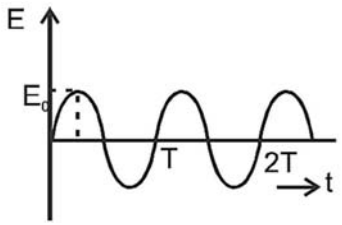
Chapter 7

Alternating Current

- Introduction of Alternating current
- Introduction to RMS current and voltage
  - Average and Instantaneous current
  - Root Mean Square current and Voltage
- AC Circuits
  - RMS Value, Hot wire Ammeter and voltmeter,
  - AC circuits
  - Purely Resistive circuit
  - Purely capacitive circuit
  - Purely Inductive circuit,
- LR, RC circuits, Power and power factor
  - Impedance
  - AC Circuit - Combinations
  - LR- Circuit and RC – Circuit
  - Power and power factor
- LCR circuit
  - Power and power factor
  - Basic terminology in a circuit
  - Choke Coil
  - LC Circuit
  - LCR Circuit
- Resonance in LCR circuits and Transformer
  - Resonant Frequency
  - Sharpness of Resonance
  - How does electricity reach our house?
  - Basis discussion of transformer- Working, Power relation, Types, Efficiency, Major Power losses
- Losses in Transformer and LC oscillations
  - Losses in transformer- Eddy current losses, Hysteresis
  - LC Oscillations
  - Parallel connection in AC

INTRODUCTION OF ALTERNATING CURRENT

When a current changes over time and goes in regular cycles, we call it AC (alternating current) if its strength stays the same, and it swings between positive and negative in each cycle.



The changing electric force (emf) at any moment can be written as $E = E_0 \sin \omega t$, where w is how fast it changes, and E_0 is the highest point it reaches.

The frequency (f) of this changing force is $\frac{\omega}{2\pi}$, and the time it takes for one full cycle (T) is $\frac{1}{f} = \frac{2\pi}{\omega}$.

When this changing force powers a circuit, the resulting current can be influenced by inductance (L), resistance (R), and capacitance (C). Because of the elements L and C, the current might not sync perfectly with the applied force. So, we usually express the alternating current as $I = I_0 \sin(\omega t + \phi)$, where ϕ is the phase, and it can be positive, zero, or negative based on the values of L and C.

INTRODUCTION TO RMS CURRENT AND VOLTAGE

Average and Instantaneous current

Electricity is called alternating when its strength or flow changes smoothly over time and regularly switches direction. This changing pattern can be shown using a curved line, like a sine or cosine curve.

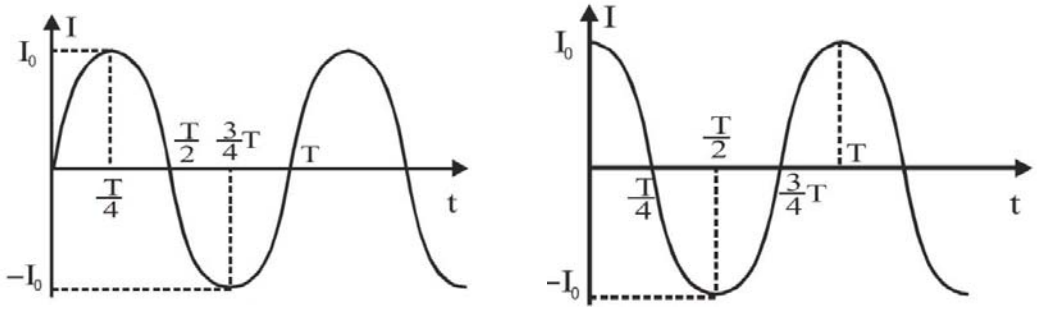
$I = I_0 \sin \omega t$ or $I = I_0 \cos \omega t$

where I = Instantaneous value of current at time t,

I_0 = Amplitude or peak value

ω = Angular frequency $\omega = \frac{2\pi}{T} = 2\pi f$

T = time period f = frequency



I as a sine function of t I as a cosine function of t

Amplitude of AC

The maximum value of current in either direction is called peak value or the amplitude of current. It is represented by I_0 .

Peak to peak value = $2I_0$

Periodic Time

The time taken by alternating current to complete one cycle of variation is called periodic time or time period of the current.

Frequency

The number of cycle completed by an alternating current in one second is called the frequency of the current.

UNIT : cycle/s ; (Hz)

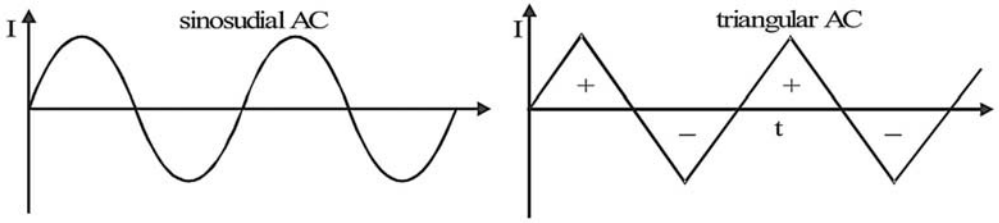
In India : f = 50 Hz , supply voltage = 220 volt

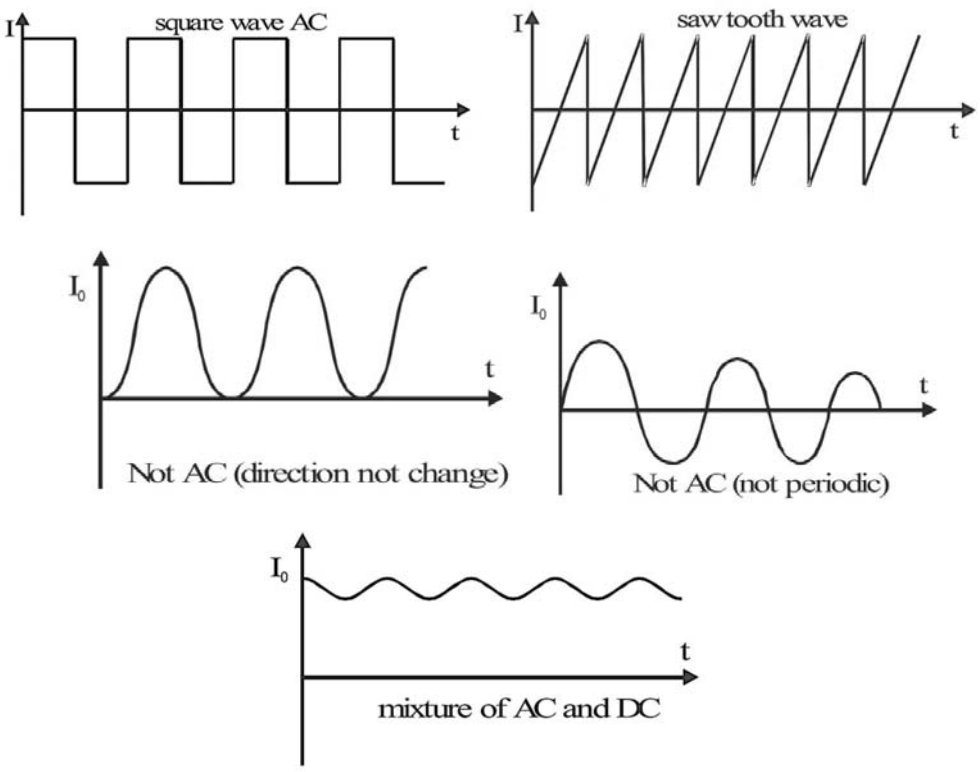
In USA :f = 60 Hz ,supply voltage = 110 volt

Condition required for Current/ Voltage to be Alternating

- Amplitude is constant
- Alternate half cycle is positive and half negative

The alternating current continuously varies in magnitude and periodically reverses its direction.





Average Value or Mean Value

The mean value of alternating current (AC) during any half cycle, whether it's going up or down, is the direct current (DC) value that would send the same amount of charge through a circuit as the AC does in the same amount of time.

average value of current for half cycle $< I > = \frac{\int_0^{T/2} Idt}{\int_0^{T/2} dt}$

Average value of $I = I_0 \sin \omega t$ over the positive half cycle :

$$I_{av} = \frac{\int_0^{\frac{T}{2}} I_0 \sin \omega t dt}{\int_0^{\frac{T}{2}} dt} = \frac{2I_0}{\omega T} = \frac{2I_0}{\omega T}[-\cos \omega t]_0^{\frac{T}{2}} = \frac{2I_0}{\pi}$$

$< \sin \theta >=< \sin 2\theta >= 0$
$< \cos \theta >=< \cos 2\theta >= 0$
$< \sin \theta \cos \theta >= 0$
$< \sin^2 \theta >=< \cos^2 \theta >= \frac{1}{2}$

For symmetric AC, average value over full cycle = 0, Average value of sinusoidal AC

Full cycle	(+ve) half cycle	(−ve) half cycle
0	$\frac{2I_0}{\pi}$	$\frac{-2I_0}{\pi}$

As the average value of AC over a complete cycle is zero, it is always defined over a half cycle which must be either positive or negative+

Maximum Value

- $I = a\sin\theta \Rightarrow I_{Max.} = a$
- $I = a + b\sin\theta \Rightarrow I_{Max.} = a + b$(if a and $b > 0$)
- $I = a\sin\theta + b\cos\theta \Rightarrow I_{Max.} = \sqrt{a^2 + b^2}$
- $I = a\sin^2\theta \Rightarrow I_{Max.} = a(a > 0)$

Root Mean Square current and Voltage

Root Mean Square (RMS) value of voltage $\varepsilon_{rms} = 220$ V

RMS value of voltage $= \varepsilon_{rms} = \frac{\varepsilon_0}{\sqrt{2}}$

RMS value of current $= i_{rms} = \frac{i_o}{\sqrt{2}}$