ELECTRICAL ENGG. CONCEPTS

A blog about electrical engineering concepts, formulas , solved problems and books for electrical engineering students.

Saturday, 21 November 2015

A.C. Fundamentals (Solved problems)

Example A sinusoidal alternating voltage of 50 Hz has an r.m.s. value of 200 V. Write down its equation for instantaneous value.

Sol. R.M.S. value of voltage, $E_{r.m.s.} = 200$ V

Frequency, $f = 50$ Hz

Maximum value, $E_m = \sqrt{2}\, E_{r.m.s.}$

$= \sqrt{2} \times 200 = 282.84$ V

Angular velocity, $\omega = 2\pi f$

$= 2\pi \times 50 = 314{\cdot}16$ rad/s

Instantaneous value is given by the equation,

$e = E_m \sin \omega t$

or $e = 282{\cdot}84 \sin 314{\cdot}16\, t$ (*Ans.*)

Example An alternating current is given by the equation $i = 100 \sin 314\, t$. Find :—

(i) Maximum value of current ;

(ii) Frequency ;

(iii) Time period ;

(iv) R.M.S. value of current ;

(v) Value of current after $t = 0{\cdot}005$ second.

Sol. Given that $i = 100 \sin 314\, t$ ...(*i*)

Instantaneous value of current is given by the equation :

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

Comparing equation (*i*) and (*ii*)

(*i*) Co-efficient of sin ωt *i.e.*

$I_m = 100$ A (*Ans.*)

(*ii*) $\sin \omega t = \sin 314\, t$

or $\omega = 314$

or $2\pi f = 314$

or frequency, $f = \frac{314}{2\pi} = 50$ Hz (*Ans.*)

(*iii*) Time period, $T = \frac{1}{f} = \frac{1}{50} = 0{\cdot}02$ s (*Ans.*)

(*iv*) R.M.S. value of current,

$I_{r.m.s.} = \frac{I_m}{\sqrt{2}} = \frac{100}{\sqrt{2}} = 70.71$ A (*Ans.*)

(*v*) Value of current after $t = 0{\cdot}005$ s *i.e.*

$i = 100 \sin 2\pi \times 50 \times 0{\cdot}005$

$= 100 \sin \frac{\pi}{2} = 100$ A (*Ans.*)

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Electric Machines

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Example An alternating current is given by the expression $i=20 \sin 628\, t$. Determine :—

(i) Maximum value of current ;
(ii) R.M.S. value of current ;
(iii) Frequency of current ;
(iv) Value of current after $t=0{\cdot}00625$ seconds ;
(v) Time taken by the current to reach a value of 10 A.

Sol. Given that $i=20 \sin 628\, t$ ...(i)

Instantaneous value of current is given by the equation ;

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

Camparing equation (i) and (ii) ;

(i) Maximum value of current, $I_m=20$ A (*Ans.*)

(ii) R.M.S. value of current, $I=\dfrac{I_m}{\sqrt{2}}=\dfrac{20}{\sqrt{2}}=14{\cdot}142$ A (*Ans.*)

(iii) $\sin \omega t=\sin 628\, t$

$\therefore \quad \omega=628$

or $\quad 2\pi f=628$

or $\quad f=\dfrac{628}{2\pi}=100$ Hz (*Ans.*)

(iv) When $t=0{\cdot}00625$ seconds

$$i=20 \sin 2\pi f t$$
$$=20 \sin 2\pi \times 100 \times 0{\cdot}00625$$
$$=20 \sin 1{\cdot}25\, \pi$$
$$=20 \sin\left(\pi+\frac{\pi}{4}\right)$$
$$=20\left(-\sin \frac{\pi}{4}\right)$$
$$=-20\times 0{\cdot}7071=-14{\cdot}142 \text{ A} \quad (Ans.)$$

(v) $\quad i=20 \sin 2\pi f t$

$10=20 \sin 2\pi f t$

or $\quad \sin 2\pi f t=0{\cdot}5$

or $\quad \sin 2\pi f t=\sin \dfrac{\pi}{6}$

or $\quad 2\pi f t=\dfrac{\pi}{6}$

$$t=\frac{\pi}{6\times 2\pi \times 100}=\frac{1}{1200} \text{ s} \quad (Ans.)$$

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About me

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Example **An alternating current of frequency 60 Hz has a maximum value of 120 A. Write down the equation for its instantaneous value. Reckoning time from the instant the current is zero and is becoming positive, find ;**

(i) **the instantaneous value after 1/360 seconds and**

(ii) **the time taken to reach 96 A for the first time.**

Sol. Maximum value of current, $I_m = 120$ A

Frequency, $f = 60$ Hz

Instantaneous value of current is given by the equation ;

$$i = I_m \sin \omega t = I_m \sin 2\pi f t$$
$$= 120 \sin 2\pi \times 60\, t$$
$$= \mathbf{120 \sin 377\, t} \quad (Ans.)$$

When the reckoning time is taken from the instant the current is zero and becoming positive, equation for current is

$$i = 120 \sin 377\, t$$

(*i*) Instantaneous value of current after $t = \frac{1}{360}$ s

$$i = 120 \sin 2\pi \times 60 \times \frac{1}{360}$$
$$= 120 \sin \frac{\pi}{3}$$
$$= 120 \times 0{\cdot}866 = \mathbf{103{\cdot}92\ A} \quad (Ans.)$$

(*ii*) Let t seconds be the time taken to reach the current to 96 A for the first time. Then

$$96 = 120 \sin 2\pi \times 60\, t$$

or $$\sin 2\pi \times 60\, t = \frac{96}{120}$$

$$\sin 2 \times 180° \times 60\, t = 0{\cdot}8 \qquad (\because \pi = 180°)$$
$$2 \times 180° \times 60\, t = \sin^{-1} 0{\cdot}8$$

$$2 \times 180° \times 60\, t = 53{\cdot}13°$$
$$t = \frac{53{\cdot}13}{2 \times 180 \times 60} = \mathbf{0{\cdot}00246\ s} \quad (Ans.)$$

Note. *On both the sides the angle must be in the same units i.e. either in degrees or in radians.*

Example *Calculate* (i) *the maximum value and* (ii) *the root-mean-square value of the following quantities* :

(i) **40 sin ωt**

(ii) **B sin (ωt − π/2)**

(iii) **10 sin ωt — 17.3 cos ωt**

Draw the vectors showing the phase difference with respect to A sin (ωt — π/6).

Sol. The instantaneous value of an alternating quantity is given by the relation.

$$i = I_m \sin \omega t \quad \text{or} \quad v = V_m \sin \omega t$$

(*i*) The given alternating quantity is 40 sin ωt

∴ Maximum value = 40 (*Ans.*)

$$\text{R.M.S. value} = \frac{\text{Max. value}}{\sqrt{2}}$$
$$= \frac{40}{\sqrt{2}} = \mathbf{28.284} \quad (Ans.)$$

The vector lies on the hosizontal axis as shown in fig. 7.28.

(*ii*) The given alternating quantity is B sin $(\omega t - \pi/2)$

$\therefore$ Maximum value=B (*Ans.*)

R.M.S. value $= \frac{B}{\sqrt{2}}$ (*Ans.*)

The vector lags behind the horizontal axis by 90° as shown in fig. 7.28.

(*iii*) The given alternating quantity is $10 \sin \omega t - 17.3 \cos \omega t$. In fact, this quantity has two components displaced from each other by 90° as shown in fig. 7.27.

Resultant maximum value$=\sqrt{(10)^2+(17.3)}$

$=20$

Let the phase angle of the resultant with the horizontal be θ°.

$\therefore \tan\theta = \frac{17.3}{10} = 1.73$

or $\theta = \tan^{-1} 1.73 = \frac{\pi}{3} = 60°$.

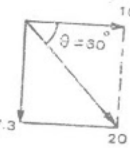

Fig. 7.27

Hence, this vector lags behind the horizontal axis by 60° as shown in fig. 7.27.

The quantity A sin $(\omega t - \pi/6)$ makes an angle of lag, $\theta_1 = \frac{\pi}{6} = 30°$

with the horizontal as shown in fig. 7.28.

All the said quantities are shown vectorially in fig. 7.27.

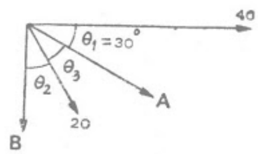

Fig. 7.28

The phase difference between first quantity (*i.e.* 40) and $A = \theta_1 = \frac{\pi}{6}$

$= 0°$ (*Ans.*)

The phase difference between second quantity (*i.e.* B) and $A = \frac{\pi}{2} - \frac{\pi}{6} = \frac{\pi}{3} = 60°$ (*Ans.*)

The phase difference between third quantity (*i.e.* 20) and $A = \theta_3 = \frac{\pi}{3} - \frac{\pi}{6} = \frac{\pi}{6} = 30°$ (*Ans.*)

Example **Three voltages represented by $e_1 = 20 \sin \omega t$, $e_2 = 30 \sin(\omega t + \pi/4)$ and $e_3 = 40 \cos(\omega t - \pi/6)$ act together in a circuit. Find an expression for the resulting voltage.**

Sol. The three voltages are represented vectorially in fig. 7.32. The third voltage (40 V) makes an angle of 30° with the vertical.

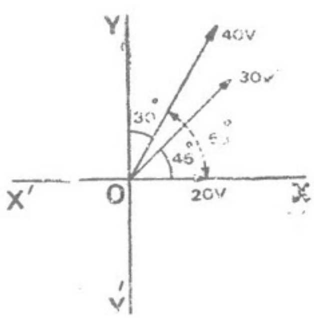

Fig. 7.32

Resolving the components along X-axis.

$E_{XX} = 20 + 30 \cos 45° + 40 \cos 60°$

$= 20 + 30 \times 0{\cdot}707 + 40 \times 0{\cdot}5$

$= 61{\cdot}21$ V

Resolving the components along Y-axis,

$E_{YY} = 0 + 30 \sin 45° + 40 \sin 60$

$= 0 + 30 \times 0{\cdot}707 + 40 \times 0{\cdot}866°$

$= 55{\cdot}85$ V

Maximum value of resultant voltage,

$E_{mr} = \sqrt{E_{XX}^2 + E_{YY}^2}$

$= \sqrt{(61{\cdot}21)^2 + (55{\cdot}85)^2}$

$= 82{\cdot}86$ V

Let φ be the angle which the resultant voltage makes with X-axis ;

$\tan\phi = \frac{E_{YY}}{E_{XX}} = \frac{55{\cdot}85}{61{\cdot}21} = 0{\cdot}9124$

$\therefore \phi = \tan^{-1} 0{\cdot}9124 = 42\ 38°$

$\therefore$ Expression for the resultant voltage,

$e_r = E_{mr} \sin(\omega t + \phi)$

$= \mathbf{82{\cdot}86 \sin(\omega t + 42{\cdot}38°)}$ (*Ans.*)

Posted by Ajay Sharma at 06:01:00

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