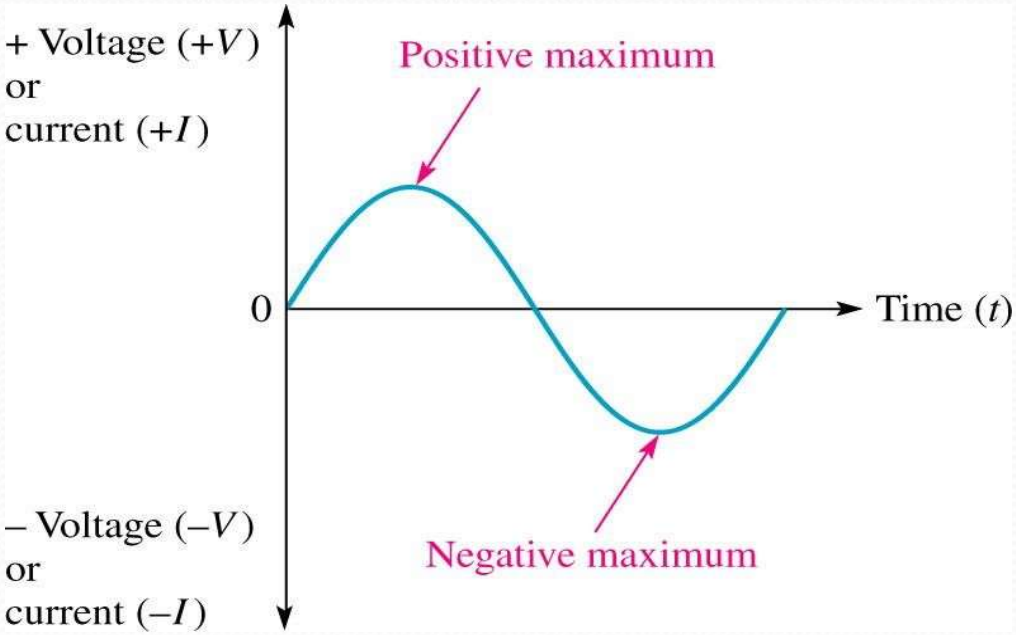
# ECE-249

## Unit-1

# Fundamentals of A.C. circuits



# Contents:

- Determination of Frequency (f)
- Periodic Voltage Or Current Waveform
  - Average Value
  - Root Mean Square (RMS) Value
  - Average and RMS Values of Sinusoidal Voltage Waveform

# Introduction of A.C.

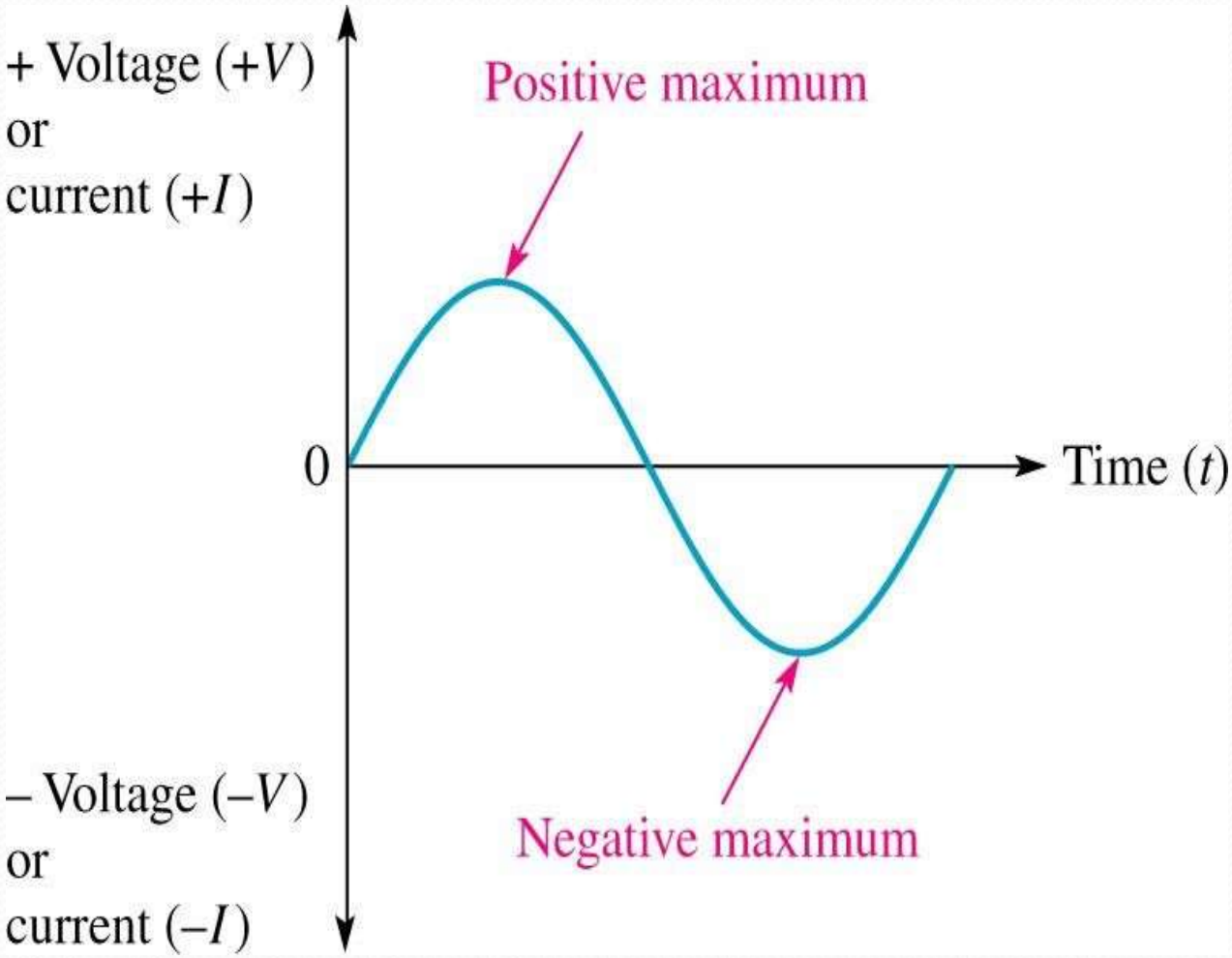
The long form of A.C. is alternating current.

Both the magnitude and direction of the A.C. changes.

The alternating current can be +ve, -ve or zero.

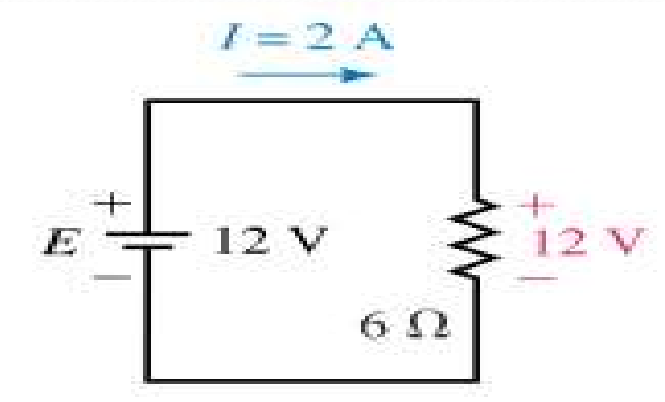
The current that changes its polarity is called as alternating current.

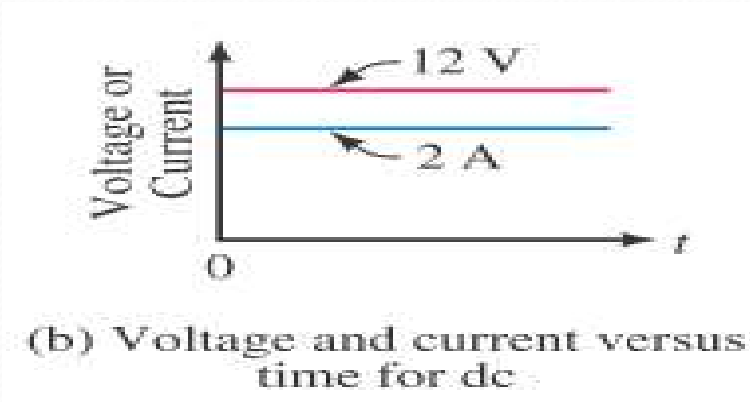
An alternating (A.C.) quantity (voltage, current or power) is defined as the one that changes its value as well as direction (polarity) with respect to time.


+ Voltage (+V)
or
current (+I)
Positive maximum
0
Time (t)
– Voltage (–V)
or
current (–I)
Negative maximum

# AC Fundamentals

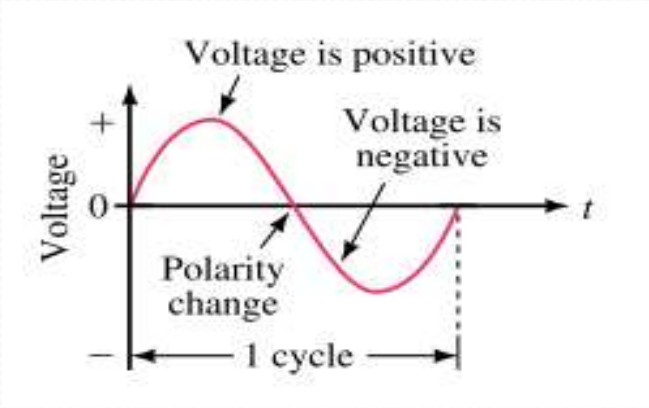
- Previously you learned that DC sources have fixed polarities and constant magnitudes and thus produce currents with constant value and unchanging direction




(b) Voltage and current versus time for dc

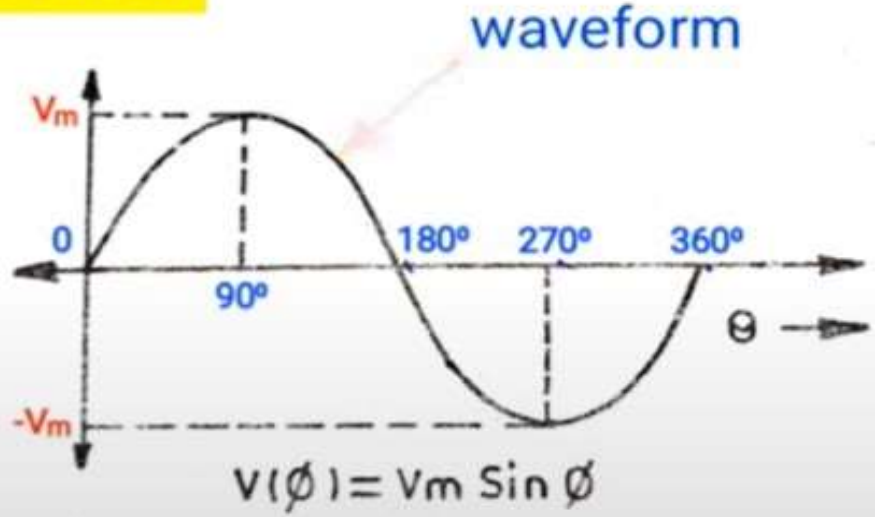
- In contrast, the voltages of ac sources alternate in polarity and vary in magnitude and thus produce currents that vary in magnitude and alternate in direction.



# SOME DEFINITIONS USE IN A.C. FUNDAMENTALS

## 1) WAVEFORM :

The nature of graph of alternating quantity against time is known as waveform or waveshape.

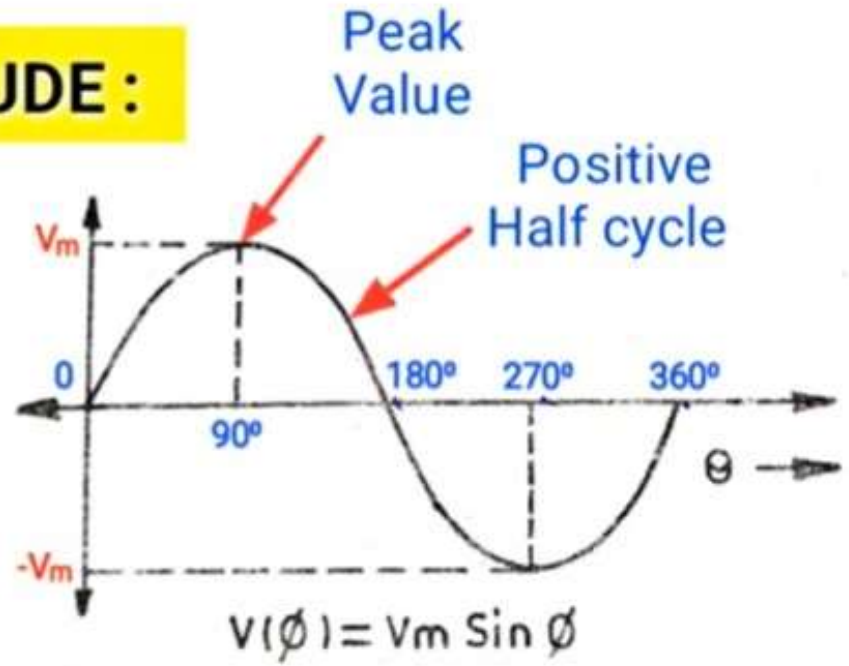



A waveform is a graphical representation of a signal in the form of a wave. It can be both sinusoidal as well as square shaped.

# SOME DEFINITIONS USE IN A.C. FUNDAMENTALS

## 2) AMPLITUDE :

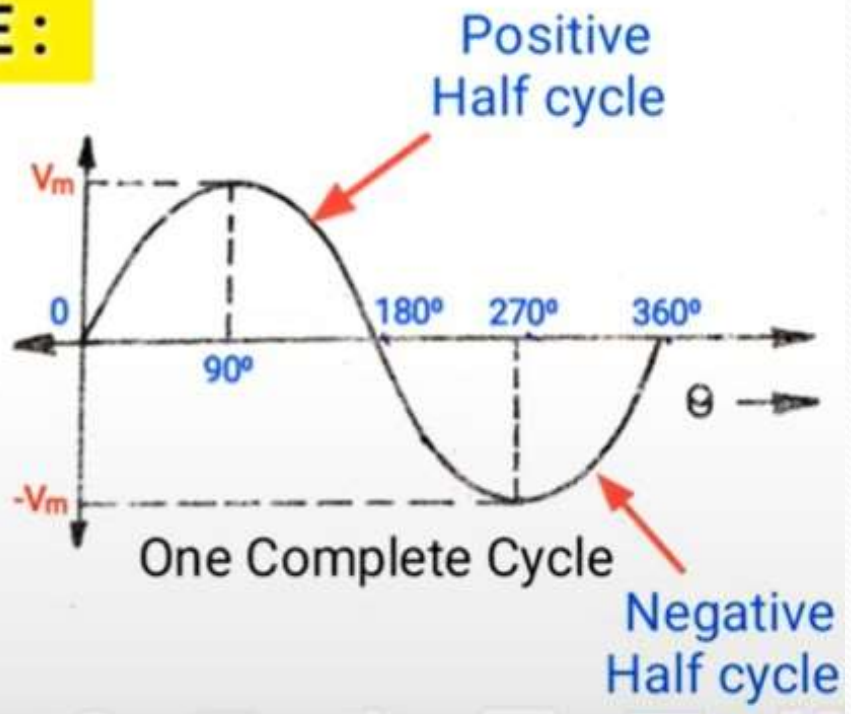
The maximum value (positive or negative) of an alternating quantity in half cycle is known as its amplitude. It is also known as peak value.



# SOME DEFINITIONS USE IN A.C. FUNDAMENTALS

## 3) CYCLE :

One complete set of positive and negative values of alternating quantity is known as a cycle.

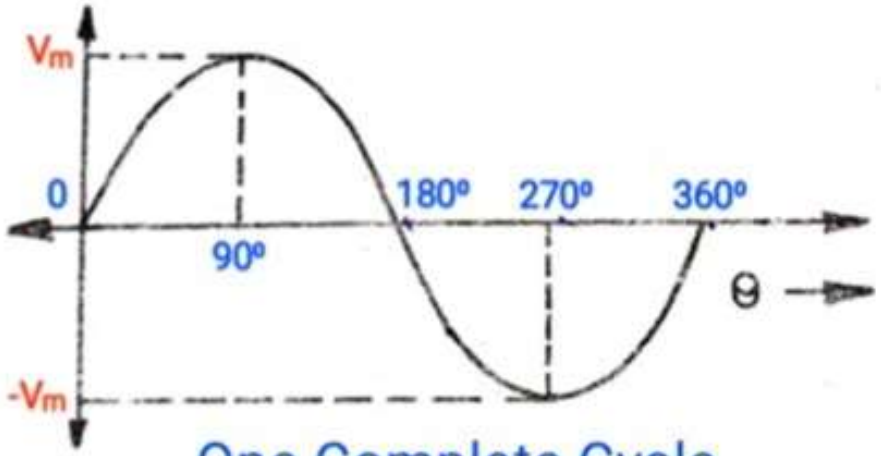


# SOME DEFINITIONS USE IN A.C. FUNDAMENTALS

## 4) TIME PERIOD :

Time required to complete one cycle of an alternating quantity is called time period.

$$T = 1 / f$$



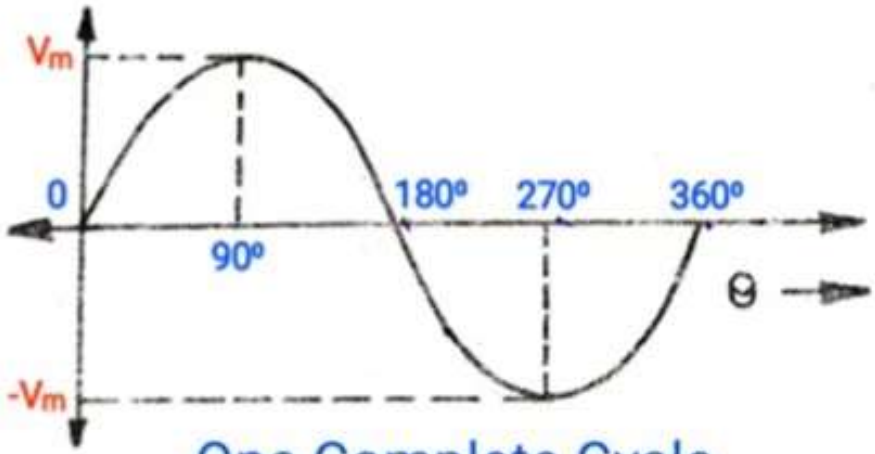
One Complete Cycle

# SOME DEFINITIONS USE IN A.C. FUNDAMENTALS

## 5) FREQUENCY :

Number of cycles per second is called the frequency of the alternating quantity.

$$f = 1 / T$$




One Complete Cycle

# SOME DEFINITIONS USE IN A.C. FUNDAMENTALS

## 6) PHASE :

It is part of time-period after the alternating quantity passed through zero position.

OR

It is the phase angle position of A.C. quantity.

# SOME DEFINITIONS USE IN A.C. FUNDAMENTALS

## 7) PHASE DIFFERENCE :

If two alternating quantities do not reach their zero value in the same direction simultaneously then they have phase difference.

The difference of phase angle between two A.C. quantities on the same reference axis is known as phase difference.

# SOME DEFINITIONS USE IN A.C. FUNDAMENTALS

## 8) ROOT MEAN SQUARE VALUE (RMS VALUE) :

It is that value of D.C. current which when flowing through a given circuit for a given time produces the same heat as produced by the alternating current when flowing through the same circuit for the same time.

$$\text{RMS value} = \frac{\text{Max.value}}{\sqrt{2}}$$

RMS value = 0.707 × Max.value

$$V_{rms} = \frac{V_m}{\sqrt{2}}$$

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

Root mean square or R.M.S. value of Alternating current is defined as that **value of steady current, which would generate the same amount of heat in a given resistance at a given time, as is done by A.C. current, when maintained across the same resistance for the same time.**

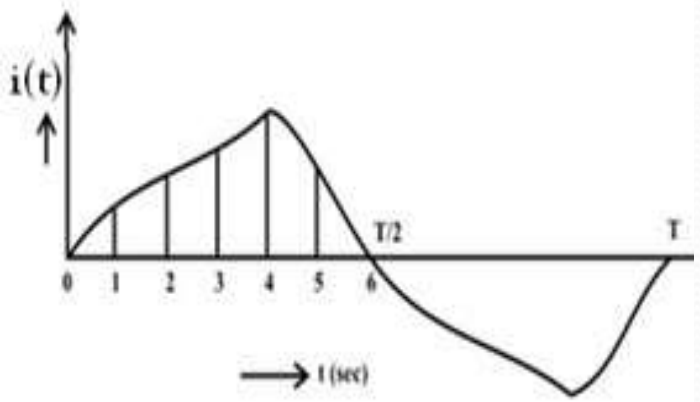
# Periodic Voltage or Current Waveform

- Average value
  - The current waveform shown in Fig, is periodic in nature, with time period T. It is positive for first half cycle, while it is negative for second half cycle.
  - The average value of the waveform, i(t) is defined as

$$I_{av} = \frac{Area\ over\ half\ cycle}{Time\ period\ of\ half\ cycle} = \frac{1}{T/2}\int_0^{T/2} i(t)\,dt = \frac{2}{T}\int_0^{T/2} i(t)\,dt$$

  - In this case, only half cycle, or half of the time period, is to be used for computing the average value, **as the average value of the waveform over full cycle is zero (0).**
  - If the half time period (T/2) is divided into 6 equal time intervals ($\Delta T$).

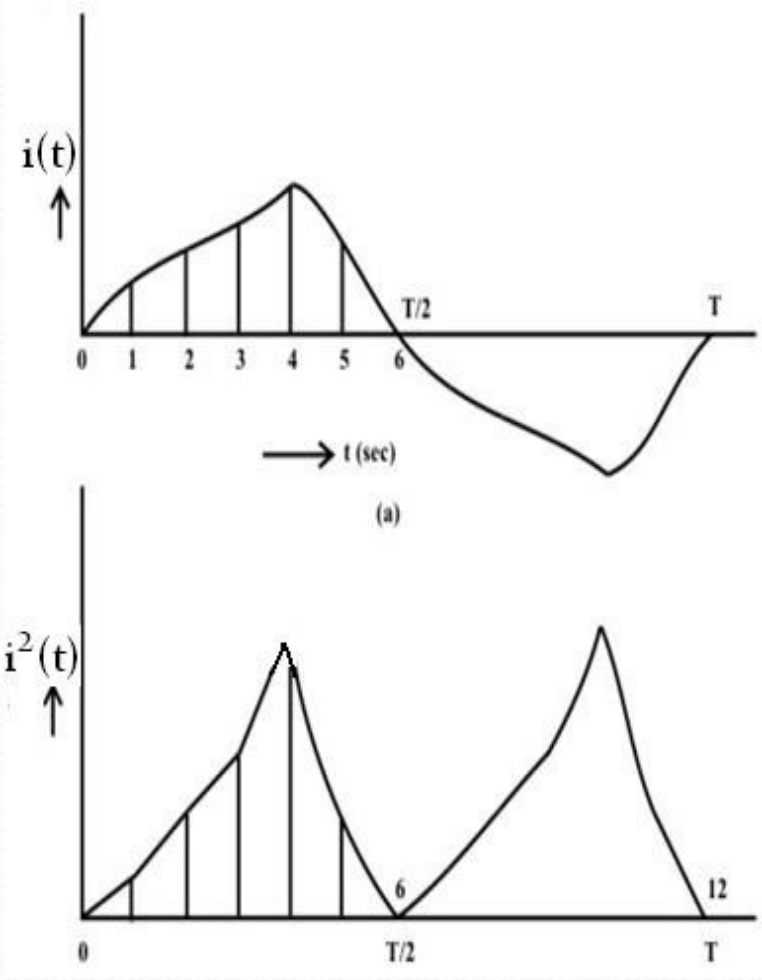
$$I_{av} = \frac{(i_1 + i_2 + i_3 + \cdots i_6)\Delta T}{6 \cdot \Delta T} = \frac{(i_1 + i_2 + i_3 + \cdots i_6)}{6}$$



# Root Mean Square (RMS) value

$$= \sqrt{\frac{\text{Area of } i^2 \text{ curve over half cycle}}{\text{Time period of half cycle}}}$$

$$= \sqrt{\frac{1}{T/2}\int_0^{T/2} i^2\,dt} = \sqrt{\frac{2}{T}\int_0^{T/2} i^2\,dt}$$



$$V_{avg} = \frac{2 \times V_m}{\pi}$$

$$\approx 0.6366 \times V_m$$

$$I_{avg} = \frac{2 \times I_m}{\pi}$$

$$\approx 0.6366 \times I_m$$

$$V_{rms} = \frac{V_m}{\sqrt{2}}$$

$$= 0.707 \times V_m$$

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

$$= 0.707 \times I_m$$

# Form factors

- The form factor of an alternating quantity is define as the ratio of RMS value to the average value.

$$\text{Form factor} = \frac{RMS\ value}{Average\ value} = \frac{0.707\,V_m}{0.637\,V_m} = 1.11$$

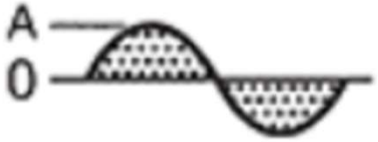
- **Peak value:-**
- The peak factor of an alternating quantity is define as the ratio of maximum value to the average value

$$\text{Peak factor (P.E.)} = \frac{Maximum\ value}{RMS\ value}$$

$$= \frac{Peak\ Value}{Peak\ Value/\sqrt{2}} = \sqrt{2}$$

$$\text{P.F.} = 1.414$$

- **NOTE:-**
  - The rms value is always greater than the average value.
  - Except for a rectangular waveform, in which the heating effect remains constant, so that the average and the rms values are same.

| Waveform | Effective value Vrms | Average value Vavg | Conversion factor Vrms/Vavg |
|---|---|---|---|
|   | $\frac{1}{\sqrt{2}}A$ <br> $\doteqdot 0.707$ | $\frac{2}{\pi}A$ <br> $\doteqdot 0.637$ | $\frac{\pi}{2\sqrt{2}}$ <br> $\doteqdot 1.111$ |

## ★ Average Voltage Value

$$V_{AV} = \frac{2V_P}{\pi} = 0.637 \times V_P$$

$$V_{AV} = \frac{2V_M}{\pi} = 0.637 \times V_M$$

## ★ Average Current Value

$$I_{AV} = \frac{2I_M}{\pi} = 0.637 \times I_M$$

# Question

Q1) Determine the average value and RMS value of sinusoidal current of peak value 40A.

Solution:- $I_{max} = 40A$

Q2) Write the instantaneous value for a 50Hz sinusoidal voltage supply for domestic purposes at 230V.

Solution:- given value $V_{rms} = 230\ V,\ f = 50\ Hz$

# Question

Q1) Determine the average value and RMS value of sinusoidal current of peak value 40A.

Solution:- Imax = 40A

$$I_{rms} = \frac{I_{max}}{\sqrt{2}}$$

$$I_{av} = 0.637\, I_{max}$$

$$I_{rms} = \frac{40}{\sqrt{2}} \approx 28.28 \text{ A}$$

$$I_{avg} = \frac{2 \times 40}{\pi} \approx 25.46 \text{ A}$$

Q2) Write the instantaneous value for a 50Hz sinusoidal voltage supply for domestic purposes at 230V.

Solution:- given value Vrms = 230 V, f = 50 Hz

$$V(t) = V_{max} \sin \omega t$$

$$V_{max} = \sqrt{2} \times V_{rms}$$

$$\omega = 2\pi f$$

Given:

- Frequency $f = 50$ Hz
- RMS voltage $V_{rms} = 230$ V

First, calculate the peak voltage $V_m$:

$$V_m = V_{rms} \times \sqrt{2} = 230 \times \sqrt{2} \approx 325.27 \text{ V}$$

Thus, the equation for the instantaneous voltage becomes:

$$v(t) = 325.27 \sin(100\pi t)$$

This formula gives the instantaneous value of the sinusoidal voltage at any time $t$.

# Thank You