TUNED AMPLIFIERS

- To amplify the selective range of frequencies, the resistive load R_C is replaced by a tuned circuit. The tuned circuit is capable of amplifying a signal over a narrow band of frequencies centered at Fr. The amplifiers with such a tuned circuit as a load are known as tuned amplifier.
- The types of amplifiers that we have discussed so far cannot work effectively at radio frequencies, even though they are good at audio frequencies.
- Also, the gain of these amplifiers is such that it will not vary according to the frequency of the signal, over a wide range.
- This allows the amplification of the signal equally well over a range of frequencies and does not permit the selection of particular desired frequency while rejecting the other frequencies.
- So, there occurs a need for a circuit which can select as well as amplify. So, an amplifier circuit along with a selection, such as a tuned circuit makes a Tuned amplifier.

WHAT IS A TUNED AMPLIFIER?

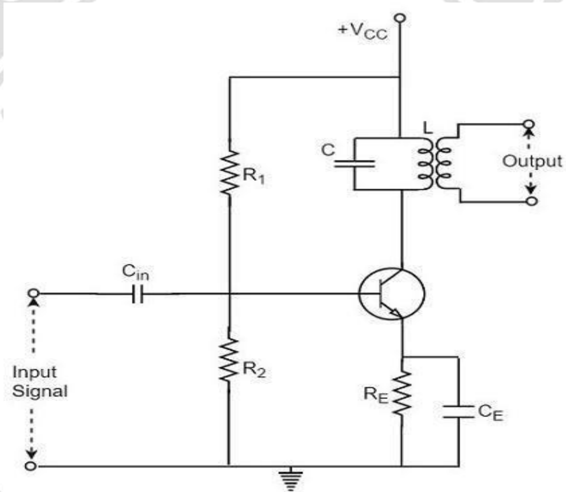
Tuned amplifiers are the amplifiers that are employed for the purpose of tuning. Tuning means selecting. Among a set of frequencies available, if there occurs a need to select a particular frequency, while rejecting all other frequencies, such a process is called Selection. This selection is done by using a circuit called as Tuned circuit. When an amplifier circuit has its load replaced by a tuned circuit, such an amplifiercan be called as a Tuned amplifier circuit.

The basic tuned amplifier circuit looks as shown below. The tuner circuit is nothing but a LC circuit which is also called as resonantor tank circuit. It selects the frequency. A tuned circuit is capable of amplifying a signal over a narrow band of frequencies that are centered at resonant frequency.When the reactance of the inductor balances the reactance of the capacitor,in the tuned circuit at some frequency, such a frequency can be called as resonant frequency. It is denoted by f_r.

The formula for resonance is:

$$2\pi f_L = \frac{1}{2\pi f_c}$$

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



Coil Losses:

- As shown in the Fig. the tuned circuit consists of a coil. Practically, coil is not purely inductive. It consists of few losses and they are represented in the form of leakage resistance in with the inductor. The total loss of the coil is comprised of copper loss, eddy current loss and hysteresis loss.
- The copper loss at low frequencies is equivalent to the d.c. resistance of the coil. Copper loss is inversely proportional to frequency. Therefore, as frequency increases, the copper loss decreases.
- Eddy current loss in iron and copper coil are due to currents flowing within the copper or core based by induction. The result of eddy currents is a loss due to heatingwithin the inductors copper or core.
- Eddy current losses are directly proportional to frequency. Hysteresis loss is proportional to the area enclosed by the hysteresis loop and to the rate at which this loop is transverse.

- It is a function of signal level and increase with frequency. Hysteresis loss is however independent of frequency.

Q Factor:

- Quality Factor (Q) is important characteristics of inductor. The Q is the ratio of reactance to resistance and therefore it is unit less.
- It is the measure of how 'pure' or 'real' an inductor is (i.e. the inductor consists only reactance).
- The higher the Q of an inductor, the fewer losses there are in the inductor. The Q factor also can be defined as the measure of efficiency with which inductor can store the energy. For a parallel resonance circuit, the sharpness of the resonance curve determines the selectivity. The smaller the resistance of the coil, the sharper the resonant curve will be. Hence the inductive reactance and resistance of the coil determine the quality of the tuned circuit.
- The ratio of inductive reactance of the coil at resonance to its resistance is known as Quality factor. It is denoted by Q.
- The dissipation factor (D) that can be referred to as the total loss within a component is defined as 1/Q. The fig. Shows the quality factor equations

$$Q = \frac{X_L}{R} = \frac{2\pi f_r L}{R}$$

for series and parallel circuits and its relation with dissipation factor.

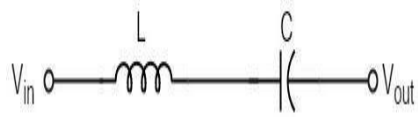
TYPES OF TUNED CIRCUITS

- A tuned circuit can be Series tuned circuit (Series resonant circuit) or Parallel tuned circuit (parallel resonant circuit) according to the type of its connection to the main circuit.

1.SERIES TUNED CIRCUIT

- The inductor and capacitor connected in series make a series tuned circuit, as shownin the following circuit diagram.

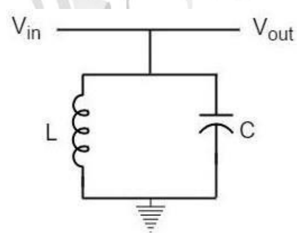
- At resonant frequency, a series resonant circuit offers low impedance which



allows high current through it. A series resonant circuit offers increasingly high impedance to the frequencies far from the resonant frequency.

2. PARALLEL TUNED CIRCUIT

- The inductor and capacitor connected in parallel make a parallel tuned circuit, as shown in the below figure.



- At resonant frequency, a parallel resonant circuit offers high impedance which doesnot allow high current through it.
- A parallel resonant circuit offers increasingly low impedance to the frequencies far from the resonant frequency.

CHARACTERISTICS OF A PARALLEL TUNED CIRCUIT

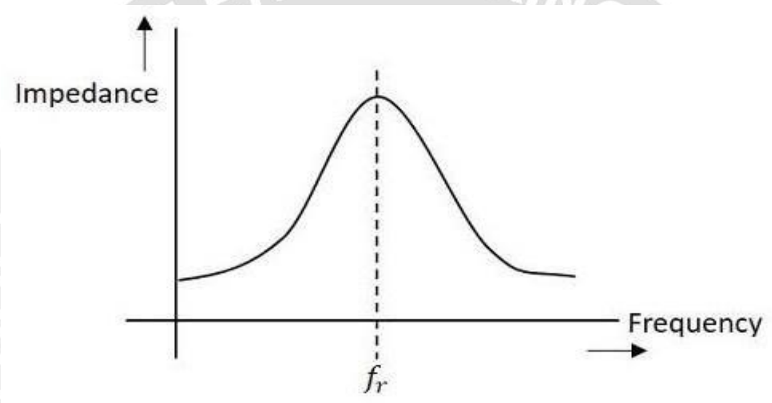
- The frequency at which parallel resonance occurs (i.e. reactive component of circuit current becomes zero) is called the resonant frequency f_r. The main characteristics of a tuned circuit are as follows.

IMPEDANCE

- The ratio of supply voltage to the line current is the impedance of the tuned circuit. Impedance offered by LC circuit is given by

$$\frac{Supply\ voltage}{Line\ Current} = \frac{V}{I}$$

- At resonance, the line current increases while the impedance decreases. The below figure represents the impedance curve of a parallel resonance circuit.



- Impedance of the circuit decreases for the values above and below the resonant frequency f_r. Hence the selection of a particular frequency and rejection of other frequencies is possible.
- To obtain an equation for the circuit impedance, let us consider Impedance of the circuit decreases for the values above and below the resonant frequency f_r. Hence the selection of a particular frequency and rejection of other frequencies is possible.
- considerLine Current $I=I_L cos\phi$

$$V/Z_r=V/Z_L\times R/Z_L$$

$$1/Z_r=R/Z^2_L$$

- Thus at parallel resonance, the circuit impedance is equal to L/CR.
- Therefore, circuit impedance Z_r is obtained as

$$Z_R = \frac{L}{CR}$$

Thus at parallel resonance, the circuit impedance is equal to L/CR.

CIRCUIT CURRENT

- At parallel resonance, the circuit or line current I is given by the applied voltagedivided by the circuit impedance Z_r i.e.,

$$\text{Line Current} \quad I = \frac{V}{Z_r}$$

$$\text{Where} \quad Z_r = \frac{L}{CR}$$

Because Z_r is very high, the line current I will be very small.

ADVANTAGES OF TUNED AMPLIFIERS

The following are the advantages of tuned amplifiers.

- The usage of reactive components like L and C, minimizes the power loss, which makes the tuned amplifiers efficient.
- The selectivity and amplification of desired frequency is high, by providing higher impedance at resonant frequency.
- A smaller collector supply V_{CC} would do, because of its little resistance in parallel tuned circuit.

It is important to remember that these advantages are not applicable when there isa high resistive collector load.

FREQUENCY RESPONSE OF TUNED AMPLIFIER

- 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 amplifieris a tuned circuit.

- The voltage gain of such an amplifier is given by

$$Voltage\ gain = \frac{QZ_C}{Z_{in}}$$

- 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 at resonant frequency, the gain of the amplifier is maximum at this resonant frequency.

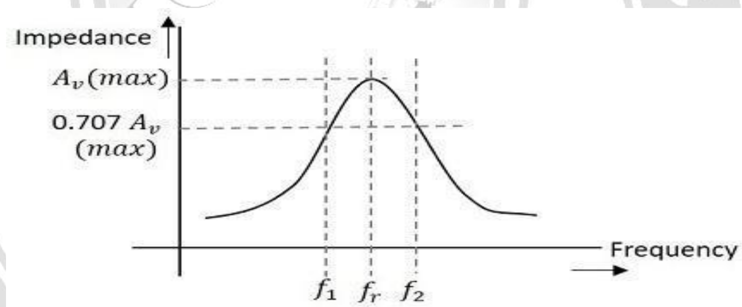


Fig- 1 Frequency Response of Tuned Amplifiers

BANDWIDTH

- The range of frequencies at which the voltage gain of the tuned amplifier falls to 70.7% of the maximum gain is called its Bandwidth.

- The range of frequencies between f_1 and f_2 is called as bandwidth of the tuned amplifier. The bandwidth of a tuned amplifier depends upon the Q of the LC circuit i.e., upon the sharpness of the frequency response. The value of Q and the bandwidth are inversely proportional. The figure above details the bandwidth and frequency response of the tuned amplifier.

RELATION BETWEEN Q AND BANDWIDTH

- The quality factor Q of the bandwidth is defined as the ratio of resonant frequency to bandwidth, i.e.,

- In general, a practical circuit has its Q value greater than 10. Under this condition, the resonant frequency at parallel resonance is given by

$$Q = \frac{f_r}{BW} \quad f_r = \frac{1}{2\pi\sqrt{LC}}$$

There are two main types of tuned amplifiers. They are −

1. Single tuned amplifier 2.Double tuned amplifier

Requirements of Tuned Amplifier:

The basic requirements of Tuned Amplifiers are:

1. The amplifier should provide selectivity of resonant frequency over a very narrow band.
2. The signal should be amplified equally well at all frequencies in the selected narrow band.
3. The tuned circuit should be so mounted that it can be easily tuned. If there is more thanone circuit to be tuned, there should be an arrangement to tune all circuit simultaneously.
4. The amplifier must provide the simplicity in tuning of the amplifier components to thedesired frequency over a considerable range of band of frequencies.

Classification of Tuned Amplifier:

We know that, multistage amplifiers are used to obtain large overall gain. Thecascaded stages 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 thestages of multistage amplifier. They are,

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