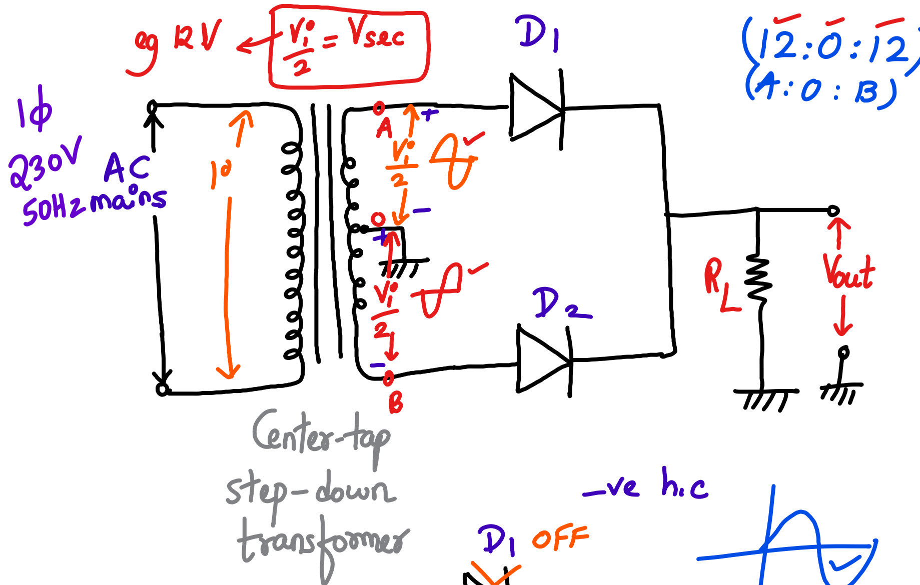
EEEE lec 34a 7/11/23

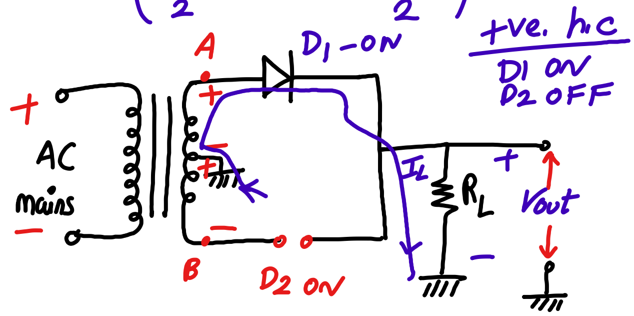
Full-wave "Center tapped" rectifier with 'R' load :

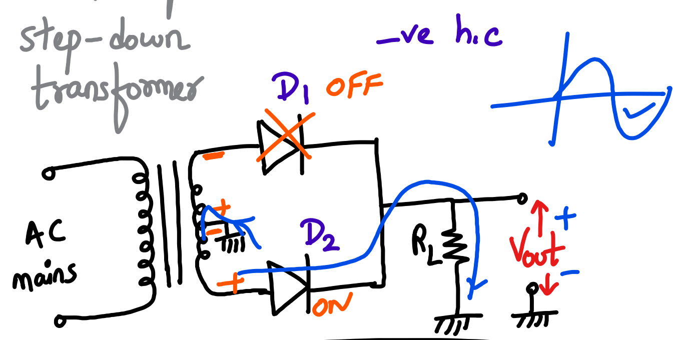
$V_i \Rightarrow$ Secondary voltage of transformer



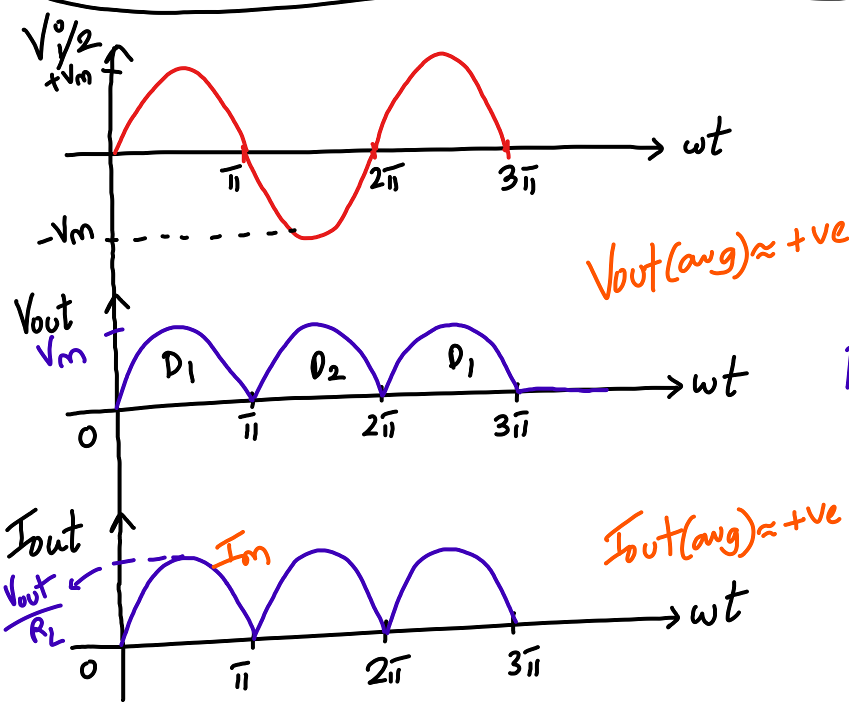
5 – 0 – 5

$\left(\frac{V_i}{2} - 0 - \frac{V_i}{2}\right)$





$$\boxed{\begin{aligned} V_{out} &= \frac{V_i}{2}(V_m \sin \omega t) \text{ if } 0 < \omega t < \pi \\ &= \frac{V_i}{2}(V_m \sin \omega t) \text{ if } \pi < \omega t < 2\pi \end{aligned}} \quad (1)$$



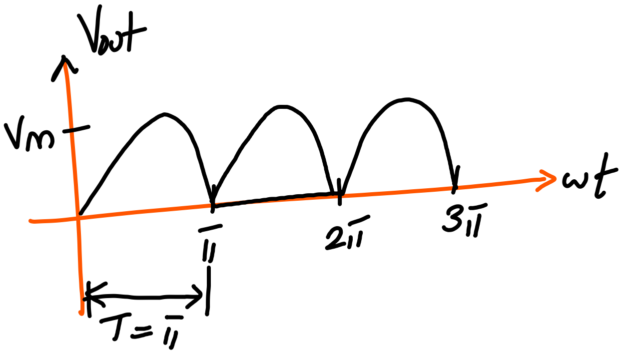
$V_{out} = I_{out} R_L$

FWR I/p & o/p waveforms

$$\boxed{I_m = \frac{V_m}{R_L}} \; *$$

FWR with 'R' load analysis:

Derive
a) Expression for rectification efficiency (η)
b) Expression for ripple factor (γ)
c) Expression for TUF



① $V_{out(avg)} = V_{dc} = \frac{1}{T}\int_0^T V_{out}\, d\omega t$

$T = \pi$

i.e $V_{dc} = \frac{1}{\pi}\int_0^{\pi} V_i(\omega t)\, d\omega t$

i.e $V_{dc} = \frac{1}{\pi}\left[\int_0^{\pi} V_m \sin\omega t\, d\omega t\right]$

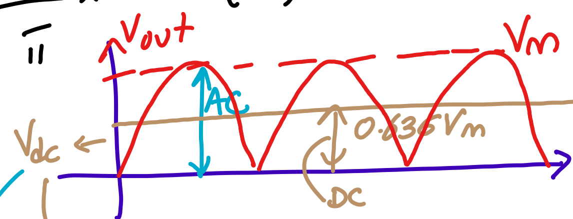
i.e $V_{dc} = \frac{V_m}{\pi}\left[-\cos\omega t\right]_{\omega t=0}^{\pi}$

ie $V_{dc} = \frac{V_m}{\pi} \times \left\{-\left[\underbrace{\cos\pi}_{-1} - \underbrace{\cos 0}_{1}\right]\right\} = \frac{V_m}{\pi} \times -1 \times (-2)$

i.e $\boxed{V_{dc} = \frac{2V_m}{\pi}}$ FWR

Vout(avg)

i.e $V_{dc} = 0.636\, V_m$



O/P of FWR : Pulsating DC (AC+DC)

$V_{out(avg)} = V_{dc} = \frac{2V_m}{\pi}$

② $I_{out(avg)} = \dfrac{V_{out(avg)}}{R_L} = \dfrac{V_{dc}}{R_L} = \dfrac{2V_m}{\pi R_L}$ $\to I_m$ $\left(V_{out(avg)} = I_{out(avg)} R_L\right)$

$\boxed{I_{out(avg)} = \dfrac{2I_m}{\pi}}$ where, $\boxed{I_m = V_m/R_L}$ $\boxed{I_{out(avg)} = I_{dc}}$

③ $V_{out(rms)} \to$ Rms value of AC component of output

$$V_{out(rms)} = \left[\frac{1}{T}\int_0^T V_{out}^2(\omega t)\, d\omega t\right]^{1/2}$$

$T = \pi$

From eqn ①,

$$\text{i.e } V_{out(rms)} = \left[\frac{1}{\pi}\int_0^\pi V_i^2(\omega t)\, d\omega t\right]^{1/2}$$

$$\text{i.e } V_{out(rms)} = \left[\frac{1}{\pi}\left\{\int_0^\pi V_m^2 \sin^2\omega t\, d\omega t\right]^{1/2}$$

$$\text{i.e } V_{out(rms)} = \left[\frac{V_m^2}{\pi}\left\{\int_0^\pi \left(\frac{1-\cos 2\omega t}{2}\right) d\omega t\right\}\right]^{1/2}$$

$\sin^2 x = \dfrac{1-\cos 2x}{2}$

$$\text{ie } V_{out(rms)} = \left[\frac{V_m^2}{2\pi}\left\{\omega t - \frac{\sin 2\omega t}{2}\right\}_{\omega t=0}^{\pi}\right]^{1/2}$$

$$\text{i.e } V_{out(rms)} = \left[\frac{V_m^2}{2\pi}\left\{(\pi - 0) - \cancel{\frac{\sin 2\pi}{2}}^{\,0} - \cancel{\frac{\sin 0}{2}}^{\,0}\right\}\right]^{1/2}$$

$$\text{ie } V_{out(rms)} = \left[\frac{V_m^2}{2\pi} \times \pi\right]^{1/2} = \left(\frac{V_m^2}{2}\right)^{1/2}$$

$$\text{i.e } \boxed{V_{out(rms)} = \frac{V_m}{\sqrt{2}}}$$ FWR

$\boxed{I_{out\,rms} = \dfrac{I_m}{\sqrt{2}}}$ where, $I_m = \dfrac{V_m}{R_L}$

$V_{out(rms)} = V_{rms}$; $I_{out\,rms} = I_{rms}$

④ Rectification efficiency (η):

$$\% \eta = \frac{P_{DC}}{P_{AC}} \times 100$$

It is the ratio of DC power at the output to the applied input AC power

$$P_{DC} = V_{dc} I_{dc} = \boxed{\frac{V_{dc}^2}{R_L}} = I_{dc}^2 R_L$$

$$P_{AC} = V_{rms} I_{rms} = \boxed{\frac{V_{rms}^2}{R_L}} = I_{rms}^2 R_L$$

ie $P_{DC} = \dfrac{V_{dc}^2}{R_L} = \dfrac{\left(\frac{2V_m}{\pi}\right)^2}{R_L} = \dfrac{4V_m^2}{\pi^2 R_L}$ — (a)

ie $P_{AC} = \dfrac{V_{rms}^2}{R_L} = \dfrac{\left(\frac{V_m}{\sqrt{2}}\right)^2}{R_L} = \dfrac{V_m^2}{2R_L}$ — (b)

ie $\% \eta = \dfrac{P_{DC}}{P_{AC}} \times 100 = \dfrac{\frac{4\cancel{V_m^2}}{\pi^2 \cancel{R_L}}}{\frac{\cancel{V_m^2}}{2\cancel{R_L}}} \times 100 = \dfrac{8}{\pi^2} \times 100$

i.e $\% \eta = \dfrac{8}{\pi^2} \times 100 \approx 81.05\%$

Rectification efficiency of FWR with 'R' load

* $\boxed{\eta_{FWR} > \eta_{HWR}}$

⑤ Ripple factor (γ):

It is the ratio of rms value of o/p AC component to the DC component of the rectifier output

Smaller the AC component → more effective is the rectifier

$$\gamma = \frac{I_{ac}}{I_{dc}} = \frac{V_{ac}}{V_{dc}} \quad ; \quad \boxed{I_{ac} = \sqrt{I_{out(rms)}^2 - I_{dc}^2}}$$

Remember it!

$$I_{out(rms)}^2 = I_{rms}^2$$

ie $$\frac{I_{ac}}{I_{dc}} = \sqrt{\frac{I_{rms}^2}{I_{dc}^2} - 1}$$

i.e $$\boxed{\gamma = \sqrt{\frac{I_{rms}^2}{I_{dc}^2} - 1}}$$

For FWR, $I_{rms} = \frac{I_m}{\sqrt{2}}$, $I_{dc} = \frac{I_m \times 2}{\pi}$

$$\gamma = \sqrt{\frac{\frac{\cancel{I_m^2}}{2}}{\frac{4\cancel{I_m^2}}{\pi^2}} - 1} = \sqrt{\frac{\pi^2}{4} - 1}$$

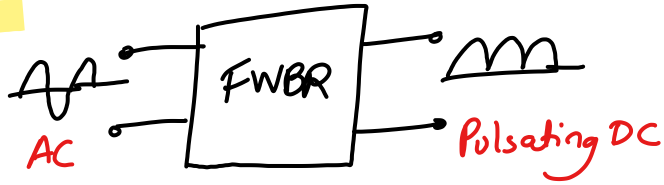
$$\boxed{\gamma = \sqrt{\frac{\pi^2}{8} - 1} \approx 0.483}$$

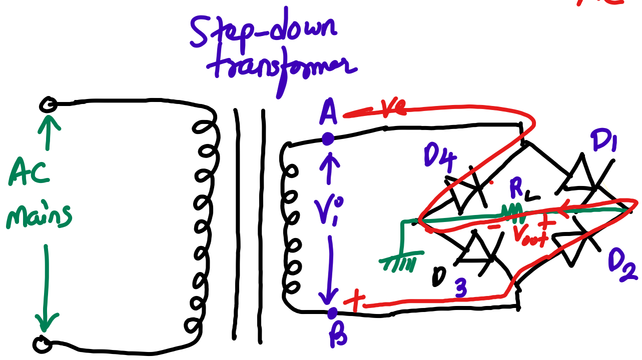
FWCTR

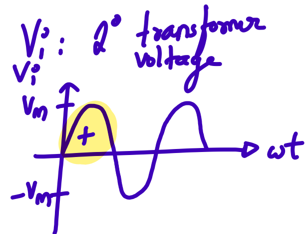
$$\gamma_{FWR} < \gamma_{HWR}$$

→ contains smaller ac component

Full-wave Bridge rectifier







$V_i = V_m \sin \omega t$


→ F.B → ON →


→ R.B → OFF →

+ve h.c of V_i → D_1 & D_3 → ON

I_{out} → $A - D_1 - R_L - D_3 - B - A$

−ve h.c of V_i → D_2 & D_4 ON

I_{out} → $B - D_2 - R_L - D_4 - A$

↳ +ve during −ve h.c also