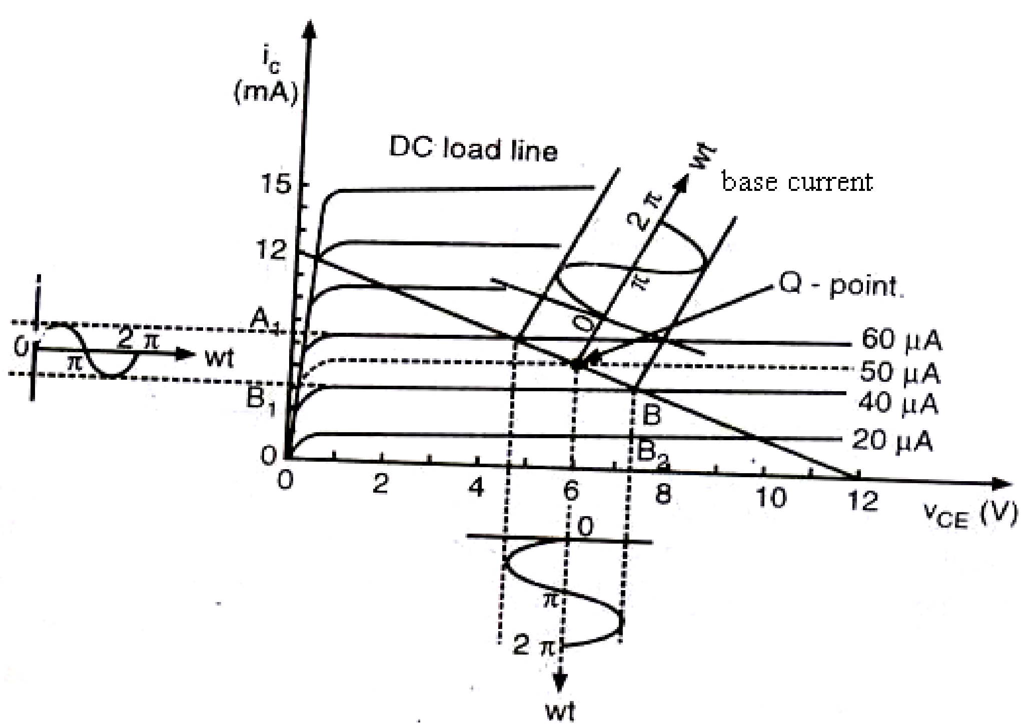


Fig 1.22

Under quiescent condition, the base current has a constant dc value. It is determined from Q-point. Now when a.c. input signal is applied, the base current varies as per the input signal. As base current varies, the operating point moves along the dc load line (Q1-Q2).

Thus the instantaneous values of collector current & voltage also vary according to input signal as shown in the graph. The variation in the collector voltage is many times larger than the variation of the input signal. The collector voltage variation reaches the output terminal through capacitor Cc_2. The output is therefore many times larger than the input.

The current gain, voltage gain & power gain of amplifier is given by,

1) Current gain, Ai = $\frac{\Delta iC}{\Delta iB}$
2) Voltage gain, Av= $\frac{\Delta VCE}{\Delta VBE}$
3) Power gain ,Ap = $\frac{ic * VCE}{iB * VBE}$

CE amplifier has large current gain, voltage gain and power gain.

1.13 Selection of the operating point :

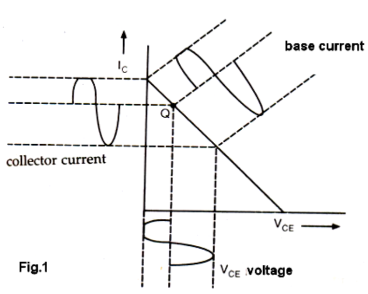


Fig 1.25

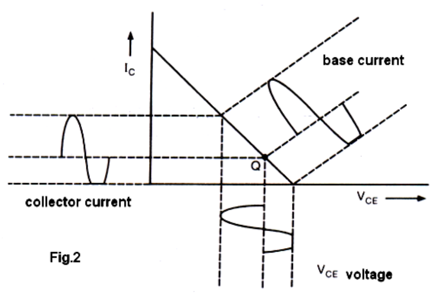


Fig 1.26

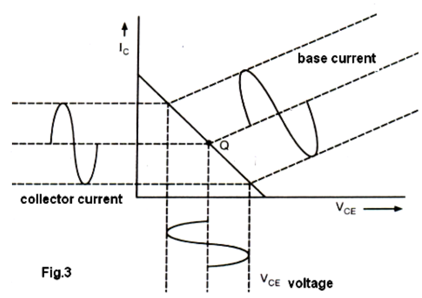


Fig 1.27

Fig.(1.25) shows the operating point near the saturation region. In this case even though the base current varies sinusoidally, the output current is clipped at the positive peak. This results in distortion of the signal. Thus operating point near the saturation region is not suitable.

Fig.(1.26) shows the operating point near the cut-off region. In this case the output signal is now clipped at negative peak, resulting in a distortion. Thus operating point near the cut-off region is not suitable.

Fig.(1.27) shows the operating point at the centre of load line. In this case the output signal is not clipped even though the input signal is sufficiently large. Thus the centre of the load line is most suitable position for the operating point.

QUESTIONS:

Short answer questions:

1) Explain construction and working of NPN transistor.
2) Explain construction and working of PNP transistor.
3) Define α and β? Derive the relation between them.
4) Explain transistor leakage currents I_{CBO} and I_{CEO}. Derive relation between them.
5) Sketch output characteristic of common emitter configuration showing various regions.
6) Explain DC load line and Q-point.

Long answer questions:

1) Draw circuit arrangement to determine the input and output characteristics of CE configuration and explain them.
2) Draw circuit arrangement to determine the input and output characteristics of CB configuration and explain them.

Select correct alternative:

Q1. A transistor has …………………

1. one pn junction
2. <u>two pn junctions</u>
3. three pn junctions
4. four pn junctions

Answer : 2

Q2. The number of depletion layers in a transistor is ………..

1. four
2. three
3. one
4. <u>two</u>

Answer : 4

Q3. The base of a transistor is …………. doped.

1. heavily
2. moderately
3. <u>lightly</u>
4. none of the above

Answer : 3

Q4. The region that has the biggest size in a transistor is ………………..

1. <u>collector</u>
2. base
3. emitter
4. collector-base-junction

Answer : 1

Q5. In a pnp transistor, the majority current carriers are …………

1. acceptor ions
2. donor ions
3. free electrons
4. <u>holes</u>

Answer : 4

Q6. The collector of a transistor is ………… doped

1. heavily
2. <u>moderately</u>
3. lightly
4. none of the above

Answer : 2

Q7. A transistor is a …………… operated device

1. <u>current</u>
2. voltage
3. both voltage and current
4. none of the above

Answer : 1

Q8. In a npn transistor, ……………. are the minority carriers

1. free electrons
2. <u>holes</u>
3. donor ions
4. acceptor ions

Answer : 2

Q9. The emitter of a transistor is ………………… doped

1. lightly
2. heavily
3. moderately
4. none of the above

Answer : 2

Q10. In a transistor, the base current is about …………. of emitter current

1. 25%
2. 20%
3. 35 %
4. 2%

Answer : 4

Q11. Most of the majority carriers from the emitter ……………….

1. recombine in the base
2. recombine in the emitter
3. pass through the base region to the collector
4. none of the above

Answer :3

Q12. In a transistor ……………….

1. $I_C = I_E + I_B$
2. $I_B = I_C + I_E$
3. $I_E = I_C - I_B$
4. $I_E = I_C + I_B$

Answer : 4

Q13. The value of α of a transistor is ………

1. more than 1
2. less than 1
3. 1
4. none of the above

Answer : 2

Q14. $I_C = \alpha I_E +$ …………

1. I_B
2. I_{CEO}
3. I_{CBO}
4. βI_B

Answer : 3

Q15. In a tansistor, I_C = 100 mA and I_E = 100.2 mA. The value of β is ………..

1. 100
2. 50
3. about 1
4. 200

Answer : 4

Q16. In a transistor if β = 100 and collector current is 10 mA, then I_E is ………..

1. 100 mA
2. 100.1 mA
3. 110 mA
4. none of the above

Answer : 2

Q17. The relation between β and α is ………….

1. $\beta = 1 / (1 - \alpha)$
2. $\beta = (1 - \alpha) / \alpha$
3. $\beta = \alpha / (1 - \alpha)$
4. $\beta = \alpha / (1 + \alpha)$

Answer : 3

Q18. The value of β for a transistor is generally ……………….

1. 1
2. less than 1
3. between 20 and 500
4. above 500

Answer : 3

Q19. The most commonly used transistor arrangement is …………… arrangement

1. <u>common emitter</u>
2. common base
3. common collector
4. none of the above

Answer : 1

Q20. The input impedance of a transistor connected in ……………. arrangement is the highest

1. common emitter
2. <u>common collector</u>
3. common base
4. none of the above

Answer : 2

Q21. The output impedance of a transistor connected in ……………. arrangement is the highest

1. common emitter
2. common collector
3. <u>common base</u>
4. none of the above

Answer : 3

Q22. The phase difference between the input and output voltages in a common base arrangement is …………….

1. 180^o
2. 90^o
3. 270^o
4. <u>0^o</u>

Answer : 4

Q23. The phase difference between the input and output voltages of a transistor connected in common emitter arrangement is ………………

1. 0^o
2. <u>180^o</u>
3. 90^o
4. 270^o

Answer : 2

Q24. The voltage gain in a transistor connected in ………………. arrangement is the highest

1. common base
2. common collector
3. <u>common emitter</u>
4. none of the above

Answer : 3

Q25. As the temperature of a transistor goes up, the base-emitter resistance ……………

1. <u>decreases</u>
2. increases
3. remains the same
4. none of the above

Answer : 1

Q26. The voltage gain of a transistor connected in common collector arrangement is ……….

1. equal to 1
2. more than 10
3. more than 100
4. <u>less than 1</u>

Answer : 4

Q27. The phase difference between the input and output voltages of a transistor connected in common collector arrangement is ………………

1. 180^o
2. <u>0^o</u>
3. 90^o
4. 270^o

Answer : 2

Q28. $I_C = \beta I_B + \ldots\ldots\ldots\ldots$

1. I_{CBO}
2. I_C
3. $\underline{I_{CEO}}$
4. αI_E

Answer : 3

Q29. $I_C = [\alpha / (1 - \alpha)] I_B + \ldots\ldots\ldots\ldots$

1. $\underline{I_{CEO}}$
2. I_{CBO}
3. I_C
4. $(1 - \alpha) I_B$

Answer : 1

Q30. $I_C = [\alpha / (1 - \alpha)] I_B + [\ldots\ldots\ldots / (1 - \alpha)]$

1. $\underline{I_{CBO}}$
2. I_{CEO}
3. I_C
4. I_E

Answer : 1

Q31. $I_{CEO} = (\ldots\ldots\ldots) I_{CBO}$

1. β
2. 1 + α
3. <u>1 + β</u>
4. none of the above

Answer : 3

Q32. If the value of α is 0.9, then value of β is ……….

1. 9
2. 0.9
3. 900
4. <u>90</u>

Answer : 4

Q33. In a transistor, signal is transferred from a …………… circuit

1. high resistance to low resistance
2. <u>low resistance to high resistance</u>
3. high resistance to high resistance
4. low resistance to low resistance

Answer : 2

Q34. The arrow in the symbol of a transistor indicates the direction of …………

1. electron current in the emitter
2. electron current in the collector
3. <u>hole current in the emitter</u>
4. donor ion current

Answer : 3

Q35. The leakage current in CE arrangement is ……………. that in CB arrangement

1. <u>more than</u>
2. less than
3. the same as
4. none of the above

Answer : 1

Q36. Three different Q points are shown on a dc load line. The upper Q point represents the …………

1. minimum current gain
2. intermediate current gain
3. <u>maximum current gain</u>
4. cutoff point

Answer : 3

Q37. A transistor has a βDC of 250 and a base current, I_B, of 20 µA. The collector current, I_C, equals to ……………
1. 500 µA
2. <u>5 mA</u>
3. 50 mA
4. 5 A

Answer : 2

Q38. A current ratio of I_C/I_E is usually less than one and is called …………
1. beta
2. theta
3. <u>alpha</u>
4. omega

Answer : 3

Q39. The ends of a load line drawn on a family of curves determine ……
1. <u>saturation and cutoff</u>
2. the operating point
3. the power curve
4. the amplification factor

Answer : 1

Q40. If an input signal ranges from 20–40 µA (microamps), with an output signal ranging from 0.5–1.5 mA (milliamps), what is the ac beta?
1. 0.05
2. 20
3. <u>50</u>
4. 500

Answer : 3

Q41. Beta's current ratio is ……..
1. <u>I_C/I_B</u>
2. I_C/I_E
3. I_B/I_E
4. I_E/I_B

Answer: 1

Q42. What is the current gain for a common-base configuration where I_E = 4.2 mA and I_C = 4.0 mA?
1. 16.8
2. 1.05
3. 0.2
4. <u>0.95</u>

Answer: 4

Q43. What is the collector current for a CE configuration with a beta of 100 and a base current of 30 µA?
1. 30 **µA**
2. 0.3 **µA**
3. <u>3 mA</u>
4. 3 MA

Answer: 3

Q44.The phase difference between the input and output ac voltage signals of a common-emitter amplifier is--------
1. 0^0
2. 90^0
3. <u>180^0</u>
4. 360^0

Answer: 3

Q44.The phase difference between the input and output ac voltage signals of a common-base amplifier is--------
1. <u>0^0</u>
2. 90^0
3. 180^0
4. 360^0

Answer:1

Q45. When transistors are used in digital circuits they usually operate in the ----

1. Linear region
2. Breakdown region
3. Active region
4. Saturation region and Cut-off region

Answer:3

Q46.When transistors are used in digital circuits they usually operate in the -----

5. Linear region
6. Breakdown region
7. Active region
8. Saturation region and Cut-off region

Answer: 4