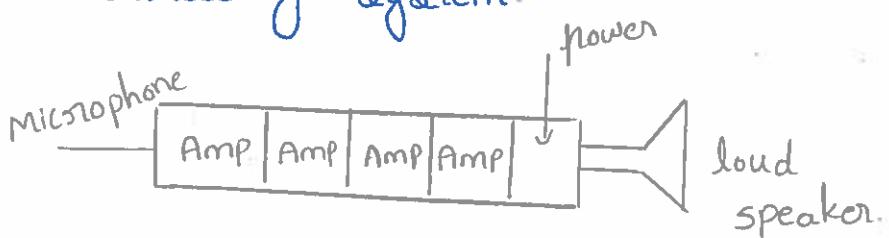


## Power Amplifiers...

Power amplifier:-

Consider, a cascade amplifier system or a public addressing system.



The system consists of many stages so it is a multistage amplifier. The i/p is sound signal and o/p is given to the load speaker. The i/p and intermediate stages are small signal amplifiers. The sufficient voltage gain is obtained by all intermediate stages. Hence, these stages are called voltage amplifiers.

For example, RC coupled amplifier, but the last stage gives an o/p to the loud speaker. Hence, the last stage must be capable of delivering large amount of AC power to the load. Hence, this type of amplifiers are called power amplifiers or large signal amplifiers.

## Classification of power amplifiers:-

For an amplifier operating point is fixed by selecting the proper DC biasing to the transistor. The position of quiescent point on the load line decides the class of operation of power amplifier. Based on this, there are 4 classes of power amplifiers.

They are

- i) class-A power amplifier.
- ii) class-B power amplifier.
- iii) class-C Power amplifier.
- iv) class-AB power amplifier.

### i) class-A power amplifier:-

The class-A power amplifiers are further classified into 2 types.

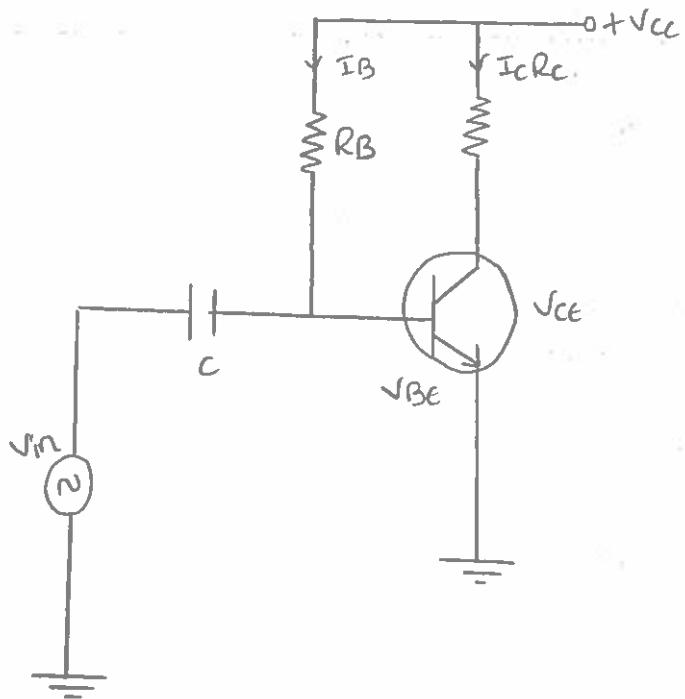
\* Direct coupled

\* Transformer coupled amplifier.

In direct coupled, the load is directly connected in the collector circuit.

In the transformer coupled type, the load is coupled to the collector using transformer.

Skip coupled class-A amplifier:-



Applying KVL to the i/p

$$V_{CC} = I_B R_B + V_{BE} \rightarrow ①$$

$$V_{CC} = I_C R_C + V_{CE} \rightarrow ②$$

From eqn ①

$$I_B = \frac{V_{CC} - V_{BE}}{R_B}$$

$V_{BE} = 0.7V$  for silicon

$V_{BE} = 0.3V$  for Germanium.

at operating point, the base current  $I_B = I_{BQ}$

$$\text{then } I_{BQ} = \frac{V_{CC} - V_{BE}}{R_B}.$$

We know that

The relation b/w  $I_{CQ}$  and  $I_{BQ}$  is

$$I_{CQ} = \beta I_{BQ}$$

from eqn ②

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

$$V_{CEQ} = V_{CC} - I_{CQ} R_C$$

The DC input power,  $P_{DC} = V_{CEQ} I_{CQ}$

for DC condition  $V_{CEQ} = V_{CC}$

$$P_{DC} = V_{CC} I_{CQ}$$

AC output power:-

$V_{min}$  = minimum instantaneous o/p voltage.

$V_{max}$  = maximum instantaneous o/p voltage.

$$\sqrt{P-P} = V_{max} - V_{min}$$

$$\text{peak voltage}, V_m = \frac{\sqrt{P-P}}{2}$$

$I_{min}$  = minimum instantaneous o/p current.

$I_{max}$  = maximum instantaneous o/p current.

$$I_{P-P} = I_{max} - I_{min}$$

$$I_m = \frac{I_{P-P}}{2}$$

$$V_{rms} = \frac{V_m}{\sqrt{2}}, I_{rms} = \frac{I_m}{\sqrt{2}}$$

Using RMS values:-

$$P_{ac} = V_{rms} \cdot I_{rms}$$

$$= \frac{V_{rms}^2}{R_L}$$

$$P_{ac} = I_{rms}^2 \cdot R_L$$

Using Peak values:-

$$P_{ac} = \frac{V_m}{\sqrt{2}} \cdot \frac{I_m}{\sqrt{2}}$$

$$P_{ac} = \frac{V_m I_m}{2}$$

$$P_{ac} = \frac{V_m^2}{2 R_L}$$

$$P_{ac} = \frac{I_m^2 R_L}{2}$$

Using peak to peak values:-

$$P_{ac} = \frac{\frac{\sqrt{P-P}}{2} \cdot \frac{I_P-P}{2}}{2}$$

$$= \frac{\sqrt{P-P} \cdot I_P-P}{8}$$

$$P_{ac} = \frac{\sqrt{P-P}}{8 R_L}$$

$$P_{ac} = \frac{I_{P-P}^2 R_L}{8}$$

The power delivered at the O/p is given as,

$$P_{ac} = \frac{(V_{max} - V_{min}) \cdot (I_{max} - I_{min})}{8}$$

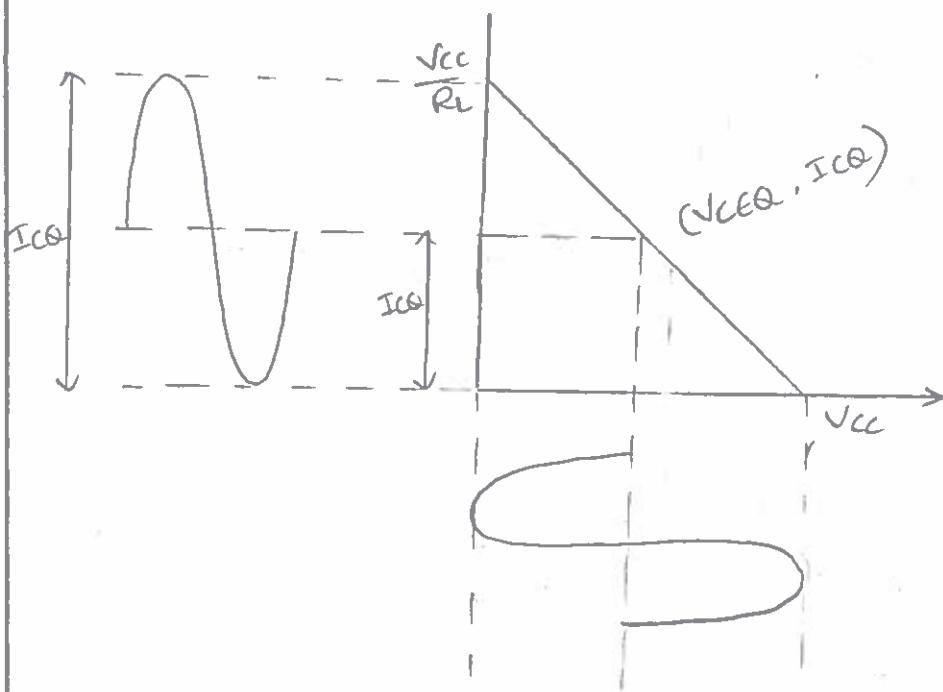
Efficiency:-

$$\text{Efficiency } \eta = \frac{P_{ac}}{P_{dc}} \times 100$$

It is defined as the ratio of O/p AC power to the input DC power.

$$\eta = \frac{(V_{max} - V_{min})(I_{max} - I_{min})}{8V_{cc} I_{ce}} \times 100$$

Maximum Efficiency:-



$$V_{max} = V_{cc}, V_{min} = 0$$

$$I_{max} = 2I_{ce}, I_{min} = 0$$

$$\text{Efficiency } \eta = \frac{(V_{CC} - 0)(2I_{CQ} - 0)}{8V_{CC}I_{CQ}} \times 100$$

$$= \frac{2V_{CC}I_{CQ}}{8V_{CC}I_{CQ}} \times 100$$

$$= \frac{200}{8}$$

$$\eta = 25\%$$

only 25% of Dc power is converted into Ac power.

Power Dissipation:-

In power amplifiers, the Dc power is converted into Ac power. practically total Dc power is not converted into Ac power. The remaining Dc power is called dissipated power which is dissipated at the junction in the form of heat.

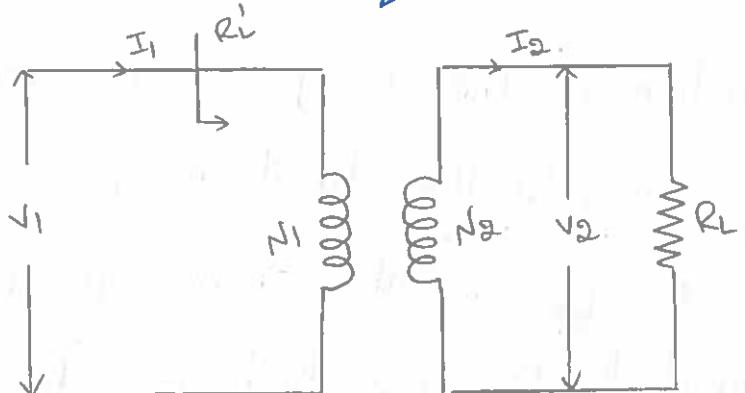
$$\text{power Dissipation } P_D = P_{DC} - P_{AC}.$$

The class-A power amplifier produces 25% of Ac power and its conduction angle is  $360^\circ$ . and operating point set at middle of the load line.

Transformer coupled class-A power amplifier:-

We know that for maximum power transfer to the load, the impedance matching is necessary. For loads like loud speakers has impedance  $3-4\Omega$ . but series FET class-A o/p impedance is very high so they are not matched. This impedance matching problem is eliminated by transformer in output side of power amplifier.

Let us assume the transformer is ideal and no loss and resistance equal to '0'.



Turns ratio of transformer is  $n = \frac{N_2}{N_1}$

Voltage ratio of transformer is  $\frac{V_2}{V_1} = \frac{N_2}{N_1} = n$

Current ratio of transformer is  $\frac{I_1}{I_2} = \frac{N_2}{N_1} = n$ .

The load impedance on secondary gets reflected on primary side and it is denoted by  $R'_L$ .

The load resistance  $R_L = \frac{V_2}{I_2}$

$$R'_L = \frac{V_1}{I_1}$$

$$V_1 = V_2 \cdot \frac{N_1}{N_2}$$

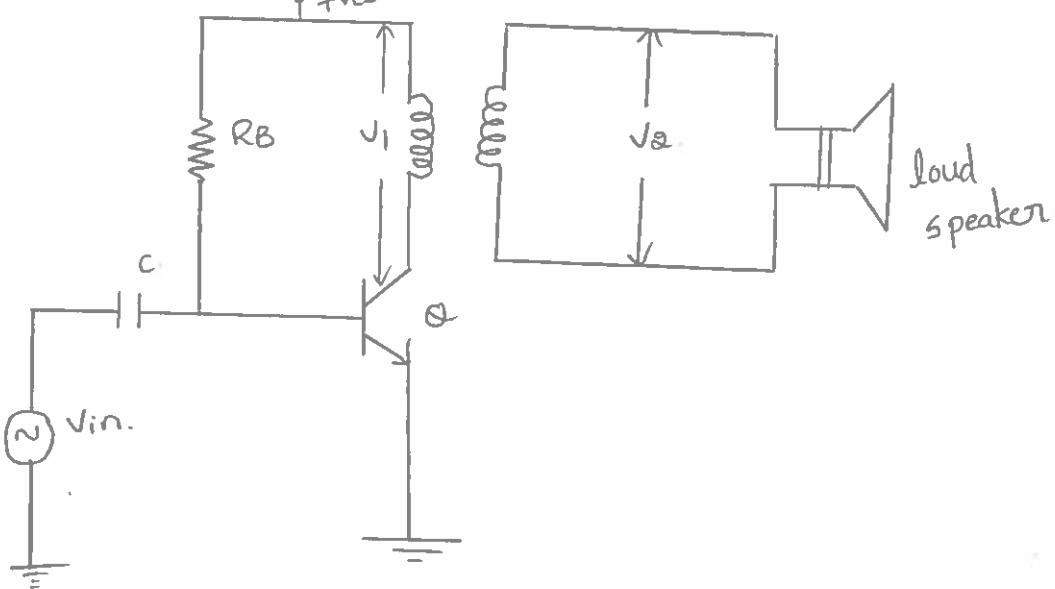
$$I_1 = I_2 \cdot \frac{N_2}{N_1}$$

$$R'_L = \frac{V_2 | Z_2 |}{I_2 | Z_2 |}$$

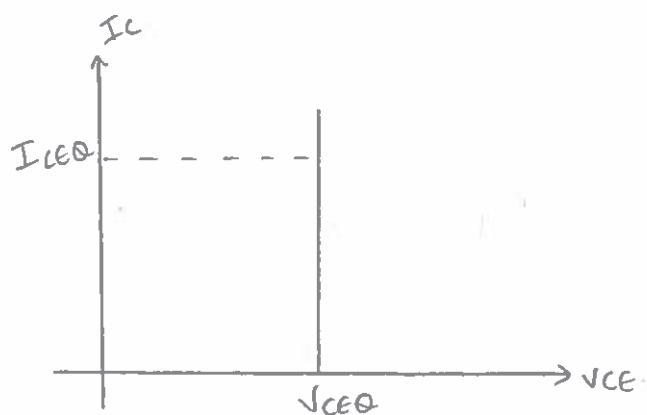
$$= \frac{V_2}{I_2} \cdot \frac{| Z_2 |^2}{| Z_2 |^2}$$

$$R'_L = R_L \cdot \frac{| Z_2 |^2}{| Z_2 |^2}$$

Circuit diagram for transformer coupled amplifier



When no Ac signal is applied then circuit has only Dc power supply. At this condition load resistance  $R_L=0$ . then slope of Dc load line is  $-1/R_L = \infty$ . The infinite slope means parallel to the y-axis.



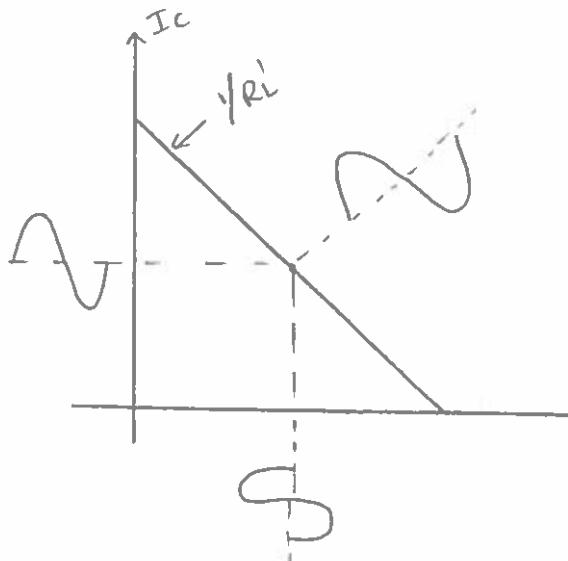
$$\begin{aligned}V_{cc} &= I_c R_c + V_{ce} \\&= I_c R_L + V_{ce} \quad (R_c = R_L).\end{aligned}$$

$$V_{cc} = V_{ce} \quad (\because R_L = 0).$$

$$\begin{aligned}\text{i/p current power } P_{in}(\text{dc}) &= V_{ce} I_c \\&= V_{cc} I_{cQ}.\end{aligned}$$

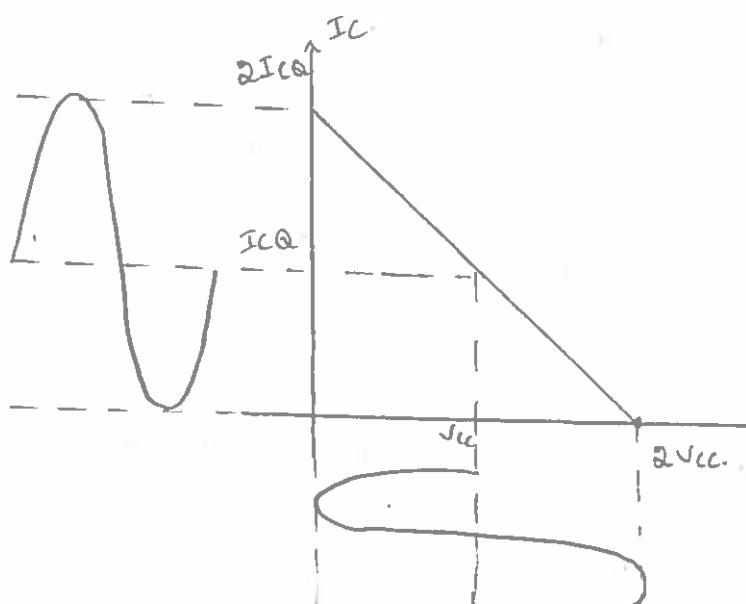
AC operation:-

For AC operation, the load resistance  $R_L$  is available and reflected resistance  $R'_L$  is also available. For AC operation we need to draw AC load line with slope  $-\frac{1}{R'_L}$ .



$$\text{Efficiency } \eta = \frac{P_{ac}}{P_{dc}} = \frac{(V_{max} - V_{min})(I_{max} - I_{min})}{8V_{cc} I_{cQ}} \times 100$$

Maximum efficiency:-



$$I_{max} = 2I_{cQ}, \quad I_{min} = 0.$$

$$V_{max} = 2V_{cc}, \quad V_{min} = 0$$

$$\text{efficiency } \eta = \frac{(2V_{cc} - 0)(2I_{cQ} - 0)}{8V_{cc} I_{cQ}} \times 100$$

$$= \frac{4V_{cc} I_{cQ}}{8V_{cc} I_{cQ}} \times 100.$$

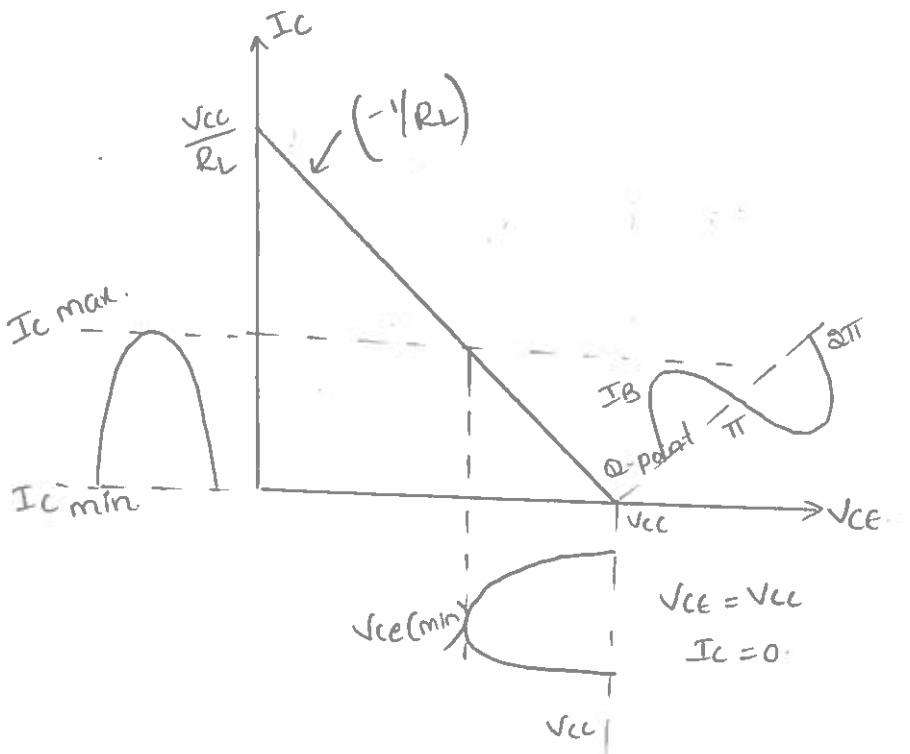
$$= \frac{400}{8}$$

$$= 50\%$$

In this case, the efficiency is increased to 50%. power dissipation in this amplifier is less because the winding DC resistance is '0'.

Class-B power Amplifier:-

The power amplifier is said to be class-B if the operating point is selected such that the output signal is obtained only for one half cycle. In class-B operation, the operating point is said at cut-off region, so the quiescent current is '0'. Hence class-B operation does not meet any biasing system. During +ve half cycle of input signal, Forward bias current, and collector current flows. During '-ve' halfcycle, the circuit is reverse bias and hence, there is not current flows through the circuit.



Q.C. flower:-

The i/p DC power of class-B amplifier is given by  $P_{in}(dc) = V_{cc} I_{dc}$ .

where,  $I_{dc}$  is average or direct current from the collector supply. If the i/p signal is '0' then  $I_{dc}=0$  when, the AC i/p signal is applied, then

$$I_{dc} = \frac{1}{2\pi} \int_0^{2\pi} I_{max} \sin t \cdot dt.$$

$$= \frac{1}{2\pi} \left[ \int_0^{\pi} I_{max} \sin t \cdot dt + \int_{\pi}^{2\pi} 0 \right]$$

$$= \frac{1}{2\pi} \int_0^{\pi} I_{max} \sin t \cdot dt.$$

$$= \frac{1}{2\pi} I_{max} \left[ -\cos t \right]_0^{\pi}$$

$$= \frac{1}{2\pi} - I_{max} [\cos \pi - \cos 0]$$

$$= - \frac{I_{max}}{2\pi} (-1 - 1)$$

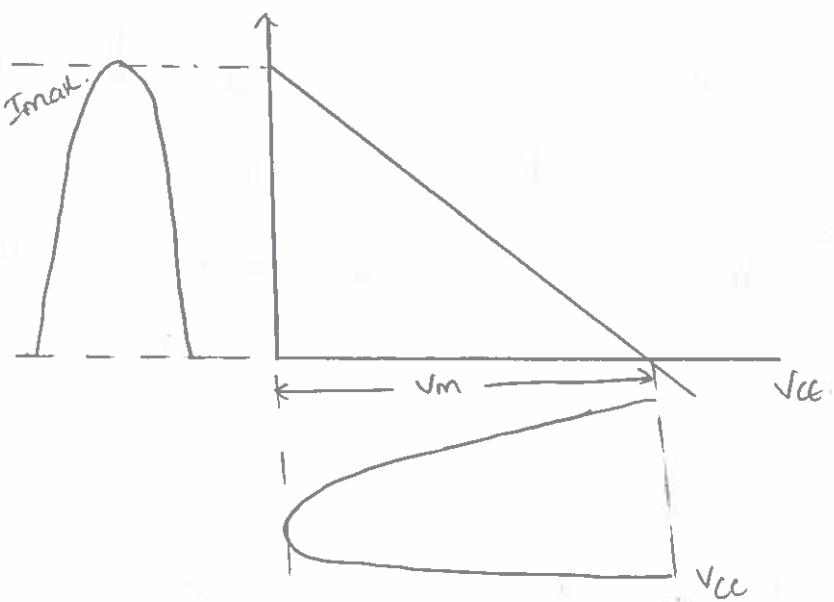
$$= \frac{I_{max}}{\pi}$$

$$P_{in}(dc) = V_{cc} I_{dc}$$

$$= V_{cc} \cdot \frac{I_{max}}{\pi}$$

AC o/p power:-

The o/p power occurs only for positive half cycle.  
then maximum values o/p voltage and o/p current is given as,



$$P_{out}(ac) = \frac{V_{rms} \cdot I_{rms}}{2}$$

We know that

$$V_{rms} = \frac{V_m}{\sqrt{2}}, \quad I_{rms} = \frac{I_m}{\sqrt{2}}$$

$$P_{out} (ac) = \frac{V_m \cdot I_m}{4}$$

$$V_m = V_{CE}, I_m = I_{max}$$

$$P_{out} (ac) = \frac{V_{CE} \cdot I_{max}}{4}$$

Efficiency :-

$$\eta = \frac{P_{ac}}{P_{dc}} = \frac{V_{CE} \cdot I_{max}}{4} \times \frac{\pi}{V_{CE} \cdot I_{max}} \times 100$$

$$= \frac{\pi}{4} \times 100$$

$$= \frac{3.14}{4} \times 100$$

$$\eta = 78.5\%$$

If, we consider  $V_{CE}$  (minimum) value. then

$$P_{out} (ac) = \frac{(V_{CE} - V_{CE(min)}) I_{max}}{4} \text{ then,}$$

$$\eta = \frac{(V_{CE} - V_{CE(min)}) I_{max}}{4} \times \frac{\pi}{V_{CE} I_{max}} \times 100$$

$$= \frac{(V_{CE} - V_{CE(min)}) \pi}{4 V_{CE}} \times 100$$

$$= \frac{\pi}{4} \cdot \frac{V_{CE} - V_{CE(min)}}{V_{CE}} \times 100$$

$$= 78.5 \left[ \frac{V_{CC} - V_{CE(\text{min})}}{V_{CC}} \right]$$

$$= 78.5 \left[ 1 - \frac{V_{CE(\text{min})}}{V_{CC}} \right].$$

Features of class-B Amplifiers:-

- \* More efficient than class-A amplifier.
- \* power wastage is 21.5% because '0' signal current is '0'.
- \* Distortion is very high.

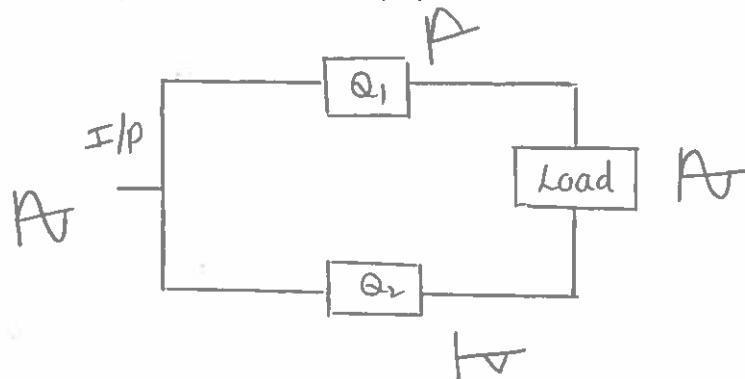
Types of class-B Amplifiers:-

To get full cycle across the load a pair of transistors is used in class-B operation. The 2 transistors conduct in alternate half cycle of i/p signal and full cycle is obtain across the output. Depending on types of two transistors whether P-N-P (or) NPN the 2 configurations of class-B amplifier are possible.

- i) when both the transistors are same type that is either NPN or PNP then the circuit is called pushpull class-B power amplifier.
- ii) when the 2 transistors form a complementary pair i.e. one NPN and other PNP. then the

circuit is called complementary symmetry class-B power amplifier.

Pushpull class-B Amplifier:-

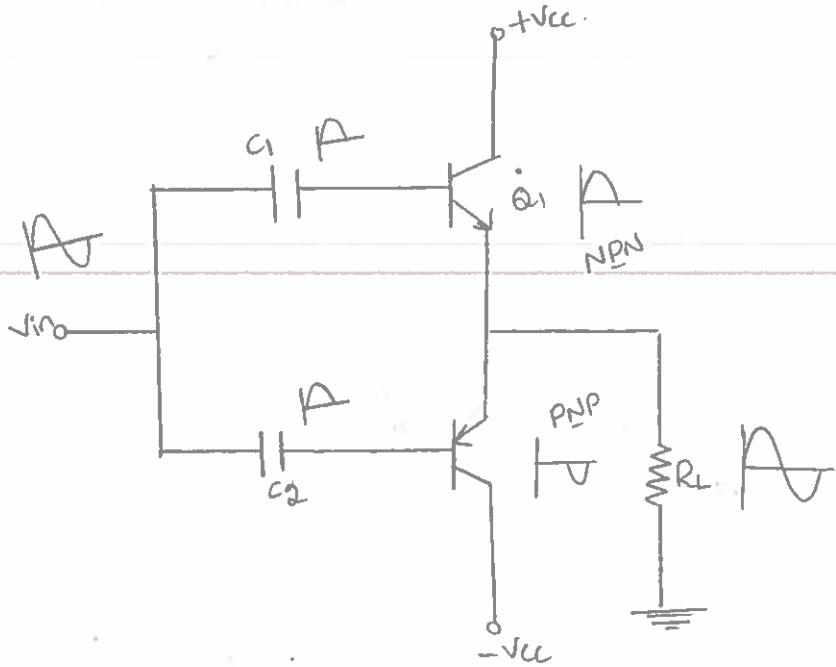


Transistor  $Q_1$  conducts for positive half cycle of i/p produce the halt cycle across load. while the transistor  $Q_2$  conducts for -ve half cycle of the i/p produce -ve cycle. So, the total o/p full cycle.

Complementary symmetry class-B push-pull amplifier:-

To reduce the disadvantage i.e. bulkiness of transformer in class-B push-pull power amplifier, we use complementary symmetry class-B push-pull power amplifier.

In this we use NPN and PNP are used and both transistors have some characteristics.



The i/p is common to both transistors  $Q_1$  &  $Q_2$  for half cycle.

$Q_1$  - ON

$Q_2$  - OFF

For -ve half cycle,

$Q_1$  - off.

$Q_2$  - ON.

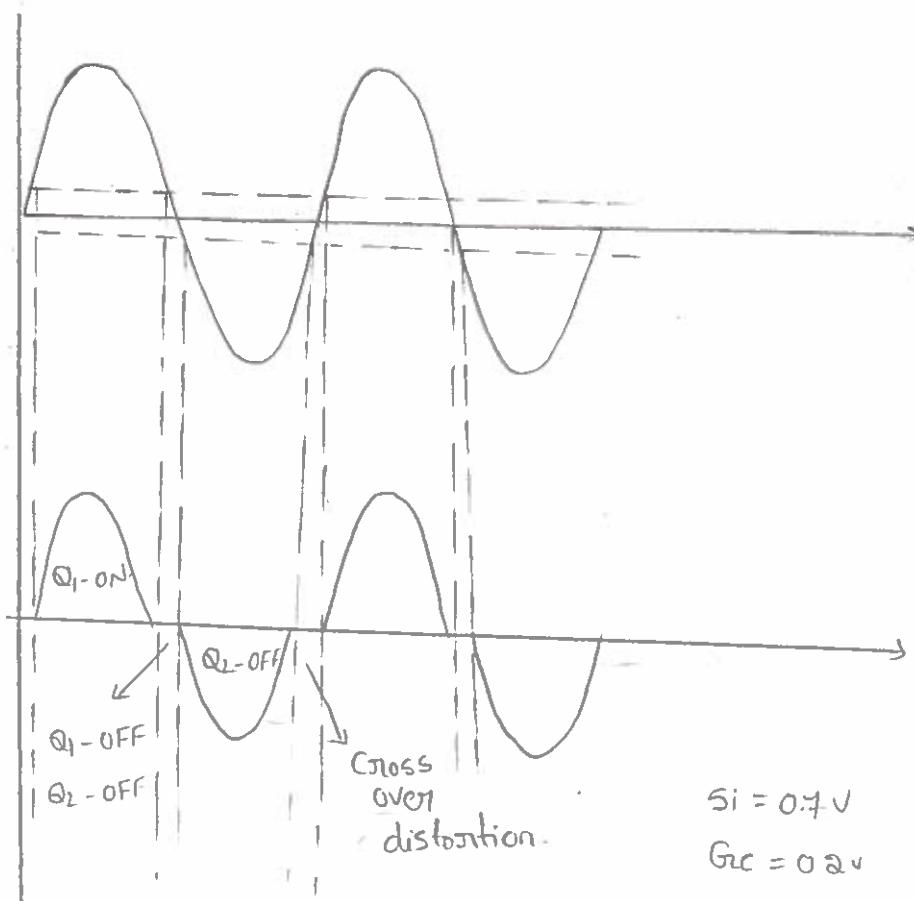
Both NPN & PNP one connected in common collector configuration to provide low o/p impedance for impedance matching.

' $\eta$ ' is same as class-B <sup>push</sup>\*pull amplifier.

Disadvantages:-

\* Cross over distortion.

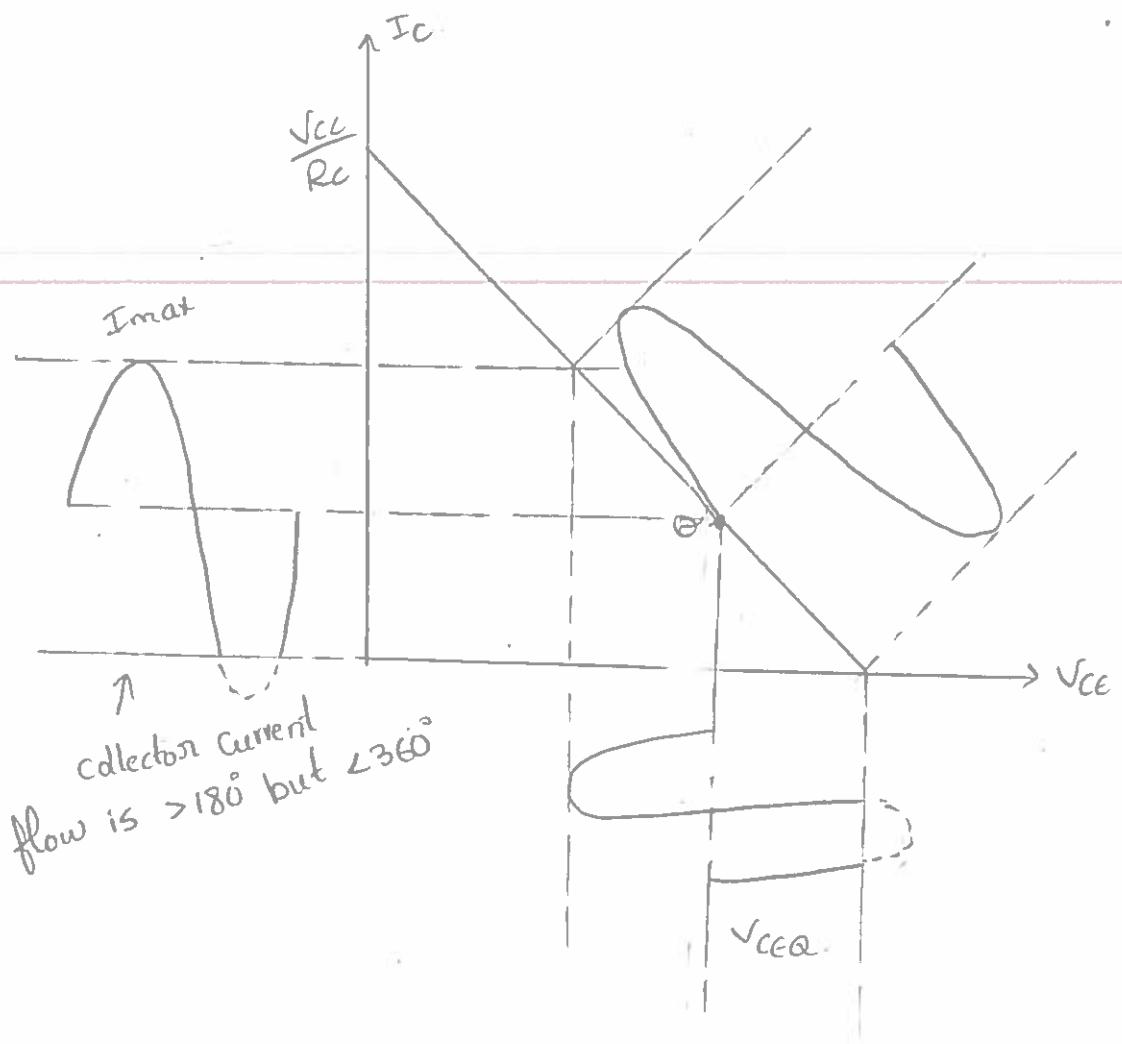
\* Two power supplies are required for NPN & PNP.



## Class-AB power amplifiers:-

The power amplifier is said to be class AB amplifier if the Q-point and the i/p signal are selected such that o/p signal is obtained for more than  $180^\circ$  but also less than  $360^\circ$  for a push pull i/p cycle.

The Q-point position is above x-axis but below the midpoint of a load line.



### Tuned Amplifiers...

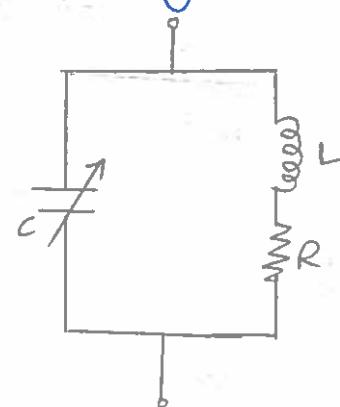
Introduction:-

A tuned parallel LC circuit that resonates at a particular frequency  $f_0$ , is shown in figure. This section deals with the tuned amplifier which amplifies the signals within a narrow frequency band centered about a frequency  $f_0$ . The tuned amplifier is designed to reject all frequencies below a lower cutoff frequency  $f_L$  and above an upper cutoff frequency  $f_H$ . The tuned amplifier is extensively used in communication equipment, especially in

broadcast receiver.

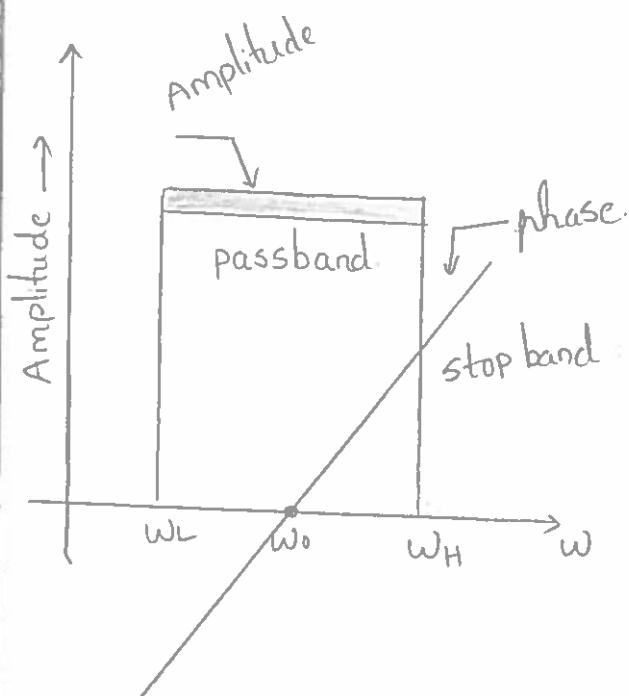
The characteristics curve of such a tuned circuit as shown in figure. The resonant frequency of the circuit is given as

$$f_0 = \frac{1}{2\pi\sqrt{LC}} \quad (\text{or}) \quad \omega_0 = \frac{1}{\sqrt{LC}}$$

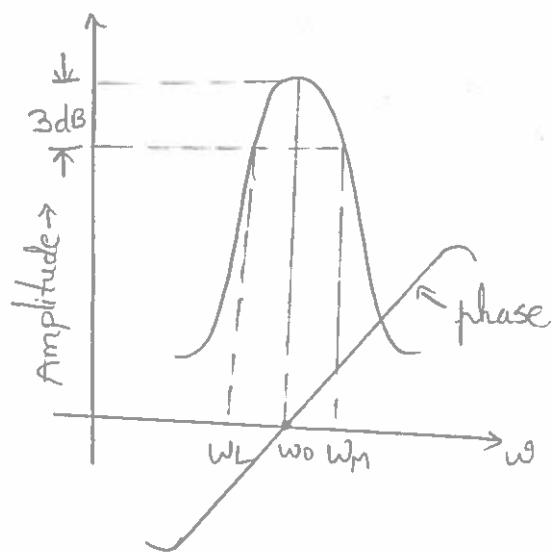


Ideal tuned circuit

The figure indicates that the response of tuned amplifier is maximum at resonant frequency, and for frequencies above and below the resonant frequency, there is a significant decrease in response curve.



a) Ideal response



b) Actual response

Q-Factor:-

In practice, the inductor posses a small resistance in addition to its inductance. The lower the value of this resistance, the better the Q-factor of the inductor.

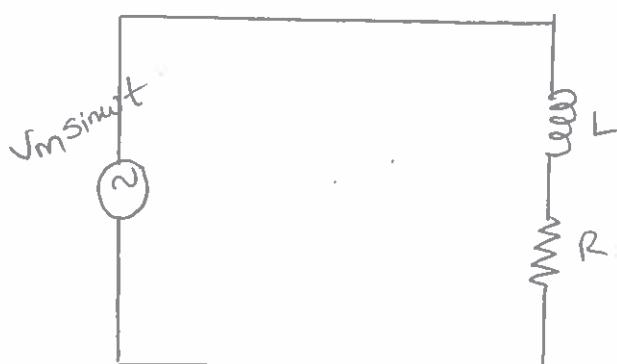
The Q-factor as quality factor of an inductor at operating frequency ' $\omega$ ' is defined as the ratio of impedance of the coil to its resistance and can be defined as

$$Q = 2\pi \times \frac{\text{maximum energy stored per cycle}}{\text{Energy dissipated per cycle.}} \rightarrow ①$$

Consider the circuit shown in figure.

Let a sinusoidal voltage " $V_m \sin \omega t$ " be applied to the circuit. Let "I<sub>m</sub>" be the peak value of the current in the circuit.

Then, maximum energy stored per cycle =  $\frac{1}{2} L I_m^2$ .



Also, average power dissipated in the inductor per cycle =  $\left(\frac{I_m}{\sqrt{2}}\right)^2 R$ .

Energy = power  $\times$  time.

Hence, energy dissipated in the inductor per cycle.

= power  $\times$  periodic time for one cycle.

$$= \left(\frac{I_m}{\sqrt{2}}\right)^2 R \times T$$

$$= \left(\frac{I_m}{\sqrt{2}}\right)^2 R \times \frac{1}{f}$$

$$= \frac{I_m^2 R}{2f}$$

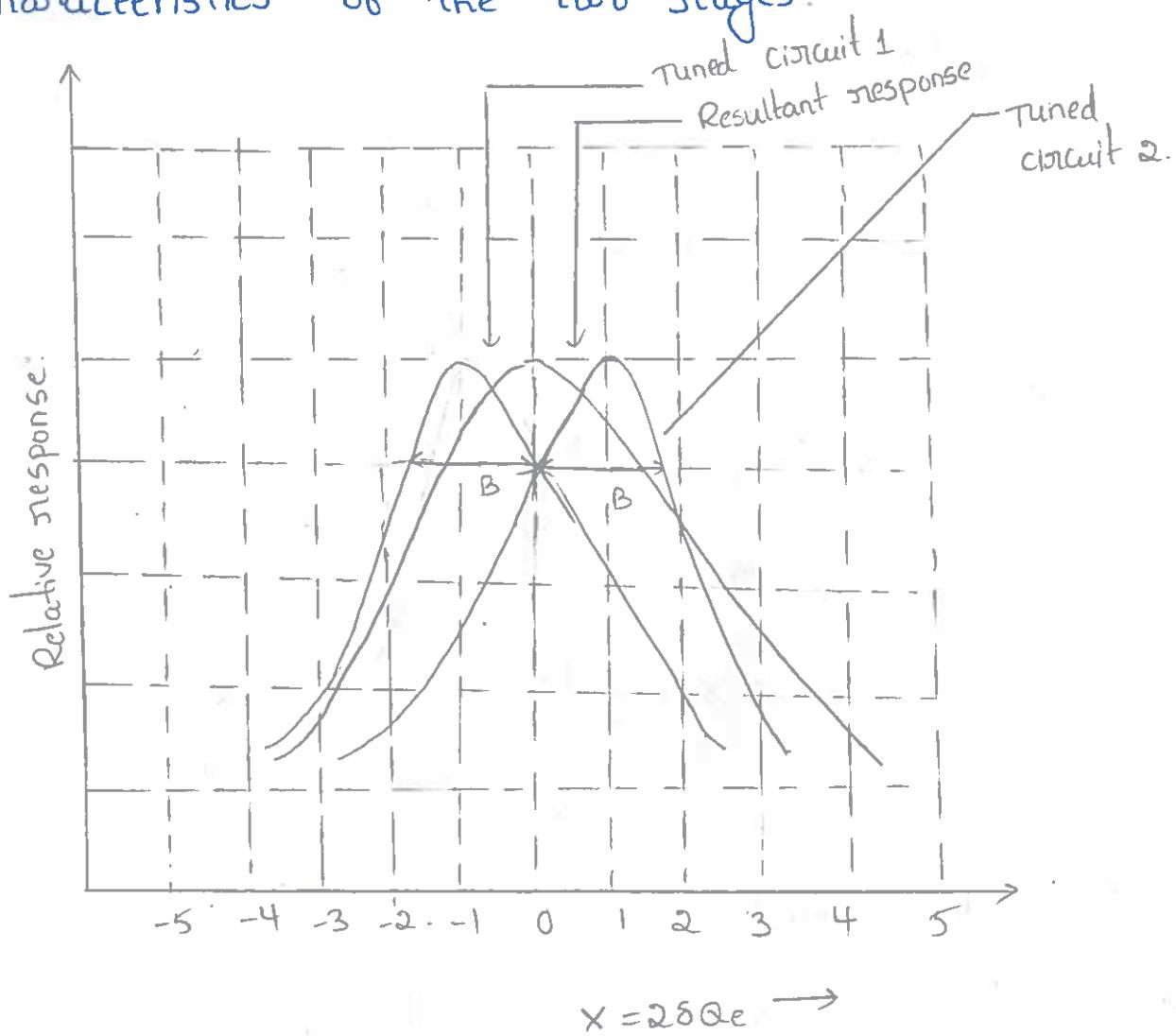
Substituting in equation 0, we get.

$$Q = 2\pi \times \frac{(1/2) L I_m^2}{\frac{I_m^2 R}{2f}} = \frac{\omega L}{R} = \frac{x_L}{R}$$

### Stagger tuned Amplifiers :-

In order to increase bandwidth, double tuned amplifiers are preferred, but alignment of double tuned amplifiers is difficult. In stagger tuned circuits, two single tuned cascade amplifiers having a certain bandwidth are taken. The resonant

frequencies of the two tuned circuits are so adjusted that they are separated by an amount equal to the bandwidth of each stage. Since, the resonant frequency are displaced or staggered, the are known as stagger tuned circuits. figure shows the combined gain characteristics of the two stages.



Stagger tuned amplifier characteristics

The resultant staggered pair will have a bandwidth i.e.  $\sqrt{2}$  times that of each of the individual single tuned circuits. The overall selectivity function will be identical in form with that of a single stage double tuned system. The relative gain of a single tuned direct coupled amplifier is given by the equation

$$\frac{A}{A_{res}} = \frac{1}{1+j25Q_e}$$

Let  $\frac{A}{A_{res}} = \frac{1}{1+jx}$ , where  $x = 25Q_e$ .

As bandwidth is  $B = \frac{f_0}{Q_e}$  and under 3dB frequency

Condition  $\delta = \frac{1}{2Q_e}$ , the equation for bandwidth can be

written as  $B = 2\delta f_0$ . Since one stage is tuned to a frequency  $\delta_0 f_0$  below  $f_0$  and the other stage is tuned to a frequency  $\delta_0 f_0$  above  $f_0$ , the corresponding selectivity function of the circuits are

$$\left(\frac{A}{A_{res}}\right)_1 = \frac{1}{1+j(x-1)} \text{ and } \left(\frac{A}{A_{res}}\right)_2 = \frac{1}{1+j(x+1)}$$

By multiplying the relative gains of the two amplifiers, the overall gain function becomes

$$\left(\frac{A}{A_{res}}\right)_{pair} = \left(\frac{A}{A_{res1}}\right)_1 \left(\frac{A}{A_{res2}}\right)_2$$

$$= \frac{1}{2 - x^2 + 2jx}$$

The magnitude of the resulting function is

$$\left| \left(\frac{A}{A_{res}}\right)_1 \left(\frac{A}{A_{res2}}\right) \right| = \frac{1}{\sqrt{(2-x)^2 + (2x)^2}}$$

$$= \frac{1}{\sqrt{4+x^4}}$$

$$= \frac{1}{\sqrt{4 + (2\delta_0 Q)^4}}$$

$$= \frac{1}{2} \frac{1}{\sqrt{1 + 4\delta_0^4 Q^4}}$$

where  $\delta_0$  is the value of  $\delta$  referred to a new frequency  $w_0$  and  $Q$  is the value of  $Q_0$  for each circuit referred to  $w_0$ . The comparison of this equation with that for double tuned circuit shows that the nature of variation is identical.

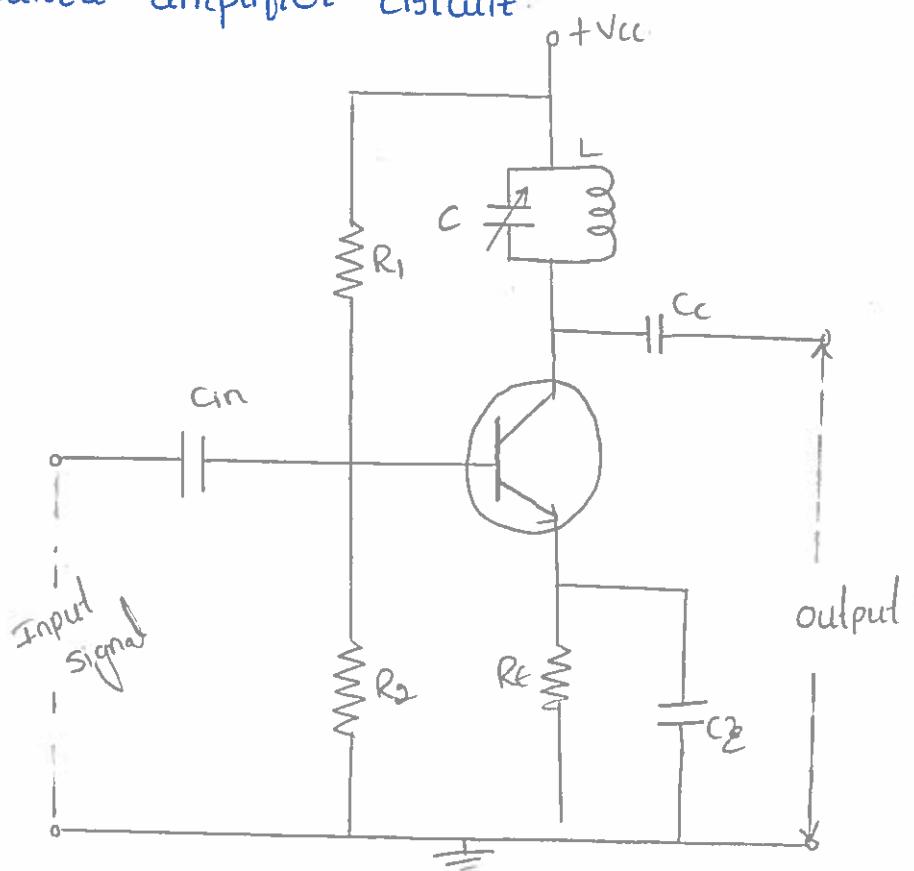
## Single tuned amplifier:-

An amplifier circuit with a single tuner section being at a collector of the amplifier circuit is called as single tuned amplifier circuit.

### Construction:-

A simple transistor amplifier circuit consisting of a parallel tuned circuit in its collector load, makes a single tuned amplifier circuit. The value of capacitance and inductance of the tuned circuit are selected such that its resonant frequency is equal to the frequency to be amplified.

The following circuit diagram shows a single tuned amplifier circuit.



The output can be obtained from the coupling capacitor  $C_c$  as shown above or from a secondary winding placed at L.

Operation:-

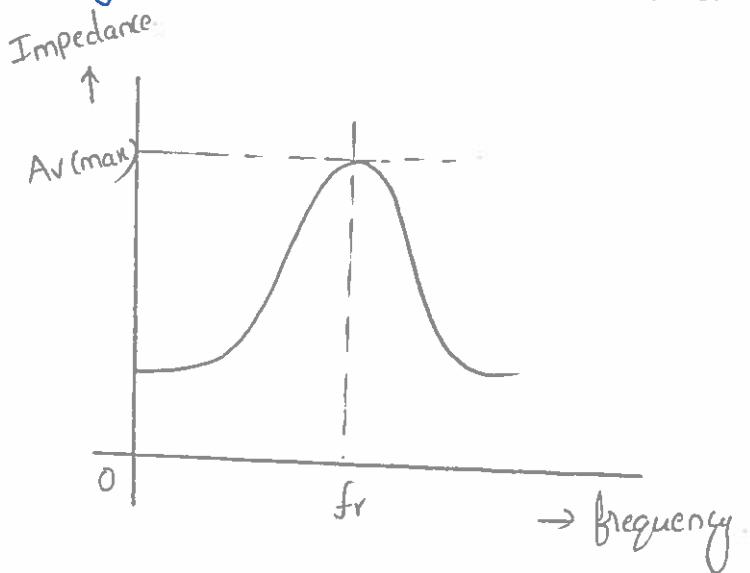
The high frequency signal that has to be amplified is applied at the input of the amplifier. The resonant frequency of the parallel tuned circuit is made equal to the frequency of the signal applied by altering the capacitance value of the capacitor 'C' in the tuned circuit. At this stage, the tuned circuit offers high impedance to the signal frequency, which helps to offer high output across the tuned circuit. As high impedance is offered only for the tuned frequency, all the other frequencies which get lower impedance are rejected by the tuned circuit. Hence the tuned amplifier selects and amplifies the desired frequency signal.

Frequency Response:-

The parallel resonance occurs at resonant frequency  $f_r$  when the circuit has a high Q, the resonant frequency  $f_r$  is given by

$$f_r = \frac{1}{2\pi LC}$$

The following graph shows the frequency response of a single tuned amplifier circuit.



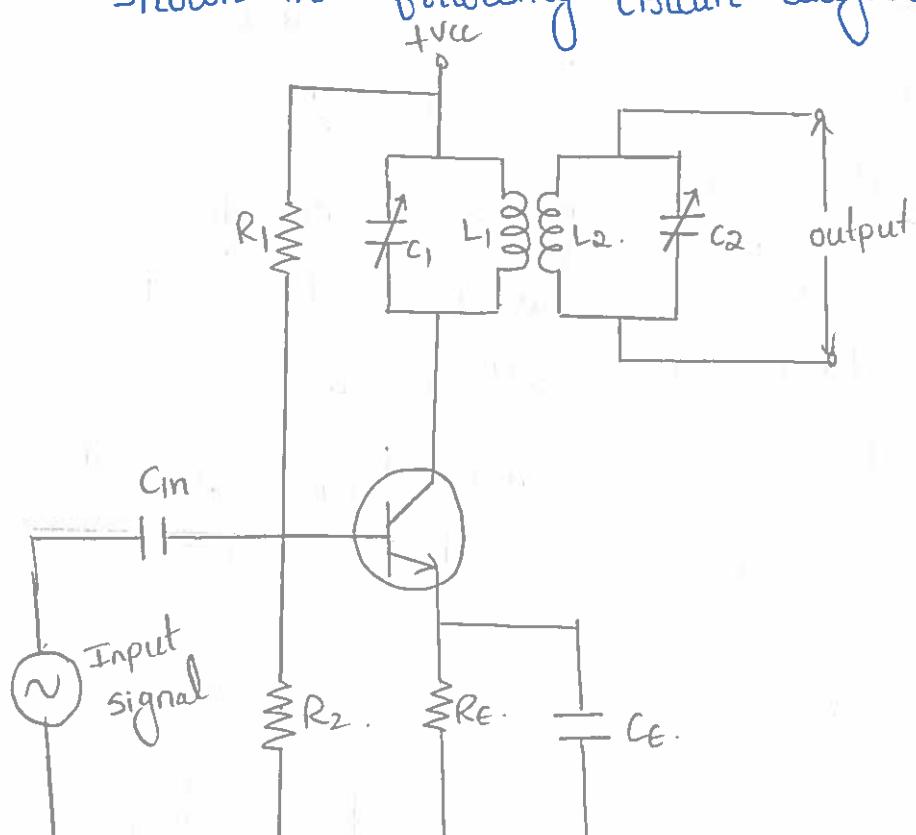
At resonant frequency  $f_r$ , the impedance of parallel tuned circuit is very high and is purely resistive. The voltage across  $R_L$  is therefore maximum, when the circuit is tuned to resonant frequency. Hence the voltage gain is maximum at resonant frequency and drops off above and below it. The higher the  $Q$ , the narrower will be curve be.

Double tuned amplifier:-

An amplifier circuit with a double tuner section being at a collector of the amplifier circuit is called double tuner amplifier circuit.

Construction:-

The construction of double tuned amplifier is understood by having a look at the following figure. This circuit consists of two tuned circuits  $L_1C_1$  and  $L_2C_2$  in the collector section of the amplifier. The signal at the output of tuned circuit  $L_1C_1$  is coupled to the other tuned circuit  $L_2C_2$  through mutual coupling method. The remaining circuit details are same as in the single tuned amplifier circuit as shown in following circuit diagram.



### Operation:-

The high frequency signal which has to be amplified is given to the input of the amplifier. The tuning circuit  $L_{1C_1}$  is tuned to the input signal frequency. At this condition, the tuned circuit offers high reactance to the signal frequency. Consequently, large output appears at the output of the tuned circuit  $L_{1C_1}$  which is then coupled to the other tuned circuit  $L_{2C_2}$  through mutual induction. These double tuned circuits are extensively used for coupling various circuits of radio and television receivers.

### Frequency response of double tuned amplifier:-

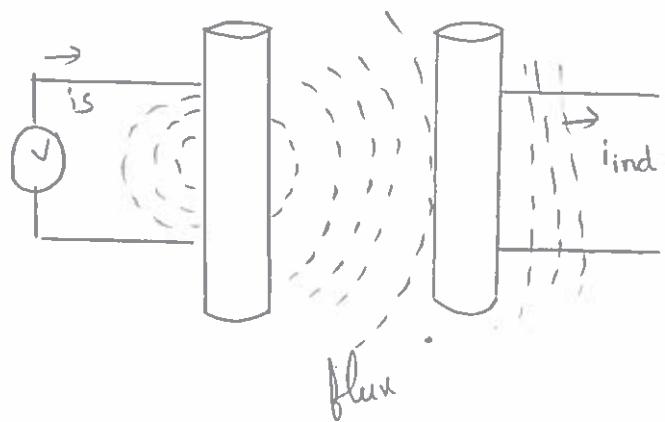
The double tuned amplifier has the special feature of coupling which is important in determining the frequency response of the amplifier. The amount of mutual inductance between the two tuned circuits states the degree of coupling, which determines the frequency response of the circuit.

In order to have an idea on the mutual inductance property, let us go through basic principle.

## Mutual Inductance:-

As the current carrying coil produces some magnetic field around it, if another coil is brought near this coil, such that it is in the magnetic flux region of the primary, then the varying magnetic flux induces an EMF in second coil. When the EMF is induced in the secondary coil due to the varying magnetic field of the primary coil, then such phenomenon is called as the mutual inductance.

The figure below gives an idea about this.

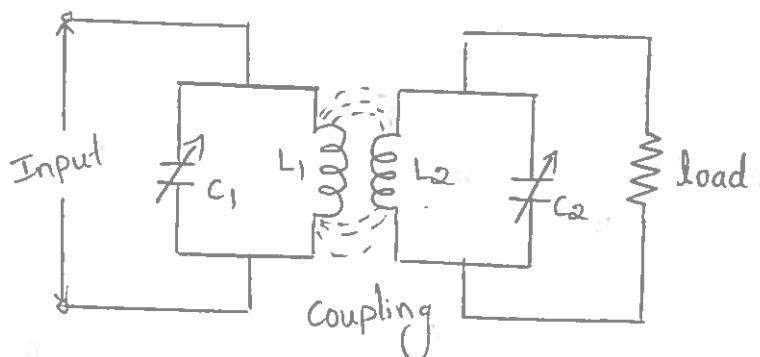


The current  $i_s$  in the figure indicates the source current while  $i_{ind}$  indicates the induced current. The flux represents the magnetic flux.

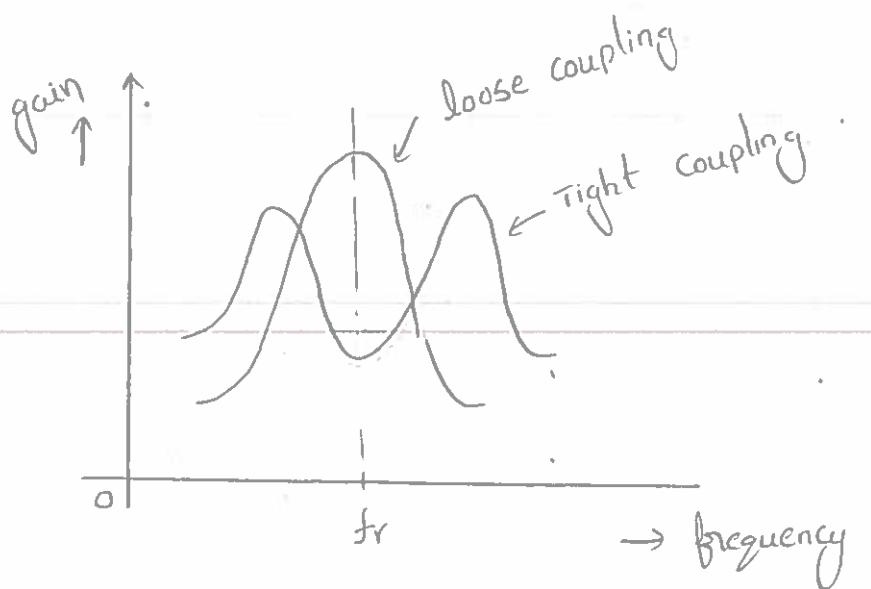
Created around the coil. This spreads to the secondary coil also. With the application of voltage, the current is flows and flux gets created. When the current is varies the flux gets varied, producing induced in the secondary coil, due to varying mutual inductance property.

Coupling:-

Under the concept of mutual inductance coupling will be as shown in the figure below.



When the coils are spaced apart, the flux linkages of primary coil L<sub>1</sub> will not link the secondary coil L<sub>2</sub>. At this condition, the coils are said to have "loose coupling". The resistance reflected from the secondary coil at this condition is small and the resonant curve will be sharp and the circuit Q is high as shown in the figure below.



On the contrary, when the primary and secondary coils are brought close together, they have 'tight coupling'. Under such conditions, the reflected resistance will be large and the circuit Q is lower. Two positions of gain maxima, one above and the other below the resonant frequency are obtained.

Bandwidth of double Tuned circuit:-

The above figure clearly states that the bandwidth increases with the degree of coupling. The determining factor in a double tuned circuit is not Q but the coupling. We understood that, for a given frequency, the tighter the coupling the greater the bandwidth will be.

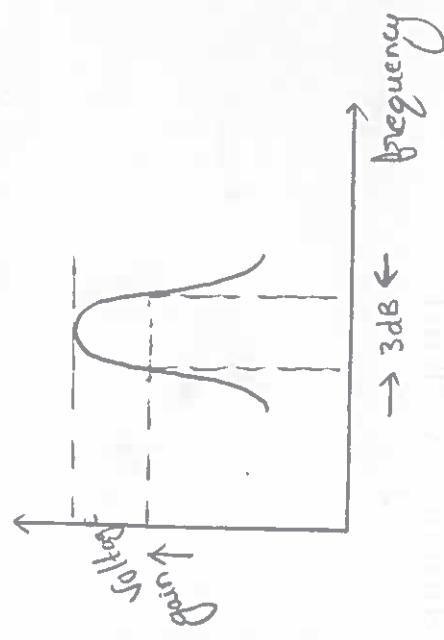
The equation for B.W is given as  $BW_{dt} = kfr$ .

where  $BW_{dt}$  = bandwidth for double tuned circuit,  
 $k$  = coefficient of coupling, and  $fr$  = resonant frequency.

## Compositions of Tuned Amplifiers:-

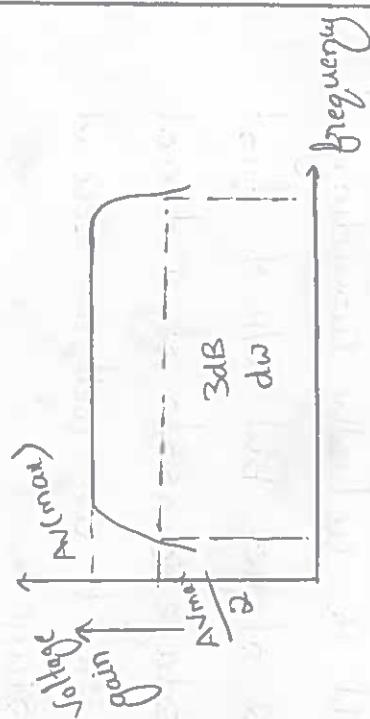
S.No	Single tuned amplifier	Double tuned amplifier	Stagger - tuned amplifier
1.	A single - tuned amplifier consists of only one tuning circuit.	A double tuned amplifier consists of two tuned circuits. It is actually cascading of 2 stages, but o/p of first stage consists of a tuned circuit as well as second stage.	Stagger tuned amplifier use a number of single tuned amplifiers in cascade.
2.	In single tuned amplifier, the tuned circuit in cascaded stages one tuned to same frequencies (synchronous tuning).	In a double tuned amplifier, the tuning circuit one tuned to same center frequency and same BW.	In stagger - tuned amplifiers, the successive amplifiers, the successive tuned circuit being tuned to difficult frequency (stagger - tuning).

3. The  $3dB$  bandwidth provided by single-tuned amplifier is narrow.



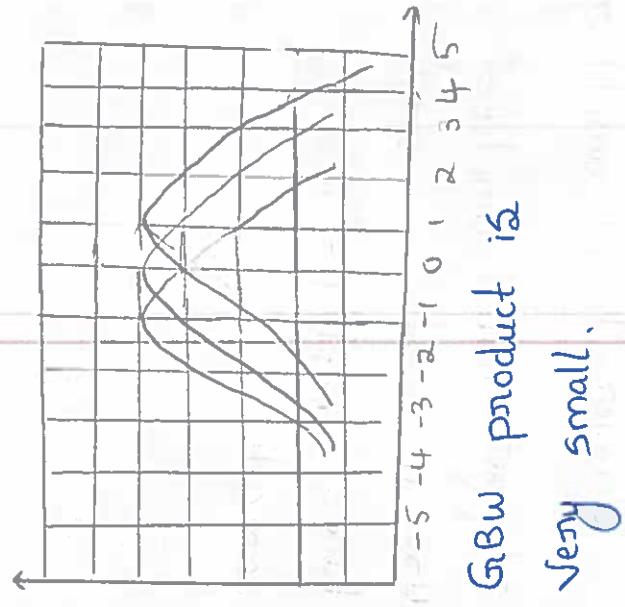
Frequency response mounts and hence  $G_{BW}$  product is small.

The  $3dB$  bandwidth provided by a double-tuned amplifiers is longer than a single tuned amplifiers.



Frequency response is flat and has steeper ends and  $G_{BW}$  product is large.

The half-power ( $3dB$ ) BW of a staggered pair is  $\sqrt{2}$  times the half power ( $3dB$ ) BW of an individual single tuned stage.



$G_{BW}$  product is very small.

5 Single tuned amplifier one is easy to design

Double-tuned amplifiers are complex to design because, the two-tuned circuit must be tuned to same centre frequency and bandwidth.

6. No isolation is required between stages.

Isolation is required between stages to prevent the second tuned circuit communicating with first tuned circuit & the changing parameters.

Design is similar to single tuned amplifier.

No isolation is required between stages.

