TUNED AMPLIFIERS

- Amplifiers which amplify a specific frequency or narrow band of frequencies are called **tuned amplifiers.**
- Tuned amplifiers are mostly used for the amplification of high or radio frequencies.
- It offers a very high impedance at *resonant frequency* and very small impedance at all other frequencies.

Advantages of Tuned Amplifiers

1. Small power loss.
2. High selectivity
3. Smaller collector supply voltage
4. Used in RF amplifiers, Communication receivers, Radar , Television ,IF amplifiers
5. Harmonic distortion is very small

Why not Tuned Circuits for Low Frequency Amplification?

- *Low frequencies are never single*
- *High values of L and C.*

Classification

Tuned Amplifiers

Small Signal

* To amplify low RF signals
* Power output is low
* Operated in class A

Single tuned | Double tuned | Staggered tuned

Large Signal

* To amplify large RF signals
* Power output is more
* Operated in class B, class C or class AB modes.
* Pushpull configuration used to further reduce harmonic distortion.

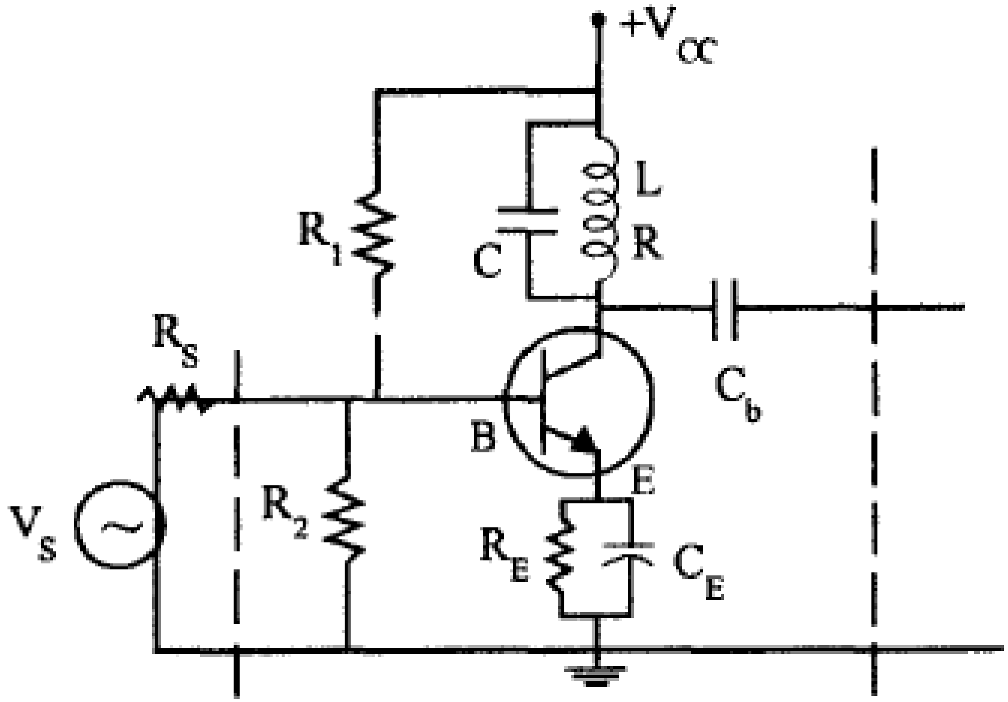
Single Tuned Amplifier

- Uses one parallel tuned circuit as the load IZI in each stage and all these tuned circuits in different stages are tuned to the same frequency. To get large Av or Ap, multistage amplifiers are used. But each stage is tuned to the same frequency, one tuned circuit in one stage.

Single tuned amplifiers are further classified as :

Capacitive coupled | Transformer coupled or inductive coupled

Single Tuned Capacitive Coupled Amplifier



Single tuned capacitive coupled amplifier:

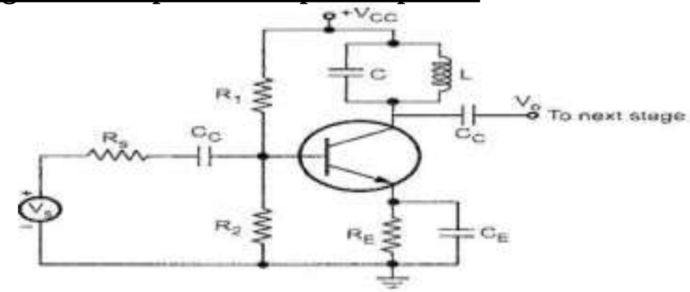


Fig. 3.13 Single tuned capacitive coupled transistor amplifier

Single tuned multistage amplifier circuit uses one parallel tuned circuit as a load in each stage with tuned circuits in all stages tuned to the same frequency. Fig. 3.13 shows a typical single tuned amplifier in CE configuration.

As shown in Fig. 3.13 tuned circuit formed by L and C acts as collector load and resonates at frequency of operation. Resistors R_1, R_2 and R_E along with capacitor C_E provides self bias for the circuit.

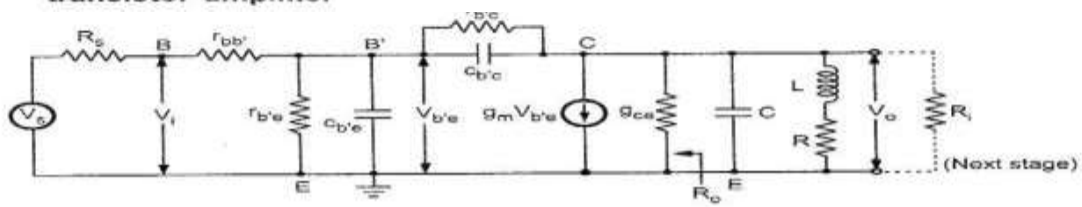


Fig. 3.14 Equivalent circuit of single tuned amplifier

The Fig. 3.14 shows the equivalent circuit for single tuned amplifier using hybrid π parameters.

As shown in the Fig. 3.14, R_i is the input resistance of the next stage and R_o is the output resistance of the current generator $g_m V_{b'e}$. The reactances of the bypass capacitor C_E and the coupling capacitors C_C are negligibly small at the operating frequency and hence these elements are neglected in the equivalent circuit shown in the Fig. 3.14.

The equivalent circuit shown in Fig. 3.14 can be simplified by applying Miller's theorem. Fig. 3.15 shows the simplified equivalent circuit for single tuned amplifier.

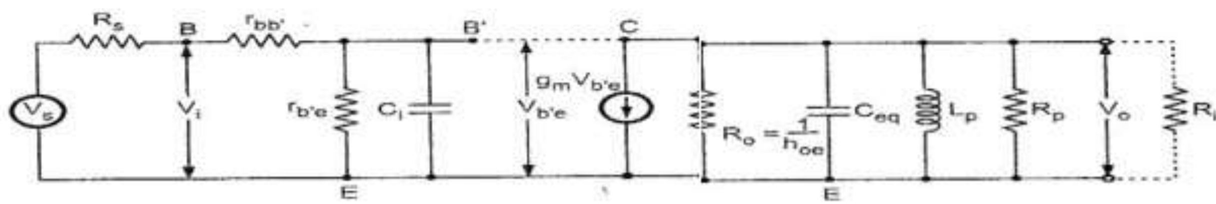


Fig. 3.15 Simplified equivalent circuit for single tuned amplifier

Here C_i and C_{eq} represent input and output circuit capacitances, respectively. They can be given as,

$$C_i = C_{b'e} + C_{b'c}(1 - A) \quad \text{where A is the voltage gain of the amplifier.} \quad \ldots(1)$$

$$C_{eq} = C_{b'c}\left(\frac{A-1}{A}\right) + C \quad \text{where C is the tuned circuit capacitance.} \quad \ldots(2)$$

The g_{ce} is represented as the output resistance of current generator $g_m V_{b'e}$.

$$g_{ce} = \frac{1}{r_{ce}} = h_{oe} - g_m h_{re} = h_{oe} = \frac{1}{R_o} \quad \ldots(3)$$

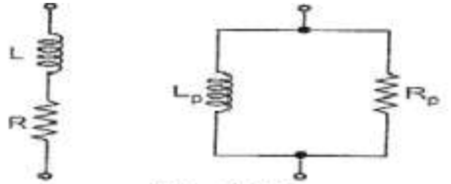


Fig. 3.16

The series RL circuit is represented by its equivalent parallel circuit. The conditions for equivalence are most easily established by equating the admittances of the two circuits shown in Fig. 3.16.

Admittance of the series combination of RL is given as,

$$Y = \frac{1}{R + j\omega L}$$

Multiplying numerator and denominator by $R - j\omega L$ we get,

$$Y = \frac{R - j\omega L}{R^2 + \omega^2 L^2} = \frac{R}{R^2 + \omega^2 L^2} - \frac{j\omega L}{R^2 + \omega^2 L^2}$$

$$= \frac{R}{R^2 + \omega^2 L^2} - \frac{j\omega^2 L}{\omega(R^2 + \omega^2 L^2)}$$

$$= \frac{1}{R_p} + \frac{1}{j\omega L_p}$$

where $$R_p = \frac{R^2 + \omega^2 L^2}{R} \quad \text{... (4)}$$

and $$L_p = \frac{R^2 + \omega^2 L^2}{\omega^2 L} \quad \text{... (5)}$$

Centre frequency

The centre frequency or resonant frequency is given as,

$$f_r = \frac{1}{2\pi\sqrt{L_p C_{eq}}} \quad \text{...(6)}$$

where $$L_p = \frac{R^2 + \omega^2 L^2}{\omega^2 L}$$

and $$C_{eq} = C_{b'e}\left(\frac{A-1}{A}\right) + C \quad \text{...(7)}$$

$$= C_o + C$$

Therefore, C_{eq} is the summation of transistor output capacitance and the tuned circuit capacitance.

Quality factor Q

The quality factor Q of the coil at resonance is given by,

$$Q_r = \frac{\omega_r L}{R} \quad \text{...(8)}$$

where ω_r is the centre frequency or resonant frequency.

This quality factor is also called unloaded Q. but in practice, transistor output resistance and input resistance of next stage act as a load for the tuned circuit. The quality factor including load is called as loaded Q and it can be given as follows:

The Q of the coil is usually large so that ωL >> R in the frequency range of operation.

From equation (4) we have,

$$R_p = \frac{R^2 + \omega^2 L^2}{R} = R + \frac{\omega^2 L^2}{R}$$

As $\frac{\omega^2 L^2}{R} >> 1$, $R_p = \frac{\omega^2 L^2}{R}$ ...(9)

From equation (5) we have,

$$L_p = \frac{R^2 + \omega^2 L^2}{\omega^2 L} = \frac{R^2}{\omega^2 L} + L$$

$$\approx L \qquad \because \omega L >> R \qquad \text{... (10)}$$

From equation (9), we can express R_p at resonance as,

$$R_p = \frac{\omega_r^2 L^2}{R}$$

$$= \omega_r Q_r L \qquad \because Q_r = \frac{\omega_r L}{R} \qquad \text{... (11)}$$

Therefore, Q_r can be expressed interms of R_p as,

$$Q_r = \frac{R_p}{\omega_r L} \qquad \text{...(12)}$$

The effective quality factor including load can be calculated looking at the simplified equivalent output circuit for single tuned amplifier.

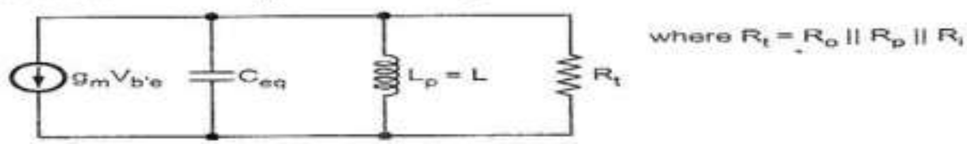


Fig. 3.17 Simplified output circuit for single tuned amplifier

$$\text{Effective quality factor } Q_{eff} = \frac{\text{Susceptance of inductance L or capacitance C}}{\text{Conductance of shunt resistance } R_t}$$

$$= \frac{R_t}{\omega_r L} \text{ or } \omega_r C_{eq} R_t \qquad \text{... (13)}$$