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

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

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

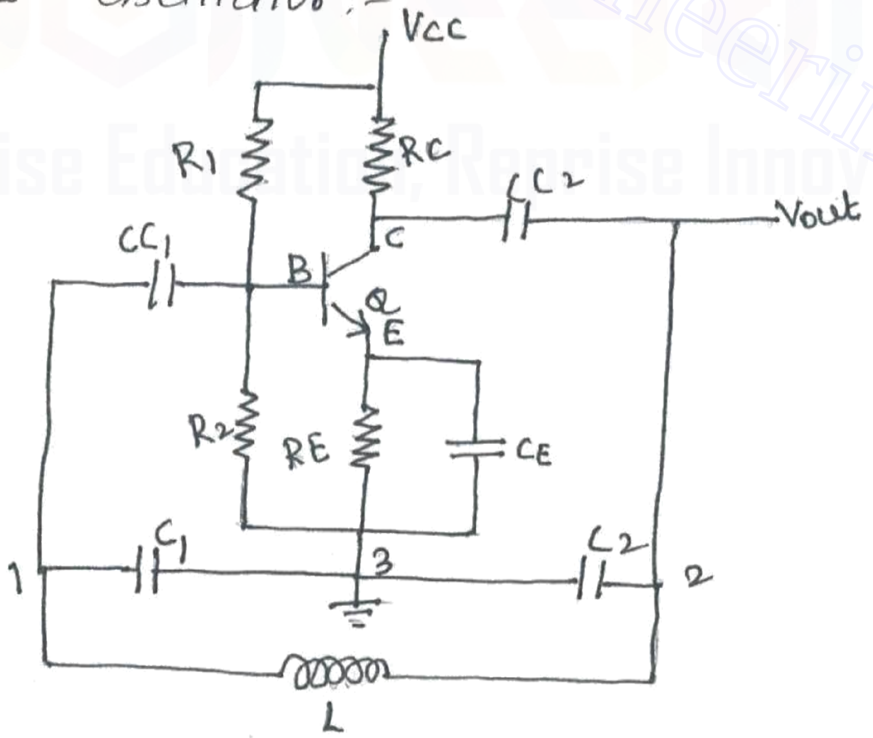
$$(L_2+M)(1+h_{fe}) - \frac{(L_1+L_2+2M)C}{C} = 0 \Rightarrow L_2 + L_2 h_{fe} + M + M h_{fe} - L_1 - L_2 - 2M = 0$$

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

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

It is the condition for sustained Oscillation.

Colpitts Oscillator:-



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→ In colpits Z_1 & Z_2 are the capacitors and Z_3 is an inductor. The resistors R_1, R_2 and R_E provides the necessary dc bias to the transistor. The bypass capacitor is C_E. The coupling capacitors are C_{C1} & C_{C2}. The feedback network consisting of C_1, C_2 & L determines the frequency of oscillator. Operation is similar to the Hartley oscillator.

$$f = \frac{1}{2\pi\sqrt{LC_{eq}}} \quad \text{where } C_{eq} = \frac{C_1 C_2}{C_1 + C_2}$$

Application:-

1) It is used for commercial signal generators for freq 1M to 800 MHz

2) It is used as local oscillator in super heterodyne radio receiver.

Analysis:-

$$Z_1 = \frac{1}{j\omega C_1} = \frac{-j}{\omega C_1}, \quad Z_2 = \frac{1}{j\omega C_2} = \frac{-j}{\omega C_2}$$

$$Z_3 = j\omega L$$

General form: $(Z_1 + Z_2 + Z_3)h_{ie} + Z_1 Z_2 (1 + h_{fe}) + Z_1 Z_3 = 0$

Substituting Z_1, Z_2 & Z_3 in above eqn

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$$h_{ie}\left[\frac{-j}{\omega C_1}-\frac{j}{\omega C_2}+j\omega L\right]+\left(\frac{-j}{\omega C_1}\right)\left(\frac{-j}{\omega C_2}\right)(1+h_{fe})+\left(\frac{-j}{\omega C_1}\right)(j\omega L)=0$$

$$h_{ie}\,j\left[\omega L-1/\omega C_1-1/\omega C_2\right]-\frac{(1+h_{fe})}{\omega^2 C_1 C_2}+\frac{\omega L}{\omega C_1}=0$$

$$j h_{ie}\left[\omega L-1/\omega C_1-1/\omega C_2\right]+\left[\frac{L}{C_1}-\frac{(1+h_{fe})}{\omega^2 C_1 C_2}\right]=0 \rightarrow (2)$$

Equating the imaginary part of eqn to zero

$$\omega L-1/\omega C_1-1/\omega C_2=0 \rightarrow (3)$$

$$\omega L=1/\omega C_1+1/\omega C_2,\quad \omega L=1/\omega\left[1/C_1+1/C_2\right]$$

$$\omega^2=\frac{1}{L}\left[\frac{C_1+C_2}{C_1 C_2}\right] \rightarrow (4)$$

$$\omega=\sqrt{\frac{C_1+C_2}{L C_1 C_2}} \rightarrow (5)$$

$$f=\frac{1}{2\pi}\sqrt{\frac{C_1+C_2}{L C_1+C_2}}$$

$$f=\frac{1}{2\pi\sqrt{L C_{eq}}} \rightarrow (6)$$

Where $C_{eq}=\dfrac{C_1 C_2}{C_1+C_2} \rightarrow (7)$

The condition for sustained oscillation is

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Obtained by equating the real part of eqn(2) to zero

$$\frac{L}{C_1} - \frac{(1+h_{fe})}{\omega^2 C_1 C_2} = 0 \rightarrow (8)$$

$$\frac{L}{C_1} = \frac{(1+h_{fe})}{\omega^2 C_1 C_2}$$

$$L = \frac{(1+h_{fe})}{\omega^2 c^2}$$

Substituting for ω^2 from eqn (4)

$$L = \frac{(1+h_{fe}) L C_1 C_2}{C_2 (C_1 + C_2)}$$

$$L = \frac{(1+h_{fe}) L C_1}{C_1 + C_2}$$

$$= C_1 C_2 = (1+h_{fe}) C_1$$

$$C_1 \left[1 + \frac{C_2}{C_1}\right] = (1+h_{fe}) C_1$$

$$h_{fe} = \frac{C_2}{C_1} \rightarrow (9)$$

This is the condition for sustained oscillation.

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