CHAPTER - 7 ALTERNATING CURRENT

Alternating Current

AC Current

Direction of current changes alternatively
$i = i_0 \sin\omega t$
$v = v_0 \sin\omega t$

RMS value or root mean square value
$i_{rms} = i_0/\sqrt{2}$
$v_{rms} = v_0/\sqrt{2}$

Mean value or Average value
$i_{mean} = 2i_0/\pi$
$v_{rms} = 2v_0/\pi$

Peak value or Max^m value
$i_0 = \sqrt{2}\, i_{rms}$
$v_0 = \sqrt{2}\, v_{rms}$

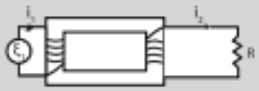
Contribution

In 1883, Nikola Tesla constructed the first induction motor at the age of 27 years only.

A C Generator

A device generating alternating current having elements magnet, Armature and graphite Brushes emf induced through coil

$E = NBA\,\omega \sin\omega t$
$i = E/R = NBA\,\omega \sin\omega t/R$



$E_2 = -N_2E_1/N_1$
$i_2 = -N_1E_1/N_2$
If $N_2 > N_1$ it is called step–up Transfomer
If $N_1 > N_2$, it is called step–down

Transformer

It is used to obtain a high AC voltage from a Low–voltage AC source or vice–versa

Efficiency of a transformer
- η = output power/Input power
- 99% efficiency can easily achieved

Power in AC Circuit

$$P = E_{rms}\, i_{rms} \cos\phi = \frac{E_0}{\sqrt{2}} \times \frac{i_0}{\sqrt{2}} \cos\phi = \frac{1}{2} E_0 i_0 \cos\phi$$

Impedance

The ratio of emf applied and the current produced in an AC circuit
$Z = E_0/i_0$ Ohm

Reactance

The hindrance offered by inductor or capacitor or both to the flow of AC (χ)

A C Circuits

Inductive (L) circuit

$$i = i_0 \sin\left(\omega t - \frac{\pi}{2}\right)$$
Phase difference b/w V& I, $\phi = \pi/2$
Power factor $\cos(\phi) = 0$
Voltage leads current by $\pi/2$
$P = 0$

Capacitive (C) circuit

$$i = i_0 \sin\left(\omega t + \frac{\pi}{2}\right)$$
$\phi = \pi/2$ or $-\pi/2$
$\cos\phi = 0$
Power(P) $= 0$
Current leads the voltage by $\pi/2$

Resistive (R) circuit

$i = i_0 \sin(\omega t)$
$\phi = 0°$
$\cos\phi = 1$
$P = V_0 I_0/2$
Current & voltage both are in same phase

R–C circuit

$i = i_0 \sin(\omega t + \phi)$
$Z = \sqrt{R^2 + X_c^2}$
$X_c = 1/\omega C$
$\tan\phi = 1/\omega CR$
$i_0 = E_0/Z$
- Power factor $\cos\phi = \dfrac{R^2}{\sqrt{R^2 + X_c^2}}$
- current leading.

L–C circuit

$$i = i_0 \sin\left(\omega t \pm \frac{\pi}{2}\right)$$
$X = X_L - X_C$
$\phi = \pi/2$
- Power factor = 0, Either voltage or current leading

L–R circuit

$i = i_0 \sin(\omega t + \phi)$
$Z = \sqrt{R^2 + X_L^2}$
$X_L = \omega L$
$\tan\phi = \omega L/R$
$i_0 = E_0/Z$
- power factor = R/Z
- voltage is leading

L–C–R circuit

$i = i_0 \sin(\omega t \pm \phi)$
$Z = \sqrt{R^2 + (X_L - X_C)^2}$
$X = X_c - X_L$
$= \left(\dfrac{1}{\omega c} - \omega L\right)$
$\tan\phi = \left(\dfrac{1}{\omega c} - \omega L\right)/R$, $i_0 = \dfrac{E_0}{Z}$