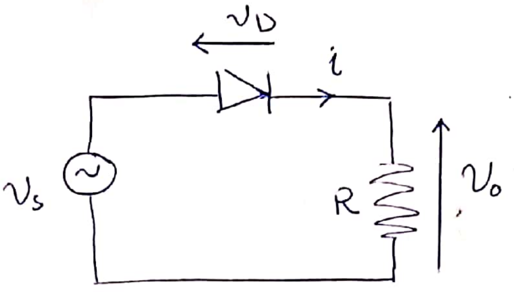
اشترت الهوالك

2.1 Uncontrolled Single phase half wave rectifier

2.1.1 Resistive load



(a)

neglecting voltage drop across diode

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

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

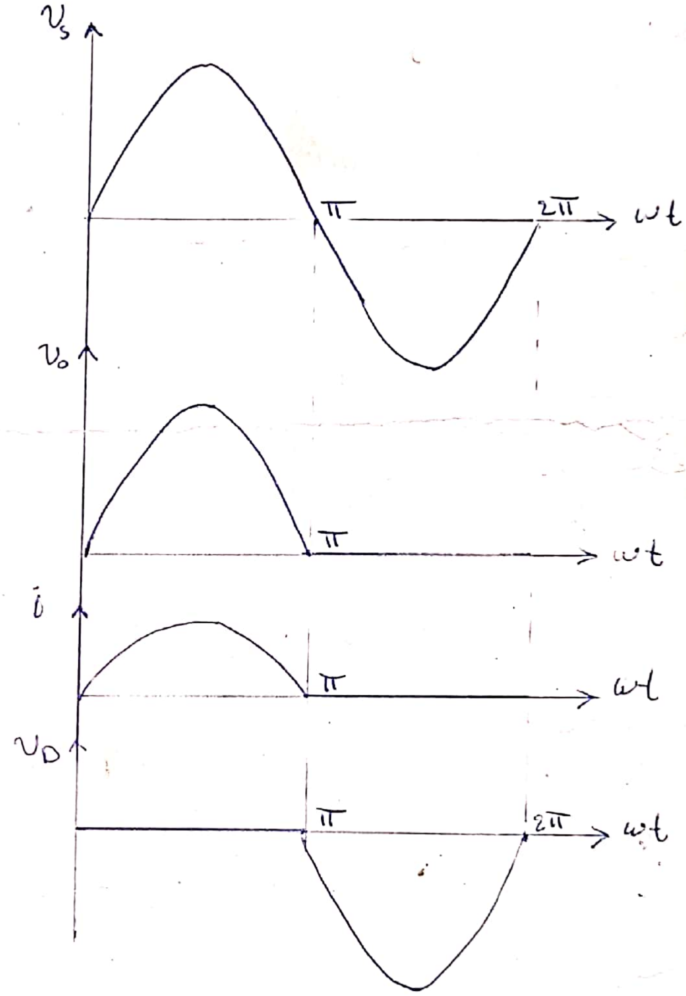
$$= \frac{V_m}{\pi}$$

$$i = v_o / R$$

$$I = V_o / R$$

if voltage drop is not neglected then

$$V_o = \frac{V_m}{\pi} - V_D \qquad (2.1)$$



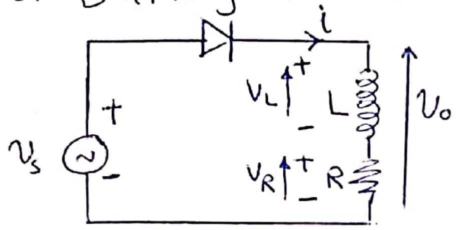
(b)

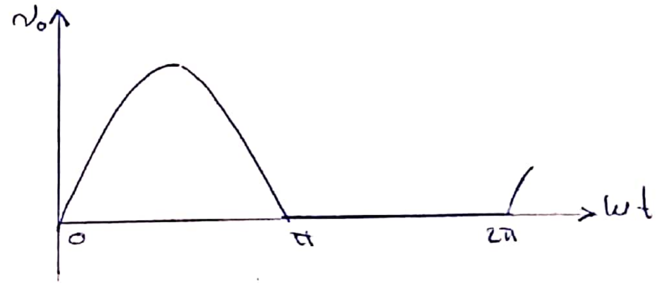
Fig.(2.1)

2.1.2 Inductive load

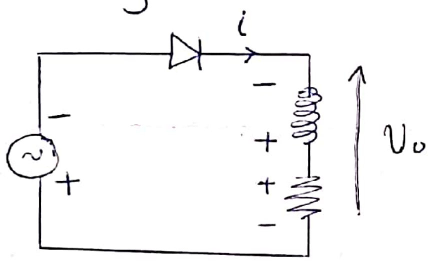
ان الحمل المتاد هو حمل حثي inductive load يتكون من (pure inductance + pure resistance)
ان الـ (pure inductance) لا تستهلك طاقة ففي الجزء الموجب من فولتية المصدر المتناوبة
تخزن الطاقة وفي الجزء السالب ترجع هذه الطاقة المخزونة الى المصدر وكالتالي:-

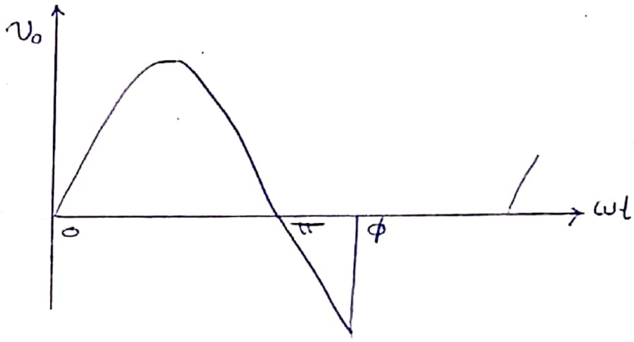
1) During +ve half cycle



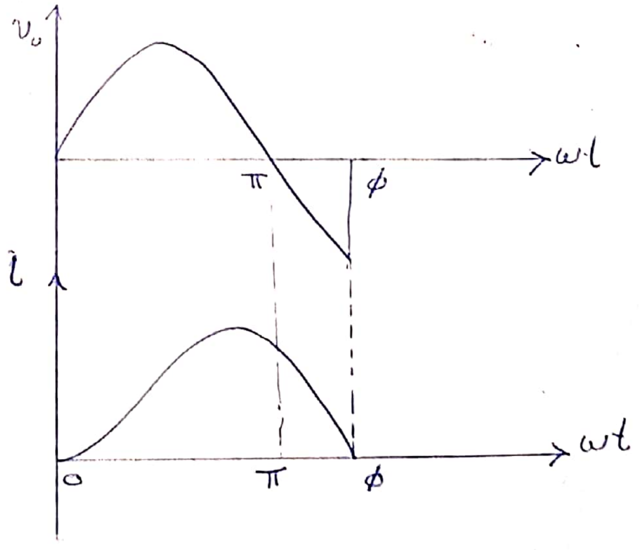


2) During −ve half cycle

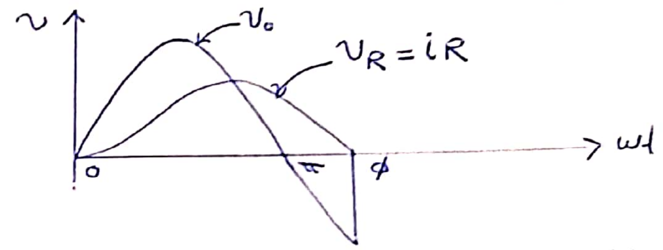




اي ان الحاثة سوف ترجع الطاقة الى المصدر ولفرض ارجاع هذه الطاقة فان الحاثة
سوف تعكس قطبيتها وتمرر التيار بنفس اتجاه التيار في الجزء الموجب الى
ان تستهلك الطاقة المخزونة في الحاثة عند الزاوية ϕ
اذن فان التيار يمر خلال الفترة $[0, \phi]$ وكالتالي:-



ان الفولتية عبر المقاومه R ستكون بنفس الطور مع التيار وكالتالي



وان الفرق بين v_o و v_R هو v_L وذلك لأن $v_o = v_R + v_L$. الآن نستطيع جمع هذه الاشكال في شكل واحد (Fig.(2.2))

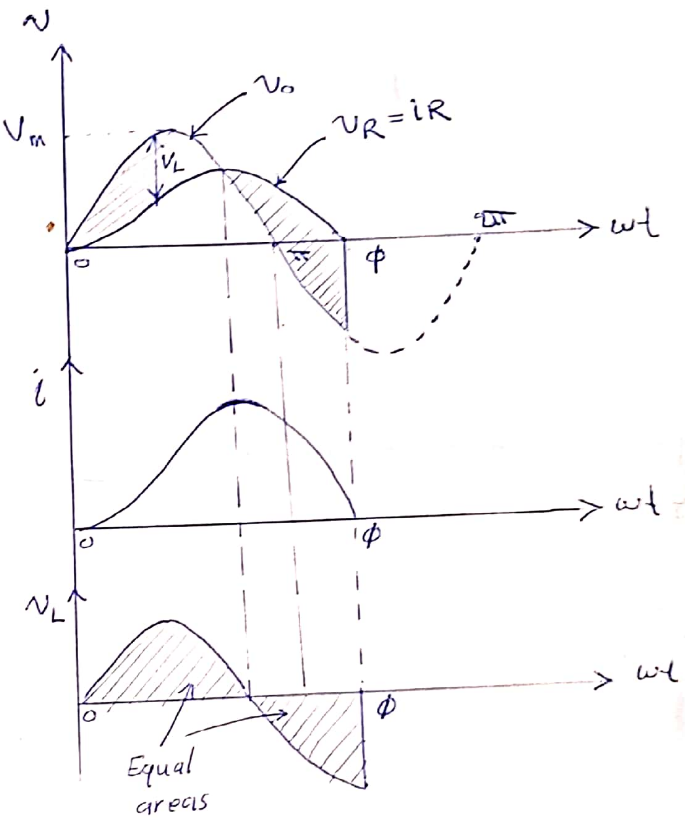
$$V_o = \frac{1}{2\pi}\int_0^{\phi} V_m \sin\omega t \, d\omega t$$

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

$$= \frac{V_m}{2\pi}\left(1-\cos\phi\right) \quad \text{.....} (2.2)$$

ϕ can be calculated from Fig (2-3) below

Where $\theta = \tan^{-1}\frac{\omega L}{R}$



Fig(2.2)

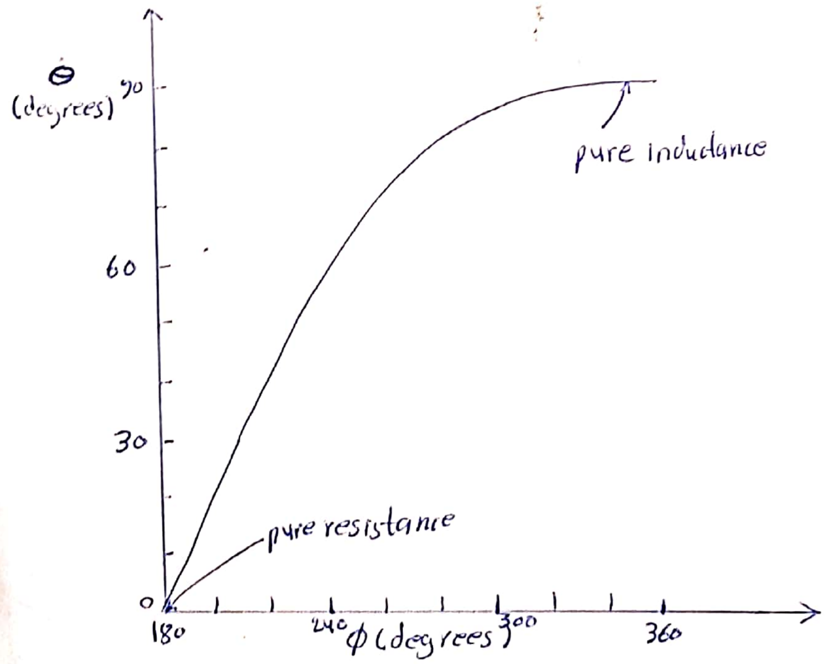


Fig. (2-3)

$V_m \sin \omega t = Ri + L\,di/dt$

$i(t) = i_t + i_{ss}$ where i_t = transient current, i_{ss} = steady state current

$$i_{ss} = \frac{V_m}{\sqrt{R^2+(\omega L)^2}} \sin(\omega t - \theta)$$

$$= \frac{V_m}{Z} \sin(\omega t - \theta)$$ Where $Z = \sqrt{R^2+(\omega L)^2}$, $\theta = \tan^{-1}(\omega L/R)$

$$i_t = A e^{-\frac{R}{L}t}$$

$i(0) = 0 = i_t(0) + i_{ss}(0)$ i.e at $t=0$ the current i is zero.

$$A e^{0} + \frac{V_m}{Z} \sin(0-\theta) = 0 \Rightarrow A - \frac{V_m}{Z}\sin\theta = 0$$

$$\Rightarrow A = \frac{V_m}{Z} \sin\theta$$

$$i(t) = i_t + i_{ss}$$

$$= \frac{V_m}{Z}\left[\sin(\omega t - \theta) + \sin\theta\, e^{-\frac{R}{L}t}\right]$$

$$\therefore i(t) = \frac{V_m}{Z}\left[\sin(\omega t - \theta) + \sin\theta\, e^{-\frac{\omega t}{\tan\theta}}\right] \quad \text{---- (2.3)}$$

2.1.3 Inductive load with freewheeling diode

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

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

$$I_{o2\pi} = \frac{V_m}{Z}\sin\theta \, \frac{1 + e^{-\pi/\tan\theta}}{e^{\pi/\tan\theta} - e^{-\pi/\tan\theta}} \quad \text{---- (2-4)}$$

$$I_{o\pi} = I_{o2\pi}\, e^{\pi/\tan\theta} \quad \text{----- (2-5)}$$

1- $0 \le \omega t \le \pi$

$$i_o = i = \frac{V_m}{Z}\sin(\omega t-\theta) + (I_{o2\pi} + \frac{V_m}{Z}\sin\theta)\, e^{-\omega t/\tan\theta} \quad \text{----- (2-6)}$$

2- $\pi \le \omega t \le 2\pi$

$$i_o = i_{D_f} = I_{o1\pi}\, e^{-\frac{(\omega t-\pi)}{\tan\theta}} \quad \text{--- (2-7)}$$

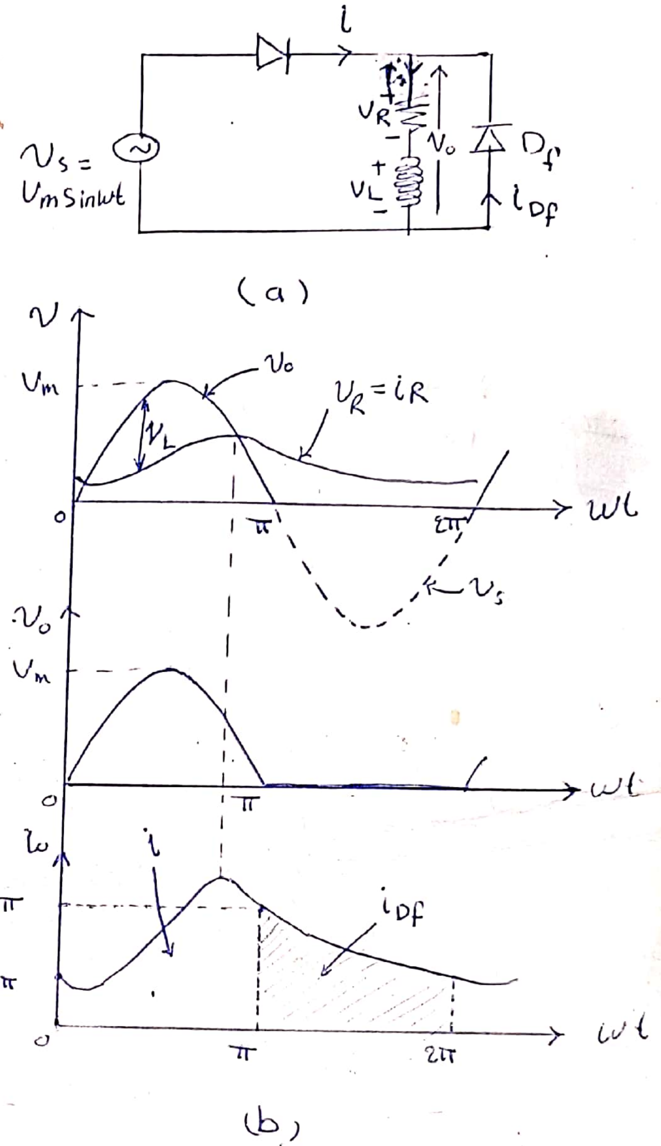


Fig. (2-4)

Example: In the circuit of figure (2-4a) the source voltage is $240\sqrt{2}\sin(2\pi 50 t)$ V, R = 10 ohms and L = 50 mH. Calculate

(a) the mean value of the load current I_o

(b) the current boundary conditions $I_{o1\pi}$, $I_{o2\pi}$.

(c) find $i_o(t)$ at $\omega t = \pi/3$ & $\omega t = 4\pi/3$

Solution

(a)

$$V_o = \frac{V_m}{\pi} = \frac{\sqrt{2}\times 240}{\pi} = 108 \ \text{V}$$

$$I_o = \frac{V_o}{R} = \frac{108}{10} = 10.8 \ \text{A}$$

(b)

$$Z = \sqrt{R^2 + (\omega L)^2}$$

$$= \sqrt{(10)^2 + (2\pi\times 50\times 50\times 10^{-3})^2}$$

$$= 18.62 \ \Omega$$

$$\tan\theta = \frac{X_L}{R} = \frac{2\pi\times 50\times 50\times 10^{-3}}{10} = \frac{15.7}{10}$$

$$= 1.57$$

$$\theta = \tan^{-1}(1.57)$$

$$= 57.5^\circ = \frac{57.5\,\pi}{180}\ \text{rad} = 0.319\pi$$

$$\sin\theta = 0.844$$

$$I_{o2\pi} = \frac{V_m}{Z}\sin\theta \, \frac{1 + e^{-\pi/\tan\theta}}{e^{\pi/\tan\theta} - e^{-\pi/\tan\theta}}$$

$$= \frac{240\sqrt{2}}{18.62} \times 0.844 \times \frac{1 + 0.135}{7.389 - 0.135}$$

$$= 2.4 \ \text{A}$$

$$I_{o1\pi} = I_{o2\pi}\, e^{\pi/\tan\theta}$$

$$= 2.4\, e^{\pi/1.57}$$

$$= 17.73 \ \text{A}$$

(c)

at $\omega t = \pi/3$:

$$i_o(t) = \frac{V_m}{Z}\sin(\omega t - \theta) + \left(I_{o2\pi} + \frac{V_m}{Z}\sin\theta\right) e^{-\frac{\omega t}{\tan\theta}}$$

$$\Rightarrow i_o = \frac{240\sqrt{2}}{18.62}\sin\left(\frac{\pi}{3} - 0.319\pi\right) + \left(2.4 + \frac{240\sqrt{2}}{18.62}\sin 0.319\pi\right) e^{-\frac{\pi/3}{1.57}}$$

$$= 18.23\sin(0.0143\pi) + (2.4 + 18.23\sin 0.319\pi)\, e^{-0.667}$$

$$= 0.8187 + (2.4 + 15.36) \times 0.5132$$

$$= 9.933 \ \text{A}$$

at $\omega t = 4\pi/3$:

$$i_o(t) = I_{o1\pi}\, e^{-\frac{(\omega t - \pi)}{\tan\theta}}$$

$$\Rightarrow i_o = 17.73\, e^{-\frac{(\frac{4\pi}{3} - \pi)}{1.57}}$$

$$= 17.73\, e^{-\frac{0.333\pi}{1.57}}$$

$$= 17.73 \times 0.5136$$

$$= 9.1 \ \text{A}$$