Amplifier: → Amplifier is a device which enhances the magnitude of input signal. The amplifier is called current, voltage or power amplifier accordingly current, voltage or power of input signal is amplified.

Classification of Amplifiers on the basis of operating point: →

(1) **Class-A Amplifier:** → If the operating point of transistor lies in mid point of dc load line, then such type of amplifier are called class-A amplifiers. These give voltage amplification without any distortion.

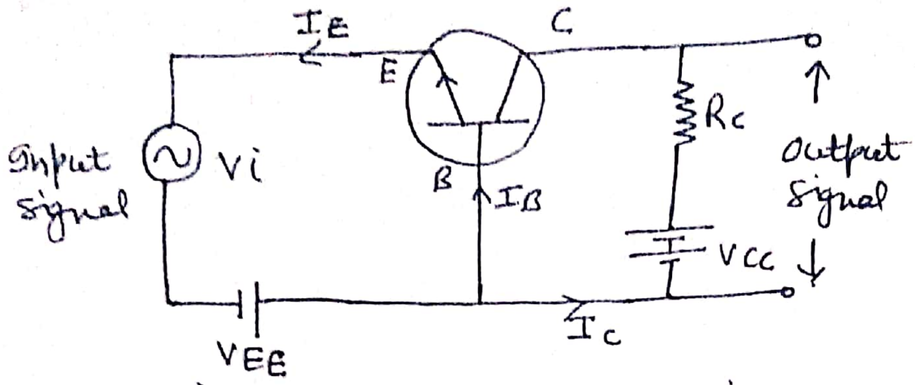
(2) **Class-B Amplifier:** → If the operating point is chosen at cut off point on dc load line, then there is a distortion in output. Such amplifiers are called as Class-B Amplifiers. These are used to amplify those audio signals, where distortion can be tolerated.

(3) **Class-C Amplifier:** → In these amplifiers operating point is in cut off region but near the cut off point. These are used in radio transmitters.

(4) **Class AB Amplifiers:** → In these amplifiers operating point is so selected that the current through the transistor flows for more than one half cycle but not through complete cycle.

Common base transistor Amplifier: →

Fig. below shows the circuit diagram of common base transistor amplifier.



In this circuit, base terminal is common to emmiter as well as collector. The transistor is biased to operate in active region i.e. battery V_{EE} forward biases the emmiter base junction and battery V_{CC} reverse biases collector base junction.

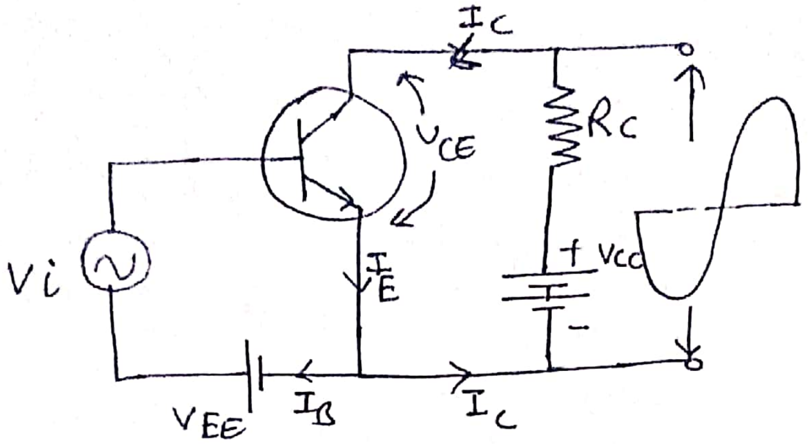
When the a.c signal V_i is applied, then it is superimposed on battery V_{EE}, emmiter base voltage V_{EB} varies with time. Thus emmiter current I_E will also vary with time. Since $I_C = \alpha I_E$, so I_C will also change. Thus a varying voltage $V_o = V_{CC} - I_C R_C$ is developed across R_C.

When +ve half of a.c input V_i comes, forward bias decreases as pottential of emmiter becomes less negative. So I_E decreases and hence I_C also decreases. Decreased I_C decreases voltage drop across R_C which will increase net collector voltage.

During -ve half input cycle of V_i, emmiter voltage will increase, increasing I_E. Due to this voltage drop across R_C increases and it decreases net V_{CB} making it less +ve.

(2) Common Emmiter NPN amplifier :→

Fig. below shows circuit diagram of common emmiter amplifier.



Applying KVL to output circuit, we get,

$$V_{CE} = V_{CC} - I_C R_C \quad \text{— (I)}$$

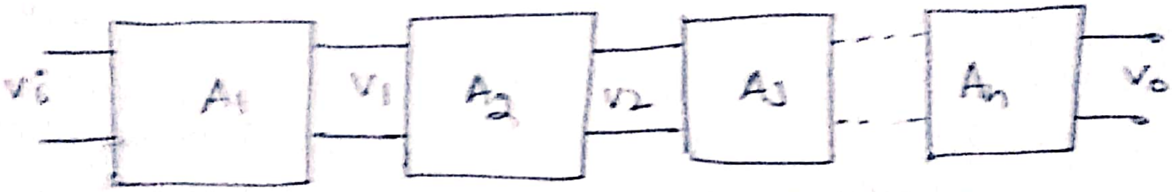
During +ve half cycle of a.c input signal v_i, forward bias of emmiter base circuit is increased, thereby increasing emmiter current & hence collector current. The increased collector current will decrease the collector emmiter voltage making it less +ve. During the -ve half cycle, the emmiter current I_E and hence collector current I_C will decrease, increasing the collector emmiter voltage, making collector more +ve.

So in a common emmiter amplifier output signal is 180° out of phase with input signal.

The current gain β of CE amplifier is quite large.

Coupling in Amplifiers →

A single stage amplifier does not give sufficient amplification to operate a device. To achieve this the amplification at two or more stages is required. The arrangement of connecting two or more amplifiers together in such a way that output of first amp becomes input of 2nd Amplifier and so on is called coupling. This arrangement of coupling is also called as Cascading of amplifiers.



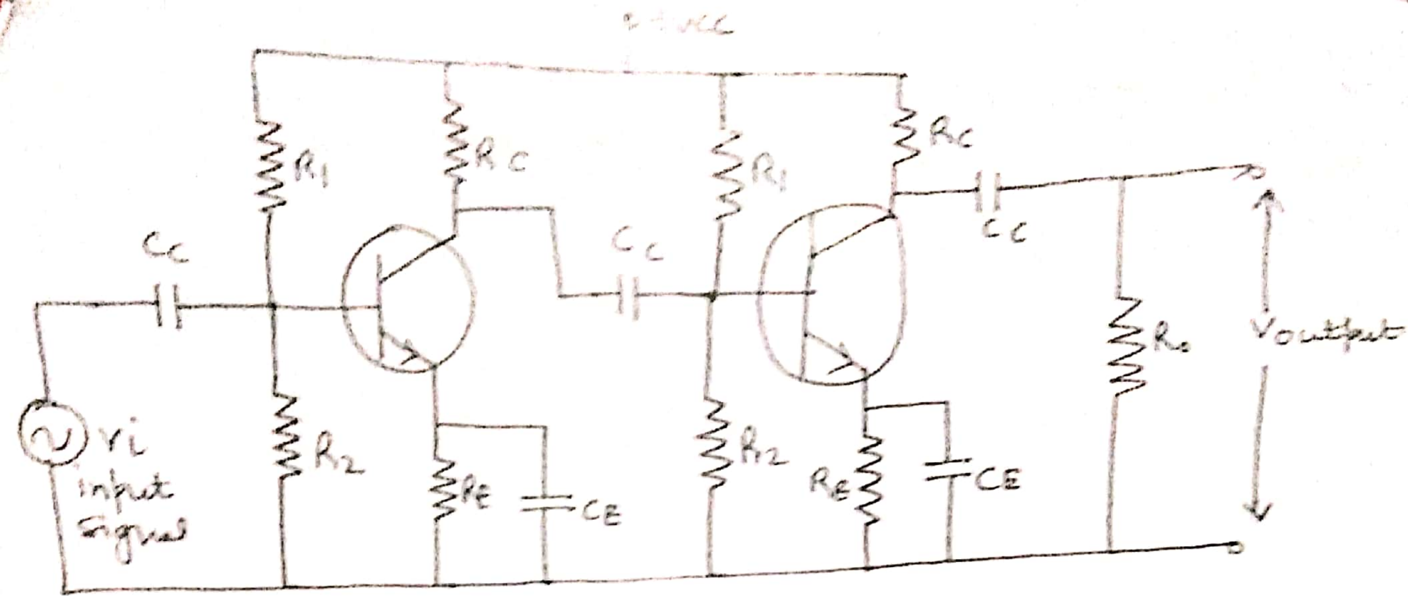
The overall gain $A = A_1 \times A_2 \times A_3 - - - \times A_n$

Methods of coupling: →

The commonly used methods of coupling are
(i) Resistance capacitance coupling
(ii) Transformer coupling
(iii) Direct coupling

RC Coupled Amplifier →

As the name indicates, Resistance capacitance coupling is used to cascade two stages of amplifiers. Fig below shows a RC coupled two stage amplifier.



In this two stage amplifier, voltage divider biasing is used. In this type of biasing, operating point does not change due to increase of temperature and also operating point is independent of current gain β; and hence transistor can be easily replaced by another in case of need.

The capacitor C_c called coupling capacitor allows a.c component of Ist stage to reach to next stage. It does not allow dc to reach from Ist to 2nd stage.

The voltage gain $A = A_1 \times A_2$

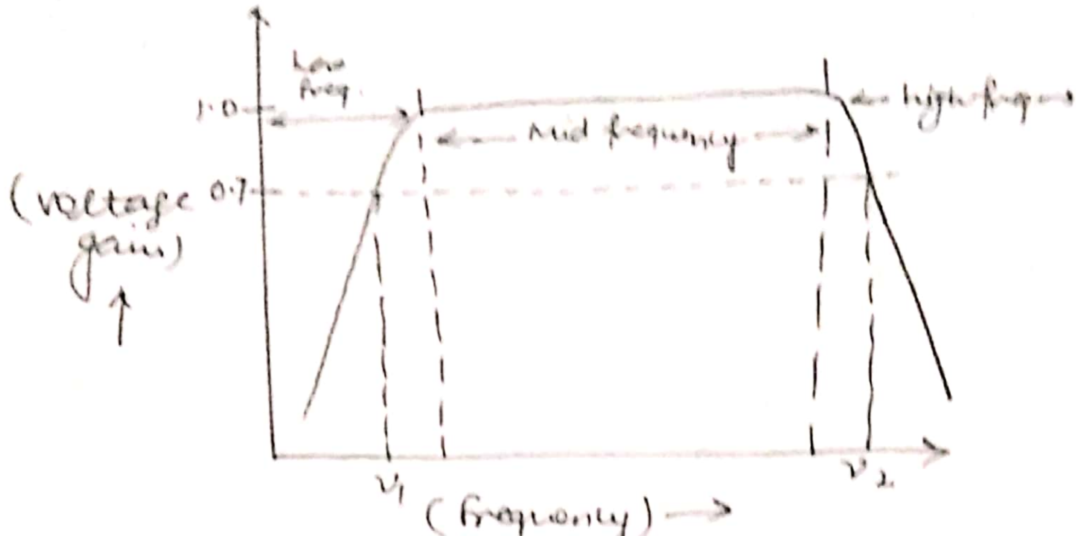
Where A_1 and A_2 are respective gain of two stages.

The voltage gain of RC coupled Amplifier depends upon the frequency range over which amplifier is used. The entire frequency range is divided into three categories.

1. <u>Low frequency range</u> → In this range, voltage gain increases with increase in freq of a.c input voltage.
2. <u>Mid frequency range</u> → In this range, voltage gain is constant.
3. <u>High frequency range</u> → In this range, voltage gain decreases with increase in frequency.

Frequency Response curve :→

Fig below shows frequency response curve for a RC coupled Amplifier.



(i) Low frequency Range :→

At low frequencies, coupling capacitor C_C offers high reactance ($X_C = \frac{1}{\omega C}$). As a result, part of output signal of certain stage drops across it and remaining part passes to next stage. This decreases the voltage gain.

The other component due to which gain reduces at low frequencies is bypass capacitor C_E. At low frequencies reactance of C_E is comparable to R_E. So emitter current divides itself along two parts flowing through C_E & R_E. So effective output voltage is reduced, hence output voltage is reduced and hence gain is reduced.

(ii) Mid frequency Range :→ At mid frequencies, reactance of coupling capacitor becomes negligible, so entire output voltage signal of a certain stage passes to next stage and thus voltage gain becomes max.

(iii) High freq. Range :→ At high frequencies, gain of amplifier reduces. Although reactance of C_C is small, the effect of various shunt capacitance as interelectrode or parasitic capacitances lowers the voltage gain.

are the two frequencies ν_1 and ν_2 at which gain becomes $1/\sqrt{2}$ times the gain in mid frequency region. These two frequencies ν_1 and ν_2 are called lower and upper cut off frequencies. The difference between these two frequencies is called bandwidth.

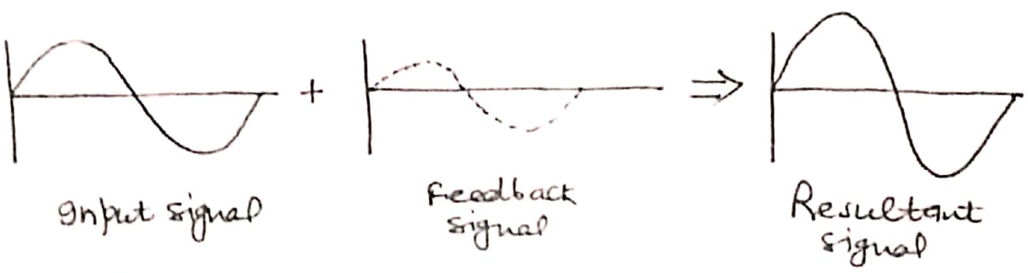
$$BW = \nu_1 - \nu_2$$

Feedback in Amplifiers: →

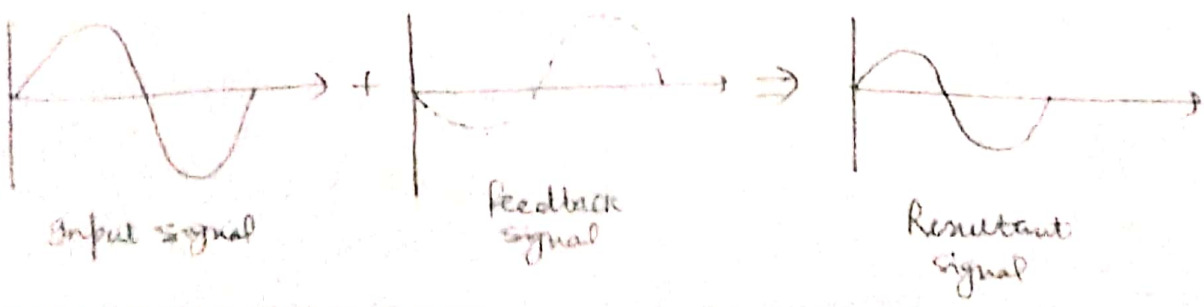
If a part of output voltage or current is fed back and combined to input signal the process is called feedback. The feedback may be +ve or −ve.

(i) Positive feedback: →

If the feedback signal, which is combined with input signal is in phase with it, the feedback is called positive or regenerative feedback. The gain of the amplifier is thus increased. However distortion and noise in output signal are also increased.

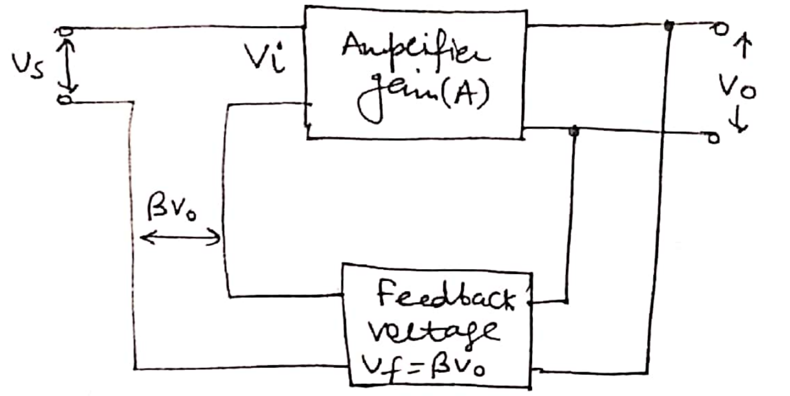


(ii) Negative feedback: → If the feedback signal which is combined with input signal is in opposite phase with it then feedback is called negative or degenerative. In this gain of amplifier is reduced. However there is reduction in distortion and noise also.



Voltage gain with feedback:→

Let us consider an amplifier with gain A and V_s is the input source signal and V_o is the output signal. Let β is the fraction of output voltage fed back to input.



It is clear that βV_o voltage is added in phase with Source input signal V_s, if feedback is +ve.

∴

$$V_i = V_s + \beta V_o \quad \text{—— (I)}$$

Also, $V_o = A V_i$ —— (II)

from (I) & (II)

$$V_o = A(V_s + \beta V_o) = AV_s + A\beta V_o$$

$$\Rightarrow V_o - A\beta V_o = AV_s$$

$$\Rightarrow V_o(1 - A\beta) = AV_s$$

$$\Rightarrow \frac{V_o}{V_s} = \frac{A}{1 - A\beta}$$

$$\Rightarrow \boxed{A_f = \frac{A}{1 - A\beta}}$$

A_f is called gain with feedback.

β is called feedback factor.

In case of -ve feedback

$$\boxed{A_f = \frac{A}{1 + A\beta}}$$

Advantages of -ve feedback :→

Following are the advantages of -ve feedback:-

1. It increases the input impedance and decreases the output impedance.
2. It increases the bandwidth.
3. It gives less frequency, amplitude and phase distortions.
4. It reduces the noise.
5. It increases the gain stability.

(1) To prove that the input impedance increases with -ve feedback, let us consider the input

$$V_i = V_s - \beta V_o \quad \text{—— (I)}$$

The current in input circuit is,

$$I_i = \frac{V_i}{Z_i} = \frac{V_s - \beta V_o}{Z_i}$$

$$\Rightarrow I_i Z_i = V_s - \beta V_o$$

$$\Rightarrow I_i Z_i = V_s - \beta A V_i \qquad \because [V_o = A V_i]$$

$$\Rightarrow V_s = I_i Z_i + \beta A V_i = I_i Z_i + \beta A (I_i Z_i)$$

$$\Rightarrow V_s = I_i Z_i (1 + A\beta)$$

$$\Rightarrow \frac{V_s}{I_i} = Z_i (1 + A\beta)$$

$$\Rightarrow \boxed{Z_{if} = Z_i (1 + A\beta)}$$

where $\frac{V_s}{I_i} = Z_{if}$ is input impedance with -ve feedback.

and Z_i = input impedance without feedback

So for a -ve feedback, input impedance increases by a factor $1 + A\beta$;

Similarly output impedance with -ve feedback reduces by $1 + A\beta$ i.e. $\boxed{Z_{of} = Z_o / 1 + A\beta}$

② To prove that, bandwidth with -ve feedback increases, let us consider -ve feedback amplifier. Actually -ve feedback decreases the lower cut off frequency ν_1 by factor $1+A\beta$ and increases the upper cut off frequency ν_2 by same factor.

i.e with -ve feedback lower and upper cut off frequencies becomes,

$$\nu_1' = \frac{\nu_1}{1+A\beta}$$

$$\nu_2' = \nu_2(1+A\beta)$$

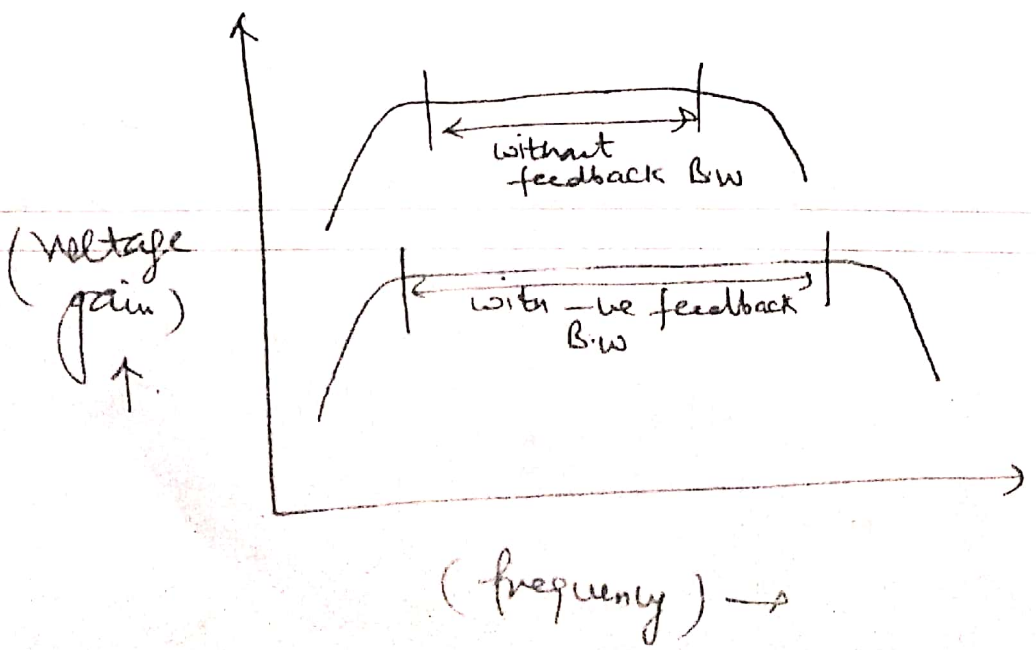
∴ Bandwidth = $\nu_2 - \nu_1$ [without feedback]

But with -ve feedback $\nu_1' <<< \nu_2'$ and also $\nu_1 \ll \nu_2$

∴ B.W with -ve feedback = ν_2'

$$\Rightarrow \boxed{\nu_2' = \nu_2(1+A\beta)}$$

∴ With -ve feedback BW increases by $1+A\beta$.



Distortion in Amplifiers:—

For faithful amplification, wave shape of signal should not change. If the output waveform is not an exact replica of the input signal waveform, the distortion is said to have been introduced.
If the amplifier does not introduce any distortion, amplifier is said to have good fidelity.
The distortion may occur in any amplifier and can be classified in following ways:-

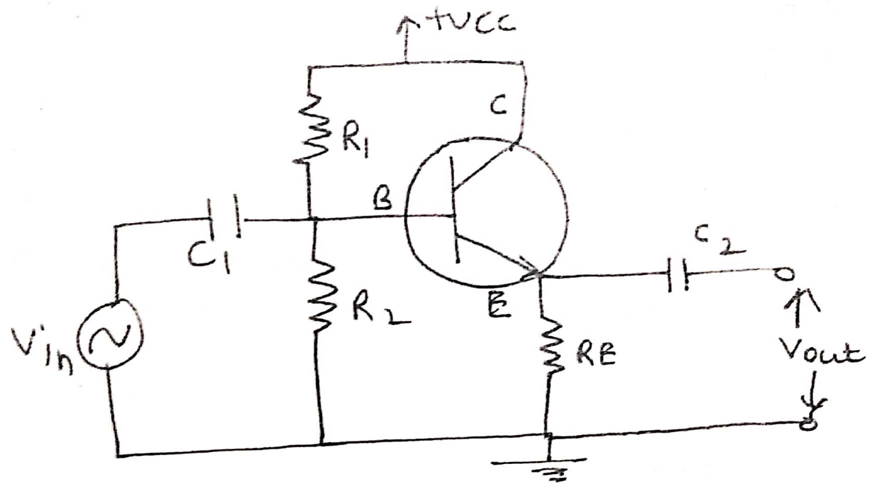
(i) Amplitude distortion:- This type of distortion is said to take place, when in the output new frequencies appear, which are not present in input signal.

(ii) Frequency distortion:— In actual practice, input signal is never a simple sinusoidal wave. It has a complex wave shape. So this signal has large no. of sinusoidal waves having different frequencies. Distortion is produced in output due to these frequencies.

(iii) Phase or delay distortion:—
If the relationship between various frequencies components in output signal is not the same as relationship in input signal, the phase distortion is said to have occured.
This distortion is objectionable in Video like T.V etc.

Emmiter follower circuit:—

A common collector amplifier is also called as emmiter follower circuit. This is because voltage at output follows the ~~input~~ emmiter. fig. below shows an emmiter follower circuit.



This circuit is also called commen collector amplifier, as collector terminal is commen to both input and output circuits.
The output voltage V_o is taken across R_E and returned back to input, with $\beta=1$.
This circuit is used for Impedance matching.