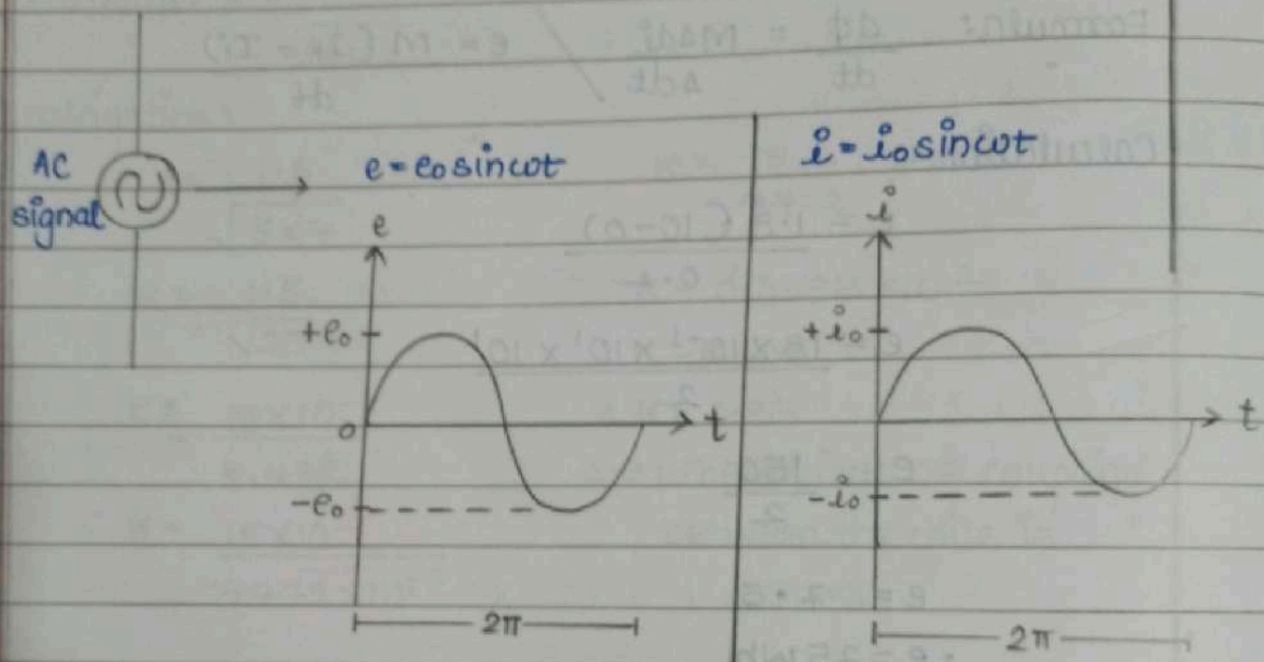
13. AC Circuit (Alternating Current)

30/07/23

★ What do you mean by peak value of alternating signal:-

→ It is the maximum value of signal i.e current or emf in either direction.



with phase difference α or ϕ
$e = (e_0 \sin\omega t \pm \alpha)$

with phase difference
$i = (i_0 \sin\omega t \pm \alpha)$

★ What is the average or mean value of AC? (1mks)

→ It is an average of all value of voltage or current over one half cycle.

★ Find the relation between average and peak value of alternating signal. (2mks)

→ (i) We know that, $e = e_0 \sin\omega t$ —(i)

30/7/23

(ii) Alternating current is given by $i = i_0 \sin\omega t$ --(ii)

(iii) Average value of current is given by -

$$I_{avg} = \frac{\int_0^{\pi} \sin\theta \, d\theta}{\int_0^{\pi} d\theta}$$

$$I_{avg} = \frac{[-\cos\theta]_0^{\pi}}{[\theta]_0^{\pi}}$$

$$= \frac{-\cos\pi - (-\cos 0)}{\pi - 0}$$

$$= \frac{-(-1) - (-1)}{\pi}$$

$$= \frac{1+1}{\pi}$$

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

$$= 0.637$$

$\therefore$ Average value is $0.637 \times i_0 = \frac{i_0}{\sqrt{2}}$

$\therefore$ e_{avg} is $0.637 \times e_0 = \frac{e_0}{\sqrt{2}}$

★ What do you mean RMS value (Root mean square)

→ It is defined as steady current which produces same amount of heat as produced by alternating current in same resistance (R) and same time (t).

30/7/23

★ Derive relation between RMS value and peak value. (2mks)

→ RMS value of current is, $i_{rms} = \sqrt{i^2_{rms}}$

$$i_{rms} = \sqrt{\frac{\int_0^{2\pi} i^2 d\theta}{2\pi}}$$ — (over half cycle)

But $i = i_0 \sin\omega t$

$$i_{rms} = \sqrt{\frac{\int_0^{2\pi} i_0^2 \sin^2\omega t \, d\theta}{2\pi}}$$

$$i_{rms} = \sqrt{\frac{i_0^2}{2\pi}\int_0^{2\pi}\left(\frac{1-\cos 2\theta}{2}\right) d\theta}$$ — $\cos 2\theta = \cancel{2\sin^2\theta + 1}$ $1 - 2\sin^2\theta$

$\sin^2\theta = \frac{\cos 2\theta - 1}{2}$

$$i_{rms} = \sqrt{\frac{i_0^2}{4\pi}\left[\theta - \frac{\sin 2\theta}{2}\right]_0^{2\pi}}$$

$$i_{rms} = \sqrt{\frac{i_0^2}{4\pi}\left[2\pi - \frac{\sin 2\times 2\pi}{2} - (0-0)\right]}$$

$$i_{rms} = \sqrt{\frac{i_0^2}{4\pi} \times 2\pi}$$

$$i_{rms} = \sqrt{\frac{i_0^2}{2}}$$

$$\boxed{i_{rms} = \frac{i_0}{\sqrt{2}}}$$

★ What is Phasor and Phasor diagram :-

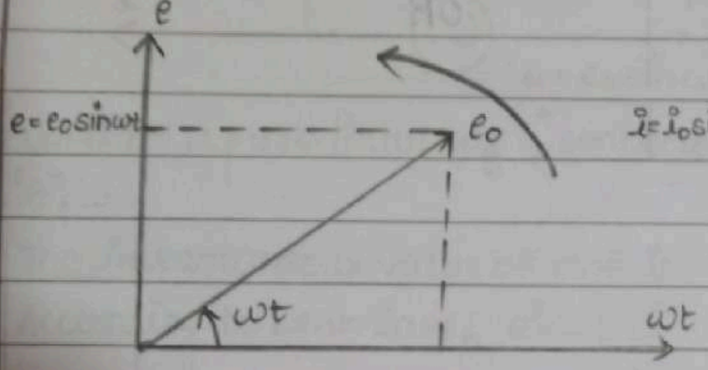
→ (i) It is a rotating vector that represents a quantity (emf or current) varying sinusoidally with time is called

(ii) Phasor and the diagram representing it is called Phasor diagram.

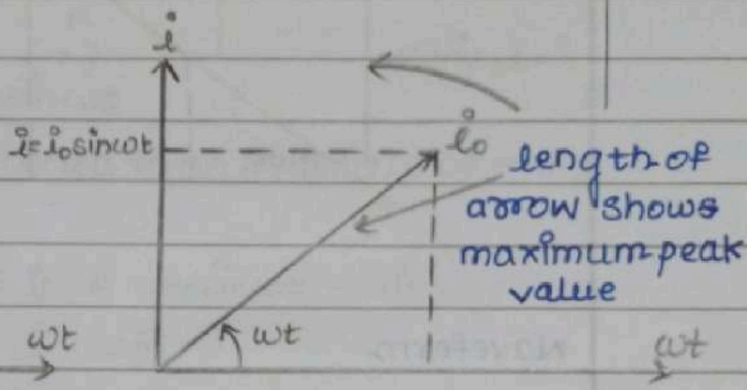
(iii) The phasor for alternating emf or current are inclined at an angle ωt or $\omega t+\alpha$.

(iv) The length of arrow represents maximum value of quantity i.e e_0 and i_0.

For emf

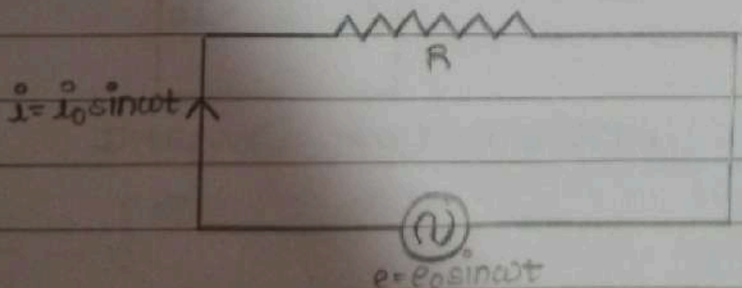


For current



★ <u>DERIVATION-I</u>

<u>Derive expression for AC circuit with resistor only. Draw phasor diagram of voltage or current, and also draw waveform.</u>



(i) consider a resistor R connected to AC source of emf 'e'.

(ii) The instantaneous value of emf is given by $e=e_0\sin\omega t$ — (i)

(iii) According to ohm's law, $i=\frac{e}{R}$

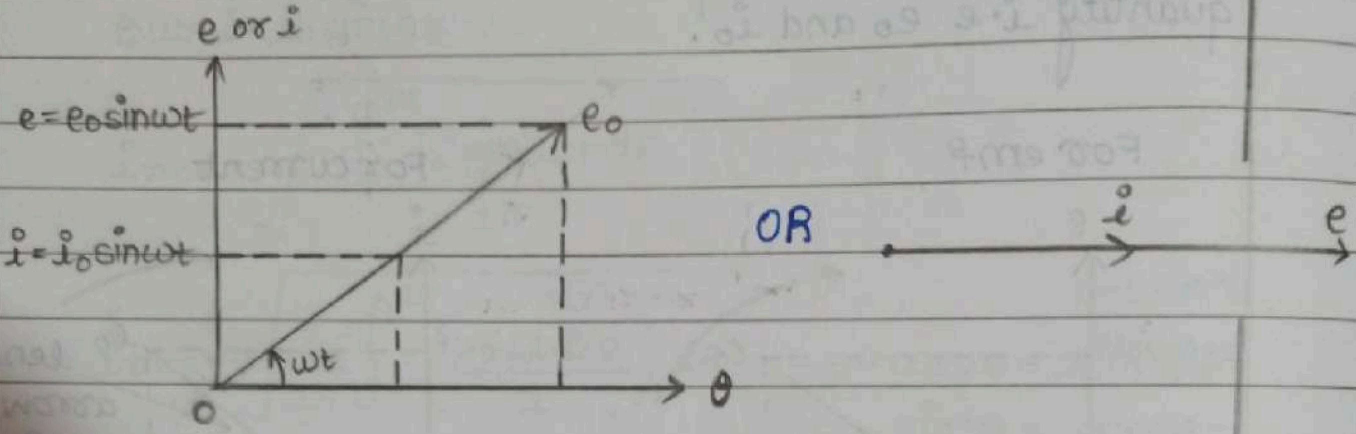
$$i=\frac{e_0\sin\omega t}{R}$$

30/7/23

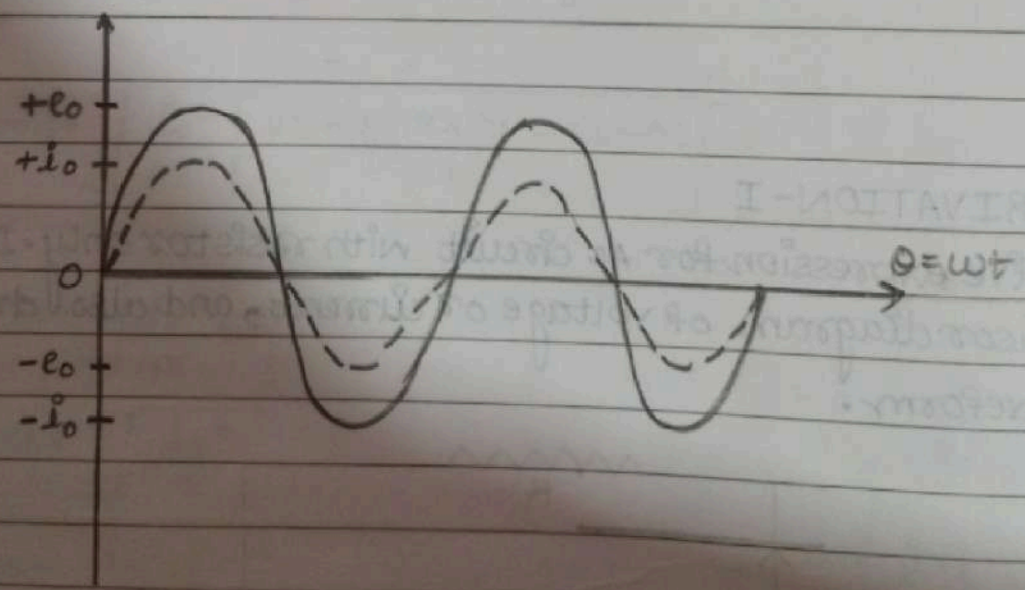
But $i_0 = \frac{e_0}{R}$

$\therefore\ i = i_0 \sin\omega t$ —(ii)

From eqn.(i) and (ii) there is zero phase difference between emf and current.

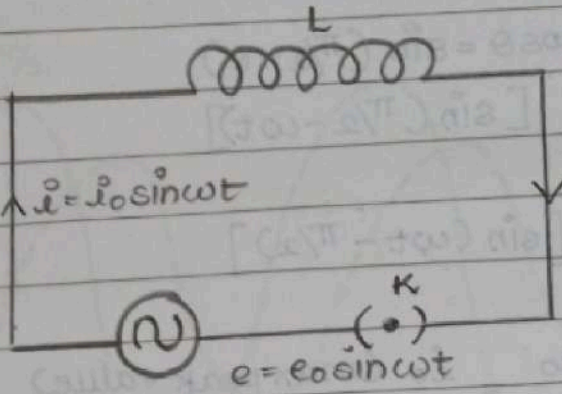


Waveform



★ DERIVATION-2

Derive expression for AC circuit with inductor. Draw its phasor diagram of emf or current and also draw waveform.



(i) Consider a pure inductor 'L' connected to an AC source of emf 'e'.

(ii) The instantaneous value of emf is $e = e_0 \sin\omega t$ — (i)

(iii) According to Lenz law, $e' = -L\frac{di}{dt}$ —(ii)

According to Kirchoff Voltage Law, $e + e' = 0$

$\therefore e = -e'$

$$e = -\left[-L\frac{di}{dt}\right]$$

$$e = L\frac{di}{dt}$$

$$\boxed{di = \frac{e}{L}\,dt}$$

Integrating on both sides,

$$\int di = \int \frac{e}{L}\,dt$$

$$\int di = \int \frac{e_0 \sin\omega t}{L}\,dt \quad \text{— from eqn. (i)}$$

$$\int di = \frac{e_0}{L}\int \sin\omega t\,dt$$

$$\int di = \frac{e_0}{L}\left(\frac{-\cos\omega t}{\omega}\right) + C$$

30/7/23

where c=0 (integration constant)

$$\int di = \frac{-e_0}{\omega L}[\cos \omega t]$$

Formula –

$$\cos\theta = \sin(\pi/2 - \theta)$$

$$i = \frac{-e_0}{\omega L}[\sin(\pi/2 - \omega t)]$$

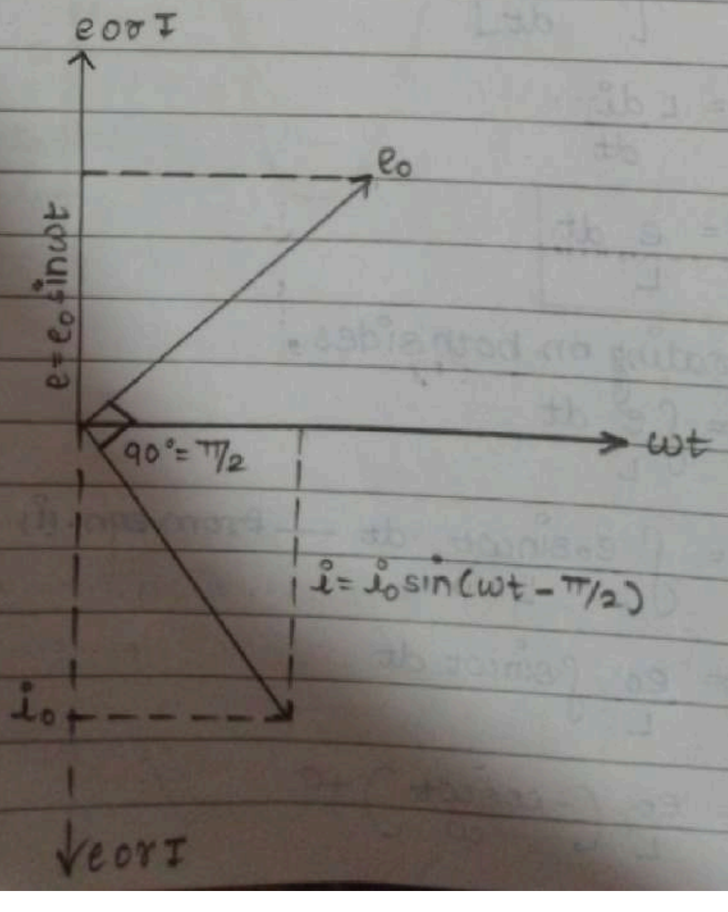
$$i = \frac{e_0}{\omega L}[\sin(\omega t - \pi/2)]$$

where, $\frac{e_0}{\omega L} = i_0$ (max peak value)

$$\boxed{i = i_0[\sin(\omega t - \pi/2)]}$$

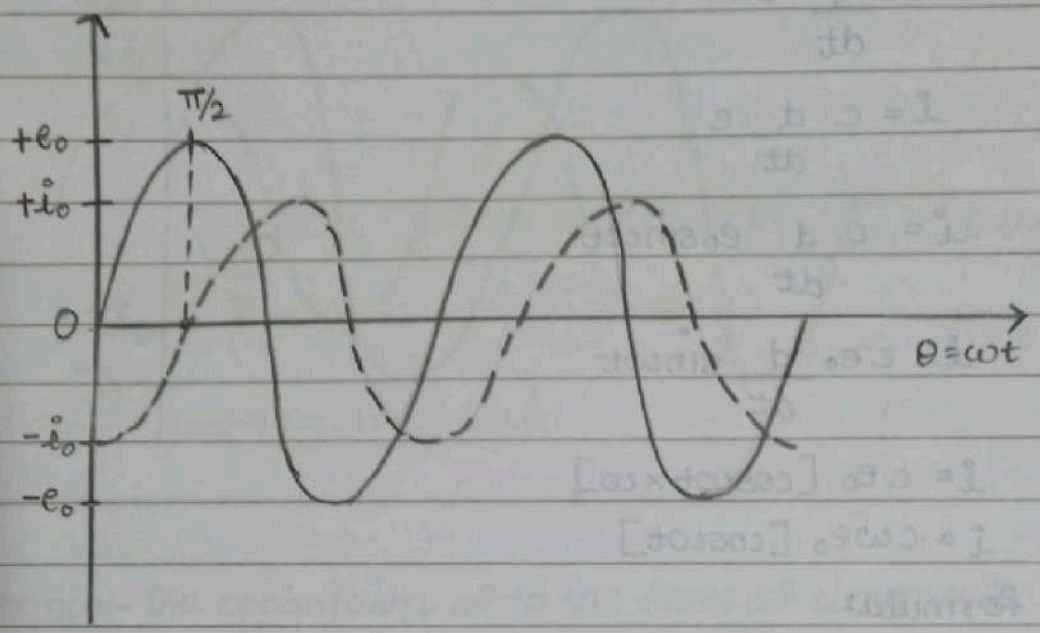
Hence, from above eqn. it is clear that current (i) lag (–) emf by 90° or $\pi/2$ OR it can be written as emf (e) lead (+) current by 90° or $\pi/2$.

Phasor diagram –



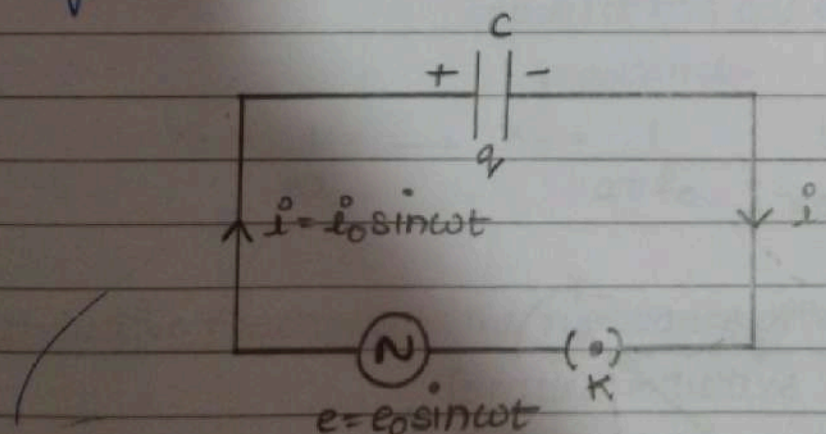
30/7/23

Waveform-



★ DERIVATION-3

Derive an expression for capacitor. Draw its phasor diagram of emf or current and also draw waveform.



(i) Consider a pure capacitor 'c' connected to an AC source of emf.

(ii) The instantaneous value of emf is $e = e_0 \sin\omega t$ —(i)

(iii) Let 'q' be the charge on the capacitor. We know that,

$$V = \frac{q}{c} \text{ —(ii)}$$

$$q = cV \rightarrow q = ce$$

30/7/23

(iv) We know that, $i = \frac{dq}{dt}$

$$i = \frac{d}{dt} ce$$

$$i = c\frac{d}{dt} e$$

$$i = c\frac{d}{dt} e_0 \sin\omega t$$

$$i = ce_0 \frac{d}{dt} \sin\omega t$$

$$i = ce_0 [\cos\omega t \times \omega]$$

$$i = c\omega e_0 [\cos\omega t]$$

formula:

$$\cos\theta = \sin(\pi/2 + \theta)$$

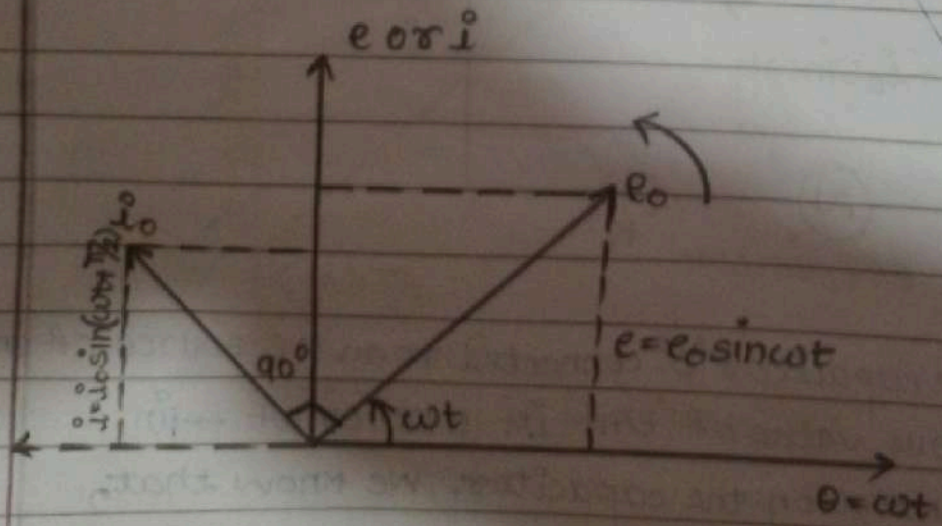
$$\cos\theta = \sin\theta (\theta + \pi/2)$$

$$i = \omega c e_0 \sin(\omega t + \pi/2)$$

where $\omega c e_0 = i_0$ (maximum peak value)

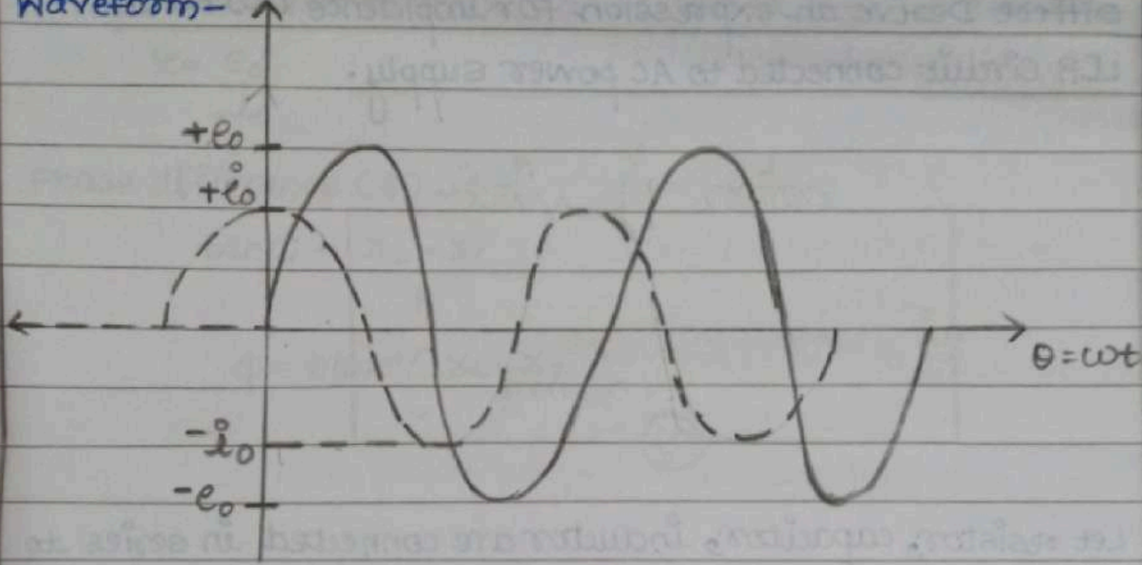
$$i = i_0 \sin(\omega t + \pi/2)$$

Phasor diagram



30/07/23

Waveform-



★ Resistance- The opposition ~~of~~ to the flow of current is called as resistance.

$$R = \frac{V}{I} \qquad \text{SI unit} = \text{Ohm}$$

★ Capacitive Reactance - The resistance offered by ~~resist~~ capacitor is called capacitive reactance.

$$X_C = \frac{1}{\omega_C} \longrightarrow X_C = \frac{1}{2\pi f_C} \qquad \text{SI unit} = \text{Ohm}$$

★ Inductive Reactance- The resistance offered by inductor is called inductive reactance.

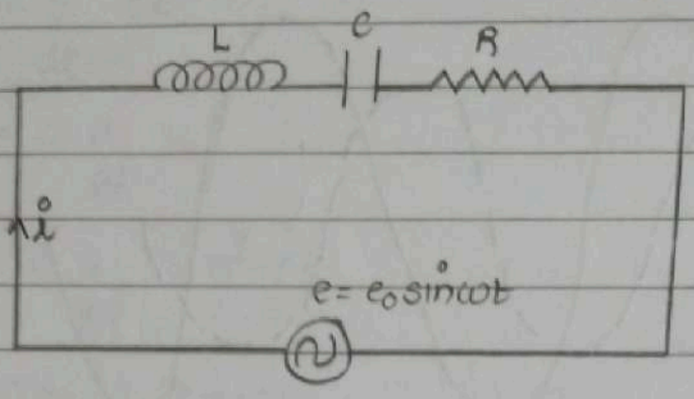
$$X_L = \omega L \longrightarrow X_L = 2\pi f_L \qquad \text{SI unit} = \text{Ohm}$$

02/08/23

★ Impedence - The resistance offered by all three resistor is called impedence.

02/08/23

* ~~Differe~~ Derive an expression for impidence (Z) of an LCR circuit connected to AC power supply.

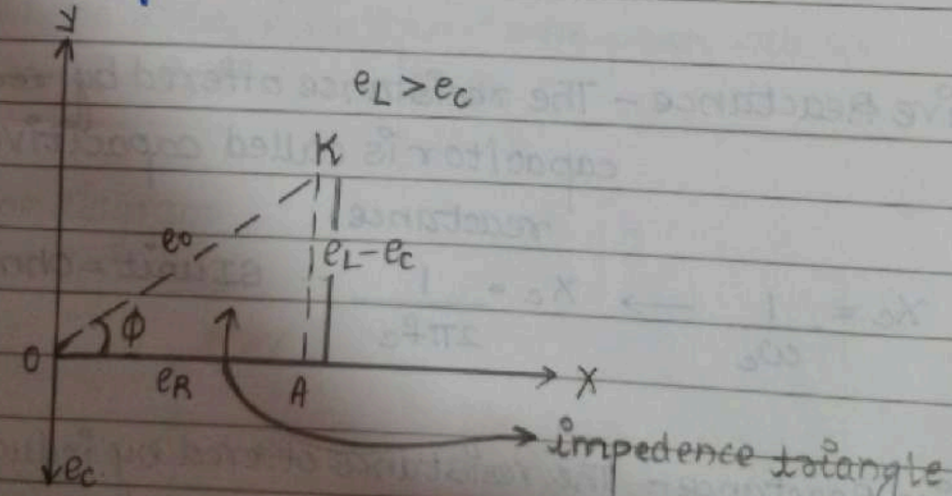


(i) Let resistor, capacitor, inductor are connected in series to which an emf is given/applied.

(ii) The voltage across inductor, capacitor, resistor is

$$e_L = i X_L$$
$$e_C = i X_C$$
$$e_r = i R$$

Phasor diagram



In ΔOAK,

$$e_0^2 = e_R^2 + (e_L - e_C)^2$$
$$e_0 = \sqrt{e_R^2 + (e_L - e_C)^2}$$
$$e_0 = \sqrt{i_0^2 R^2 + (i_0 X_L - i_0 X_C)^2}$$
$$e_0 = \sqrt{i_0^2 R^2 + i_0^2 (X_L - X_C)^2}$$
$$e_0 = i_0 \sqrt{R^2 + (X_L - X_C)^2}$$
$$\frac{e_0}{i_0} = \sqrt{R^2 + (X_L - X_C)^2}$$

02|08|23

where $z = \sqrt{R^2 + (X_L - X_C)^2}$ is called impedence

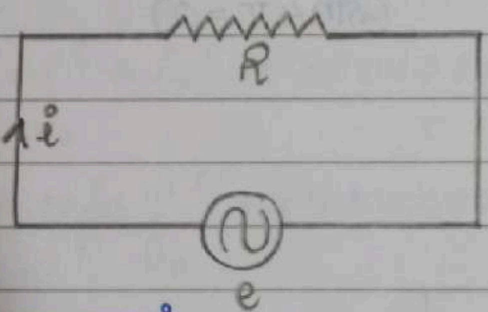
$$z = \frac{e_0}{i_0}$$

Phase difference (ϕ) is -

$$\tan\phi = \frac{X_L - X_C}{R}$$

$$\phi = \tan^{-1}\left(\frac{X_L - X_C}{R}\right)$$

★ Derive an expression for average power dissipated in in a pure resistive circuit.



Instantaneous power is

$$p = e \times i$$

$$p = e_0 \sin\omega t \times i_0 \sin\omega t$$

$$p = e_0 i_0 \sin^2\omega t$$

Average power is

$$P_{avg} = \frac{\text{work done in one cycle}}{\text{time for one cycle}}$$

$$P_{avg} = \frac{\int_0^T P\,dt}{T}$$

$$P_{avg} = \frac{\int_0^T e_0 i_0 \sin^2\omega t\,dt}{T}$$

$$P_{avg} = \frac{e_0 i_0}{T}\int_0^T \sin^2\omega t\,dt$$

02/08/23

Formula-

$$\sin^2\theta = 1-\cos^2\theta$$

$$P_{avg} = \frac{e_0 i_0}{T}\int_0^T \left(\frac{1-\cos 2\omega t}{2}\right) dt$$

$$P_{avg} = \frac{e_0 i_0}{2T}\int_0^T (1-\cos 2\omega t)\, dt$$

$$P_{avg} = \frac{e_0 i_0}{2T}\left[t - \frac{\sin 2\omega t}{2}\right]_0^T \quad \omega = \frac{2\pi}{T}$$

$$P_{avg} = \frac{e_0 i_0}{2T}\left[T - \frac{\sin 2\times 2\pi/T\times T}{2}\right]$$

$$P_{avg} = \frac{e_0 i_0}{2T}\left[T - \frac{\sin 4\pi}{2} - 0+0\right]$$

$$P_{avg} = \frac{e_0 i_0}{2T}\times T \qquad (\sin 4\pi = 0)$$

$$P_{avg} = e_0 i_0/2$$

$$P_{avg} = \frac{e_0}{\sqrt{2}}\times\frac{i_0}{\sqrt{2}}$$

$$\boxed{P_{avg} = e_{rms}\times i_{rms}}$$

Similarly average power of an inductor is zero.
Similarly average power of a capacitor is zero.

★ What is Wattless current?

Current through pure inductor or capacitor which consume no power for maintenance in the circuit is called Wattless or Ideal current.

22/08/23

★ Desire an expression for average power dissipated in LCR circuit.

(i) In LCR circuit, the current is given by -

$$i = i_0 \sin(\omega t \pm \phi)$$

(ii) Instantaneous power is given by -

$$P = e \times i$$

$$P = e_0 \sin\omega t \times i_0 \sin(\omega t \pm \phi)$$

$$P = e_0 \sin\omega t \cdot i_0 [\sin\omega t \cos\phi \pm \cos\omega t \sin\phi]$$

$$P = e_0 i_0 [\sin^2\omega t \cos\phi \pm \sin\omega t \cos\omega t \sin\phi]$$

we know that,

$$P_{avg} = \int_0^T \frac{P\,dt}{T}$$

$$P_{avg} = \int_0^T \frac{e_0 i_0 [\sin^2\omega t \cos\phi \pm \sin\omega t \cos\omega t \sin\phi]\,dt}{T}$$

$$P_{avg} = \frac{e_0 i_0}{T} \int_0^T \sin^2\omega t \cos\phi \pm \sin\omega t \cos\omega t \sin\phi \; dt \quad \text{—(i)}$$

Let $\int_0^T \sin^2\omega t = \frac{T}{2}$

Let $\int_0^T \sin\omega t \cos\omega t \; dt = 0$

Put in eqn. (i)

$$P_{avg} = \frac{e_0 i_0}{T} (\cos\phi \times T/2 \pm 0 \times \sin\phi)$$

$$P_{avg} = \frac{e_0 i_0}{T} \times \cos\phi \times \frac{T}{2}$$

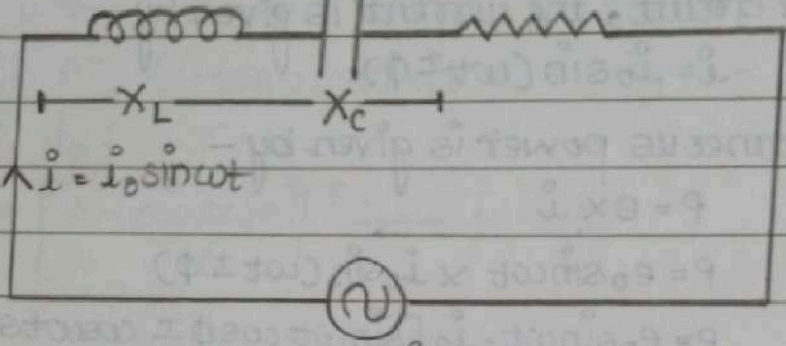
$$P_{avg} = \frac{e_0 i_0 \times \cos\phi}{2}$$

$$\boxed{P_{avg} = \frac{e_0}{\sqrt{2}} \times \frac{i_0}{\sqrt{2}} \times \cos\phi}$$

$$\boxed{P_{avg} = e_{rms} \cdot i_{rms} \cdot \cos\phi}$$

02|08|23

★ What is series resonant circuit and derive expression for resonant frequency.



(i) A circuit in which inductor 'L', capacitor 'C' and resistor 'R' connected in series.

(ii) This circuit admit maximum current at particular frequency is called series resonance circuit.

(iii) At resonance condition,

$$X_L = X_C$$

$$\omega L = \frac{1}{\omega C}$$

$$\omega^2 = \frac{1}{LC}$$

$$\omega = \sqrt{\frac{1}{LC}}$$

$$2\pi f_r = \sqrt{\frac{1}{LC}}$$

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

(iv) This is called resonant frequency and the circuit is also called as acceptor circuit because the current is maximum at the frequency.

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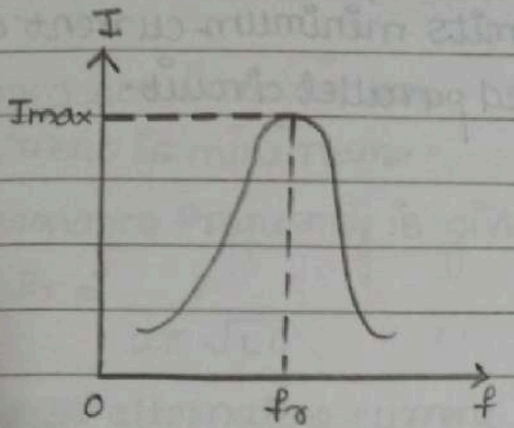
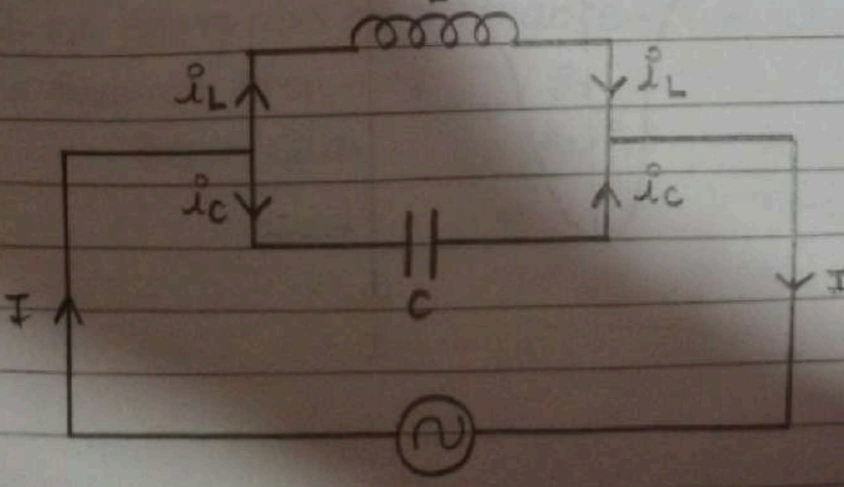
★ Series Resonance Curve :-



★ Characteristics of Series Resonance :-

(i) Impedence is minimum.
(ii) current is maximum.
(iii) When number of frequency is given to the circuit, it accepts only one frequency and rejects other frequency and the cirrent is maximum for its this frequency. Hence it is called acceptor circuit.

★ What is parallel resonant circuit and obtain an expression for resonant frequency.



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(i) A circuit in which inductor 'L' and capacitor 'C' are connected in parallel and the circuit admits minimum current at particular frequency is called parallel circuit.

(ii) At resonance condition,

$$X_L = X_C$$

$$\omega L = \frac{1}{\omega C}$$

$$\omega^2 = \frac{1}{LC}$$

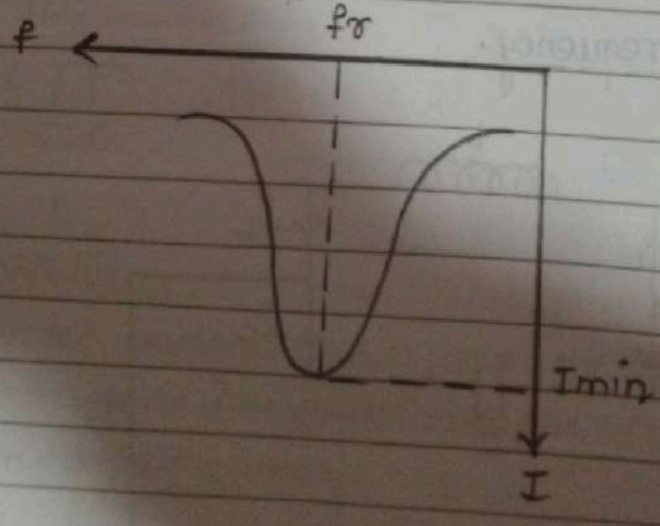
$$\omega = \sqrt{\frac{1}{LC}}$$

$$2\pi f_r = \sqrt{\frac{1}{LC}}$$

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

(iii) This is called resonant frequency and the circuit is also called rejector circuit because the current is minimum at the frequency.

★ Parallel Resonance Curve:-



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★ Characteristics of Parallel resonance :-

(i) Impedence is maximum.
(ii) Current is minimum.
(iii) Resonance frequency is given by -

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

(iii) When alternating current of different frequency is given to parallel resonance circuit. It offers high impedence ~~and~~ to the current and reject it. Hence it is called rejector circuit.

★ What is choke coil :-

(i) A choke coil is an inductor used to reduce AC current passing through a circuit without loss of energy.
(ii) The avg. power in choke coil is -

$$P_{avg} = e_{rms} \cdot i_{rms} \cdot \cos\phi$$

★ What is Quality factor?

It is the sharpness of resonance.

$$Q = \frac{\text{Resonant frequency}}{\text{Bandwidth}} = \frac{f_r}{(f_2 - f_1)}$$

02/08/23

★ Type 1

PBO on pure circuit and finding frequency and RMS current.

$$\omega = 2\pi f_r$$

$$f_r = \frac{\omega}{2\pi}$$

$$i_{rms} = \frac{e_{rms}}{R}$$

$$\text{But, } e_{rms} = \frac{e_0}{\sqrt{2}}$$

1) An alternating voltage is given by $e = 40 \sin 314T$ is connected to pure resistor of $50\,\Omega$. Find frequency of the source, the RMS current through resistor.

Data - $e = 140 \sin 314T$

$R = 50\,\Omega$

To find - f, i_{rms}

Formula - (i) $\omega = 2\pi f \longrightarrow f = \frac{\omega}{2\pi}$

(ii) $i_{rms} = \frac{e_{rms}}{\cancel{\sqrt{2}}\, R}$

Calculation - (i) finding frequency

$$e = 140 \sin 314t$$

$$e = e_0 \sin \omega t$$

$$f_r = \frac{\omega}{2\pi} = \frac{314}{2 \times 3.14} = \frac{314}{2 \times 314 \times 10^{-2}}$$

$$f_r = \frac{10^2}{2} = 50\text{ Hz}$$

(ii) finding i_{rms}

$e = 140 \sin 314t$

$e = e_0 \sin \omega t$

$e_0 = 140$

$e_{rms} = \frac{e_0}{\sqrt{2}} = \frac{140}{1.41} = \frac{14 \times 10^1}{14.1 \times 10^{-1}} = 100$

$e_{rms} = 100$

$i_{rms} = \frac{e_{rms}}{R} = \frac{100}{50} = 2A$

Ans: Frequency of source is 50Hz and RMS current is 2A.

2) $100\,\Omega$ resistor connected to 220V. 50Hz frequency. Find RMS value of current and net power consumed in one cycle.

Data - $R = 100\,\Omega$

$e_{rms} = 220$

$f = 50Hz$

To find - i_{rms}, P_{avg}

Formula - (i) $i_{rms} = \frac{e_{rms}}{R}$

(ii) $P_{avg} = e_{rms} \cdot i_{rms}$

Calculation - (i) $i_{rms} = \frac{220}{100} = 2.2A$

(ii) $P_{avg} = 220 \times 2.2 = 22 \times 10^1 \times 22 \times 10^{-1} = 484$ watt.

Ans - RMS value of current is 2.2A and net power consumed is 484 watt.

09/08/23

★ Type 2

PBO alternating voltage by equation method $e = e_0 \sin \omega t$

1) peak value = e_0

2) $\omega = 2\pi f$

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

3) $T = 1/f$

4) Instantaneous value.
(Put value of 't' in eqn)

1) An alternating voltage is given by $e = 6\sin 314t$. Find (i) the peak value (ii) frequency (iii) time period and (iv) instantaneous value at time (t) = 2 sec milli.

Data:

$e = 6\sin 314$

$t = 2ms$

To find: e_0, T, f, $e/_T = 2ms$

Soln:

1) Comparing with eqn. $e = 6\sin 314t$ with $e = e_0 \sin \omega t$

$\therefore e_0 = 6$

2) finding 'f'

$\omega = 2\pi f$

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

We know that

$e = 6\sin 314t$

$\therefore \omega = 314$

$f = \frac{314}{2 \times 3.14}$

$f = \frac{314 \times 100}{2 \times 314}$

$f = 50Hz$

3) finding 'T'

$T = 1/f$

$T = \frac{1}{50}$

$T = 0.02 sec$

4) finding 'e'

$e = e_0 \sin \omega t$

$e = 6\sin 314 \times 2 \times 10^{-3}$

$e = 12 \times 10^{-3} \sin 314$

$e = 0.012 \sin 314$

09/03/23

★ Type 3

PBO finding time period of RMS value.

1) Imp. Find the time required for a 50Hz alternating current to change its value from zero to rms value.

Data:

$f = 50Hz$

$i_{rms} = \frac{i_0}{\sqrt{2}}$

To find: t

Formula:

$i = i_0 \sin\omega t$

$\frac{i_0}{\sqrt{2}} = i_0 \sin\omega t$

Calculation:

$\frac{1}{\sqrt{2}} = \sin\omega t$

$\frac{1}{\sqrt{2}} = \sin 2\pi f t$ —($\omega = 2\pi f$)

$\frac{1}{\sqrt{2}} = \sin(2\pi \times 50)t$

$\frac{1}{\sqrt{2}} = \sin 100\pi t$

$\because \sin 45° = 1/\sqrt{2}$

$\therefore \sin 45° = \sin 100\pi t$

$\therefore \sin\frac{\pi}{4} = 100\pi \sin t$

$\therefore \cancel{\sin}\ \frac{1}{4} = 100t$

$\therefore t = 1/400 = 1/4\times10^2 = 0.25\times10^{-2}$ sec

Data:

$f = 60Hz$

$i_{rms} = \frac{i_0}{\sqrt{2}}$

To find: t

Formula:

$i = i_0 \sin\omega t$

$\frac{i_0}{\sqrt{2}} = i_0 \sin\omega t$

Calculation:

$\frac{1}{\sqrt{2}} = \sin\omega t$

$1/\sqrt{2} = \sin 2\pi f t$

$1/\sqrt{2} = \sin(2\pi \times 60)t$

$1/\sqrt{2} = \sin 120\pi t$

$\because \sin 45 = 1/\sqrt{2}$

$\sin \pi/4 = \sin 120\pi t$

$1/4 = 120t$

$1/480 = t$

$t = 0.002$ sec $= 2$ms

Ans: Time required for 50Hz is 0.25×10^{-2} sec i.e 2.5msec.

$\sqrt{2} = 1.414 = 0.707$

09/08/23 current (i) = i_{rms} — eqn: $i_0 \sin\omega t$

★ ~~Type 4~~

2) If the effective current in a 50 cycle AC circuit is 5A, what is the peak value of current? What is the current in 1/600 sec after it was zero.

Data:

$f = 50Hz$

$i_{rms} = 5A$

$t = 1/600$ sec

To find:

i_0, i

Formula:

1) $\because i_{rms} = \frac{i_0}{\sqrt{2}}$

$\therefore i_0 = i_{rms} \times \sqrt{2}$

2) $i = i_0 \sin\omega t$

calculation:

1) $i_0 = 5 \times \sqrt{2}$

$i_0 = 5 \times 1.41$

$\therefore i_0 = 7.05A$

2) ~~$i = 7.05 \sin 314 \times 1/600$~~

$i = 7.05 \sin 100\pi \times 1/600$

$i = 7.05 \sin(\pi/6)$

$i = 7.05 \times 1/2$

$i = \frac{705 \times 10-2}{2}$

$\therefore i = 352.5 \times 10-2$

$\therefore i = 3.525A$

Ans: Peak value of current is 7.05A

The current after it was zero is 3.525A.

Data:

$f = 50Hz$

$i_{rms} = 5A$

$t = 1/200 Hz$

$i_0 = 5 \times \sqrt{2}$

$i_0 = 5 \times 1.414$

$\therefore i_0 = 7.07A$

$i = 7.07 \sin 100\pi \times 1/200$

$i = 7.07 \sin(\pi/2)$

$i = 7.07 \times 1$

$\therefore i = 7.07A$

PAGE NO.:

08/23

★ Type 4

PBO RLC circuit

1) A 25 μF capacitor, a 0.10 H inductor and a 250 Ω resistor are connected in series with an AC source whose emf is given by $e = 310\sin 314t$. What is the reactance, ~~inductance~~, impedence, frequency, current and phase angle of the circuit?

Data:

$C = 25\,\mu f$

$C = 25 \times 10^{-6}\, f$

$L = 0.10\, H$

$L = 1 \times 10^{-1}\, H$

$R = 25\,\Omega$

$e = 310\sin 314t$

To find:

$f, X, Z, i, \tan\phi$

calculation -

1) finding f -

$e = 310\sin 314t$

$e = e_0 \sin\omega t$

$\therefore \omega = 314$

$\because \omega = 2\pi f$

$f = \frac{\omega}{2\pi} = \frac{314}{2 \times 3.14} = \frac{314 \times 100}{2 \times 314}$

$f = 50\,Hz$

2) finding X_L

$X_L = \omega L$

$X_L = 314 \times 10^{-1}$

$\therefore X_L = 31.4$

~~6) $i_{rms} = e_{rms}/\sqrt{2}$~~

~~$e_{rms} = e_0/\sqrt{2}$~~

~~$i_{rms} = e_0/2$~~

~~$i_{rms} = 310/2$~~

~~$\therefore i_{rms} = 155$~~

3) finding X_C

$X_C = \frac{1}{\omega C}$

$X_C = \frac{1}{314 \times 25 \times 10^{-6}}$

$X_C = \frac{1}{7850 \times 10^{-6}}$

$X_C = 127.3$

4) finding X -

$X = |X_L - X_C|$

~~$X = |31.4 - 127.3|$~~

$X = |127.3 - 31.4|$

$\therefore X = 95.9 = 96\,\Omega$

5) $Z = \sqrt{(R)^2 + (X_L - X_C)^2}$

$Z = \sqrt{(25)^2 + (95.9)^2}$

$Z = \sqrt{625 + 9216}$

$Z = \sqrt{9841}$

$Z = \sqrt{9.841 \times 10^{2}}$

$Z = 9.920 \times 10^{1}$

$Z = 99.2$

$Z \cong 99\,\Omega$

09/08/23

6) $i_{rms} = \frac{e_{rms}}{}$

$e_{rms} = e_0/\sqrt{2}$

$e_{rms} = 0.707 \times e_0$

$e_{rms} = 0.707 \times 310$

$e_{rms} = 219$

Now, $i_{rms} = \cancel{0.707 \times} 219/99$

$\therefore i_{rms} = 2.21A$

7) Phase difference –

$$\tan\phi = \frac{X_L - X_C}{R} = \frac{96}{25} = 3.84$$