2024 – 25

Alternating Current

Recall what did you study in previous class

Alternating Current

- The constant value of dc which produces same heat through a resistive element, as due to the alternating current, is known as root mean square value of ac.
- 240 V ac is the rms value of ac voltage. The amplitude of this voltage is $V_M = 240 \times \sqrt{2} \approx 340$ volt
- The power rating in ac circuit is the average power rating.
- Power consumed in a circuit is non negative.
- Phase relationships in a.c. circuits is best represented by phasor diagram. A phasor is a vector which rotates with the angular velocity ω. The magnitude of phasor is the peak value of voltage or current (V_o or I_o)
- In purely resistive AC circuit, voltage and current are in the same phase $V = V_o \sin\omega t$ and $I = I_o \sin\omega t$, where $I_o = \frac{V_o}{R}$.
- In purely resistive circuit, average power loss = $I_{rms}^2 \times R$, $= \frac{I_o}{\sqrt{2}}$, similarly $V_{rms} = \frac{V_o}{\sqrt{2}}$
- The only element which dissipates energy in ac circuit is resistor (R).
- In purely inductive circuit, inductive reactance X_L = 2pfL = ωL. Voltage is ahead of current by $\frac{\pi}{2}$, $V = V_o \sin\omega t$, $I = I_o \sin\left(\omega t - \frac{\pi}{2}\right), I_o = \frac{V_o}{X_L}$. In this circuit, average power loss = 0.
- In purely inductive or capacitive circuit, $\cos\phi = 0 \Rightarrow \phi = \frac{\pi}{2}$. Average power loss is zero. Although current is flowing in the circuit. Such a current is known as wattless current.
- In AC L-R circuit, total voltage $\sqrt{V_R^2 + V_L^2}$
- n purely capacitive AC circuit, capacitive reactance $X_C = \frac{1}{2\pi fC} = \frac{1}{C}$. The current leads the applied voltage by $\frac{\pi}{2}$ or 90º $V = V_0 \sin\omega$, $I = I_0 \sin\left(\omega t + \frac{\pi}{2}\right), I_o = \frac{V_o}{X_c} = 2\pi fCV_0$. The average power loss per cycle is zero.
- n AC C-R circuit, total voltage $V = \sqrt{V_R^2 + V_C^2}$
- A circuit containing an inductor L and a capacitor C (initially charged) with no ac source and no resistors, exhibits free oscillations. The charge of the capacitor is given by the
- When the magnetic needle oscillates in the vertical east-west plane, at right angles to magnetic meridian, then only B_V acts on it. differential equation $\frac{d^2q}{dt^2} + \frac{1}{LC}q = 0$. The sum of energy of capacitor and inductor is constant.

- For a given RLC circuit driven by voltage $V = V_o \sin\omega t$, the current is given by, $I = I_o \sin(\omega t + \phi)$ where $I_o = \dfrac{V_m}{\sqrt{R^2 + (X_C - X_L)^2}}$ and $\phi = \tan^{-1}\dfrac{X_C - X_L}{R}$, impedance $z = \sqrt{R^2 + (X_C - X_L)^2}$
- The phase difference between voltage across L and voltage across capacitor C, is 180º. Thus $V_{LC} = V_L - V_C$.
- The voltage in series LCR AC circuit is given by $V = \sqrt{V_R^2 + (V_L - V_C)^2}$
- The average power consumed = $V_{rms} \times I_{rms} \times \cos\phi$, where $\cos\phi$, is the power factor.
- In series LCR circuit, at resonance, $X_L = X_C$, the impedance Z is minimum and equal to R. In this case, the source frequency $\omega = \dfrac{1}{\sqrt{LC}}$ which equals resonant frequency.
- The quality factor $Q = w_0 \dfrac{L}{R} = \dfrac{1}{\omega_0 CR} = \dfrac{1}{R}\sqrt{\dfrac{L}{C}}$ is an indicator or "sharpness of resonance."
- The power factor in a RLC circuit is a measure of how close the circuit is to consuming maximum power.
- A step up transformer converts low ac voltage to high ac voltage but reduces the current.
- A step down transformer converts high ac voltage to a low ac voltage but increases the current accordingly.
- In transformer, the primary and secondary voltage are given by $V_S = \left(\dfrac{N_S}{N_P}\right)V_P$ and the current are given by $I_S = \left(\dfrac{N_P}{N_S}\right)I_p$.
- In step up transformer, NS > NP and step down transformer $N_S < N_P$.
- A generator converts mechanical energy into electrical energy, whereas an electric motor converts electrical energy into mechanical energy.
- A transformer does not violate the law of conservation of energy. A step up transformer changes low voltage to a high voltage but reduces the current in the same proportion.