UNIT V

Tuned Amplifiers:,

Tuned Voltage Amplifier

Stagger tuned and double tuned amplifiers,

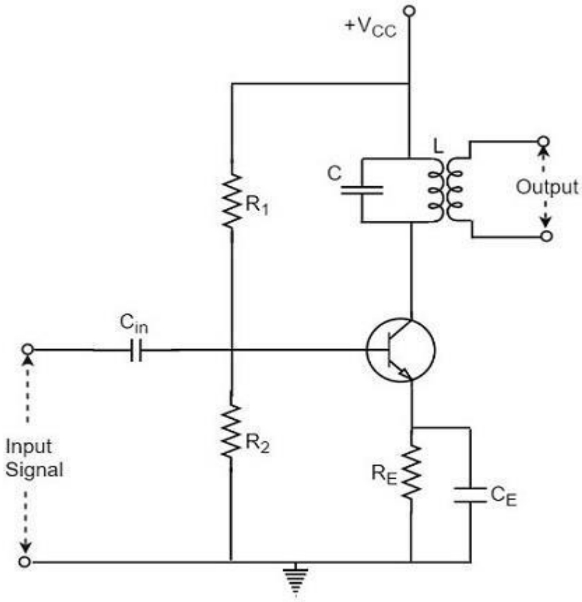
Class-CAmplifier,

RFAmplifiers

UNIT-V
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 amplifier can 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 **resonant** or **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

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

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

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.

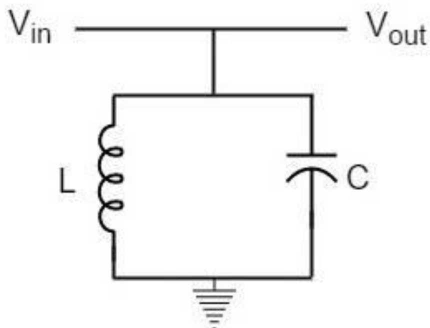
Series Tuned Circuit

The inductor and capacitor connected in series make a series tuned circuit, as shown in 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.

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 does not 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 $\mathbf{f_r}$. The main characteristics of a tuned circuit are as follows.

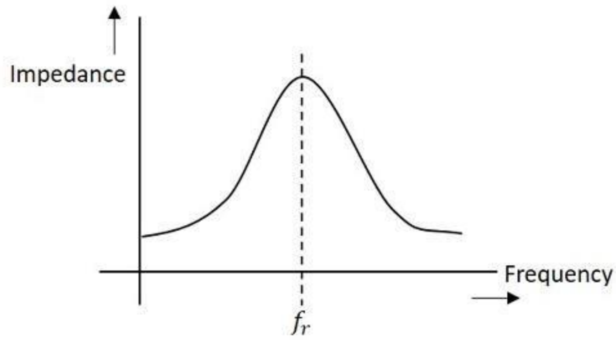
Impedance

The ratio of supply voltage to the line current is the impedance of the tuned circuit.

Impedance offered by LC circuit is given by

Supply voltage / Lineequation=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 Line Current $I=ILcos\phi$

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

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

$1/Zr=CR/L$

Since, $Z_{2L}=L/C$

Therefore, circuit impedance Z_r is obtained as

$Z_R=L/CR$

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 voltage divided by the circuit impedance Z_r i.e.,

Line Current $I=VZr$

Where $Zr=L/CR$

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

Quality Factor

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**.

$Q=X_L/R=2\pi frLR$

The higher the value of Q, the sharper the resonance curve and the better the selectivity will be.

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 VCC would do, because of its little resistance in parallel tuned circuit.

It is important to remember that these advantages are not applicable when there is a 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 amplifier is a tuned circuit.

The voltage gain of such an amplifier is given by

Voltage gain = Bz_c/Z_{in}

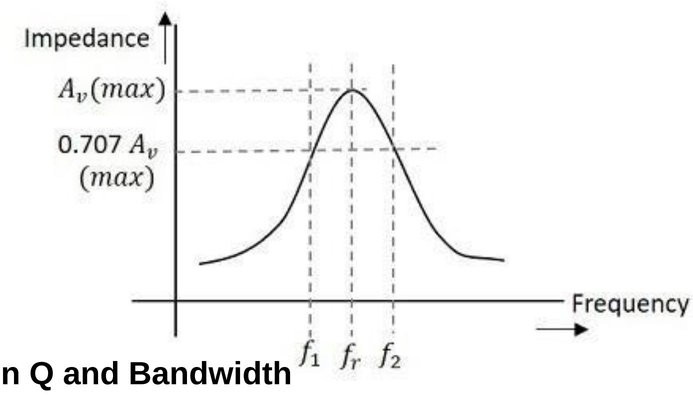
Where Z_C = effective collector load and Z_{in} = input impedance of the amplifier.

The value of Z_C depends upon the frequency of the tuned amplifier. As Z_C is maximum at resonant frequency, the gain of the amplifier is maximum at this resonant frequency.

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 below 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.,

Q=fr / BW

In general, a practical circuit has its Q value greater than 10.
Under this condition, the resonant frequency at parallel resonance is given by
$fr=1/\sqrt{2\pi LC}$

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

- Single tuned amplifier
- Double tuned amplifier

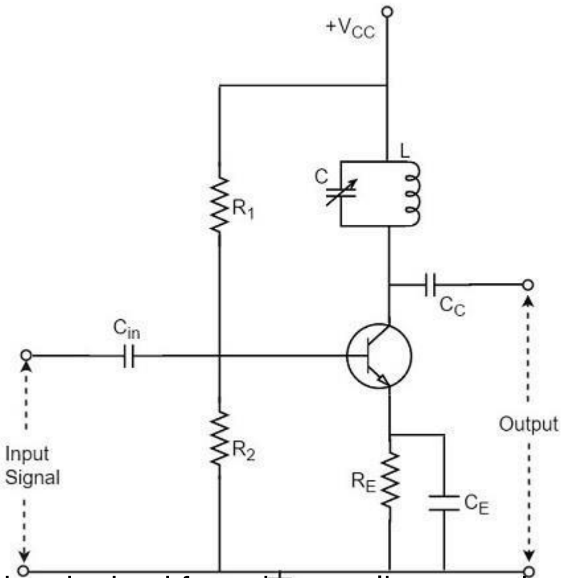
Single Tuned Amplifier

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

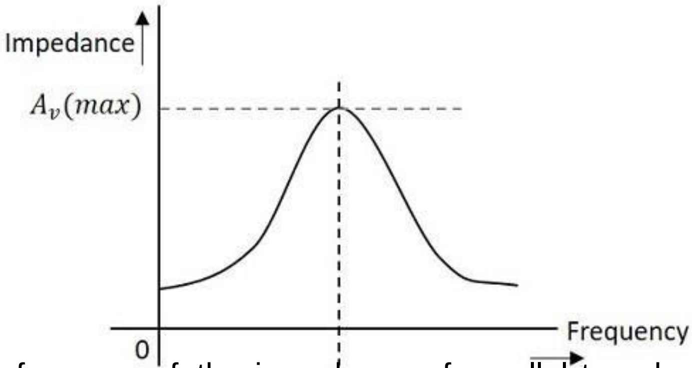
The high frequency signal that has to be amplified is applied at the input of the amplifier. The resonant frequency of the parallel tuned circuit is made equal to the frequency of the signal applied by altering the capacitance value of the capacitor C, in the tuned circuit.At this stage, the tuned circuit 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

$fr=1/\sqrt{2\pi LC}$

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



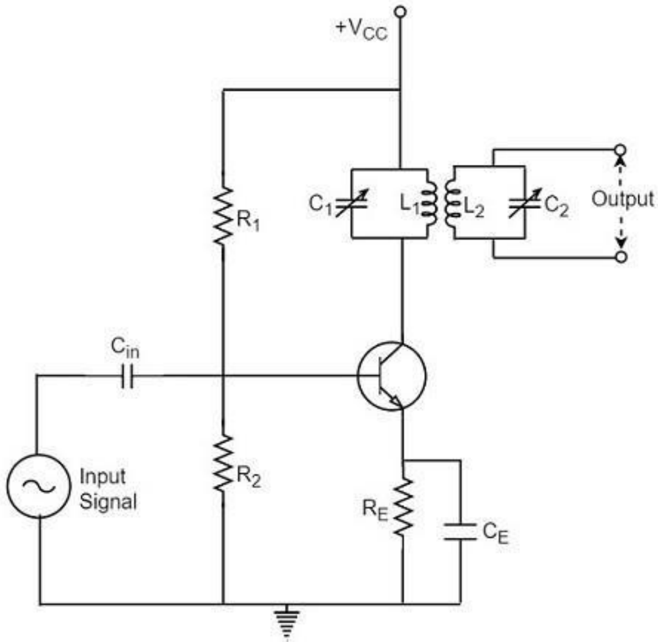
At resonant frequency f_r the impedance of parallel tuned circuit is very high and is purely resistive. The voltage across R_L is therefore maximum, when the circuit is tuned to resonant frequency. Hence the voltage gain is maximum at resonant frequency and drops off above and below it. The higher the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

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.



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 the basic principle.

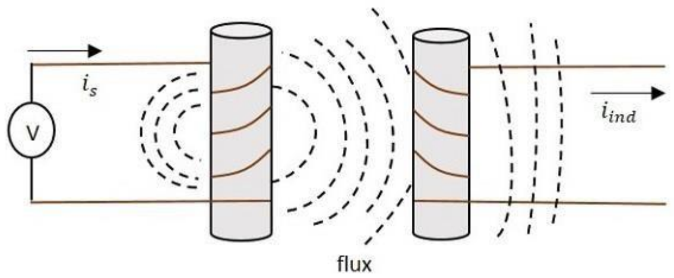
Mutual Inductance

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 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.

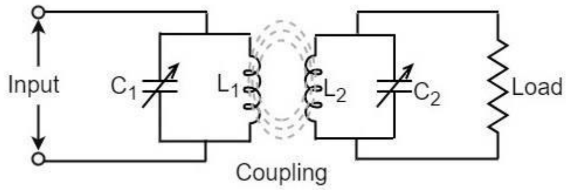
The figure below gives an idea about this.



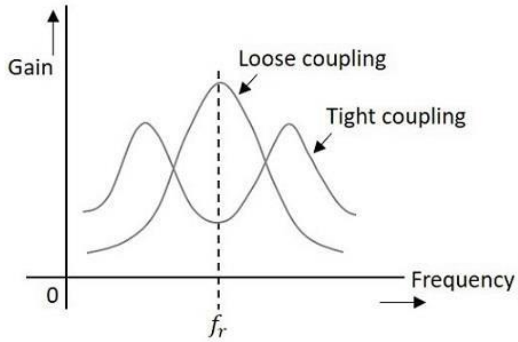
The current **i_s** in the figure indicate the source current while **i_{ind}** indicates the induced current. The flux represents the magnetic flux created around the coil. This spreads to the secondary coil also. With the application of voltage, the current **i_s** flows and flux gets created. When the current is varies the flux gets varied, producing **i_{ind}** in the secondary coil, due to the 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_1 will not link the secondary coil L_2. 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 resonance 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 bandwidth is given as

BWdt=kfr

Where BW_{dt} = bandwidth for double tuned circuit, K = coefficient of coupling, and f_r = resonant frequency.

stagger tuned amplifier:

Staggered tuned amplifier definition is an amplifier that is used to improve the total frequency response of the tuned amplifier. Usually, these amplifiers are designed to exhibit an overall response for maximal flatness in the region of the center frequency.

Staggered tuning is **a technique used in the design of multi-stage tuned amplifiers whereby each stage is tuned to a slightly different frequency**. In comparison to synchronous tuning (where each stage is tuned identically) it produces a wider bandwidth at the expense of reduced gain

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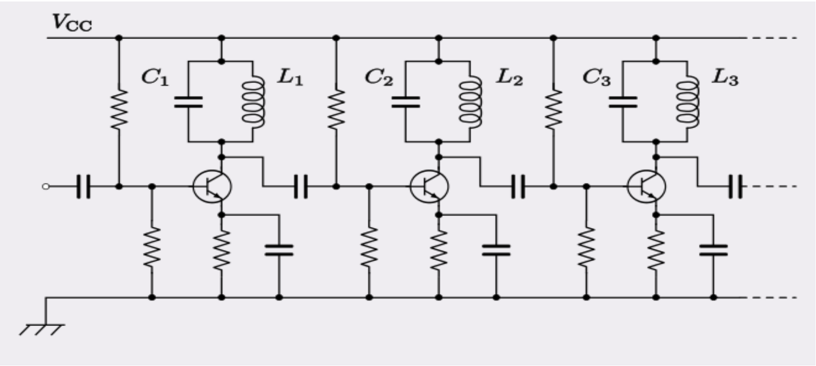
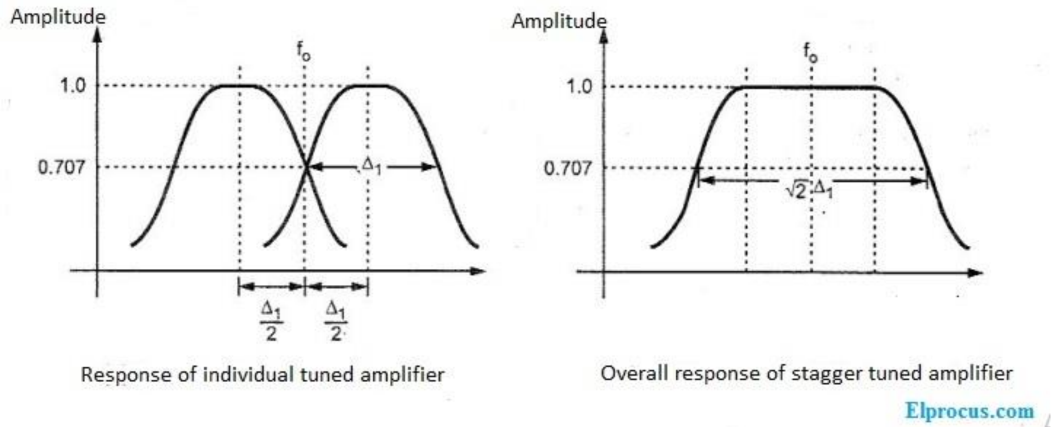
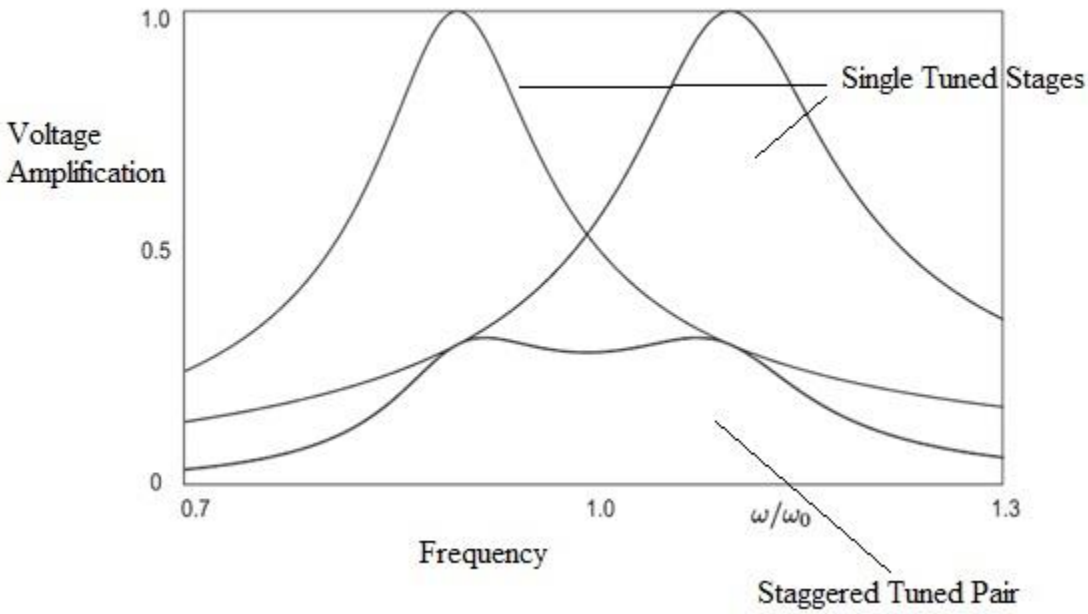


An amplifier that amplifies an exact frequency or narrow band frequency is known as a tuned amplifier. This amplifier is mostly used to amplify the frequencies of high otherwise radio. These amplifiers provide an extremely high-impedance at the resonant frequency as well as extremely minute impedance at all other frequencies. Tuned amplifiers are classified into three types namely single tuned, double-tuned and stagger tuned amplifier. The advantages of these amplifiers mainly include power loss is less; selectivity is high, less harmonic distortion, radar, TV, RF amplifiers, etc. This article discusses an overview of the stagger tuned amplifier and its applications.



The stagger tuned amplifier's total frequency response is contrasted with the equivalent and separate single tuned stages. These stages include similar resonant circuits. In the following characteristics, the staggering decrease in the total amplification of the middle frequency to 0.5 of the crest amplification of the separation stage. At middle frequency, every stage includes 0.707 crest amplification of the separation stage. Therefore, the corresponding voltage amplification for each stage of the stagger will be 0.707 times higher when the two similar stages are utilized without staggering.



But, the 3dB BW of the stagger pair is √2 times higher than the BW of an individual single tuned stage. Therefore the corresponding gain BW product for each stage of stagger tuned pair can be 0.707 x √2 is equal to 1.00 times with the separate single tuned stages.

The thought of stagger tuned can be simply expanded to additional stages. In 3-stage staggering, the tuning of the primary circuit can be adjusted to a lower frequency than the center frequency. The 3rd circuit can be adjusted to high frequency compared with middle frequency. The tuned frequency which is in middle is adjusted at the precise center frequency.

Advantages and Disadvantages

The stagger tuned amplifier advantages & disadvantages include the following.

- By using this amplifier an increased BW can be obtained. Compare with a single tune, the BW is √2 times.
- This amplifier has a high value of gain BW.
- In every stage of the amplifier, there is a small difference within the resonance. Therefore, enhanced stability within an operation can be obtained.
- The bandpass of this amplifier is faster compare with a single tuned amplifier. The alignment of this circuit is easy when we compare it with the single tuned amplifier.

Applications

The stagger tuned amplifier applications include the following.

- It is used in a superheterodyne receiver as an IF (intermediate frequency) amplifier
- It is used in UHF radio relay systems.
- It is extremely narrow-band intermediate frequency amplifier within a spectrum analyzer
- It is used like a wideband tuned amplifier intended for Y-amplifiers within oscilloscopes;
- It is used for video amplification like a wideband tuned amplifier.
- It is used like RF amplifiers within receivers.

Tuned RF amplifier:

A tuned radio frequency receiver (or TRF receiver) is a type of radio receiver that is composed of one **or** more tuned radio frequency (RF) amplifier stages followed by a detector (demodulator) circuit to extract the audio signal and usually an audio frequency amplifier.
It **possesses a good signal to noise ratio**. Tuned amplifiers provide variable bandwidth for signal amplification. As it provides radio wave transmission, hence used in radio transmitter and receiver.