Transistor switching times :

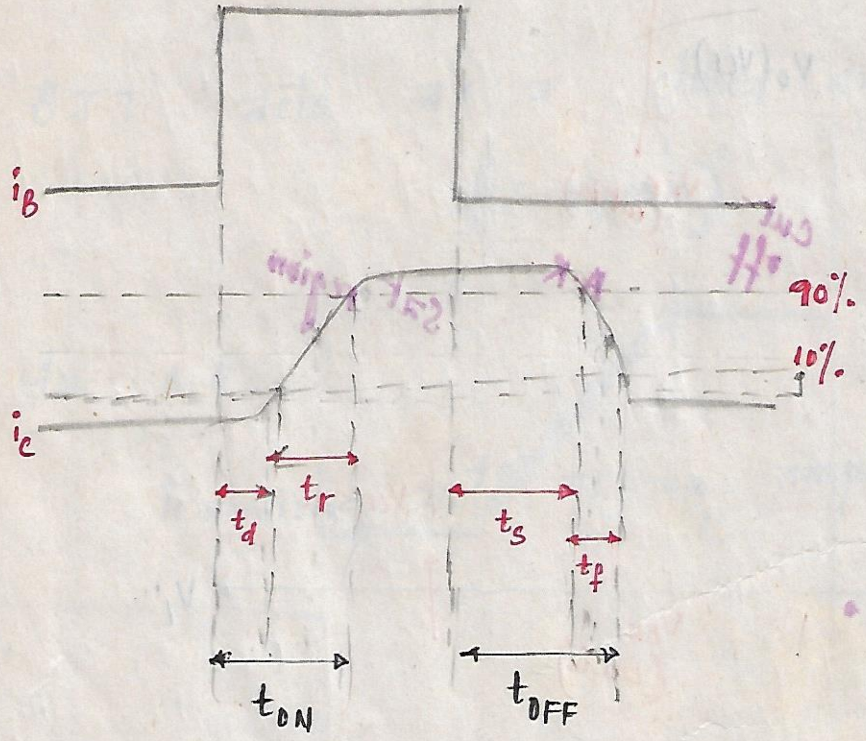
Int :

* Delay time : "t_d"

* Rise time : "t_r"

* storage time : "t_s"

* Fall time : "t_f"



Delay time (t_d) :

The time interval between the application of (i_B) and the commencement of (i_c). is called as "t_d".

Rise time (t_r) :

The time req for the (i_c) to rise from 10% to 90% of the maximum value is called "t_r"

storage time (t_s):

The time interval between the instant ($i_B = 0$) and the instant when (i_c) has fallen to 90% of it's max value is called "t_s".

Fall time (t_f):

The time required for the (i_c) to fall from (90% to 10%) of the max value is called "t_f".

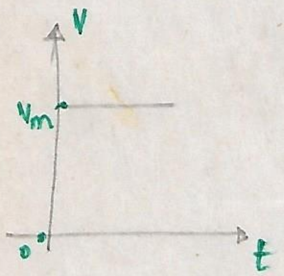
$$* \; t_{ON} = t_d + t_r$$

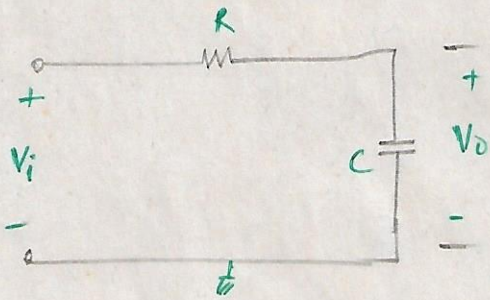
$$* \; t_{OFF} = t_s + t_f.$$

(2) * Linear wave shaping circuits : *

* time constant of R.C ckt :

Int :





Let, 'V_i' be the step input.

At $t=0$, i/p change's suddenly from (0 to V_m).

but, the cap oppose's sudden change in voltage's

$$V_c(t) = V_{fi} + (V_i - V_f)\, e^{-(t-t')/R.C}$$

* at t = 0 : *

$$V_i = 0 \quad , \quad V_f = V_m \quad , \quad t' = 0$$

$$V_c(t) = V_0 = V_m + (0 - V_m) \cdot e^{-(t-0)/R.C}$$

$$V_0 = V_m - V_m \cdot e^{-t/R.C}$$

$$V_0 = V_m\left(1 - e^{-t/RC}\right) \quad \text{--- (1)}$$

sub $t = RC$ in eq^n ①

$$V_0 = V_m (1 - e^{-1})$$

$$\boxed{\therefore V_0 = 0.632 V_m}$$

Note :

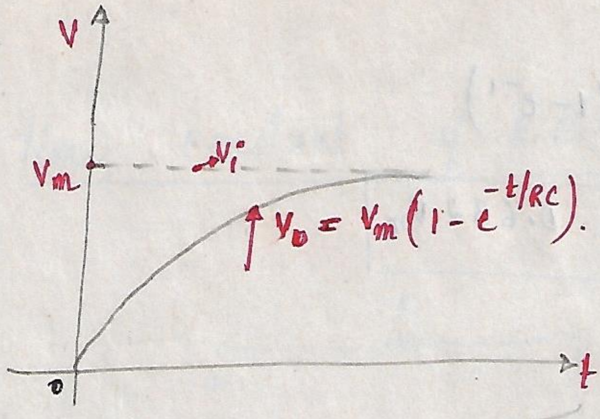
At $t = RC$, the voltage across the cap becomes equal to 63.2% of the final steady value

The product $R.C$ ⟶ time constant and is denoted by 'τ'.

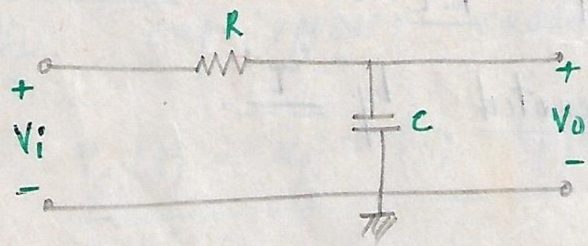
Imp: Time constant 'τ' for R.C circuit:

The 'τ' of R.C ckt is the time req for the output voltage (i.e., the voltage across the cap). to attain 63.2% of the final steady value.

plot from eq^n ① ...



Low pass R.C circuit :



$$'X_c' = \frac{1}{j\omega C}.$$

* For low freq... 'X_c' becomes high and hence, the total 'V_i' will appear across the cap (c)..

$$\boxed{\therefore V_0 \simeq V_i.}$$

* For high freq ... 'X_c' becomes low compared to 'R' and hence, the total 'V_i' will appear across 'R' and no voltage appear across 'C'.

$$\boxed{\therefore \; V_0 \simeq 0}$$

* This circuit produces output same as input for low freq, but it produces '0' output for high freq and hence, it is called as L.P R.C circuit.

Cal of Gain:

By using voltage division rule,

$$V_0 = \left[\frac{X_C}{X_C + R}\right] \cdot V_i$$

$$\frac{V_0}{V_i} = A = \left(\frac{X_C}{X_C + R}\right)$$

$X_C = \frac{1}{j\omega C}$ ... on sub..

$$A = \frac{1/j\omega C}{1/j\omega C + R}$$

$$A = \frac{1}{1 + j\omega RC}$$

$$A = \frac{1}{1 + j\omega/\omega_H}$$

where, "ω_H" $= \frac{1}{RC}$

$$\boxed{A = \frac{1}{1 + \frac{f}{f_H}}}$$

where, "f_H" $= \frac{1}{2\pi RC}$ (cut-off freq of LP RC ckt)

$$|A| = \frac{1}{\sqrt{1 + \left(\frac{f}{f_H}\right)^2}} \longrightarrow \text{mag of the gain}$$

$$\angle A = -\tan^{-1}\left[f/f_H\right] \longrightarrow \text{phase of the gain.}$$

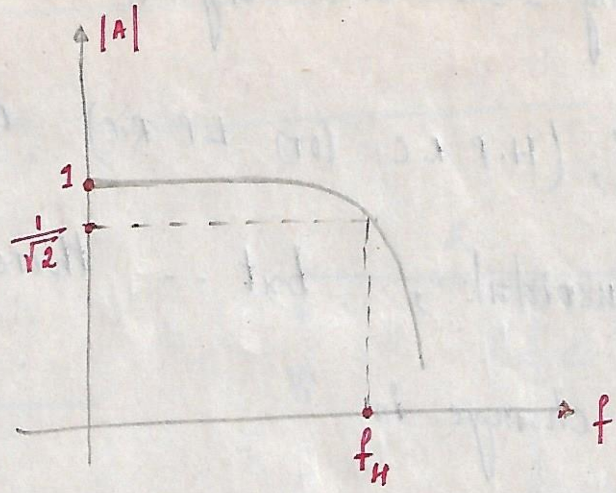
from the mag of gain ...

as $f \longrightarrow 0$, $|A| = 1$

$f \longrightarrow \infty$, $|A| = 0$

$f = f_H$, $|A| = 1/\sqrt{2}$.

plot :



Cut-off freq "$[f_H]$" of L.P R.C ckt :

If the freq at which the gain is $\frac{1}{\sqrt{2}}$ time's of max gain... is called cut-off freq.

100% sure

Response of L.P RC ckt * Imp for to the □re wave input : external.**

→ If we apply --- sin signal to the

L.W.S circuits, (H.P R.C (or) L.P R.C) . output

is also sinusoidal. , but -- there

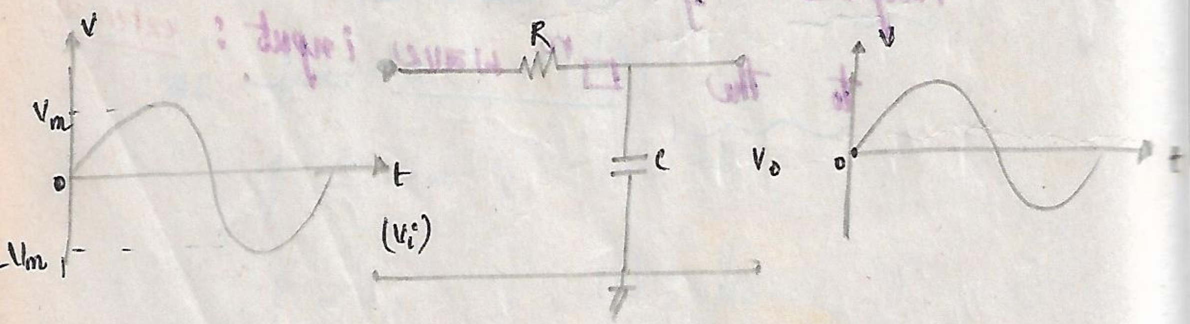
may be a change in ..

* Amplitude

* phase displacement b/w (input and output)

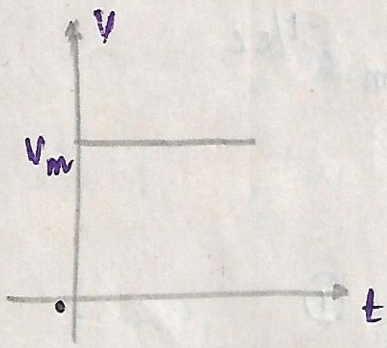
→ If we apply non- sin signal -- we get

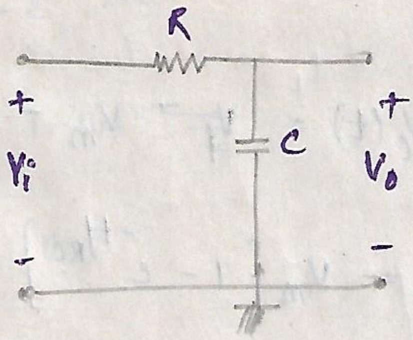
the distorted output--



Response of L.P. R.C circuit to the step input :

Imt:





At, $(t=0)$ ... V_i change's suddenly from $(0 - V_m)$ but, cap oppose's the sudden change's in vtg's. $\therefore$ V_o increase's gradually.

Cap vtg eq^n ...

$$V_o(t) = V_c(t) = V_f + (V_i - V_f)\, e^{-(t-t')/R.C} \quad \text{———} \; (*)$$

At $t = 0$ ..

$V_i = 0$

$V_f = V_m$

$t' = 0.$

sub the values of V_i, V_f and t ..

we get ...

$$V_0(t) = V_c(t) = \cancel{V_f} = V_m - V_m \cdot e^{-t/RC}$$

$$V_0(t) = V_m\left[1 - e^{-t/RC}\right] \quad \text{——— (1)}$$

Rise time (t_r):

The time taken by the output to increase from 10% to 90% of the final value

Let --

$V_0 = 0.1\, V_m$ at .. $t = t_1$

$V_0 = 0.9\, V_m$ at .. $t = t_2$

$$t_r = t_2 - t_1 \quad \text{——— (2)}$$

put -- $V_0 = 0.1\, V_m$ and $t = t_1$ in eq^n (1).

we get..

$$0.1 \cancel{V_m}(t) = \cancel{V_m}\left[1 - e^{-t_1/RC}\right]$$

$$0.1 = 1 - e^{-t_1/RC}$$

$$e^{-t_1/RC} = 1 - 0.1$$

$$e^{-t_1/RC} = 0.9$$

$$\frac{-t_1}{RC} = \ln(0.9)$$

$$\frac{\cancel{-}t_1}{R.C} = \cancel{-}0.1$$

$$\therefore \; t_1 = 0.1 R.C \quad \text{③}$$

put.. $V_0 = 0.9 V_m$ and $t = t_2$ in eq^n ①..

we get..

$$0.9 \cancel{V_m} = \cancel{V_m}\left[1 - e^{-t_2/RC}\right]$$

$$0.9 = 1 - e^{-t_2/R.C}$$

$$e^{-t_2/RC} = 1 - 0.9$$

$$e^{-t_2/R.C} = 0.1$$

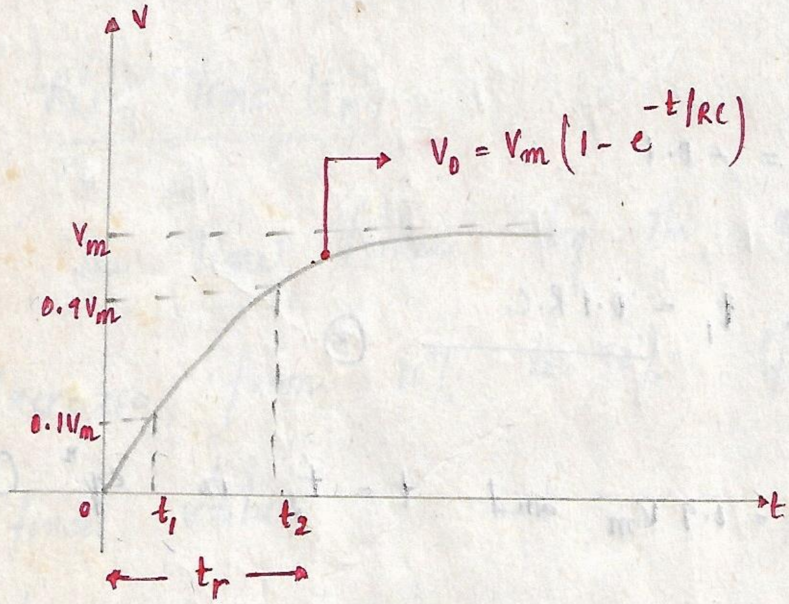
$$\frac{-t_2}{R.C} = \ln(0.1)$$

$$\cancel{-}\frac{t_2}{R.C} = \cancel{-}2.30$$

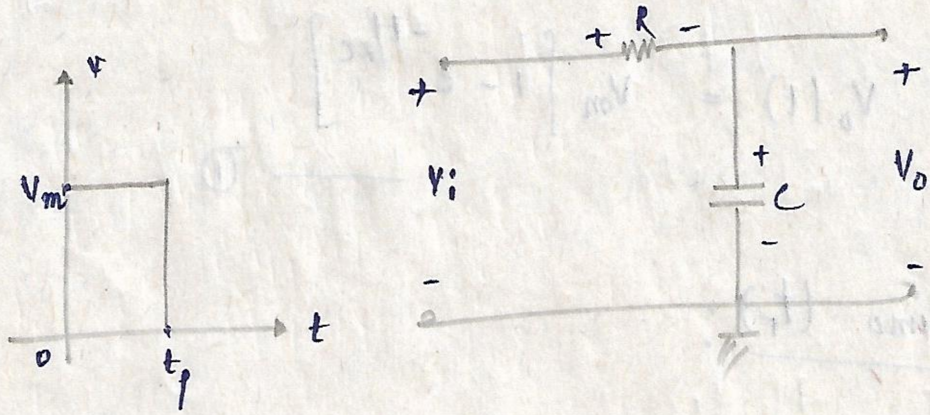
$$\therefore \quad t_2 = 2.2\,RC$$

$$\boxed{\Rightarrow t_r = 2.2 \cdot RC}$$

Response :



Responce of L.P R.C circuit to the pulse input :



At, $(t=0)$ ... V_i change's suddenly from $(0 - V_m)$, but cap oppose's sudden change in vtg. $\therefore$ V_0 inc gradually

Cap vtg eq^n ...

$$V_0(t) = V_c(t) = V_f + (V_i - V_f)e^{-(t-t')/R.C} \quad \text{—— } (*)$$

At ... $t = 0$ ...

$V_i = 0$

$V_f = V_m$

$t' = 0$

sub the values of V_i, V_f and t'

in eq^n (*) ... we get ..

$$V_o(t) = V_m - V_m \cdot e^{-t/RC}$$

$$V_o(t) = V_m \left[1 - e^{-t/RC}\right] \quad \text{---} \ (1)$$

<u>Rise time (t_r)</u> :

Let ..

$V_o = 0.1\ V_m$ at $t = t_1$

$V_o = 0.9\ V_m$ at $t = t_2$

$$\therefore \ t_r = t_2 - t_1 \quad \text{---} \ (2)$$

put $V_o = 0.1\ V_m$ and $t = t_1$ in eq^n (1) ..

$$0.1\ \cancel{V_m} = \cancel{V_m}\left[1 - e^{-t_1/RC}\right]$$

$$0.1 = 1 - e^{-t_1/RC}$$

Case - 2 :

At, $(t = t_p)$ . ..

Here, V_i change's.. suddenly from..
$(V_i$ to $0)$ but, cap opp the sudden
change in vtg's. ∴ V_o dec gradually..

At, $(t = t_p)$ ...

$V_i = V_m$

$V_f = 0$

$t' = t_p$

sub the value's in the exp..

$$V_o(t) = V_c(t) = V_f + (V_i - V_f)\, e^{-(t-t')/RC}$$

$$V_o(t) = V_m \left[e^{-(t-t_p)/RC} \right] \quad \text{--- (6).}$$

Fall time : (t_f)

The time taken by the output to fall from 90% to 10% of final value

Let --

$V_o = 0.9\, V_m$ at $t = t_3$

$V_o = 0.1\, V_m$ at $t = t_4$ ..

$$\therefore t_f = t_4 - t_3 \quad \text{------} \quad (7)$$

put, $V_o = 0.9 V_m$ and $t = t_3$ in eq^n (6) ---

we get,

$$0.9\, \cancel{V_m} = \cancel{V_m} \left[e^{-(t_3 - t_p)/R.C} \right]$$

$$0.9 = \left[e^{-(t_3 - t_p)/R.C} \right]$$

$$0.9 = \left[e^{-t_3/R.C} \right]$$

$$e^{-t_3/R.C} = 0.9$$

$$-t_3/_{R.C} = \ln(0.9)$$

$$\frac{\cancel{-}t_3}{R.C} = \cancel{-}0.1$$

$$\therefore t_3 = 0.1 RC + t_p \quad \text{------} \quad (8)$$

put, $V_0 = 0.1\ V_m$ and $t = t_4$ in eq^n

we get ...

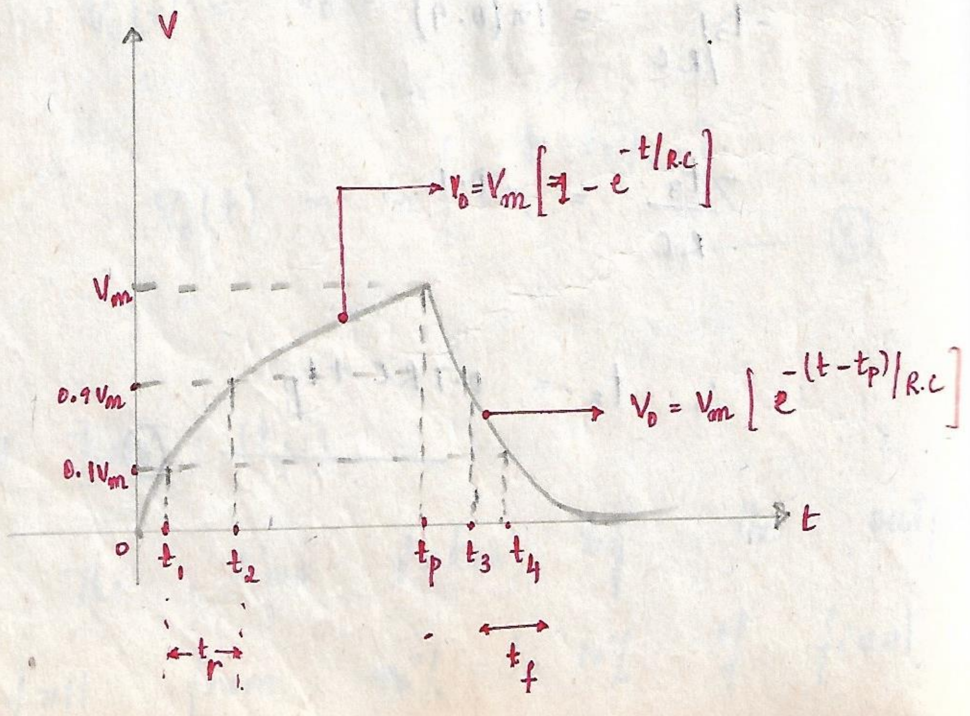
$$t_4 = 2.3\ R.C + t_p \quad (9)$$

sub (8) and (9) in eq^n (7) ...

we get ...

$$\boxed{t_f = 2.2\ R.C}$$

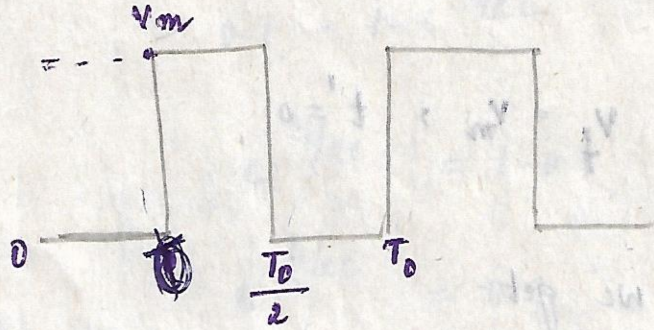
Response :



Responce of LP R.C circuit to the square wave input :

V.V. V.V. V.V. V Imp 100% ***** sure

Int :



Consider, input to a $\square^{re}$ wave varying from $(0-V_m)$ with 50% duty cycle.

Case - (i)

If $\left(0 < t < \frac{T_0}{2}\right)$.

At $t = 0$ .. (V_i) change's suddenly from $(0 - V_m)$, but cap opp the sudden change in the voltage. ∴ $(V_0)\uparrow$ gradually.

cap vtg eq^n...

$$V_0(t) = V_c(t) = V_f + (V_i - V_f) \cdot e^{-(t-t')/RC}$$

at $(t=0)$ ...

$V_i = 0$; $V_f = V_m$, $t' = 0$

on sub... we get...

$$V_0 = V_m\left[1 - e^{-t/RC}\right] \quad \text{—— (1)}$$

Rise time (t_r)

The time req for (or) by the output to inc from 10% to 90% of the max value.

Let,

$V_0 = 0.1\, V_m$ at $t = t_1$

$V_0 = 0.9\, V_m$ at --- $t = t_2$

$$t_r = t_2 - t_1 \quad \text{—— (2)}$$

put $V_0 = 0.1 V_m$ and $t = t_1$ in eq^n - ① ..

we get ....

$$0.1 \cancel{V_m}(t) = \cancel{V_m}\left[1 - e^{-t_1/RC}\right]$$

$$0.1 = 1 - e^{-t_1/RC}$$

$$e^{-t_1/RC} = 1 - 0.1$$

$$e^{-t_1/RC} = 0.9$$

$$\frac{-t_1}{RC} = \ln(0.9)$$

$$\frac{\cancel{-}t_1}{RC} = \cancel{-}0.1$$

$$\therefore \; t_1 = 0.1RC \quad \text{③}$$

put $V_0 = 0.9 V_m$ and $t = t_2$ in eq^n

① .. we get ...

$$0.9\cancel{V_m} = \cancel{V_m}\left[1 - e^{-t_2/R.C}\right]$$

$$0.9 = 1 - e^{-t_2/RC}$$

$$e^{-t_2/RC} = 1 - 0.9$$

$$e^{-t_2/RC} = 0.1$$

$$\frac{-t_2}{R.C} = \ln(0.1)$$

$$\frac{+t_2}{RC} = +2.30$$

$$\therefore t_2 = 2.2R \cdot C$$

$$\boxed{\Rightarrow t_r = 2.2 RC}$$

<u>case - 2</u> :

at $t = \frac{T_0}{2}$ ... (V_i) change's suddenly from $(V_m$ to $0)$, but cap the sudden change in vtg.: (V_0) gradually

In the interval, $\left(\frac{T_0}{2} < t < T_0\right)$ ..

$V_i = V_m$, $V_f = 0$, $t' = \frac{T_0}{2}$

on sub .. we get ...

$$V_0 = V_m\left[e^{-\left(t - \frac{T_0}{2}\right) / RC}\right] \quad \text{—— (4)}$$

<u>Fall time (t_f)</u> :

The time taken by the output

to fall from 90% to 10% of the max value

Let ... $V_0 = 0.9\, V_m$ at $t = t_3$ ...

$V_0 = 0.1\, V_m$ at $t = t_4$ ...

$\therefore\ t_f = t_4 - t_3$ ——— (5)

put, $V_0 = 0.9\, V_m$ and $t = t_3$ in eq^n ... (4) ..

we get,

$$0.9\, V_m = V_m \left[e^{-(t_3 - \frac{T_0}{2}) / RC} \right]$$

$$0.9 = \left[e^{-(t_3 - \frac{T_0}{2}) / R.C} \right]$$

$$0.9 = \left[e^{-t_3 / R.C} \right]$$

$$e^{-t_3/RC} = 0.9$$

$$\frac{-t_3}{R.C} = \ln(0.9)$$

$$\frac{\cancel{-}t_3}{RC} = +0.1$$

$$\therefore\ t_3 = 0.1\, R_C + \frac{T_0}{2}$$

——— (6)

put, $V_o = 0.1\,V_m$ and $t = t_4$ ... in eq^n

we get ..

$$t_4 = 2.3\,R.C + \frac{T_o}{2} \quad (7)$$

sub.. eq^n (6) & (7) in eq^n (5) ..

we get

$$\boxed{t_f = 2.2.\,RC}$$

Note :

$t_r = t_f = 2.2.RC$

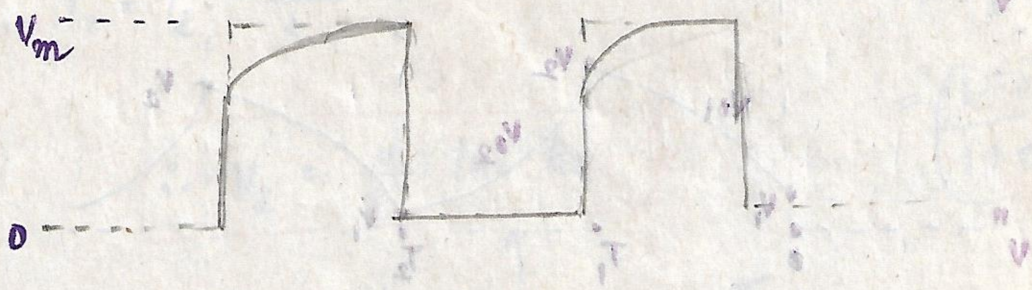
$t_r = t_f \propto R.C$

[If Rc is much smaller, $V_o \uparrow$ rapid

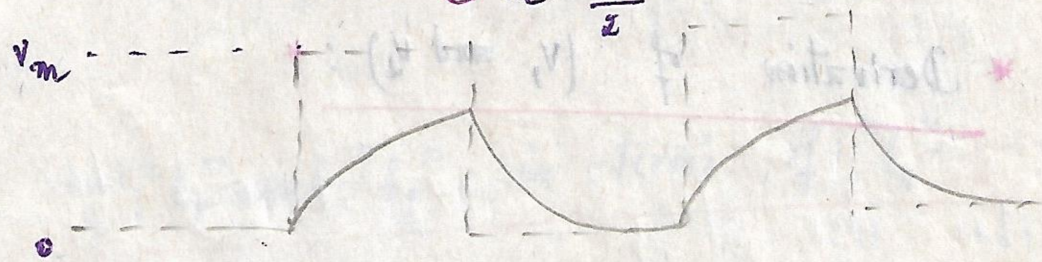
from $(0 - V_m)$.]

Response :

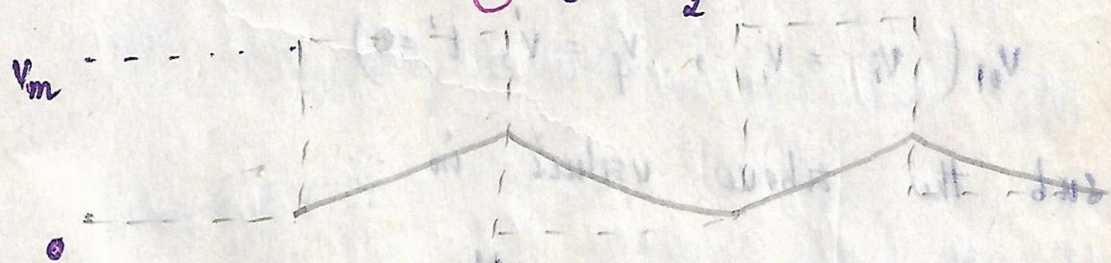
① $R_C << \frac{T_0}{2}$

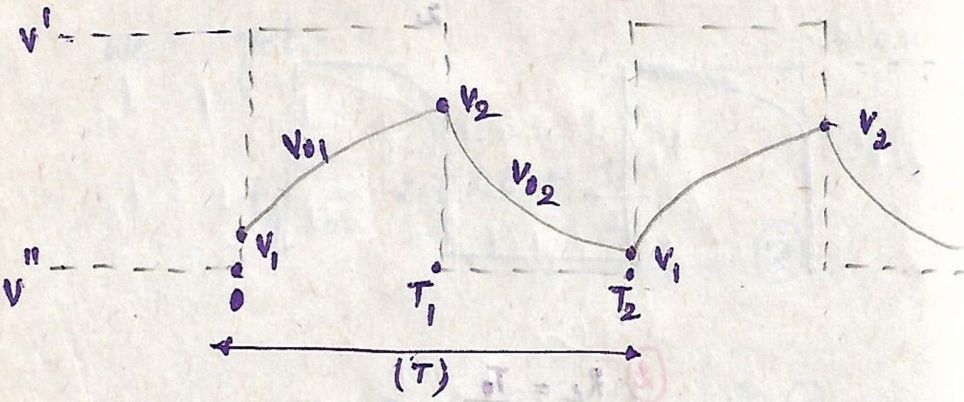


② $R_C = \frac{T_0}{2}$



③ $R_C >> \frac{T_0}{2}$





* Derivation of (V_1 and V_2) : *

$V_{01} = ?$

$V_{01}(\ V_i = V_1\ ,\ V_f = V',\ t' = 0)$

sub the above value's in ..

$$V_{01} = V' + (V_1 - V')\,e^{-t/RC}$$

$V_{02}(\ V_i = V_2\ ,\ V_f = V''\ ,\ t' = T_1)$

sub the value's in ...

$$V_{02} = V'' + (V_2 - V'')\,e^{-(t-T_1)/RC}$$

we can also say that ...

$$V' = -V'' = \frac{V}{2}$$

$V_2 = -V_1$; $V_1 = -V_2$.

$$\tanh x = \frac{e^x - e^{-x}}{e^x + e^{-x}} = \left(\frac{1-e^{-2x}}{1+e^{-2x}}\right)$$

$T_1 = T_2 = \frac{T}{2}$.

$$\boxed{\therefore V_2 = \frac{V}{2} \tanh x.}$$ * * *

cal... (V_1 and V_2). $x = \frac{T}{4RC}$

"t_r" and "t_f" in terms of "f_H" :

w.k.t ..

$$t_r = t_f = 2.2\,R.C$$

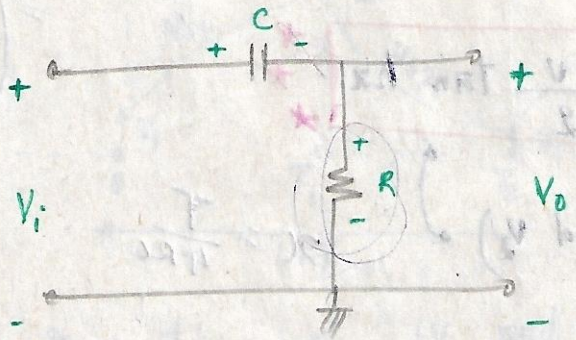
w.k.t ..

$$f_H = \frac{1}{2\pi RC} \implies R.C = \frac{1}{2\pi f_H}.$$

$$t_r = t_f = \frac{2.2}{2\pi f_H}$$

$$\boxed{t_r = t_f = \frac{0.35}{f_H}}$$ * * *

* * High pass R.C circuit : * *



→ For low freq... (X_c) becomes hig[h] compared to (R). ∴ the total (V_i) will appear across (C) and there is no vtg across (R). $\boxed{\therefore V_0 \simeq 0}$

→ For high freq... (X_c) becomes lo[w] compared to (R). ∴ the total (V_i) will appear across (R)

$\boxed{\therefore V_0 \simeq V_i}$

→ ~~For high freq~~, this circuit produce's output same as input for high freq, but it produce's zero output for low freq. Hence, this circuit is called as H.P R.C circuit.

Calculation of Gain: (A) = ?

By using vtg. division rule, ...

$$V_0 = \left[\frac{R}{X_c + R}\right] \cdot V_i$$

$$V_0 = \left[\frac{R}{R + \frac{1}{j\omega C}}\right] \cdot V_i$$

$$A = \frac{V_0}{V_i} = \frac{\cancel{R}}{\cancel{R}\left(1 + \frac{1}{j\omega RC}\right)}$$

$$A = \frac{1}{1 + \frac{\omega_L}{+j\omega}}$$

where, $\omega_L = \frac{1}{R.C}$

$$f_L = \frac{1}{2\pi RC}$$

$$A = \frac{1}{1 + \frac{f_L}{jf}}$$

$$\therefore \quad A = \frac{1}{1 - j\frac{f_L}{f}}$$

$$|A| = \frac{1}{\sqrt{1 + \left(\frac{f_L}{f}\right)^2}} \longrightarrow \text{mag of gain}$$

$$\angle A = \tan^{-1}\left[\frac{f_L}{f}\right] \longrightarrow \text{phase of gain}$$

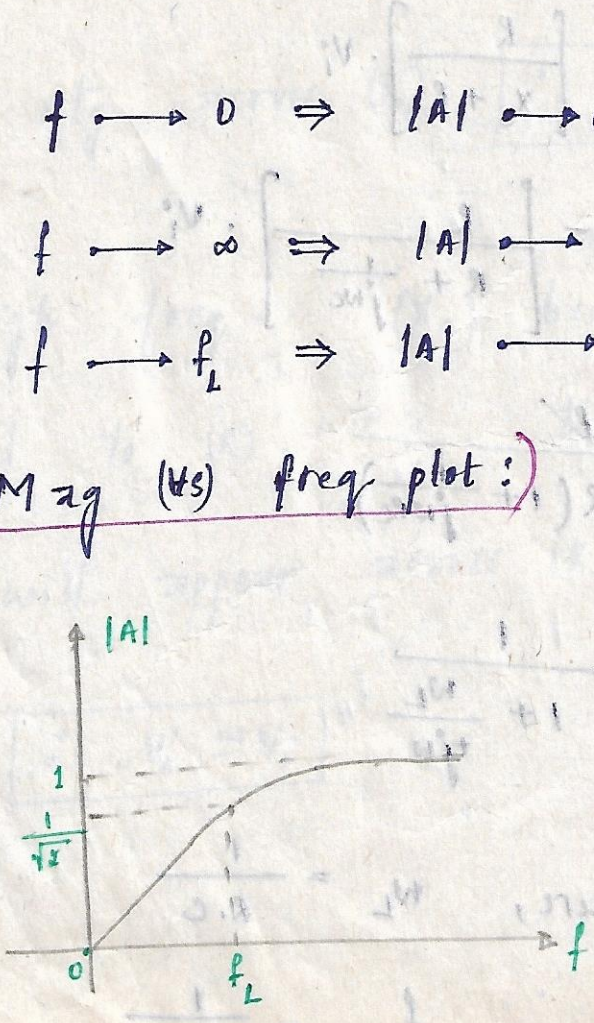
As,

$f \longrightarrow 0 \Rightarrow |A| \longrightarrow 0$

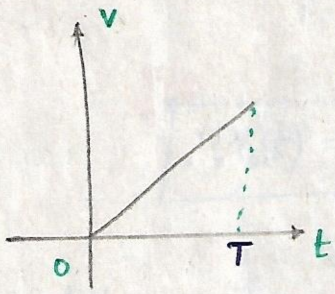
$f \longrightarrow \infty \Rightarrow |A| \longrightarrow 1$

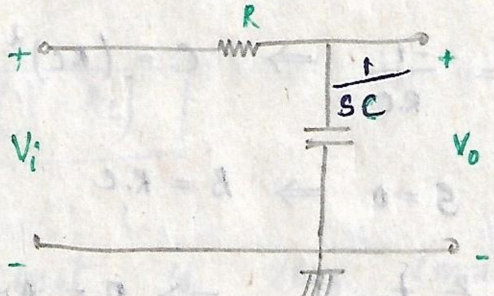
$f \longrightarrow f_L \Rightarrow |A| \longrightarrow \frac{1}{\sqrt{2}}$

(Mag (vs) freq plot :)



Response of L.P R.C circuit to the Ramp input :





Math rep of ramp input ..

$$V_i(t) = \alpha t \quad ; \quad V_i(S) = \frac{\alpha}{S^2}.$$

By using voltage division rule ...

$$V_0(S) = \left(\frac{\frac{1}{S.C}}{\left(R + \frac{1}{S.C}\right)}\right) . V_i(S)$$

$$V_0(S) = \left[\frac{1}{1 + R.S.C}\right] . \frac{\alpha}{S^2}$$

$$= \frac{\alpha}{R.C}\left[\frac{1}{S^2\left(S + \frac{1}{R.C}\right)}\right]$$

P.F ...

$$V_0(S) = \frac{\alpha}{R.C}\left[\frac{A}{S} + \frac{B}{S^2} + \frac{C}{\left(S + \frac{1}{R.C}\right)}\right]$$

A = ? ; B = ? ; C = ?

$$V_0(s) = \frac{\alpha}{R.C}\left[\frac{A}{s} + \frac{B}{s^2} + \frac{C}{\left(s+\frac{1}{RC}\right)}\right]$$

$$1 = A.s\left(s+\frac{1}{R.C}\right) + B.\left(s+\frac{1}{R.C}\right) + Cs^2$$

$$s = \frac{-1}{R.C} \Rightarrow C = (RC)^2$$

$$s = 0 \Rightarrow B = R.C$$

s^2 terms $\Rightarrow 0 = A + C$

$$\Rightarrow A = -C = -(R.C)^2$$

$$V_0(s) = \frac{\alpha}{RC}\left[\frac{-(RC)^2}{s} + \frac{R.C}{s^2} + \frac{(RC)^2}{\left(s+\frac{1}{R.C}\right)}\right]$$

$$V_0(s) = \frac{-\alpha.R.C}{s} + \frac{\alpha}{s^2} + \frac{\alpha R.C}{\left(s+\frac{1}{R.C}\right)}$$

Now:

Applying inverse lap. transform on b.s..

we get,

$$V_0(t) = -\alpha R.C + \alpha t + \alpha R.C\, e^{-t/R.C}$$

$$\left[\because e^{-x} = 1 - \frac{x}{1!} + \frac{x^2}{2!} - \frac{x^3}{3!} + \frac{x^4}{4!} - \frac{x^5}{5!} + \cdots\cdots\right]$$

→ If time const R.C is very small..

we can neglect the expo. term

i.e., $e^{-t/RC} \simeq 0$.

$$\boxed{\therefore V_0(t) = \alpha\,(t - RC)}$$

→ When time const is very small relative to the total ramp time "T", the ramp will be transmitted with min distortion..

→ The output follow's the input, but it is delayed by 1 time const from the input.

→ If the time const is large compared with (T) . . . i.e., $\frac{RC}{T} >> 1 \Rightarrow \frac{RC}{T} >> 1$.

→ If $V_0(t) = \alpha(t - R.C) + \alpha . RC\, e^{-t/RC}$

$$= \alpha\,(t - R.C) + \alpha . RC \left[1 - \frac{t}{R.C} + \frac{(t/RC)^2}{2!} - \frac{(t/RC)^3}{3!} + \dots\right]$$

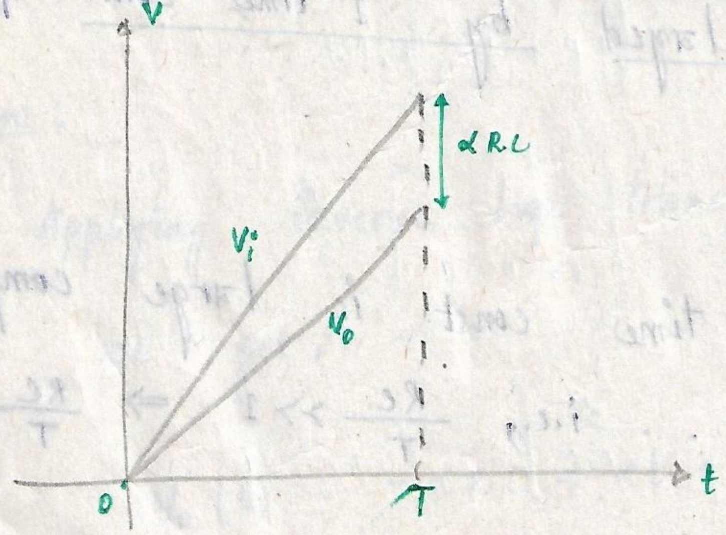
If $\therefore$ ($RC >> T$) $\therefore$ we can neglect the higher order term's ...

$$= \alpha(t - R.C) + \alpha \cdot R \cdot C \left[1 - \frac{t}{R.C} + \frac{t^2}{2(R.C)^2}\right]$$

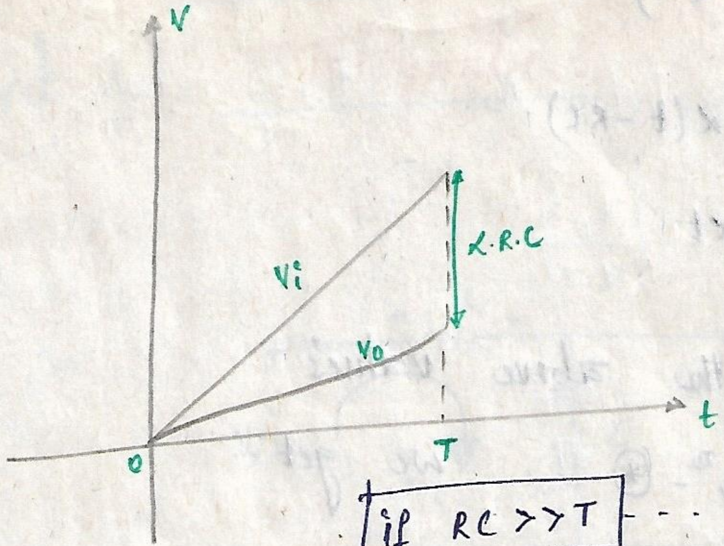
$$= \cancel{\alpha t} - \alpha R.C + \alpha R.C - \cancel{\alpha t} + \frac{\alpha t^2}{2R.C}$$

$$\boxed{\therefore \; V_0(t) = \frac{\alpha t^2}{2 \cdot RC}}$$

Response:



$\boxed{\text{if } RC << T}$ ..



$\boxed{\text{if } RC >> T}$ ...

Transmission Errors (e_t)

Int: It is defined as, the ratio of the diff between input and output to the input at the end of the ramp $(t = T)$.

Mathematically ...

$$e_t = \left. \frac{V_i - V_o}{V_i} \right|_{t = T}$$

(*)

If .. $(RC << T)$ ...

$$V_o(t) = \alpha(t - R.C) \cdots$$

$$V_i(t) = \alpha t$$

on sub the above value's in eq^n - (*) .. we get ..

$$e_t = \frac{\cancel{\alpha t} - \alpha(t-RC)}{\cancel{\alpha t}}$$

$$e_t = \frac{\cancel{\alpha t} - \cancel{\alpha t} + \alpha RC}{\alpha t} = \frac{\cancel{\alpha} RC}{\cancel{\alpha} t}$$

$$\boxed{\therefore\ e_t = \frac{RC}{T}}$$

(e_t) in terms of (f_H) ..!.

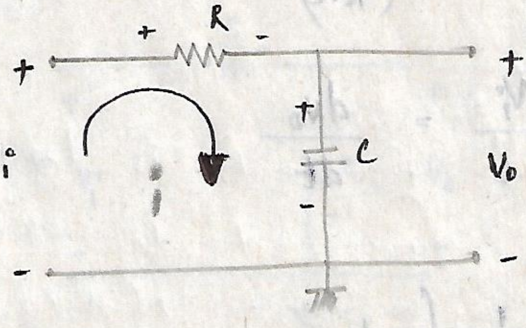
w.k.t ...

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

$$\boxed{e_t = \frac{RC}{2\pi f_H T}}$$

LP R.C circuit as an integrator :

Int



applying K.V.L .. $V_0 = \frac{1}{C}\int i\,dt$

we get .. $\boxed{i \propto \int V_i\,dt} \quad i = C\frac{dV_0}{dt}$

$$-V_i + iR + V_0 = 0$$

$$V_i = R.C.\frac{dV_0}{dt} + V_0$$

$$\frac{V_i}{R.C} = \frac{dV_0}{dt} + \frac{V_0}{R.C}$$

$$V_0 = \frac{1}{C}\int i\,dt$$

$$i = C.\frac{dV_0}{dt}$$

$\left(\frac{dV_0}{dt}\right) \longrightarrow$ transient response

$\left(\frac{V_0}{RC}\right) \longrightarrow$ steady state response.

If T.C R.C is very high ...

we can neglect the steady state

response i.e., $\left(\frac{V_o}{R.C}\right)$

$$\therefore \frac{V_i}{R.C} = \frac{dV_o}{dt}$$

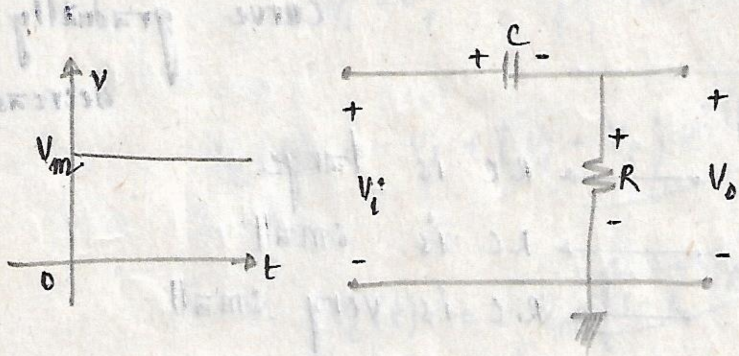
$$V_o = \frac{1}{R.C}\int V_i\,dt$$

$$\boxed{V_o \propto \int V_i\,dt}$$

$\therefore$ L.P R.C circuit, with R.C >> Pulse width

is called as "R.C" integrator"

Int: **Response of H.P R.C ckt to the step input :**



appling K.V.L to the loop...

we get...

$$-V_i + V_c + V_o = 0$$

$$V_o = V_i - V_c \ldots$$

at.. $t = 0$ ...

$V_i = 0$ | $V_c(t) = V_f + (V_f - V_i) \cdot e^{-(t-t')/RC}$

$V_f = V_m$

$t' = 0$

$$V_c(t) = V_m\left[1 - e^{-t/RC}\right] \quad \text{①}$$

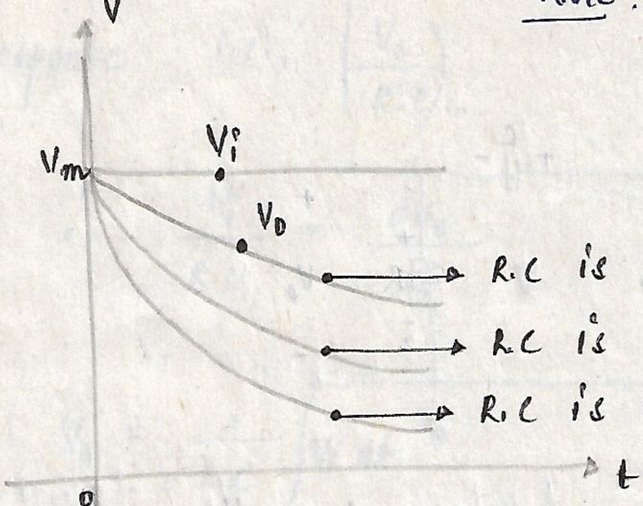
at, $t = 0$; $V_i = V_m$ and $V_c = V_m\left[1 - e^{-t/RC}\right]$

$$V_o = V_m - V_m\left(1 - e^{-t/R.C}\right)$$

$$V_o = \cancel{V_m} - \cancel{V_m} + V_m \cdot e^{-t/R.C}$$

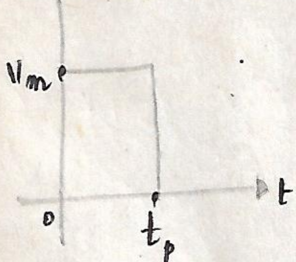
$$\boxed{\therefore V_o(t) = V_m \cdot e^{-t/RC}}$$

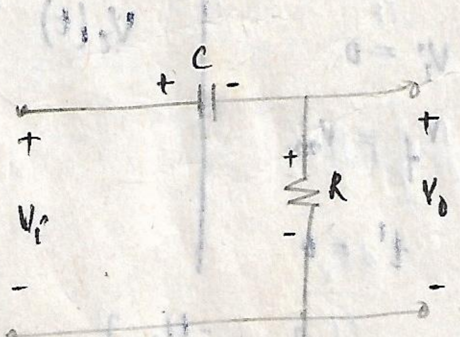
Response :



Note : Here, the output curve gradually decreases

Response of H.P R.C ckt to the pulse input :





applying K.V.L to the loop ..

we get ...

$$-V_i + V_c + V_0 = 0$$

$$V_0 = V_i - V_c \ldots$$

at, $t = 0 : \ldots$

$$V_i = 0; \quad V_f = V_m; \; t' = 0$$

$$V_c(t) = V_f + (V_i - V_f)\, e^{-(t-t')/RC}$$

$$\therefore V_c(t) = V_m\left[1 - e^{-t/RC}\right].$$

at, $t = 0 \ldots$

$$V_i = V_m$$

$$V_c = V_m\left[1 - e^{-t/RC}\right]$$

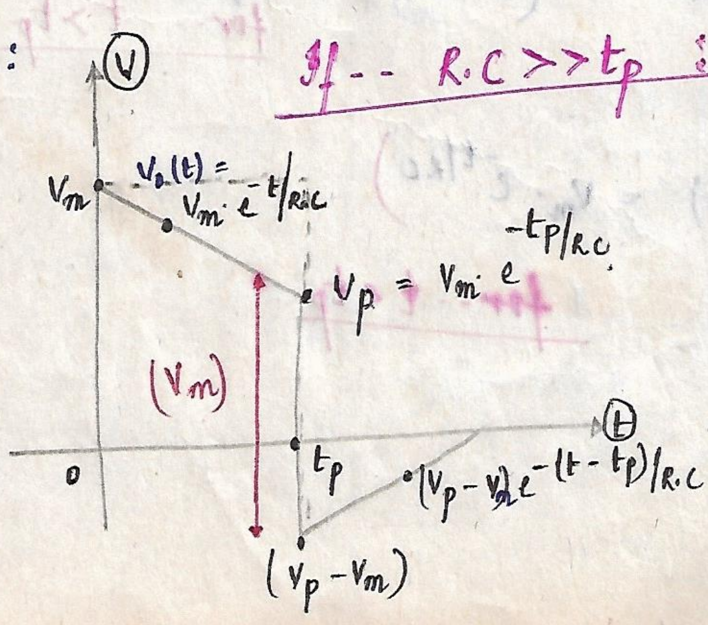
$$V_0 = V_m - V_m\left[1 - e^{-t/RC}\right]$$

$$V_0 = \cancel{V_m} - \cancel{V_m} + V_m e^{-t/RC}$$

$$\boxed{\therefore V_0(t) = V_m e^{-t/RC}}$$

Response :

If -- $R.C >> t_p$:



* At, $\underline{t = t_p}$ ---- $\underline{V_o(t) = V_p = V_m \cdot e^{-t_p/RC}}$.

* At, $\underline{t = t_p}$ ..... $\because$ the input fall's by V_m (v) suddenly and $\because$ the voltage across the cap (V_o) can not change instantaneusly, the output also fall's suddenly from $(V_p - V_m)$.

* For $(t > t_p)$ --- the output rise's exponentially toward's zero with a T.C $\rightarrow$ R.C

$$\therefore V_o = (V_p - V_m)\, e^{-(t-t_p)/R.C}$$

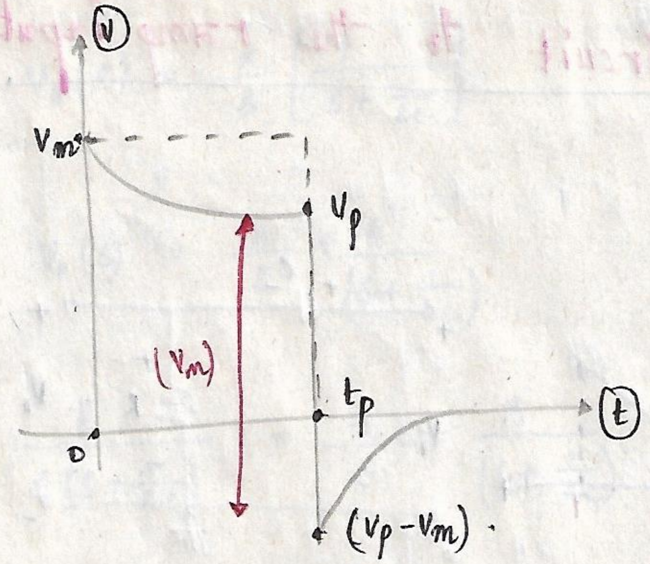
$$\left(\therefore V_o(t) = \left(V_m \cdot e^{-t/RC} - V_m\right) e^{-(t-t_p)/R.C}\right)$$

for.. $t > t_p$

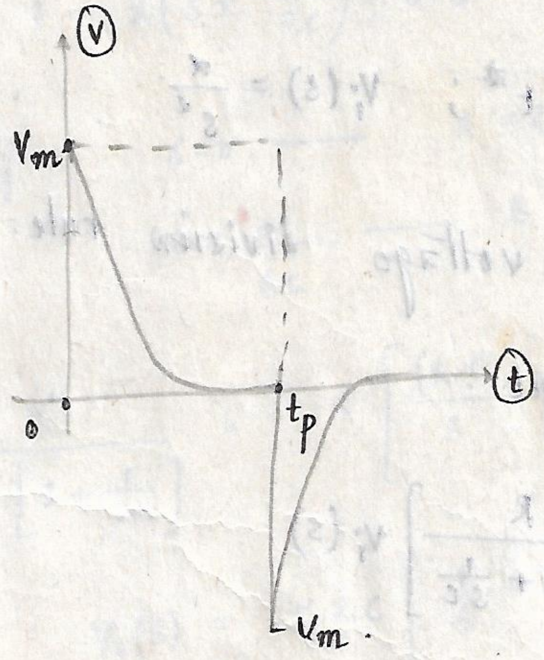
$$\left(\therefore V_o(t) = V_m \cdot e^{-t/RC}\right)$$

for.. $t < t_p$

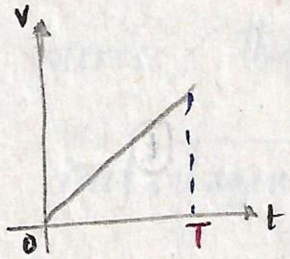
If $R.C \simeq t_p$:

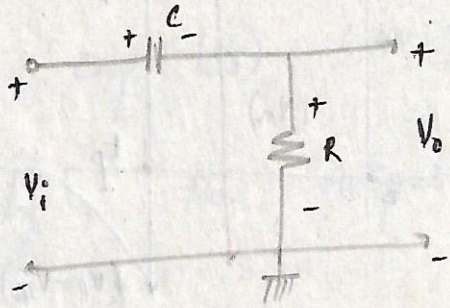


If $R.C << t_p$:



Response of H.P R.C circuit to the ramp input:





Math rep of ramp input:

$$V_i(t) = \alpha t \; ; \quad V_i(s) = \frac{\alpha}{s^2}$$

By using voltage division rule..

we get..

$$V_o(s) = \left[\frac{R}{R + \frac{1}{sC}}\right] V_i(s)$$

$$V_o(s) = \frac{\left[\frac{RSC}{1 + RSC}\right]}{\cancel{sc}} \cdot V_i(s)$$

$$\cancel{V_o(s) = \frac{R}{R\left(1 + \frac{1}{SRC}\right)} \cdot V_i(s)}$$

$$V_0(s) = \frac{1}{\cancel{RC}}\left[\frac{S \cdot \cancel{RC}}{S+\frac{1}{RC}}\right] \cdot \frac{\alpha}{s^{\cancel{2}}}$$

$$V_0(s) = \frac{\alpha}{\cancel{s}}\left[\frac{1}{S+\frac{1}{RC}}\right]$$

$$V_0(s) = \frac{A}{S} + \frac{B}{\left(S+\frac{1}{R.C}\right)}$$

$$\frac{1}{s\left(s+\frac{1}{R.C}\right)} = \frac{A}{S} + \frac{B}{\left(S+\frac{1}{R.C}\right)}$$

partial fraction's ....

$$1 = A\left(S+\frac{1}{RC}\right) + B.S.$$

If .. $S=0 \longrightarrow A = R.C$

$S = \frac{-1}{R.C} \longrightarrow B = -R.C$

$$\frac{\alpha}{s\left[s+\frac{1}{R.C}\right]} = \alpha\left[\frac{(R.C)}{S} - \frac{(R.C)}{\left(S+\frac{1}{R.C}\right)}\right]$$

$$V_0(s) = \alpha.R.C\left[\frac{1}{S} - \frac{1}{\left(S+\frac{1}{R.C}\right)}\right]$$

apply ... I.L.T .. on b.s.. we get..

$$V_0(t) = \alpha.R.C\left[1 - e^{-t/RC}\right] \text{ —— } 1$$

$$V_0(t) = \alpha.RC\left[1 - \left(1 - \frac{t}{R.C} + \left(\frac{t}{R.C}\right)^2 \cdot \frac{1}{2!} \cdots\right)\right]$$

If .. $R.C >> T$ ... then, we can neglect the higher order terms.

$$V_0(t) = \alpha.R.C\left[\cancel{1}-\cancel{1}+\frac{t}{R.C}-\frac{t^2}{2(R.C)^2}\right]$$

$$V_0(t) = \alpha t - \frac{\alpha t^2}{2.R.C}$$

$$V_0(t) = \alpha t \cdot \left(1-\frac{t}{R.C}\right) \quad \text{—— (2)}$$

Response :