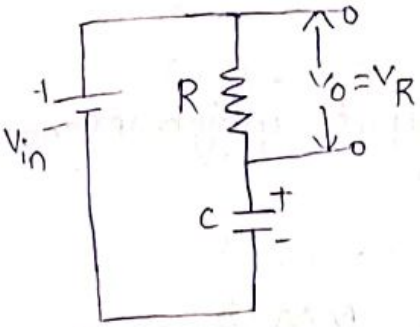
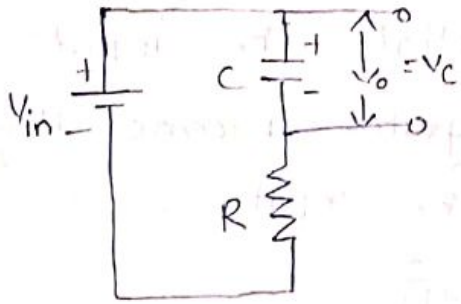
1. Linear Wave Shaping

RC Networks



High pass filter



low pass filter

* The output is taken at Resistor then circuit is known as high pass filter.
* The output is taken at capacitor then the circuit is known as low pass filter.
* The high pass filter is known as Differentiator and low pass filter is known as integrator
* It is a physical device which is used to allows only Required information and removes unwanted information is known as filter.
* The filter which allows only high pass frequency and eliminates low frequency is known as high pass filter.
* The filter which allows only low frequency and eliminates All high frequencies is known as low pass filter.
* VLF ⟶ UHF : Here, Very low frequency can be converted into ultra High frequency

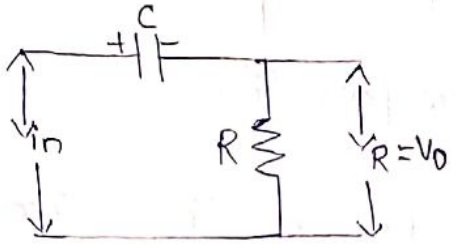
www.Jntufastupdates.com Scanned by CamScanner

but it allows only high frequency range.

* High frequency and low frequency is divided by cut-off region for frequency.

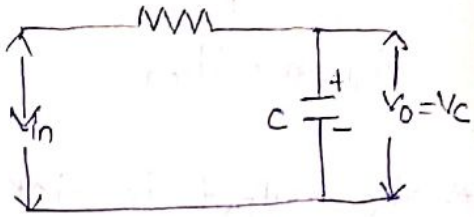
* Differentiator means the output which differentiate the input.

* Integrator means the output which integral of the input.



High pass filter

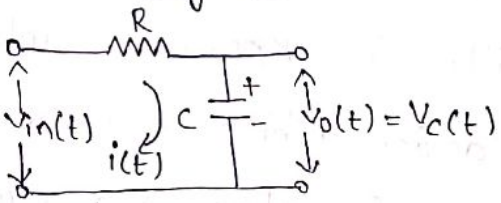
$$V_0(t) = \frac{d}{dt} V_{in}(t)$$



low pass filter

$$V_0(t) = \int V_{in}(t)\, dt$$

LPF as integrator:



we know that voltage across capacitor

$$V_C = \frac{1}{C} \int i(t)\, dt \quad -(1)$$

$$i(t) = \frac{V}{R} = \frac{V_{in}(t)}{R}$$

$$i(t) = \frac{V_{in}(t)}{R} \quad -(2)$$

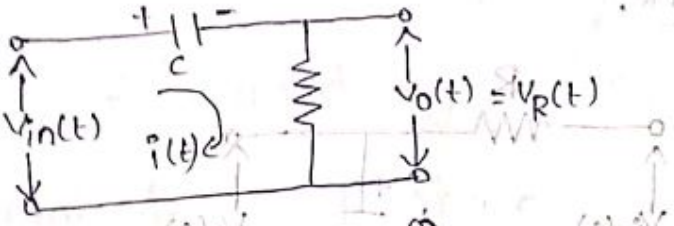
Substitute (2) in (1)

$$V_c(t) = \frac{1}{RC} \int V_{in}(t)\, dt$$

$$\boxed{V_0(t) = \frac{1}{RC} \int V_{in}(t)\, dt}$$

www.Jntufastupdates.com Scanned by CamScanner

HPF as Differentiator:



$$V_R(t) = i(t) \cdot R \quad \text{---} (1)$$

$$V_c(t) = \frac{1}{C} \int i(t)\, dt$$

$$\frac{d}{dt} C V_c(t) = i(t)$$

$$\frac{d}{dt} C V_{in}(t) = i(t) \quad \text{---} (2)$$

Substitute (2) in (1)

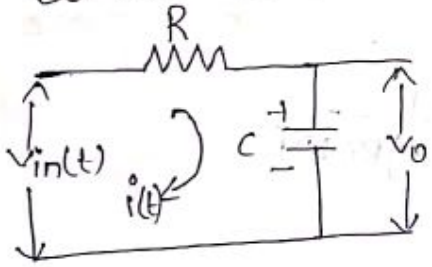
$$V_R(t) = i(t) \cdot R$$

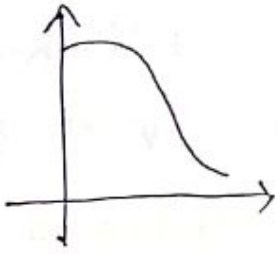
$$= \frac{d}{dt} C V_{in}(t) \cdot R$$

$$V_R(t) = RC \frac{d}{dt} V_{in}(t)$$

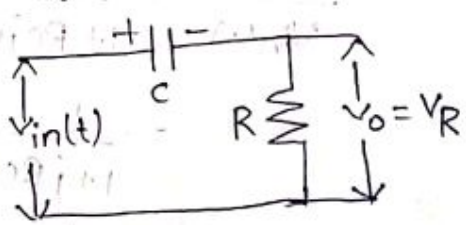
$$\boxed{V_o(t) = RC \frac{d}{dt} V_{in}(t)}$$

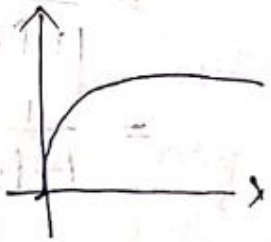
Low pass RC N/w





High pass RC N/w

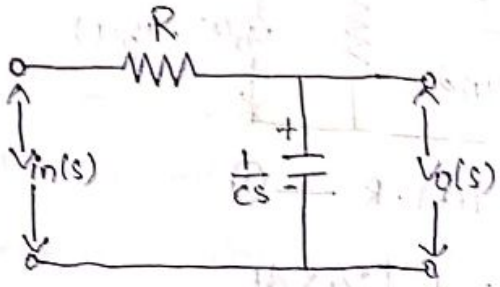




frequency value increases then Reactance value decreases. Insulator nothing but blocking capacitor.

www.Jntufastupdates.com Scanned by CamScanner

The Response of Low pass Rc Network for Sinusoidal input network:



In frequency domain

$R \rightarrow R$

$C \rightarrow \frac{1}{Cs}$

$$V_o(s) = \frac{\frac{1}{Cs}}{R+\frac{1}{Cs}} \cdot V_{in}(s) \qquad \left(V_{in} = \frac{R_2}{R_2+R_1} \cdot V_{in}\right)$$

$$\frac{V_o(s)}{V_{in}(s)} = \frac{\frac{1}{Cs}}{\frac{RCs+1}{Cs}}$$

$$\frac{V_o(s)}{V_{in}(s)} = \frac{1}{1+RCs}$$

Here we know that $\boxed{s = j\omega}$

$$\frac{V_o(s)}{V_{in}(s)} = \frac{1}{1+RCj\omega}$$

$$= \frac{1}{1+jRC\omega} = \frac{1}{1+jRC2\pi f}$$

$$= \frac{1}{1+jf2\pi RC}$$

$$= \frac{1}{1+j\cdot\frac{f}{\frac{1}{2\pi RC}}}$$

$$\frac{V_o(s)}{V_{in}(s)} = \frac{1}{1+j\left(\frac{f}{f_H}\right)}$$

www.Jntufastupdates.com Scanned by CamScanner

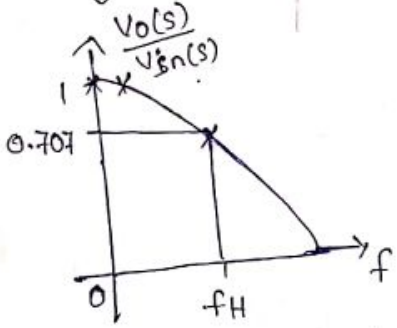
Here $f_H = \frac{1}{2\pi RC}$ ⇒ upper cutoff frequency

f is input signal frequency

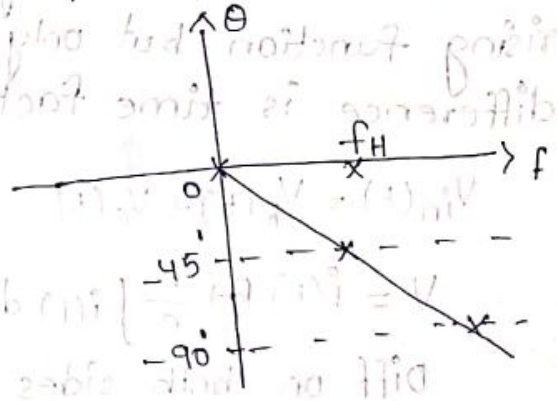
Magnitude	phase
$\left\|\frac{V_o(s)}{V_{in}(s)}\right\| = \frac{1}{\sqrt{1+\left(\frac{f}{f_H}\right)^2}}$	$\theta = -\tan^{-1}\left(\frac{f}{f_H}\right)$

frequency (f)	Magnitude	phase $\theta = \tan^{-1}\left(\frac{f}{f_H}\right)$
$f = 0$	1	0
$f \uparrow, f < f_H$	$\simeq 1$	$0 \le \lvert\theta\rvert \le 45^\circ$
$f = f_H$	0.707	-45°
$f = \infty$	0 $\frac{V_o(s)}{V_{in}(s)} = \text{const}$	-90°

Magnitude plot



Phase plot



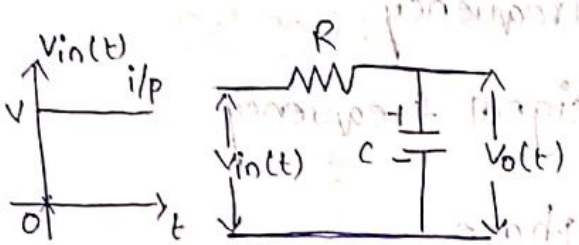
Bandwidth is known as the difference b/w High frequency to low frequency.

Bandwidth $= f_H - f_L$
$= f_H - 0$
$= f_H$

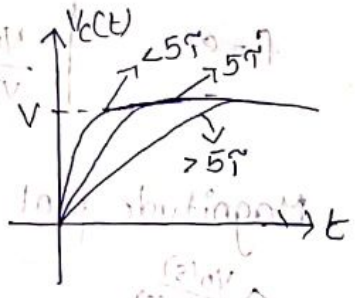
3 dB freq =
→ o/p = 0.707 times of input

www.Jntufastupdates.com Scanned by CamScanner

Response of Lowpass Rc Network for step input:



1. A step voltage is one which is having a sudden change at $t=0$.
2. When a step voltage is applied to a capacitor, that capacitor stores that information in a exponentially rising function format.
3. To reach the maximum value, the capacitor takes five time constants ($\tau = Rc$), 5τ.
4. For different values of time constants the voltage across capacitor is shown as below.
5. If we observe the three graphs that is for 5τ, $<5\tau$, $>5\tau$ all are exponentially rising function but only the difference is time factor.



$$V_{in}(t) = V_R(t) + V_c(t)$$

$$V = i(t)R + \frac{1}{C}\int i(t)\,dt$$

Diff on both sides wrt 't'

$$\frac{dv}{dt} = \frac{d}{dt} i(t)R + \frac{1}{C} i(t)$$

$$0 = R\frac{d}{dt} i(t) + \frac{1}{C} i(t)$$

Laplace transform on both sides

$$0 = R\,LT\left[\frac{d}{dt} i(t)\right] + \frac{1}{C} LT[i(t)]$$

www.Jntufastupdates.com Scanned by CamScanner

$$0 = R\left[sI(s) - I(0^+)\right] + \frac{1}{C} I(s)$$

$$-\frac{1}{C} I(s) = R\left[sI(s) - I(0^+)\right]$$

$$\frac{1}{RC} I(s) + sI(s) = I(0^+)$$

$$I(s)\left[s + \frac{1}{RC}\right] = I(0^+) \quad \text{—— (1)}$$

Where $I(0^+) = \frac{V - V'}{R}$ —— (2)

where V = final voltage

V' = initial voltage

eqn (2) in (1)

$$I(s)\left[s + \frac{1}{RC}\right] = \frac{V - V'}{R}$$

$$I(s) = \frac{\frac{V - V'}{R}}{\left(s + \frac{1}{RC}\right)} \quad \text{—— (3)}$$

wkt $V_0(s) = V_i(s) - I(s)R$. —— (4)

eqn (3) in (4)

$$V_0(s) = \frac{V}{s} - \frac{\frac{V - V'}{R}}{\left(s + 1/RC\right)} \times R$$

$$V_0(s) = V_c(s) = \frac{V}{s} - \frac{V - V'}{s + \frac{1}{RC}}$$

ILT on both sides

$$V_c(t) = V - (V - V')e^{-t/RC}$$

$$\boxed{V_c(t) = V - (V - V')e^{-t/RC}}$$

where V = final voltage, V' = initial voltage

www.Jntufastupdates.com Scanned by CamScanner

$$V_c(t) = V - (V - V')\, e^{-(t-t_i)/RC}$$

Response at particular time

at $t_i = 0$, $V_{in} = 0 = V'$

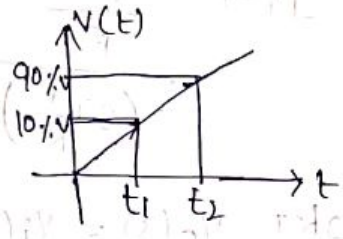
$$V_c(t) = V - (V - 0)\, e^{-(t/RC)}$$

$$= V - V e^{-t/RC}$$

$$V_c(t) = V\left(1 - e^{-t/RC}\right)$$

Calculation of rise time:-

Rise time: The time required for the o/p to reach from 10-90% of its maximum value (t_r).



at $t = t_1 \Rightarrow 0.1V$

$t = t_2 \Rightarrow 0.9V$

W.K.T

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

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

at $t = t_1$

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

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

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

$$-t_1/RC = \ln(0.9)$$

$$t_1 = 0.1RC$$

at $t = t_2$

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

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

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

$$-t_2/RC = \ln(0.1)$$

$$t_2 = -\ln(0.1)RC$$

$$t_2 = 2.3RC$$

www.Jntufastupdates.com Scanned by CamScanner

Rise time $= t_2 - t_1$

$= 2.3RC - 0.1RC$

$= 2.2RC$

Relationship b/w band width & rise time:-

for a CRC circuit $B.\omega = f_H$

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

$$B\omega = \frac{1}{2\pi RC}$$

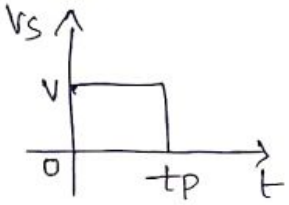
$$RC = \frac{1}{2\pi B\omega} \text{ and}$$

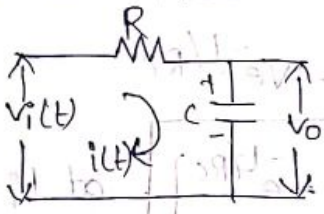
$\omega \cdot K \cdot T$ $t_r = 2.2RC$

$$t_r = 2.2 \cdot \frac{1}{2\pi B\omega}$$

$$\boxed{t_r = \frac{0.35}{B\omega}}$$

Response of LP R.C CKT for pulse i/p:-





For pulse $V_s = V$ at $0 \le t \le t_p$

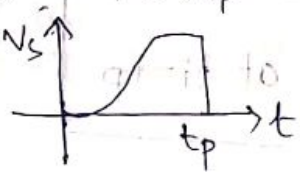
$= 0$ elsewhere

case (i): Response for $0 \le t \le t_p$

case (ii): Response for $t \ge t_p$

Case (i): $0 \le t \le t_p$

condition 1:- $T << t_p$ — sufficient time & it reaches max. value



www.Jntufastupdates.com Scanned by CamScanner

Condition 2: V_s

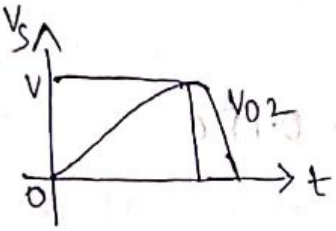


fig (a) $T >> t_p$

fig (b): $T >> t_p$

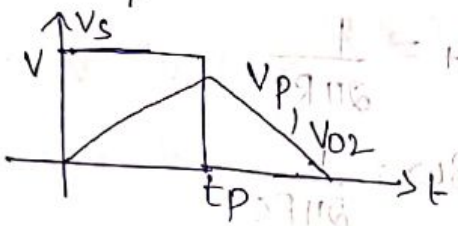
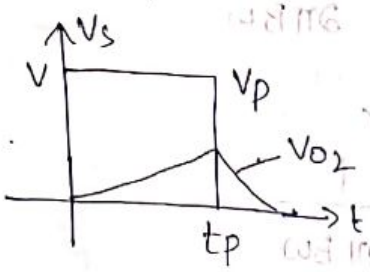


fig (c): $T = t_p$



W.K.T $V_c(t) = V_f - (V_f - V_{in})e^{-(t-t_i)/RC}$

$t_i = 0$, $V_{in} = 0$, $V_f = V$

$= V - (V-0)e^{-(t-0)/RC}$

$= V - Ve^{-t/RC}$

$$\boxed{V_0(t) = V\left[1 - e^{-t/RC}\right]} \quad \text{at } t_i = 0$$

$$\boxed{t = t_p \Rightarrow V_c(t) = V\left[1 - e^{-(t-t_p)/RC}\right]}$$

at $t_i = t_p$, $V_{in} = V_p$, $V_f = 0$

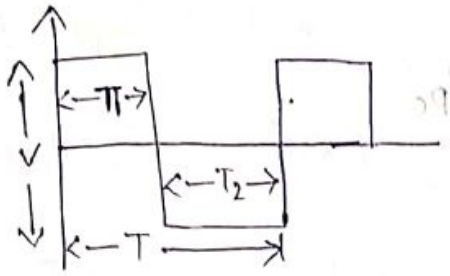
$V_c(t) = V_f - (V_f - V_{in})e^{-(t-t_i)/RC}$

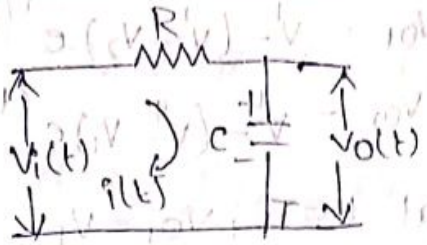
$= 0 - (0 - V_p)e^{-(t-t_p)/RC}$

$$\boxed{V_0(t) = V_p e^{-(t-t_p)/RC} \quad \text{at } t_i = t_p}$$

www.Jntufastupdates.com Scanned by CamScanner

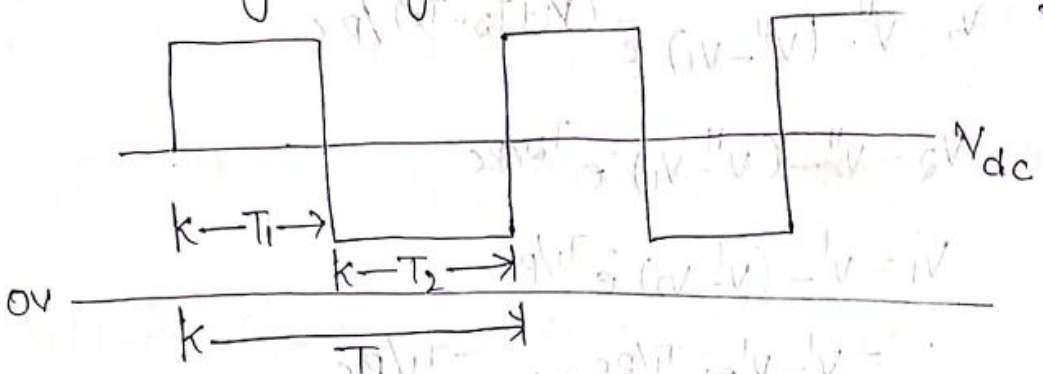
Response of Lp RC N/w for square wave i/p:-

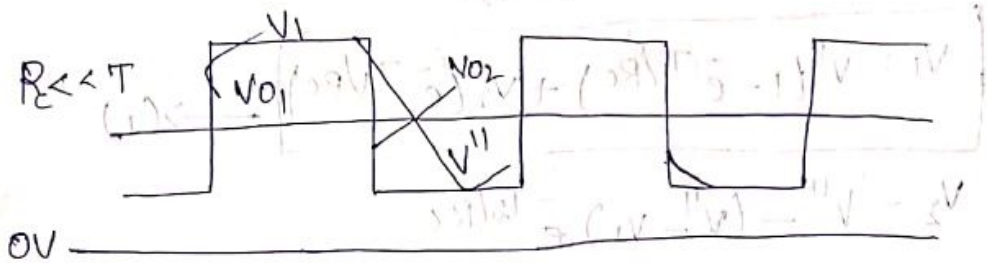


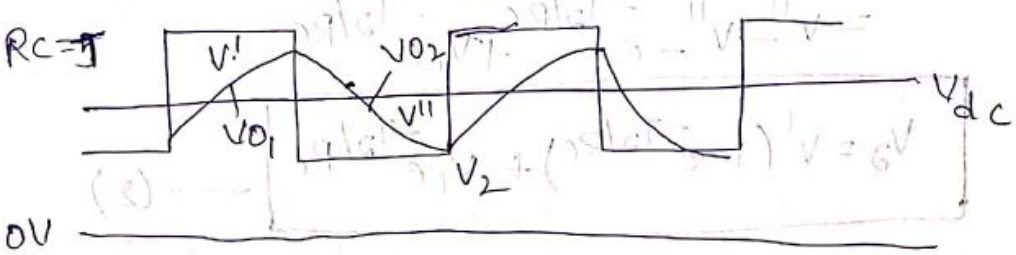


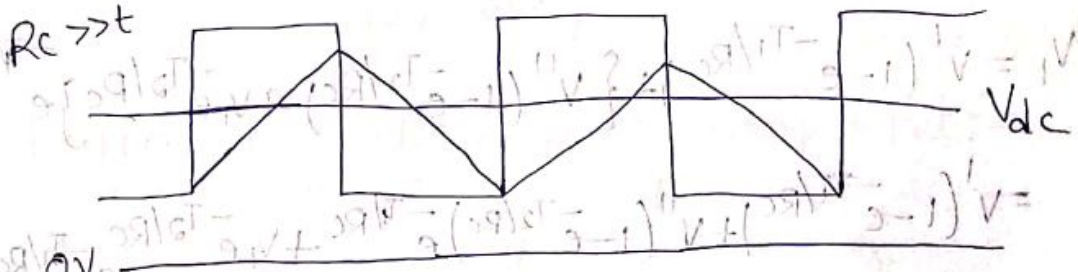
We use the symmetrical wave in nature and periodic signal fig (a) input.

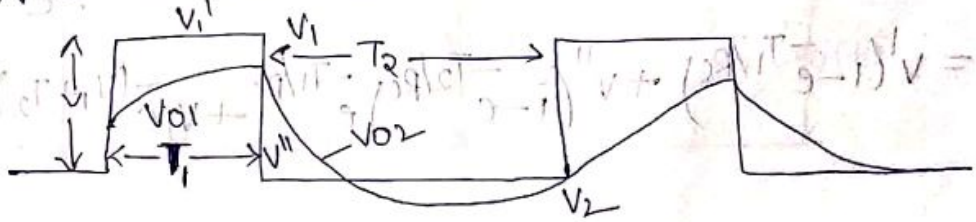
$V' = V'' - \frac{V}{2}$











www.Jntufastupdates.com Scanned by CamScanner

$$V_c(t) = V_f - (V_f - V_{in})e^{-t/RC}$$

$$V_{o1} = V' - (V' - V_2)e^{-t/RC}$$

$$V_{o2} = V'' - (V'' - V_1)e^{-(t-T_1)/RC}$$

at $t = T_1$, $V_{o1} = V_1$

$t = T_1 + T_2$, $V_{o2} = V_2$

$$V_1 = V' - (V' - V_2)e^{-T_1/RC}$$

$$V_2 = V'' - (V'' - V_1)e^{-(T_1+T_2-T_1)/RC}$$

$$V_2 = V'' - (V'' - V_1)e^{-T_2/RC}$$

$$V_1 = V' - (V' - V_2)e^{-T_1/RC}$$

$$= V' - V'e^{-T_1/RC} + V_2 e^{-T_1/RC}$$

$$\boxed{V_1 = V'(1 - e^{-T_1/RC}) + V_2(e^{-T_1/RC})} \longrightarrow (1)$$

$$V_2 = V'' - (V'' - V_1)e^{-T_2/RC}$$

$$= V'' - V'' - e^{-T_2/RC} + V_1 e^{-T_2/RC}$$

$$\boxed{V_2 = V'(1 - e^{-T_2/RC}) + V_1 e^{-T_2/RC}} \longrightarrow (2)$$

(2) in (1)

$$V_1 = V'(1 - e^{-T_1/RC}) + \{V''(1 - e^{-T_2/RC}) + V_1 e^{-T_2/RC}\}e^{-T_1/RC}$$

$$= V'(1 - e^{-T_1/RC}) + V''(1 - e^{-T_2/RC})e^{-T_1/RC} + V_1 e^{-T_2/RC} \cdot e^{-T_1/RC}$$

$$V_1 = V'(1 - e^{-T_1/RC}) + V''(1 - e^{-T_2/RC})e^{-T_1/RC} + V_1 e^{-(T_1+T_2)/RC}$$

$$V_1 - V_1 e^{-(T_1+T_2)/RC} = V'(1-e^{-T_1/RC}) + V''(1-e^{-T_2/RC})$$

$$V_1 - V_1 e^{-(T_1+T_2)/RC} = V'(1-e^{-T_1/RC}) + V''(e^{-T_1/RC})(1-e^{-T_2/RC})$$

$$V_1(1-e^{-(T_1+T_2)/RC}) = V'(1-e^{-T_1/RC}) + V''(1-e^{-T_2/RC})e^{-T_1/RC}$$

$$\left.\begin{aligned} T_1 = T/2 &\Rightarrow V' = V/2 \\ T_2 = T/2 &\Rightarrow V'' = -V/2 \end{aligned}\right\} \quad V' = -V''$$

$$V_1(1-e^{-T/RC}) = \frac{V}{2}(1-e^{-T/2RC}) - \frac{V}{2}(1-e^{-T/2RC})e^{-T/2RC}$$

$$V_1(1-e^{-T/RC}) = \frac{V}{2}(1-e^{-T/2RC}) - \frac{V}{2}e^{-T/2RC} + \frac{V}{2}e^{-T/RC}$$

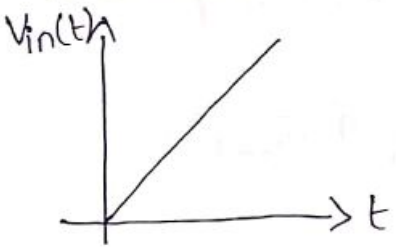
$$V_1(1-e^{-T/RC}) = \frac{V}{2}\left\{(1-e^{-T/2RC}) - e^{-T/2RC} + e^{-T/RC}\right\}$$

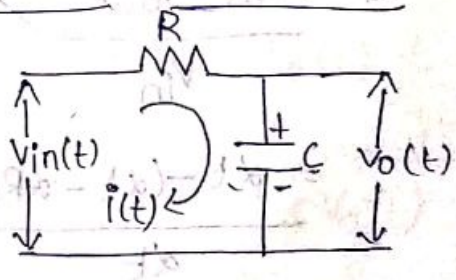
$$V_1 = \frac{V}{2}\left\{\frac{(1-2e^{-T/2RC}+e^{-T/RC})}{(1-e^{-T/RC})}\right\}$$

$$V_1 = \frac{V}{2}\left\{\frac{(1-e^{-T/2RC})^2}{(1+e^{-T/2RC})(1-e^{-T/2RC})}\right\}$$

$$V_1 = \frac{V}{2}\left\{\frac{(1-e^{-T/2RC})}{(1+e^{-T/2RC})}\right\}$$

Response of Lp RC N/w for Ramp input:-





www.Jntufastupdates.com Scanned by CamScanner

$r(t) = \alpha t$

$V_{in}(t) = V_R(t) + V_c(t)$

$V_{in}(t) = V_R(t) + V_o(t)$

$V_o(t) = V_{in}(t) - V_R(t)$

$= \alpha t - V_R(t)$

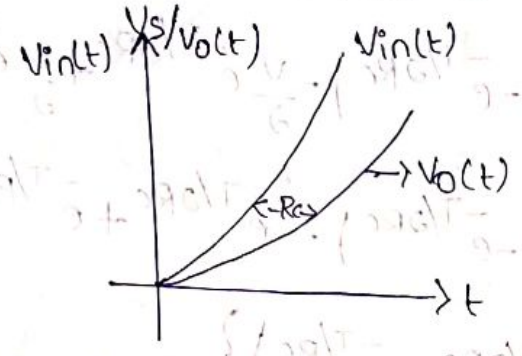
$= \alpha t - \alpha Rc\left(1 - e^{-t/Rc}\right)$

$V_o(t) = \alpha t - \alpha Rc + \alpha Rc\, e^{-t/Rc}$

$V_o(t) = \alpha(t - Rc) + \alpha Rc\, e^{-t/Rc}$

where

$V_R(t) = \alpha Rc\left(1 - e^{-t/Rc}\right)$



* If Rc is small then the distortion is minimum.
* If Rc is high then the distortion is maximum.

Transmission error:-

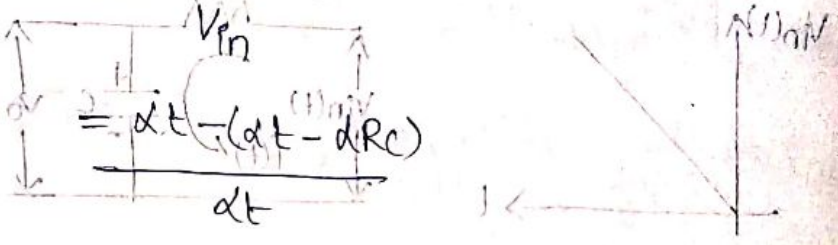
$V_{in} = \alpha t$ — Here i/p and o/p is seperated by Rc times.

$O/P = \alpha(t - Rc)$

It is defined as the ratio of the difference b/w V_{in} and V_{out} to V_{in}.

$te = \dfrac{V_{in} - V_{out}}{V_{in}}$

$= \dfrac{\alpha t - (\alpha t - \alpha Rc)}{\alpha t}$



www.Jntufastupdates.com Scanned by CamScanner

$$= \frac{dt - dt' + dRC}{dt}$$

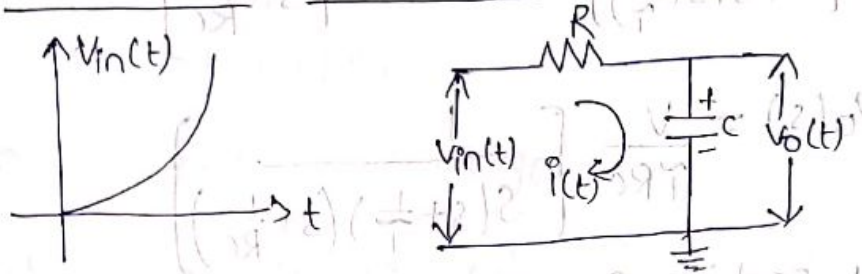
$$\boxed{t_e = \frac{RC}{t}}$$

WORT $f_H = \frac{1}{2\pi F_H}$

$$t_e = \frac{1}{2\pi F_H t}$$

$$\boxed{t_e = \frac{1}{2\pi f_2 t}}$$

Response of LP RC N/W for exponential input:-



$$V_{in}(t) = V(1 - e^{-t/RC})$$

$$V_{in}(t) = V_R(t) + V_o(t)$$

$$V(1 - e^{-t/RC}) = i(t)\,R + V_o(t)$$

$$V_o(t) = \frac{1}{C}\int i(t)\,dt$$

$$C\frac{d}{dt} V_o(t) = i(t)$$

$$V(1 - e^{-t/RC}) = RC\left(\frac{dV_o}{dt}(t)\right) + V_o(t)$$

$$V(1 - e^{-t/RC}) = RC\frac{d}{dt} V_o(t) + V_o(t)$$

www.Jntufastupdates.com Scanned by CamScanner

$$V - Ve^{-t/\tau} = RC\frac{d}{dt}V_0(t) + V_0(t)$$

L.T on both sides

$$\frac{V}{s} - \frac{V}{s+\frac{1}{\tau}} = RC\,sV_0(s) + V_0(s)$$

$$V\left[\frac{1}{s} - \frac{1}{s+\frac{1}{\tau}}\right] = V_0(s) + RC\left[s+\frac{1}{RC}\right]$$

$$V\left[\frac{s+\frac{1}{\tau}-s}{s\left(s+\frac{1}{\tau}\right)}\right] = V_0(s)\,RC\left[s+\frac{1}{RC}\right]$$

$$V\left[\frac{1}{\tau s\left(s+\frac{1}{\tau}\right)}\right] = V_0(s)\,RC\left[s+\frac{1}{RC}\right]$$

$$V_0(s) = \frac{V}{\tau RC}\left[\frac{1}{s\left(s+\frac{1}{\tau}\right)\left(s+\frac{1}{RC}\right)}\right]$$

By partial fraction

$$V_0(s) = V\left[\frac{1}{s} - \frac{1}{\left(1-\frac{RC}{\tau}\right)\left(s+\frac{1}{\tau}\right)} + \frac{1}{\left(\frac{\tau}{RC}-1\right)\left(s+\frac{1}{RC}\right)}\right]$$

$$V_0(s) = V\left[\frac{1}{s} - \frac{1}{(1-n)\left(s+\frac{1}{\tau}\right)} + \frac{1}{\left(\frac{1}{n}-1\right)\left(s+\frac{1}{RC}\right)}\right]$$

$$= V\left[\frac{1}{s} - \frac{1}{(1-n)\left(s+\frac{1}{\tau}\right)} + \frac{n}{(1-n)\left(s+\frac{1}{RC}\right)}\right]$$

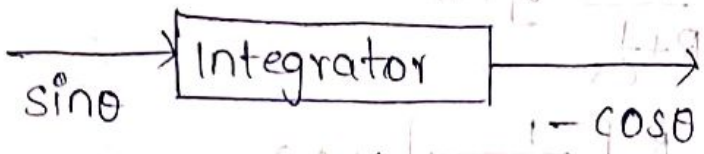
Inverse laplace Transforms

www.Jntufastupdates.com Scanned by CamScanner

$$V_0(t) = V\left[1 - \frac{1}{(1-n)}e^{-t/\tau_1} + \left(\frac{n}{1-n}\right)e^{-t/RC}\right]$$

condition for perfect Integrator:-

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



$$\theta = -\tan^{-1}\left(\frac{f}{H}\right)$$

$$= -\tan^{-1}(2\pi RCf)$$

$$= -\tan^{-1}(\omega RC)$$

$$\theta = -\tan^{-1}(\omega RC) = -90^\circ$$

$$|\theta| = \tan^{-1}(\omega RC) = 90^\circ$$

$$\tan^{-1}(\omega RC) = 90^\circ$$

$\omega RC = 14, \quad \theta \cong 85$

$\omega RC = 15, \quad \theta \cong 86$

$\omega RC = 20, \quad \theta \cong 87$

$\omega RC \geq 15, 86$

$\omega RC \geq 15$

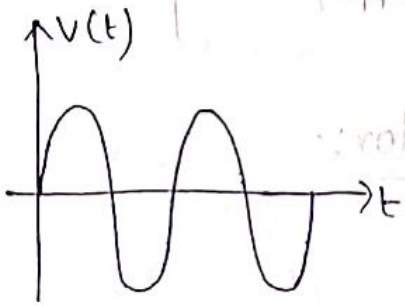
$2\pi f RC \geq 15$

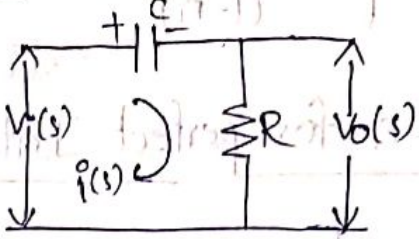
$$\frac{RC}{T} \geq \frac{15}{2\pi}$$

$$\boxed{RC \geq \frac{15T}{2\pi}}$$

www.Jntufastupdates.com Scanned by CamScanner

Response of high pass RC N/w for sinusoidal i/p:





$$V_o(s) = \frac{R}{R+\frac{1}{Cs}} V_I(s)$$

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

$$\frac{V_o(s)}{V_I(s)} = \frac{1}{1+\frac{1}{RCj\omega}} = \frac{1}{1+\frac{1}{jRC\,2\pi f}}$$

$$= \frac{1}{1+\frac{1}{j}\frac{1}{2\pi RC}\frac{1}{f}}$$

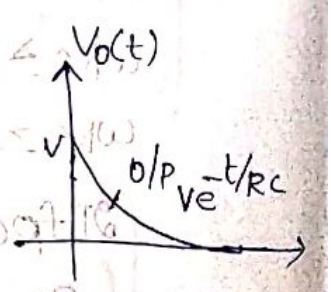
where $f_L = \frac{1}{2\pi RC}$

$$\frac{V_o(s)}{V_I(s)} = \frac{1}{1-j\frac{f_L}{f}}$$

$$\left|\frac{V_o(s)}{V_I(s)}\right| = \frac{1}{\sqrt{1+\left(\frac{f_L}{f}\right)^2}}$$

$$\theta = -\tan^{-1}\left(\frac{f_L}{f}\right)$$

frequency	magnitude	phase
$f=0$	0	90°
$f<f_L$	$\cong 0$	$0 \le \lvert\theta\rvert \le 45^\circ$
$f=f_L$	0.707	-45°
$f=\infty$	1	-4



Band width:- $B\omega = f_H - f_L$

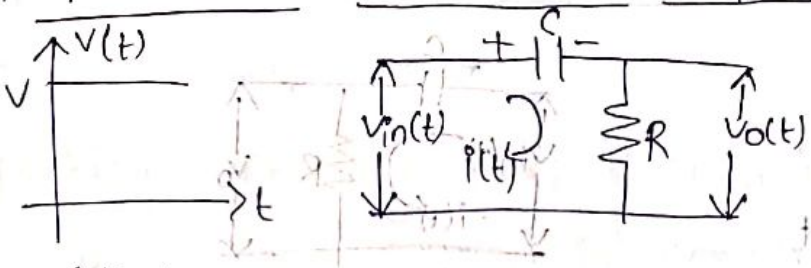
$= \infty - f_L$

for high pass $f_H = \infty$, $f_L = f_L$

$\boxed{B\cdot\omega = \infty}$

www.Jntufastupdates.com Scanned by CamScanner

Response of HP RC N/w for step input :-



$$V_{in}(t) = V_C(t) + V_R(t)$$

$$V_{in}(t) = V_C(t) + V_o(t)$$

$$V = \frac{1}{C}\int i(t)\,dt + V_o(t)$$

$$V = \frac{1}{C}\int \frac{V_o(t)}{R}\,dt + V_o(t)$$

$$V = \frac{1}{RC}\int V_o(t)\,dt + V_o(t)$$

diff on both sides

$$\frac{dV}{dt} = \frac{1}{RC}V_o(t) + \frac{d}{dt}V_o(t)$$

$$\boxed{0 = \frac{1}{RC}V_o(t) + \frac{d}{dt}V_o(t)}$$

Standard eqn for both LP & HP

$K = 0$, $0 \longrightarrow$ volts

$V_{in} = V$

$V_f = 0$

$$V_o(t) = V_f + (V_f - V_{in})e^{-(t-t_1)/RC}$$

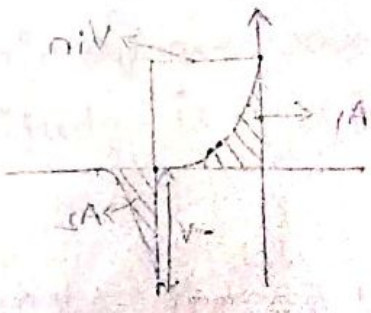
$$\Rightarrow 0 - (0 - V)e^{-t/RC} = V_o(t)$$

$$V_o(t) = Ve^{-t/RC}$$

$t = \infty$, steady state

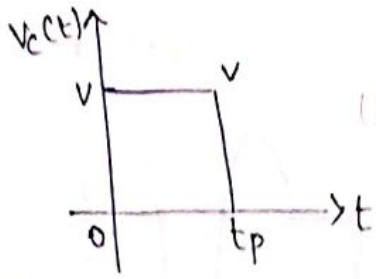
$$V_o(t) = Ve^{-\infty/RC}$$

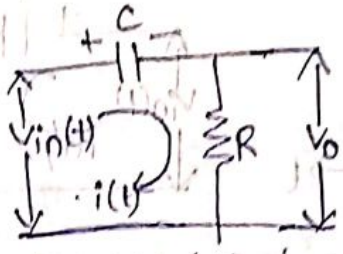
$$\boxed{V_o(t) = 0}$$



www.Jntufastupdates.com Scanned by CamScanner

Response of Hp Rc n/w for pulse:





Here for the circuit we have to find response for two conditions

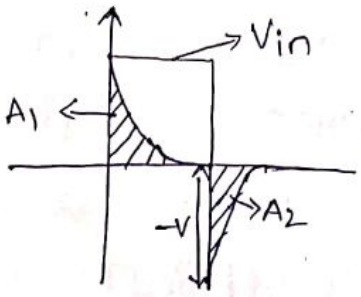
1) $0 \le t \le tp$
2) $t \ge tp$

For $0 \le t \le tp$ we have to find response for $Rc << tp$ and $Rc >> tp$

(i) $Rc << tp$: when we applying a pulse it is having an amplitude of tp at $t=0$ and a pulse is similar to a step for $0 \le t \le tp$. So, the output is exponentially decaying the curve.

At $t=tp$ the input falls from V to 0 volts and when their is change in i/p the o/p must also change. So, at $t=tp$, the output is -ve and it reduces zero has exponentially decaying format.

when $Rc << tp$

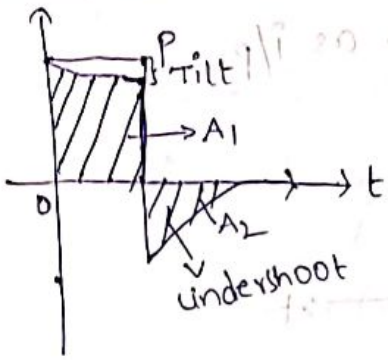


www.Jntufastupdates.com Scanned by CamScanner

If time constant is minimum, where having lot of disturtion.

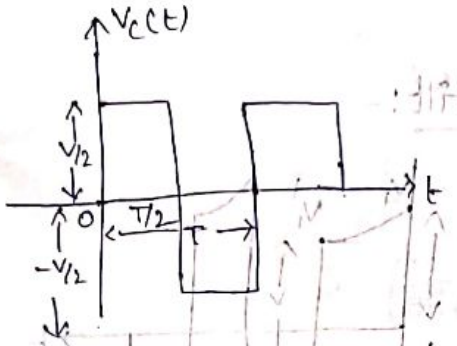
peaking:- for High pass RC n/w if time constant is low then the pulse is converted to spikes (pipe) and this process is called peaking

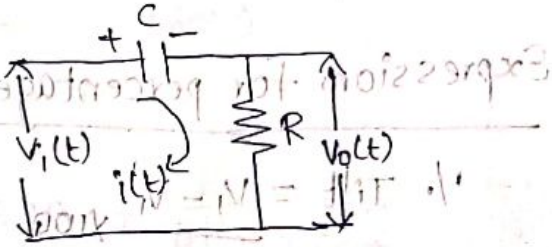
If $R_C >> t_p$



Here if $R_C >> t_p$ the positive portion is going to have tilt and -ve portion is going to have effect called undershoot. However, the area A_1, A_2 are equal.

Response of High pass RC N/w for Square wave i/p:



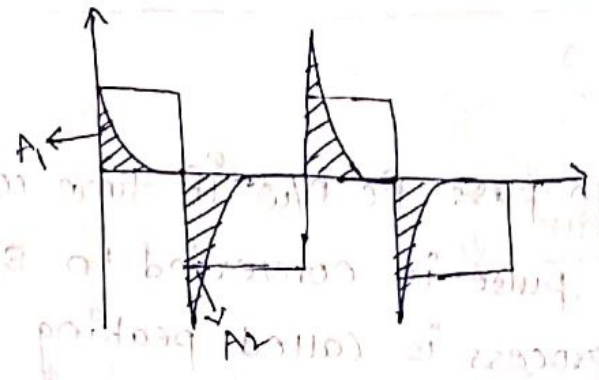


Here we applying a symmetric square wave in which the peak to peak amplitude is 'V' volts.

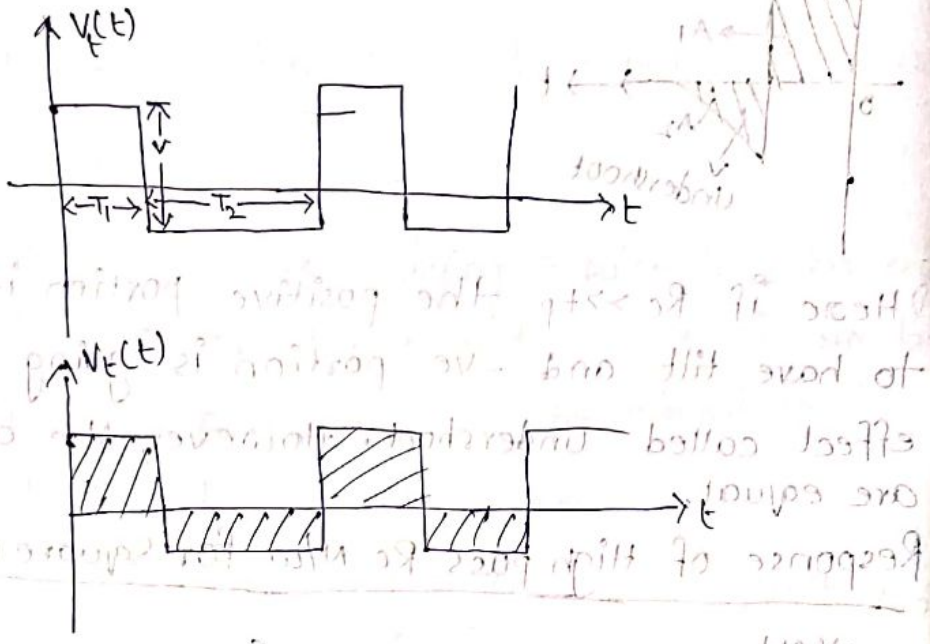
If $R_C << T$:

If we apply the i/p for 0 to t/2 the o/p looks like the pulse and at $t = t/2$ the i/p falls from "$+V/2$ to $-V/2$" then the o/p is known

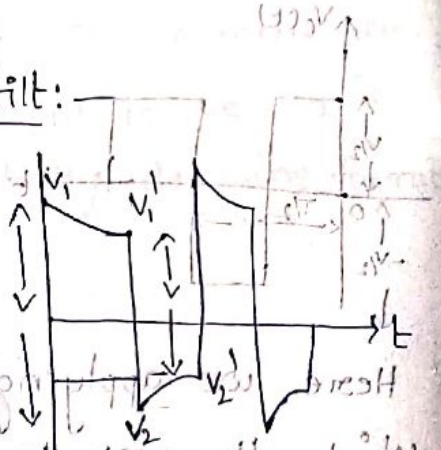
www.Jntufastupdates.com Scanned by CamScanner



IF the i/p is antisymmetrical (asymmetrical) where having large amount of time then the o/p is exactly similar to ~~input~~ same as i/p.



Expression for percentage of tilt:



$$\% \text{ Tilt} = \frac{|V_1 - V_1'|}{V/2} \times 100$$

$$V_1 = -V_2$$

$$V_1' = -V_2'$$

$$T_1 = T/2 = T/2 = T_2$$

$$V_1' = V_1 e^{-T/2RC}$$

$$V_2' = V_2 e^{-T/2RC}$$

$$V = V_1 - V_2 e^{-T/2RC}$$

$$= V_1 - (-V_1) e^{-T/2RC}$$

$$V = V_1 (1 + e^{-T/2RC})$$

$$\boxed{V = V_1 (1 + e^{-T/2RC})} \quad \text{---(2)}$$

$$V_1 - V_1' \Rightarrow V_1 - V_1 e^{-T/2RC}$$

$$V_1 - V_1' \Rightarrow V_1 (1 - e^{-T/2RC}) \quad \text{---(3)}$$

Sub (2) & (3) in (1)

$$\text{tilt} = \frac{V_1 - V'}{V/2}$$

$$= \frac{V_1 (1 - e^{-T/2RC})}{\frac{V_1 (1 + e^{-T/2RC})}{2}} \times 100$$

$$= \frac{1 - e^{-T/2RC}}{1 + e^{-T/2RC}} \times 200$$

$$\% \text{ tilt} = \frac{1 - \left(1 - \frac{T}{2RC}\right)}{1 + \left(1 - \frac{T}{2RC}\right)} \times 200$$

$$= \frac{\frac{T}{2RC}}{2 - \left(\frac{T}{2RC}\right)} \times 200 = \frac{\frac{T}{2RC}}{2} \times 200$$

$$\% \text{ tilt} = \frac{T}{2RC} \times 100$$

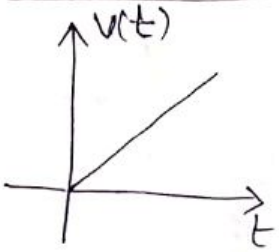
$$f_L = \frac{1}{2\pi RC} \qquad 2RC = \frac{1}{\pi f_L}$$

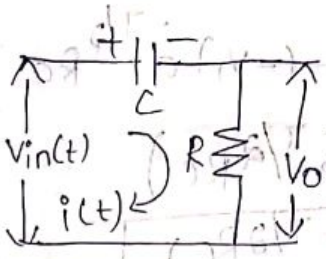
$$\% \text{ tilt} = \frac{T}{\frac{1}{\pi f_L}} \times 100 \Rightarrow \pi f_L T \times 100$$

$$\boxed{\% \text{ tilt} = \frac{\pi f_L}{f} \times 100}$$

www.Jntufastupdates.com Scanned by CamScanner

Response of HP RC N/w for Ramp i/p:-





$$V_{in}(t) = \alpha t \Rightarrow V_I(s) = \frac{\alpha}{s^2}$$

$$V_o(t) = \frac{R}{R+1/Cs} \cdot V_i(s)$$

$$V_o(s) = \frac{RCs}{(RCs+1)} V_I(s)$$

$$V_o(s) = \left(\frac{RCs}{1+RCs}\right)\frac{V}{s^2}$$

$$V_o(s) = \frac{\alpha RC}{s(1+RCs)}$$

$$= \frac{\alpha RC}{RCs\left(\frac{1}{RC}+s\right)}$$

$$= \frac{\alpha}{s\left[s+\frac{1}{RC}\right]}$$

$$= \alpha\left[\frac{A}{s} + \frac{A}{s+\frac{1}{RC}}\right]$$

$$= \alpha\left[\frac{RC}{s} - \frac{RC}{s+\frac{1}{RC}}\right]$$

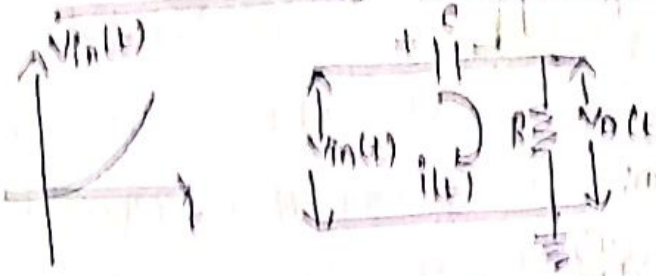
$$V_o(s) = \alpha RC\left[\frac{1}{s} - \frac{1}{s+\frac{1}{RC}}\right]$$

Inverse LT on b.s

$$\boxed{V_o(t) = \alpha RC\left[1-e^{-t/RC}\right]}$$

www.Jntufastupdates.com Scanned by CamScanner

Response of High pass RC N/w for exponential i/p:



we know that $V_i(t) = V\left[1 - e^{-t/RC}\right]$

$$\boxed{V_i(t) = V\left[1 - e^{-x}\right]}$$

$V_i(t) = V_c(t) + V_R(t)$

$V_i(t) = V_c(t) + V_o(t)$

$V_o(t) = V_i(t) - V_c(t)$

$V_o(t) = V\left[1 - e^{-x}\right] - V_c(t)$

From LPRC N/w

$$V_c(t) = V\left[1 - \frac{e^{-x}}{1-n} + \frac{n}{1-n} e^{-x/n}\right]$$

$$V_o(t) = V\left[1 - e^{-x}\right] - V\left\{1 + \frac{e^{-x}}{1-n} + \frac{n}{1-n} e^{-x/n}\right\}$$

$$= V - Ve^{-x} - V + \frac{V}{1-n} e^{-x} - \frac{nV}{1-n} e^{-x/n}$$

$$= \frac{V}{1-n} e^{-x} - Ve^{-x} - \frac{nV}{1-n} e^{-x/n}$$

$$= Ve^{-x}\left[\frac{1}{1-n} - 1\right] - \frac{nV}{1-n} e^{-x/n}$$

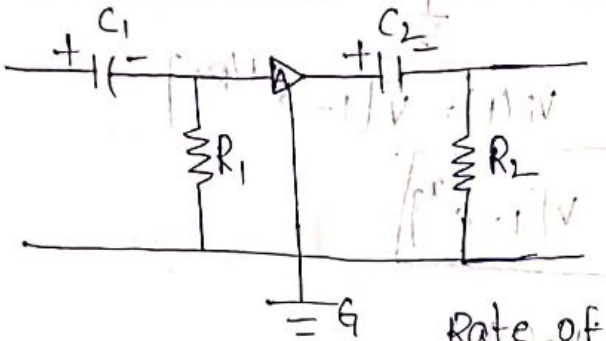
$$= Ve^{-x}\left[\frac{x - x + n}{1-n}\right] - \frac{nV}{1-n} e^{-x/n}$$

$$= \frac{Vn}{1-n} e^{-x} - \frac{nV}{1-n} e^{-x/n}$$

www.Jntufastupdates.com Scanned by CamScanner

$$V_0(t) = \frac{nV}{1-n}\left[e^{-x} - e^{-x/n}\right]$$

Double differentiation:-



Rate of rise Amplifier

1. The above N/w consists of two RC circuits seperated by an amplifier. Here the amplifier is a linearly operated one.
2. If the impedance of amplifier is high then the o/p impedance of the n/w is more there by causing loading effects.
3. The time constant of R_1C_1 and R_2C_2 must be less than the time constant of the i/p signal so that it works as a perfect differentator.
4. If the i/p is the ramp then this Double differentiator it converts into impulse.
5. output is equal to input X Amplification factor. and hence it is called rate of rise
6. Amplifier.

Aduinatator :-

Adunitators are nothing but a device which are used aduinate or decrease the signal strength. Here let us consider a simple resistance n/w as a aduinator as shown in figure.

* when the output of an aduinator is been given to an amplifier a stray capacitance C_2 will be added in parallel to the resistance R_2.

* For figure 'A' if you input is V_i its get modified as $V_o = \frac{R_2 R_1}{R_1 + R_2} * V_i$

* using thevenin's theorem, the figure b can be redrawn as shown in figure c. where

$$R = \frac{R_1 R_2}{R_1 + R_2}$$

* finally to maintain balancing condition the above n/w (fig 'c') is redrawn as shown in figure b.

* for the bridge balancing condition $R_1 C_1 = R_2 C_2$ that is no current flow from X to y.

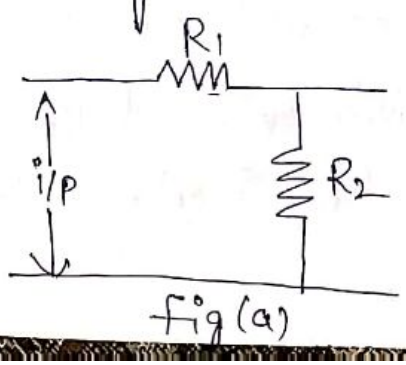


fig (a)

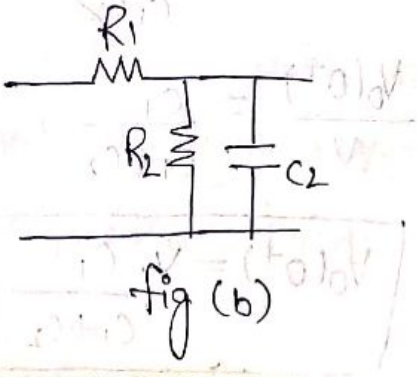


fig (b)

www.Jntufastupdates.com Scanned by CamScanner

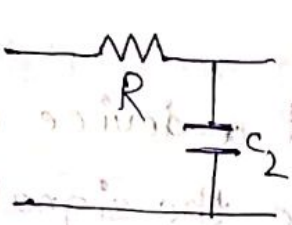


fig (c)

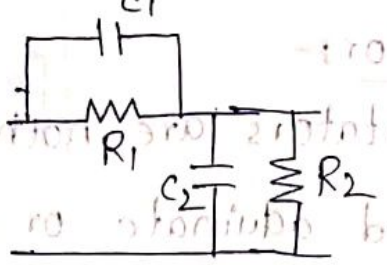


fig (d)

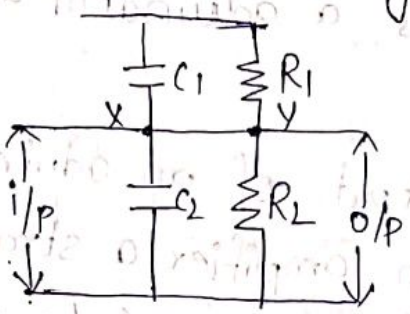


fig (e)

We know that $V = \frac{Q}{C}$

Initial voltage across C_1 $V_1 = \frac{Q}{C_1}$

Initial voltage across C_2 $V_2 = \frac{Q}{C_2}$

$V = V_1 + V_2$

$V = \frac{Q}{C_1} + \frac{Q}{C_2} = \frac{Q(C_1+C_2)}{C_1 C_2}$

$$\boxed{V = \frac{Q(C_1+C_2)}{C_1 C_2}}$$

$V_0(0^+) = \frac{Q}{C_2}$

$\frac{V_0(0^+)}{V} = \frac{Q/C_2}{\frac{Q(C_1+C_2)}{C_1 C_2}}$

$\frac{V_0(0^+)}{V} = \frac{C_1}{C_1+C_2}$

$$\boxed{V_0(0^+) = V \frac{C_1}{C_1+C_2}}$$

www.Jntufastupdates.com Scanned by CamScanner

$$V_0(\infty) = \frac{R_2}{R_1+R_2} \cdot V$$

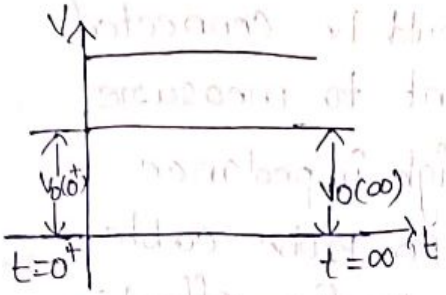
for perfect compensation

$$V_0(0^+) = V_0(\infty)$$

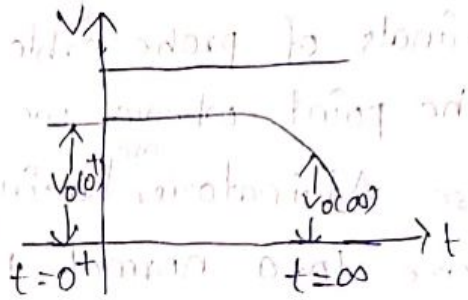
$$\frac{C_1}{C_1+C_2} = \frac{R_2}{R_1+R_2}$$

$$R_1C_1 + R_2C_1 = R_2C_1 + R_2C_2$$

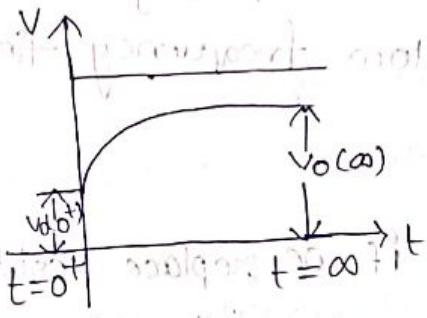
$$\boxed{R_1C_1 = R_2C_2}$$



perfect compensation



Under compensation



Over compensation

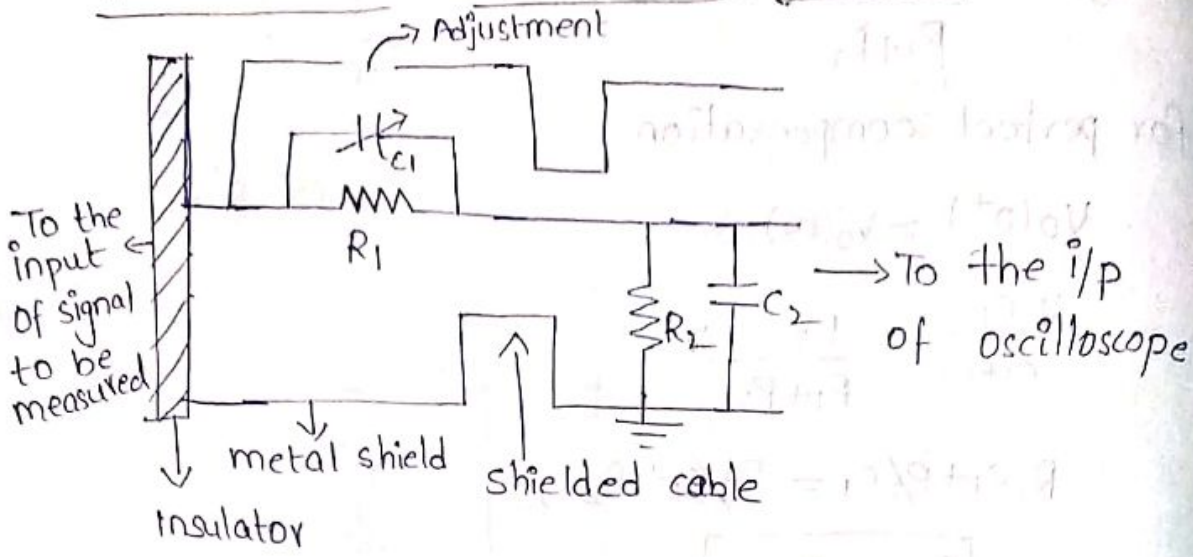
* The voltages from $V_0(0^+)$ to $V_0(\infty)$ exponentially may rise (or) decay with a time constant.

$\tau = RC$.

* At low frequencies the circuit acts as (cap) Resistive divider and at high frequencies the circuit acts as capacitive divider.

www.Jntufastupdates.com Scanned by CamScanner

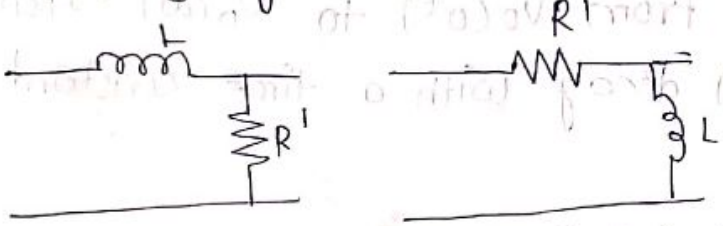
Applications of Adiinator as CRO probe:-



* To measure the signal level then the i/p terminals of probe cable should be connected to the point where we want to measure.
* These Adiinators are having high impedance compare to a normal 1:1 CRO probe cable such that we can minimize loading effects.
* by making the use of adjustment terminal we can measure low frequency time constants.

RL circuits:-

In a RC circuit if we replace Resistor 'R' and Capacitor 'C' by Inductor 'L' and Resistor 'R'' then we are going to form RL circuits.



RL LPF fig (a) RL HPF fig (b)

If we replace like that, the time constant of RC circuit is equal to the time constant of RL circuit. i.e, $RC = L/R'$

www.Jntufastupdates.com Scanned by CamScanner

To have higher time constant we have to use an inductor which gives much higher impedance and it is possible by Iron core inductor.

The Establishment of Iron core inductor is Expensive and it is physically undesirable.

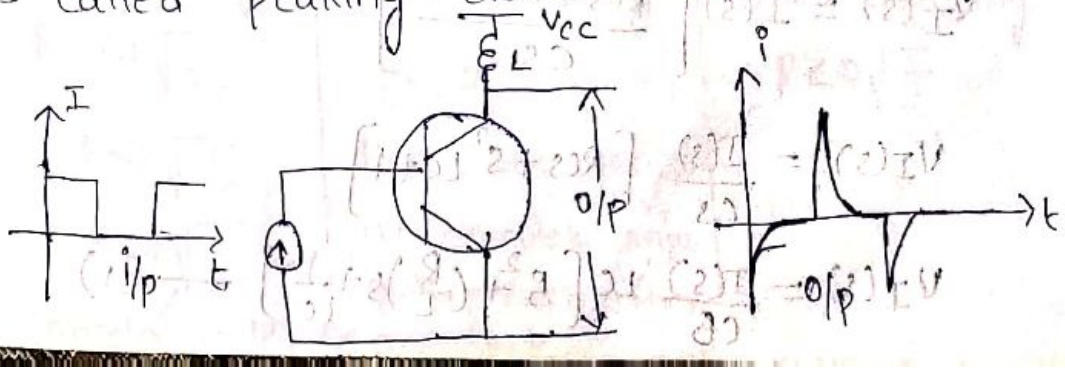
From figure 'a' the impedance '(X_L)' $(j2\pi fL)$ of a inductor is directly proportional to frequency.

At low frequencies the inductor offers minimum impedance, so full amount of i/p is collected across resistor. as the frequency increased, the inductor offers much impedance correspondingly Aduination takes place. Hence it's acts as low pass filter.

From figure 'b' at low frequencies the impedance of inductor is minimum and as the frequencies increase we get o/p as maximum across the inductor. Hence it acts as high pass filter.

Peaking circuit:-

A circuit which produces spikes from pulses is called peaking circuit.

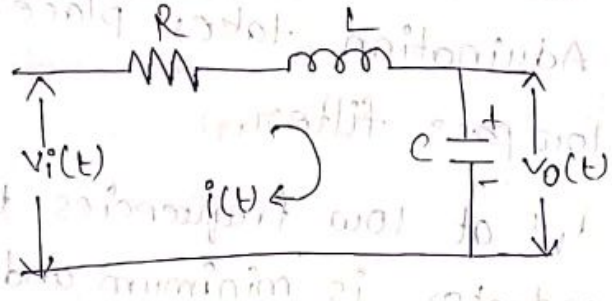


www.Jntufastupdates.com Scanned by CamScanner

If the bias voltage and input voltage both are linearly operated then the voltage across inductor ($L\frac{di}{dt}$) opposes the sudden changes and hence the inductor acts as open ckt at Abrupt times.

If the input is half peak to peak voltage then the voltage is $\frac{h_{fe}I}{h_{oe}}$ and the time constant is $h_{oe}L$ as the transistor is replaced by hybrid parameter model.

RLC circuits:-



$$V_i(t) = i(t)R + L\frac{di(t)}{dt} + \frac{1}{C}\int i(t)\,dt$$

Apply L.T on both sides

$$V_I(s) = I(s)R + LsI(s) + \frac{1}{Cs}I(s)$$

$$= I(s)\left[R + Ls + \frac{1}{Cs}\right]$$

$$V_I(s) = I(s)\left[\frac{RCs + LCs^2 + 1}{Cs}\right]$$

$$V_I(s) = \frac{I(s)}{Cs}\left[RCs + s^2LC + 1\right]$$

$$V_I(s) = \frac{I(s)}{Cs}LC\left[s^2 + \left(\frac{R}{L}\right)s + \frac{1}{LC}\right] \longrightarrow (1)$$

www.Jntufastupdates.com Scanned by CamScanner

$V_o(s) = \frac{1}{Cs} I(s)$ → from figure ⟶ (2)

from equ ①

$$I(s) = \frac{V_I(s)\, Cs}{LC\left[s^2 + \left(\frac{R}{L}\right)s + \frac{1}{LC}\right]} \quad \text{---(3)}$$

equ ③ in ②

$$V_o(s) = \frac{1}{Cs}\left[\frac{V_I(s)\, Cs}{LC\left[s^2 + \left(\frac{R}{L}\right)s + \frac{1}{LC}\right]}\right]$$

$$V_o(s) = \frac{V_I(s)}{LC\left[s^2 + \left(\frac{R}{L}\right)s + \frac{1}{LC}\right]}$$

$$\frac{V_o(s)}{V_I(s)} = \frac{1}{LC\left[s^2 + \left(\frac{R}{L}\right)s + \frac{1}{LC}\right]}$$

$\Rightarrow s^2 + \left(\frac{R}{L}\right)s + \frac{1}{LC}$ ⇒ characteristic equation

$$s_1 s_2 = -\left(\frac{R}{L}\right) \pm \frac{\sqrt{(R/L)^2 - \frac{4}{LC}}}{2}$$

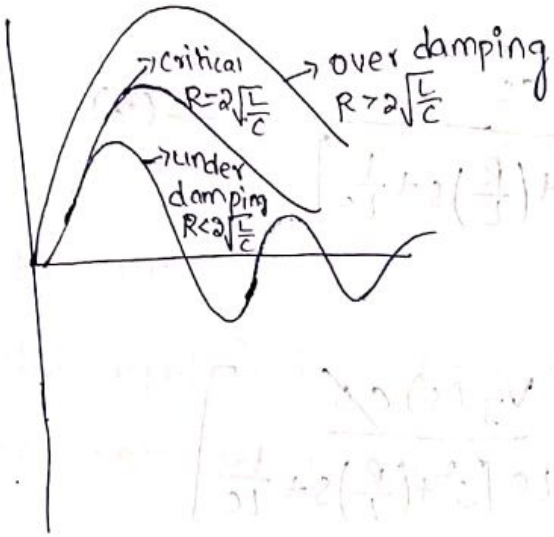
$$s_1 s_2 = -\left(\frac{R}{2L}\right) \pm \sqrt{\left(\frac{R}{2L}\right)^2 - \frac{1}{LC}}$$

If $\left(\frac{R}{2L}\right)^2 > \frac{1}{LC}$	If $\left(\frac{R}{2L}\right)^2 = \frac{1}{LC}$	If $\left(\frac{R}{2L}\right)^2 < \frac{1}{LC}$
over damping	critical damping	under damping
$R > 2L\sqrt{\frac{1}{LC}}$	$R = 2\sqrt{\frac{L}{C}}$	$R < 2\sqrt{\frac{L}{C}}$
$R > 2\sqrt{\frac{L^2}{LC}}$	Hence the roots are complex conjugative each other	
$R > 2\sqrt{\frac{L}{C}}$		

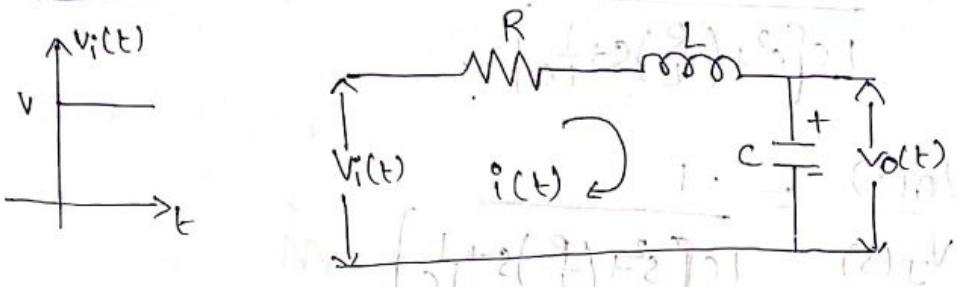
Characteristic impulse impedance

www.Jntufastupdates.com Scanned by CamScanner

In critical damping roots are real and equal.
In over damping roots are real and different.



Step response:-



WKT $V_o(s) = \frac{1}{Cs} I(s)$ —(1)

$$V_o(s) = \frac{V_I(s)}{LC\left[s^2+(R/L)s+\frac{1}{LC}\right]} \quad \text{—(2)}$$

Sub (2) in (1)

$$I(s) = V_o(s)Cs$$

$$= \frac{V_I(s)\cdot Cs}{LC\left[s^2+\left(\frac{R}{L}\right)s+\frac{1}{LC}\right]}$$

$$I(s) = \frac{V_I(s)\cdot s}{L\left[s^2+\left(\frac{R}{L}\right)s+\frac{1}{LC}\right]}$$

$V_i(t) = V$

$V_I(s) = V/s$

 Scanned by CamScanner

$$I(s) = \frac{\frac{V}{s}\cdot s}{L\left[s^2+\left(\frac{R}{L}\right)s+\frac{1}{LC}\right]}$$

$$I(s) = \frac{V}{L\left[s^2+(R/L)s+1/LC\right]}$$

over damping

$R > 2\sqrt{\frac{L}{C}}$

$$i(t) = \frac{V}{2AL}\left[e^{-s_1 t} - e^{-s_2 t}\right]$$

If $s_1 > s_2$

where

$$A = \sqrt{\left(\frac{R}{2L}\right)^2 - \frac{1}{LC}}$$

critical damping

$R = 2\sqrt{\frac{L}{C}}$

$$i(t) = \frac{Vt}{L} e^{-Rt/2L}$$

under damping

$R < 2\sqrt{\frac{L}{C}}$

$$i(t) = \frac{V}{BL} e^{-Rt/2L} \sin Bt$$

where

$$B = \sqrt{\frac{1}{LC} - \left(\frac{R}{2L}\right)^2}$$

Ringing circuit :-

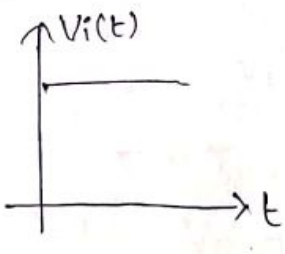
A circuit which is used to generate oscillations is called ringing circuit.

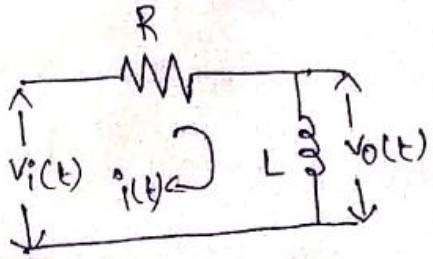
It generates oscillations at undamped condition.

A ringing circuit is used to generate regular pulses which are seperated by time 't' which finds its most of the applications in triggering circuits.

RL circuit :-

step response :-





www.Jntufastupdates.com Scanned by CamScanner

$$V_i(t) = V_R(t) + V_L(t)$$

$$= V_R(t) + V_0(t)$$

$$V_i(t) = i(t)R + L\frac{di(t)}{dt}$$

$$V_I(s) = I(s)R + LsI(s)$$

$$\frac{V}{s} = I(s)\left[R + Ls\right]$$

$$I(s) = \frac{V}{s(R+Ls)} \quad \text{——(1)}$$

from figure

$$V_0(s) = Ls\left(I(s)\right) \quad \text{——(2)}$$

$$I(s) = \frac{V_0(s)}{Ls}$$

www.Jntufastupdates.com Scanned by CamScanner

problems on high pass Rc N/w:-

1) A 10Hz symmetrical square wave, whose peak to peak, Amplitude is 2V. Impressed upon high pass Rc circuit whose lower 3dB frequency is 5Hz. then calculate and sketch the output wave form, in particular what is the peak to peak output Amplitude?

Sol:- given that

$V_i(p-p) = 2V$

$f = 10Hz$

$f_L = 5Hz$

wkt $f = \frac{1}{T}$

$T = \frac{1}{f} = \frac{1}{10}$

$\boxed{T = 0.1sec}$

wkt $f_L = \frac{1}{2\pi Rc}$

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

$= \frac{1}{2(3.14)\times 5}$

$\boxed{Rc = 0.03sec}$

$\boxed{Rc < T}$

It is a symmetrical square

$V_1 = -V_2$

$V_1' = -V_2'$

$T_1 = T_2$

wkt $V_1 = \frac{V}{1+e^{-T/2Rc}}$

www.Jntufastupdates.com Scanned by CamScanner

$$V_1 = \frac{2}{1+e^{-0.1/2(0.03)}}$$

$$\boxed{V_1 = +1.656\ V}$$

$$\boxed{V_2 = -1.656\ V \quad \therefore V_2 = -V_1}$$

WKT

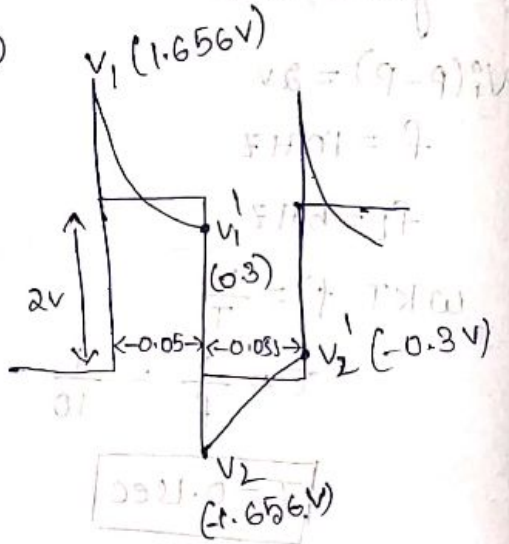
$$V_1' = V_1 e^{-T/2RC}$$

$$= 1.656 e^{-0.1/2(0.03)}$$

$$\boxed{V_1' = 0.3\ V}$$

$$V_2' = -V_1'$$

$$\boxed{V_2' = -0.3\ V}$$



O/p peak to peak amp = V

$$V = |V_1| + |V_2|$$

$$= 1.656 + 1.656$$

$$\boxed{V = 3.312\ V}$$

(2) A square wave whose peak to peak value is 1V extends ± 0.5 w.r.to ground. The half Period is 0.1 seconds, this voltage is impressed upon RC differentiating circuit whose time constant is 0.2 sec then determine maximum and minimum values of O/p voltage in steady state.

$RC = 0.2\text{sec}$ | $T = T_1 + T_2$, $T = 0.2\text{sec}$, $V = 1V$

www.Jntufastupdates.com Scanned by CamScanner

(3) A 10Hz square wave is fed to an amplifier. calculate and plot the o/p wave form under the following conditions.

(i) The lower 3dB frequency is A) 0.3Hz, B) 3Hz

C) 30Hz

(4) If a square wave of 5KHz is applied to an Rc high pass circuit and the resultant wave form measured on a CRO was tilted from 15V to 10V. then find the lower 3dB frequency of the high pass Rc circuit.

Sol:- given that

$f = 5KHz$, $V_1 = 15V$, $V_1' = 10V$

~~The~~ - the peak to peak voltage $V = 15 + 15$

$V = 30V$

WKT

$$\% \text{ tilt} = \frac{V_1 - V_1'}{\frac{V}{2}} \times 100$$

$$= \frac{15 - 10}{\frac{30}{2}} \times 100$$

$$= \frac{5}{15} \times 100$$

$$= 33.3\%$$

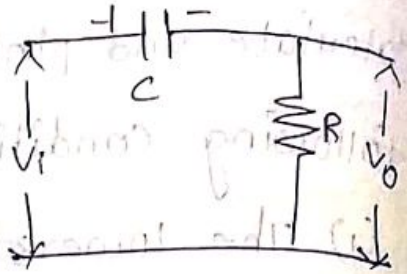
WKT $\% \text{ tilt} = \frac{\pi f_L}{f} \times 100$

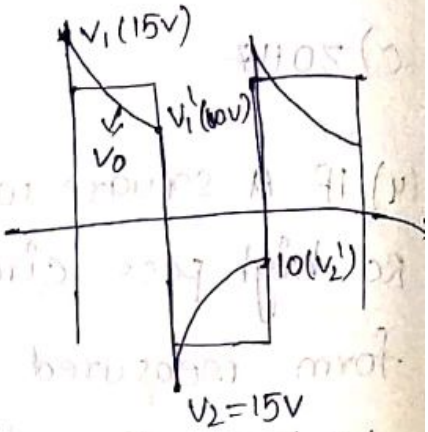
www.Jntufastupdates.com Scanned by CamScanner

$$f_L = \frac{\cdot 1 \cdot \text{tilt} \times f}{\pi \times 100}$$

$$= \frac{33.3 \times 5 \times 10^3}{3.14 \times 100}$$

$$f_L = 530.2 \text{ Hz}$$





(5) The oscilloscope has a coupling capacitor $C_c = 1\mu f$. when the input resistance $R_i = 1M\Omega$ then determine the minimum square frequency that can be displayed if the tilt is not to exceed 1% ?

(6) Calculate the lowest square wave frequency that can be passed by an amplifier with a cutt off frequency of 10Hz, if the output tilt is not to exceed 2% ?

(7) An exponential i/p is applied to an high Rc circuit

(a) If $n \neq 1$ prove that the peak of the o/p pulse occurs at $x = 2.90 \left(\frac{n}{n-1}\right) \log n$

(b) If $n = 1$ prove that the peak of o/p pulse occurs at $x = 1$.

Sol:- ~~Part~~-A we know that $\boxed{V_o(t) = \frac{V_n}{n-1}\left[e^{-x/n} - e^{-x}\right]}$

www.Jntufastupdates.com Scanned by CamScanner

peak value of o/p pulse occurs at

$$\frac{dV_o}{dx} = 0$$

$$\frac{dV_o}{dx} = \frac{d}{dx}\left[\frac{V_n}{n-1}\left[e^{-x/n} - e^{-x}\right]\right]$$

$$0 = \frac{V_n}{n-1}\left[\frac{d}{dx}\left[e^{-x/n} - e^{-x}\right]\right]$$

$$= \frac{V_n}{n-1}\left[e^{-x/n}\left(\frac{-1}{n}\right) - e^{-x}(-1)\right]$$

$$0 = \frac{V_n}{n-1}\left[-\left(\frac{e^{-x/n}}{n}\right) + e^{-x}\right]$$

$$\frac{-V_n}{n-1}\cdot\frac{e^{-x/n}}{n} + \frac{V_n}{n-1}e^{-x} = 0$$

$$\frac{V_n}{n-1}\cdot e^{-x} = +\frac{V_n}{n-1}\frac{e^{-x/n}}{n}$$

$$ne^{-x} = e^{-x/n}$$

log on both sides

$$\log_e n(-x)\log_e e = \left(\frac{-x}{n}\right)\log_e e$$

$$-x\log_e n(1) = \frac{-x}{n}(1)$$

$$-\log_e n(1)(-x) = \frac{-x}{n}(1)$$

$$-x\log_e n = \frac{-x}{n}$$

$$\log_e n = \frac{-x}{n} + x$$

$$\frac{-x}{n} + x = \log_e n$$

$$x\left(\frac{-1}{n} + 1\right) = \log_e n$$



www.Jntufastupdates.com Scanned by CamScanner

$$x\left(\frac{n-1}{n}\right) = \log_e n$$

$$x = \log_e n\left(\frac{n}{n-1}\right)$$

$$= \left(\frac{n}{n-1}\right)\log_{10} n\,(2.3)$$

$$\log_e n = \frac{\log_{10} n}{\log_{10} e} = \frac{1}{\frac{1}{2.3}}$$

$$\boxed{x = 2.3\left(\frac{n}{n-1}\right)\log_{10} n}$$

(B) For a high pass RC ckt by applying exponential input. If $\tau = RC$ and $n=1$. the output voltage

$$\boxed{V_0 = V x e^{-x}}$$

$$\frac{dV_0}{dx} = 0$$

$$\frac{dV_0}{dx} = \frac{d}{dx}\left(V x e^{-x}\right)$$

$$0 = V x e^{-x}(-1) + e^{-x}(V)$$

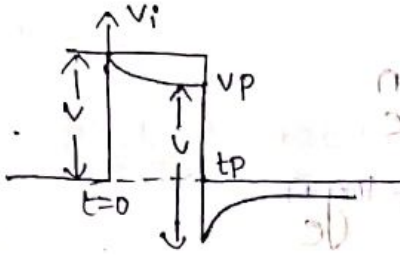
$$V e^{-x} - V x e^{-x} = 0$$

$$V e^{-x}[1-x] = 0$$

$$\boxed{1-x=0}$$

$$\boxed{x=1}$$

(8) A pulse shown below is applied to a high pass RC circuit, prove by direct integration, the aera under the curve is 0.



www.Jntufastupdates.com Scanned by CamScanner

Sol:- Case(i) :- $0 \le t \le t_p$

$$\text{Area 1} = \int_0^{t_p} V e^{-t/RC}\, dt$$

$$= V \int_0^{t_p} e^{-t/RC}\, dt$$

$$= V \left[\frac{e^{-t/RC}}{1/RC} \Big|_0^{t_p} \right]$$

$$= -VRC \left(e^{-t_p/RC} - e^{-0/RC} \right)$$

$$\therefore A_1 = -VRC \left(e^{-t_p/RC} - 1 \right)$$

Case(2):- $\infty > t \ge t_p$

$$A_2 = \int_{t_p}^{\infty} (V_p - V) e^{-(t-t_p)/RC}\, dt$$

$$= \int_{t_p}^{\infty} \left(V e^{-t/RC} - V \right) e^{-(t-t_p)/RC}\, dt$$

$$= \int_{t_p}^{\infty} V e^{-t/RC} \cdot e^{-t/RC} e^{t_p/RC}\, dt - \int_{t_p}^{\infty} V e^{-t/RC} \cdot e^{t_p/RC}\, dt$$

$$= V \left[\int_{t_p}^{\infty} e^{-t/RC}\, dt - e^{t_p/RC} \int_{t_p}^{\infty} e^{-t/RC}\, dt \right]$$

$$= V \left[-RC \cdot e^{-t/RC} \Big|_{t_p}^{\infty} - e^{t_p/RC} \cdot e^{-t/RC} (-RC) \Big|_{t_p}^{\infty} \right]$$

$$= V \left[(-RC)\left(e^{-\infty/RC} - e^{-t_p/RC} \right) - e^{t_p/RC} (-RC) \left[e^{-\infty/RC} - e^{-t_p/RC} \right] \right]$$

www.Jntufastupdates.com Scanned by CamScanner

$$A_2 = -VRC\left[\left(0 - e^{-tp/RC}\right) - e^{tp/RC}\left(0 - e^{-tp/RC}\right)\right]$$

$$= -VRC\left[-e^{-tp/RC} + e^{tp/RC}\cdot e^{-tp/RC}\right]$$

$$= -VRC\left[-e^{-tp/RC} + 1\right]$$

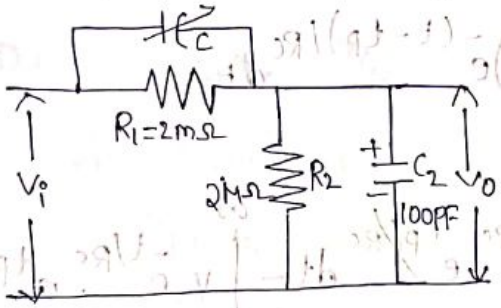
$$A_2 = -VRC\left[1 - e^{-tp/RC}\right]$$

$$A_1 + A_2 = -VRC\,e^{-tp/RC} + VRC - VRC + VRC\,e^{-tp/RC}$$

$$\boxed{A_{total} = 0}$$

Problems on Aduinator :-

(1) compute and draw to scale and o/p wave form for C=100PF ; C=150PF and C=50PF and their input is 25 v step.



For perfect compensation $R_1C_1 = R_2C_2$

$$C_1 = \frac{R_2C_2}{R_1}$$

$$= \frac{2\times10^{6}\times100\times10^{-12}}{2\times10^{6}}$$

$$\boxed{C_1 = 100pF}$$

a) $C_1 = 100PF$

$$V_0(0^+) = V\cdot\frac{C_1}{C_1+C_2} = V\,\frac{100PF}{200PF} = 0.5V$$

www.Jntufastupdates.com Scanned by CamScanner

$V_0(0^+) = 0.5 \times 25 = 12.5$

$V_0(\infty) = V \cdot \frac{R_2}{R_1+R_2} = 25 \times \frac{2}{2+2} = \frac{25 \times 2}{4} = 12.5\,V$

(b) $C_1 = 150\,pF$

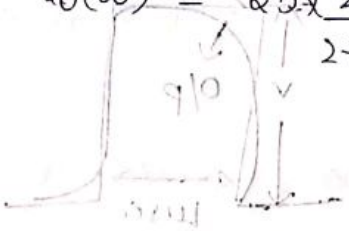
$V_0(0^+) = V \cdot \frac{C_1}{C_1+C_2} = 25 \times \frac{150\,pF}{250\,pF} = 15V$

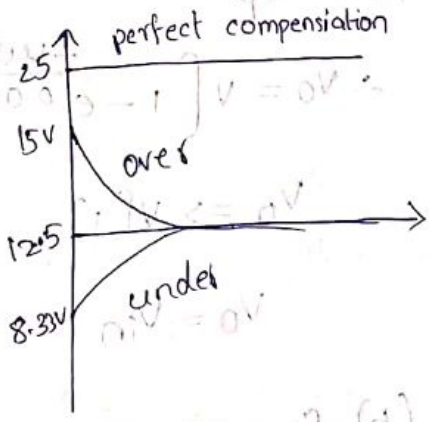
$V_0(\infty) = 25 \times \frac{2}{2+2} = 12.5\,V$

(c) $C_1 = 50\,pF$

$V_0(0^+) = 25 \times \frac{50\,pF}{150\,pF} = 8.33\,V$

$V_0(\infty) = 25 \times \frac{2}{2+2} = 12.5\,V$





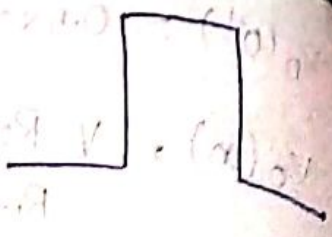
Problems on Lp Rc ckt:

1) An ideal 1 microsecond pulse is FET to an amplifier. Calculate and plot the o/p wave form under the following conditions.

(a) The upper 3dB frequency is (a) 10 MHz
(b) 1 MHz
(c) 0.1 MHz

www.Jntufastupdates.com Scanned by CamScanner

$t_p = 1\,\mu sec$



(a) $f_H = 10MHz$

WKT $V_0 = V\left[1 - e^{-t_p/RC}\right]$

$= V\left[1 - e^{-1\mu sec/RC}\right]$

$f_H = 10MHz$

WKT $f_H = \frac{1}{2\pi RC}$

$RC = \frac{1}{2\pi \times 10MHz}$

$\boxed{RC = 0.015\,\mu sec}$

$RC = 0.015\mu sec$

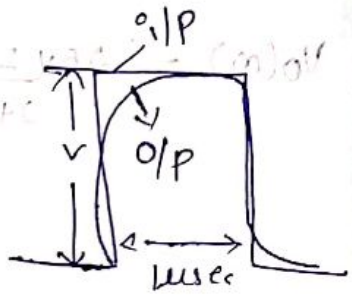
$t_p = 1\mu sec$

$RC << t_p$

$\therefore V_0 = V\left[1 - e^{\frac{-1\mu sec}{0.015\mu sec}}\right]$

$V_0 \Rightarrow V[1]$

$V_0 = V_{in}$



(b) $f_H = 1MHz$

WKT $V_0 = V\left[1 - e^{-t_p/RC}\right]$

$= V\left[1 - e^{-1\mu/RC}\right]$

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

$= \frac{1}{2\pi \times 1}$

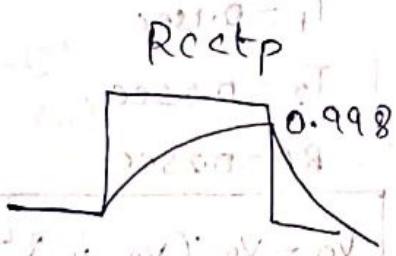
$RC = 0.15\,\mu sec$

www.Jntufastupdates.com Scanned by CamScanner

$t_p = 1\mu sec$

$RC = 0.15\ \mu sec$

$RC \ll t_p$



$$\therefore V_O = V\left[1 - e^{\frac{-1\mu sec}{0.15\mu sec}}\right]$$

$$= V[0.998]$$

$$V_O = 0.998\, V_{in}$$

(c) $f_H = 0.1 MHz$

$$\omega \cdot KT \quad V_O = V\left[1 - e^{-1\mu/RC}\right]$$

$$RC = \frac{1}{2\pi f_H} = \frac{1}{2\pi \times 0.1\, MHz}$$

$$= 1.59\ \mu sec$$

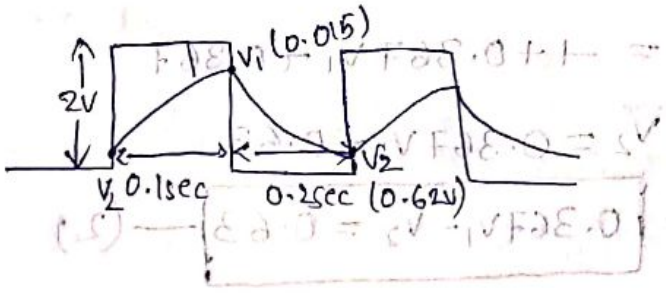
$RC >> t_p$

$$\therefore V_O = V\left[1 - e^{\frac{-1\mu s}{1.59\mu s}}\right]$$

$$V_O = V[0.466]$$

$$V_O = 0.466\, V_{in}$$

(3) A square wave whose peak to peak amplitude is 2V extends ±1V w.r. to ground. the duration of positive possible section is 0.1sec and that of negative section is 0.2 sec. If this wave form is impressed upon Rc integrating CKt whose time constant is 0.2 sec. what are the steady state maximum and minimum values of o/p waveform.



www.Jntufastupdates.com Scanned by CamScanner

V_i (P-P) = 2V

$T_1 = 0.1 sec$

$T_2 = 0.2 sec$

$RC = 0.2 sec$

$$V_0 = V_f - (V_f - V_{in}) e^{-t/RC} \quad \text{---(1)}$$

at $t = T_1$

$$V_0 = V_f + (V_{in} - V_f) e^{-t/RC}$$

$$V_1 = 1 + (V_2 - 1) e^{-0.1/0.2}$$

$$V_1 = 1 + (V_2 - 1) e^{-1/2}$$

$$= 1 + (V_2 - 1) 0.606$$

$$V_1 = 1 + 0.606 V_2 - 0.606$$

$$V_1 = 0.606 V_2 + 0.394$$

$$V_1 - 0.606 V_2 = 0.394 \quad \text{---(1)}$$

at $t = T_2$

$$V_0 = V_f + (V_{in} - V_f) e^{-t/RC}$$

$$V_2 = -1 + (V_1 - (-1)) e^{-0.2/0.2}$$

$$V_2 = -1 + (V_1 + 1) e^{-1}$$

$$V_2 = -1 + (V_1 + 1) 0.367$$

$$V_2 = -1 + 0.367 V_1 + 0.367$$

$$V_2 = 0.367 V_1 - 0.63$$

$$0.367 V_1 - V_2 = 0.63 \quad \text{---(2)}$$

 Scanned by CamScanner

solving equ(1) & (2) (2)×0.606 —(4)

$V_1 - 0.406V_2 = 0.394$ —(3)

$0.222V_1 - 0.406V_2 = 0.381$ —(4)

$0.778V_1 = 0.013$

$V_1 = \frac{0.013}{0.778} = 0.015$

from (2)

$0.367(0.015) - V_2 = 0.63$

$V_2 = 0.624$

$V_1 = 0.015$ | $V_2 = 0.6242$

(2) The o/p wave form from an amplifier under pulse test has a rise time of 1μsec determine the upper 3dB frequency amplifier.

Sol:- $t_r = 1\mu sec$

W.K.T $t_r = \frac{0.35}{BW}$

$t_r = \frac{0.35}{f_H}$

$f_H = \frac{0.35}{1\times10^{-6}}$

$\boxed{f_H = 0.35MHz}$

For 'n' no: of stages whose individual rise times are $t_{r1}, t_{r2}, t_{r3}, \ldots t_{rn}$ respectively then the resultant rise time t_r is given by

$$t_r = 1.05\left(\sqrt{t_{r1}^2 + t_{r2}^2 + \ldots + t_{rn}^2}\right)$$

www.Jntufastupdates.com Scanned by CamScanner