UNIT III TUNED AMPLIFIERS

Coil losses, unloaded and loaded Q of tank circuits, small signal tuned amplifiers - Analysis of capacitor coupled single tuned amplifier - Double tuned amplifier - Effect of cascading single tuned and double tuned amplifiers on bandwidth - Stagger tuned amplifiers - Stability of tuned amplifiers - Neutralization - Hazeltine neutralization method.

3.3.Classification of Tuned Amplifier:

We know that, multistage amplifiers are used to obtain large overall gain. The cascadedstages of multistage tuned amplifiers can be categorized as given below:

1. Single Tuned Amplifiers
2. Double Tuned Amplifiers
3. Stagger Tuned Amplifiers

These amplifiers are further classified according to coupling used to cascade the stages ofmultistage amplifier. They are,

1. Capacitive Coupled
2. Inductive Coupled
3. Transformer Coupled

3.3.1.DOUBLE TUNED AMPLIFIER

- An amplifier circuit with a double tuner section being at the collector of the amplifier circuit is called as 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 the 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 the following circuit diagram.
- Fig shows double tuned RF amplifier in CE configuration. Here, voltage

developed across tuned circuit is coupled inductively to another tuned circuit. Both tuned circuits are tuned to the same frequency.

- The double tuned circuit can provide a bandwidth of several percent of the resonant frequency and gives steep sides to the response curve. Let us analyze the double tuned circuit.
- The Fig. shows the coupling section of a transformer coupled double tuned amplifier.
- The Fig. shows the equivalent circuit for it, in which transistor is replaced by the current source with its output resistance (R_o). The C_1 and L_1 are the tank circuit components of the primary side.
- The resistance R_1 is the series resistance of the inductance L_1. Similarly on the second side L_2 and C_2 represent the tank circuit components of the secondary side and R_2 represents resistance of the inductance L_2.
- The resistance R_i represents the input resistance of the next stage.

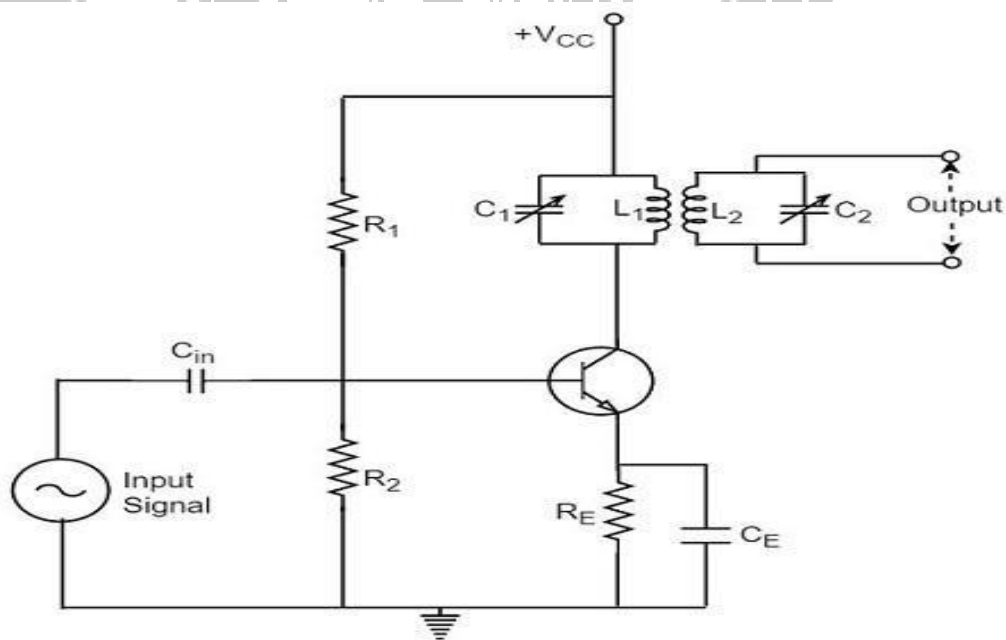

Fig 3.3.1 Double Tuned Amplifier

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.

3.3.2.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 thebasic principle.
- For an amplifier to be efficient, its gain should be high. This voltage gain depends upon β, input impedance and collector load. The collector load in a tuned amplifier is a tuned circuit.
- The voltage gain amplifier is given
  Voltage gain = Bz_C/Z_{in}
- Where Z_C = effective collector load and
- Z_{in} = input impedance of the amplifier.
- The value of Z_C depends upon the frequency of the tuned amplifier.
- As Z_C is maximum atresonant frequency, the gain of the amplifier is maximum at this resonant frequency.

3.3.3.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 the second coil. If this first coil is called as Primary coil, the second one can be called as a Secondary 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.

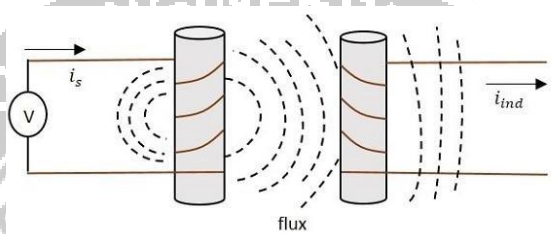

Fig.3.3.3. Mutual Inductance

- The current i_s in the figure indicate the source current while i_{ind} indicates the inducedcurrent.
- The flux represents the magnetic flux created around the coil. This spreads to the secondary coil also.
- With the application of voltage, the current i_s flows and flux gets created.
- When the current is varies the flux gets varied, producing i_{ind} in the secondary coil, due to theMutual inductance property.

3.3.4.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_1 will not link the secondary coil L_2. At this condition, the coils are said to have Loose coupling.

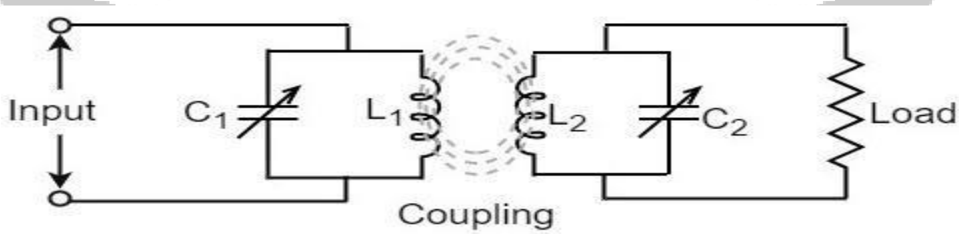

Fig.3.3.4.Coupling

- The resistance reflected from the secondary coil at this condition is small and the resonance curve will be sharp and the circuit Q is high as shown in the figure below.

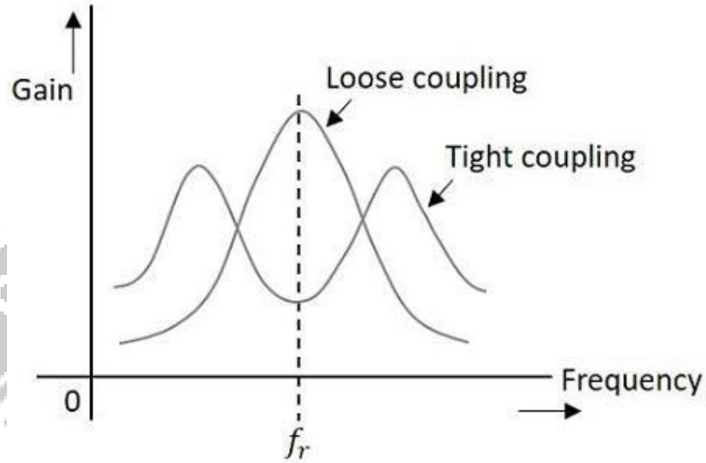

Fig 3.3.4a Coupling

- 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.

3.3.5.BANDWIDTH OF DOUBLE TUNED CIRCUIT

- The above figure clearly states that the bandwidth increases with the degree ofcoupling.
- 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 thebandwidth will be.
- The equation for bandwidth is given as

$$BW_{dt} = kf_r$$

Where

BW_{dt} = bandwidth for double tuned circuit,

K = coefficient of coupling, andf_r = resonant frequency.

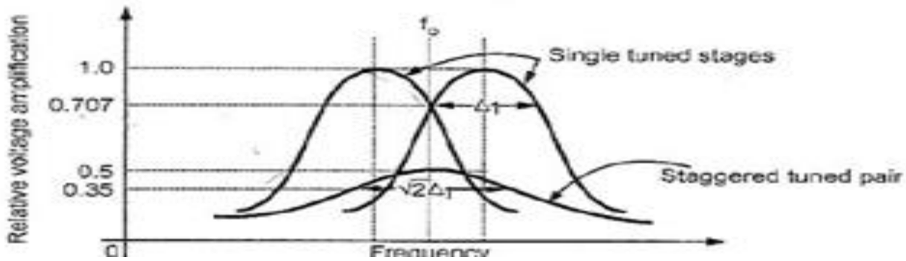

Fig.3.3.5 Band width

Q factors of double tuned circuit

$$Q_1 = \frac{\omega_r L_1}{R_{11}} \text{ and } Q_2 = \frac{\omega_r L_2}{R_{22}}$$

Output Voltage

$$V_o = -\frac{j}{\omega_r C_2} I_2$$

Transfer Admittance

$$\dot{Y}_T = \frac{kQ^2}{\omega_r \sqrt{L_1 L_2}\left[4Q\delta - j(1 + k^2Q^2 - 4Q^2\delta^2)\right]}$$

Voltage Gain (Av)

$$= \left[\frac{g_m \omega_r \sqrt{L_1 L_2}\, kQ^2}{4Q\delta - j(1 + k^2Q^2 - 4Q^2\delta^2)}\right]$$

Frequencies

$$f_1 = f_r\left(1 - \frac{1}{2Q}\sqrt{k^2Q^2 - 1}\right) \text{ and}$$

$$f_2 = f_r\left(1 + \frac{1}{2Q}\sqrt{k^2Q^2 - 1}\right)$$

Gain Magnitude

$$|A_p| = \frac{g_m \omega_o \sqrt{L_1 L_2}\, kQ}{2}$$

- We know that, the 3 dB bandwidth for single tuned amplifier is $2f_r$ / Q. Therefore, the 3 dB bandwidth provided by double tuned amplifier (3.1ff / Q) is substantially greater than the 3 dB bandwidth of single tuned amplifier.

Compared with a single tuned amplifier, the double tuned amplifier,

1. Possesses a flatter response having steeper sides.
2. Provides larger 3 dB bandwidth.
3. Provides large gain-bandwidth product.

3.3.6.Effect of cascading Single Tuned Amplifier on Bandwidth:

- In order to obtain a high overall gain, several identical stages of amplifiers can be usedin cascade.
- The overall gain is the product of the voltage gains of the individual stages. Let us see the effect of cascading of stages on bandwidth.

3.3.7. Effect of cascading Double Tuned Amplifiers on Bandwidth:

- When a number of identical double tuned amplifier stages are connected in cascade, the overall bandwidth, of the system is thereby narrowed and the steepness of the sides of the response is increased, just as when single tuned stages are cascaded.
- The quantitative relation between the 3 dB bandwidth of n identical double tuned critically coupled stages compared with the bandwidth Δ_2 of such a system can be shown to be 3 dB bandwidth for n identical stages double tuned amplifiers is,

$$\Delta_2 \times \left(2^{\frac{1}{n}} - 1\right)^{\frac{1}{4}}$$

where Δ_2 is the 3 dB bandwidth of single stage double tuned amplifier. The above equation assumes that the bandwidth Δ_2 is small compared with the resonant frequency.