Semiconductor Devices and Circuits

Single Stage Amplifiers and Power Amplifiers

(Unit III - Part I)

III B.Sc Physics

V Semester

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Chapter 1

Amplifiers

1.1 Introduction

An amplifier is an important part of any electronic device. Its purpose is to increase the magnitude or the energy level of an input AC signal to any desired level. It generally consists of an *active device* connected to a network of *passive components* and is energised by a *DC supply.*

If an electronic device is to be useful for constructing a general purpose amplifier, it must satisfy the following requirements

1. it must have a considerable current or voltage gain
2. it must have a linear relationship between the input and output, that is, its output should have a "one-to-one" correspondence with its input
3. this linearity of characteristic should extend over a large portion of its output
4. it should lend itself to *cascading*, that is, it can be connected in series to form a multi-stage amplifier.

A bipolar transistor possess all of these properties and hence may be used as an active device in constructing an amplifier circuit.

1.2 Transistor as an Amplifier in Common-Emitter (CE) Configuration

A transistor in common emitter configuration can act as an amplifier circuit. This circuit is shown in Fig. 1.1.

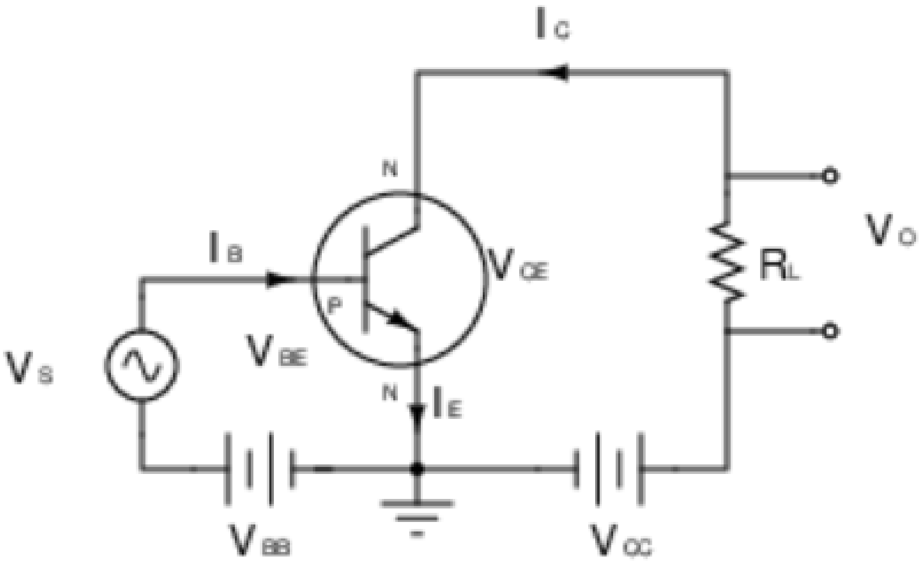

FIGURE 1.1: A transistor amplifier in common emitter configuration

For a transistor to function properly, we should have

1. the base-emitter junction to be forward biased and
2. the collector-emitter junction to be reverse biased.

These conditions are satisfied by the DC supplies $+\mathbf{V_{BB}}$ and $+\mathbf{V_{CC}}$ respectively. A small signal voltage v_s from a signal generator is applied to the base of the transistor. An amplified form of this signal voltage, but inverted in phase by 180^o or π-radians is obtained at the output across the load resistance R_L.

1.3 Operation

When no signal is applied, the input circuit is forward biased by the DC power supply $+V_{BB}$. Therefore a DC collector current I_{C0} flows across the collector circuit. This is called as the *zero signal collector current*. When the signal voltage V_s is turned on, this collector current will not remain constant but will increase or decrease depending on the change in the forward bias voltage applied to the base-emitter junction.

During the positive half of the signal voltage V_s, the forward bias across the emitter-base junction increases. This causes more number of electrons to flow from the base to the collector, giving rise to a large collector current. This large collector current I_{C0} will produce a large voltage drop across the load resistance R_L.

On the other hand, during the negative half cycle of the signal voltage V_s, the forward bias across the emitter-bade junction decreases. This will cause less number of electrons to get injected into the collector from the base, thereby giving rise to a fall in the collector current. This reduced collector current I_{C0} will now produce a smaller voltage drop across the load resistance R_L. Thus an amplified output of the signal waveform is obtained across the load.

The change in the phase of the output from that of the input voltage arises because of *transistor action*.

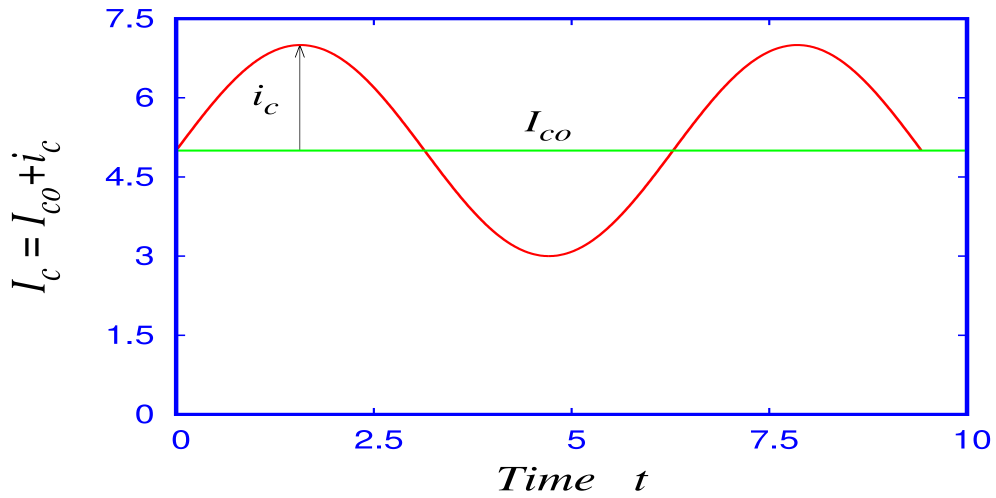

FIGURE 1.2: The total current across the collector terminal I_c is given as the sum of the DC component I_{C0} and the AC component i_c, that is $I_C = I_{C0} + i_c$.

1.4 Analysis of the Collector Currrent

The instantaneous collector current flowing across the resistance R_L is given as a sum of two parts, that is,

$$I_C = I_{C0} + i_c, \tag{1.1}$$

where I_{C0} is the pure DC current that is flowing in the absence of an AC signal and i_c is the AC component that flows when the input signal is applied. The AC component causes the total collector current to increase or decrease as shown in Fig. 1.2.

The useful output is the voltage drop across the collector load R_L arising due to the AC component of the collector current i_c. The zero signal collector current I_C0 is just to ensure that the base-emitter junction remains forward biased at all times. The performance of the amplifier can be analysed graphically by drawing the DC and AC *equivalent circuits* and the DC and AC *load lines* for the circuit. This will be explained in detail in the section on single stage RC coupled transistor amplifier.

1.5 Parameters of a Transistor Amplifier in CE Configuration

The performance of the transistor amplifier depends upon the the parameters such as input resistance, output resistance, effective collector load, current gain, voltage gain and power gain. These parameters are explained below.

1. **Input Resistance (R_i):** This is the ratio of the small change in the base-emitter voltage ΔV_{BE} to the resulting change in the base current I_B, when the collector-emitter voltage is kept a constant, that is

$$R_i = \left(\frac{\Delta V_{BE}}{\Delta I_B}\right)_{V_C E} \Omega s. \tag{1.2}$$

2. **Output Resistance (R_o):** It is the ratio of the change in the collector-emitter voltage ΔV_{CE} to the change in collector current I_C when the base current I_B is held a constant and is given as

$$R_o = \left(\frac{\Delta V_{CE}}{\Delta I_C}\right)_{I_B} \Omega s. \tag{1.3}$$

3. **Effective Collector Load (R_{AC}):** It is the total output resistance as seen by the AC collector current and is given by

$$R_{AC} = R_L \| R_o \qquad \text{or}$$
$$R_{AC} = \frac{R_L \times R_o}{R_L + R_o} \simeq R_L. \tag{1.4}$$

Note: As the collector-base junction is reverse biased, the effective collector load will naturally be a very large quantity ($\simeq K\Omega$ s)

4. **Current Gain (β):** This is the ratio of the change in the collector current ΔI_C to the change in the base current ΔI_B, when the collector-emitter voltage ΔV_{CE} is held a constant, that is
$$\beta = \left(\frac{\Delta I_C}{\Delta I_B}\right)_{V_{CE}}. \tag{1.5}$$
Usually we find the current gain to vary in the range $20 < \beta \leq 500$.

5. **Voltage Gain (A_V):** This is the ratio of the change in the collector-emitter voltage ΔV_{CE} to the change in the input voltage ΔV_{BE}, that is
$$\begin{aligned} A_V &= \frac{\Delta V_{CE}}{\Delta V_{BE}} \\ &= \frac{\Delta I_C \times R_L}{\Delta I_B \times R_i} \\ &\simeq \left(\frac{\Delta I_C}{\Delta I_B}\right) \times \left(\frac{R_L}{R_i}\right) \\ A_V &= \beta \times \left(\frac{R_L}{R_i}\right). \end{aligned} \tag{1.6}$$

6. **Power Gain (A_P):** This is the ratio of the output signal power to the power of the input signal, that is
$$A_P = \frac{\Delta V_{CE} \times \Delta I_C}{\Delta V_{BE} \Delta I_B} = A_V \times \beta. \tag{1.7}$$

1.6 Characteristics of the Transistor Amplifier in CE Configuration

A transistor amplifier in the CE configuration has the following characteristics,

1. a low input resistance R_i, usually of the order of $(1 - 2k\Omega)$
2. a high output resistance R_o, of the order of $50k\Omega$
3. a large current gain $\beta \gg 1$
4. a large voltage gain $A_V = 1500$
5. a large power gain $A_P = 10,000$ or 40 dB.
6. it causes a reversal in phase of 180^o or π-radians.

1.7 Single Stage RC Coupled Transistor Amplifier

A single stage RC coupled transistor amplifier is shown in Fig. 1.3.

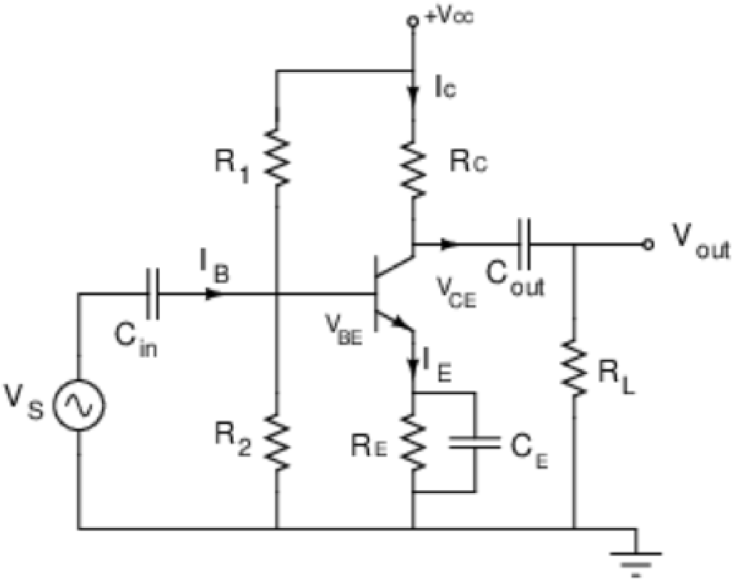

FIGURE 1.3: A single stage RC coupled transistor amplifier.

1.7.1 Circuit Description

The circuit uses

1. a n-p-n transistor in CE configuration
2. a voltage divider bias

The collector DC supply $+V_{CC}$ reverse biases the collector with respect to the emitter. The DC voltage to the base is given from $+V_{CC}$ itself by a voltage-divider network $(R_1 - R_2)$. Effectively the voltage across the resistance R_2 is given by

$$V_2 = \left\{ \frac{V_{CC}}{R_1 + R_2} \right\} \times R_2 \tag{1.8}$$

The current flowing through the resistances R_1 and R_2 is given by the ratio of the total voltage to the total resistance, that is

$$I = \left\{ \frac{V_{CC}}{R_1 + R_2} \right\}$$

Hence the voltages across the resistance R_1 is given by

$$\begin{aligned} V_1 &= I \times R_1 \\ V_1 &= \left\{ \frac{V_{CC}}{R_1 + R_2} \right\} \times R_1 \end{aligned}$$

similarly the voltage across resistance R_2 is given by

$$\begin{aligned} V_2 &= I \times R_2 \\ V_2 &= \left\{ \frac{V_{CC}}{R_1 + R_2} \right\} \times R_2 \end{aligned}$$

Therefore by selecting suitable resistances R_1 and R_2, the desired DC operating point or Quiescent point or **Q**-point can be had.

The resistance R_C is called as the collector resistance. It is in fact a current limiting resistance. When the collector current I_C exceeds a certain value, the collector-base junction gets heated very much, thereby damaging the transistor. This resistance R_C limits the collector current to acceptable low values.

A transistor is a temperature sensitive device. When the temperature increases, the base current I_B increases. This causes the collector current I_C to increase, since

$$I_C = \beta I_B \tag{1.9}$$

If this were to continue, then the transistor will be driven to *saturation* and hence will breakdown. This is called as *thermal-runaway condition.* This is avoided by including the emitter resistance I_E. By applying Krichhoff's voltage law (KVL) to the input when DC currents alone are present, we have

$$\begin{aligned} V_2 &= V_{BE} + I_E R_E \qquad \text{or} \\ V_{BE} &= V_2 - I_E R_E, \end{aligned} \tag{1.10}$$

where I_E is the current flowing across the emitter. We know

$$I_E = I_B + I_C \tag{1.11}$$

Hence as I_B and I_C increase, the emitter current I_E increases, causing a large voltage drop $I_E \times R_E$ across the emitter resistance R_E. Consequently the base-emitter voltage V_{BE} gets reduced according to the Eqn. (1.10). This causes the base current I_B to get reduced, which in turn pulls down the collector current I_C to normal levels.

In a similar manner, the reverse process may also occur. When the base-emitter voltage V_{BE} is reduced, the resistance R_E will try to restore the collector current I_C to normal values by increasing V_{BE}.

The AC signals to be amplified are applied at the base of the transistor through the I/P coupling capacitor C_{in}. As the resistance of a capacitor for AC signals is low, it readily allows the AC signal to pass through it. On the other hand, as its resistance to the DC currents is high, it blocks the DC currents from the amplifier from entering the signal source and damaging or *swamping* it.

The coupling capacitor C_{out} couples the amplified signal to the load, while preventing the DC components from reaching it.

> *Note:* The AC resistance of a component is called as *reactance* and is denoted by X. The AC resistance of a capacitor, called as *capacitative reactance* is given by
>
> $$X_C = \frac{1}{j\omega C},$$
>
> where ω is the angular frequency of the signal and C is its capacitance value. The term $j = \sqrt{-1}$ is the imaginary unit. As the angular frequency for an AC signal is high, the capacitative reactance of the capacitor for the AC signal is low. Hence AC signals can freely flow through the capacitor. On the other hand the angular frequency of the DC voltage is zero, that is $\omega = 0$. This causes the capacitor to offer very high resistance to the DC voltages, (ideally infinity).

From Eqn. (1.10) we find that if the emitter current I_E fluctuates, then $I_E R_E$ and hence V_{BE} will fluctuate. This will cause the **Q** point to vary, thereby causing the amplifier to be unstable. This is overcome with the help of the emitter-bypass capacitance C_E.

This capacitor provides a low resistance path for the AC signals to flow to the ground, thereby causing the DC component of the emitter current I_E to remain a constant.

> *Note:* The capacitor C_E is so selected that if offers least resistance to even the highest frequency component of the AC signal. Usually the emitter-bypass capacitance is selected so that $X_{CE} \leq \frac{R_E}{10}$.

1.8 Graphical Analysis

The current gain, voltage gain and other parameters of the amplifier can be evaluated using graphical analysis. This method is based on analysing the variations in the collector currents and voltages when the base current is varied.

In an amplifier as both DC and AC signal voltages and currents flow, the analysis is difficult. Hence we separate the circuit into two parts, namely the DC equivalent part and the AC equivalent part and analyse the currents and voltages individually.

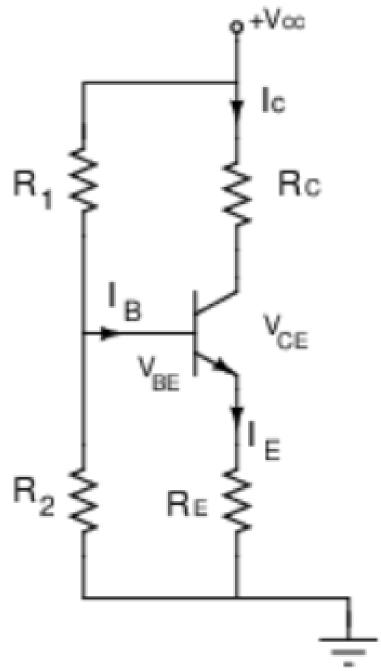

FIGURE 1.4: The DC equivalent circuit of a single stage RC coupled transistor amplifier.

1.8.1 The DC Equivalent Circuit

This can be obtained by

1. considering all the capacitors as open switches
2. reducing all the AC signal sources to zero.

The DC equivalent circuit of the single stage RC coupled transistor amplifier is shown in Fig. 1.4.

Applying the Kirchhoff's voltage law (KVL) to the output section, we have

$$V_{CC} = I_C R_C + V_{CE} + I_E R_E. \tag{1.12}$$

But from Eqn. (1.11) we find that if $I_B \ll I_C$, $I_E \simeq I_C$. Hence Eqn. (1.12) can be rewritten as

$$V_{CC} = V_{CE} + I_C(R_C + R_E). \tag{1.13}$$

Rearranging Eqn. (1.13) gives

$$\boxed{I_C = -\left\{\frac{1}{R_C + R_E}\right\} V_{CE} + \left\{\frac{V_{CC}}{R_C + R_E}\right\}} \tag{1.14}$$

The Eqn. (1.14) is known as the equation of a DC Loadline.
The DC load line is defined as that line drawn on the output characteristic of the transistor circuit which defines the values of the currents and voltages at any instant of time.

> *Note:*
> The Eqn. (1.14) resembles the equation for a straight line, namely
>
> $$y = ax + b,$$
>
> where $y = I_c$, $x = V_{CE}$, the *slope* $a = -\left\{\frac{1}{R_C + R_E}\right\}$ and the *y-intercept* $b = \left\{\frac{V_{CC}}{R_C + R_E}\right\}$.

To draw a straight line, we require two extreme points. These may be located mathematically on the output $(V_{CE} - I_C)$ characteristic of the transistor.

Case (i):

If we imagine the collector current as zero, that is, if $I_C = 0$, then from Eqn. (1.14) we have $V_{CE} = V_{CC}$. This point of maximum collector-emitter voltage will lie on the $x - axis$.

Case (ii):

On the other hand if we assume the collector-emitter voltage to be zero, that is, $V_{CE} = 0$, then from Eqn. (1.14) we have $I_C = \left\{\dfrac{V_{CC}}{R_C + R_E}\right\}$. This value of maximum collector current will lie on the $y - axis$.

Then joining these two points on the $(V_{CE} - I_C)$ characteristic of the transistor, the DC load line can be drawn, as shown in Fig. 1.5. When the base current is zero, that is

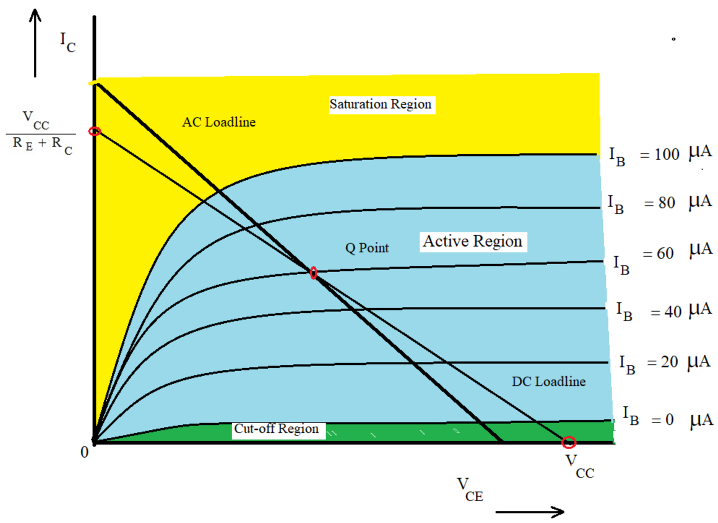

FIGURE 1.5: The DC and AC Load lines of the single stage RC coupled transistor amplifier drawn on the output characteristic $(V_{CE} - I_C)$ of the transistor.

$I_B = 0$, the collector current is almost zero, that is $I_C \simeq 0$. This means the transistor is driven to **cut-off** or a non-conducting state. When the base current is a maximum, say $I_B = 100\mu A$, the collector current becomes maximum, that is the transistor is driven to **saturation**. The region between the saturation and cut-off regions is called as the **active region**. These three regions are shown in Fig. 1.5. The base emitter voltage V_{BE} is so chosen that the operating point or the **Q** point lies at the center of the active region.

Quiescent Point:

The quiescent point or the operating point or the **Q** point is that point on the DC load line which represents the values of the collector current I_C and collector emitter voltage V_{CE} when no input signal is applied, that is when $V_S = 0$.

Note: quiẽscére refers to a state of rest or silence. Therefore quiescent point refers to a resting or inactive state or still condition of the amplifier in the absence of AC signals.

1.8.2 The AC Equivalent Circuit

The AC equivalent circuit of the single stage amplifier can be drawn by considering

1. all DC voltages to be zero
2. capacitors as short circuits, that is they are considered as closed switches.

The AC equivalent circuit is shown in Fig. 1.1 From the AC equivalent circuit shown in

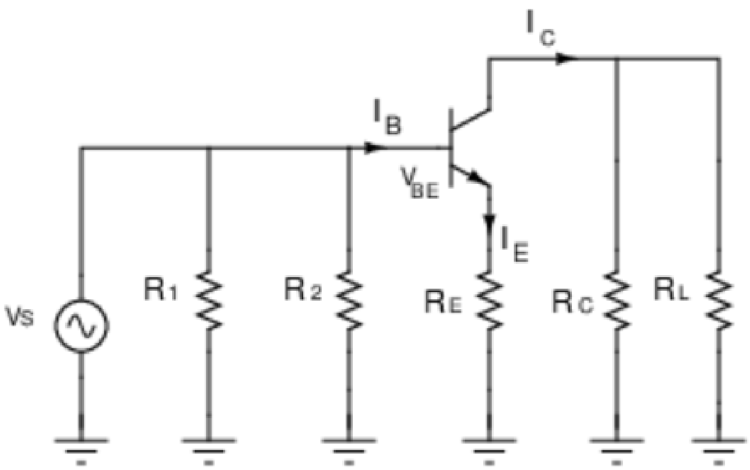

FIGURE 1.6: The AC equivalent circuit of a single stage RC coupled transistor amplifier.

Fig. 1.6, we find that the collector resistance R_C is in parallel with the load resistance R_L. Hence the total AC resistance at the output is

$$\begin{aligned} \frac{1}{R_{ac}} &= \frac{1}{R_C} + \frac{1}{R_L} \qquad \text{or} \\ R_{ac} &= \left\{ \frac{R_L R_C}{R_C + R_L} \right\} \end{aligned} \tag{1.15}$$

Hence the slope of the AC loadline will be $-\left(\frac{1}{R_{ac}}\right)$. This is steeper when compared to the slope $-\left(\frac{1}{R_C + R_E}\right)$ of the DC loadline. The AC load line is also shown in Fig. 1.5.

The AC load line is defined as the line drawn on the output characteristic, that is the ($V_{CE} - I_C$) characteristic of the transistor along which the output currents and output voltages are varied when the AC signal is applied.

1.9 Parameters of the Single Stage RC Coupled Transistor Amplifier

The variations of the collector currents I_C with respect to the variations of the collector emitter voltage V_{CE} when the base current I_B is varied due to variations in the base emitter voltage V_{BE} are shown in Fig. 1.7. From these variations the parameters of the amplifier can be evaluated.

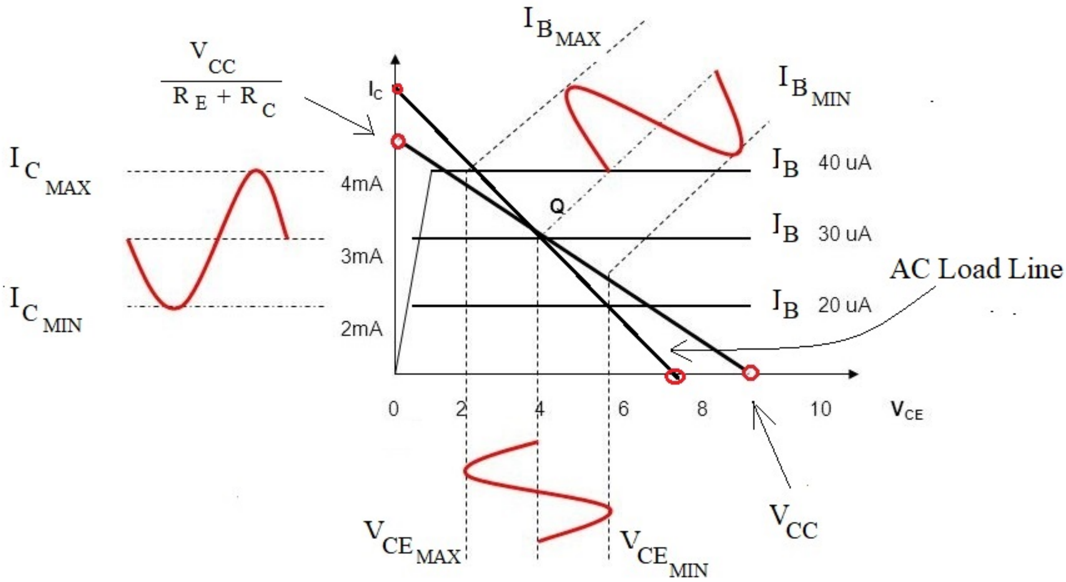

FIGURE 1.7: Graph showing the DC load line, the Q point and the AC load line along which the Q point varies. Further it shows the variations in the output currents I_C and voltages V_{CE} when the input current I_B is changed

1. **Current Gain β :**

   This is defined as the ratio of the change in the collector current to the change in the base current when the collector emitter voltage is held a constant.

$$\beta = \left(\frac{\Delta I_C}{\Delta I_B}\right)_{V_{CE}} \quad \text{or}$$

$$\beta = \frac{I_{C(max)} - I_{C(min)}}{I_{B(max)} - I_{B(min)}} \tag{1.16}$$

2. **Voltage Gain A_V :**

   This is defined as the ratio of the change in the collector emitter voltage to the change in the base emitter voltage, that is

$$A_V = \left(\frac{\Delta V_{CE}}{\Delta V_{BE}}\right) \qquad \text{or}$$

$$A_V = \frac{V_{CE(max)} - V_{CE(min)}}{V_{BE(max)} - V_{BE(min)}} \tag{1.17}$$

3. **Power Gain A_P :**

   This is defined as the ratio of the output power obtained from the amplifier to the input power supplied to the circuit. It is given as the product of the voltage gain and the current gain, that is

$$A_P = A_V \beta \tag{1.18}$$

Chapter 2

Power Amplifiers

2.1 Introduction

Any amplification system consists of three stages,

1. an initial stage
2. an intermediate stage or driver stage and
3. a final stage.

The initial and intermediate stages employ voltage amplifiers, while the final stage consists of a power amplifier. Fig. 2.1. A voltage amplifier is a current controlled device

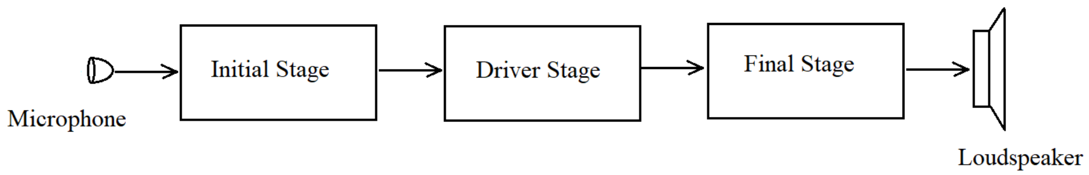

FIGURE 2.1: Block diagram showing the three stages, namely, the initial, intermediate and final stages of a power amplifier

that serves to increase the voltage across the load. On the other hand, a power amplifier is designed to develop a large amount of power across the output.

2.2 Differences Between Voltage and Power Amplifiers

The essential difference between a power amplifier and a voltage amplifier lies in the fabrication of the transistor employed.

Sl No:	Voltage Amplifier	Power Amplifier
1	Transistors with high current gain ($\beta > 100$)are used. This means the base should be thin	As power amplifiers should handle large currents, low current gain ($\beta < 100$) transistors with thick bases are used.
2	The power dissipation factor of the transistor is low ($< 0.5W$)	the power dissipation factor of the transistor is high ($> 0.5W$)
3	The output impedance of the circuit is high	The output impedance of the circuit is low
4	Here RC coupling is used	Here transformer coupling is used for proper impedance matching
5	Input voltages and collector currents are low	The input voltages and collector currents are high

2.3 Types of Amplifiers

Amplifiers are classified into four types depending on the signal obtained at the output.

1. **Class A Amplifier:** Here the output current at the collector flows for the full cycle of the input signal
2. **Class B Amplifier:** Here the output current at the collector flows for only half the cycle of the input signal
3. **Class C Amplifier:** Here the output current at the collector flows for a little less than half the cycle of the input signal
4. **Class AB Amplifier:** Here the output current at the collector flows for a little greater than half the cycle of the input signal

These output currents in these four types of amplifiers as a function of the input AC signal waveform are shown in Fig. 2.6.

Note: (i) The distortion (deviation of the output voltage from that of the input signal waveform) is least in Class-A while it is the greatest in Class-C amplifier. (ii) On the other hand, the collector efficiency is the greatest in Class-C operation and is the least in Class-A operation.

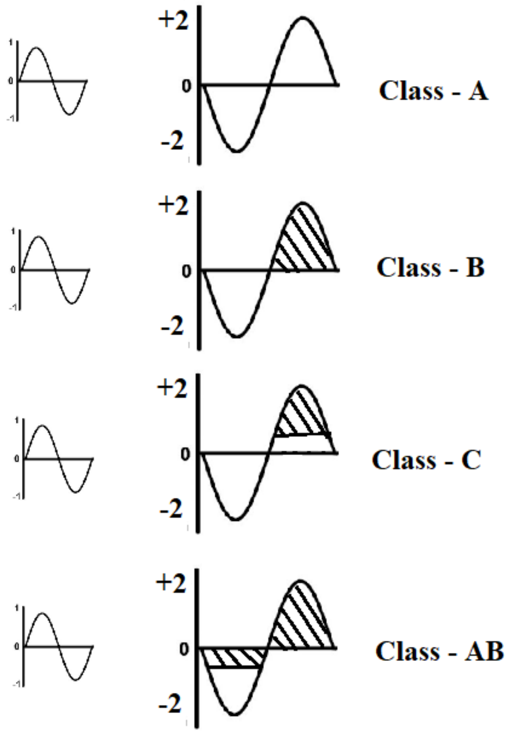

FIGURE 2.2: Classification of amplifiers based on the relation between the input and output currents. For Class-A operation, the output current flows for the full cycle of the input AC signal, while for Class-B it is for half the input cycle, for Class-C it is for less than half the input cycle and for Class-AB it is for a little greater than half the input cycle. The shaded regions shows absence of the current in one cycle of the output AC signal.

2.4 Class B Push-Pull Amplifier

A *Class B push-pull* amplifier consists of two transistors that complement each other. It combines the high efficiency characteristic of the Class-C amplifier with the low distortion of a Class-A amplifier.

2.4.1 Circuit Description

The circuit of this amplifier is shown in Fig. 2.3. It consists of two transistors, say $(n-p-n)$, connected back-to-back in *push-pull* configuration. The AC signal to be amplified is applied to the bases of the two transistors T_1 and T_2 through a centre tapped input transformer Tr_1. These two voltages are equal in magnitude but differ in phase to each other by π radiations or 180^o. Thus the input transformer acts as a phase splitter,

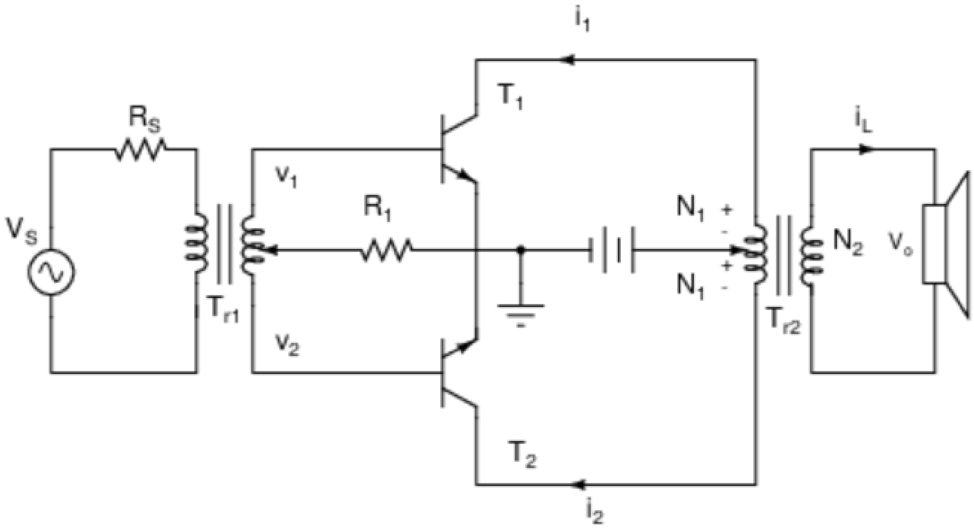

FIGURE 2.3: Two $(n - p - n)$ transistor Class-B amplifiers connected back-to-back in push-pull configuration

providing two voltages that are equal in magnitude but opposite in phase. This is shown in Fig. 2.4.

The collectors of the two transistors T_1 and T_2 are connected to the *centre-tapped* primary of the output transformer Tr_2. This transformer serves to join the two halves producing in the load resistance R_L a full AC signal. The load resistance R_L, usually a loudspeaker is connected across the secondary of this output transformer Tr_2. The turns ratio $2N_1 : N_2$ can be suitably adjusted for proper impedance matching.

2.4.2 Circuit Operation

Let the input AC signal v_i induce a voltage having a peak value $(2v_p)$ in the secondary of the input transformer Tr_1. As the secondary coil of this transformer is centre-tapped, the input AC signal is split into two components v_1 and v_2 differing in phase by π radians, that is

$$v_1 = v_p \cos(\omega t) \tag{2.1}$$

$$v_2 = v_p \cos(\omega t + \pi) \quad \text{or}$$

$$v_2 = -v_1, \tag{2.2}$$

since $\cos(\omega t + \pi) = -\cos(\omega t)$. Let the transistors be biased to operate in Class-B mode. Let I_{CQ} be the quiescent collector currents and let i_{c1} and i_{c2} be the AC components of

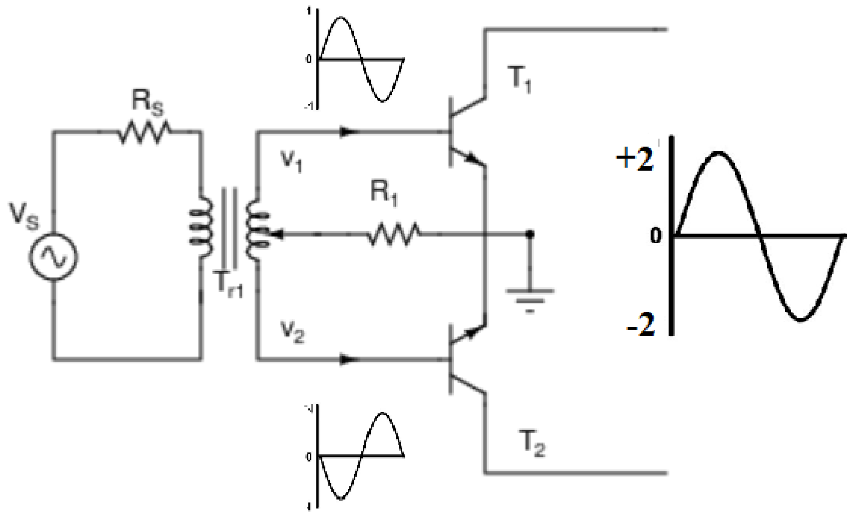

FIGURE 2.4: The input section of a Class-B Push-Pull Amplifier showing the split in the input AC signal.

the collector currents, such that we have

$$i_1 = I_{CQ} + i_{c1} \tag{2.3}$$

$$i_2 = -(I_{CQ} - i_{c2}) \tag{2.4}$$

When the AC input signal is applied, the output currents in the two transistors, namely i_1 and i_2 flow in opposite directions through the two halves of the primary coil of the output transformer Tr_2. These currents are found to be the superposition of the AC components i_{c1} and i_{c2} on the DC component $\pm I_{CQ}$ and the resultant current in the secondary of the output transformer Tr_2 is obtained by the cancelling of the DC quiescent current and reinforcing of the AC components. This is shown in Fig. 2.6. The flux produced by this resultant AC component is induced to the secondary coil of the output transformer Tr_2 and a nett output power is delivered to the load, say a loud speaker. From Fig. 2.5 we find that the if the current i_1 increases, the current i_2 decreases, that is the transistor T_1 is driven to saturation while the transistor T_2 is driven to cut-off. This means that while one of the transistor is *pushed-up* the other transistor is *pulled-down*. This cycle gets repeated alternately. Hence this amplifier is called as the **push-pull amplifier**.

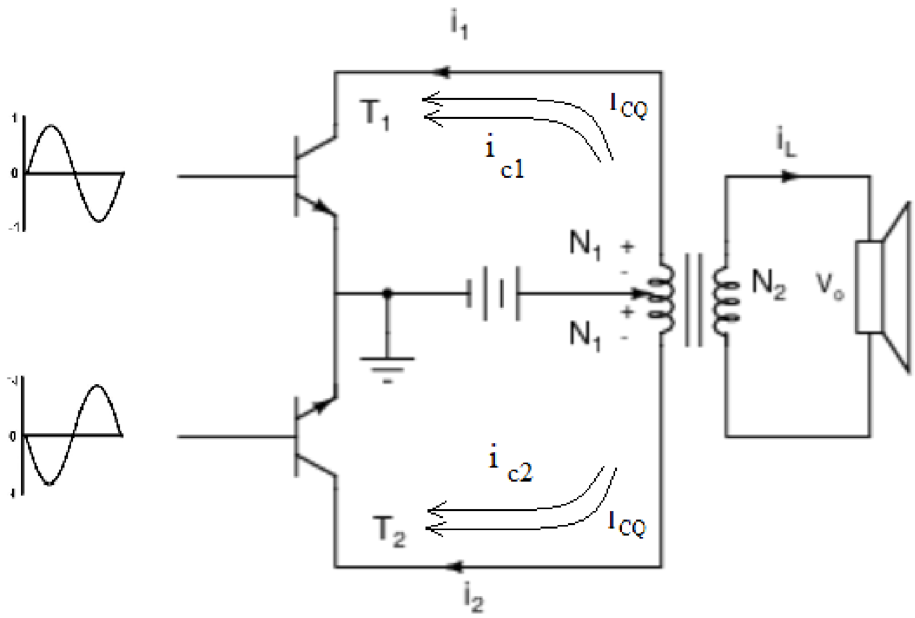

FIGURE 2.5: The output section of a Class-B Push-Pull Amplifier showing the quiescent DC components I_{CQ}s and the AC collector currents i_{c1} and i_{c2}.

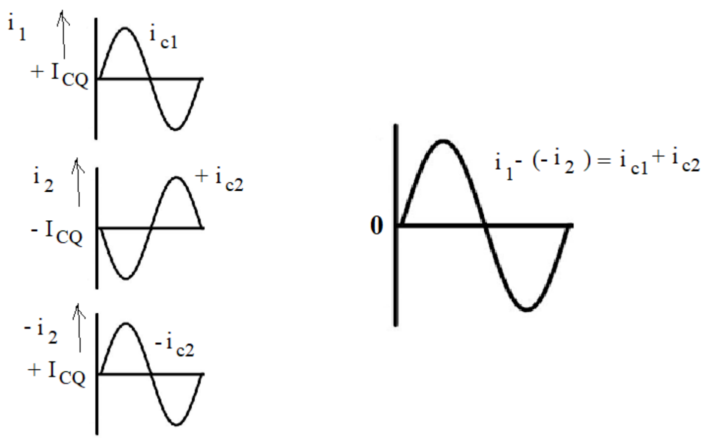

FIGURE 2.6: The output collector currents i_1 and i_2 shown as the superposition of the AC components i_{c1} and i_{c2} on to the DC quiescent collector current I_{CQ} and the resultant current in the secondary of the output transformer Tr_2 obtained by the cancelling of the DC quiescent current and reinforcing of the AC components.

> *Note:* A maximum power is transferred to the load if the effective load resistance as seen by the secondary of the output transformer Tr_2 is $R'_L = \left(\frac{2N_1}{N_2}\right)^2 R_L$

2.5 Parameters of the Class B Push-Pull Power Amplifier

1. **Collector Efficiency:** is given by

$$\eta = \frac{\pi}{4}\left[1 - \frac{v_{in}}{V_{cc}}\right] \times 100\% \tag{2.5}$$

If $v_{in} \ll V_{CC}$, then $\eta = \frac{\pi}{4} \times 100\%$, or $\eta = 78.5\%$.

2. **Collector Dissipation Factor:** Let the maximum power generated at the output be $P_{max} = \frac{V_{CC}^2}{2R'_L}$. Then the maximum power which is dissipated is given as

$$\begin{aligned} P_{D(max)} &= \frac{2V_{CC}^2}{\pi^2 R'_L} \quad \text{or} \\ P_{D(max)} &= \frac{4}{\pi^2}\frac{V_{CC}^2}{2R'_L} \quad \text{or} \\ P_{D(max)} &= \frac{4}{\pi^2}P_{max} \end{aligned} \tag{2.6}$$

From Eqn. (2.6), the power dissipated is $P_{D(max)} = 0.4 \times P_{max}$.

3. **Distortion:** This is the measure of the deviation of the output waveform from that of the input AC signal. The main distortion is due to the third harmonic component of the AC signal. The output power is given as

$$P = \left(1 + D_3^2\right) P_1 \tag{2.7}$$

where P_1 is the power of the first harmonic and $D_3 = \left|\frac{B_3}{B_1}\right|$ is the distortion introduced due to the third harmonic component.

2.6 Merits and Demerits of a Class-B Push-Pull Amplifier

2.6.1 Merits

1. The distortion of the output signal is a minimum.

2. As DC components I_{CQ}s are cancelled out, the transformer need not handle large currents. Hence transformers having small sized cores can be used thereby reducing the cost.

3. They have high efficiency and longer battery life.

4. The ripple voltages contained in the power supply due to inadequate filtering get cancelled out.

2.6.2 Demerits

1. This amplifier requires a driver stage to provide two signals in phase opposition

2. If the two transistors are not identical, unequal amplification and hence high distortion may result.