EEE 1231
Electronic Devices and Circuits

Lecture-6

Comparison of Transistor Connections

S. No.	Characteristic	Common base	Common emitter	Common collector
1.	Input resistance	Low (about 100 Ω)	Low (about 750 Ω)	Very high (about 750 kΩ)
2.	Output resistance	Very high (about 450 kΩ)	High (about 45 kΩ)	Low (about 50 Ω)
3.	Voltage gain	about 150	about 500	less than 1
4.	Applications	For high frequency applications	For audio frequency applications	For impedance matching
5.	Current gain	No (less than 1)	High (β)	Appreciable

Commonly Used Transistor Connection

Out of the three transistor connections, the common emitter circuit is the most efficient. It is used in about 90 to 95 per cent of all transistor applications. The main reasons for the widespread use of this circuit arrangement are :

(*i*) **High current gain.** In a common emitter connection, I_C is the output current and I_B is the input current. In this circuit arrangement, collector current is given by :

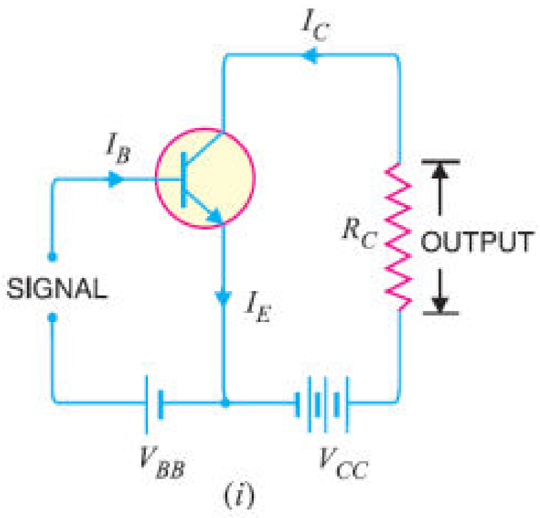
$$I_C = \beta I_B + I_{CEO}$$

As the value of β is very large, therefore, the output current I_C is much more than the input current I_B. Hence, the current gain in *CE* arrangement is very high. It may range from 20 to 500.

(*ii*) **High voltage and power gain.** Due to high current gain, the common emitter circuit has the highest voltage and power gain of three transistor connections. This is the major reason for using the transistor in this circuit arrangement.

(*iii*) **Moderate output to input impedance ratio.** In a common emitter circuit, the ratio of output impedance to input impedance is small (about 50). This makes this circuit arrangement an ideal one for coupling between various transistor stages. However, in other connections, the ratio of output impedance to input impedance is very large and hence coupling becomes highly inefficient due to gross mismatching.

Commonly Used Transistor Connection



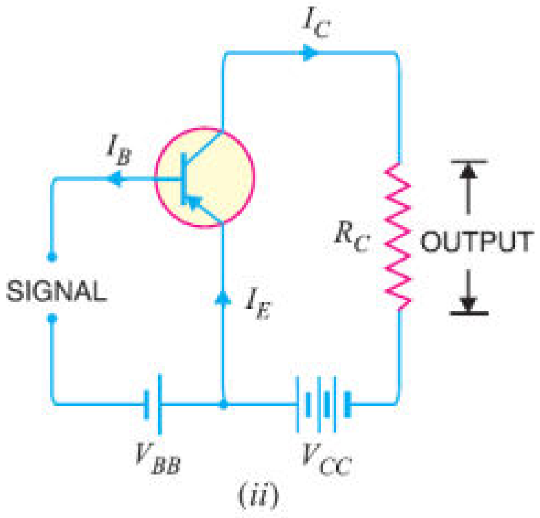


Fig: (*i*) common emitter n-p-n transistor circuit (*ii*) common emitter p-n-p transistor circuit

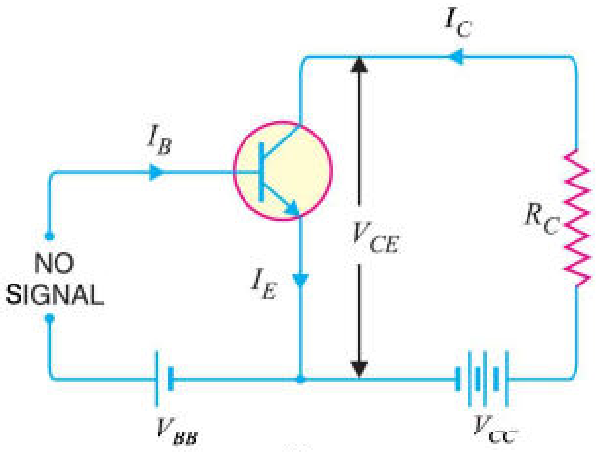
Transistor Load Line Analysis

- In the transistor circuit analysis, it is generally required to determine the collector current for various collector-emitter voltages.

- **D.C load line**: Consider a common emitter n-p-n transistor circuit shown in Fig. 8.35 (i) where no signal is applied. Therefore, D.C. conditions prevail in the circuit. The output characteristics of this circuit are shown in Fig. 8.35 (ii).

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

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



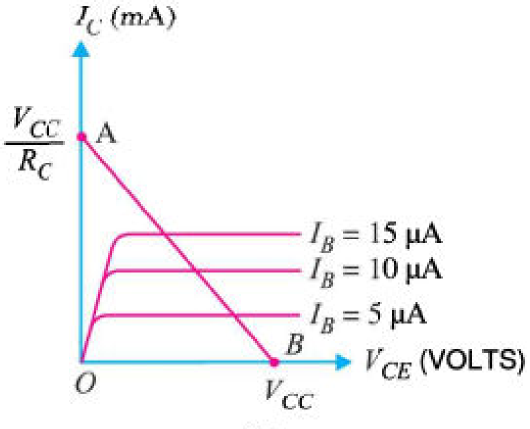


Fig. 8.35

Transistor Load Line Analysis

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*).

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

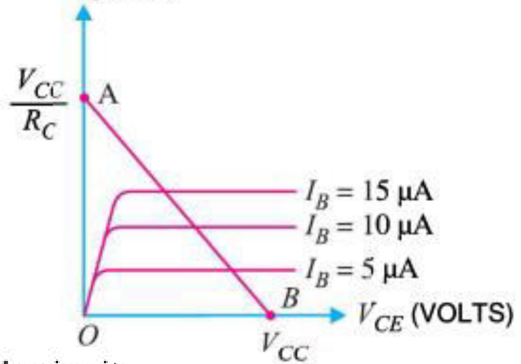
$$V_{CE} = V_{CC} - I_C R_C$$

or

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

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

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.



(*ii*)

Why load line ? The resistance R_C connected to the device is called load or load resistance for the circuit and, therefore, the line we have just constructed is called the load line.

Operating Point

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

It is called operating point because the variations of I_C and V_{CE} take place about this point when signal is applied. 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.

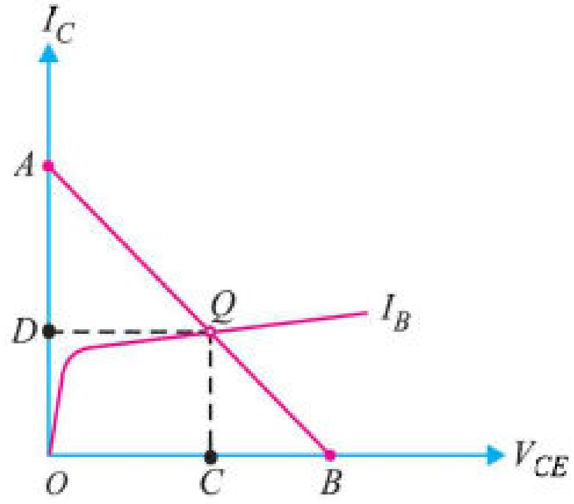
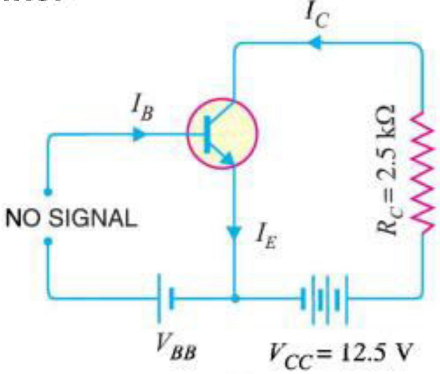


Fig. 8.37

Math Problems

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



(*i*)

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

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

When $I_C = 0$, then,

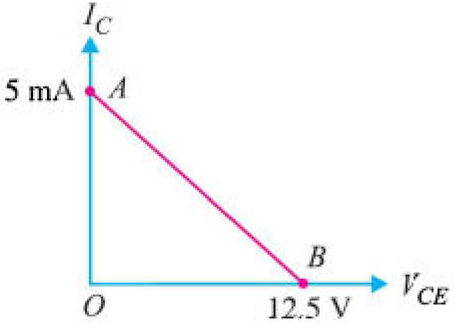
$$V_{CE} = V_{CC} = 12.5 \text{ V}$$

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*).



(*ii*)

Single Stage Transistor Amplifier

Single Stage Transistor Amplifier

- When only one transistor with associated circuitry is used for amplifying a weak signal, the circuit is known as single stage transistor amplifier.

- A single stage transistor amplifier has one transistor, bias circuit and other auxiliary components. Although a practical amplifier consists of a number of stages, yet such a complex circuit can be conveniently split up into separate single stages.

- By analyzing carefully only a single stage and using this single stage analysis repeatedly, we can effectively analyze the complex circuit.

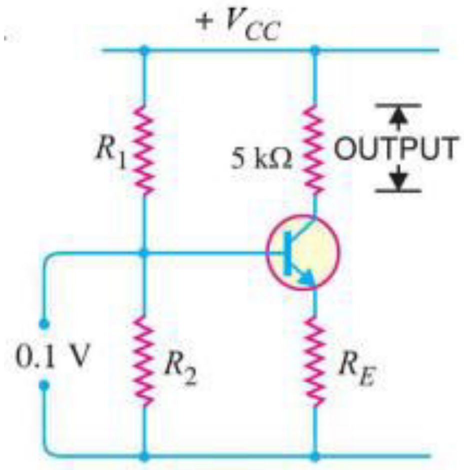


Fig. 10.1

How Transistor Amplifies

Fig. 10.1 shows a single stage transistor amplifier. When a weak a.c. signal is given to the base of transistor, a small base current (which is a.c.) starts flowing. Due to transistor action, a much larger (β times the base current) a.c. current flows through the collector load R_C. As the value of R_C is quite high (usually 4-10 kΩ), therefore, a large voltage appears across R_C. Thus, a weak signal applied in the base circuit appears in amplified form in the collector circuit. It is in this way that a transistor acts as an amplifier.

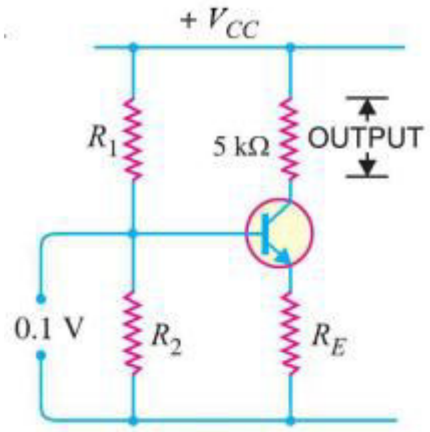


Fig. 10.1

Practical Circuit of Transistor Amplifier

It is important to note that a transistor can accomplish faithful amplification only if proper associated circuitry is used with it. Fig. 10.3 shows a practical single stage transistor amplifier. The various circuit elements and their functions are described below :

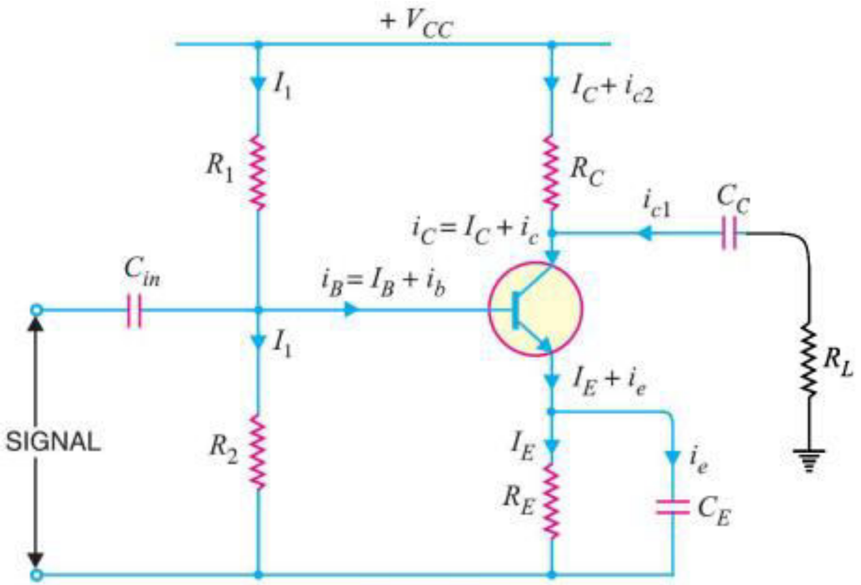


Fig. 10.3

D.C & A.C Equivalent Circuits

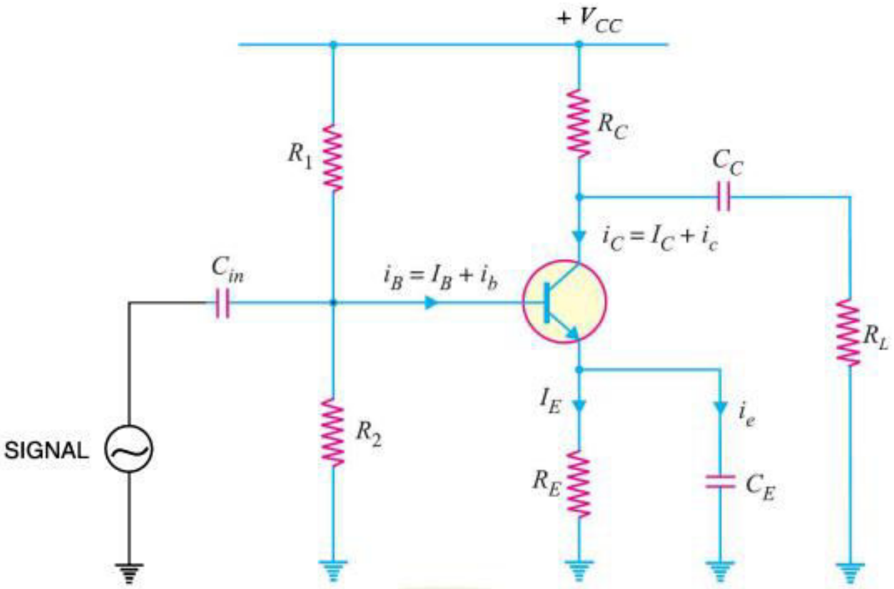


Fig. 10.8

D.C Equivalent Circuits

(*i*) **D. C. equivalent circuit.** In the d.c. equivalent circuit of a transistor amplifier, only d.c. conditions are to be considered *i.e.* it is presumed that no signal is applied. As direct current cannot flow through a capacitor, therefore, *all the capacitors look like open circuits in the d.c. equivalent circuit.* It follows, therefore, that in order to draw the equivalent d.c. circuit, the following two steps are applied to the transistor circuit :

(*a*) Reduce all a.c. sources to zero.

(*b*) Open all the capacitors.

Applying these two steps to the circuit shown in Fig. 10.8, we get the d.c. equivalent circuit shown in Fig. 10.9. We can easily calculate the d.c. currents and voltages from this circuit.

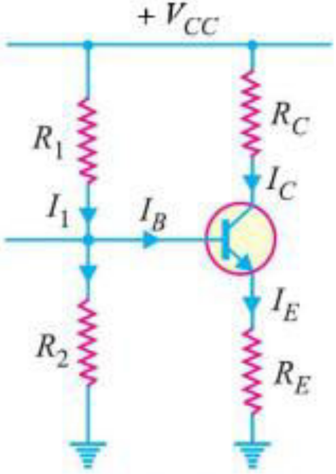


Fig. 10.9

A.C Equivalent Circuits

(*ii*) **A.C. equivalent circuit.** In the a.c. equivalent circuit of a transistor amplifier, only a.c. conditions are to be considered. Obviously, the d.c. voltage is not important for such a circuit and may be considered zero. The capacitors are generally used to couple or bypass the a.c. signal. The designer intentionally selects capacitors that are large enough to appear as *short* circuits to the a.c. signal. It follows therefore, that in order to draw the a.c. equivalent circuit, the follc two steps are applied to the transistor circuit :

(*a*) Reduce all d.c. sources to zero (*i.e.* $V_{CC} = 0$).

(*b*) Short all the capacitors.

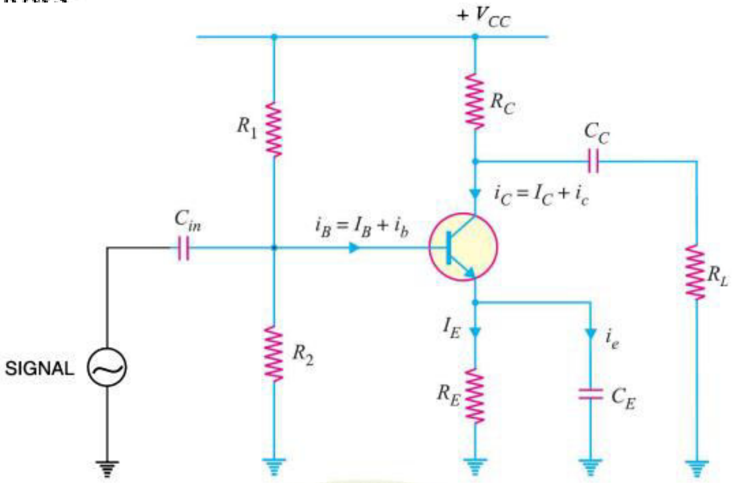


Fig. 10.8

A.C Equivalent Circuits

Applying these two steps to the circuit shown in Fig. 10.8, we get the a.c. *equivalent circuit shown in Fig. 10.10. We can easily calculate the a.c. currents and voltages from this circuit.

* Note that R_1 is also in parallel with transistor input so far as signal is concerned. Since R_1 is connected from the base lead to V_{CC} and V_{CC} is at "ac ground", R_1 is effectively connected from the base lead to ground as far as signal is concerned.

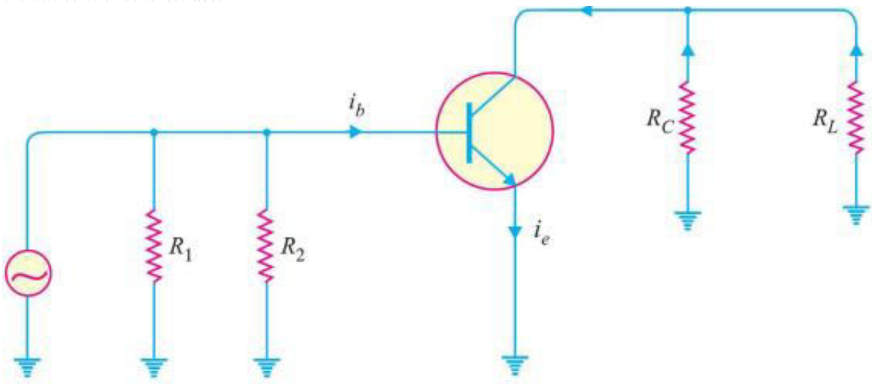


Fig. 10.10

It may be seen that total current in any branch is the sum of d.c. and a.c. currents through that branch. Similarly, the total voltage across any branch is the sum of d.c. and a.c. voltages across that branch.