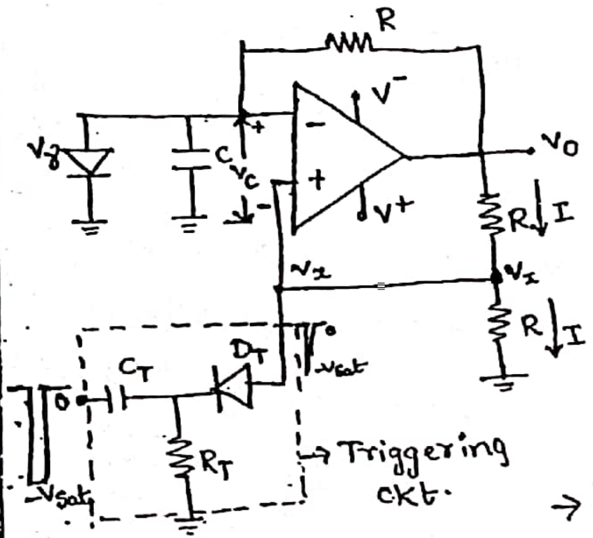
* Monostable Multivibrator :- (Pulse Generator).

- The MMV has one stable & one Quasi state.
- once the supply given the MMV in the stable state. To change the state apply a trigger pulse [negative going amplitude pulse of short duration $T_p \sim 0$].
- After trigger pulse applied, the MMV enters into Quasi state. It remains in the Quasi state for a predetermined time(T), after this time the MMV automatically come backs to origi state (stable state). In the Quasi state, it generates a pulse of duration (T) – "pulse generator".
- It is also called as "voltage to Time converter." It is als. "UNIVIBRATOR" (or) "one shoot vibrator".



$V_x = V_o\left(\dfrac{R_2}{R_1+R_2}\right) = \beta V_o$

Let the 'C' is initially uncharged

$\boxed{V_c = 0} \rightarrow$ D-off.

once the supply given, the MMV in the stable stable.

Let $V_o = +V_{sat} \rightarrow$ stable state o/p

$V_o = +V_{sat}$ $V_x = \beta V_{sat}$.

→ As $V_o = V_{sat}$ is given to 'c' & Diode combination through 'R'. Now the 'c' starts charging towa +V_{sat} through 'R' with $T = RC$.

when $V_c = V_\gamma$; D- becomes ON → replaced by V_γ.

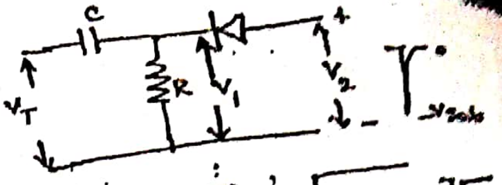
Now the 'c' stop's charging $\left\{\begin{matrix} V_c = V_\gamma, & V_o = V_{sat} \\ D\text{-ON}, & V_x = \beta V_{sat} \end{matrix}\right\}$ → Stable State of MMV.

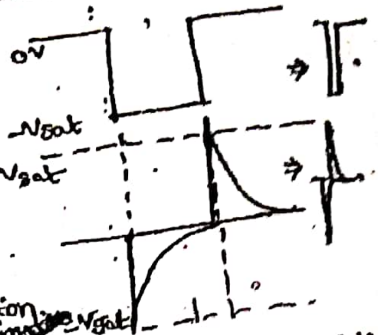
→ Now apply a trigger pulse to change the state.

After trigger pulse, the potential at Non. inv. termin becomes $(\beta V_{sat} - V_{sat}) \rightarrow -ve$.

The $V_c > (\beta V_{sat} - V_{sat}) \Rightarrow \boxed{V_0 = -V_{sat}}$

Now $\boxed{V_0 = -V_{sat}}$ $\boxed{V_x = -\beta V_{sat}}$





As $V_0 = -V_{sat}$ is given to 'c' & diode combination D-off. Now the 'c' discharges towards $-V_{sat}$ through R' with $\tau = RC$.

when $V_c < -\beta V_{sat} \Rightarrow V_0 = V_{sat}$

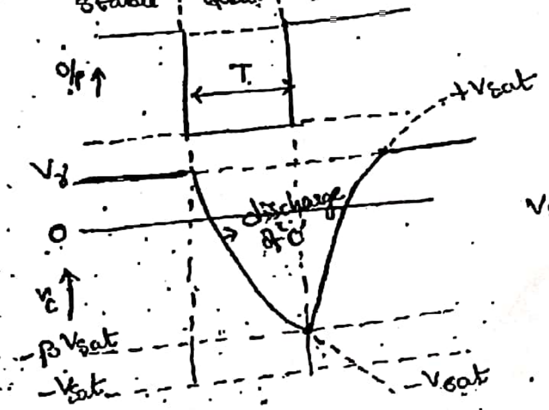
Now $V_0 = +V_{sat}$, $V_x = \beta V_{sat}$.

As $V_0 = V_{sat}$ is given to 'c' & diode combination ~~...~~ through R Now 'c' starts charging towards V_{sat} through R with $\tau = RC$. The 'c' stops charging

when $V_c = V_\gamma \Rightarrow$ D-ON -

$$\left.\begin{matrix} V_c = V_\gamma & V_0 = V_{sat} \\ \text{D-ON} & V_x = \beta V_{sat} \end{matrix}\right\} \text{stable states.}$$

O/p wave form:-



pulse width (T):-

To calculate T, consider discharging of 'c'.

$$\boxed{V_c = V_f + (V_i - V_f)\, e^{-t/\tau}}$$

$V_i = V_\gamma$, $V_f = -V_{sat}$, $\tau = RC$, at $t = T$, $V_c = -\beta V_{sat}$

$$-\beta V_{sat} = -V_{sat} + (V_\gamma + V_{sat})\, e^{-T/RC}$$

$$V_{sat}(1-\beta) = (V_\gamma + V_{sat})\, e^{-T/RC}$$

$$e^{-T/RC} = \frac{V_\gamma + V_{sat}}{V_{sat}(1-\beta)}$$

$$\boxed{T = RC \ln\left[\frac{V_\gamma + V_{sat}}{V_{sat}(1-\beta)}\right]}.$$

$$\beta = \frac{R_2}{R_1+R_2} \Rightarrow 1-\beta = \left(\frac{R_1}{R_1+R_2}\right)$$

$$\frac{1}{(1-\beta)} = \left(\frac{R_1+R}{R_1}\right)$$

$$= \left(1 + \frac{R_2}{R}\right)$$

$$\boxed{T = RC \ln\left[\frac{V_\gamma + V_{sat}}{V_{sat}}\left(1 + \frac{R_2}{R_1}\right)\right]}$$

If $V_\gamma <<< V_{sat}$ (or) V_γ Neglected

$$\boxed{T = RC \ln\left(1 + \frac{R_2}{R_1}\right)}$$

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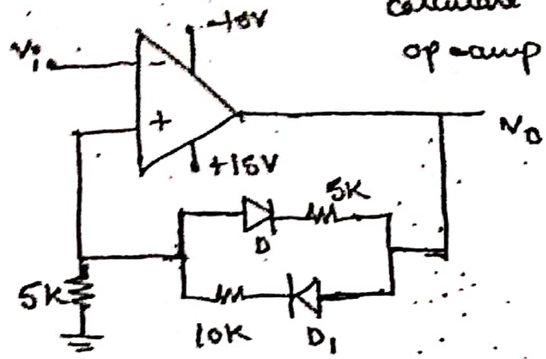
Pb:- calculate UTP & LTP value for the op-amp ckt shown

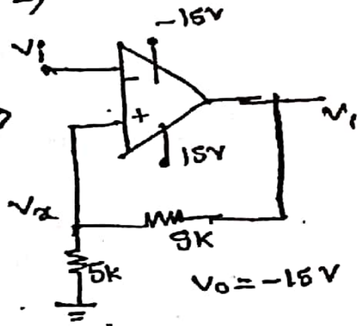


Sol:-

$$V_{LTP} = V_{ref} + (V_{sat} - V_{ref})\left(\frac{R_2}{R_1+R_2}\right)$$

$$= 0 - \cancel{15}^{3}\left(\frac{5}{\cancel{10}_2}\right)$$

$$\boxed{V_{LTP} = -\frac{15}{2}V = -7.5V}$$



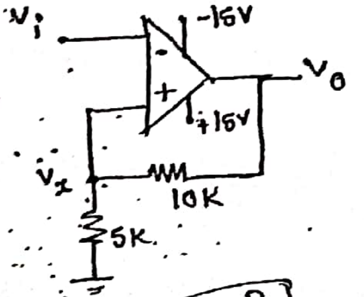
$V_o = -15V$

D_1 - OFF - O.C
D_2 - ON - S.C

$$V_{UTP} = +\cancel{15}\left[\frac{5}{\cancel{15}}\right] = +5V$$

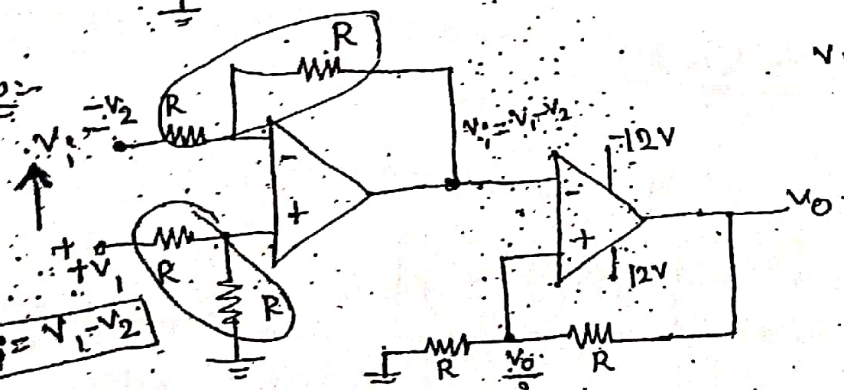
when $V_0 = +15V$

D_1 - ON - S.C
D_2 - OFF - O.C



$V = 12$

Pb:-



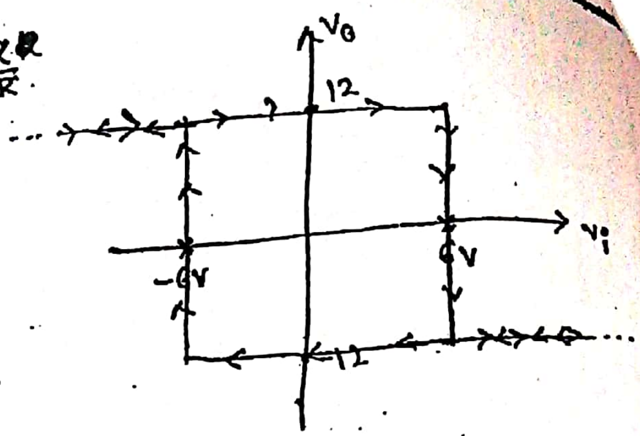
$\boxed{V_i = V_1 - V_2}$

Draw the Transfer char. curve for the op-amp ckt shown?

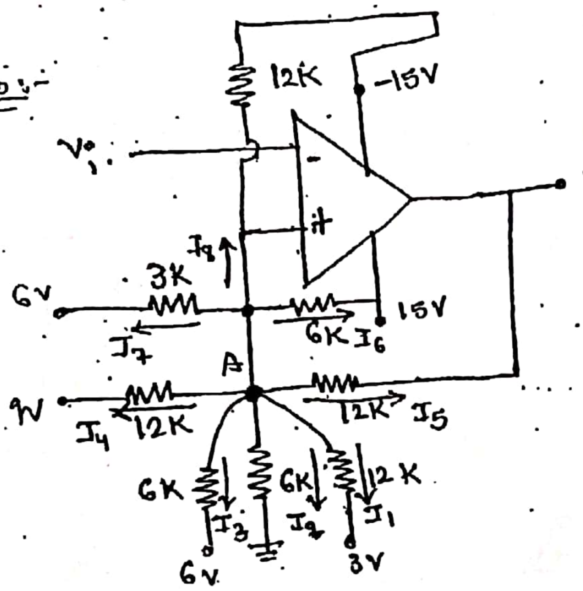
$V_x = V_{UTP} = +12\left(\frac{1}{2}\right)\frac{R}{R}$

$= 6V.$

$V_{LTP} = \underline{-6V}.$



Pb:-



Calculate the UTP & LTP values.

Sol:- when ever the multiple voltages are there apply KCL at point 'A':

$I_1 + I_2 + I_3 + I_4 + I_5 + I_6 + I_7 + I_8 = 0$

$$\frac{V_A - 3}{12k} + \frac{V_A - 0}{6k} + \frac{V_A - 6}{6k} + \frac{V_A - 9}{12k} + \frac{V_A - V_0}{12k} + \frac{V_A - 15}{6k} + \frac{V_A - 6}{3k} + \frac{V_A + 15}{12k} = 0$$

$$\frac{-V_0 + V_A - \cancel{3} + 2V_A + 2V_A - 12 + V_A - 9 + V_A + 2V_A - 30 + 4V_A - 24 + V_A + \cancel{15}}{12K} = 0$$

$14V_A - 63 - V_0 = 0$

$\boxed{V_A = \left(\frac{V_0 + 63}{14}\right)}$

when $V_0 = 15V$

$V_A = V_{UTP} = \frac{15+63}{14} = \frac{78}{14} = \underline{5.571V}.$

when $V_0 = -15V$

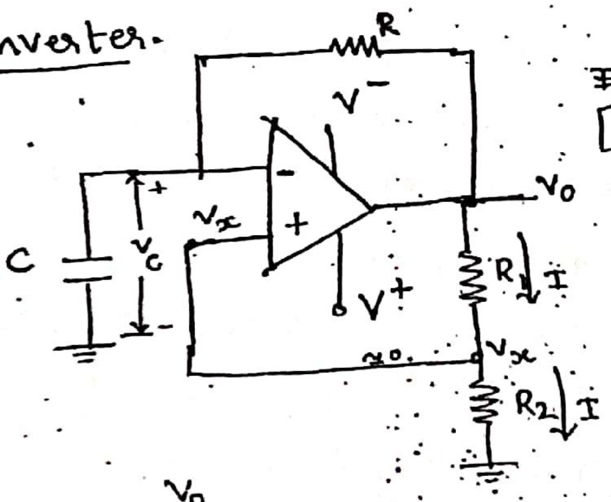
$V_A = V_{LTP} = \frac{-15+63}{14} = \frac{48}{14} = \underline{3.428V}.$

* Astable Multivibrator :-
(Square wave Generator)

* The Astable Multivibrator has no stable states.
  - Two states are QUASI
* The o/p of AMV continuously changes b/w two states. As its o/p continuously changes b/w two states the o/p is a square wave.

→ AMV is also called free Running oscillator.
→ AMV is also called a Relaxation oscillator.
→ AMV is also called voltage to frequency converter.

~~It produces only a~~
[It generates the square wave.]



$$I = \frac{V_0}{R_1+R_2}$$

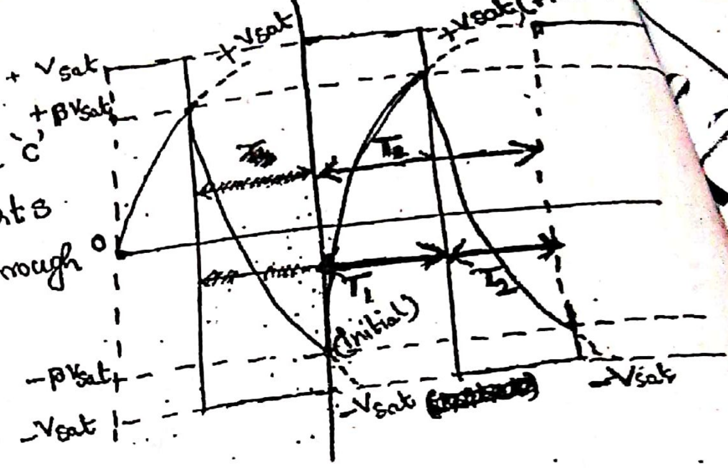
$$V_x = I R_2 = V_0 \underbrace{\left[\frac{R_2}{R_1+R_2}\right]}_{\beta}$$

$$\boxed{V_x = \beta V_0}, \ \beta < 1$$

Let the 'c' is initially uncharged $\boxed{V_c = 0}$

Once the supply given, the AMV is in one of its QUASI state.

Let $\underline{V_0 = +V_{sat}}$.



$V_x = \beta V_{sat}$.

As $V_0 = V_{sat}$ is given to the 'c' through R. Now the 'c' starts charging towards $+V_{sat}$ through 'R' with $\tau = RC$.

when $V_c > \beta V_{sat} \Rightarrow V_0 = -V_{sat}$:

Now $\underline{V_0 = -V_{sat}}$

$V_x = -\beta V_{sat}$

As $V_0 = -V_{sat}$ is given to 'c' through R. Now the 'c' discharges towards $-V_{sat}$ through 'R' with $\tau = \underline{RC}$

when $V_c < -\beta V_{sat} \Rightarrow V_0 = +V_{sat}$.

Now $V_0 = V_{sat}$; $V_x = \beta V_{sat}$.

As $V_0 = V_{sat}$ is given to 'c' through R. The 'c' starts charging towards $+V_{sat}$ through 'R' with $\tau = RC$.

* Like this the process is goes on. Due to continuous charging & discharging of 'c' b/w βV_{sat} & $-\beta V_{sat}$ square wave oscillations generated at the o/p.

Calculation of freq of oscillations:-

$$f = \frac{1}{T} = \frac{1}{T_1 + T_2} \quad \because \boxed{T = T_1 + T_2}$$

T_1 :- To calculate T_1 consider charging of 'c'.

$$\boxed{V_c = V_f + (V_i - V_f)\, e^{-t/\tau}}$$

V_i = Inital value
V_f = final value

$\because V_i = -\beta V_{sat}$, $V_f = V_{sat}$, $\tau = RC$; at $t = T_1$, $V_c = \beta V_{sat}$.

$$\beta V_{sat} = V_{sat} + (-\beta V_{sat} - V_{sat})e^{-T_1/RC}$$

$$-V_{sat}(1-\beta) = -V_{sat}(1+\beta)e^{-T_1/RC}$$

$$1-\beta = (1+\beta)e^{-T_1/RC}$$

$$e^{T_1/RC} = \left(\frac{1+\beta}{1-\beta}\right)$$

$$\boxed{T_1 = RC\ln\left(\frac{1+\beta}{1-\beta}\right)}$$

T_2:- To calculate T_2, consider discharging of 'c'.

$V_i = \beta V_{sat}$, $V_f = -V_{sat}$, $\tau = RC$, at $t = T_2$, $V_c = -\beta V_{sat}$

$$-\beta V_{sat} = -V_{sat} + (\beta V_{sat} + V_{sat})e^{-T_2/RC}$$

$$\cancel{V_{sat}}(1-\beta) = \cancel{V_{sat}}(1+\beta)e^{-T_2/RC}$$

$$(1-\beta) = (1+\beta)e^{-T_2/RC}$$

$$e^{T_2/RC} = \frac{(1+\beta)}{(1-\beta)}$$

$$\boxed{T_2 = RC\ln\left(\frac{1+\beta}{1-\beta}\right)}$$

As $T_1 = T_2$ ⇒ The o/p wave form is $\left(\frac{1+\beta}{1-\beta}\right)$

where $\beta = \frac{R_2}{R_1+R_2}$

$$\left(\frac{1+\beta}{1-\beta}\right) = \frac{1+\frac{R_2}{R_1+R_2}}{1-\frac{R_2}{R_1+R_2}} = \frac{R_1+2R_2}{R_1+\cancel{R_2}-\cancel{R_2}} = \frac{R_1+2R_2}{R_1}$$

$$= \left(1+\frac{2R_2}{R_1}\right)$$

$$T = T_1 + T_2 = 2RC\ln\left(\frac{1+\beta}{1-\beta}\right)$$

$$\boxed{T = 2RC\ln\left(1+\frac{2R_2}{R_1}\right)}$$

$$\therefore f = \frac{1}{T} = \frac{1}{2RC\ln\left(1+\frac{2R_2}{R_1}\right)}$$

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$\underline{T_2}$:- $V_i = 5V$, $V_f = -15V$, $\tau = RC$,
at $t = T_2$, $V_c = -7.5V$

$$-7.5 = -15 + (5+15)e^{-T_2/RC}$$

$$7.5 = 20e^{-T_2/RC}$$

$$e^{T_2/RC} = \frac{20}{7.5}$$

$$T_2 = RC \ln(2.667)$$

$$T = T_1 + T_2$$

$$= RC[\ln(2.667) + \ln(2.25)]$$

$$= RC[\ln(2.667 \times 2.25)]$$

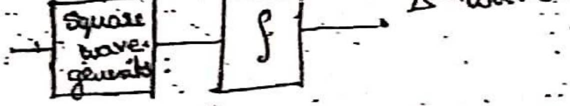
$$= 0.1m[\ln(2.667 \times 2.25)]$$

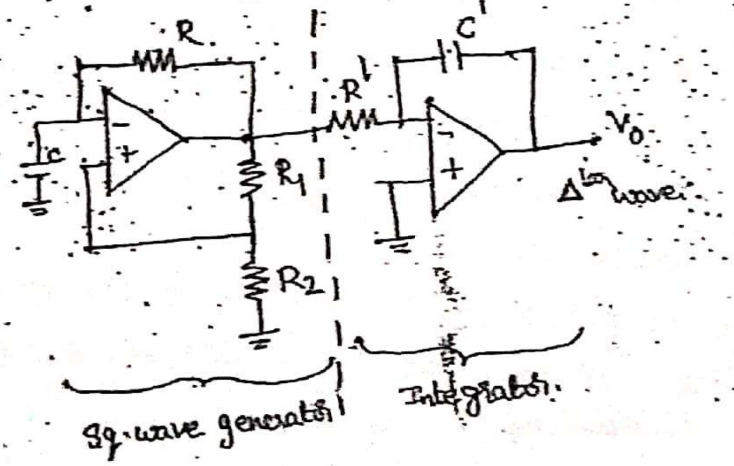
$$T = 0.179\text{ msec}$$

$$\boxed{f = \frac{1}{T} = 5.58KHz}$$

* Δ^{lar} wave generator:-

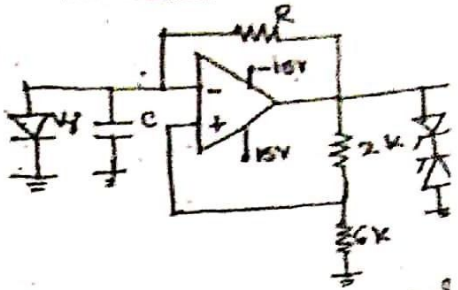
By integrating the square wave we get Δ^{lar} wave





Pb:- Monostable problem

①



Calculate for the ckt shown pulse width generated by the ckt when a trigger pulse is app for (i) $V_\gamma = 0.7V$ (ii) $V_\gamma = 0V$.

Sol:- Assume that $\tau = 10$ msec
$V_z = 6.3V$.

when $V_\gamma = 0.7V$

$$V_{sat} = (V_\gamma + V_z) = 7V$$

$$T = RC \ln\left[\frac{7.7}{7}(1+3)\right]$$

$$= 10m \ln(4.4)$$

$$T = 14.81\text{ msec}$$

(ii) when $V_\gamma = 0$

$$T = RC \ln\left(1 + \frac{R_2}{R_1}\right)$$

$$= 10m \ln\left(1 + \frac{6K}{2K}\right)$$

$$= 10m \ln(1+3)$$

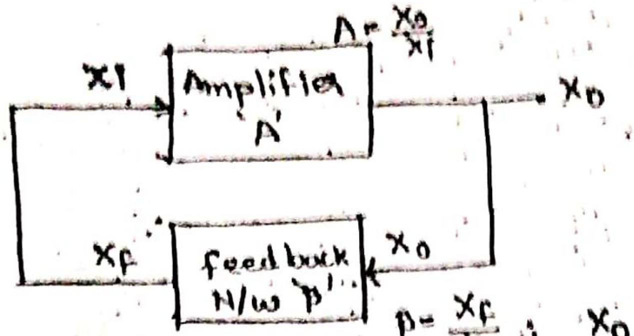
$$= 10m \ln(4)$$

$$= 13.86\text{ m sec}$$

Sinusoidal oscillators:-

A ckt which generates undamped sinusoidal oscillations is called sinusoidal (or) Harmonic oscillators.

*(undamped means Amplitude constant "periodically")



$\beta = \frac{X_f}{X_0}$; $X_0 = \frac{X_f}{\beta}$

In oscillators, $X_f = X_i$

$X_0 = A X_i$

$\frac{X_f}{\beta} = A X_i \Rightarrow \boxed{X_f = A\beta X_i}$

$\therefore A\beta = 1$

$A\beta \rightarrow$ loop gain

$A\beta = 1 = 1 + j0 = 1\angle 0°$.

(i) The magnetude of loop gain = 1.
(ii) The total phase of the loop is 0° or 360° } "BARKHAUSEN" CRITERIA / conditions.

To get undamped oscillations the ckt must satisfy the above conditions.

→ If the amplifier introduces 180° of phase [Inverting amplifier CE amplifier] the remaining 180° must introduced by the feedback.

→ If the amplifier introduces 0° of phase [Non-inverting Amplifier, CE-CE cascaded Amplifier] the feedback N/w must introduce 0° of phase.

→ The Feed back N/w consists R, L, C → in oscillators

The transfer function of the feed back N/w.

$$\Rightarrow \frac{X_f(s)}{X_o(s)} = \beta = \beta_{real} \pm j\,\beta_{imaginary}.$$

The gain of the amplifier 'A' → is always real value

The magnitude of the loop gain, $\boxed{A\beta = 1}$

$\beta = \frac{1}{A}$ → must be real

→ To get undamped oscillation, the imaginary part of 'β' must be zero.

$\Rightarrow \boxed{\beta_{imaginary} = 0}$

from this we get the freq of oscillations generated by the ckt.

→ The feed back factor $\boxed{\beta = \beta_{real}}$.

The gain of the amplifier $A = \frac{1}{\beta}$

$$\Rightarrow \boxed{A = \frac{1}{\beta_{real}}}$$

→ Depending on the components used in the feed back N/w, the oscillators are classified into:

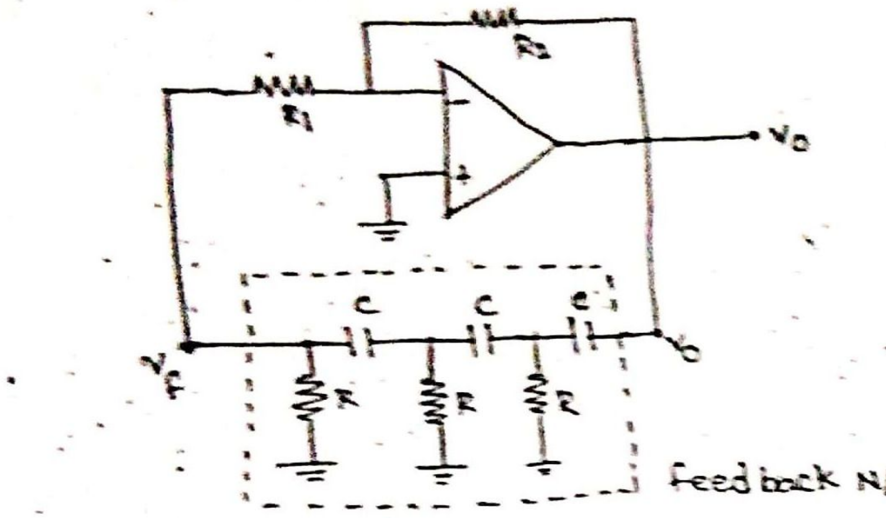
1. RC oscillators
   - RC phase shift oscillator
   - wein Bridge oscillator

   } Audio frequency oscillators.

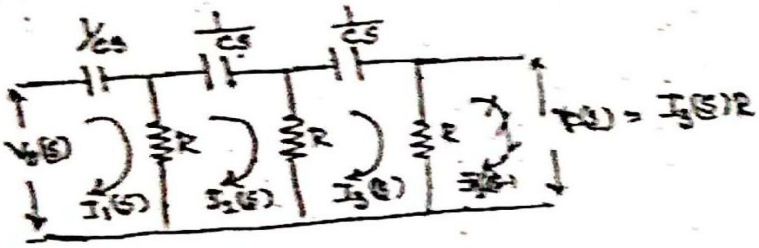
2. LC oscillators
   - Hartely oscillator
   - colpitts oscillator

   } Radio freq oscillators.

1. RC phase shift oscillator:



Find the transfer function:-



$$V_o(s) = I_1(s)\left[R + \frac{1}{sc}\right] - I_2(s)R \longrightarrow ①$$

$$0 = -I_1(s)R + I_2(s)\left[2R + \frac{1}{sc}\right] - I_3(s)R \longrightarrow ②$$

$$0 = -I_2(R) + I_3(s)\left[2R + \frac{1}{sc}\right] \longrightarrow ③$$

$$\begin{bmatrix} R+\frac{1}{sc} & -R & 0 \\ -R & 2R+\frac{1}{sc} & -R \\ 0 & -R & 2R+\frac{1}{sc} \end{bmatrix} \begin{bmatrix} I_1(s) \\ I_2(s) \\ I_3(s) \end{bmatrix} = \begin{bmatrix} V_o(s) \\ 0 \\ 0 \end{bmatrix}$$

$$A = R + \frac{1}{sc}\left[\left(2R+\frac{1}{sc}\right)^2 - R^2\right] + R\left[-R\left[2R+\frac{1}{sc}\right]\right]$$

$$= \left(R+\frac{1}{sc}\right)\left[3R^2 + \frac{1}{s^2c^2} + \frac{4R}{sc}\right] - R^2\left(2R+\frac{1}{sc}\right)$$

$$= 3R^3 + \frac{R}{s^2c^2} + \frac{4R^2}{sc} + \frac{3R^2}{sc} + \frac{1}{s^3c^3} + \frac{4R}{s^2c^2} - 2R^3 - \frac{R^2}{sc}$$

$$\Delta = R^3 + \frac{6R^2}{sC} + \frac{5R}{s^2C^2} + \frac{1}{s^3C^3}.$$

$$\Delta_3 = \begin{bmatrix} R+\frac{1}{sC} & -R & V_0(s) \\ -R & 2R+\frac{1}{sC} & 0 \\ 0 & -R & 0 \end{bmatrix} = V_0(s)\left[R^2 - 0\right].$$
$$= V_0(s) R^2$$

$$I_3(s) = \frac{\Delta_3}{\Delta} = \frac{V_0(s) R^2}{R^3 + \frac{6R^2}{sC} + \frac{5R}{s^2C^2} + \frac{1}{s^3C^3}}.$$

$$V_f(s) = I_3(s) R = \frac{V_0(s)\; R^3}{R^3 + \frac{6R^2}{sC} + \frac{5R}{s^2C^2} + \frac{1}{s^3C^3}}$$

$$V_f(s) = \frac{V_0(s)}{1 + \frac{6\cancel{R^2}}{sC\cancel{R^3}} + \frac{5\cancel{R}}{s^2C^2\cancel{R^3}2} + \frac{1}{s^3C^3R^3}}$$

$$V_f(s) = \frac{V_0(s)}{1 + \frac{6}{sCR} + \frac{5}{s^2C^2R^2} + \frac{1}{s^3C^3R^3}}$$

$$T.F = \frac{V_f(s)}{V_0(s)} = \frac{1}{1 + \frac{6}{sCR} + \frac{5}{s^2C^2R^2} + \frac{1}{s^3C^3R^3}}$$

put $s = j\omega$.

$$T.F = \beta = \frac{1}{1 - j\frac{6}{\omega CR} + (-1)\frac{5}{\omega^2C^2R^2} + j\frac{1}{\omega^3C^3R^3}}$$

$$= \frac{1}{\left(1 - \frac{5}{\omega^2C^2R^2}\right) + j\left(\frac{1}{\omega^3C^3R^3} - \frac{6}{\omega CR}\right)}$$

To get undamped oscillations, the imaginary part of β must be zero.

$$\frac{1}{\omega^3 C^3 R^3} = \frac{6}{\omega C R}$$

$$\omega^2 C^2 R^2 = \frac{1}{6} \Rightarrow \omega^2 = \frac{1}{R^2 C^2 (6)} \Rightarrow \omega = \frac{1}{RC\sqrt{6}}$$

$$2\pi f = \frac{1}{RC\sqrt{6}}$$

$$\boxed{f = \frac{1}{2\pi RC\sqrt{6}}}$$

The feedback factor is

$$\beta = \frac{1}{1 - \frac{5}{\omega^2 C^2 R^2}} = \frac{1}{1 - 5(6)}$$

$$\boxed{\beta = \frac{-1}{29}}$$

180° of phase b/w V_o & V_f.

The gain of the amplifier $A = \frac{1}{\beta} = -29$.

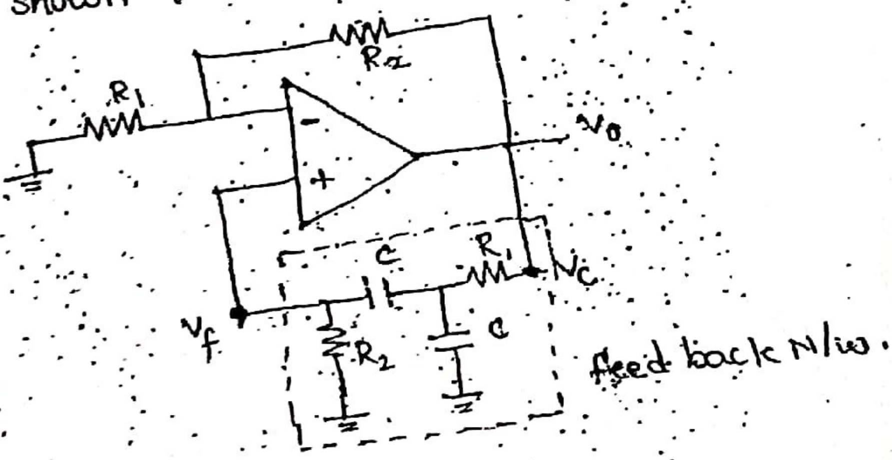
$$\therefore \boxed{A = -29}$$

$$A = +\frac{R_2}{R_1} = +29$$

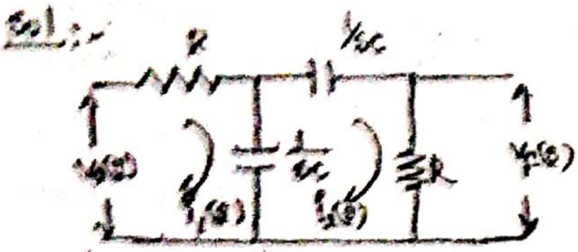
$$\boxed{R_2 = 29 R_1}$$

∴ Each RC N/w introduces 60° of phase in the above ckt.

1. calculate the freq of oscillations generated by the op-amp ckt shown & also calculate the Relation ship b/w R_1 & R_2.



Sol:-



$V_o(s) = I_1(s)\left[R + \frac{1}{sC}\right] - I_2(s)\frac{1}{sC}$ $\longrightarrow ①$

$0 = I_2(s)\left[\frac{2}{sC} + R\right] - I_1(s)\frac{1}{sC}$ $\longrightarrow ②$

from eq ②

$\frac{I_1(s)}{sC} = I_2(s)\left[R + \frac{2}{sC}\right]$

substitute $I_1(s)$ in eq ①

$I_1(s) = I_2(s)\left[sCR + 2\right]$

$V_o(s) = I_2(s)\left[sCR+2\right]\left[R + \frac{1}{sC}\right] - I_2(s)\frac{1}{sC}$

$= I_2(s)\left[sCR^2 + R + 2R + \frac{2}{sC} - \frac{1}{sC}\right]$

$= I_2(s)\left[sCR^2 + 3R + \frac{1}{sC}\right]$

$V_o(s) = \frac{I_2(s)}{sC}\left[s^2C^2R^2 + 3sCR + 1\right]$

But $V_f(s) = I_2(s)R$

$I_2(s) = \frac{V_f(s)}{R}$

$V_o(s) = \frac{V_f(s)}{sCR}\left[1 + 3sCR + s^2C^2R^2\right]$

$\frac{V_f(s)}{V_o(s)} = \left[\frac{sCR}{1 + 3sCR + s^2C^2R^2}\right]$

$T.F = \left[\frac{1}{3 + sCR + \frac{1}{sCR}}\right]$

Put $s = j\omega$

$\beta = \frac{1}{3 + j\omega CR - j\frac{1}{\omega CR}}$

$= \frac{1}{3 + j\left[\omega CR - \frac{1}{\omega CR}\right]}$

To get undamped oscillation the imaginary part of 'β' must be zero.

$\omega CR = \frac{1}{\omega CR}$

$\omega = \frac{1}{RC}$

$\boxed{f = \frac{1}{2\pi RC}}$

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

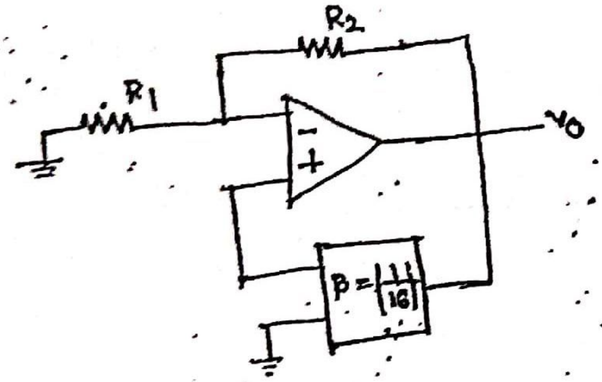
Gain of the Amp $A = \frac{1}{\beta}$

$\boxed{A = 3}$

$A = 1 + \frac{R_2}{R_1} = 3$

$\frac{R_2}{R_1} = 2$

$\boxed{R_2 = 2R_1}$

⇒ 

(a) $R_2 = 16R_1$

(b) $R_1 = 16R_2$

(c) $R_2 = 15R_1$

(d) $R_1 = 15R_2$

f = 2KHZ

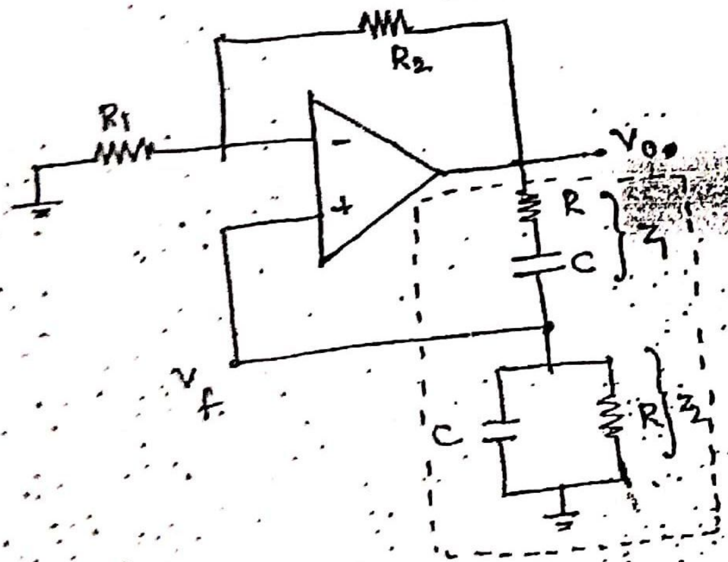
$A\beta = 1$

$\therefore A = \frac{1}{\beta} = \frac{1}{\frac{1}{16}} = 16.$

$A = 1 + \frac{R_2}{R_1} = 16.$

$\Rightarrow \frac{R_2}{R_1} = 15 \Rightarrow \boxed{R_2 = 15R_1}$

2. Wein Bridge oscillator:-



$Z_1 = R + \frac{1}{cs} = \left(\frac{1+sCR}{sc}\right)$

$Z_2 = \frac{R \cdot \frac{1}{cs}}{R + \frac{1}{cs}} = \left(\frac{RCS}{sCR+1}\right)$

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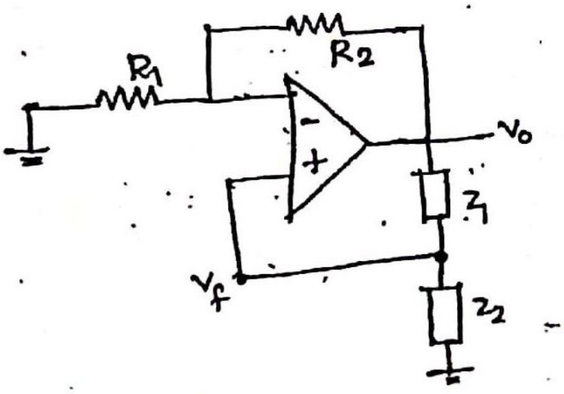


$$V_f(s) = V_o(s)\left[\frac{Z_2}{Z_1+Z_2}\right]$$

$$\frac{V_f(s)}{V_o(s)} = T\cdot F = \beta = \left(\frac{Z_2}{Z_1+Z_2}\right)$$

$$\beta = \frac{\frac{R}{1+sCR}}{\frac{1+sCR}{sC} + \frac{R}{1+sCR}}$$

$$\beta = \frac{\frac{R}{\cancel{1+sCR}}}{\frac{(1+sCR)^2+sCR}{\cancel{1+sCR}\,(sC)}} = \frac{sCR}{(1+sCR)^2+sCR}$$

$$= \frac{sCR}{1+s^2C^2R^2+2sCR+sCR}$$

$$= \frac{sCR}{1+s^2C^2R^2+3sCR}$$

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

* put $s = j\omega$

$$T\cdot F = \beta = \frac{1}{-j\frac{1}{\omega CR}+j\omega CR+3} = \frac{1}{3+j\left[\omega CR - \frac{1}{\omega CR}\right]}$$

To get undamped oscillations, the imaginary part 'β' must be zero.

$$\omega CR = \frac{1}{\omega CR}$$

$$\omega = \frac{1}{RC}$$

$$\boxed{f = \frac{1}{2\pi RC}}$$

feedback factor, $\beta = \frac{1}{3}$

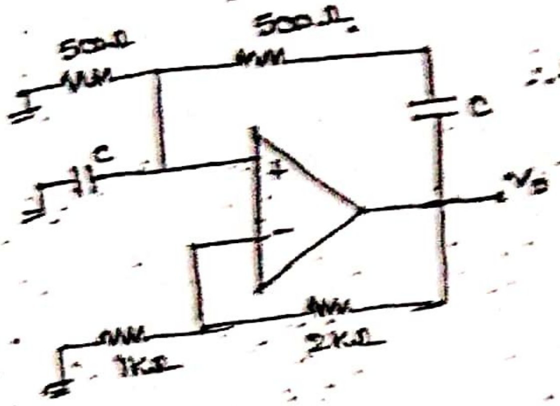
Gain of the Amp $A = \frac{1}{\beta}$

$$\boxed{A = 3}$$

$$A = 1+\frac{R_2}{R_1} = 3$$

$$\frac{R_2}{R_1} = 2 \Rightarrow \boxed{R_2 = 2R_1}$$

Pb:- The ckt shown



$\therefore f = 3\,kHz$

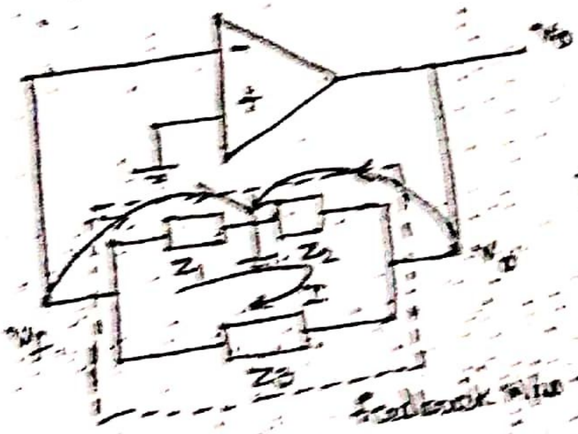
$f = \frac{1}{2\pi RC} \Rightarrow C = \frac{1}{2\pi f R}$

$= \frac{1}{2\pi \times 3 \times 10^{3} \times 500} = \frac{1}{3\pi}\,\mu F.$

LC oscillators:-

In LC oscillators, the feedback n/w consists Inductors & Capacitors only.

General form:-



Z_1 & Z_2 → same type elements (i.e L (or) C).

Z_3 → opposite type element (i.e C (or) L)

$\therefore V_f = IZ_1$

$V_o = -IZ_2$

The feed back factor, $\beta = \frac{V_f}{V_o} = \frac{IZ_1}{-IZ_2} \Rightarrow \boxed{\beta = \frac{-Z_1}{Z_2}}$.

The gain of the amp, $A = \frac{1}{\beta} = \frac{-Z_2}{Z_1} \Rightarrow \boxed{A = \frac{-Z_2}{Z_1}}$

for freq. of oscillations,

Apply KVL to feedback n/w

$0 - I(z_1 + z_2 + z_3) = 0$

$I(z_1 + z_2 + z_3) = 0$

To satisfy this condition,

$$\boxed{(z_1 + z_2 + z_3) = 0}$$

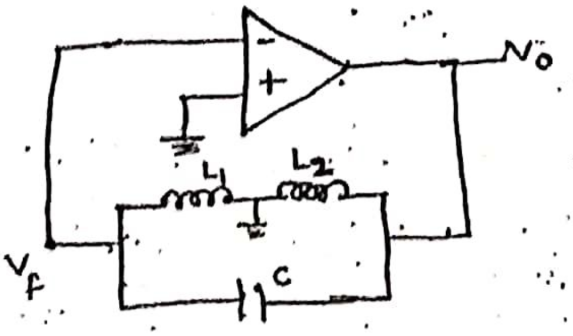
from this we get the freq of oscillations generated from the ckt.

1. <u>Hartely</u> <u>oscillator</u> :-

z_1 & z_2 $\rightarrow$ Inductors

z_3 $\rightarrow$ capacitor

$z_1 = j\omega L_1$, $z_2 = j\omega L_2$, $z_3 = \frac{1}{j\omega C} = \frac{-j}{\omega C}$.



$\rightarrow$ The feed back factor,

$$\beta = \frac{-z_1}{z_2} = \frac{-j\omega L_1}{j\omega L_2}$$

$$\boxed{\beta = \frac{-L_1}{L_2}} \quad \boxed{L_2 > L_1}$$

$\therefore \beta < 1$.

$\rightarrow$ The gain of the Amp. $A = \frac{1}{\beta} = \frac{-z_2}{z_1}$

$$\boxed{A = \frac{-L_2}{L_1}}$$

$\rightarrow$ for freq of oscillations.

$z_1 + z_2 + z_3 = 0$

$j\omega L_1 + j\omega L_2 - \frac{j}{\omega C} = 0$

$j\omega[L_1 + L_2] = \frac{j}{\omega C}$ $\quad$ $\omega^2 = \frac{1}{(L_1+L_2)C}$ $\Rightarrow \omega = \frac{1}{\sqrt{4C\,L_1 L_2}}$

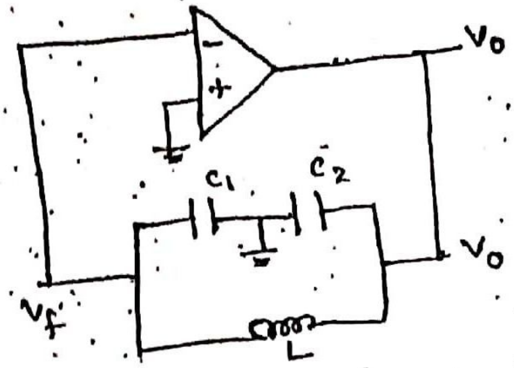
$\boxed{f = \frac{1}{\ldots}}$

2. Colpitts oscillator :-

Z_1 & Z_2 → capacitors

Z_3 → Inductor

$$Z_1 = \frac{1}{j\omega C_1}, \quad Z_2 = \frac{1}{j\omega C_2} \quad \& \quad Z_3 = j\omega L$$



→ The feed back factor, $\beta = \frac{-Z_1}{Z_2}$

$$\beta = -\frac{\frac{1}{j\omega C_1}}{\frac{1}{j\omega C_2}} = -\frac{j\omega C_2}{j\omega C_1} = \frac{-C_2}{C_1}$$

$$\boxed{\beta = \frac{-C_2}{C_1}} \quad \boxed{C_1 > C_2}$$

→ The gain of the Amp, $A = \frac{1}{\beta}$

$$\boxed{A = \frac{-C_1}{C_2}}$$

→ for freq of oscillations,

$$Z_1 + Z_2 + Z_3 = 0$$

$$\frac{-j}{\omega C_1} - \frac{j}{\omega C_2} + j\omega L = 0$$

$$\frac{-j}{\omega}\left[\frac{1}{C_1} + \frac{1}{C_2}\right] + j\omega L = 0$$

$$\cancel{j}\omega L = \frac{\cancel{j}}{\omega}\left[\frac{1}{C_1} + \frac{1}{C_2}\right]$$

$$\omega^2 L = \left[\frac{C_2 + C_1}{C_1 C_2}\right]$$

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

$$\omega = \frac{1}{\sqrt{L\left(\frac{C_1 C_2}{C_1 + C_2}\right)}}$$

$$f = \frac{1}{2\pi} \times \frac{1}{\sqrt{L\left(\frac{C_1 C_2}{\ldots}\right)}}$$

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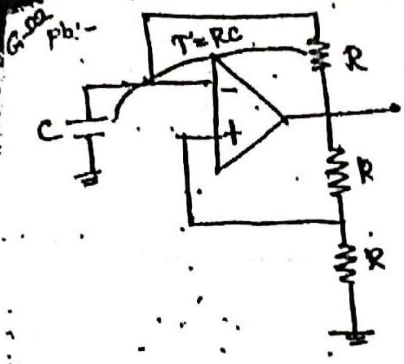
G.Q. pb:-



Calculate the Time period of oscillation generated by op-amp ckt?

(a) $\tau \ln 2$

(b) $2\tau \ln 2$

(c) $\tau \ln 3$

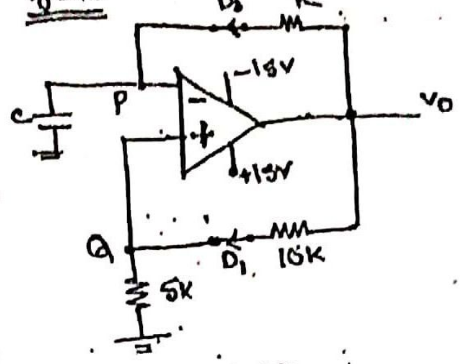
✓(d) $2\tau \ln 3$

Sol. $\tau = 2RC \ln\left(1+\frac{2R_2}{R_1}\right)$

$= 2RC \ln\left(1+\frac{2\cancel{R}}{\cancel{R}}\right)$

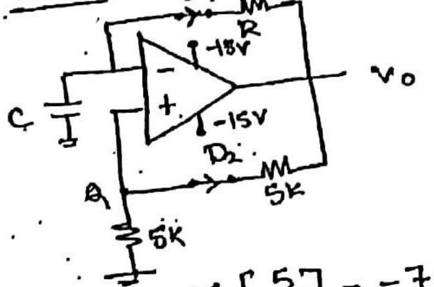
$= 2\tau \ln(3)$.

$V_0 = 15V$



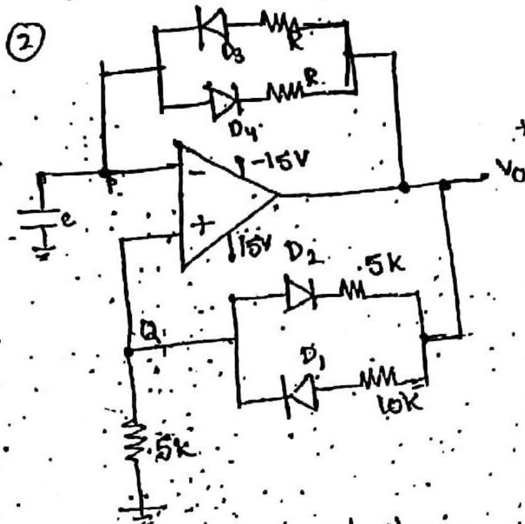
$V_Q = 15\left[\frac{5}{15}\right] = 5V$

$V_0 = -15V$



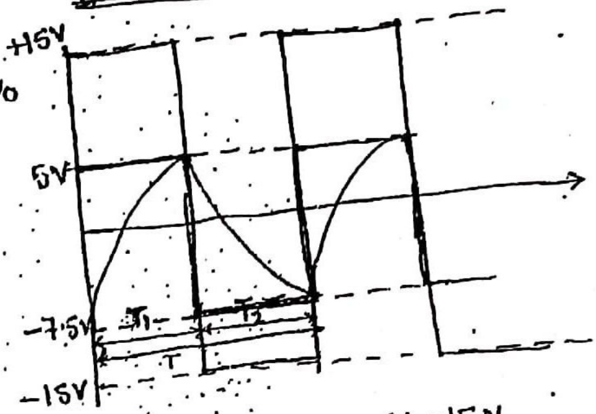
$V_Q = -15\left[\frac{5}{10}\right] = -7.5V.$

(2)



For the op-amp ckt shown draw the wave forms at P & Q & o/p. Calculate the freq of oscillations generated by this ckt Assume that $\tau = 0.1$ msec

o/p wave form:-



T_1:- $V_i = -7.5V$ $V_f = 15V$,

$\tau = RC$ at $t = T_1$ $V_c = 5V$

$5 = 15 + (-7.5-15)\, e^{-T_1/RC}$

$-10 = -22.5\, e^{-T_1/RC}$

$e^{T_1/RC} = \frac{22.5}{10} = 2.25$

$\boxed{T_1 = RC \ln(2.25)}$

$$A_{CL} = \frac{1+\frac{R_2}{R_1}}{1-\frac{j}{\omega RC}}$$ Replace $1+\frac{R_2}{R_1}$ with A_{max} and $\frac{1}{RC}$ with ω_c.

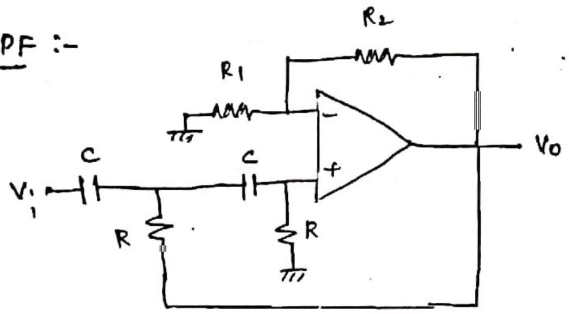
(121)

$$\Rightarrow A_{CL} = \frac{A_{max}}{1-j\frac{f_c}{f}}.$$

$$\boxed{|A_{CL}| = \frac{|A_{max}|}{\sqrt{1+\left(\frac{f_c}{f}\right)^2}}, \quad \angle A_{CL} = \tan^{-1}\left(\frac{f_c}{f}\right)}$$

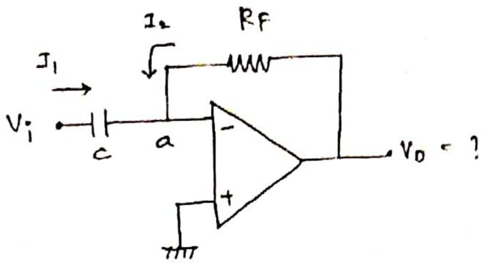
* $\boxed{f_c = \frac{1}{2\pi RC}}$

→ Second order HPF :-



Q. Design 2nd order active HPF having cutoff frequency 5 KHz ?

19. Differentiator :-



$V_a = 0$

KCL at a : $I_1 + I_2 = 0$

$$C \times \frac{d}{dt}(V_i - 0) + \frac{V_o - 0}{R_F} = 0$$

$$\Rightarrow \boxed{V_o = -CR_F \frac{dV_i}{dt}}$$

V_i	V_o
	(spikes)
Sine	Inverted Cosine.

Gain of Differentiator:-

$$A_{CL} = \frac{V_o}{V_i} = -\frac{Z_F}{Z}$$

$$Z_F = R_F, \quad Z = \frac{1}{SC}$$

$$\boxed{A_{CL} = \frac{-R_F}{\frac{1}{SC}} = -SR_FC.}$$ Transfer function of Differentiator.

put $S = j\omega$ we get

$$A_{CL} = -j\omega R_F C$$

$$A_{CL} = -j\frac{\omega}{\omega a} \quad \text{where} \quad R_F C = \frac{1}{\omega a}.$$

$$\Rightarrow \boxed{A_{CL} = -j\frac{f}{fa}}$$

$$\boxed{|A_{CL}| = \frac{f}{fa}, \quad \angle A_{CL} = -90^\circ \text{ or } 270^\circ}$$

At $f = fa \Rightarrow |A_{CL}| = 1$

fa is Unity gain frequency of differentiator.

$$\boxed{fa = \frac{1}{2\pi R_F C}}$$

If $f \to \infty$ then $|A_{CL}| \to \infty$

Due to infinite gain differentiator becomes Unstable at very high frequencies.

If input V_i is not applied, differentiator may become high frequency noise and may provide non-zero output which is Unwanted.

TO overcome this drawback of instablity or high frequency noise amplicatn, a resistor R can be Connected in Series with capacitor C. Such Circuit is Called practical Differentiator.