

In a transistorized Hartley oscillator, the two inductances are 2mH and $20\mu\text{H}$ while the frequency is to be changed from 950kHz to 2050kHz .

Calculate the range over which the capacitor is to be varied.

Sol:- Hartley oscillator,

$$L_1 = 2\text{mH}, \quad L_2 = 20\mu\text{H}$$

$$L_{\text{eq}} = L_1 + L_2 = 2\text{mH} + 20\mu\text{H} = \underline{2.02\text{mH}}$$

$$f_0 = \frac{1}{2\pi\sqrt{\text{leg } C}} \Rightarrow C = \frac{1}{4\pi^2 \text{leg } f_0^2}$$

a) When $f_0 = 950\text{kHz}$

$$C = \frac{1}{4\pi^2 \text{leg } f_0^2} = \frac{1}{4\pi^2 \times 2.02 \times 10^{-3} \times (950\text{K})^2}$$

$$\underline{C = 13.89\text{pf}}$$

b) When $f_0 = 2050\text{kHz}$

02

$$C = \frac{1}{4\pi^2 L_{eq} f_0^2} = \frac{1}{4\pi^2 \times 2.02 \times 10^{-3} \times (2050)^2}$$

$$\underline{C = 2.98 \text{ pF}}$$

∴ The range of capacitances is from
 2.98 pF to 13.89 pF

In a colpitt's oscillator, the values of the inductor $L_3 = 40\text{mH}$, $C_1 = 100\text{pf}$, $C_2 = 500\text{pf}$

1. Find the frequency of oscillations
2. If the opv voltage is 10V, find the feedback voltage.
3. Find the minimum gains if the frequency is changed by changing L_3 alone.
4. Find the value of C_1 for a gain of 10
5. Find the new oscillating frequency.

$$\underline{\text{Sol}}^n: \textcircled{1} \quad f_0 = \frac{1}{2\pi\sqrt{L_3 C_{eq}}}$$

$$C_{eq} = \frac{C_1 C_2}{C_1 + C_2} = 83.33\text{ pf}$$

$$f_0 = \frac{1}{2\pi\sqrt{40\text{mH} \times 83.33\text{ pf}}}$$

$$f_0 = 87.17\text{ KHz}$$

$$\textcircled{2} \quad \frac{V_{out}}{V_f} = \frac{X_{C_1}}{X_{C_2}} = \frac{\frac{1}{\omega C_1}}{\frac{1}{\omega C_2}} = \frac{C_2}{C_1}$$

$$V_f = V_{out} \times \frac{C_1}{C_2} = 10 \times \frac{100\text{pF}}{500\text{pF}} = 2\text{V}$$

\textcircled{3} \quad Av \rightarrow \text{Gain depends on } C_1 \text{ & } C_2 \text{ only & is independent of } L_3

$$\text{Gain} = Av = \frac{C_2}{C_1} = \frac{500\text{pF}}{100\text{pF}} = 5$$

$$\textcircled{4} \quad \frac{C_2}{C_1} = 10 \Rightarrow C_1 = 50\text{pF}$$

Now, $C_1 = 50\text{pF}$ and $C_2 = 500\text{pF}$

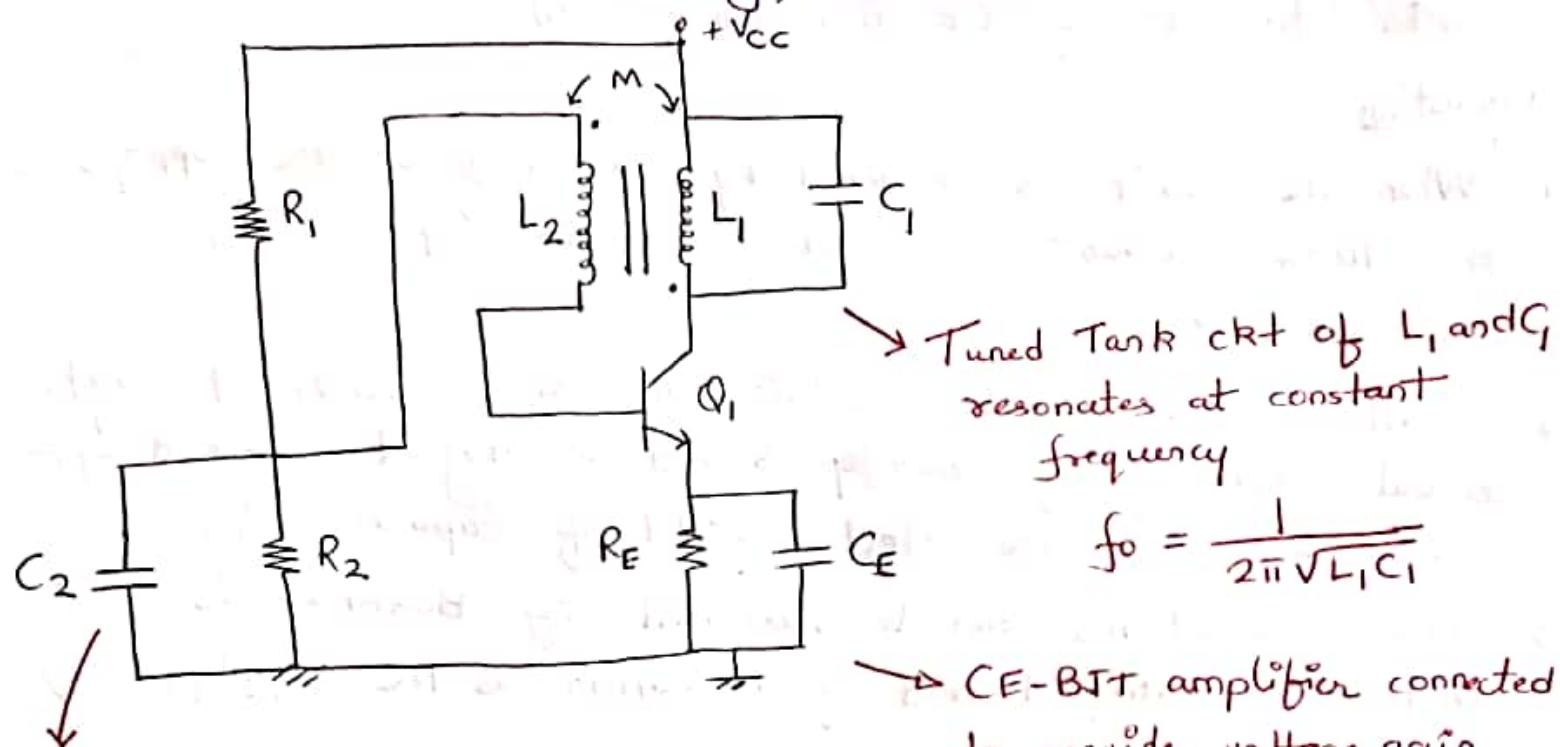
$$\textcircled{5} \quad f_0 = \frac{1}{2\pi\sqrt{L_3 C_{eq}}}$$

$$C_{eq} = \frac{C_1 C_2}{C_1 + C_2} = \frac{50 \times 500}{50 + 500} \text{ pF} = 45.45\text{pF}$$

$$f_0 = \frac{1}{2\pi\sqrt{40 \times 10^{-3} \times 45.45\text{pF}}}$$

$f_0 = 118.03 \text{ KHz}$

* Tuned - collector (Armstrong) oscillator:-



It provides ac ground for 2° winding (L_2)

- In this circuit, the collector drives an LC tank circuit.
- The feedback signal is taken from 2° winding (L_2) and feedback to the base.
- There is a phase-shift of 180° in the transformer and another 180° phase shift is provided by CE-BJT amplifier.
- This means that the total phase-shift around the loop is zero and hence the f_{lb} is +ve.
- The feedback fraction of the oscillator is given by

$$K = \frac{M}{L_1}$$

$M \rightarrow$ Mutual inductance between 1° and 2° windings

$L_1 \rightarrow$ Self-inductance of 1° winding

Note: To start the oscillations, the voltage gain must be greater than $(1/K)$, so that loop gain $|A \cdot K| \geq 1$.

• Armstrong oscillator uses a tank ckt (L_1 & C_1) connected at the collector terminal of CE BJT amplifier (Q_1).

Operation:

1. When the circuit is energized by switching on the supply, the collector current flows which charges capacitor C_1 in the tank circuit.
2. Oscillations are generated within the tank circuit through mutual exchange of energy stored in magnetic field of inductor L_1 and the electric field of capacitor C_1 .
3. These oscillations can be sustained if Barkhausen's criterion is satisfied and if a continuous DC supply ($+V_{cc}$) is given.
4. During startup, any internal noise signals present at the base of Q_1 are picked up and amplified causing the tuned tank ckt of L_1 and C_1 to resonate at a frequency (f_0).
5. The frequency of oscillations produced by the tank ckt is given by,

$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$

These oscillations induce some voltage in 2^o winding (L_2) by mutual inductance, i.e. they are inductive coupled back to base of amplifier, providing a +ve feedback path where the minimum required gain for starting oscillations is

$$|Av| = \frac{1}{K} = \frac{L_1}{M}$$

$$\text{Loop gain } |Av \cdot K| = 1$$

where M is the mutual inductance.

- Armstrong oscillators can work up to 50MHz and they are used in radio-receiver ckt's.

Advantages:-

- Compared to RC oscillator's, LC (Armstrong) oscillators can operate at very high frequencies (RF range).
- Frequency variation's in o/p waveform is extremely simple by changing tank ckt's capacitance C_1 .

Drawbacks:-

- The feedback network circuits contain transformer (with 1° winding L_1 and 2° winding L_2) which is large, bulky and expensive.

for a LC tank ckt \rightarrow Max Impedance is obtained at resonance.

Case ① Under non-resonance condition, impedance of LC tank ckt is low i.e [R_c low, A_v low, o/p low] o/p is damped oscillation's.

Case ②: If resonance occurs, impedance of LC tank ckt will be maximum, i.e [R_c high, A_v high, o/p high] \rightarrow sustained oscillation's produced at freqn f_o.

At resonance,

$$X_{L_1} = X_{C_1}$$

$$\omega L_1 = \frac{1}{\omega C_1}$$

$$\omega^2 = \frac{1}{L_1 C_1}$$

$$\omega = \frac{1}{\sqrt{L_1 C_1}}$$

$$\Rightarrow f_o = \frac{1}{2\pi\sqrt{L_1 C_1}}$$