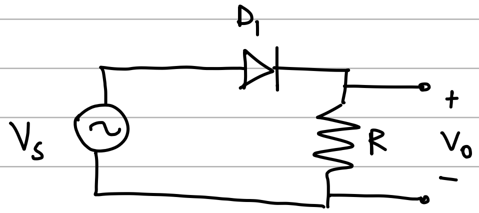
Half wave rectifier:

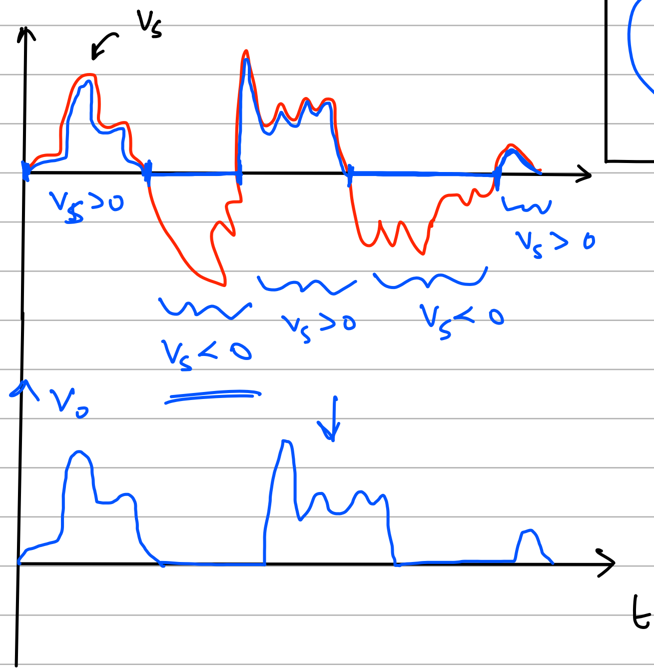


$V_s < 0$:

$V_o = 0$

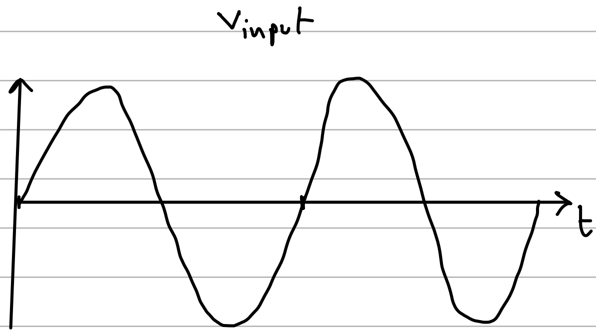
$V_s > 0$:

$V_o = V_s$

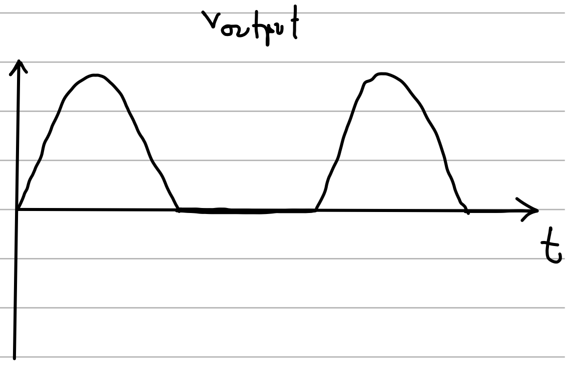


Key takeaway:

① Circuit keeps only +ve part of input.



⇒



5 10 12 7 2

$$\text{Avg}: \frac{(5+10+12+7+2)}{\#\text{ points}} = \frac{36}{5} = 7.2$$

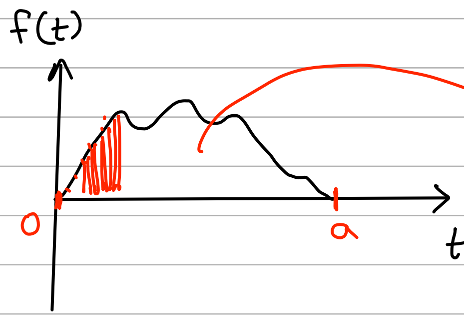
5 10 12 7 2 5 10 12 7 2 5 10 12 7 2

$$\text{Avg}: \frac{(5+10+12+7+2)+(5+10+12+7+2)+(5+10+12+7+2)}{3 \times 5}$$

↳ # points in duration

$$= \frac{\cancel{3}\times(5+10+12+7+2)}{\cancel{3}\times 5} = \frac{(5+10+12+7+2)}{5}$$

$$= 7.2$$

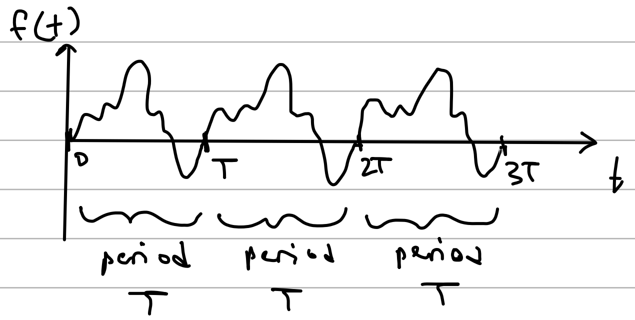


$\Rightarrow$ Average value :

$$\frac{\boxed{\int_0^a f(t)\,dt}}{a}$$

$\rightarrow$ the equivalent of adding data points

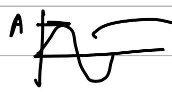
$$\operatorname{Lt}_{n\to\infty}\sum_{i=1}^{n} \Rightarrow \int$$



$\Rightarrow$ Average :

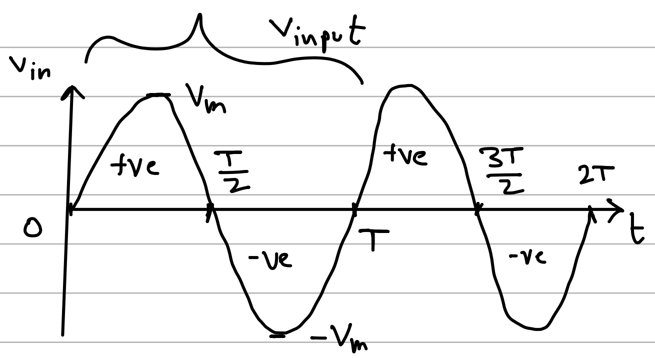
$$\frac{\int_0^{3T} f(t)\,dt}{3T}$$

$$= \frac{\int_0^{T} f(t)\,dt}{T}$$

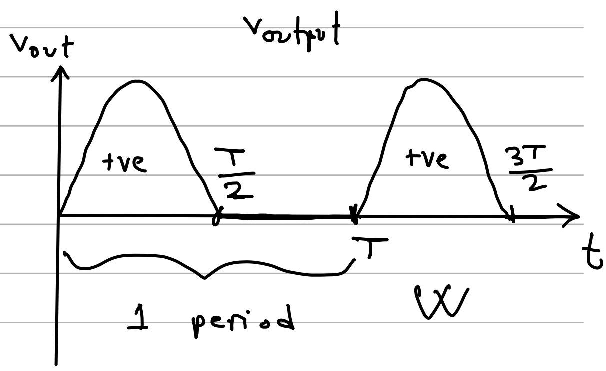


$\rightarrow A\sin(\omega t)$

1 period



$\Rightarrow$



Input :

$$V_{avg} = \frac{\int_0^T v_{in}\,dt}{T}$$

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

$$= \frac{1}{T}\int_0^T V_m \sin(\omega t)\,dt$$

$$= 0$$

Output :

$$V_{avg} = \frac{\int_0^T v_{out}\,dt}{T}$$

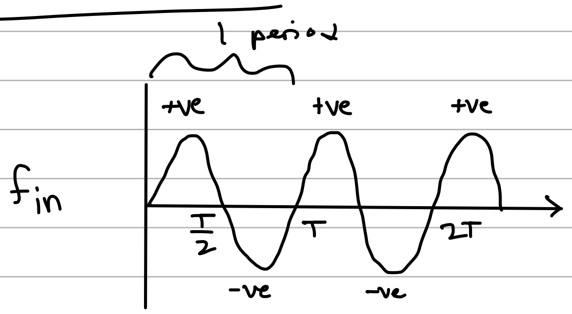
zero

$$= \frac{\int_0^{\frac{T}{2}} V_m \sin(\omega t)\,dt + \cancel{\int_{\frac{T}{2}}^{T} (0)\,dt}}{T}$$

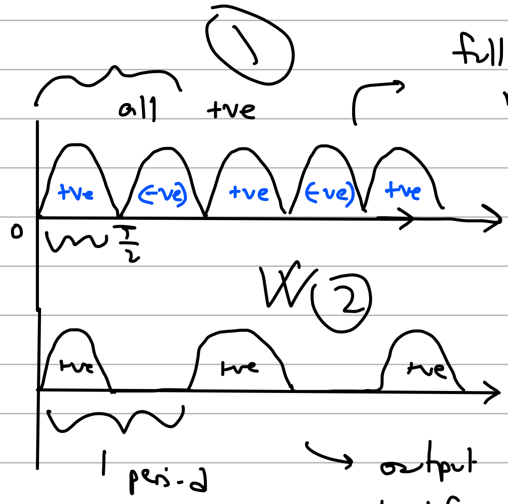
$$= \frac{1}{T}\int_0^{\frac{T}{2}} V_m \sin(\omega t)\,dt$$

$$= \frac{1}{\pi} V_m$$

Full wave :



⇒



→ full wave rectifier

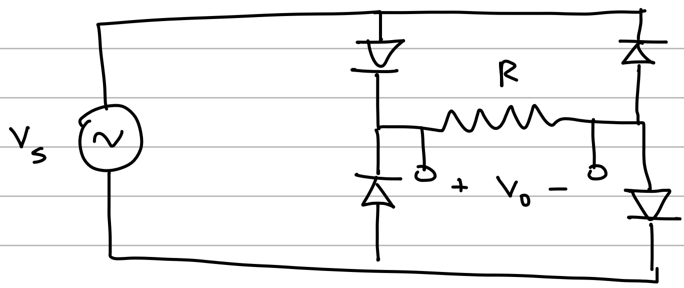
$f = 2f_{in}$

$f = f_{in}$

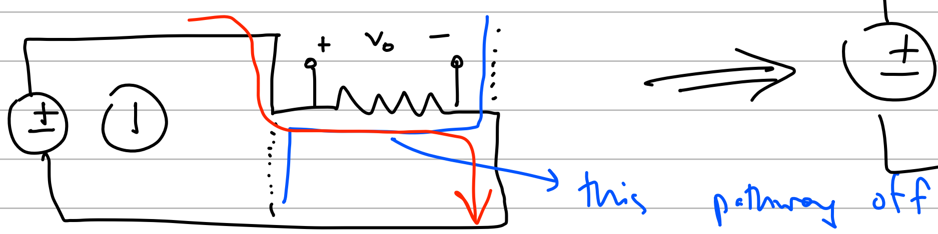
→ output from half wave rectifier

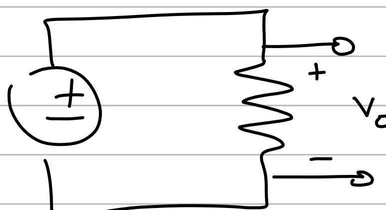
1 → has higher avg. value

∴ has higher DC characteristic



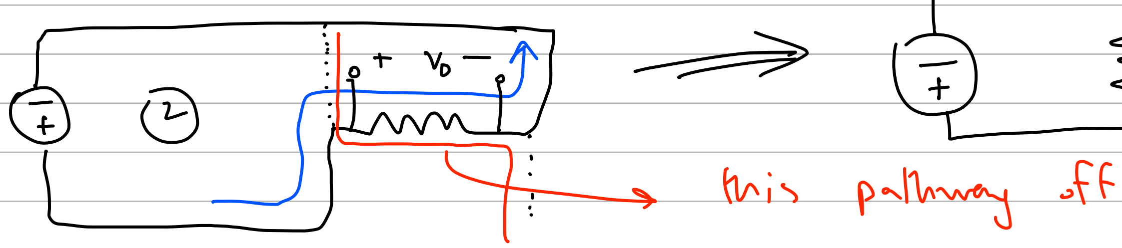
+ve cycle :

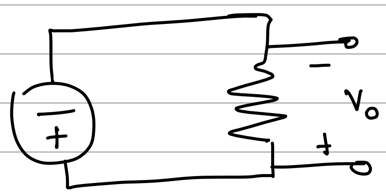


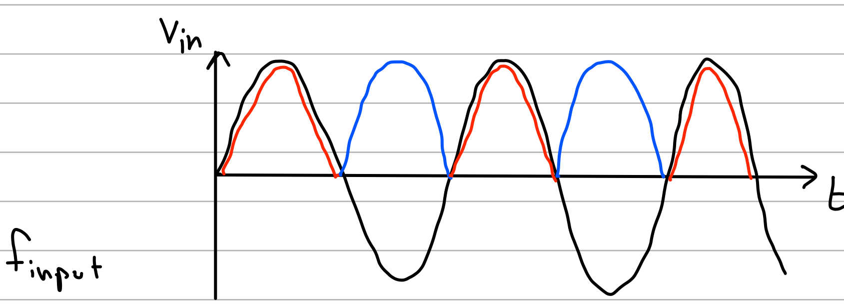


$V_o = V_s$

−ve cycle :

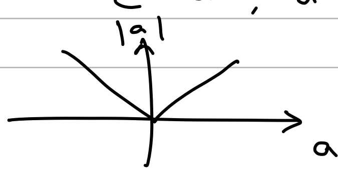




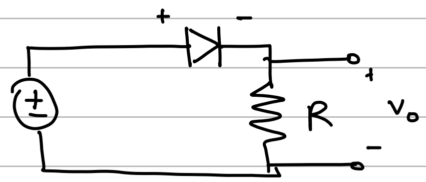


absolute value :

$$|a| = \begin{cases} a & ; \ a > 0 \\ -a & ; \ a < 0 \end{cases}$$



Half wave:

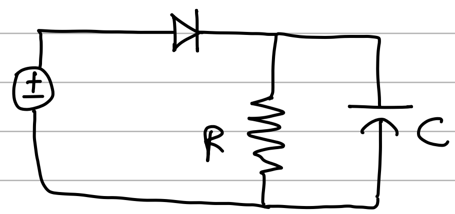


$$V_p = V_m - V_D$$

$$f = f_{input}$$

$$V_{DC} = \frac{1}{T}\int_0^{\frac{T}{2}} (V_m \sin\omega t - V_D)\,dt$$

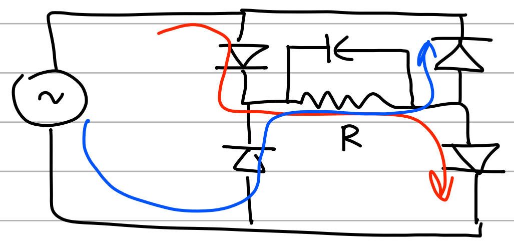
$$= \frac{1}{\pi}V_m - \frac{V_D}{2}$$

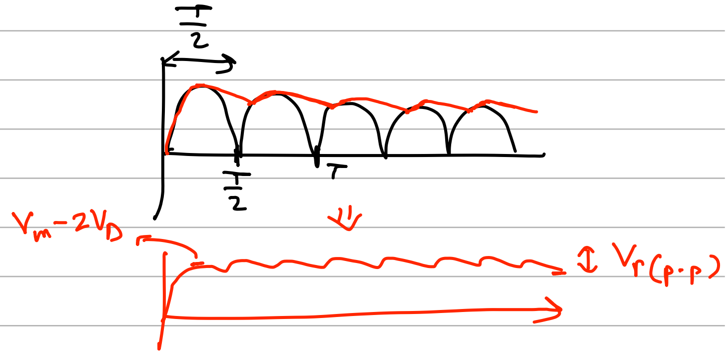


$$V_{r(p-p)} = \frac{V_p}{f \cdot RC}$$

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

Full wave:





$$V_p = V_m - 2V_D$$

$$f = 2f_{input}$$

$$V_{DC} = \frac{1}{\left(\frac{T}{2}\right)}\int_0^{\frac{T}{2}} (V_m \sin\omega t - 2V_D)\,dt$$

$$= \frac{2}{\pi}V_m - 2V_D$$

$$V_{r(p-p)} = \frac{V_p}{f \cdot RC}$$

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

RMS → equivalent DC value of an AC waveform

Monday : 9:00 pm

Without capacitor, Fullwave + halfwave :

HW :

$$\boxed{f = f_{in}}$$

$$V_{dc} / V_{avg} = \frac{V_m}{\pi} - \frac{V_D}{2}$$

$$V_p = V_m - V_D$$

FW :

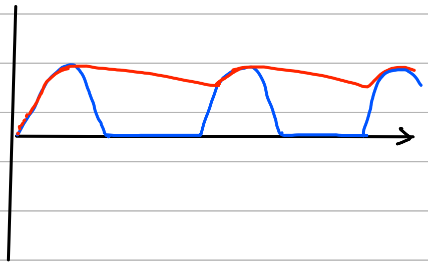
$$\boxed{f = 2 f_{in}}$$

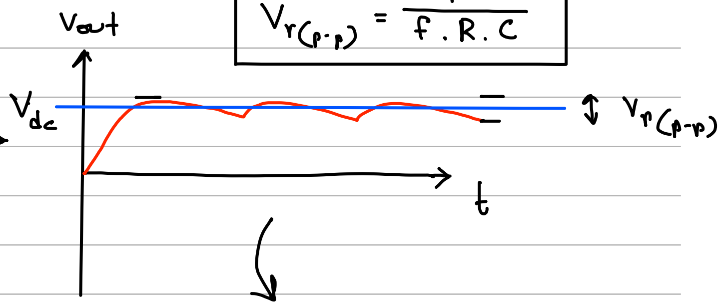
$$V_{dc} / V_{avg} = \frac{2}{\pi} V_m - 2V_D$$

$$V_p = V_m - 2V_D$$

With capacitor [HW + FW formula same] :

① $$\boxed{V_{r(p\text{-}p)} = \frac{V_p}{f \cdot R \cdot C}}$$



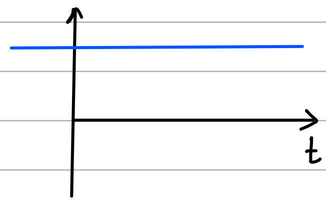


In general :

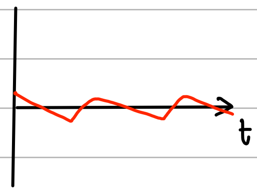
$$\boxed{V_{rms} = \sqrt{\frac{1}{T} \int_0^T V_{AC}^2 \, dt}}$$

→ rms is a characteristic of an AC wave form

DC + AC



\+



Multimeter DC ⟶ V_{dc} / V_{avg}

" AC ⟶ V_{rms}

V_{dc} / V_{avg}

② $$\boxed{V_{dc} = V_p - \frac{V_{r(p\text{-}p)}}{2}}$$

$V_{r(rms)}$

③ $$\boxed{V_{r(rms)} = \frac{V_p}{2\sqrt{3} \, f \cdot R \cdot C}}$$

For rectifiers : $V_{ac} \downarrow\downarrow\downarrow = V_{r(rms)} \downarrow\downarrow\downarrow$

---

③ ⟶ $$V_{r(rms)} = \frac{V_p}{2\sqrt{3} \, f RC} = \frac{1}{2\sqrt{3}} V_{r(p\text{-}p)}$$

Summarise table :

Without Capacitor

	HW	FW
Peak , V_p	$V_m - V_D$	$V_m - 2V_D$
Avg. , V_{dc} / V_{avg}	$\frac{V_m}{\pi} - \frac{V_D}{2}$	$\frac{2V_m}{\pi} - 2V_D$
output freq. , f	f_{in}	$2f_{in}$

With Capacitor

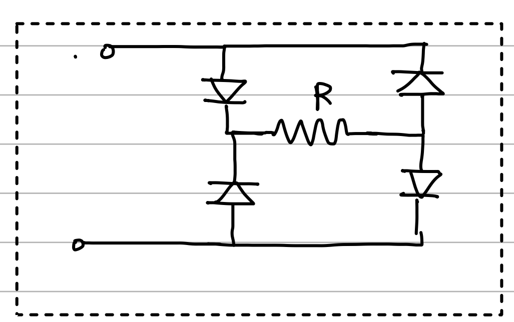
	HW	FW
Peak, V_p	$V_m - V_D$	$V_m - 2V_D$
ripple freq, f_R	f_{in}	$2f_{in}$
Peak to peak ripple, $V_{r(p-p)}$	$\frac{V_p}{fRC}$	
RMS ripple, $V_{r(rms)}$	$\frac{1}{2\sqrt{3}} V_{r(p-p)}$	
Output avg., V_{dc} / V_{avg}	$V_p - \frac{V_{r(p-p)}}{2}$	

Q. We have a FW rectifier.

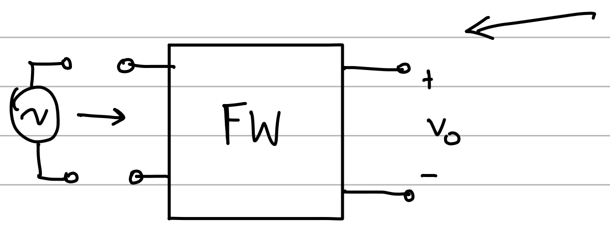
$V_i = V_m \sin(\omega t)$ ↳ amp. ↳ $\omega = 2\pi f$

$v_i = 8\sin(2000\pi t) \longrightarrow$ FW $\longrightarrow V_o$

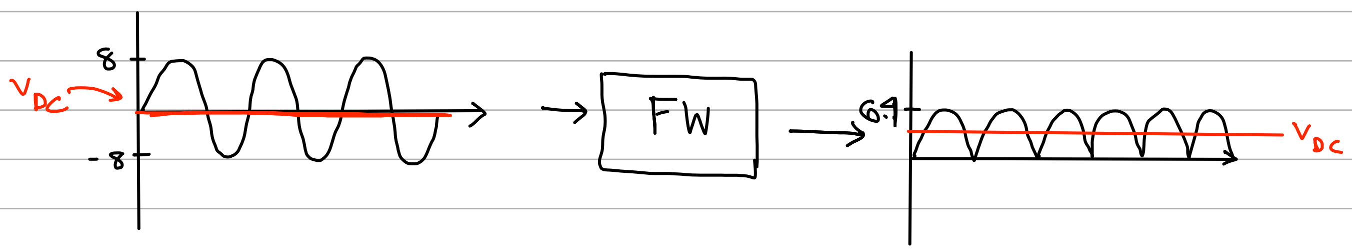
ⓐ Draw FW circuit.



②



ⓑ Draw input, output voltage.



ⓒ $R = 50k\Omega$, $V_D = 0.8V$ } → find peak of input, output. Also DC value.

Input,

$V_p = 8\,V$

$V_{DC} = 0\,V$

Output,

$V_p = V_m - 2V_D$

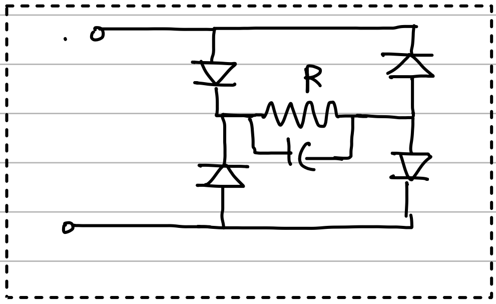
$= 8 - 2 \times 0.8 = 6.4\,V$

$V_{DC} = \frac{2}{\pi} V_m - 2V_D$

$= \frac{2}{\pi} \times 8 - 2 \times 0.8$

$= 3.49\,V$

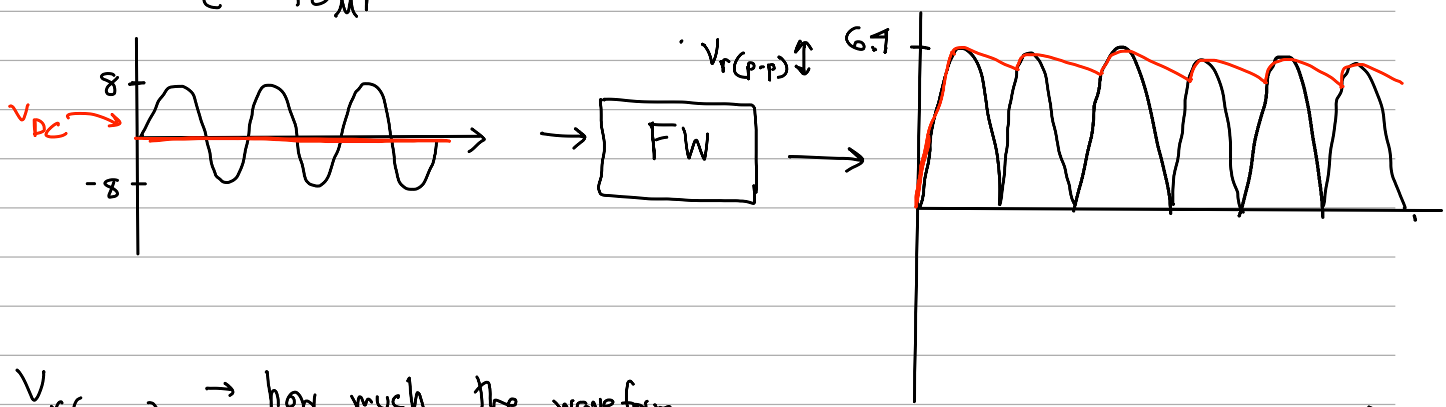
d) $10\,\mu F$ capacitor added in FW.



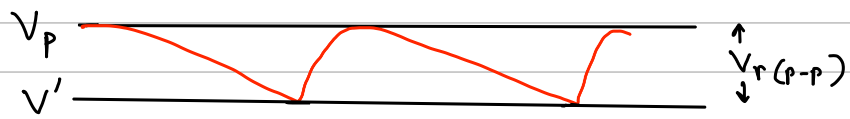
$R = 50\,k\Omega$

$V_D = 0.8\,V$

$C = 10\,\mu F$



$V_{r(p-p)}$ → how much the waveform drops from V_p.



$$V_{r(p-p)} = \frac{V_p}{f\,RC} = \frac{6.4}{2000 \times (50 \times 10^3) \times (10 \times 10^{-6})}$$

$= 6.4 \times 10^{-3}\,V$

$$V_{DC} = V_p - \frac{V_{r(p-p)}}{2} = 6.4 - (3.2 \times 10^{-3})$$

$= 6.3968\,V$

$V_i = 8 \sin(2000\pi t)$

$\omega = 2000\pi$

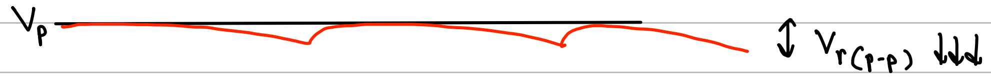
$f_{in} = \frac{\omega}{2\pi}$

$= \frac{2000\pi}{2\pi}$

$= 1000\,Hz$

$f = 2f_{in} = 2 \times 1000$

$= 2000\,Hz$



(f) Suppose, we want ripple 1% of input peak. Value of C ?

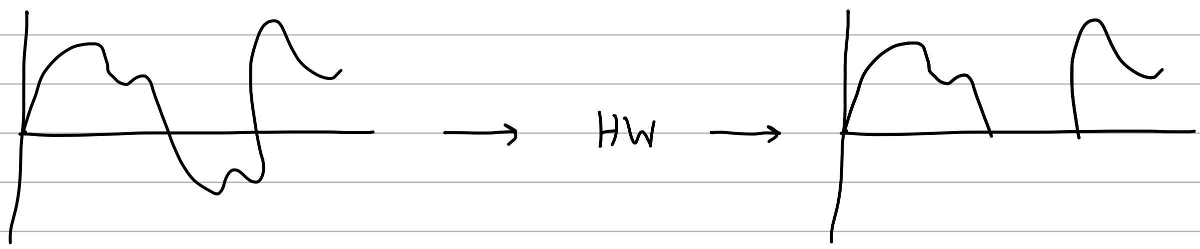
$$V_{r(p-p)} = 1\% \text{ of } V_{\text{input peak}} = \frac{1}{100} \times 8 = 0.08$$

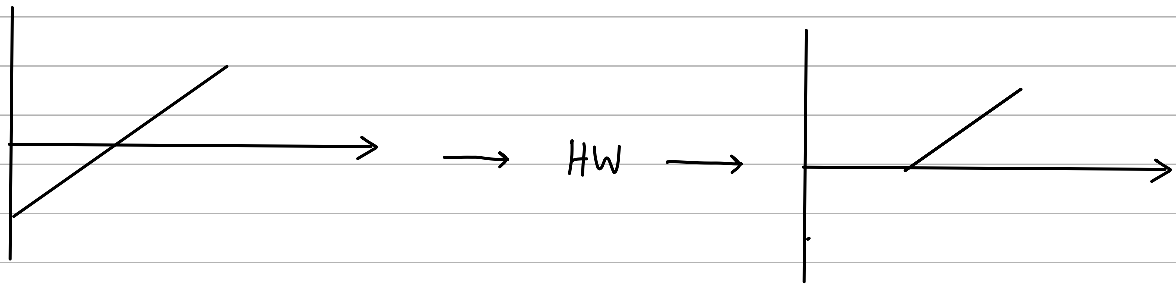
$$V_{r(p-p)} = \frac{6.4}{fRC} = 0.08$$

$$\Rightarrow \frac{6.4}{f \times R \times 0.08} = C \qquad \therefore C = \frac{6.4}{2000 \times 50 \times 10^3 \times 0.08}$$

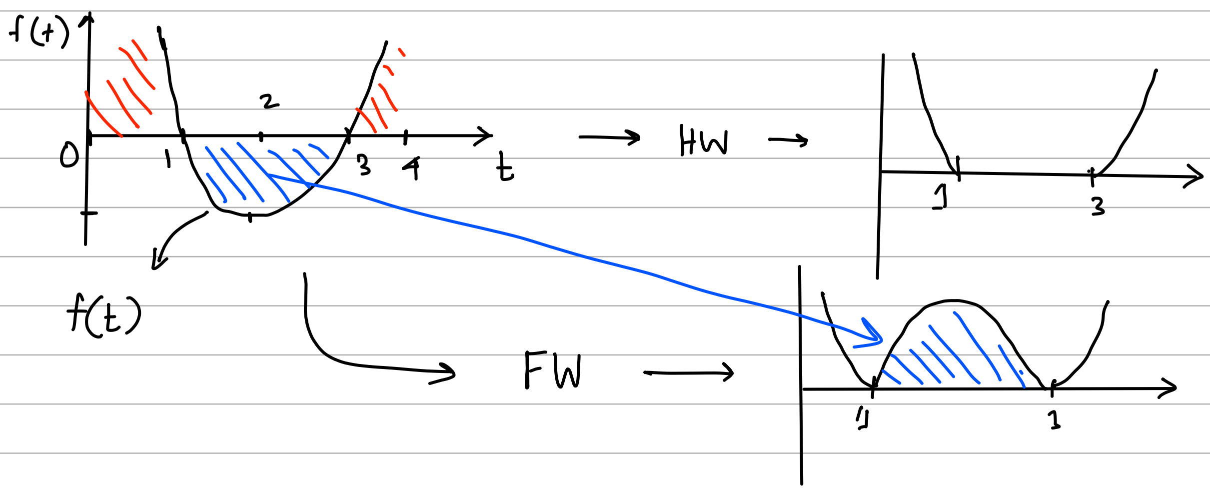
$$= 0.8 \, \mu F$$

$$= 8 \times 10^{-7} \, F$$





$$V_{dc} = \frac{1}{T} \int_0^T V \, dt$$



$$V_{dc} = \frac{1}{4}\int_0^4 f(t)\,dt = \frac{1}{4}\left[\int_0^1 f(t)\,dt + \underbrace{\int_1^3 f(t)\,dt}_{\text{blue part}} + \int_3^4 f(t)\,dt\right]$$

For FW:

$$V_{dc} = \frac{1}{4}\left[\int_0^1 f(t)\,dt + \left|\int_1^3 f(t)\,dt\right| + \int_3^4 f(t)\,dt\right]$$