Basic Electrical Technology

[ELE 1051]

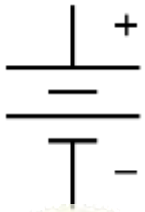
SINGLE PHASE AC CIRCUITS

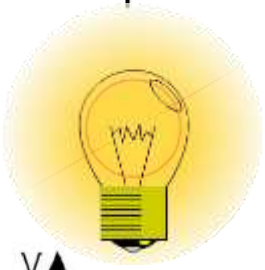
L14 - Introduction to AC, Generation of AC, Average & RMS value

Topics covered…

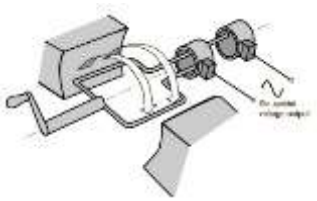
- DC vs AC
- Generation of AC
- Terminologies
- Average value and Root Mean Square (RMS) value

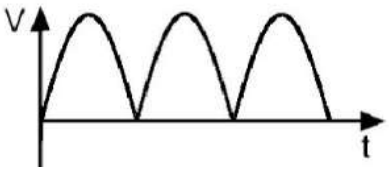
DC vs. AC

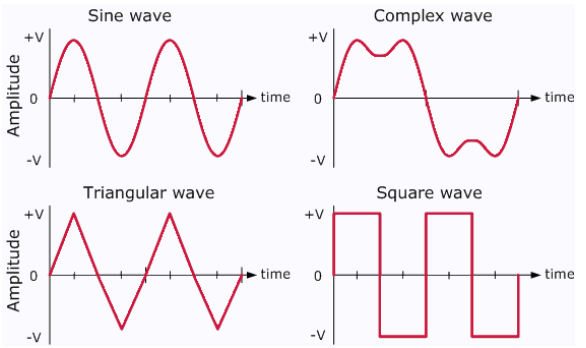




	DC	AC
Obtained from	Battery / cell / derived from AC	AC Generator
Polarity	Positive and Negative	Oscillatory
Frequency	Zero	50Hz or 60Hz
Types	Constant or pulsating	**Sinusoidal**, Trapezoidal, Triangular, Square







Terminologies

Period(T) :

- one cycle time

Frequency (f):

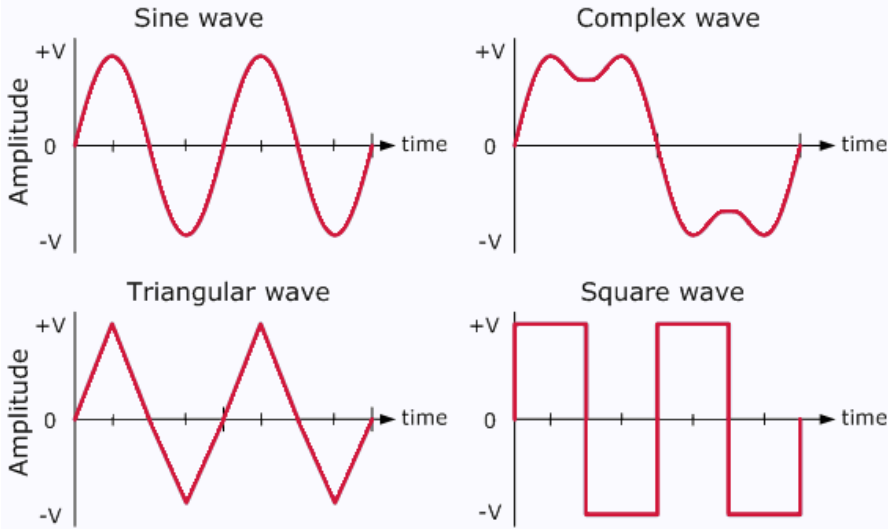
- $f=\frac{1}{T}$

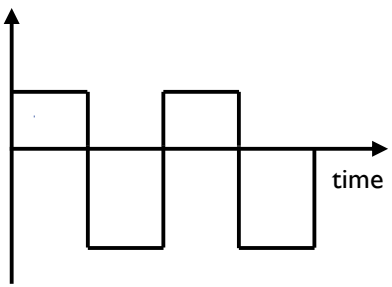
Average value :

- $F_{avg} = \frac{1}{T}\int_0^T f(t)dt$

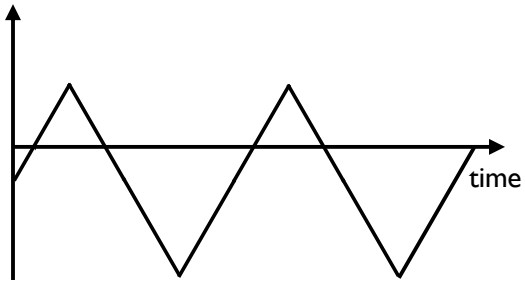
RMS value :

- $F_{rms} = \sqrt{\frac{1}{T}\int_0^T f^2(t)dt}$





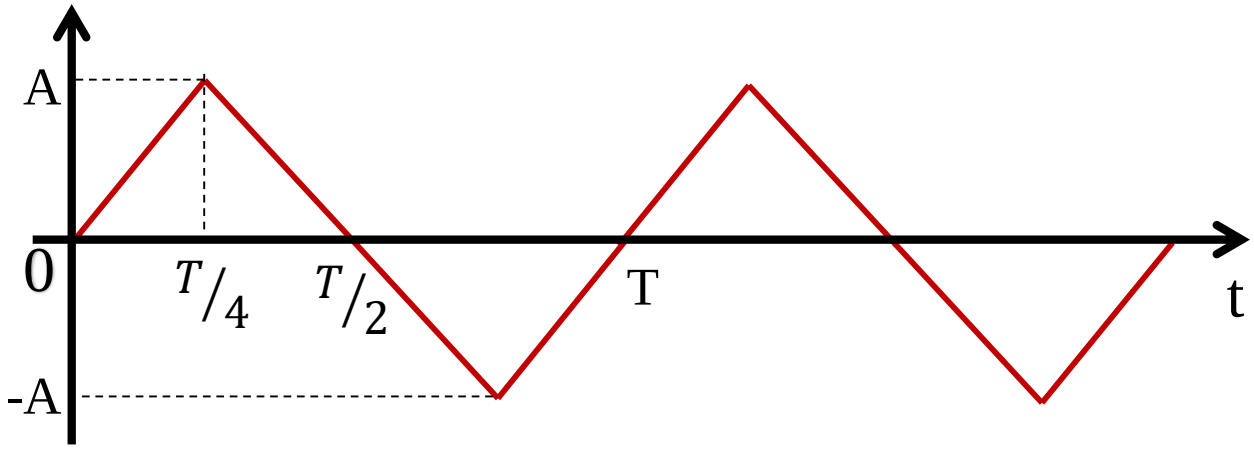
Asymmetric square wave



Asymmetric triangular waveform,

Exercise 1

Find the Average value and RMS value of the given non-sinusoidal waveform



Answer:

$$\boldsymbol{Average\ Value = \frac{A}{2}} \qquad \boldsymbol{RMS\ Value = \frac{A}{\sqrt{3}}}$$

Generation of Alternating EMF

Generation of Alternating EMF

EMF Equation

EMF induced per conductor is

$$e = B\,l\,v\,\sin\theta$$

EMF Induced in one Coil is

$$e = 2\,B\,l\,v\,\sin\theta$$

If, b = width of the coil,

$$v = \pi\,b\,n$$ *'n' is the speed in revolutions per sec.*

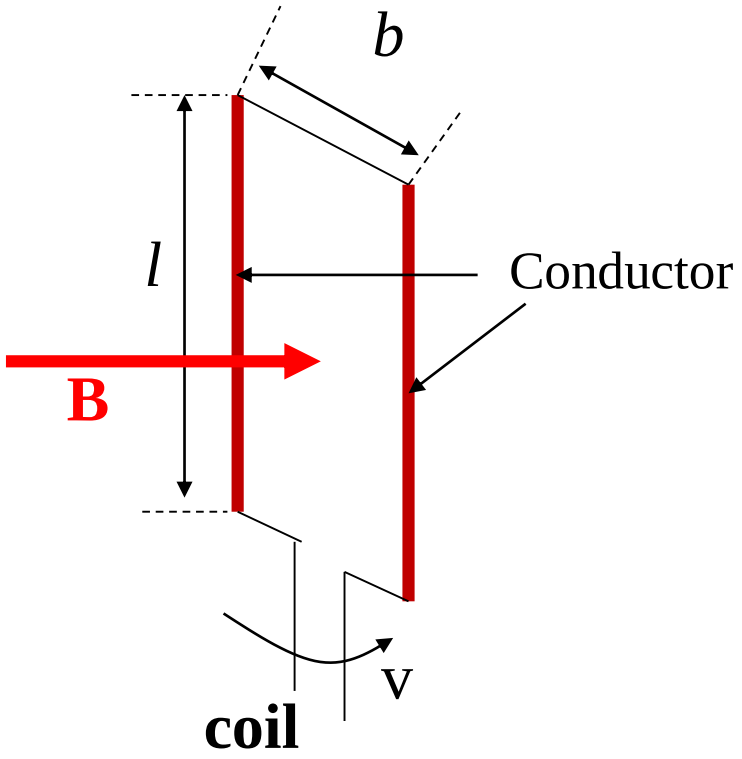
$$e = 2\,B\,l\,b\,\pi\,n\,\sin\theta$$

$$= 2\,B\,A\,\pi\,n\,\sin\theta$$

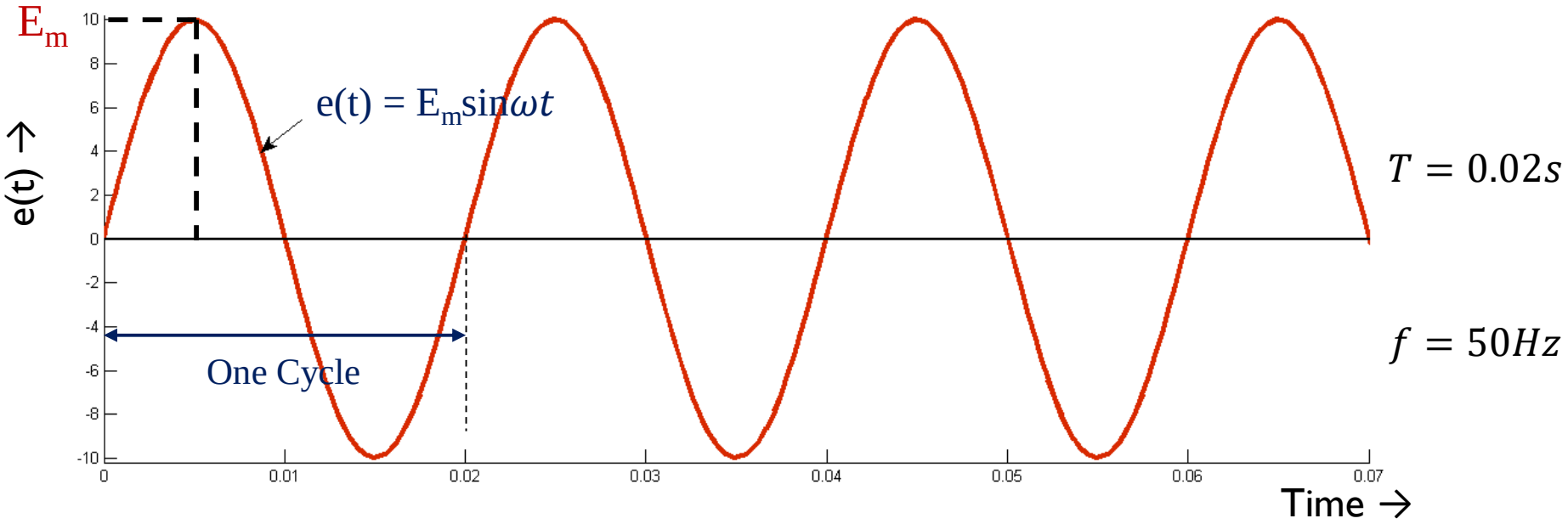
If there are N turns in the coil, the emf induced is,

$$e = 2\,\pi\,n\,B\,A\,N\,\sin\theta$$

$$\boxed{e = E_m \sin\theta}$$



Sinusoidal AC waveform



Cycle: Each repetition of the alternating quantity, recurring at equal intervals

Period (T): Duration of one cycle

Instantaneous Value (e(t)): The magnitude of a waveform at any instant in time

Peak Amplitude: Maximum value or peak value of alternating quantity

Frequency (f): Number of cycles in one second (Hz) $f = \frac{1}{T}$

Average value of Sinusoidal Alternating Current

Definition: "*It is that steady current which transfers the same amount of charge to any circuit during the given interval of time, as is transferred by the alternating current to the same circuit during the same time*"

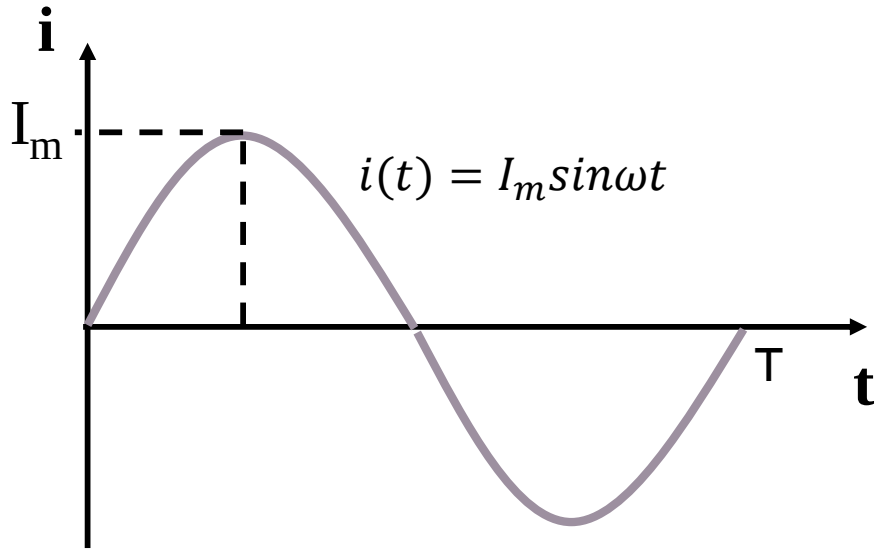
For a periodic function f(t) with period T,

$$F_{avg} = \frac{1}{T}\int_0^T f(t)\,dt$$

For sinusoidal signal,

$$I_{avg} = \frac{1}{T/2}\int_0^{T/2} I_m \sin\omega t\,dt$$

$$\boxed{I_{av} = \frac{2I_m}{\pi}}$$



RMS value of Sinusoidal Alternating Current

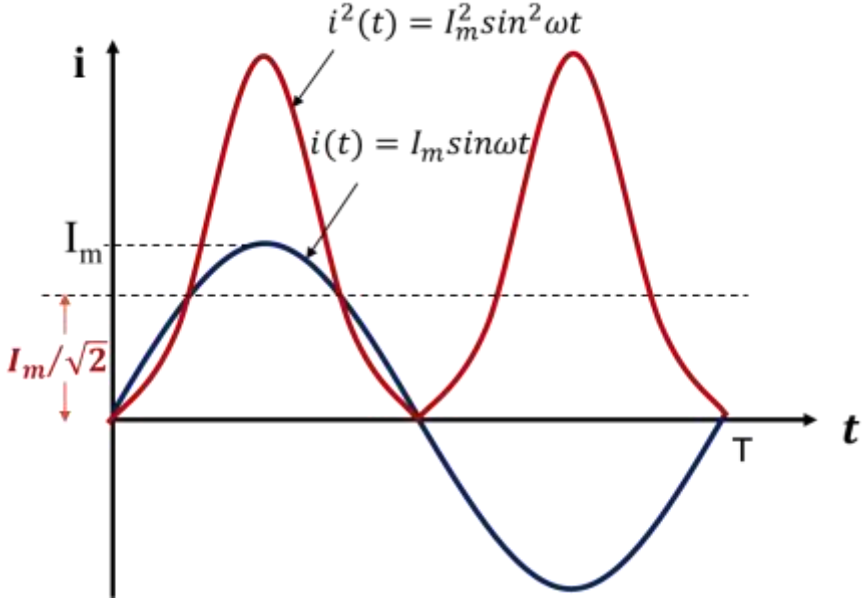
Definition: "*It is that value of direct current which when flowing through a circuit produces the same amount of heat for a given interval of time as that of the alternating current flowing through the same circuit during the same time*"

For a periodic function f(t) with period T,

$$F_{rms} = \sqrt{\frac{1}{T}\int_0^T f^2(t)\,dt}$$

$$I_{rms} = \sqrt{\frac{1}{T}\int_0^T I_m^2 \sin^2\omega t\, dt}$$

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



Form Factor & Peak Factor

$$Form\ Factor = \frac{RMS\ Value}{Average\ Value} = 1.11\ for\ sinusoidal$$

$$Peak\ Factor = \frac{Maximum\ Value}{RMS\ Value} = \sqrt{2}\ for\ sinusoidal$$

Exercise 1

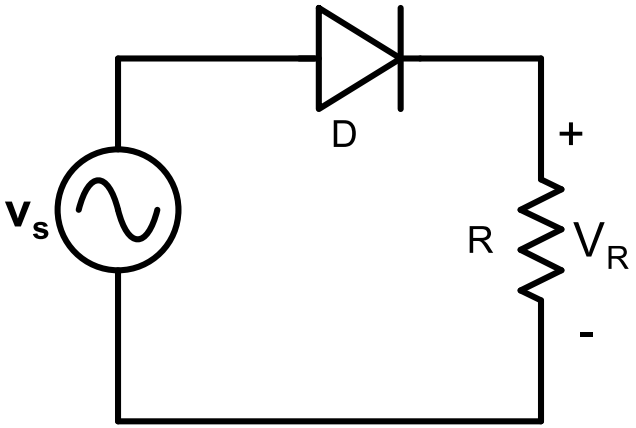
If an alternating voltage has the equation **$v(t) = 141.4 \sin 377t$**, calculate

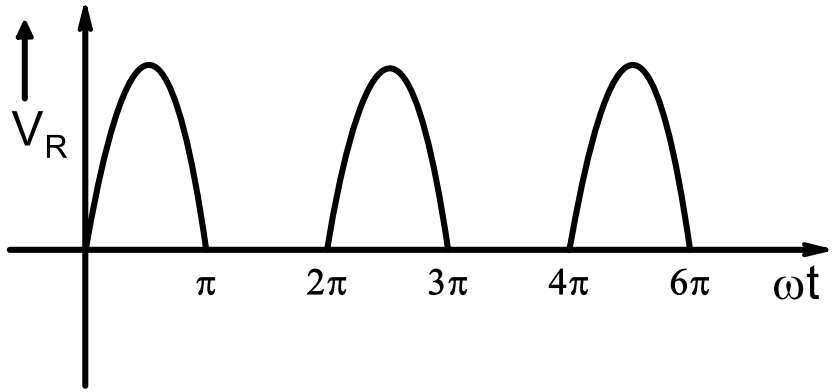
a. Maximum voltage value
b. RMS value of the voltage
c. Frequency
d. The instantaneous voltage when t = 3ms

Answers:

a) Maximum Value = 141.4 V
b) RMS Value = 100 V
c) Frequency = 60 Hz
d) Instantaneous voltage = 127.8V

For the circuit shown below, sketch the the voltage across the resistance, & then find the Average value and RMS value of the same.





Ans: $V_{R\,avg} = \frac{V_m}{\pi}$; $V_{R\,RMS} = \frac{V_m}{2}$

Summary

- Alternating quantity
  - time dependent
  - takes positive & negative values in every cycle
  - Types: **Sinusoidal**, triangular, square
- Generation of AC
- RMS value / Effective value for Sinusoidal AC

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

- Average value of a Sinusoidal AC

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