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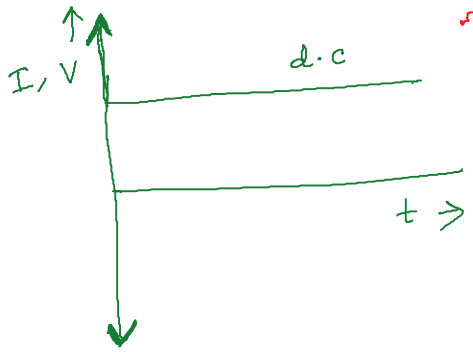
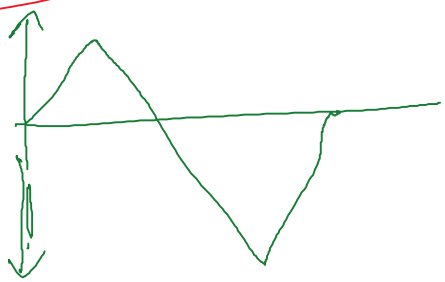
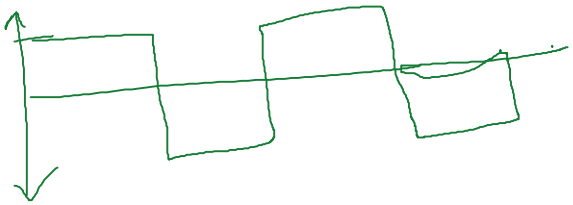
A.C Fundamentals



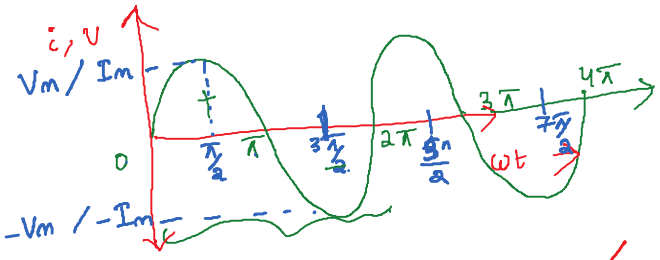


$i = I_m \sin\omega t$



(1) **Cycle** :- 1 complete set of +ve or -ve value of an alternating quantity is called 1 cycle.

1 cycle → 360° or 2π radian



(2) **Peak value / Maximum / Amplitude / Crest value (Im/Vm)**

The maximum value of an alternating quantity is called its amplitude.

(3) **Instantaneous value (v, i)**

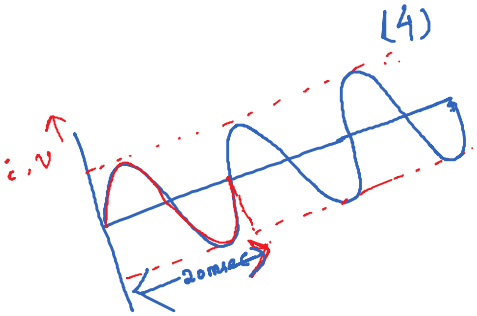
$v = V_m \sin\omega t$ $\quad i = I_m \sin\omega t$

The value of alternating quantity at any instant is called its instantaneous value.

- / Hz or cycles/sec]

instantaneous value

(4) **Frequency** (Hz or cycles/sec)



The no of cycles that covered in 1 sec is called its Frequency.

$$f = \frac{1}{T}$$

(5) **Time period** T

The time taken in sec to complete 1 cycle is called its time period

(6) **Angular Frequency**

$\omega = 2\pi f$ rad/sec

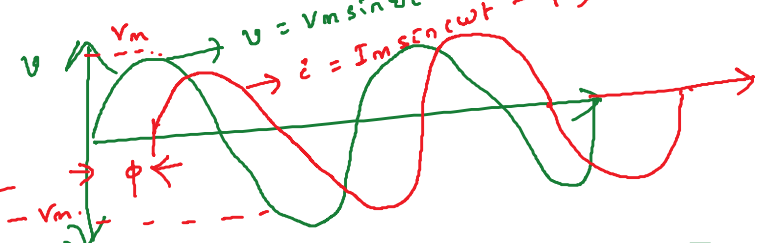
The no of radians that covered in 1 sec is called its angular frequency

(7) **Phase difference**

$v = V_m \sin \omega t$ $\quad i = I_m \sin(\omega t \pm \phi)$

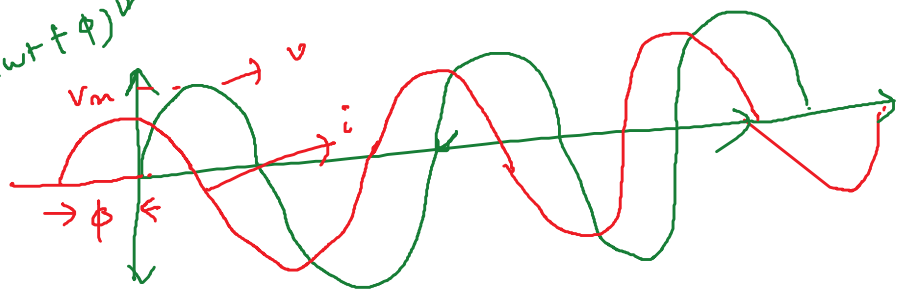
$i = I_m \sin(\omega t - \phi)$

Lag



$i = I_m \sin(\omega t + \phi)$

Lead



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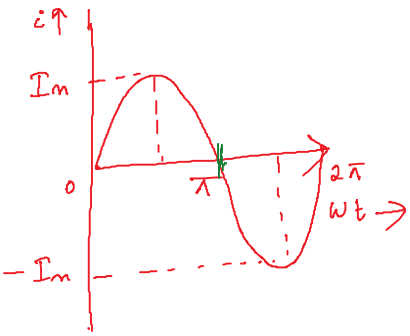
Avg Value



$$i_{av} = \frac{\text{Area under full cycle}}{\text{Length of full cycle}}$$

$$= \frac{\int_0^{2\pi} i\, d(\omega t)}{2\pi} = \int_0^{2\pi} \frac{I_m \sin\omega t\, d(\omega t)}{2\pi}$$

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

$\cos n\pi = (-1)^n$

$$= \frac{-I_m}{2\pi}\left[\cos 2\pi - \cos 0\right]$$

$$= \frac{-I_m}{2\pi}\left[1 - 1\right] = 0$$

$$I_{av}\Big]_{\text{half cycle}} = \int_0^{\pi} \frac{i\, d(\omega t)}{\pi}$$

$$= \int_0^{\pi} \frac{I_m \sin\omega t\, d(\omega t)}{\pi}$$

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

1, 2, 3, 4, 5, 6

$$\text{Avg} = \frac{1+2+3+4+5+6}{6}$$

$$\text{rms value} = \sqrt{\frac{1^2+2^2+3^2+4^2+5^2+6^2}{6}}$$

$$= \frac{-I_m}{\pi}\left[\cos\pi - \cos 0^\circ\right]$$

$$= \frac{-I_m}{\pi}\left[-1-1\right]$$

$$I_{av} = \frac{2I_m}{\pi} = 0.637\, I_m.$$

R.M.S Value

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

HW

$i = I_m \sin\omega t$

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R.M.S Value / Effective value

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

$$= \sqrt{\int_0^{2\pi} \frac{[I_m \sin\omega t]^2}{2\pi}\, d(\omega t)}$$

$$= \sqrt{\frac{I_m^2}{2\pi}\left[\int_0^{2\pi} \sin^2\omega t\, d(\omega t)\right]}$$

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

$$= \sqrt{\frac{I_m^2}{4\pi}\left[\int_0^{2\pi} d(\omega t) - \int_0^{2\pi} \cos 2\omega t\, d(\omega t)\right]}$$

$$= \sqrt{\frac{I_m^2}{4\pi}\left[(2\pi - 0) - \left[\frac{\sin 2\omega t}{2}\right]_0^{2\pi}\right]}$$

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

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

Ex :- $v = 40 \sin\omega t$

$V_{rms} = \frac{40}{\sqrt{2}}$

$V_{avg} = \frac{2 \times 40}{\pi} = \frac{80}{\pi}$

Def^ :- The rms value of an alternating quantity is defined as that steady current flowing

Def" :- The rms value of a quantity is defined as the steady (d.c) current flowing through a given resistance for a given time which produces the same amount of heat when an alternating current flows through the same resistance for the same time.

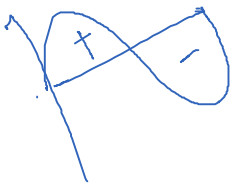
$P = I^2R$

$P = i^2R$

$= (I_m \sin\omega t)^2 R$

$= I_m^2 R \left[\frac{1 - \cos 2\omega t}{2}\right]$

$= \frac{I_m^2 R}{2} - \frac{I_m^2 R}{2}\cos 2\omega t$



$P_{avg\ a.c} = \frac{I_m^2 R}{2}$

$P_{avg.\ d.c} = I^2R$

$I^2R = \frac{I_m^2 R}{2}$

$I_{eff} = I = \frac{I_m}{\sqrt{2}}$

Form Factor

$= \frac{\text{R.M.S value}}{\text{Avg value}}$

Peak factor

$= \frac{\text{Max value}}{\text{R.M.S value}}$

$= \frac{I_m}{}$

$4\sin 314t$

$4\sin 314t$

Avg value.

$= \frac{I_m}{I_m/\sqrt{2}} = \frac{\pi}{2\sqrt{2}}$

$= \frac{2I_m}{\pi}$

$= 1.11$

$= \frac{I_m}{I_m/\sqrt{2}}$

$= \sqrt{2}$

$= 1.414$

$160^\circ \Rightarrow \pi$ radian

$90^\circ \Rightarrow \frac{\pi}{180} \times 90 = \frac{\pi}{2}$

$\sin 90^\circ = 1$

$\sin \frac{\pi}{2} = 1$ Q.1

$i = 141.4 \sin 314t$ ($2\pi f$)

Calculate (i) max value.

(ii) f

(iii) T

(iv) $i] = ?$ $t = 3$ ms

Sol^ :- (i) $I_m = 141.4$ A

(ii) $f = 50$ Hz

(iii) $T = 20$ ms

$141.4 \sin 2 \times \frac{180}{\pi} \times 50 \times 3 \times 10^{-3}$

$2 \times 3.142 \times 50$

$= 314.2$

(v) $i] = 141.4 \sin 314 \times 5 \times 10^{-3}$

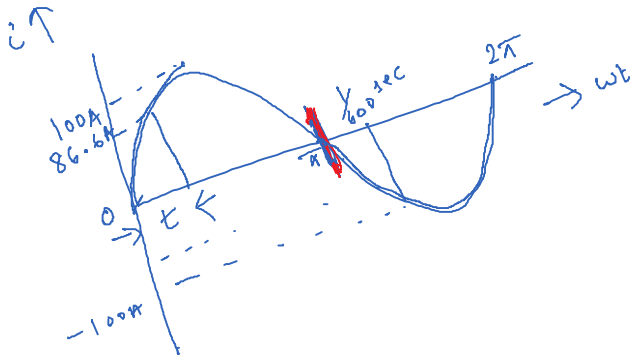
$= 20$

$= 114.35$ A

Q.2 An alternating current of $f = 50$ Hz has maximum value of 100A

Calculate (i) its value $\frac{1}{600}$ sec after the current is zero and decreasing

(ii) how many seconds the current is after zero and increasing and will attain the value of 86.6A.



(ii) $i = I_m \sin \omega t$

$86.6 = 100 \sin 314.2t$

$\sin 314.2t = \left(\frac{86.6}{100}\right)$

$t = \frac{1}{314.2} \sin^{-1}\left(\frac{86.6}{100}\right)$

$= 3.33 \text{ msec.}$

(i) $i = I_m \sin(\omega t + \pi)$

$= 100 \sin\left(314.2 \times \frac{1}{600} + \pi\right)$

$= -100 \sin\left(\frac{314.2}{} \times \frac{1}{600}\right)$

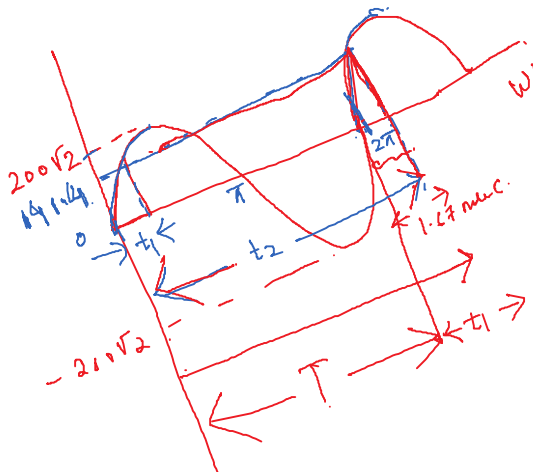
$= -100 \sin\left(2\pi \times 50 \times \frac{1}{600}\right)$

$= -100 \sin \frac{\pi}{6}$

$= -50A$

Q. 3

An alternating current of $f = 50Hz$ has max value $200\sqrt{2}A$. Reckoning from the instant the current is zero and becoming +ve, find the time taken to reach for first time the current $141.4A$ and 2nd time?



a) $i = I_m \sin \omega t$

a) $i = I_m \sin \omega t$

$141.4 = 200\sqrt{2} \sin 2\pi \times 50\, t$

$t_1 = 1.67$ msec

$f = 50$ hz

$T = \frac{1}{50} = 20$ msec.

(b)

$\omega t = 2\pi$

$t = \frac{2\pi}{2\pi f}$

$= \frac{1}{f} = 20$ msec

$t_2 = T + t_1$

$= 20\text{msec} + 1.67 = 21.67$ msec