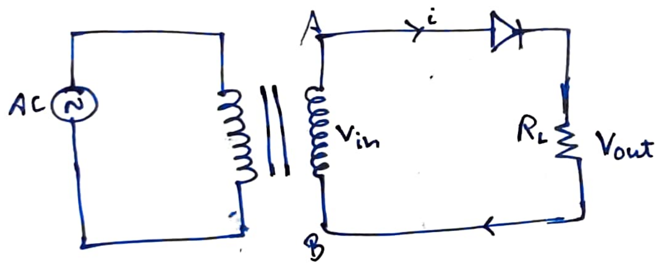
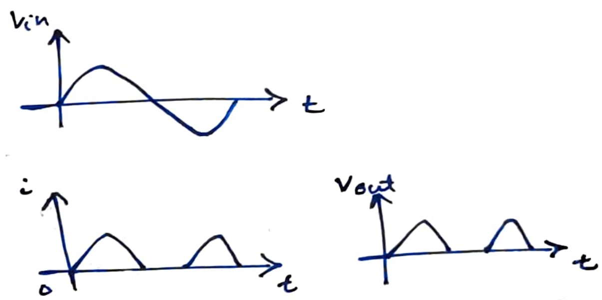
| | HWR Ideal | HWR Practical $(V_m)_{practical} = V_m - V_k$ | Bridge FWR Ideal | Bridge FWR Practical $(V_m)_{practical} = V_m - 2V_k$ | Center Tap FWR Ideal | Center Tap FWR Practical $(V_m)_{prac} = V_m - V_k$ |
|---|---|---|---|---|---|---|
| $V_{dc}$ | $\frac{V_m}{\pi}$ | $\frac{V_m - V_k}{\pi}$ | $\frac{2V_m}{\pi}$ | $\frac{2(V_m - 2V_k)}{\pi}$ | $\frac{2V_m}{\pi}$ | $\frac{2(V_m - V_k)}{\pi}$ |
| $V_{rms}$ | $\frac{V_m}{2}$ | $\frac{V_m - V_k}{2}$ | $\frac{V_m}{\sqrt{2}}$ | $\frac{V_m - 2V_k}{\sqrt{2}}$ | $\frac{V_m}{\sqrt{2}}$ | $\frac{V_m - V_k}{\sqrt{2}}$ |
| $I_{dc}$ | $\frac{I_m}{\pi}$ | $\frac{I_m}{\pi}$ | $\frac{2I_m}{\pi}$ | $\frac{2I_m}{\pi}$ | $\frac{2I_m}{\pi}$ | $\frac{2I_m}{\pi}$ |
| $I_{rms}$ | $\frac{I_m}{2}$ | $\frac{I_m}{2}$ | $\frac{I_m}{\sqrt{2}}$ | $\frac{I_m}{\sqrt{2}}$ | $\frac{I_m}{\sqrt{2}}$ | $\frac{I_m}{\sqrt{2}}$ |
| $\gamma$ | 1.21 | 1.21 | 0.48 | 0.48 | 0.48 | 0.48 |
| $\eta$ | 40.6% | 40.6% | 81.2% | 81.2% | 81.2% | 81.2% |
| PIV | $\geq V_m$ | $\geq V_m$ | $\geq V_m$ | $\geq V_m - V_k$ | $\geq 2V_m$ | $\geq 2V_m - V_k$ |
| freq. | $f_0 = f_i$ | $f_0 = f_i$ | $f_0 = 2f_i$ | $f_0 = 2f_i$ | $f_0 = 2f_i$ | $f_0 = 2f_i$ |

→ Half Wave Rectifier




$$* \; V_{DC} \text{ or } V_{avg} = \frac{1}{2\pi}\int_0^{2\pi} V \, d\omega t$$

$$V = V_m \sin\omega t$$

$$\Rightarrow V_{dc} = \frac{1}{2\pi}\left[\int_0^{2\pi} V_m \sin(\omega t)\, d\omega t\right]$$

$$= \frac{1}{2\pi}\left[\int_0^{\pi} V_m \sin(\omega t)\, d\omega t + \int_{\pi}^{2\pi} 0 \, d\omega t\right]$$

$$= \frac{V_m}{2\pi}\left(-\cos\omega t\right)_0^{\pi}$$

$$= \frac{V_m}{2\pi}\left[-(-1) - (-1)\right] = \frac{V_m}{\pi}$$

$$* \; V_{rms} = \left[\frac{1}{2\pi}\int_0^{2\pi} (V_m \sin\omega t)^2 d\omega t\right]^{1/2}$$

$$= \left[\frac{V_m^2}{2\pi}\int_0^{\pi} (\sin^2\omega t) + \int_{\pi}^{2\pi} 0\right]^{1/2}$$

$$= \left[\frac{V_m^2}{2\pi}\int_0^{\pi}\left(\frac{1-\cos 2\omega t}{2}\right) d\omega t\right]^{1/2}$$

$$= \left[\frac{V_m^2}{2\pi}\left(\frac{\omega t}{2} - \frac{\sin 2\omega t}{2(2)}\right)_0^{\pi}\right]^{1/2}$$

$$= \left[\frac{V_m^2}{2\pi}\left(\frac{\pi}{2}\right)\right]^{1/2} = \frac{V_m}{2}$$

* $I_{dc} / I_{avg} = \frac{1}{2\pi}\int_0^{\pi} i \, d\theta \quad = \frac{1}{2\pi}\int_0^{\pi} \frac{V_m \sin\theta}{r_f + R_L} \, d\theta$

$i = \frac{V_m \sin\theta}{r_f + R_L}$

$I_{avg} = \frac{V_m}{(r_f + R_L) 2\pi}\int_0^{\pi} \sin\theta \, d\theta = \frac{V_m}{2\pi (r_f + R_L)} \left[ \cos\theta \right]_0^{\pi} = \frac{2 V_m}{2\pi (r_f + R_L)}$

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

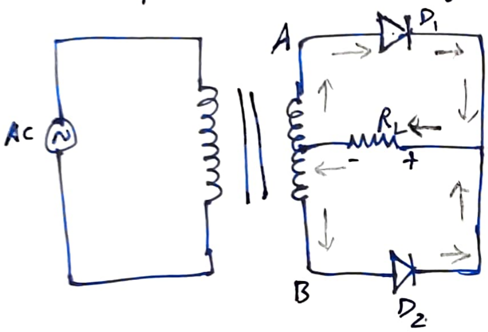
* DC power $P_{dc} = I_{dc}^2 R_L$
* AC power input $= I_{rms}^2 (r_f + R_L)$
* $\eta = \frac{\text{dc power output}}{\text{input AC power}}$
* $\gamma = \sqrt{\left(\frac{I_{rms}}{I_{dc}}\right)^2 - 1}$

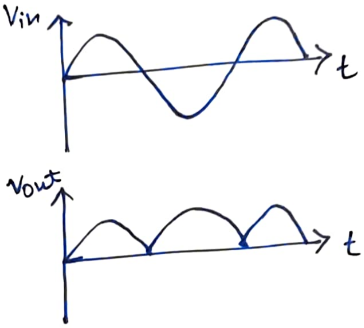
$I_{dc} = \frac{I_m}{\pi}$

$I_{rms} = \frac{I_m}{2}$

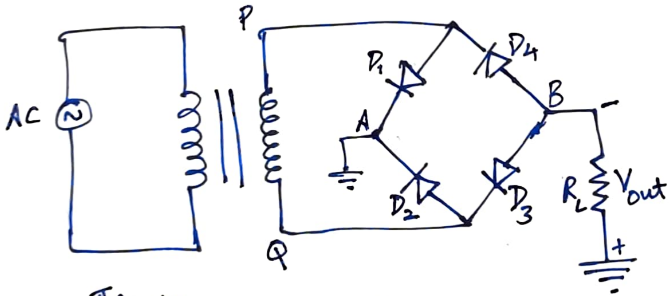
Power rating $= 0.7 \, V_m$

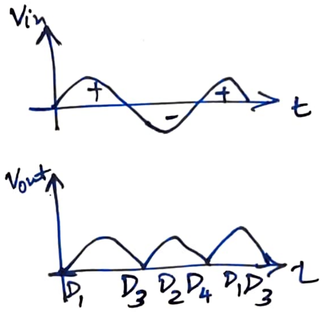
→ Centre-Tapped Full wave Rectifier




→ Full Wave Bridge Rectifier




* $I_{dc} = \frac{1}{\pi}\int_0^{\pi} i \, d\theta \; \ldots\ldots = \frac{2 I_m}{\pi}$

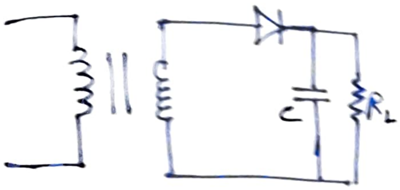
* $V_{dc} = \frac{1}{\pi}\int_0^{\pi} v \, d\omega t \; \ldots\ldots = \frac{2 V_m}{\pi}$

* $V_{rms} = \left[ \frac{1}{\pi}\int_0^{\pi} (V_m \sin\omega t)^2 \, d\omega t \right]^{1/2} \ldots = \frac{V_m}{\sqrt{2}}$

* $P_{dc} = I_{dc}^2 R_L$
* AC i/P Power $= I_{rms}^2 (r_f + R_L)$
* $\eta = \frac{P_{dc}}{P_{ac}}$
* $\gamma = \sqrt{\left(\frac{I_{rms}}{I_{dc}}\right)^2 - 1}$

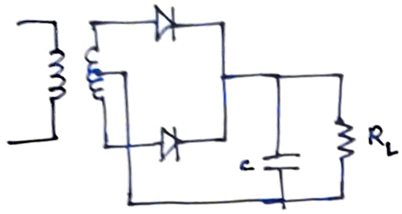
C filter

HWR

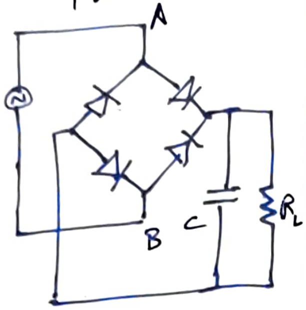



FWR

CT




FWR




$$V_r(rms) = \frac{I_{DC}}{2\sqrt{3}fC}$$

$$V_{dc} = V_m - \frac{I_{dc}}{2fC}$$

$$\gamma = \frac{1}{2\sqrt{3}fCR_L}$$

Ripple Voltage $V_r(rms) = \dfrac{I_{DC}}{4\sqrt{3}fC}$

DC voltage across filter C $V_{dc} = V_m - \dfrac{I_{DC}}{4fC}$

Ripple Factor $\gamma = \dfrac{V_r(rms)}{V_{dc}}$

$$\gamma = \frac{1}{4\sqrt{3}fCR_L}$$

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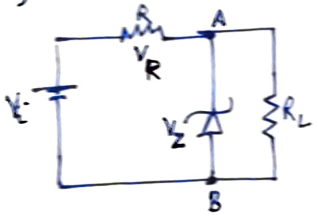
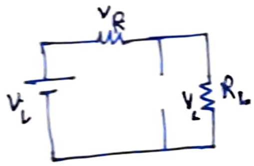
→ Case i) Fixed $V_i$ & Fixed $R_L$




Find $V_{AB}$, $V_{AB} = \dfrac{V_i R_L}{R+R_L}$

- if $V_{AB} < V_Z$ Diode OFF



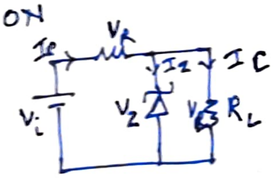

$V_L = V_{AB}$

$V_R = V_i - V_L$

$I_L = \dfrac{V_L}{R_L}$ $\quad I_R = \dfrac{V_R}{R}$ $\quad I_Z = 0$

$P_Z = 0$

- if $V_{AB} > V_Z$ Diode ON

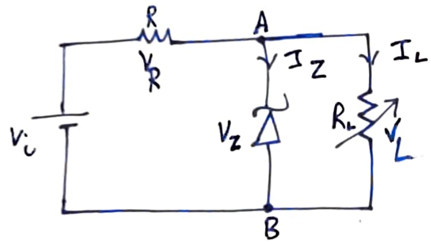



$V_L = V_Z$

$V_R = V_i - V_L$

$I_R = I_Z + I_L$

→ Case ii) Fixed $V_i$ & Variable $R_L$




Finding $R_{Lmin}$ & $R_{Lmax}$ such that Diode is ON

$V_L = V_{AB} = V_Z$

$$V_Z = \frac{V_i R_{Lmin}}{R + R_{Lmin}}$$

$$I_{Lmax} = \frac{V_L}{R_{Lmin}}$$

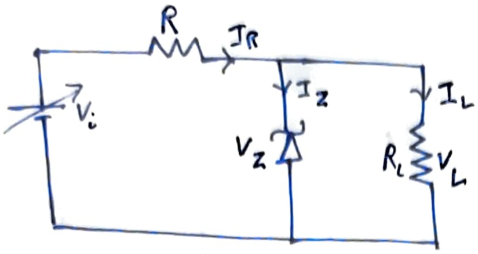
$V_R = V_i - V_Z$

$I_R = \dfrac{V_R}{R}$, $\quad I_R = I_{Z_{max}} + I_{Lmin}$

$$R_{Lmax} = \frac{V_L}{I_{Lmin}}$$

$$P_{Zmax} = V_Z I_{Zmax}$$

→ Case iii) Variable $V_i$ & Fixed $R_L$




$V_{i_{min}}$ →

$$V_{AB} = V_L = V_Z$$

$$V_Z = \frac{V_{i_{min}} R_L}{R + R_L}$$

$V_{i\,max}$ →

$$I_L = \frac{V_L}{R_L} = \frac{V_Z}{R_L}$$

$$I_{R_{max}} = I_{Z_{max}} + I_L$$

$$V_R = V_i - V_Z$$

$$V_i = V_R + V_Z$$

$$V_{i\,max} = V_{R\,max} + V_Z$$

$$V_{i\,max} = I_{R_{max}}(R) + V_Z$$