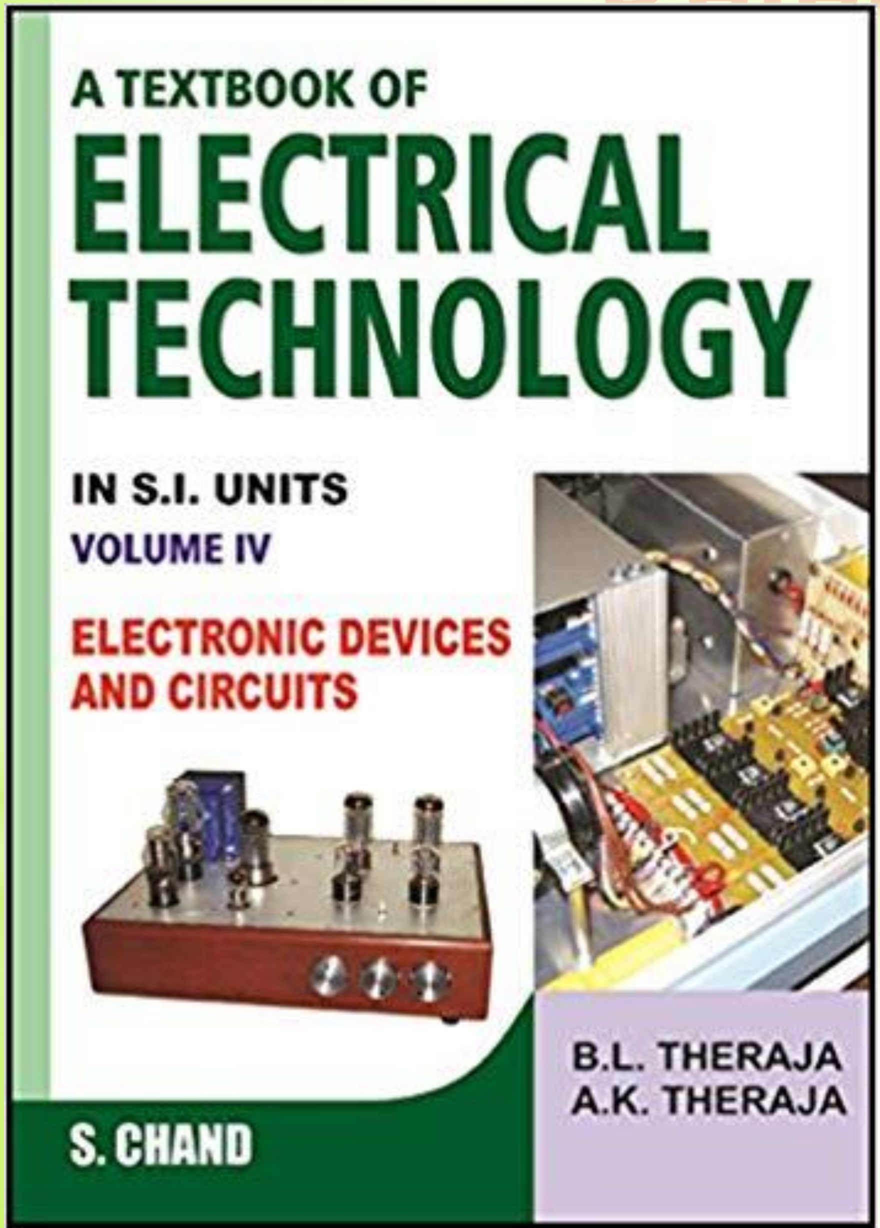
Analog Electronics

References


A TEXTBOOK OF
ELECTRICAL
TECHNOLOGY
IN S.I. UNITS
VOLUME IV
ELECTRONIC DEVICES
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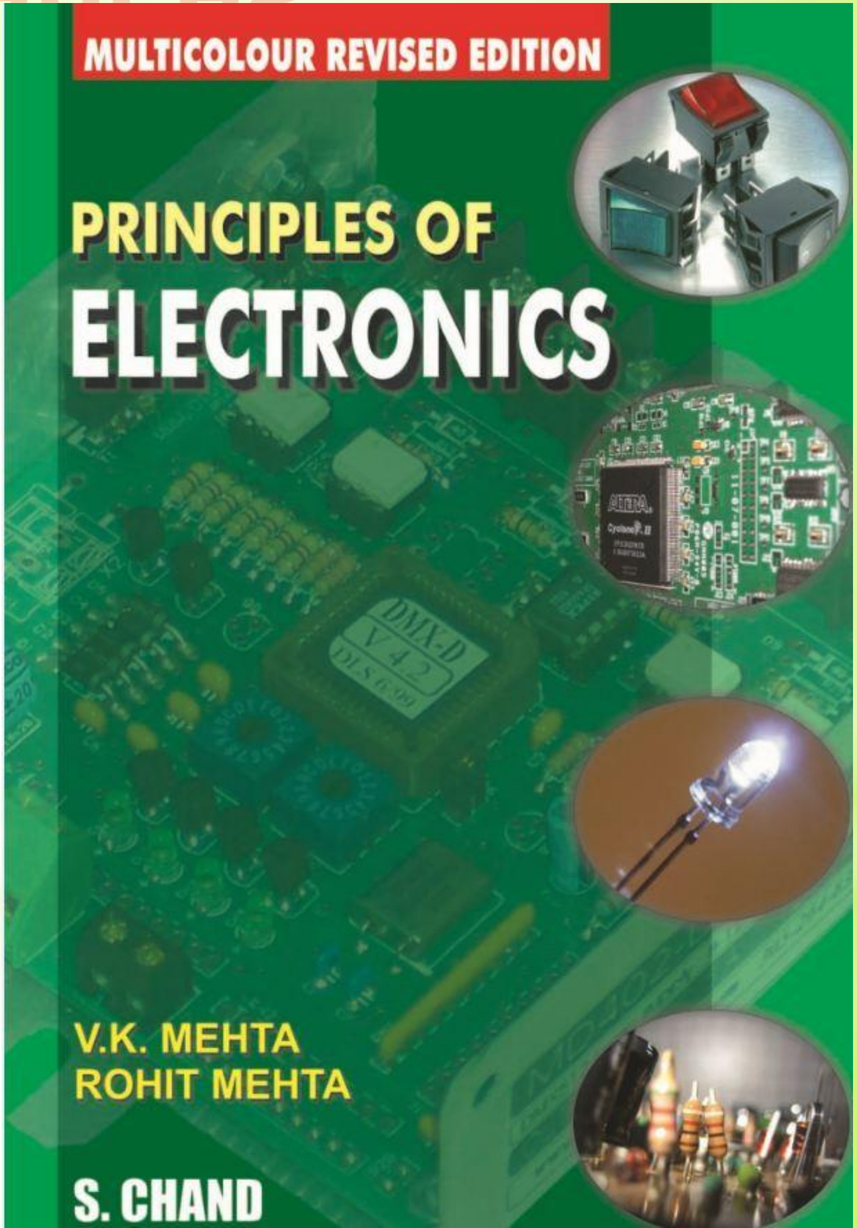
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Transistor Load Line Analysis

The value of collector-emitter voltage V_{CE} at any time is given by ;

$$V_{CE} = V_{CC} - I_C R_C \quad ...(i)$$

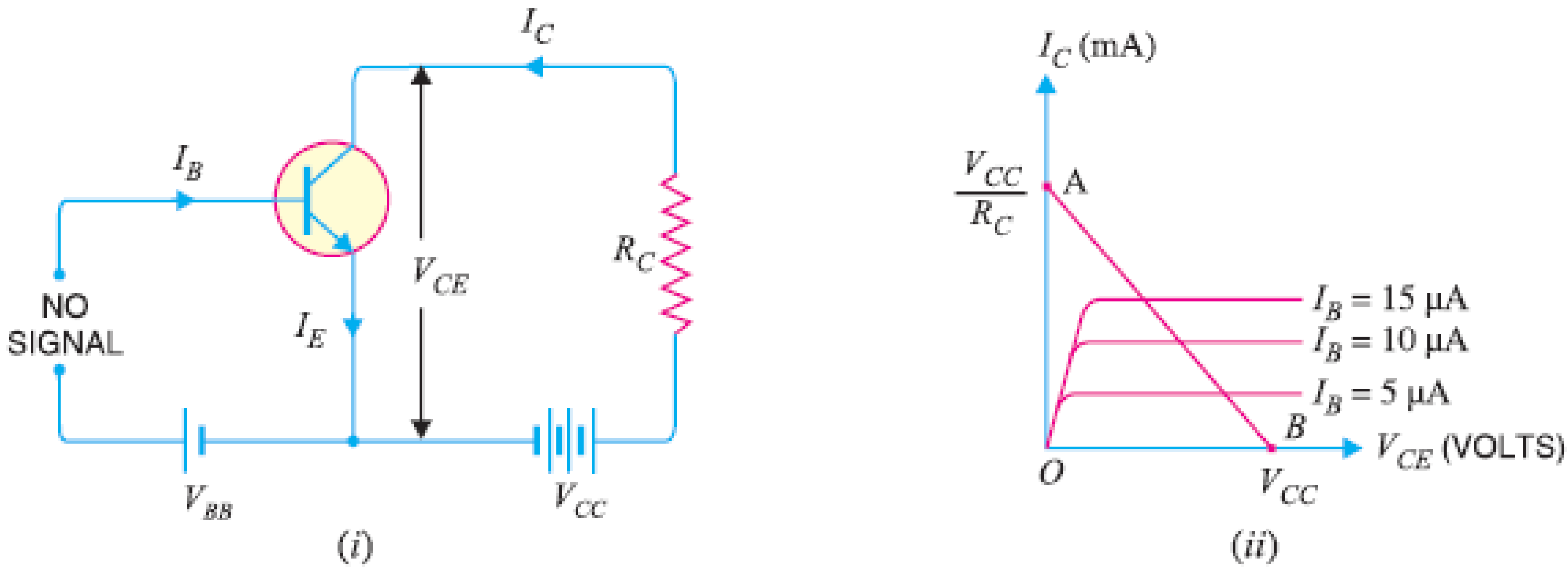


Fig. 8.35

As V_{CC} and R_C are fixed values, therefore, it is a first degree equation and can be represented by a straight line on the output characteristics. This is known as *d.c. load line* and determines the locus of $V_{CE} - I_C$ points for any given value of R_C. To add load line, we need two end points of the straight line. These two points can be located as under :

(i) When the collector current $I_C = 0$, then collector-emitter voltage is maximum and is equal to V_{CC} *i.e.*

$$\text{Max. } V_{CE} = V_{CC} - I_C R_C$$
$$= V_{CC} \qquad (\because I_C = 0)$$

This gives the first point B ($OB = V_{CC}$) on the collector-emitter voltage axis as shown in Fig. 8.35 (ii).

Transistor Load Line Analysis

(*ii*) When collector-emitter voltage $V_{CE} = 0$, the collector current is maximum and is equal to V_{CC}/R_C *i.e.*

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

or

$$0 = V_{CC} - I_C R_C$$

$$\therefore \quad \text{Max. } I_C = V_{CC}/R_C$$

This gives the second point A ($OA = V_{CC}/R_C$) on the collector current axis as shown in Fig. 8.35 (*ii*). By joining these two points, d.c. *load line AB is constructed.

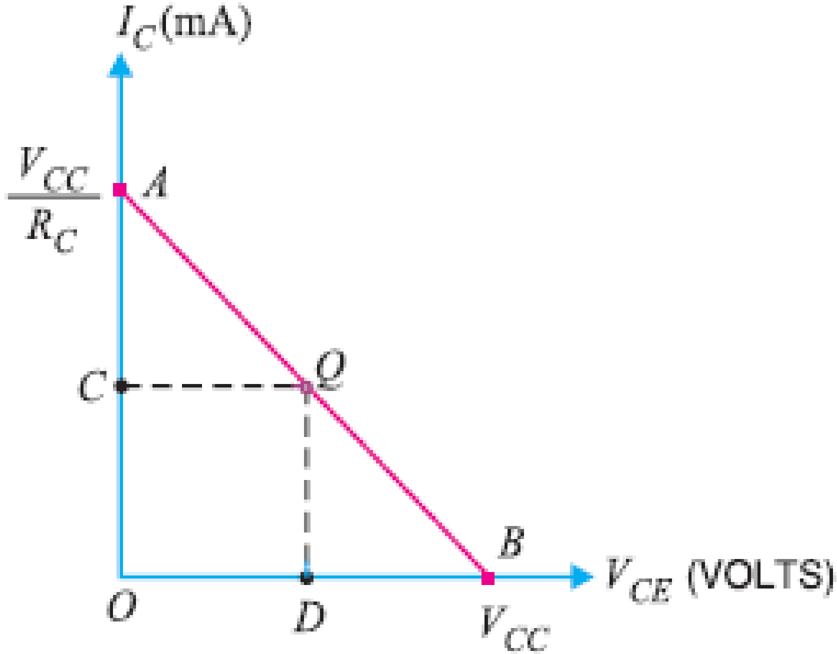


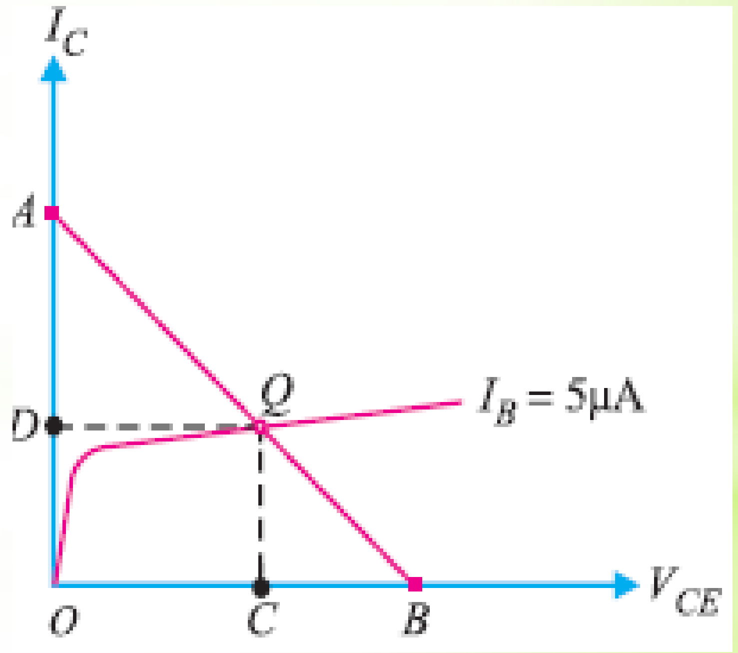
Fig. 8.36

Importance. The current (I_C) and voltage (V_{CE}) conditions in the transistor circuit are represented by some point on the output characteristics. The same information can be obtained from the load line. Thus when I_C is maximum (= V_{CC}/R_C), then $V_{CE} = 0$ as shown in Fig. 8.36. If $I_C = 0$, then V_{CE} is maximum and is equal to V_{CC}. For any other value of collector current say OC, the collector-emitter voltage $V_{CE} = OD$. It follows, therefore, that load line gives a far more convenient and direct solution to the problem.

Operating Point

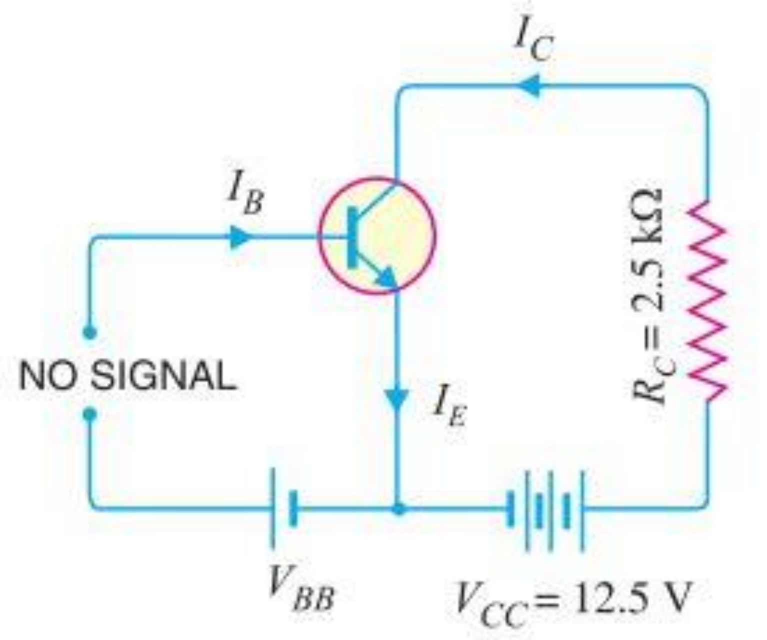
The zero signal values of I_C and V_{CE} are known as the operating point.

It is also called quiescent (silent) point or Q-point because it is the point on $I_C - V_{CE}$ characteristic when the transistor is silent i.e. in the absence of the signal.



P1

Example 8.22. *For the circuit shown in Fig. 8.38 (i), draw the d.c. load line.*



Example 8.22. *For the circuit shown in Fig. 8.38 (i), draw the d.c. load line.*

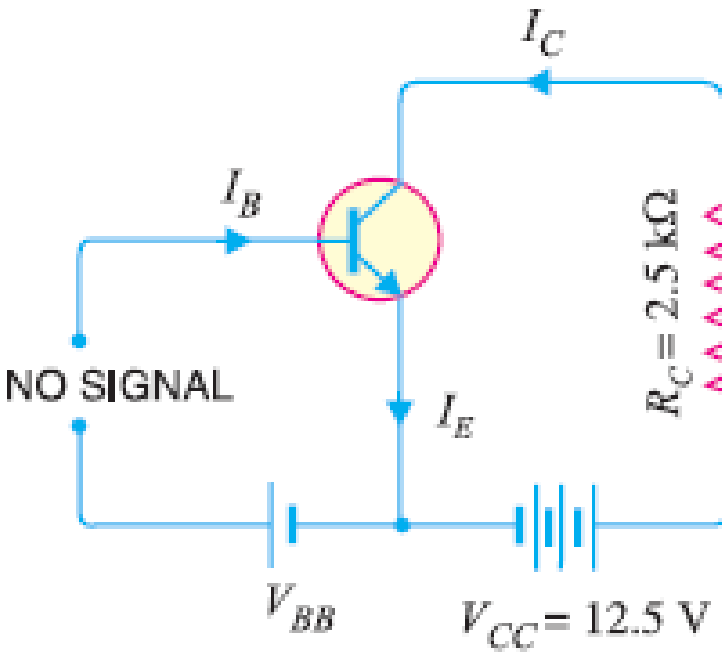
Solution. The collector-emitter voltage V_{CE} is given by ;

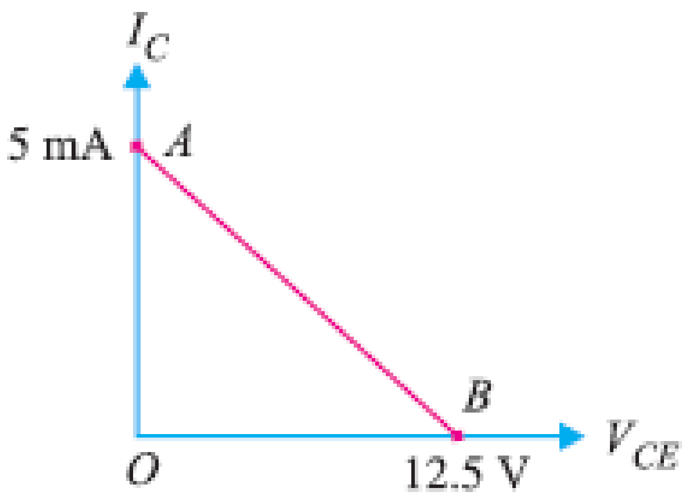
$$V_{CE} = V_{CC} - I_C R_C$$

When $I_C = 0$, then,

$$V_{CE} = V_{CC} = 12.5 \text{ V}$$

This locates the point B of the load line on the collector-emitter voltage axis.





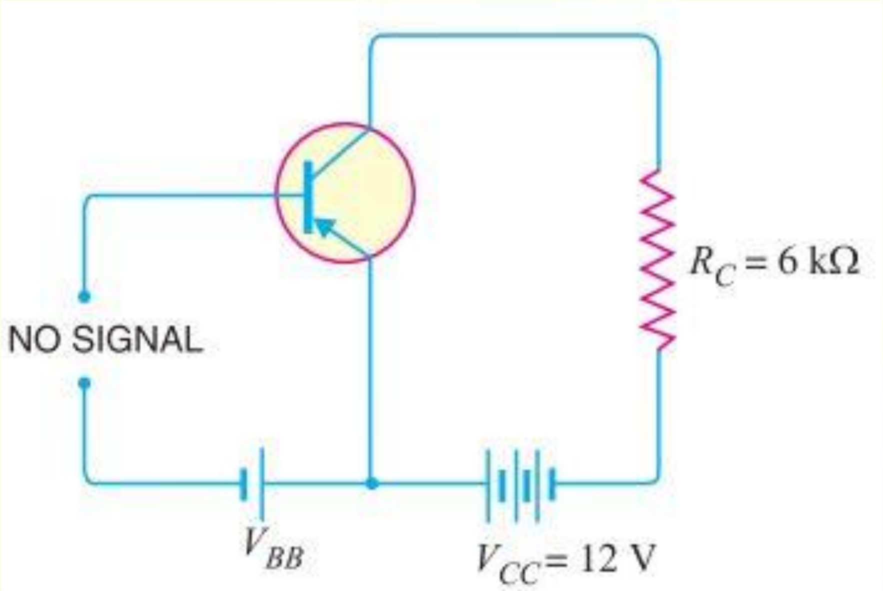
When $V_{CE} = 0$, then,

$$I_C = V_{CC}/R_C = 12.5 \text{ V}/2.5 \text{ k}\Omega = 5 \text{ mA}$$

This locates the point A of the load line on the collector current axis. By joining these two points, we get the d.c. load line AB as shown in Fig. 8.38 (*ii*).

P2

Example 8.23. *In the circuit diagram shown in Fig. 8.39 (i), if V_{CC} = 12V and R_C = 6 kΩ, draw the d.c. load line. What will be the Q point if zero signal base current is 20μA and β = 50 ?*



Example 8.23. *In the circuit diagram shown in Fig. 8.39 (i), if V_{CC} = 12V and R_C = 6 kΩ, draw the d.c. load line. What will be the Q point if zero signal base current is 20μA and β = 50 ?*

Solution. The collector-emitter voltage V_{CE} is given by :

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

When $I_C = 0$, $V_{CE} = V_{CC} = 12$ V. This locates the point *B* of the load line. When $V_{CE} = 0$, $I_C = V_{CC}/R_C = 12 \text{ V}/6 \text{ k}\Omega = 2$ mA. This locates the point *A* of the load line. By joining these two points, load line *AB* is constructed as shown in Fig. 8.39 (*ii*).

Zero signal base current, $I_B = 20\ \mu\text{A} = 0.02$ mA

Current amplification factor, $\beta = 50$

∴ Zero signal collector current, $I_C = \beta I_B = 50 \times 0.02 = 1$ mA

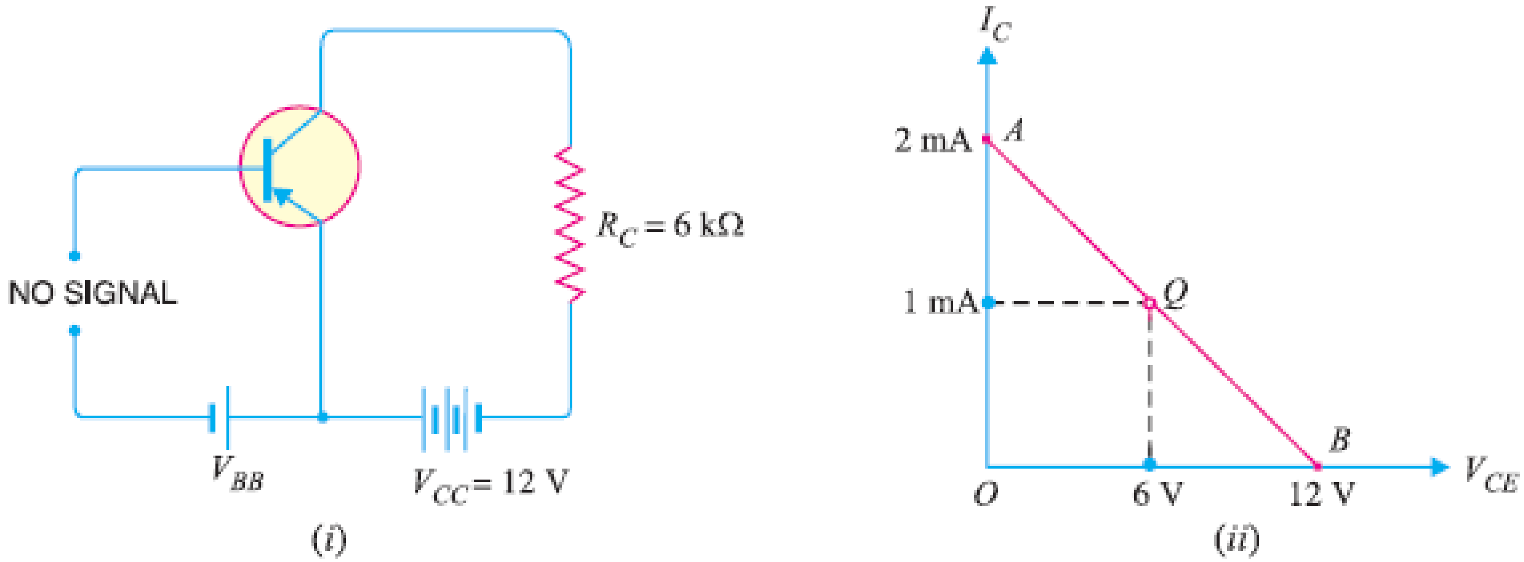


Fig. 8.39

Zero signal collector-emitter voltage is

$$V_{CE} = V_{CC} - I_C R_C = 12 - 1 \text{ mA} \times 6 \text{ k}\Omega = 6 \text{ V}$$

∴ Operating point is **6 V, 1 mA**.

Fig. 8.39 (*ii*) shows the *Q* point. Its co-ordinates are I_C = 1 mA and V_{CE} = 6 V.

Example 8.24. *In a transistor circuit, collector load is 4 kΩ whereas quiescent current (zero signal collector current) is 1mA.*

(i) *What is the operating point if V_{CC} = 10 V ?*

(ii) *What will be the operating point if R_C = 5 kΩ ?*

Example 8.24. *In a transistor circuit, collector load is 4 kΩ whereas quiescent current (zero signal collector current) is 1mA.*

(i) What is the operating point if V_{CC} = 10 V ?

(ii) What will be the operating point if R_C = 5 kΩ ?

Solution. $V_{CC} = 10 \text{ V}, I_C = 1 \text{ mA}$

(i) When collector load $R_C = 4 \text{ k}\Omega$, then,

$$V_{CE} = V_{CC} - I_C R_C = 10 - 1 \text{ mA} \times 4 \text{ k}\Omega = 10 - 4 = 6 V$$

∴ Operating point is **6 V, 1 mA**.

(ii) When collector load $R_C = 5 \text{ k}\Omega$, then,

$$V_{CE} = V_{CC} - I_C R_C = 10 - 1 \text{ mA} \times 5 \text{ k}\Omega = 10 - 5 = 5 V$$

∴ Operating point is **5 V, 1 mA**.

Thank You All