Single Phase AC Circuits

Problems on Basic Sine Wave:

(32) The maximum value of a sinusoidal alternating current of frequency 50 HZ is 25A. Write the equation for the instantaneous expression of current. Determine its value at 3ms & 14ms.

Given, $I_m = 25A$, $f = 50HZ$

$\omega = 2\pi f = 100\pi$ rad/sec.

$i = 25 \sin(100\pi t)$ A

(i) At 3ms,

$$i = 25 \sin\left(100\pi \times \frac{180^\circ}{\pi} \times 3\times10^{-3}\right)$$

$$\underline{i = 20.225A}$$

(ii) At 14ms,

$$i = 25 \sin\left(100\pi \times \frac{180^\circ}{\pi} \times 14\times10^{-3}\right)$$

$$\underline{i = -23.776A}$$

(33) A sinusoidal voltage of 50HZ has a max. value of $200\sqrt{2}$ volts. At what time measured from a +ve max. value the instantaneous voltage be equal to 141.4 volts.

Given, $V_m = 200\sqrt{2}$, $f = 50HZ$.

$V = 200\sqrt{2} \sin(100\pi t)$ V

When $V = 141.4$,

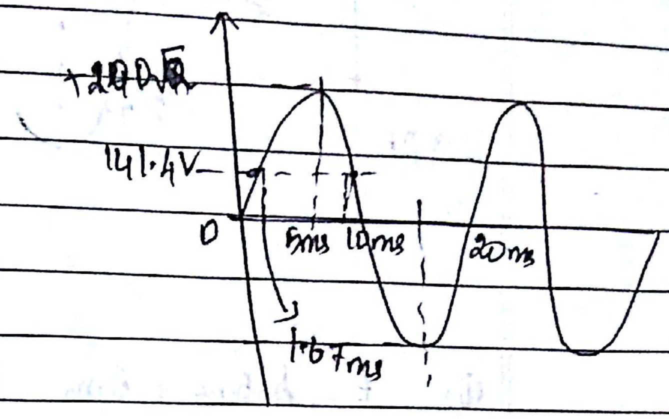
$$\frac{141.4}{200\sqrt{2}} = \sin\left(100\pi t \times \frac{180^\circ}{\pi}\right)$$

$$t = 1.667\,ms$$

From +ve max,

$$t = 10ms - 1.665\,ms$$

$$t = 8.33\,ms$$



(34) A sinusoidal wave of frequency 50HZ has its max. value of 9.2A. What will be its value at
(I) 0.002s after passing thro' zero in +ve direction.
(II) 0.0045s after the wave passes thro' +ve max.
Sketch the waveform of current showing the current value at the above time instants.

~~Vmax~~ $I_m = 9.2A$

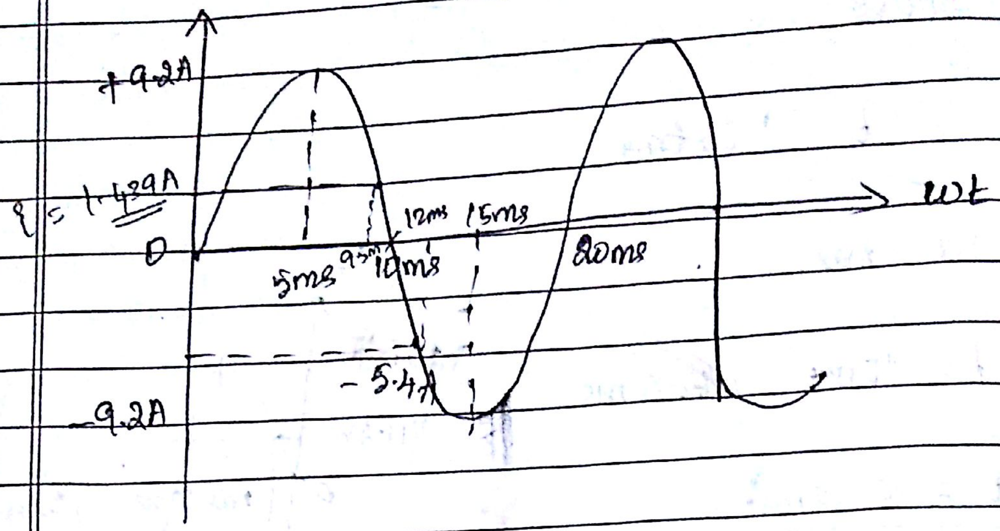
$f = 50HZ$

$$i = 9.2 \sin(100\pi t)\ A$$

(I) $t = 2ms + 10ms$ (after passing thro' zero in +ve direction)

$$i = 9.2 \sin\left(100\pi \times \frac{180^\circ}{\pi} \times 12m\right)$$

$$i = -5.407\ A$$



(ii) $t = 4.5ms + 5ms$ [after passing thro' +ve max)

$i = 9.2 \sin(100\pi \times \frac{180^\circ}{\pi} \times 9.5 \times 10^{-3})$

$\underline{i = 1.439A}$

(35.) Four Single Phase generators whose emf's can be represented by $e_1 = 20\sin\omega t$, $e_2 = 40\sin(\omega t + \pi/_2)$ $e_3 = 30\sin(\omega t - \pi/_6)$, $e_4 = 10\sin(\omega t - \pi/_3)$ are Connected in series. Find the resultant emf. Also, find the max. value of resultant emf & its phase angle relative to e_2.

$e_1 = 20\sin\omega t = 20\angle 0^\circ = 20 + j0$
$e_2 = 40\sin(\omega t + 90^\circ) = 40\angle 90^\circ = 0 + j40$
$e_3 = 30\sin(\omega t - 30^\circ) = 30\angle -30^\circ = 25.98 - j15$
$e_4 = 10\sin(\omega t - 60^\circ) = 10\angle -60^\circ = (5 - j8.66)V$

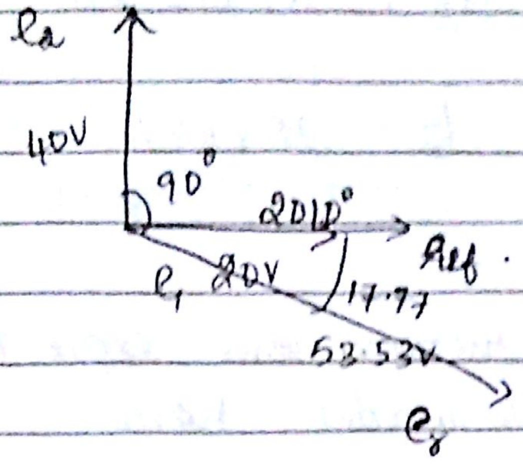
$e_r = e_1 + e_2 + e_3 + e_4$

$= 20 + j0 + 0 + j40 + 25 - j15 + 5 - j8.66$

$= 50.98 - j\,16.34$

$$\boxed{e_r = 53.53 \angle -17.77^\circ \text{ V}}$$

(ii)



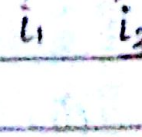
Phase angle b/w e_2 and e_r $= \underline{107.77^\circ}$

(36) There are 3 conducting wires connected to a junction. The currents flowing into the jn in 2 wires are $i_1 = 10 \sin 314t$ A and $i_2 = 15 \cos(314t - 45^\circ)$ A. What is the current leaving the jn in third wire? What is its value at $t = 0$?

Given, $i_1 = 10 \sin 314t = 10\angle 0^\circ$ A

$i_2 = 15 \sin(314t + 90^\circ - 45^\circ) = 15\angle 45^\circ$ A

$i_3 = i_1 + i_2$



$= 10 + j0 + 10.606 + j\,10.606$

$= 20.606 + j\,10.606$

$i_3 = 23.175 \angle +27.235^\circ$ A

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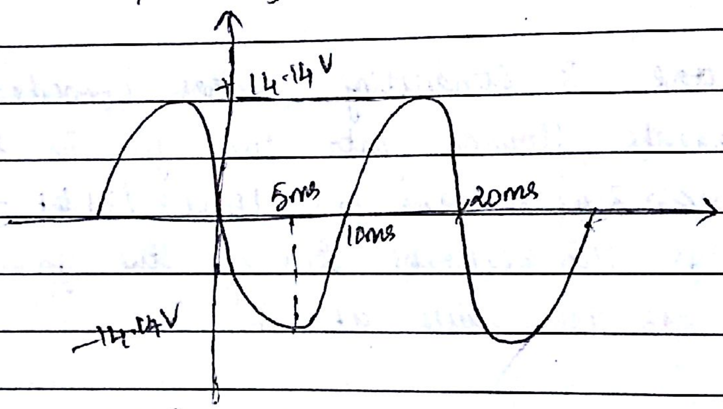
$$\boxed{i_3 = 23.175 \sin(\overset{314t}{\omega t} + 27.35^\circ)}$$

At $t=0$, $i_3 = 23.175 \sin(314(0) + 27.35^\circ)$

$$\underline{i_3 = 10.647A}$$

(37) Dedue the instantaneous expressions for the following sinusoidal waves.

(i) Wave with 50Hz freq, with ~~max.~~ rms value of 10units, reaching its −ve max. at 5th ms.



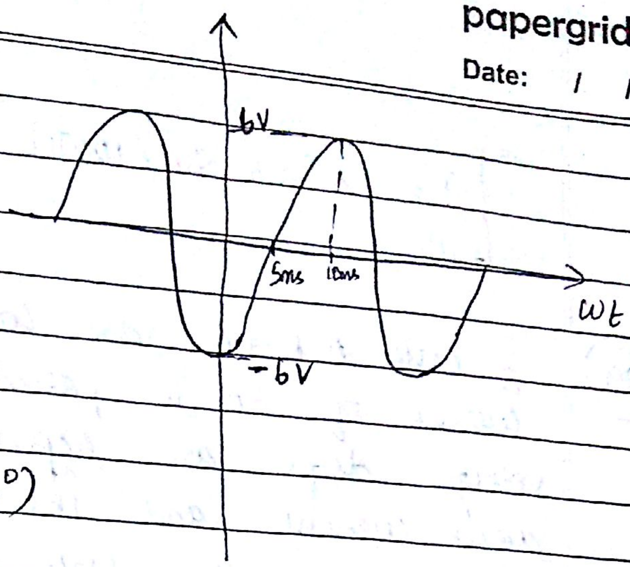
$V_m = 10\sqrt{2} = 14.14\,V$, $\omega = 100\pi = 314$ rad/sec

$V = V_m \sin(\omega t + 180^\circ)$

$V = 14.14 \sin(314t + 180^\circ)\ V.$

(ii) Wave with 50Hz freq, with V_m = 6units reaching its +ve max. at 10th ms.

$V_m = 6V$, $\omega = 100\pi = 314$ rad/sec.



$V = V_m \sin(\omega t - 90^\circ)$

$V = 6 \sin(314t - 90^\circ)$

(iii) Comment on the Phase relation of the above two waves.

→ second wave leads the first wave by an angle of 90°

cos

→ second wave leads first wave by a time duration of 5ms.

RL Series Circuit.

38. Find the instantaneous expression for the current when a voltage represented by $V = 283 \sin 100\pi t$ is applied to a coil having $R = 50\Omega$ & $L = 0.159H$.

→ $R = 50\Omega$, $X_L = \omega L = 100\pi \times 0.159 = 49.951\,\Omega$

→ $V_m = 283V$

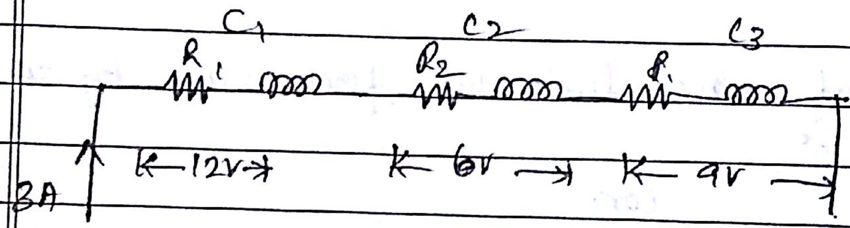
→ $i = I_m \sin(\omega t - \phi)$ for R-L

→ $Z = R + jX_L = 50 + j49.951 = 70.676 \angle 44.97^\circ$ ϕ

→ $I_m = \frac{V_m}{|Z|} = \frac{283}{70.676} = 4.004A$

$$\boxed{i = 4.004 \sin(100\pi t - 44.97^\circ)\ A}$$

(39.) 3 coils A, B & C are connected in series. When a current of 3A is passed thro' the circuit, the voltage drops are respectively 12V, 6V & 9V on direct current and 15V, 9V, 12V on a.c. Find for each of the coils, (i) Internal parameters (ii) Power dissipated when alternating current flows thro' the circuit. (iii) applied voltage across it. Draw the phasor diagram. Find the overall p-f of the circuit.



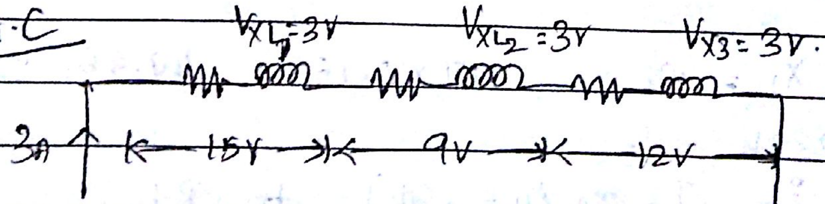
D.C

$\rightarrow V_1 = IR_1 \Rightarrow R_1 = 12/3 = 4\Omega$

$\rightarrow V_2 = IR_2 \Rightarrow R_2 = 6/3 = 2\Omega$

$\rightarrow V_3 = IR_3 \Rightarrow R_3 = 9/3 = 3\Omega$

A.C



$\rightarrow X_{L_1} = \frac{3}{3} = X_{L_2} = X_{L_3} = 1\Omega$

$\phi_1 = \tan^{-1}\left(\frac{X_{L1}}{R_1}\right) = \tan^{-1}\left(\frac{1}{4}\right) = 14.036^\circ$

$\phi_2 = \tan^{-1}\left(\frac{X_{L2}}{R_2}\right) = \tan^{-1}\left(\frac{1}{2}\right) = 26.565^\circ$

$\phi_3 = \tan^{-1}\left(\frac{X_{L3}}{R_3}\right) = \tan^{-1}\left(\frac{1}{3}\right) = 18.435^\circ$

$\rightarrow Z_1 = R_1 + jX_{L1} = (4 + j1)\,\Omega \qquad L_1 = 3.183\,mH$

$\rightarrow Z_2 = R_2 + jX_{L2} = (2 + j1)\,\Omega \qquad L_2 = 3.183\,mH$

$\rightarrow Z_3 = R_3 + jX_{L3} = (3 + j1)\,\Omega \qquad L_3 = 3.183\,mH.$

Power dissipated

$\rightarrow P_1 = I^2 R_1 = 3^2 \times 4 = 36\,W$

$P_2 = I^2 R_2 = 3^2 \times 2 = 18\,W$

$P_3 = I^2 R_3 = 3^2 \times 3 = 27\,W$

Applied voltage.

$\rightarrow Z_T = Z_1 + Z_2 + Z_3 = (9 + j3)\,\Omega = 9.487 \angle 18.44^\circ$

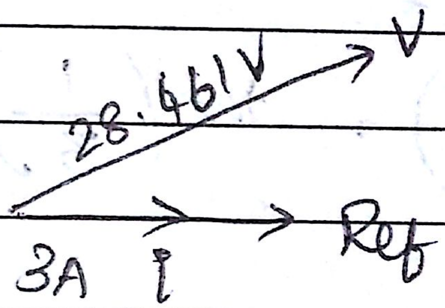
$\rightarrow i = 3A$

$\rightarrow v = iZ_T = 3 \times 9.487 \angle 18.44^\circ$

$= 28.461 \angle 18.44^\circ\,V$

→ Overall p.f = $\cos\phi$ = 0.9486 (lag)

→ Phasor diagram.



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