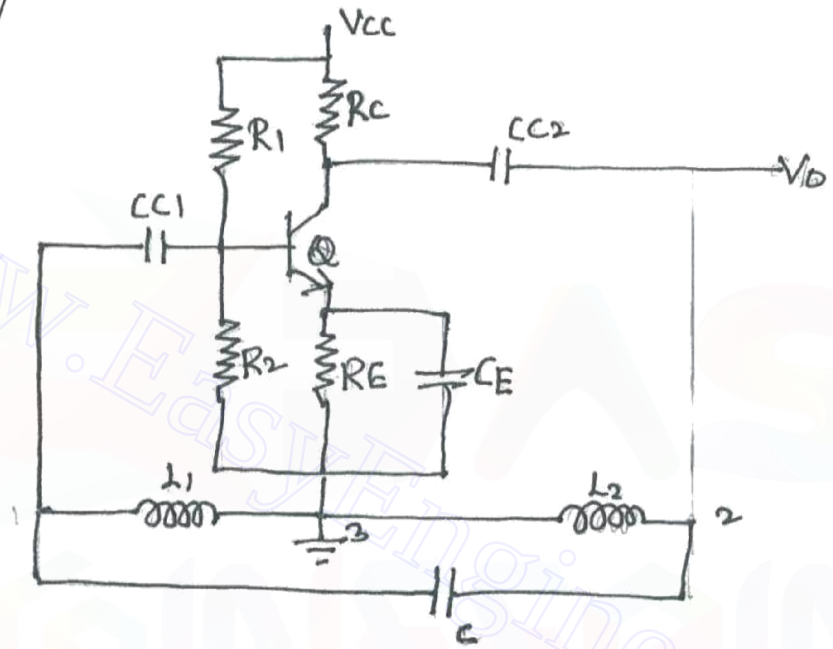
2) Explain the Hartley and Colpits Oscillator and derive its frequency of Oscillation

LC Oscillators:-

i) Hartley Oscillators:



→ It is an example of LC Oscillator Z_1, Z_2 are inductor and Z_3 is a Capacitor. Resistors R_1 & R_2 & R_E provide the necessary dc bias to the transistor the feedback network consisting of L_1, L_2 and C determines the frequency of Oscillation

→ C_E is the bypass capacitor, C_{C1} and C_{C2} are coupling capacitors.

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Operation :→ When the supply voltage +Vcc is switched ON, a transient current is produced in the tank circuit & consequent damped harmonic oscillation are set up in the circuit

→ The oscillatory circuit in the tank circuit produces ac voltage across L_1 and L_2. as terminal 3 is earthed at zero potential → If terminal 1 is at +ive potential with respect to 3 at any instant terminal 2 will be at a negative potential with respect to 3 at the same instant. Thus the phase difference between terminals 1 & 2 is always 180°.

→ In the CE mode, the transistor provides a phase shift of 180°. Thus the total phase shift of 360° is achieved that satisfies barkhausen criterion. Thus the frequency of oscillation is determined by the tank consisting of L_1, C_2 & C. The frequency of Oscillation is given as $f = \frac{1}{2\pi\sqrt{L_{eq}}}$

Where $L_{eq} = L_1 + L_2 + 2M$

$M \rightarrow$ mutual inductance L_1 & L_2

The condition for sustained Oscillation is $h_{fe} \geq \frac{L_1+M}{L_2+M}$

Analysis :-

In this Oscillator Z_1 & Z_2 are inductive reactances & Z_3 is capacitance reactance

$$Z_1 = j\omega L_1 + j\omega M, \quad Z_2 = j\omega L_2 + j\omega M$$

$$Z_2 = \frac{1}{j\omega C} = -\frac{j}{\omega C}$$

Substituting for Z_1 & Z_2 and Z_3 in general eqn

$$(Z_1 + Z_2 + Z_3)h_{ie} + Z_1 Z_3 + Z_1 Z_2(1+h_{fe}) = 0 \rightarrow (1)$$

$$\left[(j\omega L_1 + j\omega L_2 + j\omega M + j\omega M - \frac{j}{\omega C}\right]h_{ie} + \left[(j\omega L_1 + j\omega M) \times -\frac{j}{\omega C}\right]$$
$$+ (j\omega L_1 + j\omega M)(j\omega L_2 + j\omega M)(1 + h_{fe}) = 0 \rightarrow (2)$$

$$\left[j\omega[L_1 + L_2] + 2M - \frac{1}{\omega^2 C}\right]h_{ie} + \left[j^2\omega(L_1+M)\left(\frac{1}{\omega C}\right)\right]$$
$$+ \left[j^2\omega^2(L_1+M)(L_2+M)(1+h_{fe})\right] = 0$$

$$j\omega h_{ie}\left[(L_1 + L_2 + 2M) - \frac{1}{\omega^2 C}\right] + j^2\omega\left[(L_1 + M)\left(-\frac{1}{\omega C}\right) - \omega^3(1+h_{fe})\right.$$
$$\left.(L_1L_2 + L_1M + L_2M + M^2)\right] = 0$$

Multiplying and dividing by ω throughout

$$j\omega h_{ie}\left[(L_1 + L_2 + 2M) - \frac{1}{\omega^2 C}\right] - \omega^2(1+h_{fe})(L_1+M)(L_2+M)$$
$$- \frac{j^2\omega^2 L_1 - j^2\omega^2 M}{C\omega^2} = 0$$

$$j\omega h_{ie}\left[(L_1 + L_2 + 2M) - \frac{1}{\omega^2 C}\right] - \omega^2(L_1+M)\left[(L_2+M)(1+h_{fe}) - \frac{1}{\omega^2 C}\right] = 0 \rightarrow (3)$$

Equating imaginary part eqn (3) to zero

$$L_1 + L_2 + 2M - \frac{1}{\omega^2 C} = 0 \rightarrow (4) \quad \left[\because \omega \neq 0 \ \& \ h_{ie} \neq 0\right.$$

$$\frac{1}{\omega^2 C} = L_1 + L_2 + 2M \qquad \omega = \frac{1}{\sqrt{(L_1 + L_2 + 2M)C}} \rightarrow (5)$$

$$f = \frac{1}{2\pi\sqrt{(L_1 + L_2 + 2M)C}} \rightarrow (6)$$

$$f = \frac{1}{2\pi\sqrt{L_{eq}C}} \rightarrow (7) \quad \text{where } L_{eq} = L_1 + L_2 + 2M$$

The condition for sustained oscillation is obtained by equating the real part of eqn(3) to zero.

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$$\omega^2(L_1+M)\left[(L_2+M)(1+h_{fe})-\frac{1}{\omega^2 C}\right]=0$$

$\because$ $\omega^2 \neq 0$, $L_1+M \neq 0$, we get

$(L_2+M)(1+h_{fe}) - 1/\omega^2 C = 0$, substituting for ω^2 from eqn ①

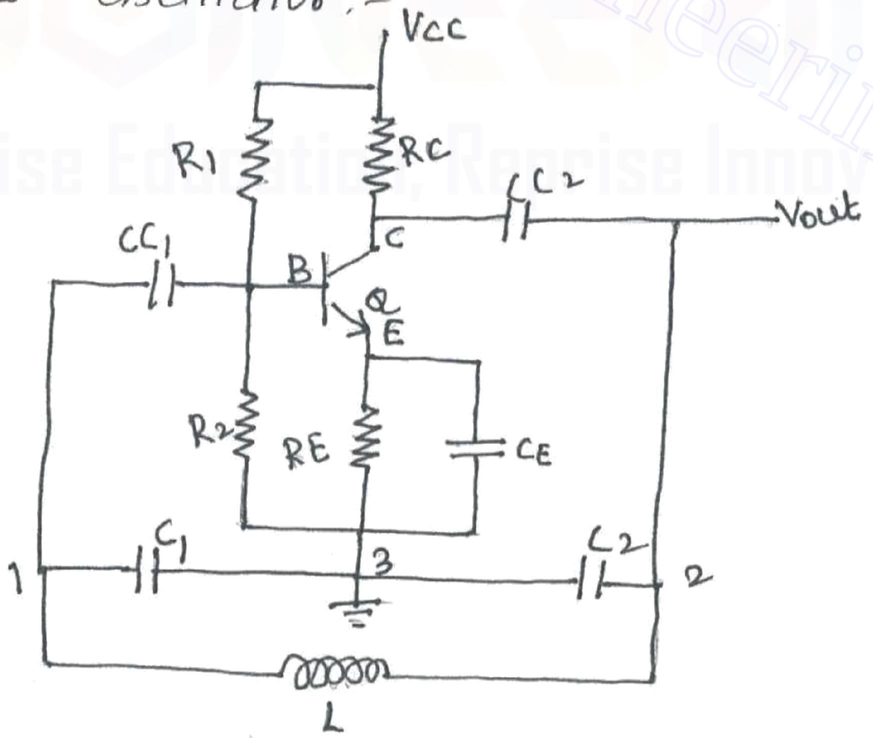
$$(L_2+M)(1+h_{fe}) - \frac{(L_1+L_2+2M)C}{C} = 0 \Rightarrow L_2 + L_2 h_{fe} + M + M h_{fe} - L_1 - L_2 - 2M = 0$$

$h_{fe}(L_2+M) - M - L_1 = 0$ $\therefore$ $h_{fe}(L_2+M) = L_1+M$

$$h_{fe} = \frac{L_1+M}{L_2+M}$$

It is the condition for sustained Oscillation.

Colpitts Oscillator:-



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