05/07/11

## To Find the type of Sampling Network

1. By Shorting the output $V_o = 0$, if feedback signal $x_f \to 0$, then we can say that it is voltage sampling.
2. By opening the output loop $i_o = 0$. If feedback signal $x_f$ become zero then we can say that it is current sampling.

## 3. To find the type of mixing network

3) If the feedback signal is subtracted from the externally applied signal as a voltage in the input loop, we can say that it is series mixing.

4) If the feedback signal is subtracted from the externally applied signal as a current in the input loop, we can say that it is shunt mixing.

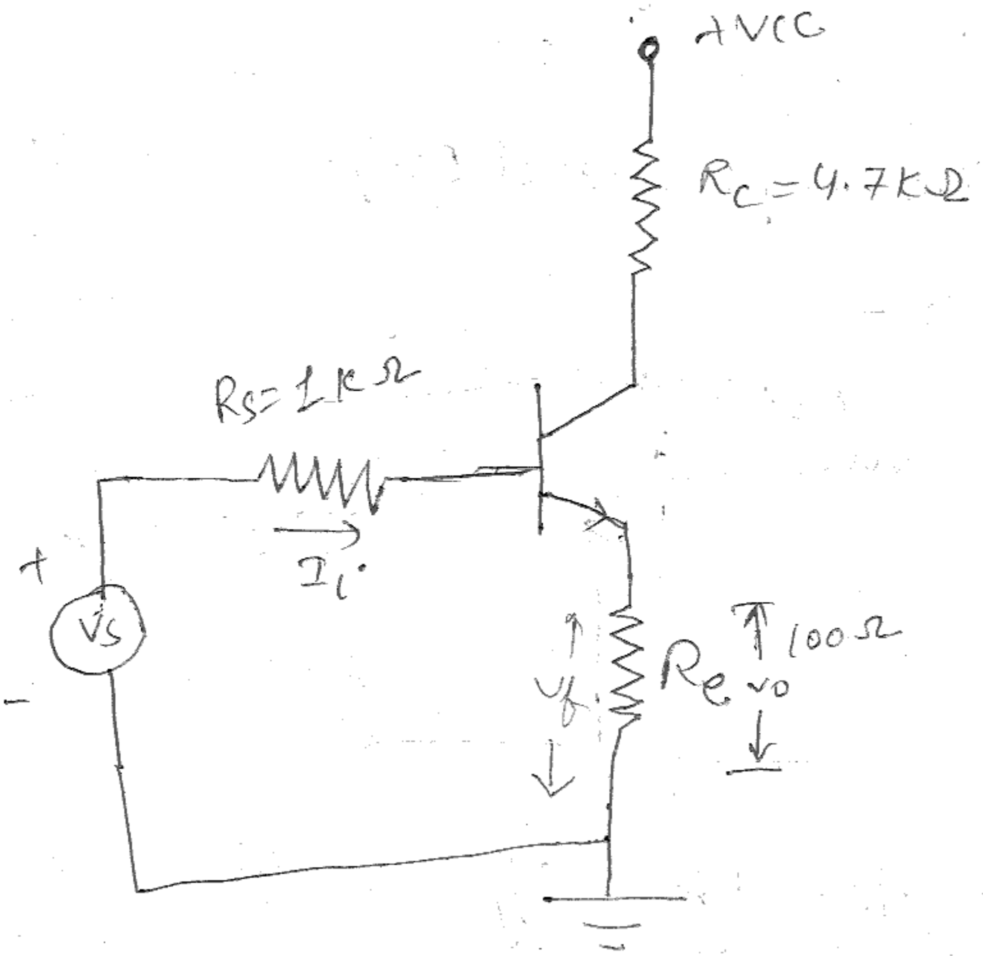
5) Replace each active device by its h parameter model at low frequency.

6. Find the open loop gain (gain without feedback).
A of the Amplifier

7. Indicate $x_f$ and $x_o$ on the circuit and Evaluate $\beta = \frac{x_f}{x_o}$.

8. From A and $\beta$ find D (Desensitivity)
$A_f$, $R_{if}$, $R_{of}$ and $R'_{of}$ (taking $R_c$ into account)

Ex <u>voltage series feedback</u> (for analy



1. Identify topology

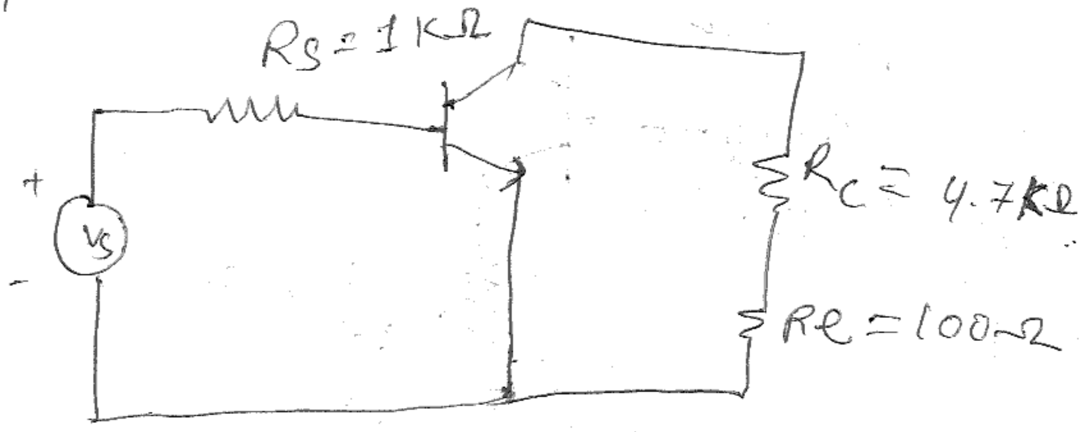
By shorting O/P voltage $V_o = 0$, feedback signal becomes zero and hence it is voltage sampling.

looking at figure (writing KVL) the feedback signal $V_f$ is subtracted from the externally applied signal $V_s$ and hence it is series mixing.

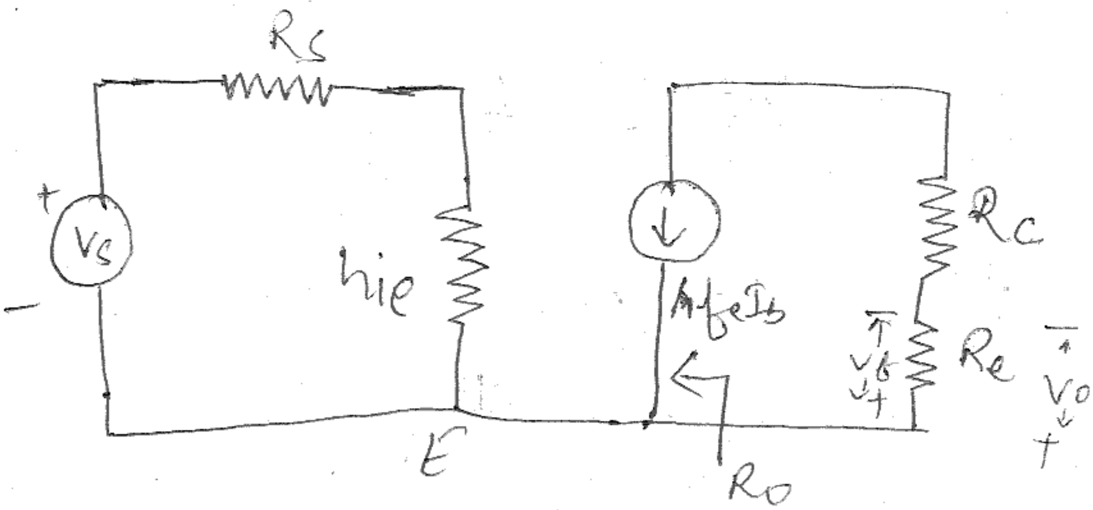
Combining two conditions, we can say that it is voltage series feedback amplifier.

2. Find the input and output circuit

I/P ckt




3. Replace transistor by h parameter equivalent circuit.




## Open loop Gain :-

$$A_v = \frac{V_o}{V_s} = \frac{h_{fe} I_b R_e}{V_s}$$

$$V_s = I_b R_s + I_b h_{ie}$$

$$A_v = \frac{h_{fe} \cancel{I_b} R_e}{\cancel{I_b}(R_s + h_{ie})}$$

$$\boxed{A_v = \frac{h_{fe} R_e}{R_s + h_{ie}}}$$

$h_{fe} = 50 \quad R_e = 100$

$R_s = 1k\Omega \quad h_{ie} = 1.1K$

$$A_v = \frac{50 \times 100}{1 + 1.1} = 2.38$$

$$\beta = \frac{V_f}{V_o} = 1$$

$$D = 1 + A\beta$$
$$= 1 + (2.38) \cdot 1$$
$$= 3.38$$

$$A_{vf} = \frac{A}{1 + A\beta} = \frac{2.38}{3.38} = 0.7$$

$$R_i = R_s + h_{ie} = 1K + 1.1K = 2.1K$$

$$R_{if} = R_i D = (2.1K)(3.38)$$
$$= 7.098K$$

$$R_o = \alpha, \; R_{of} = \alpha, \; R'_{of} = \frac{R'_o}{D} \quad R'_o = R_e$$

$$R'_{of} = \frac{R_e}{D} = \frac{100}{3.38}$$
$$= 29.58\,\Omega$$

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# UNIT- II

## OSCILATORS

### Barkhausen criteria :-

The frequency at which a Sinusoidal Oscillator will operate is the frequency for which total shift introduced as a Signal proceeds from the input terminals, through the amplifier and feedback N/W and ~~the~~ again to the input is Precisely zero.
of course an intergoal multiple of $2\pi$.

Stated more precisely the frequency of a Sinusoidal oscillator is determined by the condition that the loop gain phase Shift is zero.

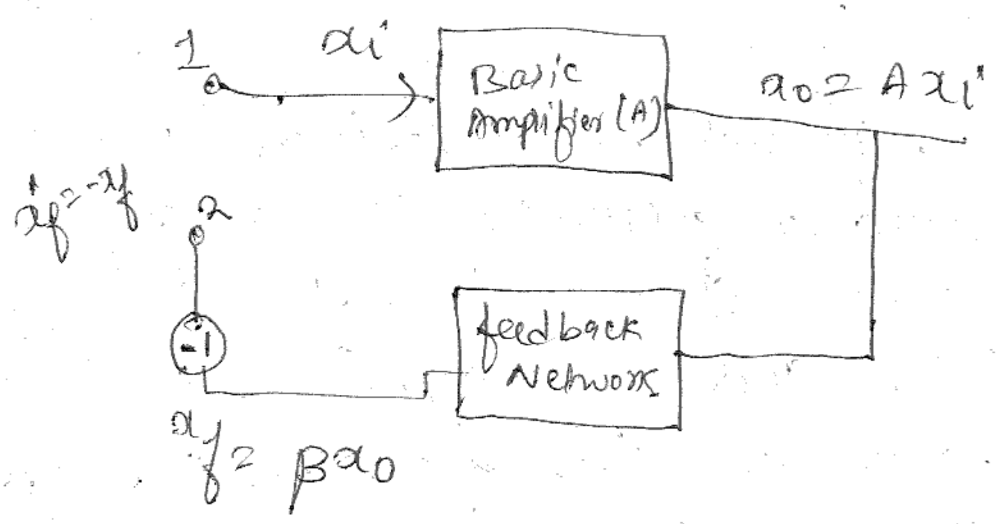
Oscillations will not be Sustained if at the oscillator frequency, the magnitude of the product of the transfer gain of the amplifier and the magnitude of the feedback factor of the feedback N/W (The magnitude of the loop gain) are less than unity.

The condition of unity loop gain $-A\beta = 1$ is called a Barkhausen Criteria. This condition implies of course more than magnitude of $|A\beta| = 1$ and that the phase of $-A\beta$ is zero.

The above principles are consistent with the feed back formula

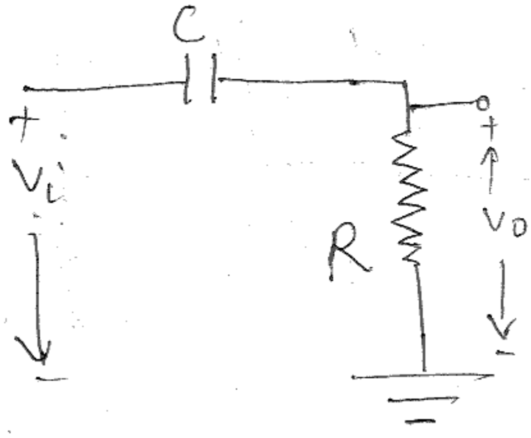
$$A_f = \frac{A}{1 + A\beta} \quad \text{for if } -A\beta = 1$$

then $A_f \rightarrow \infty$ which may be interpreted to mean that there exist an output voltage even to the absence of an Externally applied signal voltage.




Oscillator

# RC PHASE SHIFT OSCILLATOR :-




$Z = R - \frac{j}{\omega C}$

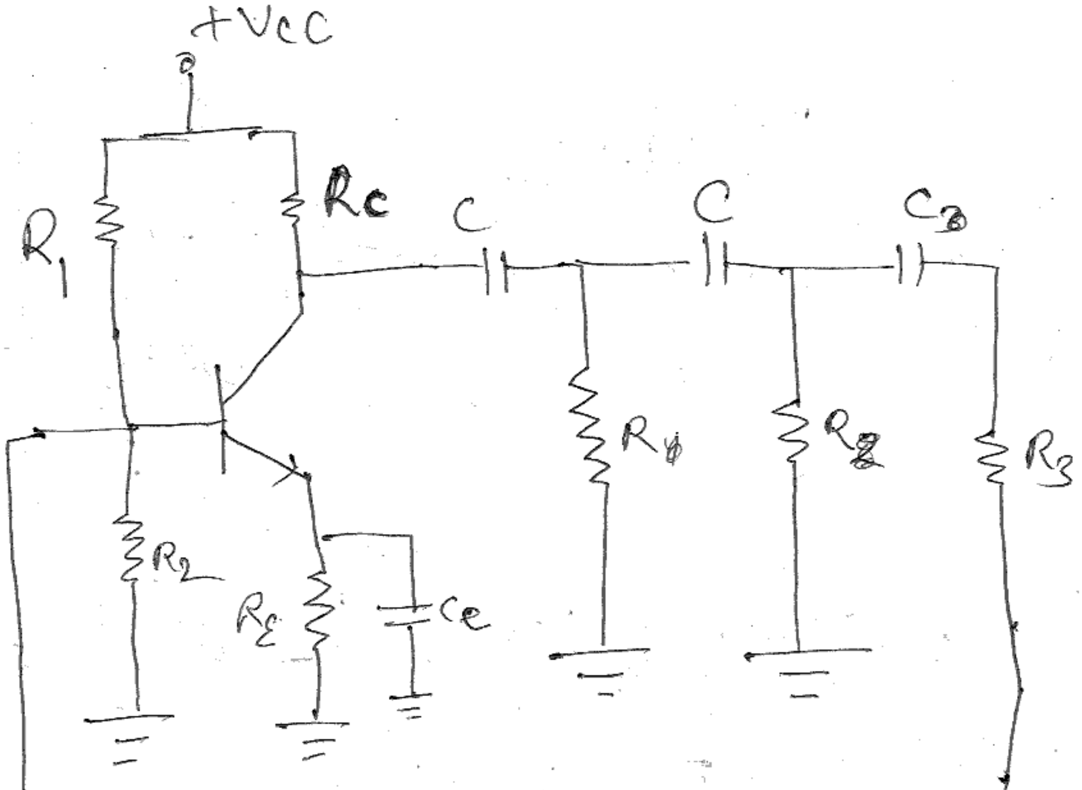
$X_C = Z \angle -\phi$

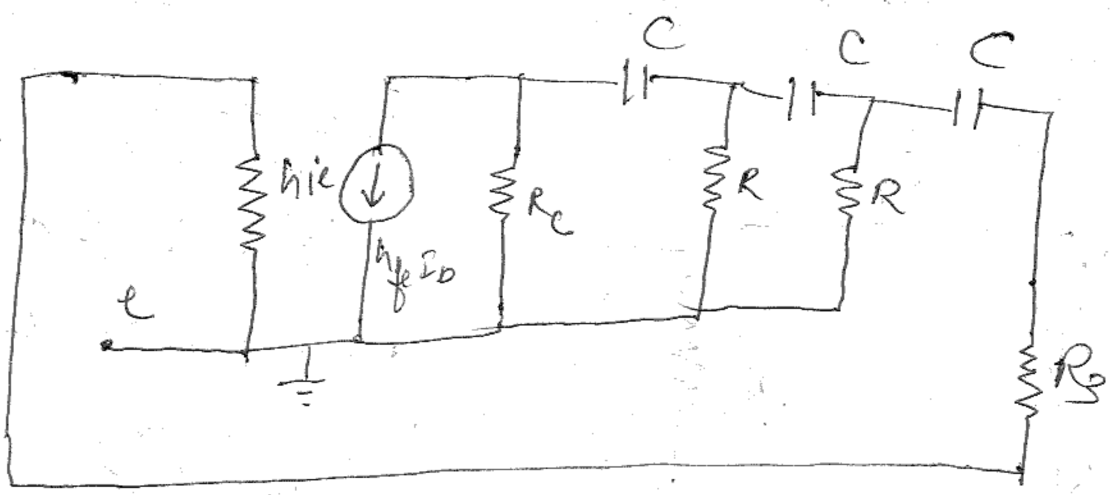
$v_i = V_m \sin \omega t$

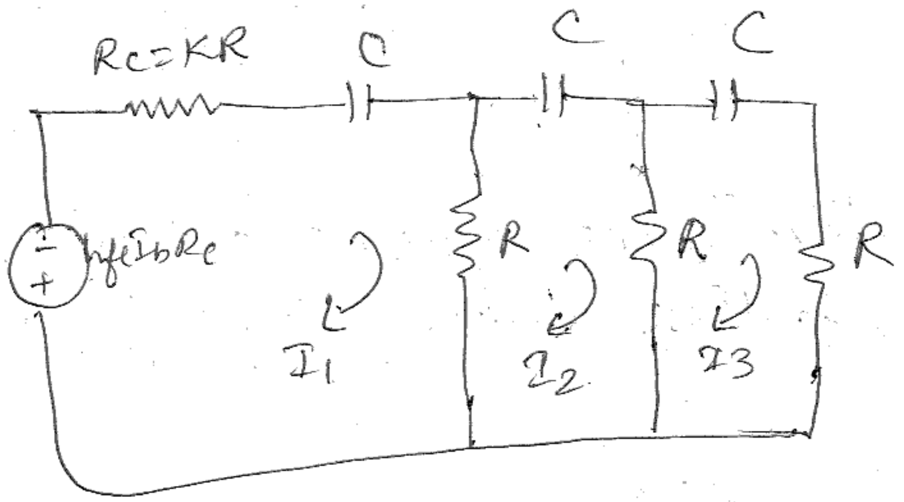
$I = \frac{V_m/\sqrt{2}}{|Z| \angle -\phi}$

$I = |I| \angle +\phi$

The positive phase angle $+\phi$ indicates that the current leads applied voltage by angle $\phi$






$$D = \begin{bmatrix} (K+1)R + \frac{1}{SC} & -R & 0 \\ -R & 2R+\frac{1}{SC} & -R \\ 0 & -R & 2R+\frac{1}{SC} \end{bmatrix}$$

$$\Delta = (K+1)R+\frac{1}{SC}\left[\left(2R+\frac{1}{SC}\right)^2 - R^2\right] +$$

$$R\left[-R\left(2R+\frac{1}{SC}\right)+0\right]$$

$$\Delta = \left[(K+1)R + \frac{1}{SC}\right]\left[4R^2 + \frac{1}{S^2C^2} + \frac{4R}{SC} - R^2\right]$$

$$+ \left[-2R^3 - \frac{R^2}{SC}\right]$$

$$= \left\{\frac{(K+1)RSC + 1}{SC}\right\}\left\{\frac{4R^2S^2C^2 + 1 + 4RSC - R^2S^2C^2}{S^2C^2}\right\}$$

$$- \left[\frac{2R^3SC + R^2}{SC}\right]$$

$$= \left\{\frac{KSRC + RSC + 1}{SC}\right\}\left\{\frac{3R^2S^2C^2 + 4RSC + 1}{S^2C^2}\right\} - \left\{\frac{2R^3SC + R^2}{SC}\right\}$$

$$= \frac{\left[3KS^3R^3C^3 + 4KS^2R^2C^2 + KSRC + 3R^3S^3C^3 + 4R^2S^2C^2 + RSC + 3R^2S^2C^2 + 4RSC + 1\right]}{S^3C^3} - \frac{2R^3SC + R^2}{SC}$$

$$= \frac{3R^3S^3C^3(K+1) + S^2R^2C^2(4K+7) + SRC(K+4) + 1 - (2R^3S^3C^3 + R^2S^2C^2)}{S^3C^3}$$

$$= \frac{3R^3S^3C^3(K+1) - 2R^3S^3C^3 + S^2R^2C^2(4K+7) - R^2S^2C^2 + SRC(K+5) + 1}{S^3C^3}$$

$$= 1 + R^3 S^3 C^3 (3K+1) + S^2R^2C^2 (4K+6) + SRC(K+5)$$
$$\overline{\quad S^3 C^3 \quad}$$

$$\Delta I_3 = \begin{bmatrix} (K+1)R + \frac{1}{SC} & -R & -h_{fe} I_b K R \\ -R & 2R + \frac{1}{SC} & 0 \\ 0 & -R & 0 \end{bmatrix}$$

$$= \left[(K+1)R + \frac{1}{SC}\right][0] + R[0] - h_{fe} I_b K R \, (R^2 - 0)$$

$$\Delta I_3 = -h_{fe} I_b K R^3$$

$$I_3 = \frac{\Delta I_3}{\Delta} = \frac{-h_{fe} I_b K R^3 S^3 C^3}{(3K+1) R^3 S^3 C^3 + (4K+6) S^2 R^2 C^2 + (K+5) SRC + 1}$$

$I_3$ = output current of the feedback circuit

$I_b$ = Input current of the amplifier

$I_c = h_{fe} I_b$ = input current of the feedback circuit.

$$\beta = \frac{\text{output of feedback ckt}}{\text{Input of feedback ckt}}$$

$$= \frac{I_3}{h_{fe} I_b}$$

$$A = \frac{\text{Output of Amplifier circuit}}{\text{Input to amplifier ckt}}$$

$$= \frac{h_{fe} I_b}{I_b} = h_{fe}$$

$$A\beta = \frac{\cancel{h_{fe}} I_3}{\cancel{h_{fe}} I_b} = \frac{I_3}{I_b}$$

$$A\beta = \frac{I_3}{I_b} = \frac{-h_{fe} K R^3 s^3 C^3}{(3K+1) R^3 C^3 s^3 + (4K+6) R^2 s^2 C^2 + (K+5) sRC + 1}$$

Sub $s = j\omega$, $s^2 = (j\omega)^2 = j^2\omega^2 = -\omega^2$

$s^3 = (j\omega)^3 = j^2 \cdot j\omega^3$
$= -j\omega^3$

$$A\beta = \frac{I_3}{I_b} = \frac{-h_{fe}\cdot KR^3(-j\omega^3)C^3}{(3K+1)R^3C^3(-j\omega^3) + (4K+6)R^2(-\omega^2)C^2 + (K+5)(j\omega)RC + 1}$$

$$= \frac{+h_{fe}\, jKR^3C^3\omega^3}{-j(3K+1)R^3C^3\omega^3 - (4K+6)R^2\omega^2C^2 + j(K+5)\omega RC + 1}$$

$$= \frac{h_{fe}\, jKR^3C^3\omega^3}{\left[1-(\omega^2C^2R^2)(4K+6)\right] + j\left(\omega RCK + j\omega RC - 3K\omega^3 R^3 - \omega^3C^3R^3\right)}$$

$$A\beta = \frac{h_{fe}\, jKR^3C^3\omega^3}{\left[1-4K\omega^2C^2R^2 - 6\omega^2C^2R^2\right] + j\left[\omega RCK + j\omega RC - 3K\omega^3C^3R^3 - \omega^3C^3R^3\right]}$$

$$A\beta = \frac{h_{fe}\, jKR^3C^3\omega^3}{\left[1-4K\omega^2C^2R^2 - 6\omega^2C^2R^2\right] + j\omega\left[RCK + 5RC - 3K\omega^2C^3R^3 - \omega^2C^3R^3\right]}$$

Dividing Numerator and denominator by $j\omega^3R^3C^3$

$$A\beta = \frac{Kh_{fe}}{\left\{\dfrac{1-4K\omega^2C^2R^2 - 6\omega^2C^2R^2}{-j\,\omega^3R^3C^3}\right\} - \dfrac{\left\{(j\omega)(3K\omega^2R^3C^3 + \omega^2R^3C^3 - 5RC - KRC\right\}}{-j\omega^3R^3C^3}}$$

At resonating frequency

$$\beta = \frac{\omega^2 RC\,[3RC]}{[1-\omega^2R^2C^2]^2 + \omega^2\,[3RC]^2}$$

$$\omega^2 = \frac{1}{R^2C^2}$$

$$\beta = \frac{\dfrac{3}{\cancel{R^2C^2}}\,\cancel{R^2C^2}}{\left[1-\dfrac{1}{\cancel{R^2C^2}}\cdot\cancel{R^2C^2}\right]^2 + \dfrac{1}{R^2C^2}\times 9R^2C^2}$$

$$= \frac{3}{9} = \frac{1}{3}$$

$$\beta = \frac{1}{3}$$

$$|A\beta| \geq 1$$

$$A \geq \frac{1}{\beta} \Rightarrow A \geq \frac{1}{1/3} \Rightarrow A \geq 3$$

$$\boxed{A \geq 3}$$

Suppose $R_1 \neq R_2$ ; $C_1 \neq C_2$

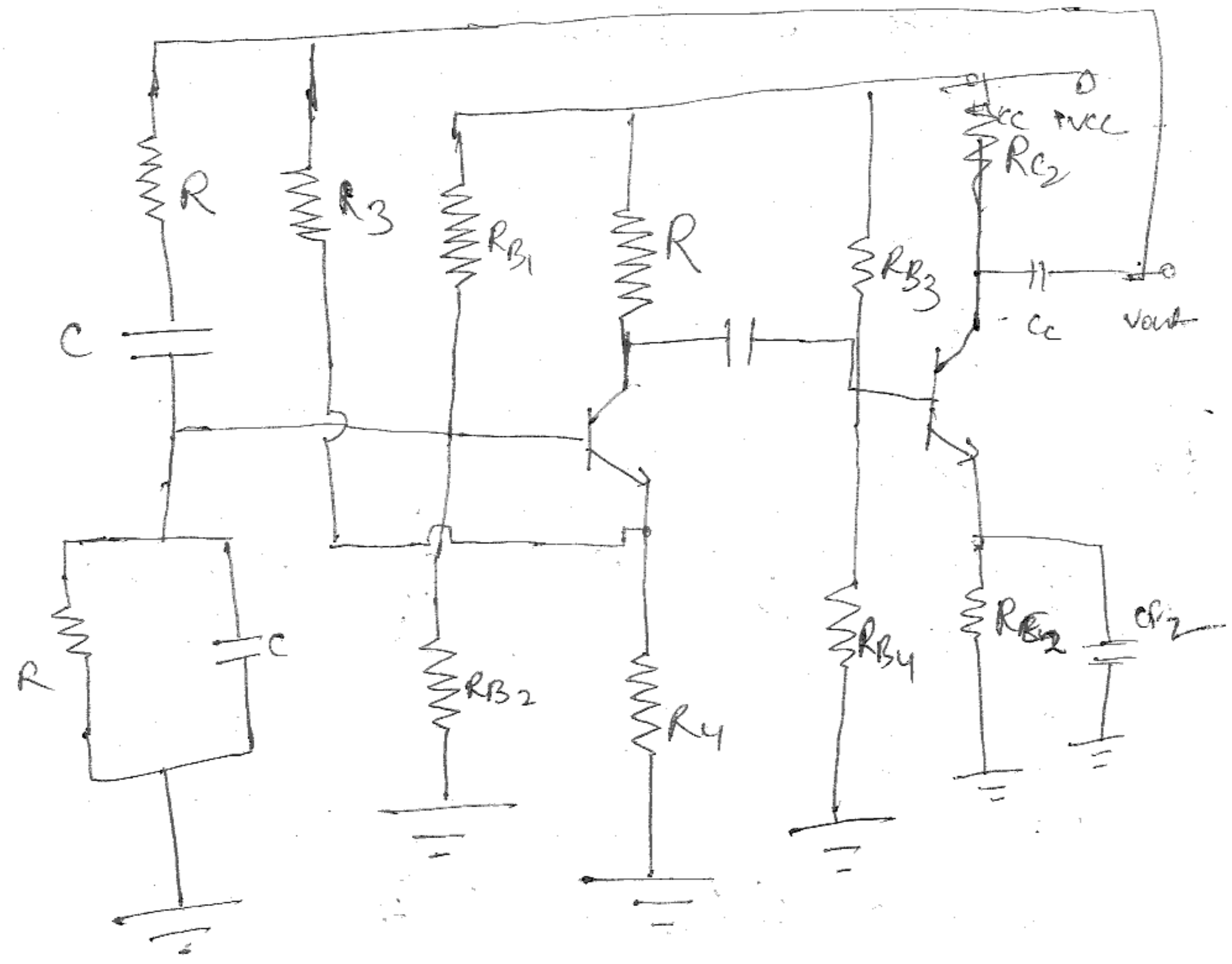
$$f = \frac{1}{2\pi\sqrt{R_1R_2C_1C_2}}$$

$$\beta = \frac{C_1 R_2}{R_1 C_1 + R_2 C_2 + C_1 R_2}$$

$$A\beta \geq 1$$

$$A \geq \frac{R_1 C_1 + R_2 C_2 + C_1 R_2}{C_1 R_2}$$

x



In this circuit two stage common Emitter transistor amplifier is used. Each stage contributes $180^\circ$ phase shift hence the total phase shift due to amplifier stage becames $360^\circ$ which is necessary as per the oscillator conditions. The bridge consists of R and C in series and R & C in parallel, $R_3$ & $R_4$.

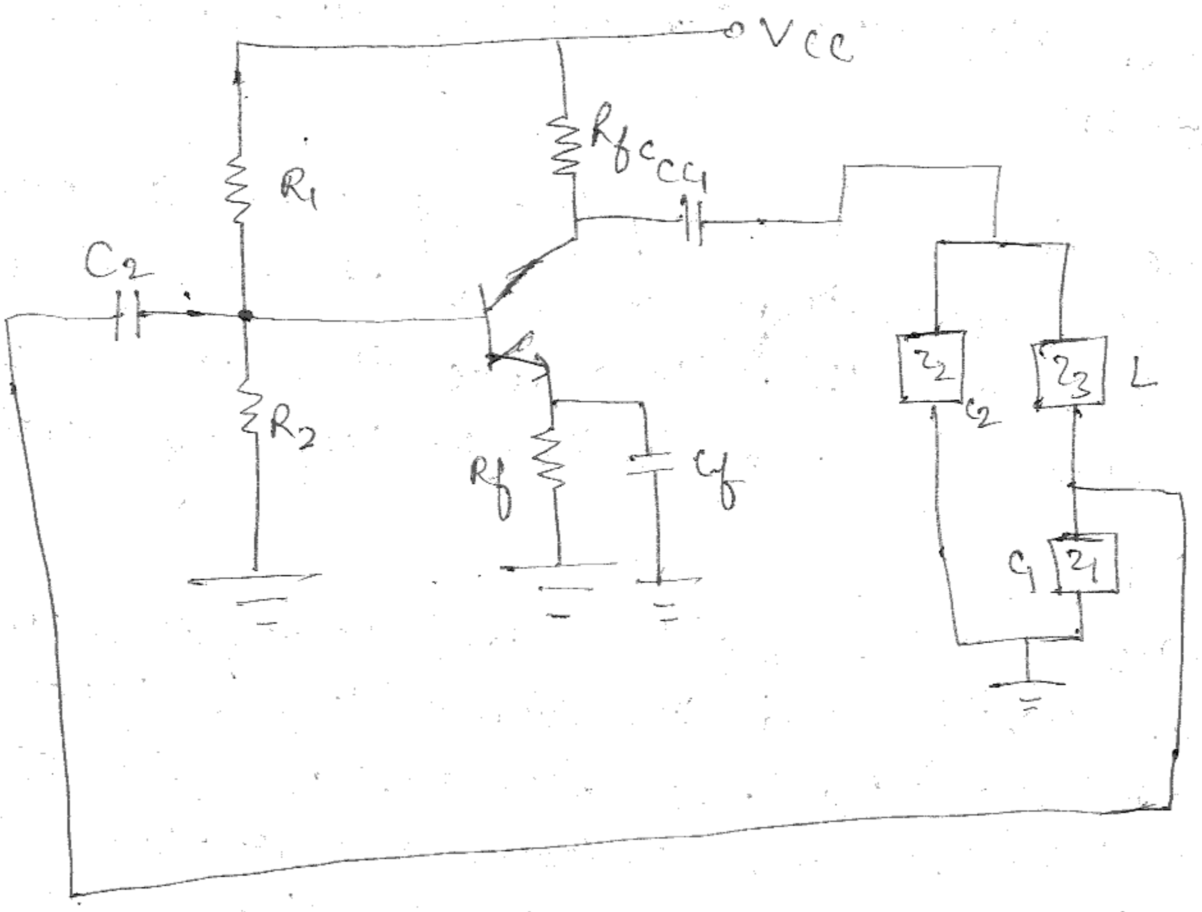
The feedback is applied from the character of $Q_2$ through the coupling capacitor to the bridge circuit.

The Resistance $R_4$ shows the dual purpose of emitter resistance of the transistor $Q1$ and also the Element of the wein Bridge.

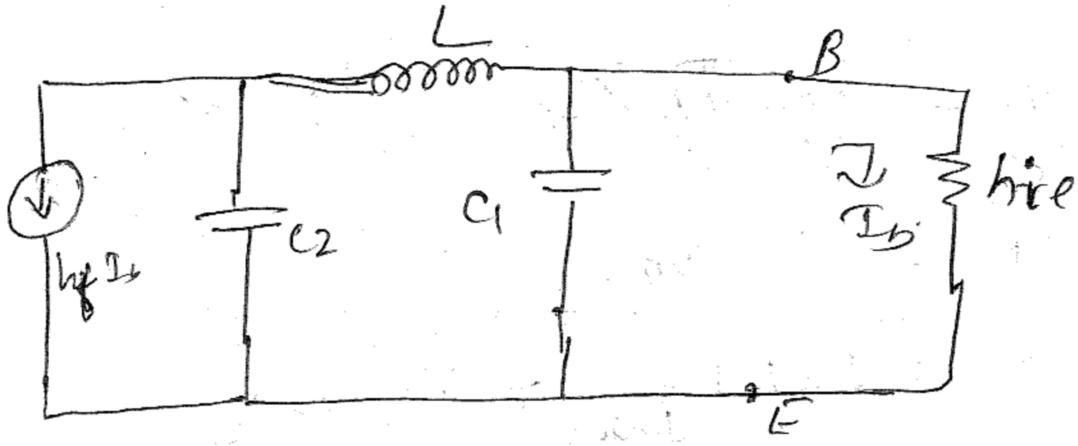
The two stage amplifier provides a gain much more than 3 and it is necessary to reduce it. To reduce the gain -ve feedback is used without bypassing resisteme $R_4$.

The negative feedback can accomplish the gain stability and can control the output magnitude. The -ve feedback also reduces the distortion and therefore output obtained is pure sinusoidal in nature. The amplitude stability can be improved using a non-linear resistor for $R_y$. Due to this the loop gain depends on the amplitude of the oscillations. Increase in the amplitude of the oscillations, increases the current through non linear resistance which results into an increase in the value of non-linear resistance $R_y$.

when this value increases, a greater amount of -ve feedback is applied. This reduces the loop gain & hence signal amplitude gets reduced & controlled.



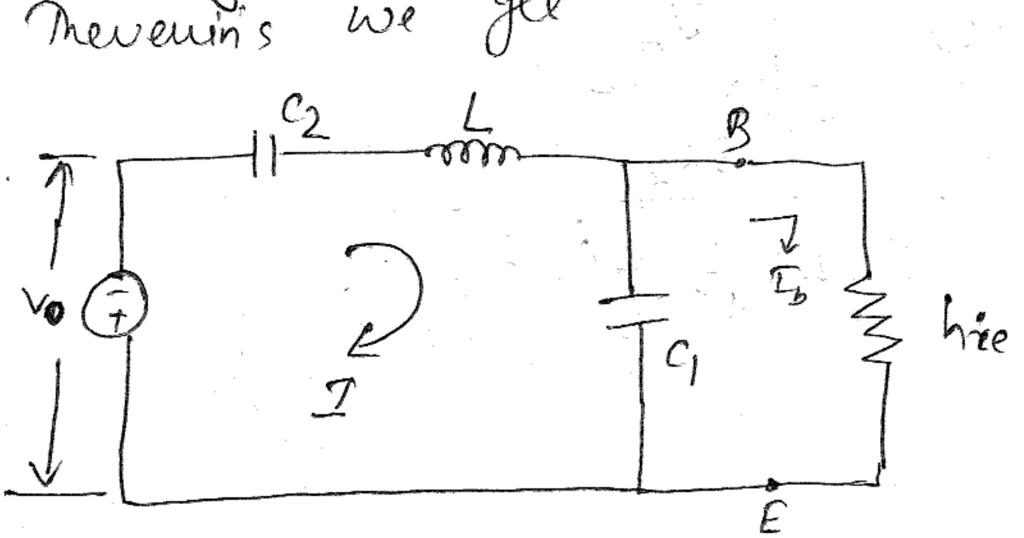

TRANSISTORISED COLPITTS OSCILLATOR




The O/P current $I_c$ which is $h_{fe} I_b$ acts as i/p to the feedback network while the base current $I_b$ acts as the O/P current of the tank circuit, flowing through the input impedence of the amplifier $h_{ie}$, the Equivalent circuit of the tank circuit is shown in fig.

Converting the current source into voltage source we get the equivalent circuit as shown in fig

Converting the Norton's Equivalent to Thevenin's we get



$$V_0 = h_{fe} I_b X_{c_2} = h_{fe} I_b \cdot \frac{1}{j\omega C_2}$$

$$I = \frac{-V_0}{j\omega L + \frac{1}{j\omega C_2} + X_{c_1} \| h_{ie}}$$

$$X_{c_1} \| h_{ie} = \frac{\frac{1}{j\omega C_1} \times h_{ie}}{h_{ie} + \frac{1}{j\omega C_1}}$$

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

Replacing $j\omega$ by $S$

$$I = \frac{\frac{-h_{fe} I_b}{S C_2}}{\left(SL + \frac{1}{SC_2}\right) + \left(\frac{\frac{h_{ie}}{SC_1}}{h_{ie} + \frac{1}{SC_1}}\right)}$$

$$I = \frac{\dfrac{-h_{fe} I_b}{sC_2}}{\left(sL + \dfrac{1}{sC_2}\right) + \dfrac{h_{ie}}{h_{ie}sC_1 + 1}}$$

$$= \frac{-h_{fe} I_b / sC_2}{\left(\dfrac{s^2 LC_2 + 1}{sC_2}\right) + \dfrac{h_{ie}}{h_{ie}sC_1 + 1}}$$

$$= \frac{-h_{fe} I_b (1 + h_{ie}sC_1)}{(s^2 LC_2 + 1)(h_{ie}sC_1 + 1) + h_{ie}sC_2}$$

$$= \frac{-h_{fe} I_b (1 + sC_1 h_{ie})}{1 + h_{ie}sC_1 + s^3 LC_1C_2 h_{ie} + s^2 LC_2 + h_{ie}sC_2}$$

$$I = \frac{-h_{fe} I_b (1 + sC_1 h_{ie})}{s^3 LC_1C_2 h_{ie} + s^2 LC_2 + h_{ie}s(C_1 + C_2) + 1} \quad \text{— (1)}$$

$$I_b = \frac{I X_{C_1}}{X_{C_1} + h_{ie}} = \frac{I / sC_1}{\dfrac{1}{sC_1} + h_{ie}}$$

$$= \frac{I / sC_1}{\dfrac{1 + sC_1 h_{ie}}{sC_1}}$$

$$I_b = \frac{I}{1 + sC_1 h_{ie}} \quad \text{— (2)}$$

Sub (1) in (2)

$$I_b = \frac{-h_{fe} I_b (1+s\cancel{C_1} h_{ie})}{[s^3 L C_1 C_2 h_{ie} + s^2 L C_2 + s h_{ie}(C_1+C_2)+1] \cancel{(1+sC_1 h_{ie})}}$$

$$\cancel{I_b} = \frac{-h_{fe} \cancel{I_b}}{s^3 L C_1 C_2 h_{ie} + s^2 L C_2 + s h_{ie}(C_1+C_2)+1}$$

$$s^3 L C_1 C_2 h_{ie} + s^2 L C_2 + h_{ie} s (C_1+C_2) + 1 = -h_{fe}.$$

$$-h_{fe} = -j\omega^3 L C_1 C_2 h_{ie} - \omega^2 L C_2 + j\omega h_{ie}(C_1+C_2) + 1$$

imaginary part will be zero

$$-j\omega^3 L C_1 C_2 h_{ie} + j\omega h_{ie}(C_1+C_2) = 0$$

$$-\omega^3 L C_1 C_2 h_{ie} + \omega h_{ie}(C_1+C_2) = 0$$

$$+\omega h_{ie}(-\omega^2 L C_1 C_2 + (C_1+C_2)) = 0$$

$$\omega h_{ie} \neq 0$$

$$-\omega^2 L C_1 C_2 + C_1 + C_2 = 0$$

$$C_1 + C_2 = \omega^2 L C_1 C_2$$

$$\omega^2 = \frac{C_1 + C_2}{L C_1 C_2}$$

$$\omega^2 = \frac{1}{L \frac{C_1 C_2}{C_1 + C_2}} = \frac{1}{L C_{eq}}.$$

$$\cancel{\omega^2}\ C_{eq} = \frac{C_1 C_2}{C_1 + C_2}$$

$$\omega = \frac{1}{\sqrt{L C_{eq}}}$$

$$2\pi f = \frac{1}{\sqrt{L C_{eq}}}$$

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

For Real part

$$1 = \frac{-h_{fe}}{1 + s^2 L C_2}$$

$$1 = \frac{-h_{fe}}{1 - \omega^2 \cdot L C_2}$$

$$= \frac{-h_{fe}}{1 - \frac{1}{\cancel{L} C_{eq}} \cdot \cancel{L} C_2}$$

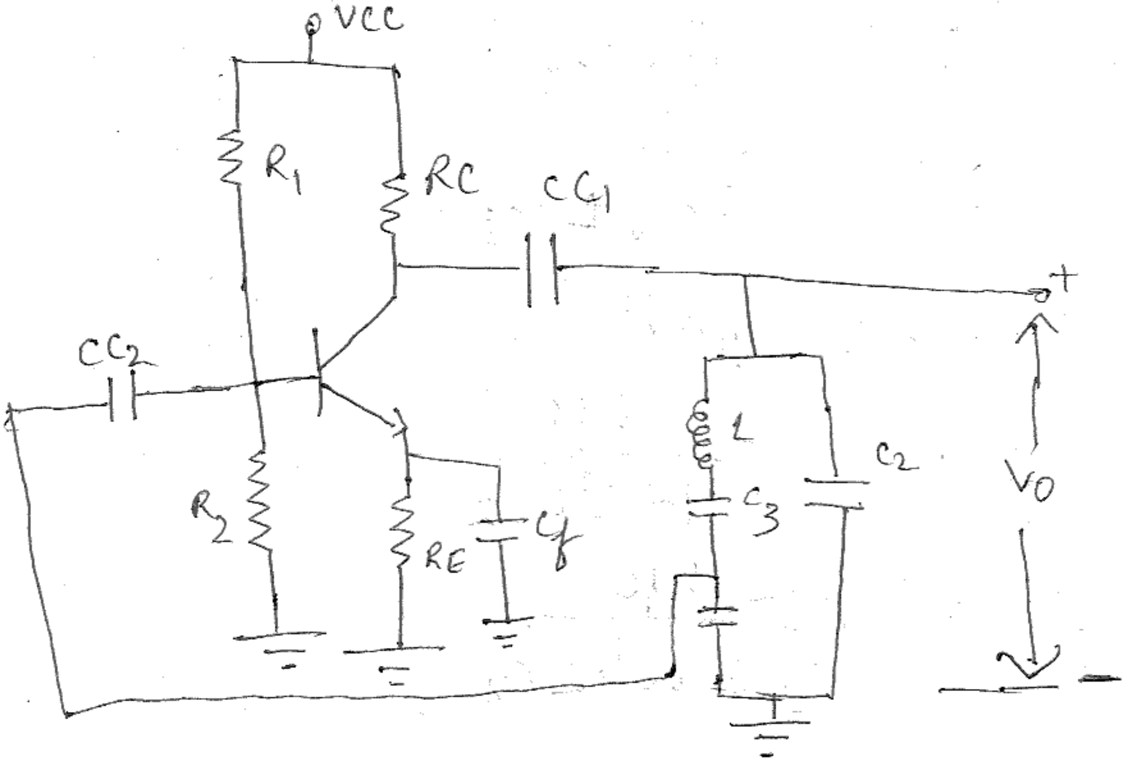
$$= \frac{-h_{fe}}{1 - \left(\frac{C_1 + C_2}{C_1 \cancel{C_2}}\right) \cancel{C_2}}$$

$$= \frac{-h_{fe}}{\cancel{1} - \cancel{1} - \frac{C_2}{C_1}}$$

$$1 = \frac{h_{fe}}{\frac{C_2}{C_1}}$$

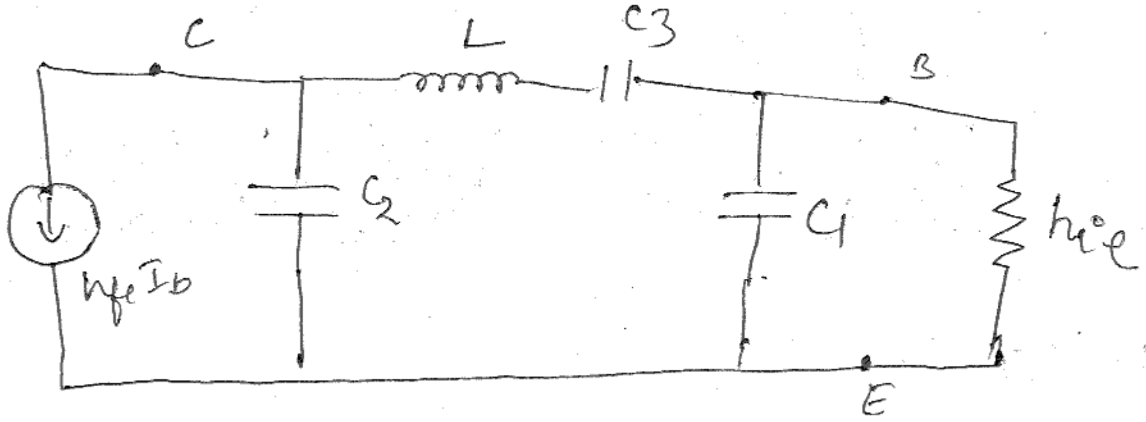
$$\boxed{h_{fe} = \frac{C_2}{C_1}}$$

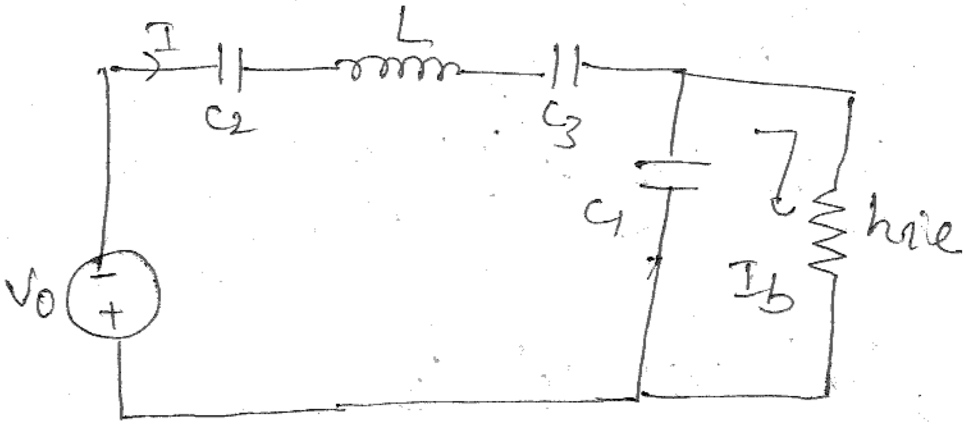
## Clap oscillator




## Derivation of frequency of oscillation

Advantage of $C_3$ is that it can be kept variable, as frequency is dependent on $C_3$, it can be varied at desired range.




$$V_0 = h_{fe} I_b \, X C_2 = h_{fe} I_b \frac{1}{j\omega C_2}$$

$$I = \frac{-V_0}{[XC_2 + X_L + XC_3] + [XC_1 \,||\, h_{ie}]}$$

$$XC_2 + X_L + XC_3 = \frac{1}{j\omega C_2} + \frac{1}{j\omega C_3} + j\omega L$$

$$XC_1 \,||\, h_{ie} = \frac{\frac{1}{j\omega C_1} \times h_{ie}}{\frac{1}{j\omega C_1} + h_{ie}}$$

$$I = \frac{-h_{fe} I_b / j\omega C_2}{\left[\frac{1}{j\omega C_2} + \frac{1}{j\omega C_3} + j\omega L\right] + \left[\frac{h_{ie}}{1 + j\omega C_1 h_{ie}}\right]}$$

$$= \frac{-h_{fe} I_b}{\left[\frac{j\omega C_2}{j\omega C_2} + \frac{j\omega C_2}{j\omega C_3} + \frac{j\omega L x}{j\omega C_2}\right] + \left[\frac{h_{ie} j\omega C_2}{1 + j\omega C_1 h_{ie}}\right]}$$

Put. $j\omega = S$

$$= \frac{-h_{fe} I_b}{\left(1 + \frac{C_2}{C_3} + S^2 L C_2\right] + \left[\frac{h_{ie} S C_2}{1 + S C_1 h_{ie}}\right)}$$

$$= \frac{-h_{fe} I_b \left[1 + S C_1 h_{ie}\right] C_3}{(1 + S C_1 h_{ie})\left[C_3 + C_2 + S^2 L C_2 C_3\right] + (h_{ie} S C_2) C_3}$$

$$= \frac{-h_{fe} I_b C_3 (1 + S C_1 h_{ie})}{C_3 + C_2 + S^2 L C_2 C_3 + S C_1 C_3 h_{ie} + S C_1 C_2 h_{ie} + S^3 C_1 C_2 C_3 L h_{ie} + h_{ie} S C_2 C_3}$$

$$I = \frac{-h_{fe} I_b C_3 (1 + S C_1 h_{ie})}{S^3 C_1 C_2 C_3 L h_{ie} + S^2 L C_2 C_3 + (C_1 C_3 h_{ie} + C_1 C_2 h_{ie} + C_2 C_3 h_{ie}) S + C_3 + C_2}$$

$$I_b = \frac{I \times C_1}{X C_1 + h_{ie}} = \frac{\frac{I}{S C_1}}{\frac{1}{S C_1} + h_{ie}}$$

$$I_b = \frac{I}{1 + h_{ie} s C_1}$$

$$\cancel{I_b} = \frac{-h_{fe} \cancel{I_b} C_3 (1 + \cancel{h_{ie}} s C_1)}{[s^3 h_{ie} C_1 C_2 C_3 L + s^2 L C_2 C_3 + h_{ie} s (C_1 C_3 + C_1 C_2 + C_2 C_3) + (C_2 + C_3)][\cancel{1 + h_{ie} s C_1}]}$$

$$1 = \frac{-h_{fe} C_3}{[s^3 h_{ie} C_1 C_2 C_3 L + s^2 L C_2 C_3 + h_{ie} s (C_1 C_3 + C_1 C_2 + C_2 C_3) + (C_2 + C_3)]}$$

$s^3 = -j\omega^3$ , $s^2 = -\omega^2$, $s = j\omega$

$$1 = \frac{-h_{fe} C_3}{-j\omega^3 h_{ie} C_1 C_2 C_3 L - \omega^2 L C_2 C_3 + h_{ie} j\omega (C_1 C_3 + C_1 C_2 + C_2 C_3) + (C_2 + C_3)]}$$

Taking imaginary part as zero.

$$-\omega^3 h_{ie} C_1 C_2 C_3 L + h_{ie} \omega (C_1 C_3 + C_1 C_2 + C_2 C_3) = 0$$

$$\omega h_{ie} \left[ -\omega^2 C_1 C_2 C_3 L + C_1 C_3 + C_1 C_2 + C_2 C_3 \right] = 0$$

$$\omega h_{ie} \neq 0$$

$$-\omega^2 C_1 C_2 C_3 L + C_1 C_3 + C_1 C_2 + C_2 C_3 = 0$$

$$C_1 C_3 + C_1 C_2 + C_2 C_3 = \omega^2 C_1 C_2 C_3 L$$

$$\omega^2 = \frac{C_1 C_3 + C_1 C_2 + C_2 C_3}{C_1 C_2 C_3 L}$$

$$\omega^2 = \frac{1}{L C_{eq}}$$

$$C_{eq} = \frac{C_1 C_2 C_3}{C_1 C_2 + C_2 C_3 + C_2 C_3}$$

$$\omega = \frac{1}{\sqrt{L C_{eq}}}$$

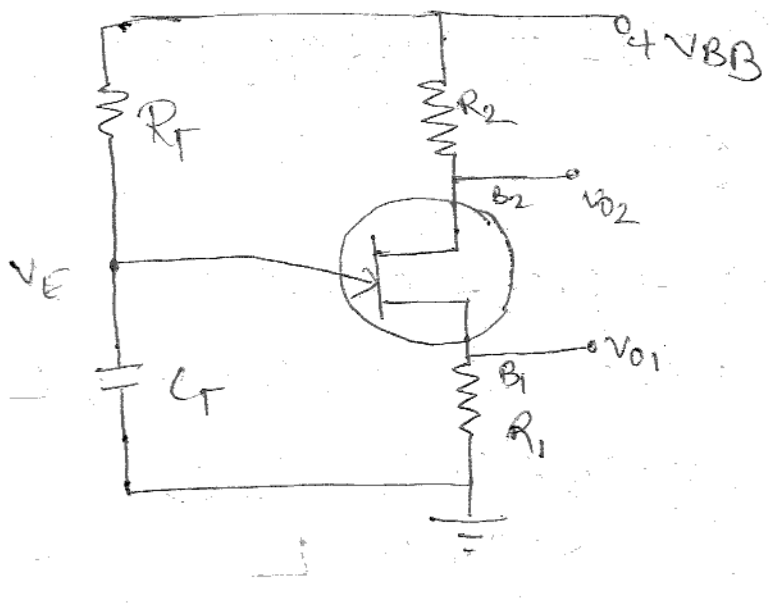
$$2\pi f = \frac{1}{\sqrt{L C_{eq}}}$$

$$\boxed{f = \frac{1}{2\pi \sqrt{L C_{eq}}}}$$

This is the required frequency of Clap oscillator.

<u>18/7/11</u>

## <u>Negative Resistance oscillator</u>



$$V_P = \eta V_{BB} + V_D$$

$\eta \rightarrow$ Stand-off ratio

$V_D \rightarrow$ cutin voltage of diode.

$$V_C(t) = V_V + V_{BB}\left[1 - e^{-t/R_T C_T}\right]$$

$$V_C(t) = V_P \text{ at } t = T$$

$$V_P = V_V + V_{BB}\left[1 - e^{-t/R_T C_T}\right].$$

$$\eta V_{BB} + V_D = V_V + V_{BB}\left[1 - e^{-t/R_T C_T}\right].$$

$$\eta = \left[1 - e^{-T/R_T C_T}\right]$$

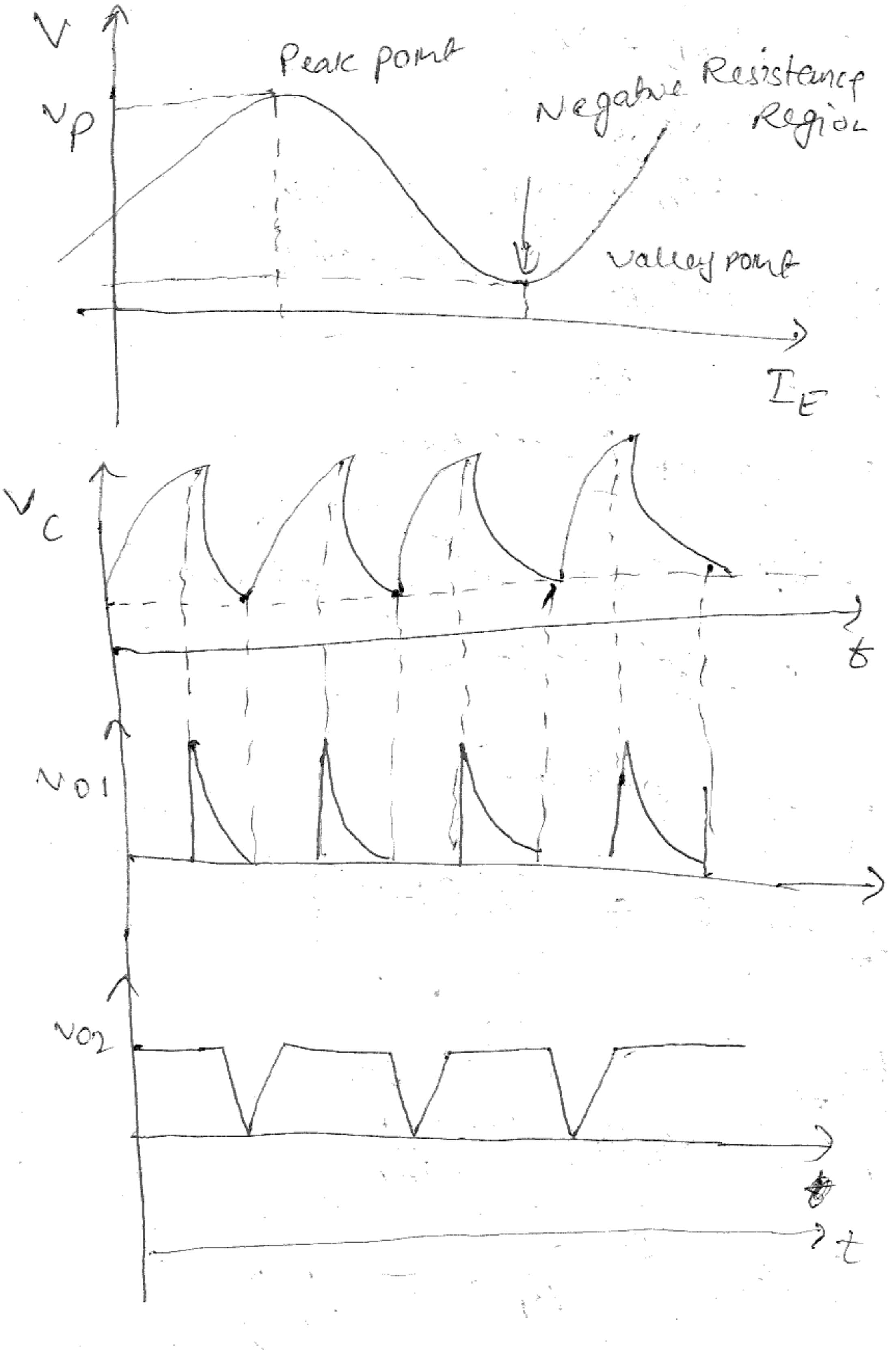
$$1 - \eta = e^{-T/R_T C_T}$$

$$\frac{-T}{R_T C_T} \ln e = \ln(1-\eta)$$

$$\frac{T}{R_T C_T} = \ln\left(\frac{1}{1-\eta}\right)$$

$$T = R_T C_T \ln\left(\frac{1}{1-\eta}\right)$$

$$f_0 = \frac{1}{T} = \frac{1}{R_T C_T \ln\left(\frac{1}{1-\eta}\right)}.$$




Q. In a certain oscillator circuit the gain of the amplifier is $A = \frac{-16 \times 10^6}{j\omega}$ and the feedback factor of the feedback

Now is $\beta = \frac{10^3}{[2\times10^3 + j\omega]^2}$ . verify the Book.

hausen criterion for the sustained oscillation. Also find the frequency at which circuit will oscillate.

Soln

$$A\beta = \frac{-16\times10^6}{j\omega} \cdot \frac{10^3}{[2\times10^3+j\omega]^2}$$

$$= \frac{-16\times10^9}{j\omega\left[4\times10^6 + j^2\omega^2 + 4\times10^3 j\omega\right]}$$

$$= \frac{-16\times10^9}{4\times10^6 j\omega + j^3\omega^3 + 4\times10^3 j^2\omega^2}$$

$$A\beta = \frac{-16\times10^9}{4\times10^6 j\omega - j\omega^3 - 4\times10^3\omega^2}$$

Now equating imaginary part to zero

$$4\times10^6 j\omega - j\omega^3 = 0$$

$$j\omega(4\times10^6 - \omega^2) = 0$$

$$4\times10^6 = \omega^2$$

$$\omega^2 = 4\times10^6$$

$$\boxed{\omega = 2\times10^3}$$

$$A\beta = \frac{-16\times10^9}{4\times10^6\times2\times10^3 j - j(2\times10^3)^3 - 4\times10^3\omega^2}$$

$$= \frac{-16\times10^9}{8\times\cancel{10^9} j - 8\times\cancel{10^9} j - 4\times10^3\times(2\times10^3)^2}$$

$$= \frac{-16\times10^9}{\cancel{8\times10} - 4\times4\times10^3\times10^6}$$

$$= \frac{-16\cancel{\times10^9}}{-16\cancel{\times10^9}}$$

$$\boxed{A\beta = 1}$$

Barkhausen criterion satisfied