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Basic Electrical Engineering

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Section:- A

1. Explain Form Factor And peak Factor

(a) Form Factor:-

The ratio of RMS value to the average value of an alternating quantity is known as Form Factor.

$$\text{Form Factor} = \frac{\text{R.M.S Value}}{\text{Average value}}$$

(b) Peak Factor:-

The ratio of Maximum value to RMS value of an alternating quantity is known as peak Factor.

$$\text{peak Factor} = \frac{\text{Maximum Value}}{\text{RMS Value}}$$

2. Explain the term Q-Factor and power Factor

power Factor:-

(1) The angle of cosine between resultant voltage and resultant current.

$$P.F = \cos \phi \quad \{ 0 \leq P.F \leq 1 \}$$

(2) P.F = True power

Apparent power

$$(3) P.F = \cos \phi = \frac{R}{Z}$$

Quality Factor:- $Q = 2\pi \times \frac{\text{Maximum energy stored}}{\text{Energy dissipated per cycle}}$

$$Q = \frac{\omega L}{R} = \frac{1}{\omega RC}$$

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3. Explain Active, Reactive and Apparent power.

- 1:- Apparent power - the total power that appear to be transfer between the source and load is called Apparent power.
- 2:- True power - the power which is actually consumed in the circuit is called true power.
- 3:- Reactive power - the component of apparent power which is neither consume nor any useful work in the circuit is called Reactive power.

4. List the various effect of series Resonance

1. $V_L = V_C$

$I X_L = I X_C$

2. $X_L = X_C$

$\omega L = 1$

ωC

$\omega^2 = 1$

$L C$

$\omega = 1 \sqrt{LC}$

$\omega = 1 \sqrt{LC}$ (angular resonant frequency)

3. $f = 1 \sqrt{LC}$ (Resonant frequency)

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

4. $V = V_R$ (pure resistive in nature)

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

$Z_{\text{min}} = R$

6. $I = \frac{V}{Z}$

$I_{\text{max}} = \frac{V}{R}$

7. power Factor = 1

8. phase angle $0^\circ = \phi$

5. prove that in a purely inductive circuit current lags the voltage by 90° .

Ans:-

$\leftarrow L \rightarrow$

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

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

$di = \frac{V_{\text{max}} \sin \omega t dt}{L}$

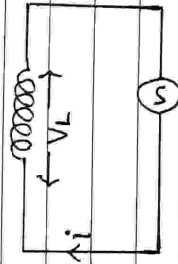
Integrating, $\int di = \int \frac{V_{\text{max}} \sin \omega t dt}{L}$

$i = \frac{V_{\text{max}}}{L} \int \sin \omega t dt$

$i = -\frac{V_{\text{max}}}{L} \cos \omega t$

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

phasor diagram:-

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

$$i = I_m \sin(\omega t - \pi/2)$$

$$\text{where } I_m = \frac{V_m}{L\omega}$$

$$X_L = \omega L$$

$$X_L = 2\pi fL \quad X_L \propto f$$

In a pure capacitive circuit current leads the voltage by 90° ?

$$Q = CV$$

$$i = \frac{dQ}{dt}$$

$$i = \frac{d(CV_m \sin \omega t)}{dt}$$

$$i = CV_m \omega \cos \omega t$$

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

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

$$\text{where } I_m = \omega C V_m$$

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

$$X_C = \frac{1}{2\pi fC}$$

6.

Explain and derive (RMS) value or Average value for a sine wave for complete cycle. Average value is 0.
 Sinusoidal current is given by

$$i = I_m \sin \theta$$

Average value,

$$i_{avg} = \int_0^\pi i \, d\theta$$

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

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

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

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

$$= -\frac{I_m}{\pi} [-1 - 1] \Rightarrow \frac{2I_m}{\pi} = 0.707 I_m \quad 0.637 I_m$$

RMS value :-

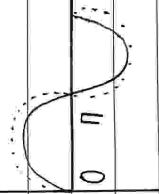
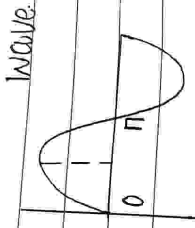
$$i^2 = I_m^2 \sin^2 \theta$$

$$I_{rms} = \sqrt{\int_0^\pi i^2 \, d\theta}$$

$$= \frac{I_m}{\sqrt{\pi}} \int_0^\pi \sin^2 \theta \, d\theta$$

$$= \frac{I_m^2}{\sqrt{\pi}} \int_0^\pi \sin^2 \theta \, d\theta$$

$$= \frac{I_m^2}{\sqrt{\pi}} \int_0^\pi \sin^2 \theta \, d\theta$$



$$\begin{aligned} & \int_0^\pi \sin^2 \theta \, d\theta \\ &= \int_0^\pi \frac{1 - \cos 2\theta}{2} \, d\theta \\ &= \int_0^\pi \frac{d\theta}{2} - \int_0^\pi \frac{\cos 2\theta}{2} \, d\theta \\ &= \frac{\pi}{2} - \frac{1}{4} [\sin 2\theta]_0^\pi \\ &= \frac{\pi}{2} - 0 \\ I_{rms} &= \sqrt{\frac{1}{\pi} \times \frac{\pi}{2}} \\ &= \frac{1}{\sqrt{2}} = 0.707 I_m \end{aligned}$$

7. Find the average value of $\sin^2 \theta$ for a half cycle.

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7. Find the average value, RMS value, form factor & peak factor for a half wave and full wave rectified current.

For half wave Rectified Current.

$$i = I_m \sin \theta$$

$$I_{avg} = \frac{1}{\pi} \int_0^{\pi} i d\theta$$

$$= \frac{1}{\pi} \int_0^{\pi} I_m \sin \theta d\theta$$

$$= \frac{I_m}{\pi} \int_0^{\pi} \sin \theta d\theta$$

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

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

$$= -\frac{I_m}{\pi} (-2)$$

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

$$\text{form factor} = 1.1$$

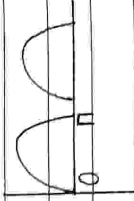
$$\text{peak factor} = 1.414$$

RMS value:-

$$i^2 = I_m^2 \sin^2 \theta$$

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

$$= \sqrt{\frac{I_m^2}{\pi} \int_0^{\pi} \sin^2 \theta d\theta}$$



$$\int_0^\pi \sin^2 \theta \, d\theta$$

$$\int_0^\pi \frac{1 - \cos 2\theta}{2} \, d\theta$$

$$= \frac{\pi}{2} - 0$$

$$I_{\text{RMS}} = \sqrt{\frac{I_m^2 \times \frac{\pi}{2}}{\pi}}$$

$$I_{\text{RMS}} = \frac{I_m}{\sqrt{2}}$$

For Full wave Rectified current

$$i = I_m \sin \theta$$

$$I_{\text{avg}} = \frac{\int_0^\pi i \, d\theta + \int_\pi^{2\pi} i \, d\theta}{\pi}$$

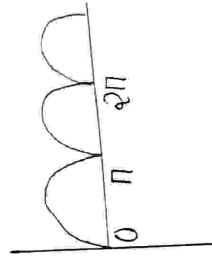
$$= \frac{\int_0^\pi i \, d\theta}{\pi}$$

$$= \frac{1}{\pi} \int_0^\pi I_m \sin \theta \, d\theta$$

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

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

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



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$$i^2 = 100 \sin^2 \theta$$

$$\text{RMS :- } I_{\text{RMS}} = \sqrt{\frac{\int_0^\pi i^2 d\theta + \int_\pi^{2\pi} i^2 d\theta}{2\pi}}$$

$$= \sqrt{\frac{100^2 \int_0^\pi \sin^2 \theta d\theta + 0}{2\pi}}$$

$$= \text{Now, } \int_0^\pi \sin^2 \theta d\theta = \pi$$

$$\sqrt{\frac{100^2 \times \pi}{2\pi}} = 100 \quad \text{peak factor} = \sqrt{2}$$

$$\text{form factor} = 1.57$$

power

8. The equation of an alternating current is $i = 143.43 \sin 628t$ determine

- (1) maximum value (2) Frequency (3) Time period
(4) instantaneous value at $t = 3 \text{ ms}$.

$$i = 100 \sin \omega t$$

$$i = 143.43 \sin 628t$$

- (1) maximum value of current = 143.43 Amp .

$$\omega = 2\pi f$$

$$628 = 2\pi f$$

(2) $f = 628 = 100 \text{ Hz}$

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

(3) $T = 1/f = 1 = 0.01 \text{ sec}$

$$\begin{aligned}(4):- \quad i &= 142.42 \sin 628t \\ i &= 142.42 \sin 628 \times 0.003 \\ &= 142.42 \sin 1.884 \\ &= 142.42 \times 0.032 \\ &= 0.42726 \text{ Amp.}\end{aligned}$$

9. What do you mean by Series Resonance?

Series Resonance

A series RLC AC circuit is said to be in resonance when Circuit power factor is unity.

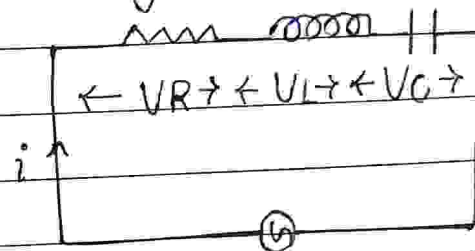
Consider a Series RLC circuit as shown in Fig.

The circuit impedance is given by

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

$$I = \frac{V}{Z}$$

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



Resonance will occur in this circuit when circuit power factor is unity and this will happen when $X_L = X_C$. Regardless of the value of inductance L and capacitance C there is one frequency at which $X_L = X_C$ and is called resonant frequency and given by f_r at series resonance.

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

10. Explain RL circuit.

RL series AC circuit

Let V = RMS value of applied voltage

I = RMS value of circuit current

$$V_R = IR$$

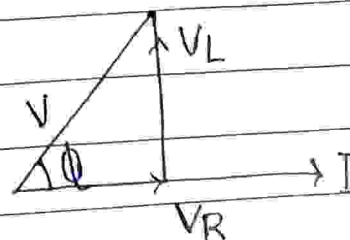
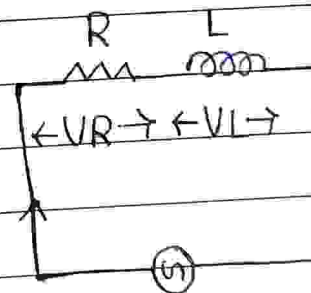
$$V_L = IX_L$$

phasor diagram

$$V^2 = V_R^2 + V_L^2$$

$$V^2 = (IR)^2 + (IX_L)^2$$

$$V^2 = I^2 (R^2 + X_L^2)$$



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$$\frac{V^2}{I^2} = (R^2 + X_L^2)$$

$$\frac{V}{I} = \sqrt{R^2 + X_L^2}$$

the quantity $\sqrt{R^2 + X_L^2}$ offers opposition to current flow and called impedance of a circuit.

Represent by Z and measured in Ω therefore $I = V/Z$

$$V = IZ$$

\Rightarrow