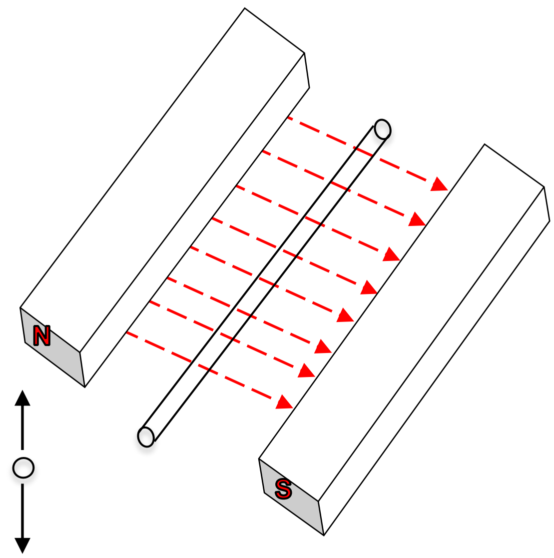
(24) Alternating current (A.C)



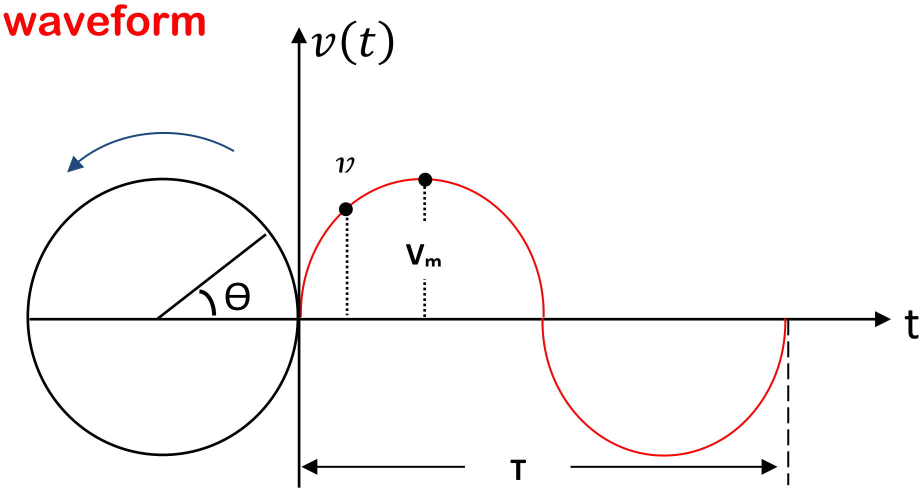
$e = B.l.v$ volt

E: induced e.m.f

B: magnetic flux density .

L: effective length of conductor

(25) Sinusoidal waveform



(26) sin wave equation

$v = Vm \sin\theta$ also $i = Im \sin\theta$

$v = Vm \sin wt$

$v = Vm \sin 2\pi f t$

$v = Vm \sin\frac{2\pi}{T} t$

Where :

v: instantaneous voltage in [volts]

V_m : maximum voltage in [volts]

ω: angular velocity in radian/seconds

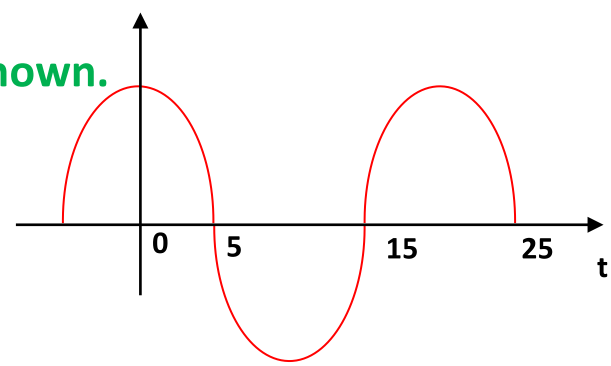
T : periodic time in [seconds]

EX: Find T if the frequency f is 60HZ , 1000HZ

1- $T = \frac{1}{f} = \frac{1}{60} = 0.01667 \ s$

2- $T = \frac{1}{f} = \frac{1}{1000} = 0.001 \ s \ = 1ms$

Ex: find the frequency for the wave form shown.



$$T = 25 - 5 = 20 \, ms$$

$$f = \frac{1}{20 \times 10^{-3}} = 50 \, HZ$$

EX : find the angular velocity (ω) of a sine wave if the frequency is 60 HZ .

$\omega = 2\pi f = 2\pi \times 60 \ = 377$ [rad / sec]

EX : if $\omega = 500$ [rad / sec] ,find (f) and (T).

$\omega = 2\pi f = \frac{2\pi}{T}$ $\qquad$ $T = \frac{2\pi}{\omega} = \frac{2\pi(\,rad)}{500\ (rad/sec)}$=12.57 [m sec]

$f = \frac{1}{T} = \frac{1}{12.57 \times 10^{-3}} = 79.58\ [HZ]$

(27) Degrees and radians

1 radian = 57.3°

$$red = \frac{\pi}{180} \times degree$$

$$degree = \frac{180}{\pi} \times rad$$

EX: $90° = \frac{\pi}{180} \times 90 = \frac{\pi}{2} \ (rad)$

$30° = \frac{\pi}{180} \times 30 = \frac{\pi}{6} \ (rad)$

EX : $\frac{\pi}{3} \ (rad) = \frac{180}{\pi} \times \frac{\pi}{3} = 60°$

$3 \ \frac{\pi}{2} \ (rad) = \frac{180}{\pi} \times 3\frac{\pi}{2} = 270°$

(28) Relationship between frequency , speed and number of pole pair in an alternator .

If an alternator has (p) pairs of pole and if the speed of rotation is (n) revolution per second ,then the frequency is:-

$f = pn$ cycle / second or (HZ)

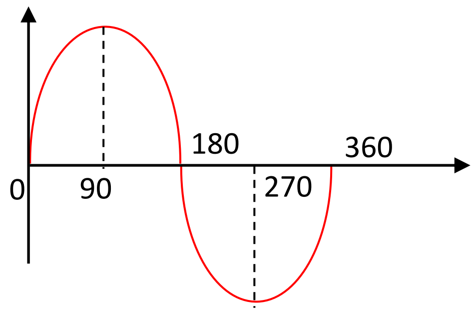
EX: an alternator has 2 poles , find the speed if the frequency is to be 50 HZ.

Solution:

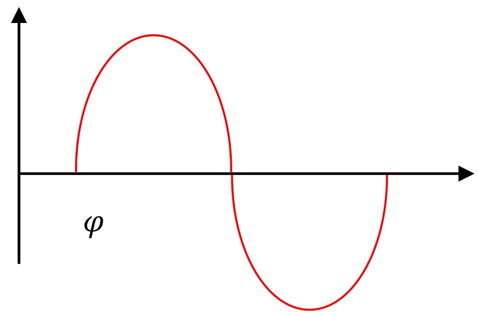
$f = pn \qquad n = \frac{f}{p} = \frac{50}{1} = 50 \quad r.p.s$

or $n = 50 \times 60 = 3000 \quad r.p.m$

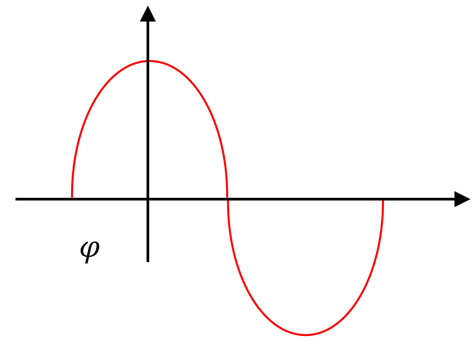
(29) phase shift



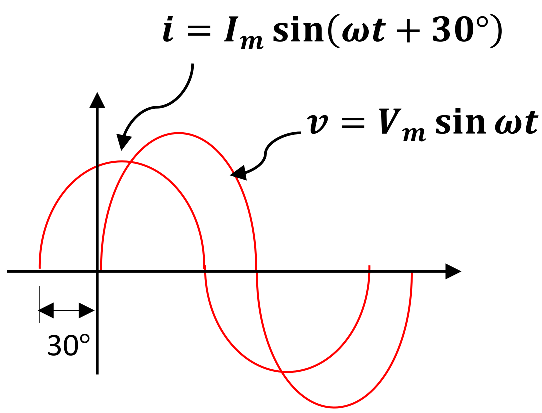
$v = V_m \sin \omega t$

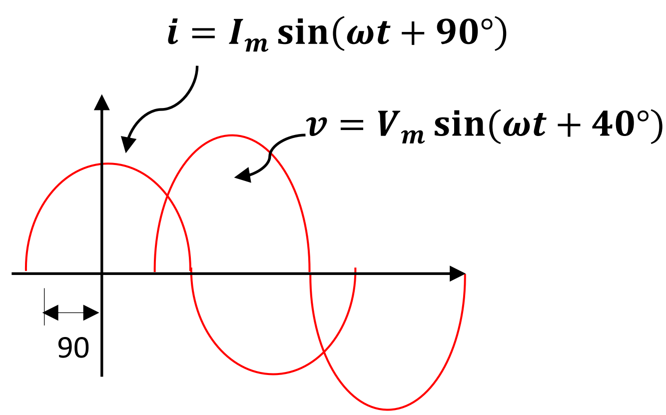


$v = V_m \sin(\omega t - \varphi)$



$v = V_m \sin(\omega t + \varphi)$





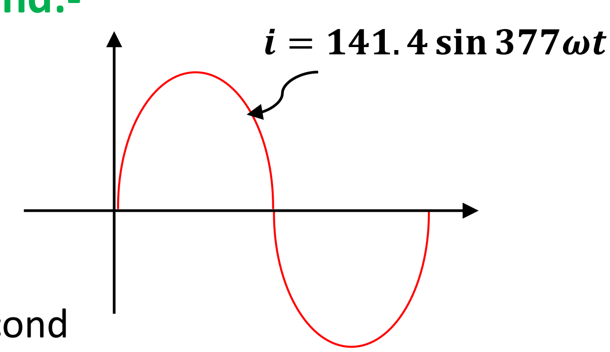
(i) **LEADS** (V) by30°

or (V) **LAGS** (i) by30°

(i) **LEADS** (V) by 130°

or (V) **LAGS** (i) by130°

EX: for the waveform shown below, find:-



1- Maximum current
2- Frequency
3- Instantaneous current at t= 0.003 second

Solution:

1- $i = I_m \sin \omega t$ $\therefore$ $I_m = 141.4\ A$

$i = 141 \sin 377t$ $\omega = 377 \quad rad/sec$

2- $\omega = 2\pi f$ $f = \frac{\omega}{2\pi} = \frac{377}{2\pi} = 60\ HZ$

3- $T = \frac{1}{f} = \frac{1}{60} = 0.066\ second$

4- $i = I_m \sin \omega t$

$= 141.4 \sin(377 * 0.003)$

$i = 141.4 \sin 1.131$ $((\theta^\circ = \frac{\theta_{rad} \times 180}{\pi}))$

$i = 141.4 \sin 64.83$

= 127.8 A

(30) Average value and Root Mean Square value.

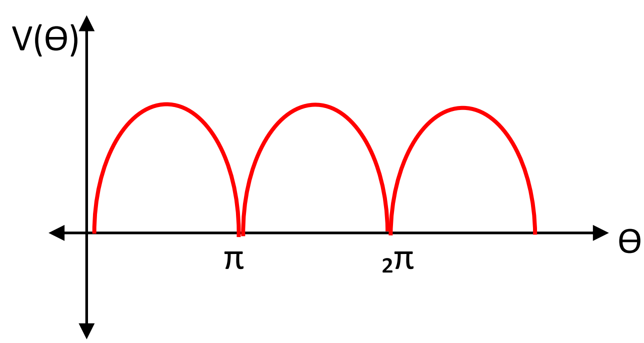
(i) For sinusoidal voltage or current waveforms the average value can be calculated be the equation below

$$V_{av.} = \frac{1}{T} \int_0^T v(\theta) d\theta$$

$$I_{av.} = \frac{1}{T} \int_0^T i(\theta) d\theta$$

For complete sinusoidal waveform Average vale = 0, since the positive half equal the negative half of the waveform .

EX:- the output of a full-wave rectifier is shown below derive an expression for the average value :



Solution:

$$\boldsymbol{V_{av} = \frac{1}{T} \int_0^T V(\theta)\, d\theta}$$

$$V_{dc} = \frac{1}{\pi}\left[\int_0^{\pi} V(\theta)\, d\theta\right]$$

$$= \frac{1}{\pi}\left[\int_0^{\pi} V_m \sin\theta\, d\theta\right]$$

$$= \frac{V_m}{\pi}\left[\int_0^{\pi} \sin\theta\, d\theta\right]$$

$$= \frac{V_m}{\pi}[-\cos\theta]$$

$$= -\frac{V_m}{\pi}[\cos\pi - \cos 0]$$

$$= -\frac{V_m}{\pi}[-1-1] = \frac{V_m}{\pi} * 2$$

$$V_{av.} = 2\frac{V_m}{\pi}$$

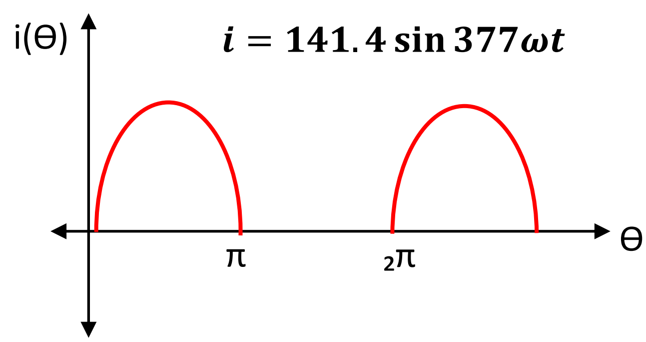
(ii) The Root Mean Square value (R.M.S) can be calculate as shown

$$V_{(RMS)} = \sqrt{\frac{1}{T}\int_0^T v^2(\theta)}$$

$$I_{(RMS)} = \sqrt{\frac{1}{T}\int_0^T i^2(\theta)}$$

EX :-the output of a half-wave rectifier is shown below , derive an expression for the R.M.S value.

solution:



$$I_{rms} = \sqrt{\frac{1}{T}\int_0^T i^2 d\theta}$$

$$= \left[\frac{1}{2\pi}\int_0^{\pi} {I_m}^2 \sin\theta^2\, d\theta\right]^{\frac{1}{2}}$$

$$= \left[\frac{{I_m}^2}{2\pi}\int_0^{\pi} \frac{1-\cos 2\theta}{2}\, d\theta\right]^{\frac{1}{2}}$$

$$= \left[\frac{{I_m}^2}{2\pi} * \frac{1}{2}\left[\theta - \frac{1}{2}\sin 2\theta\right]\right]^{\frac{1}{2}}$$

$$= \left[\frac{{I_m}^2}{4\pi}\left\{(\pi - 0) - \frac{1}{2}(\sin 2\pi - \sin 2 * 0)\right\}\right]^{\frac{1}{2}}$$

$$= \left[\frac{{I_m}^2}{4\pi}\pi\right]^{\frac{1}{2}}$$

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

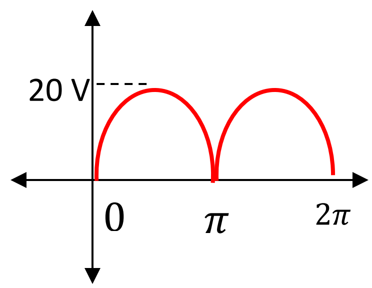
(31) Form factor (Kf) and peak Factor (Ka)

$$K_f = \frac{R.M.S\ valu}{average\ value}$$

$$K_a = \frac{Maximum\ value}{R.M.S\ valu}$$

EX : for the wave form shown below, if the frequency is 100 HZ, calculate :-

1- Average Value
2- R.M.S Value
3- Form factor ((K_f) and peak factor (K_a)



$$V_{av} = 2\frac{V_m}{\pi} = \frac{2\times 20}{\pi} = 12.73 \quad V$$

$$V_{rms} = \frac{V_m}{\sqrt{2}} = \frac{20}{\sqrt{2}} = 14.18 \quad V$$

$$K_f = \frac{V_{rms}}{V_{av.}} = \frac{14.18}{12.73} = 1.11$$

$$K_a = \frac{V_{max}}{V_{rms}} = \frac{20}{14.18} = 1.41$$