Topic Name : Lecture 11 (Rough)

Day :

Time : Date : / /

DC value / Average value :

[# The signal must be periodic.]

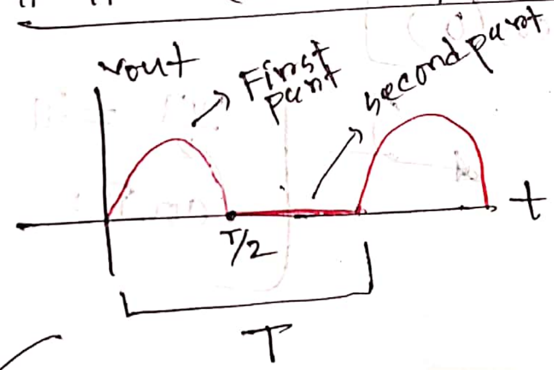
$$V_{AV} = \frac{1}{T}\int_0^T v(t)\,dt$$

T → time period

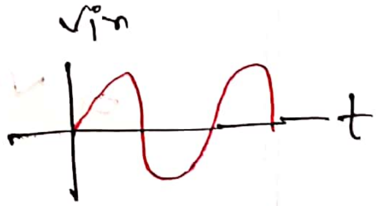
$\frac{1}{T}$ → Time period.

$v(t)$ → signal

H.W (~~ide~~ rectifier) (ideal diode) :



suppose input is $V_{in} = V_m \sin(\omega t)$



$$\therefore \text{Area} = \int_0^T V_{out}(t)\,dt$$

$$= \underbrace{\int_0^{T/2} V_{out}(t)\,dt}_{\text{First part}} + \underbrace{\int_{T/2}^{T} V_{out}(t)\,dt}_{\text{second part}}$$

$$= \int_0^{T/2} V_{out}(t)\,dt + 0$$

Topic Name : Day : Time : Date : / /

$$= \int_0^{T/2} V_m \sin(\omega t)\, dt$$

[For H.W. rectifier of ideal diode $V_{out} = V_{in}$]

$$= V_m \int_0^{T/2} \sin(\omega t)\, dt$$

$$= V_m \left[-\frac{\cos \omega t}{\omega} \right]_0^{T/2}$$

$\boxed{\omega = \frac{2\pi}{T}}$ → omega

$$= \cancel{V_m} \frac{d}{\omega}$$

$$= V_m \frac{1}{\omega} \left[-\cos\left(\frac{\omega T}{2}\right) + \cos(0) \right]$$

$\frac{\omega T}{2} = \pi$

$\cos \pi = -1$

$$= V_m \cdot \frac{1}{\omega} \cdot 2$$

$$= V_m \frac{1}{\frac{2\pi}{T}} \cdot 2$$

$$= \frac{T \cdot V_m}{\pi}$$

$$= \frac{T}{\pi} V_m \rightarrow \text{only Area.}$$

$\therefore$ $\boxed{\text{Average / DC value of H.W.R.}}$

$$V_{AV} = \frac{\text{Area}}{T} = \frac{T}{\pi} V_m \cdot \frac{1}{T} = \frac{1}{\pi} V_m$$

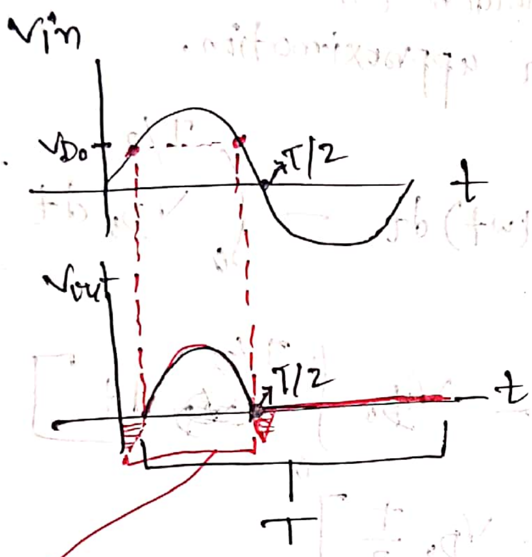
$$\boxed{\therefore V_{AV} = \frac{1}{\pi} V_m}$$

Topic Name :

Day :

Time : Date : / /

H.W.R (Real diode)



$V_{in} = V_m \sin(\omega t)$

$\therefore V_{out} = V_m \sin(\omega t) - V_{D_0}$

$\therefore$ Area of output waveform:

$\therefore \quad \frac{1}{T}\int_0^T V_{out}(t)\,dt$

$= \frac{1}{T}\int_0^{T/2} V_{out}(t)\,dt + \int_{T/2}^{T} V_{out}(t)\,dt$

$= \frac{1}{T}\int_0^{T/2} V_{out}(t)\,dt + 0$

$= \frac{1}{T}\int_0^{T/2} \underbrace{\left[V_m \sin(\omega t) - V_{D_0}\right]}\,dt$

but this not 100% ~~exact~~ correct equation because if we consider it small part of wave still include ~~for~~ below the time axis

Topic Name : Day : Time : Date : / /

~~but~~ but as $V_{D_0} = 0.7V$ is too small we can ~~take~~ consider this error. This is an approximation.

$$= \frac{1}{T}\left[\int_0^{T/2} V_m \sin(\omega t)\,dt - \int_0^{T/2} V_{D_0}\,dt\right]$$

$$= \frac{1}{T}\left[\frac{T}{\pi}V_m - V_{D_0}\int_0^{T/2} dt\right]$$

$$\underbrace{= \frac{1}{T}\underbrace{\left[\frac{T}{\pi}V_m - V_{D_0}\frac{T}{2}\right]}_{\text{only Area}}}_{\cancel{V_{AV}}\ \text{Average Value / DC value of H.W.R (real diode.}}$$

~~VAV (7)~~

$$\underbrace{\boxed{V_{AV} = \frac{1}{\pi}V_m - \frac{1}{2}V_{D_0}}}_{\text{Half wave rectifier o/p (Real diode)}}$$

Topic Name :

Day :

Time : Date : / /

~~FW~~

Full wave rectifier (F.W.R) (~~Rea~~ Ideal diode)

Average value / DC value,

$$\boxed{V_{AV} = \frac{2}{\pi} V_m}$$

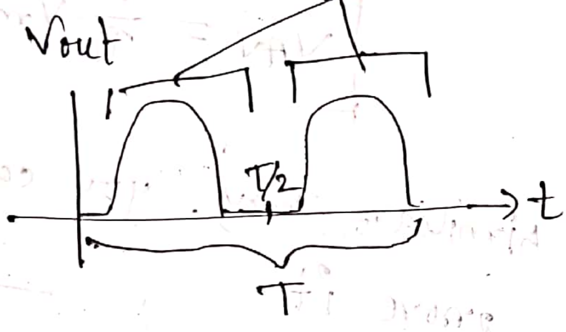
[similar way, you can prove it.]

Topic Name : Day : Time : Date : / /

Full wave rectifier (Real diode)

output

both part has same area



$V_{out} = V_m \sin(\omega t) - 2V_{D0}$

$$\therefore \quad \text{Area} = \int_0^T V_{out}(t)\,dt$$

$$= 2\int_0^{T/2} V_{out}(t)\,dt$$

$$= 2\int_0^{T/2} \left[V_m \sin(\omega t)\,\cancel{dt} - 2V_{D0}\right] dt$$

$$= 2\left[\int_0^{T/2} V_m \sin(\omega t)\,dt - \int_0^{T/2} 2V_{D0}\,dt\right]$$

$$= 2\left[\frac{T}{\pi} V_m - 2V_{D0}\,\frac{T}{2}\right]$$

Topic Name : Day : Time : Date : / /

$\therefore V_{AV} = \frac{Area}{T}$

$\therefore \boxed{V_{AV} = \frac{2}{\pi} V_m - 2V_{D0}}$ F.W. rectifier (Real diode) Average / DC value

$\boxed{\begin{array}{l} V_m = \text{input peak} \\ V_p = \text{output peak} \end{array}}$

summary

Model		H.W. rectifier	F.W. rectifier
Ideal diode	Peak value of output V_p	V_m	V_m
Real diode (CVD)	Peak value of output V_p	$V_m - V_{D0}$	$V_m - 2V_{D0}$
Ideal diode	Average/DC value, V_{AV} or V_{DC}	$\frac{1}{\pi} \cdot V_m$	$\frac{2}{\pi} \cdot V_m$
Real diode (CVD)	Average/DC value, V_{AV} or V_{DC}	$\frac{1}{\pi} \cdot V_m - \frac{1}{2} V_{D0}$	$\frac{2}{\pi} \cdot V_m - 2V_{D0}$

Topic Name : Day : Time : Date : / /

Ex: 4

~~Supp~~ $V_{in} = 5 \sin(\omega t)$

and $V_{D0} = 0.7$

what is V_{DC}/V_{AV} for F.W rectifier (Real diode)?

Soln:

$$V_{DC} \text{ or } V_{AV} = \frac{2}{\pi} V_m - 2V_{D0}$$

$$= \frac{2}{\pi} \cdot 5 - 2 \times 0.7$$

$$= 1.7830 \text{ V (Ans)}$$

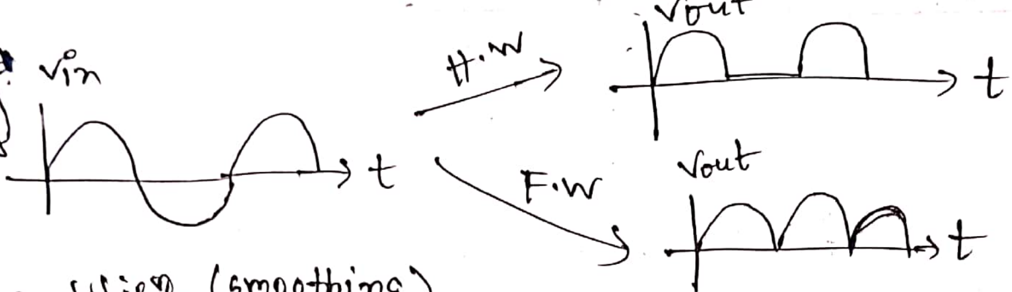
Here
$5 \sin(\omega t)$
$V_m \sin(\omega t)$
$\therefore V_m = 5$

Topic Name : Day : Time : Date : / /

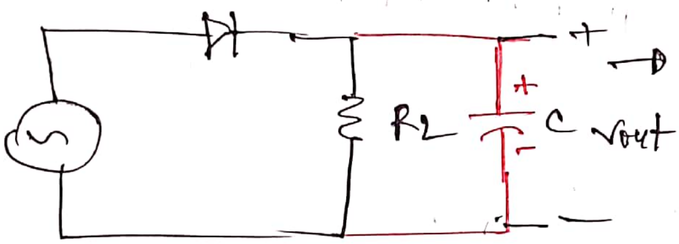
Pulsating to Flat DC

Rectifier - smoothing :

without smoothing



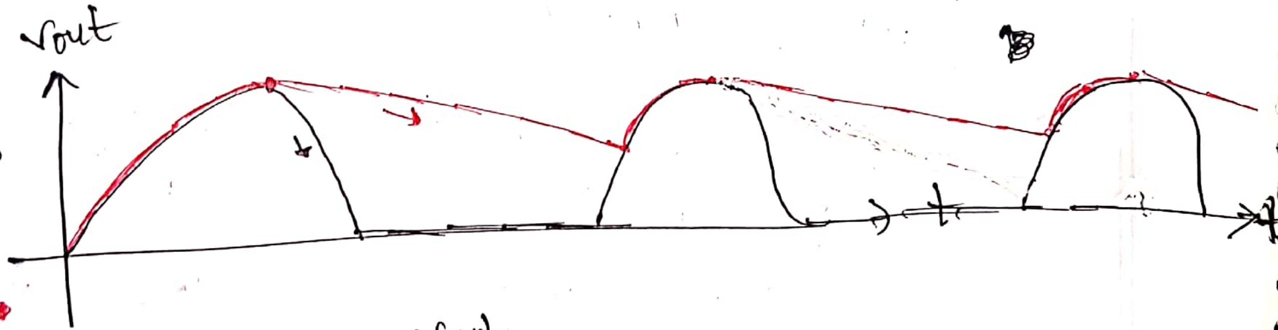
H.W Rectifier (smoothing)



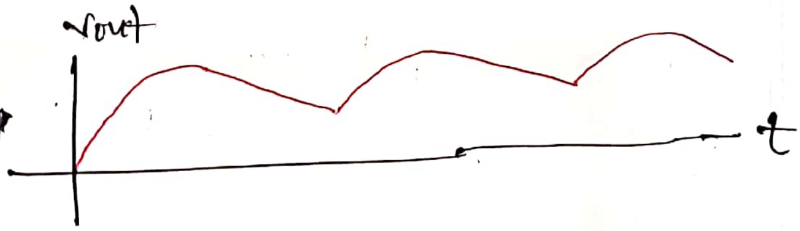
→ Just need to add a capasitor parrallal to the Load resistor

Black → without capasitor

Red → with capasitor



so we get after smoothing



capasitor → stores changes
→ does not allow to fall the voltage suddenly.

if capasitance (capasitor value) is high enough it will dischange slowly.

Topic Name : ______ Day : ______
Time : Date : / /

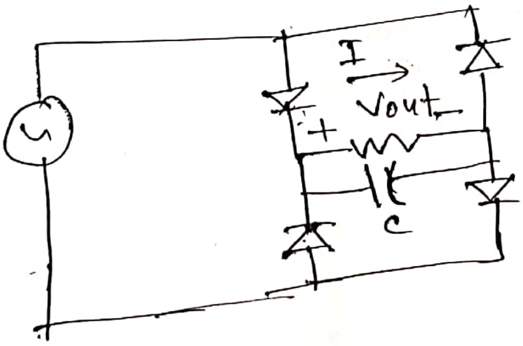
If ~~capa~~ value of capasitor is slow it will discharge fastly.

So, what do we want ?

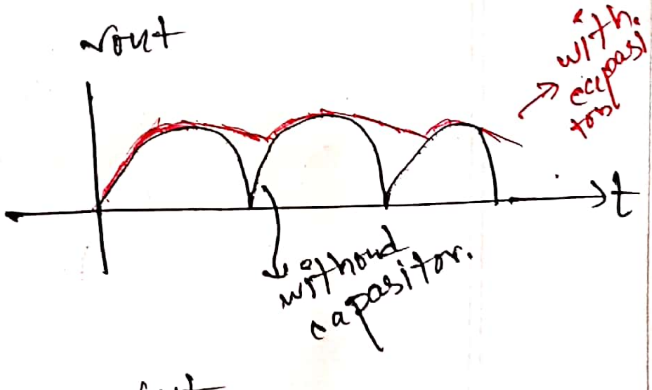
⇒ As we want or our Aim is to ~~A~~ make Ac to Dc. That is Dc is flat. And since Higher value of capasitor provide more flat output as it discharge slowly. so we want higher value of capasitor.

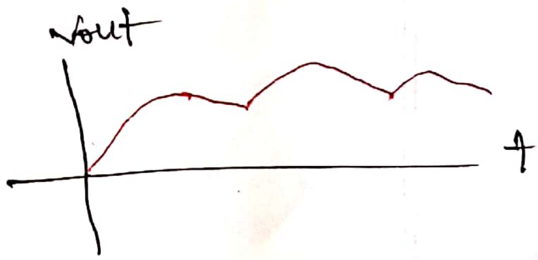
For full wave rectifier

Same as half wave, just need to add a capasitor parallel to load.



⇒





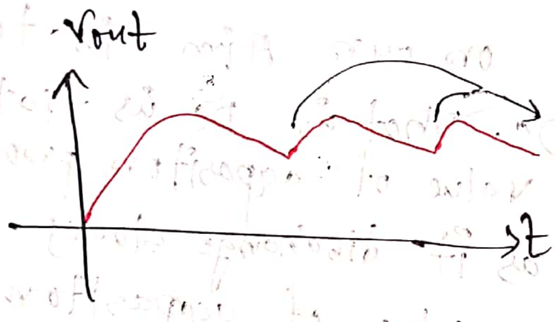
Topic Name :

Day :

Time : Date : / /

But they arenot still smooth enough.

They are like wave and the small wave called Ripple.

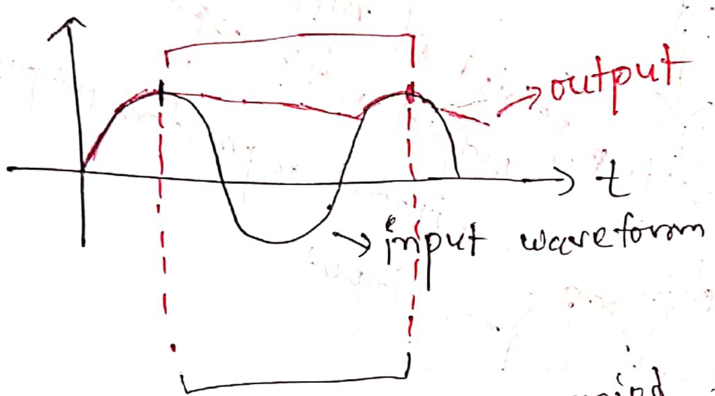


The less Ripple we have in our output the ~~to~~ more flatter will be it.

Topic Name : Day : Time : Date : / /

H.W rectifier

$T_r \rightarrow$ Time period of the ripple.



$T_s \rightarrow$ time period of the input signal.

$\because \boxed{T_r = T_s}$

Now we know, frequency $f = \frac{1}{T}$

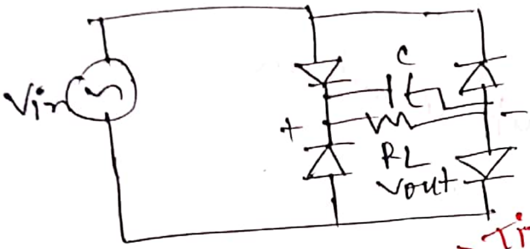
$\because \boxed{f_r = f_s}$

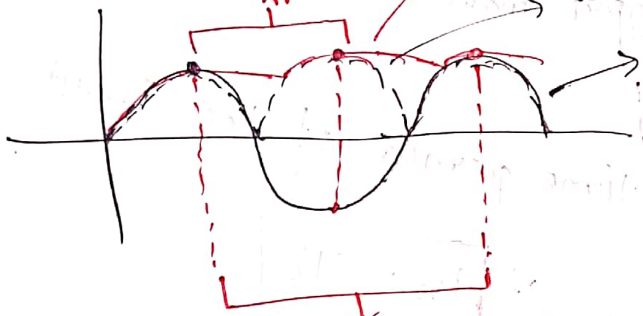
f_r → frequency of the ripple

f_s → frequency of the signal.

Topic Name :
Day :
Time : Date : / /

For Fullwave rectifier





$$\therefore \boxed{T_r = \frac{T_s}{2}}$$

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

$$\therefore \boxed{f_r = 2 f_s}$$

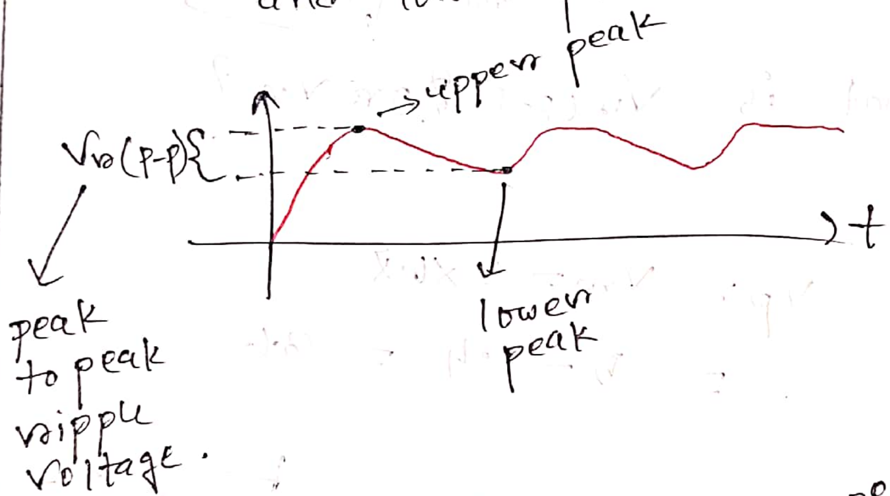
$f_r \rightarrow$ frequency of ripple

$f_s \rightarrow$ frequency of signal (input)

Topic Name : ______ Day : ______
Time : Date : / /

Peak to peak Ripple voltage ($V_r(p\text{-}p)$ or V_r)

Basically voltage difference of upper peak and lower peak of the ripple.



$$\therefore \boxed{V_r\,(\text{peak to peak}) = \frac{V_p}{f_r * RC}}$$

V_p → peak of output voltage

or V_r → ripple voltage

f_r → frequency of ripple

Both for H.W and F.W rectifier

R = output/Load resistor value

C = capasitance value

Topic Name : ______ Day : ______ Time : Date : / /

Ex:

$V_i = 5\sin(2\pi * 60 * t)$; F.W. rectifier

$R = 10k\Omega$, $C = 10\mu F$, $V_{D_0} = 0.7\,V$

micro $\boxed{\mu \to 10^{-6}}$

(A) what is $V_r(p-p)$ or V_r?

soln:

$V_p = V_m - 2\times 0.7$

$= 5 - 1.4 = 3.6$

Here $\omega = 2\pi * 60$ | $\omega = 2\pi f$

$\Rightarrow 2\pi f = 2\pi * 60$

$\Rightarrow f = 60$

$\therefore$ frequency of ripple,

$f_r = 2f_s$ $[f_s = f = 60]$

$= 2 * 60$

$= 120\ Hz$

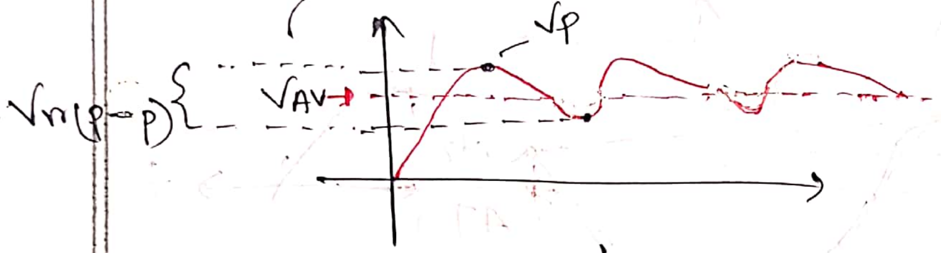
$\therefore V_r$ or $V_r(p-p) = \dfrac{V_p}{f_r * R * C} = \dfrac{3.6}{120 * (10 * 10^3) * (10 * 10^{-6})}$

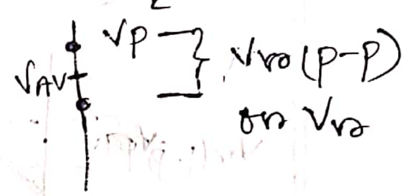
$= \dfrac{3}{10} = 0.3\,V$ (Ans)

Topic Name : Day :
Time : Date : / /

what will be the DC/Average Value after adding capacitor? V_{AV} or V_{DC}

→ that is,





$$\therefore \boxed{V_{AV} \text{ or } V_{DC} = V_p - \frac{V_{r(p-p)}}{2}}$$

$$\boxed{\cancel{V_{rms}} \quad V_{r(rms)} = \frac{V_{r(p-p)}}{2\sqrt{3}} = \frac{V_p}{2\sqrt{3} f_r \cdot RC}}$$

summary

	HW	FW
ripple frequency, f_r	f_s	$2f_s$
$V_{r(p-p)}$ or V_r	$\frac{V_{p(output)}}{f_r * RC}$	$\frac{V_{p(output)}}{f_r * RC}$
V_{AV}/V_{DC} after adding capasitor	$V_p - \frac{V_{r(p-p)}}{2}$	$V_p - \frac{V_{r(p-p)}}{2}$

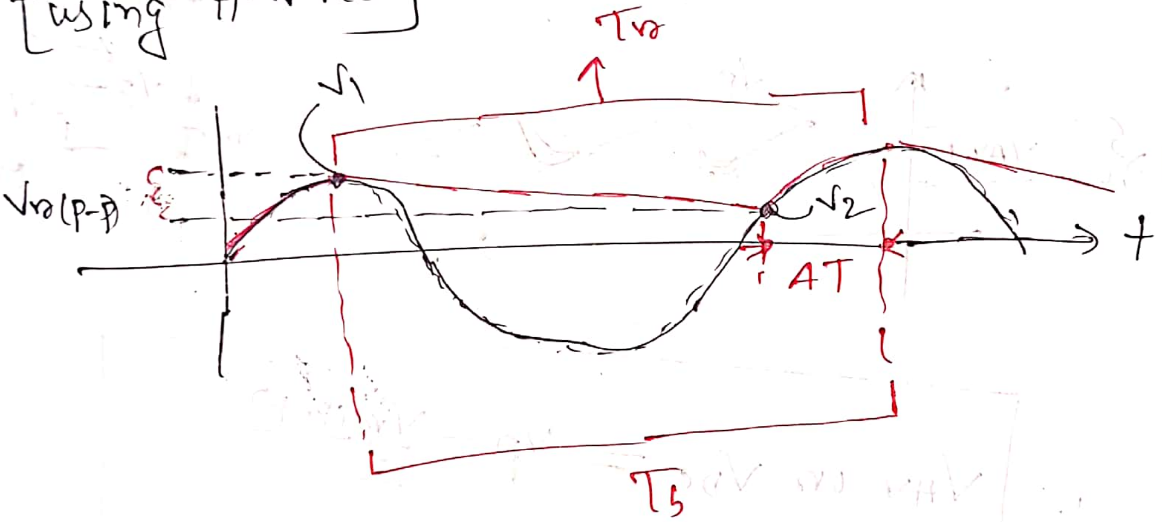
~~Vrms~~

$\cancel{V_{r(rms)} = \frac{V_p}{2\sqrt{3} f_r RC}}$

Topic Name : [Dont need any derivation for exam] Day : Time : Date :

[Derivation of $V_{r(p-p)} = \frac{V_p}{f_r * RC}$]

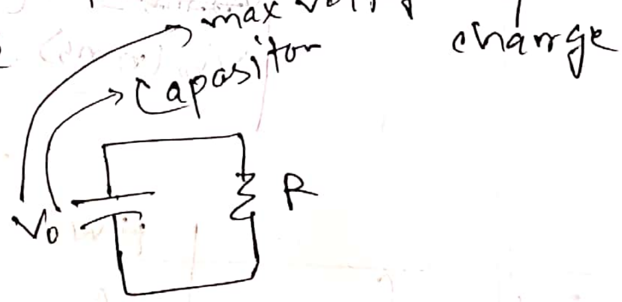
[using H.W Rec.]



$\therefore$ Discharging time of capasitor $(T_s - \Delta T)$

$\Delta T \rightarrow$ charging time

Now if we have



Voltage of cap. $V_c(t) = V_0 e^{-t/RC}$

$\therefore V_1 = V_p$

$V_2 = V_p e^{-(T_s - \Delta T)/RC}$

Topic Name : Day : Time : Date : / /

Assumptions:

1. $\Delta T \ll T_s$

$\therefore V_2 \simeq V_p e^{-T_s/RC}$

$= V_p \left[1 + \left(-\frac{T_s}{RC}\right) + \left(-\frac{T_s}{RC}\right)^2 \frac{1}{2!} + (\cdot)^3 \frac{1}{3!} + \cdots\right]$

2. $T_s \ll RC$

So, $\simeq V_p \left[1 - \frac{T_s}{RC}\right]$

$\therefore V_{r(p-p)} = V_1 - V_2$

$= V_p - V_p \left[1 - \frac{T_s}{RC}\right]$

$= V_p \cdot \frac{T_s}{RC}$ $\left[T_s = \frac{1}{f_s}\right]$

$= \frac{V_p}{f_s * RC}$

H.W

Similarly, $\boxed{\text{F.W}} \Rightarrow \boxed{V_{r(p-p)} = \frac{V_p}{2 f_s * RC}}$

Topic Name :

Day :

Time : Date : / /

50

$$\boxed{V_{r}(p-p) = \frac{V_p}{f_r * RC}}$$

$$\boxed{\begin{aligned} V_{DC} &= \frac{V_1+V_2}{2} \\ &= V_1 - \frac{V_r}{2} \end{aligned}}$$