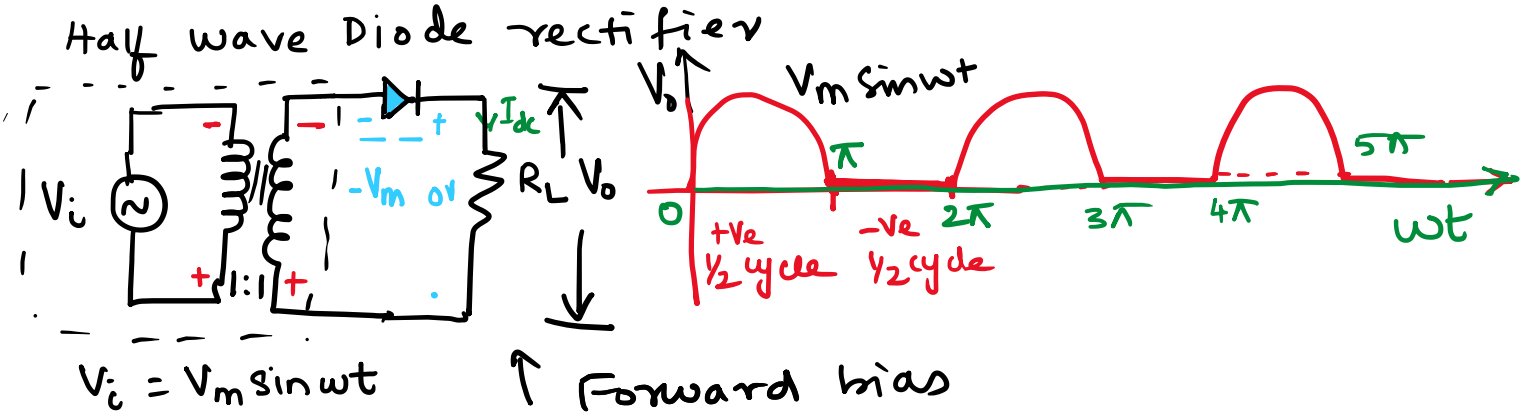
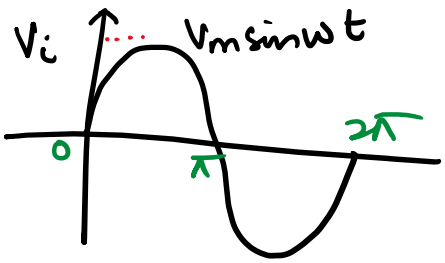
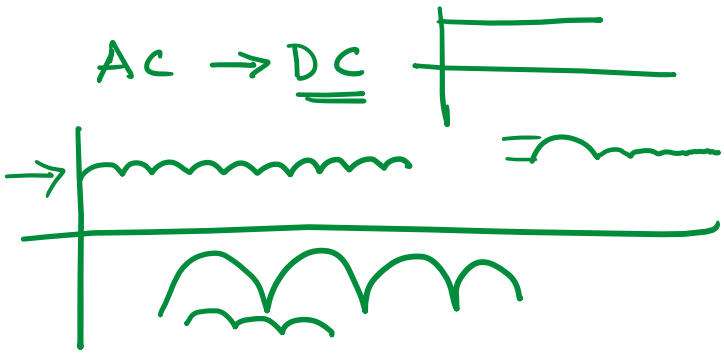
Chapter3: Semiconductor Devices and Circuits

1. Half-wave diode rectifier

- a. DC Output current
- b. DC Output voltage
- c. RMS current and Voltage
- d. Rectifier Efficiency
- e. Ripple factor
- f. Peak Inverse Voltage







- ✓ a. DC Output current / Avg.
- ✓ b. DC Output voltage / Avg.
- ✓ c. RMS current and Voltage
- ✓ d. Rectifier Efficiency
- e. Ripple factor
- f. Peak Inverse Voltage

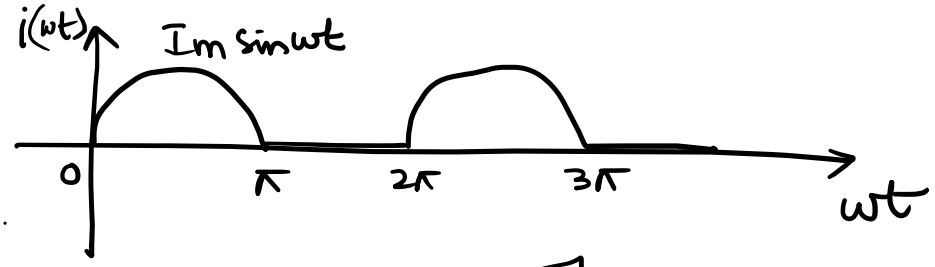
$V_i = V_m \sin\omega t$

$i_1 = I_m \sin\omega t \quad 0 \le \omega t \le \pi$

$= 0 \quad \pi \le \omega t \le 2\pi$

$$I_m = \frac{V_m}{(R_f + R_L)}$$; R_f : forward bias Diode resistance

a) DC output current :/ Avg. o/p current



$$I_{dc} = \frac{1}{2\pi}\left[\int_0^{2\pi} i(wt)\, d\omega t\right]$$

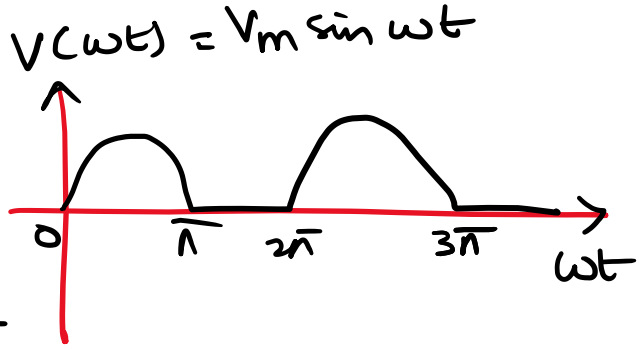
$$= \frac{1}{2\pi}\left[\int_0^{\pi} I_m \sin\omega t\, d\omega t + \int_{\pi}^{2\pi} 0\right]$$

$$\checkmark\ I_{dc} = \frac{I_m}{2\pi}\left[-\cos\omega t\right]_0^{\pi} = \frac{I_m}{\pi}\ \checkmark$$

$$\checkmark\ I_{dc} = \frac{V_m}{(R_f + R_L)\,\pi} \quad \because\ R_f \lll R_L$$

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

(b) DC output Voltage :-



$$V_{dc} = I_{dc} \cdot R_L = \frac{V_m}{\pi R_L} \cdot R_L = \frac{V_m}{\pi}$$

(c) RMS current and Voltage

$$I_{rms} = \sqrt{\frac{1}{2\pi}\int_0^{2\pi} (i\omega t)^2 \, d\omega t}$$

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

$$\left(\sin^2\omega t \rightarrow \frac{1-\cos 2\omega t}{2}\right)$$

$$= \left[\frac{I_m^2}{2\pi}\left[\frac{\omega t}{2} - \frac{\sin 2\omega t}{4}\right]_0^{\pi}\right]^{1/2} = \frac{I_m}{2}$$

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

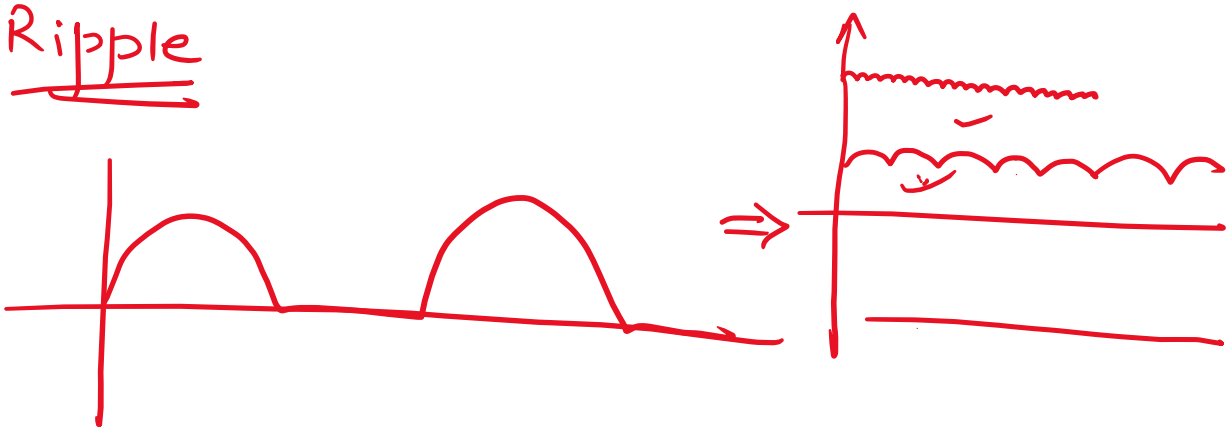
$$\rightarrow V_{rms} = I_{rms} \cdot R_L = \frac{I_m R_L}{2} = \frac{V_m}{2}$$

(iv) Rectifier efficiency η : $= \frac{o/p}{g/p} =$

$$\eta = \frac{DC\ o/p}{AC\ g/p} = \frac{P_{dc}}{P_{ac}} = \frac{V_{dc} \cdot I_{dc}}{V_{rms} I_{rms}}$$

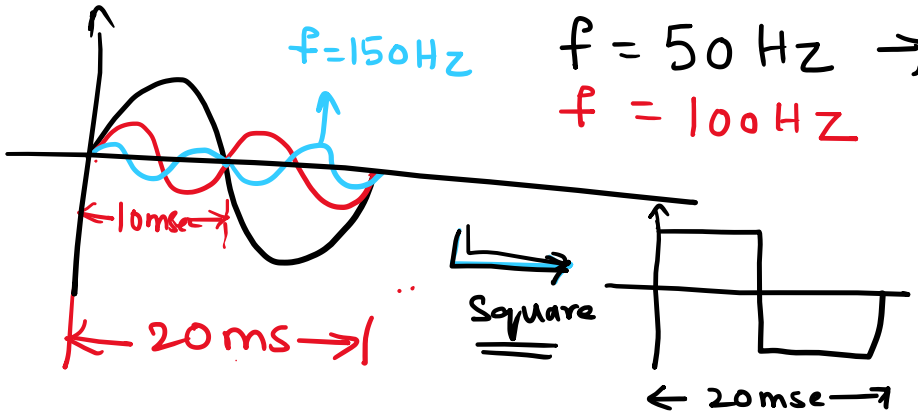
$$\eta = \frac{\frac{V_m}{\pi} \cdot \frac{I_m}{\pi}}{\frac{V_m}{2} \cdot \frac{I_m}{2}} \Rightarrow \eta = \frac{4}{\pi^2} = 40.6\ \%$$

(v) Ripple



Gives idea about the waviness of the rectified voltage & is defined as

$$\gamma = \frac{I_{h,rms}}{I_{dc}} = \frac{V_{h,rms}}{V_{dc}}$$

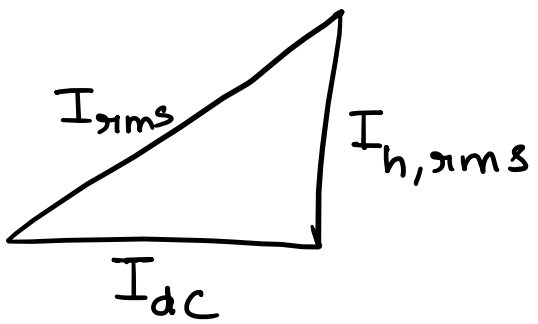


$f = 50\ Hz \rightarrow$ fundamental freq.

$f = 100\ Hz$

$$f = \frac{1}{T} = \frac{1}{10\ msec} = 100\ Hz$$

$f = 150\ Hz$



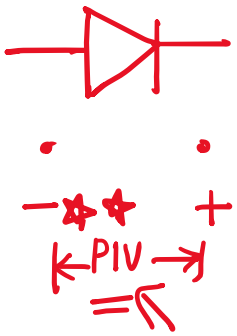
$$I_{rms} = \sqrt{I_{h,rms}^2 + I_{dc}^2}$$

$$\gamma = \frac{I_{h,rms}}{I_{dc}} = \frac{\sqrt{I_{rms}^2 - I_{dc}^2}}{I_{dc}}$$

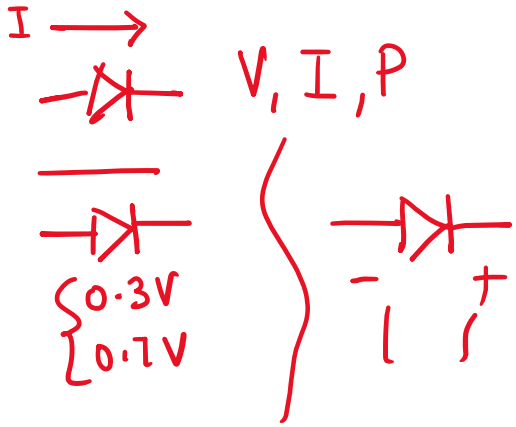
$$\gamma = \sqrt{\left(\frac{I_{rms}}{I_{dc}}\right)^2 - 1} = \sqrt{\left(\frac{I_{m/2}}{I_{m/\pi}}\right)^2 - 1}$$

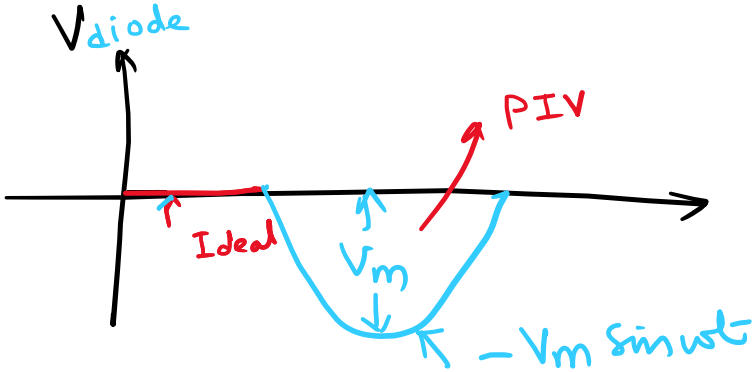
$$\boxed{\gamma = 1.21}$$ ✓

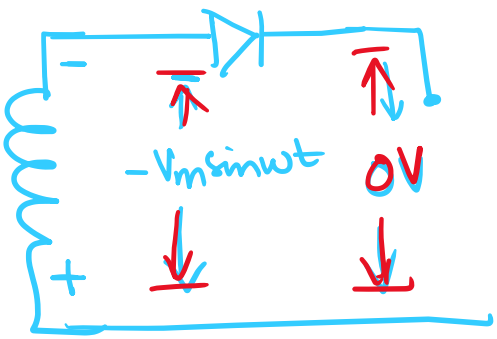
Reverse Bias



Peak Inverse Voltage :-

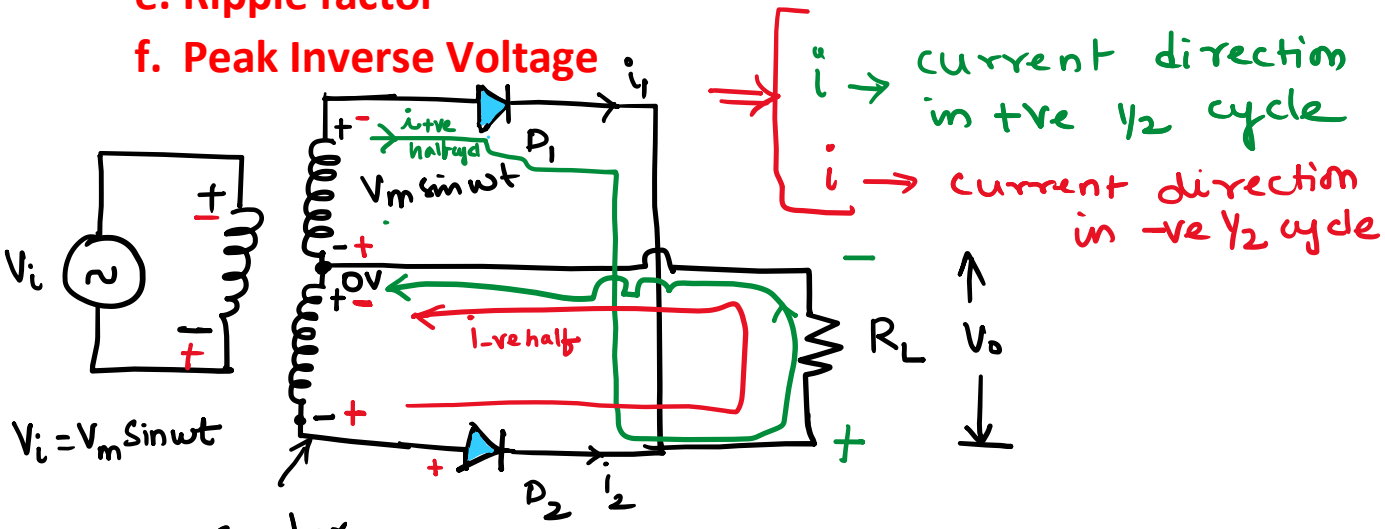




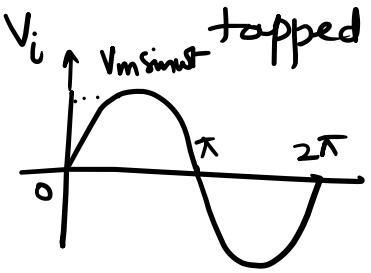


2. Full Wave diode rectifier

a. DC Output current
b. DC Output voltage
c. RMS current and Voltage
d. Rectifier Efficiency
e. Ripple factor
f. Peak Inverse Voltage

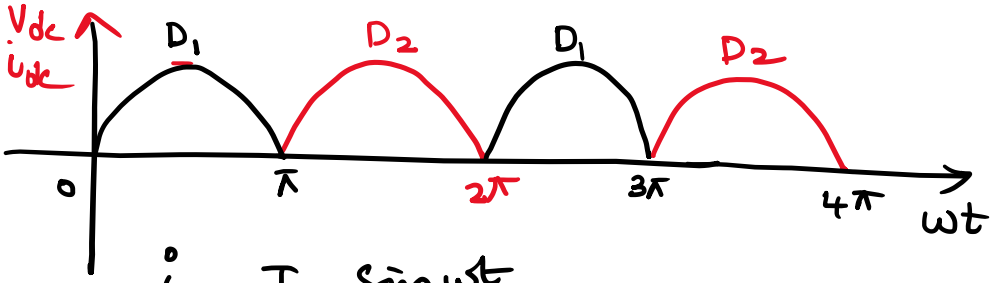


center tapped t/f



+ve. ½ cycle of AC o/p

D_1 → F.B & D_2 → R.B



$i = I_m \sin\omega t$

$V = V_m \sin\omega t$

(a) DC or Average Current I_{dc}.

$$I_{dc} = \frac{1}{2\pi}\int_0^{2\pi} (I_m \sin\omega t \, d\omega t) \text{ (or) } \frac{1}{\pi}\int_0^{\pi} I_m \sin\omega t \, d\omega t$$

$$= \frac{I_m}{2\pi}\left[\left[-\cos\omega t\right]_0^{\pi} + \left[-\cos\omega t\right]_{\pi}^{2\pi}\right] = \frac{2I_m}{\pi}$$

(b) Average / DC output voltage.

$$V_{dc} = \frac{1}{2\pi}\int_0^{2\pi} V_m \sin\omega t \, d\omega t = \frac{2V_m}{\pi}$$ ✓

(c) RMS current & voltage:

$$I_{rms} = \sqrt{\frac{1}{\pi}\int_0^{\pi} (I_m^2 \sin^2\omega t)\, d\omega t} = \frac{I_m}{\sqrt{2}}$$ ✓

$$V_{rms} = \sqrt{\frac{1}{\pi}\int_0^{\pi} (V_m^2 \sin^2\omega t)\, d\omega t} = \frac{V_m}{\sqrt{2}}$$ ✓

$$V_{rms} = \frac{I_m \cdot R_L}{\sqrt{2}}$$ ✓

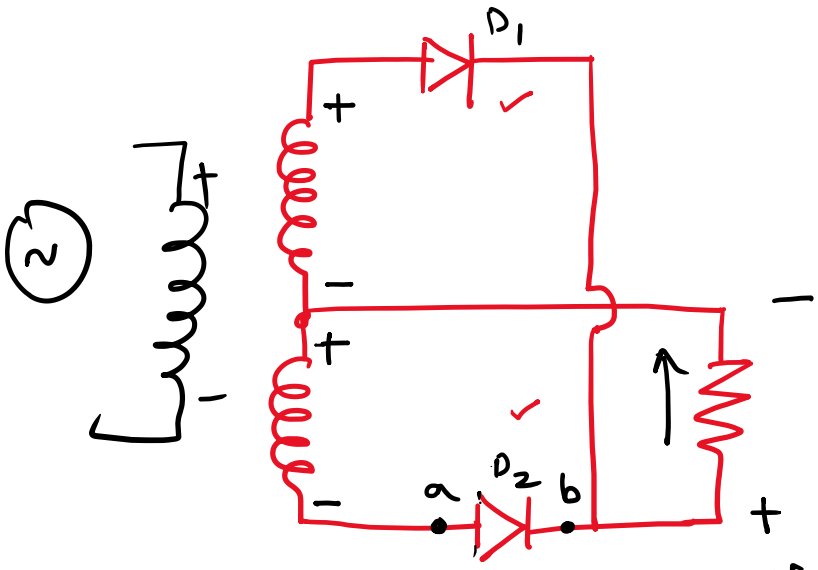
(v) Rectifier $\eta = \frac{P_{dc}}{P_{ac}} = \frac{V_{dc} \cdot I_{dc}}{V_{rms}\, I_{rms}}$

$$\eta = \frac{\frac{2V_m}{\pi} \cdot \frac{2I_m}{\pi}}{\frac{V_m}{\sqrt{2}} \frac{I_m}{\sqrt{2}}} = \frac{8}{\pi^2} = 81.14\%$$

(vi) Ripple factor: $\gamma = \frac{I_{h,rms}}{I_{dc}} = \frac{V_{h,rms}}{V_{dc}}$

$$\gamma = \sqrt{\left(\frac{I_{rms}}{I_{dc}}\right)^2 - 1} = \sqrt{\left(\frac{I_m/\sqrt{2}}{2I_m/\pi}\right)^2 - 1} = 48.38\%$$

(vii) Peak Inverse Voltage

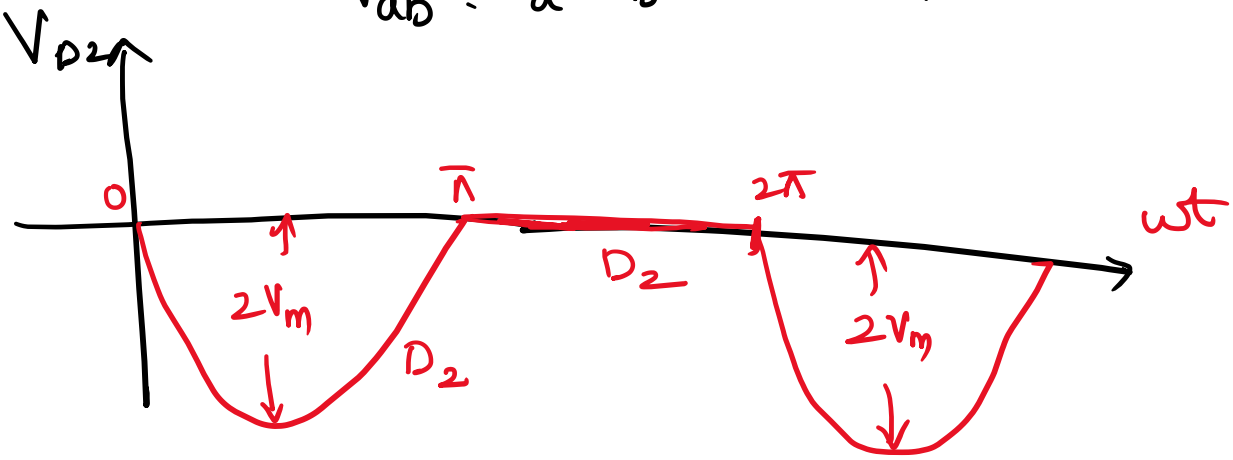


PIV = 2Vm

$V_o = V_m \sin \omega t$

$V_a = -V_m \sin \omega t$; $V_b = V_m \sin \omega t$

$V_{ab} = V_a - V_b = -2V_m \sin \omega t$



PIV in full wave diode rectifier = $2V_m$