Single stage BJT Amplifier:

Previously we saw how proper biasing raise the strength of a transistor and thus act as an amplifier. Amplification may be single stage or Multi stage.

A transistor operating in the **active region** has the capability to amplify weak signals. Amplification is the process of increasing the signal strength (increase in the amplitude). If a large amplification is required, the transistors are cascaded with coupling elements like resistors, capacitors, and transformers which is called as multistage amplifiers.

When only one transistor is used with an associated circuit to amplify a weak signal, the circuit is known as a single **stage transistor amplifier**. It consists of a transistor, bias circuit, and the auxiliary components (resistance, capacitors) fig.1

The purpose of BJT amplifier is to amplify the applied small signal.

Circuit Diagram:

To achieve **faithful amplification** in a transistor amplifier, we must use proper associated circuitry with the transistor.

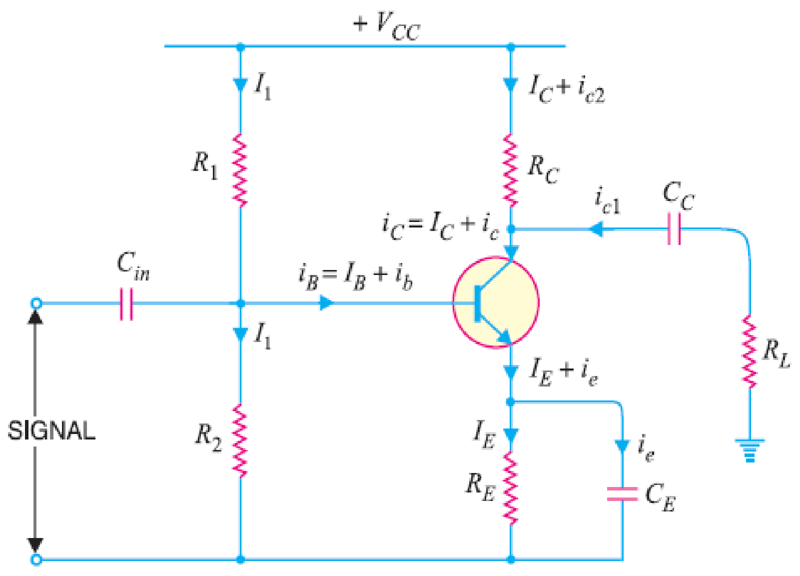


Figure 1. Practical single stage transistor amplifier circuit

The various circuit elements and their functions are described as follows:

(i) Biasing Circuit (Voltage biasing circuit)

The resistances R_1, R_2 and R_E provide biasing and stabilisation.
The biasing circuit must establish a proper operating point. DC voltage is used for biasing purpose.

(ii) Input Capacitor (C_{in})
A capacitor of value 10 μF is used to couple the signal to the base of the transistor.

Otherwise, the signal source resistance will come across R_2 and thus can change the bias. This capacitor allows only the a.c. signal to flow but isolates the signal source from R_2 .

(iii) Emitter Bypass Capacitor (C_E)

An emitter bypass capacitor of value 100 μF is used in parallel with R_E to provide a low reactance path to the amplified a.c. signal.

If this capacitor is not connected in the output circuit then the amplified a.c. signal will flow through R_E and cause a voltage drop across it, thereby reducing the output voltage.

(iv) Coupling Capacitor (C_C)

The coupling capacitor of value 10 μF is used to couple one stage of amplification to the next stage.

If it is not used, the bias condition of the next stage will be drastically changed due to the shunting effect of R_C . This is because R_C will come in parallel with the resistance R_1 of the biasing circuit of the next stage amplifier circuit and hence, alter the biasing condition of the next stage.

Therefore, the coupling capacitor is used to isolates the d.c. of one stage from the next stage and allows the a.c. signal only.

How signal is amplified?

When a weak a.c. signal is applied to the base of the transistor, a small base current starts flowing in the input circuit. Due to transistor action, a much larger (β times the base current) a.c. current flows through the the load Rc in the output circuit. Since the value of load resistance Rc is very high, a large voltage will drop across it.

Thus, a weak signal applied in the base circuit appears in amplified form in the collector circuit. In this way the transistor acts as an amplifier.

Various Circuit Currents

(i) Base Current

When no signal is applied in the base circuit, d.c. base current $I_{B,}$ also known as zero signal base current flows due to the biasing circuit.

When a.c. signal is applied, a.c. base current i_b flows in the base circuit.

Hence, the total base current i_B is given by :

$$i_B = I_B + i_b$$

(ii) Collector Current

When no signal is applied, a d.c. collector current $I_{C,}$ also known as zero signal collector current flows due to the biasing circuit.

When a.c. signal is applied, a.c. collector current i_c also flows in the collector circuit.

Hence, the total collector current i_C is given by :

$$i_C = I_C + i_c$$

where

$$I_C = \beta I_B = \text{zero signal collector current}$$

$$i_c = \beta i_b = \text{collector current due to signal.}$$

(iii) Emitter Current

When no signal is applied, a d.c. emitter current $I_{E,}$ flows due to the biasing circuit.
When a.c. signal is applied, a.c. emitter current i_e also flows .
Hence, the total emitter current i_E is given by :

$$i_E = I_E + i_e$$

It is useful to keep in mind that :

$$I_E = I_B + I_C$$

$$i_e = i_b + i_c$$

Now base current is usually very small, therefore,

$$I_E \simeq I_C \quad \text{and} \quad i_e \simeq i_c$$

D.C. and A.C. Equivalent Circuits

To analyse the action of a transistor in a simple way, the analysis is divided into two parts such as; d.c. analysis and a.c. analysis.

In d.c. analysis, we will consider all the d.c. sources at the same time and work out the d.c. currents voltages in the circuit.

Similarly, in a.c. analysis, we will consider all the a.c. sources at the same time and work out the a.c. currents and voltages .

For this analysis let us consider the amplifier circuit shown in fig. below .

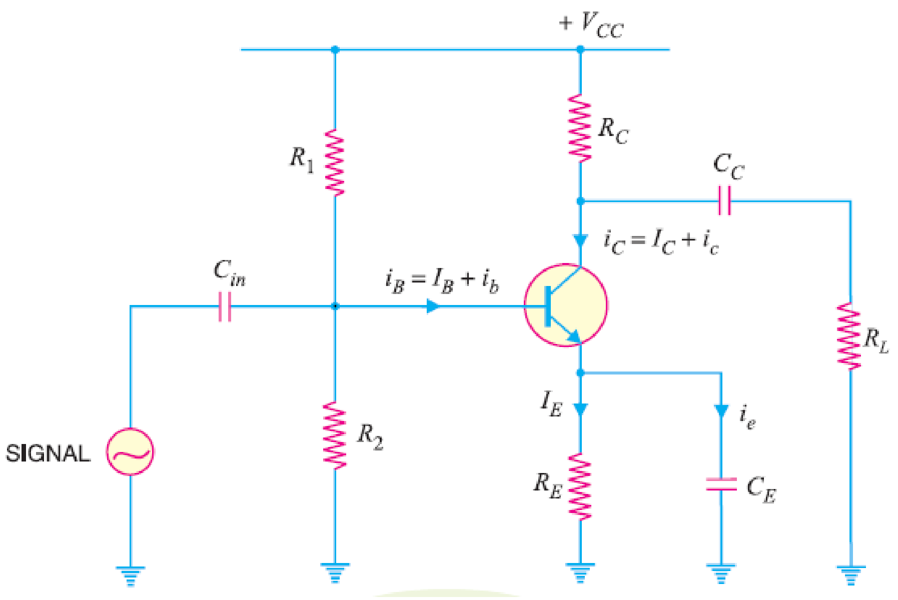


Figure 2. Amplifier circuit

(1) D.C. Equivalent Circuit

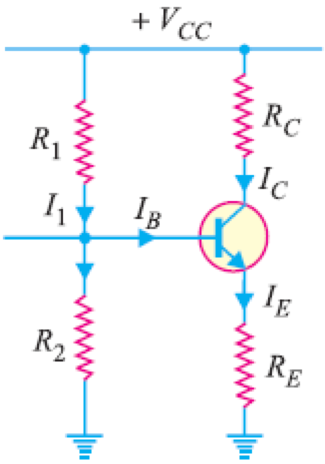
In the d.c. equivalent circuit of a transistor amplifier, only d.c. conditions must be considered. So let us assume there is no signal applied to the circuit.

Since, d.c. currents can not pass through the capacitors, hence, all the capacitors look like open circuits in the d.c. equivalent circuit.

Therefore, to draw the d.c. equivalent circuit, the following two steps are applied to the transistor amplifier circuit :

1. Make all the a.c. sources zero or Remove all the a.c sources
2. Open all the capacitors

Applying these two steps to the circuit shown in fig.3, we will get the d.c. equivalent circuit as shown in fig. below.



Now we can easily calculate the d.c. currents and voltages from this circuit.

(2) A.C. Equivalent Circuit

In the a.c. equivalent circuit of a transistor amplifier, only a.c. conditions must be considered.

In this case, d.c. voltage is not so important hence, may be assumed to be zero.

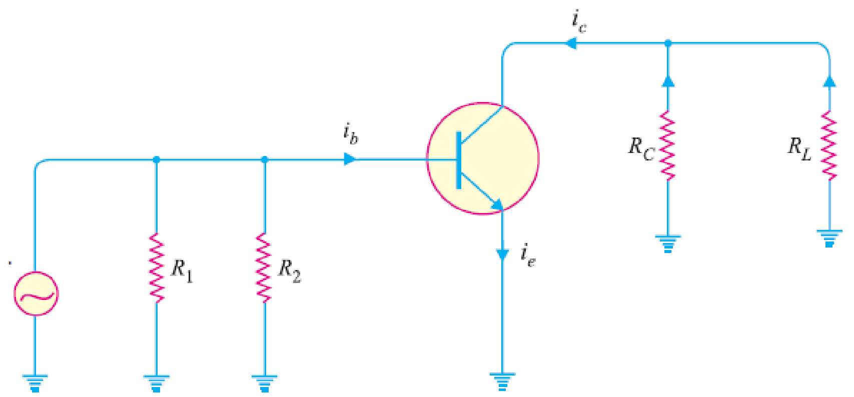
The capacitors are used in the circuit to couple or bypass the a.c. signal.

The capacitors are generally taken of large values so as to appear as short circuits to the a.c. signal.

Therefore, to draw the a.c. equivalent circuit, the following two steps are applied to the transistor amplifier circuit :

1. Make all the d.c. sources zero or Remove all the d.c. sources
2. Short all the capacitors

Applying these two steps to the circuit shown in fig.3, we will get the a.c. equivalent circuit as shown in fig. below.



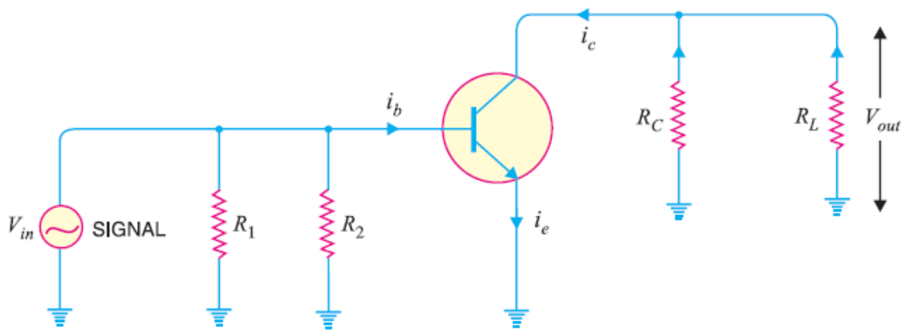
Now we can easily calculate the a.c. currents and voltages from this circuit.

Voltage Gain of Single stage Transistor Amplifier

The voltage gain of a single stage transistor amplifier is the ratio of a.c. output voltage to a.c. input signal voltage.

Hence, in order to determine the voltage gain, you should consider only the a.c. currents and voltages in the circuit. In other words you have to consider the a.c. equivalent circuit of the transistor amplifier.

The a.c. equivalent circuit of a transistor amplifier is shown in fig. below.



As far as a.c. signal is concerned, load R_C appears in parallel with R_L.
Therefore, the effective load resistance for a.c. is given by :

$$\text{a.c. load, } R_{AC} = R_C \parallel R_L = \frac{R_C \times R_L}{R_C + R_L}$$

$$\text{Output voltage, } V_{out} = i_c\, R_{AC}$$

$$\text{Input voltage, } V_{in} = i_b\, R_{in}$$

$$\therefore \quad \text{Voltage gain, } A_v = V_{out}/V_{in}$$

$$= \frac{i_c\, R_{AC}}{i_b\, R_{in}} = \beta \times \frac{R_{AC}}{R_{in}}$$

Incidentally, power gain is given by :

$$A_p = \frac{i_c^2\, R_{AC}}{i_b^2\, R_{in}} = \beta^2 \times \frac{R_{AC}}{R_{in}}$$