BEEE101L – Basic Electrical Engineering

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Module 2 : AC Circuits 6 Hrs

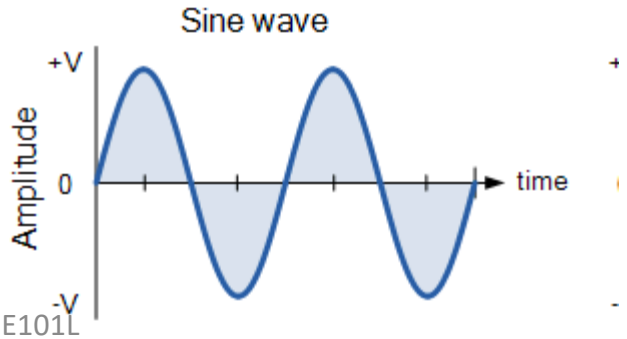
Alternating voltages and currents, RMS, average, form factor, peak factor; Single phase RL, RC, RLC series and parallel circuits; Power and power factor; Balanced three phase systems

Course Outcome

- Evaluate AC circuit parameters

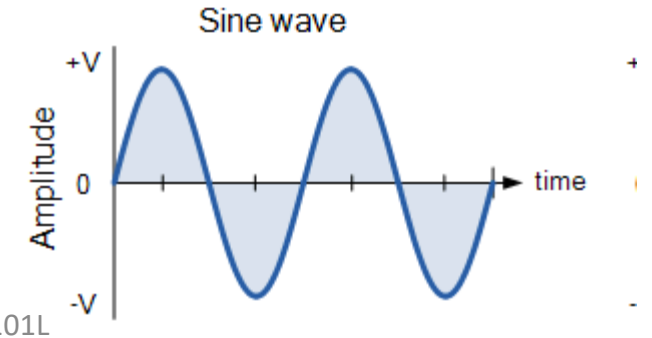
Terminology

- **Waveform** – It is a graph in which the instantaneous value of any quantity is plotted against time
- **Alternating waveform** – This is a wave which reverses its direction at regular recurring intervals
- **Periodic waveform** – It repeats itself after definite time intervals



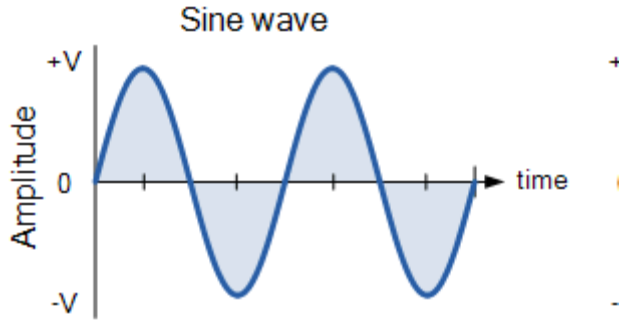
Terminology

- **Sinusoidal waveform** – It is an alternating waveform in which sine law is followed
- **Non-sinusoidal waveform** – It is an alternating waveform in which sine law is not followed
- **Cycle**– One complete set of positive and negative halves constitute a cycle
- **Frequency** – The number of cycles per second of an alternating quantity



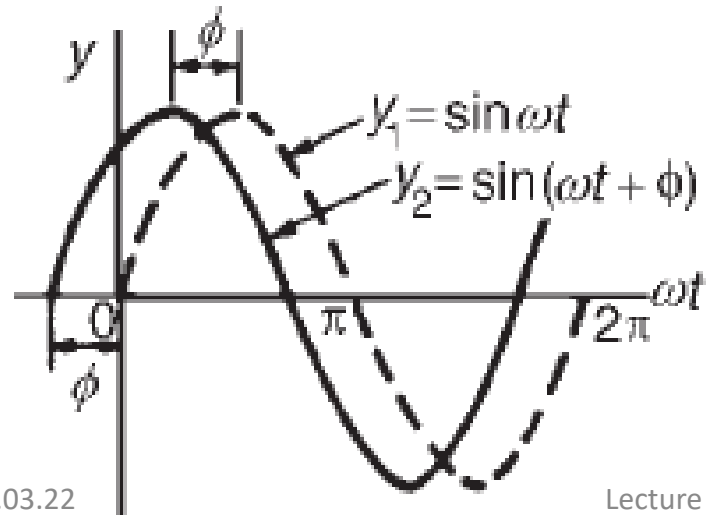
Terminology

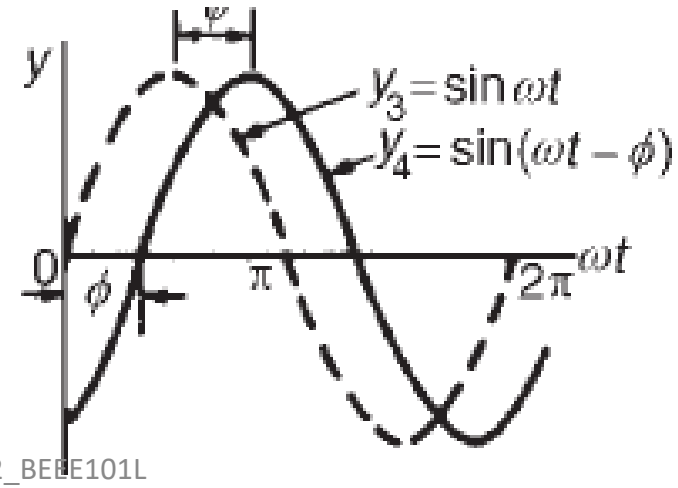
- **Period**– Time taken to complete one cycle
- **Amplitude** – The maximum positive and negative value of an alternating quantity
- **Instantaneous values** - The values of the alternating quantities at any instant of time



Terminology

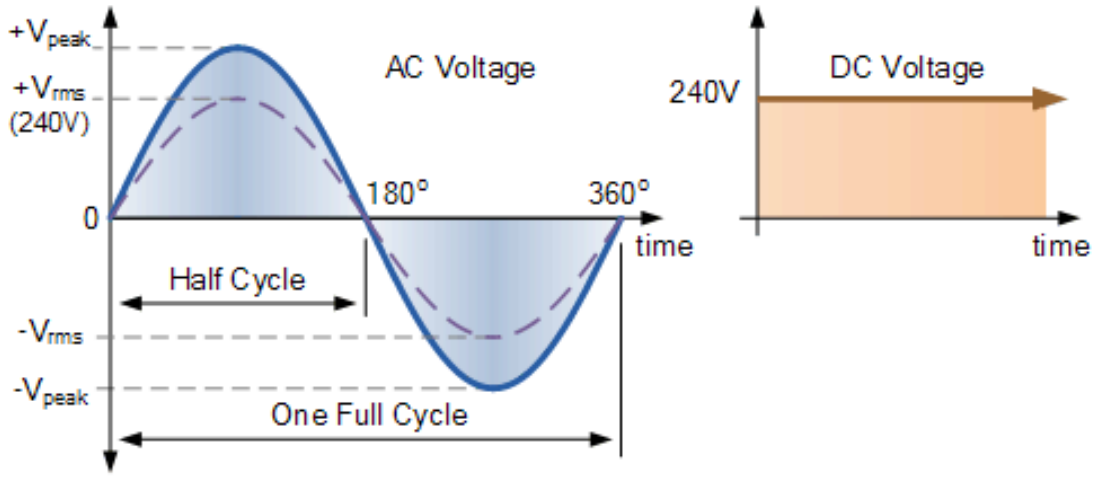
- **Phase** – The time that has elapsed since the quantity has last passed through zero point of reference and passed positively
- **Phase difference** – It is used to compare the phase of two waveforms





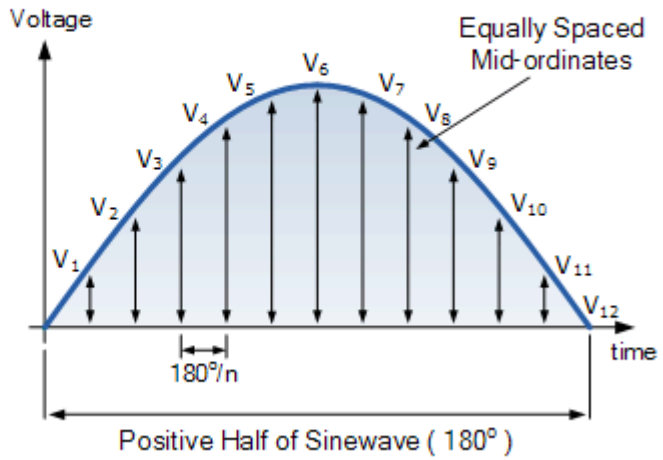
- **RMS value** – The steady state value of (DC) current which when flows in a given circuit for a given time produces the same heat as would be produced by the alternating current flowing in the same circuit for the same time.

RMS Voltage Equivalent



Graphical Method

Graphical Method

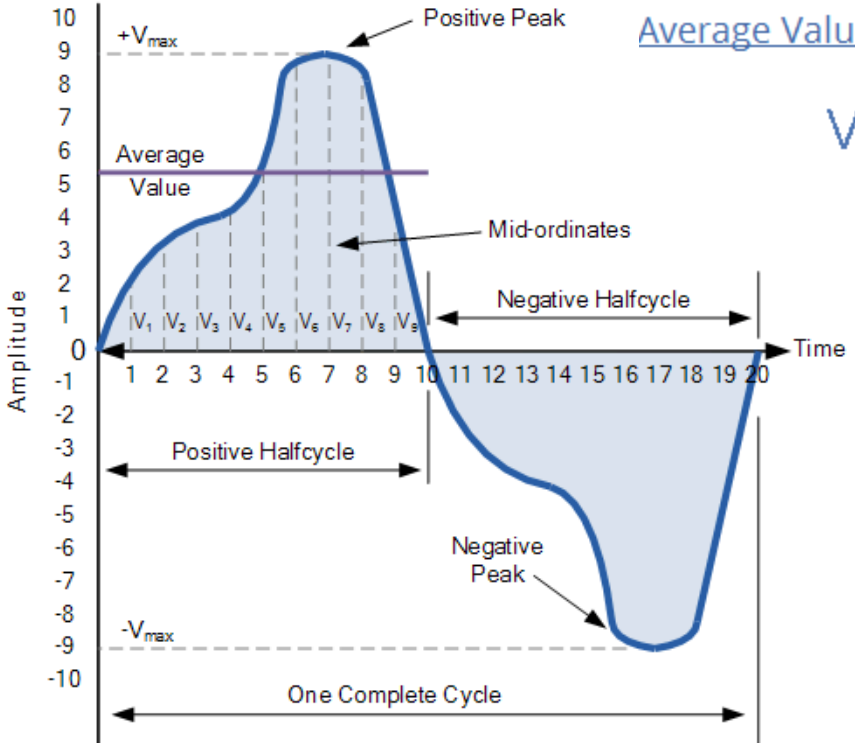


$$V_{RMS} = \sqrt{\frac{\text{sum of mid-ordinate (voltages)}^2}{\text{number of mid-ordinates}}}$$

$$V_{RMS} = \sqrt{\frac{V_1^2+V_2^2+V_3^2+V_4^2\ldots.+V_{11}^2+V_{12}^2}{12}}$$

- **Average value –** Steady current which transfers across the circuit the same charge as would be transferred by the ac across the same circuit in the same time.

Average Value of a Non-sinusoidal Waveform



Average Value of an AC Waveform

$$V_{average} = \frac{V_1 + V_2 + V_3 + V_4 + \ldots + V_n}{n}$$

Find the average and RMS value of a sinusoidal wave (Analytical method)

- $I_{rms}=\frac{I_m}{\sqrt{2}}$=0.707 I_m
- $I_{av}=\frac{2I_m}{\Pi}$=0.637 I_m

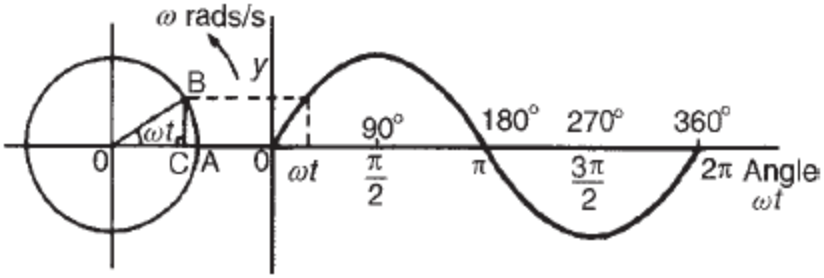
Find the average and RMS value of a sinusoidal wave (Analytical method)

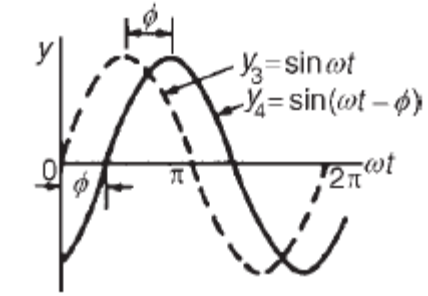
- **Form factor (FF)** – the ratio of RMS value to the average value
- **Peak factor** – the ratio of peak value to RMS value

- $I_{rms}=\frac{I_m}{\sqrt{2}}=0.707\ I_m$
- $I_{av}=\frac{2I_m}{\Pi}=0.637\ I_m$

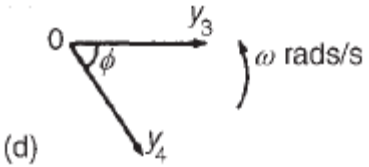
Phasor representation

- **A rotating vector is known as phasor**

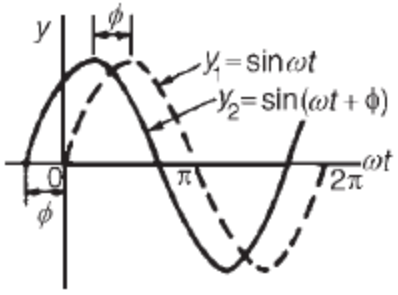




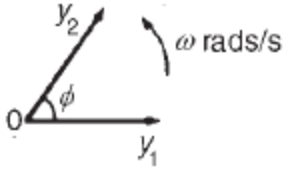
(c) y_4 leads y_3 by ϕ



(d)

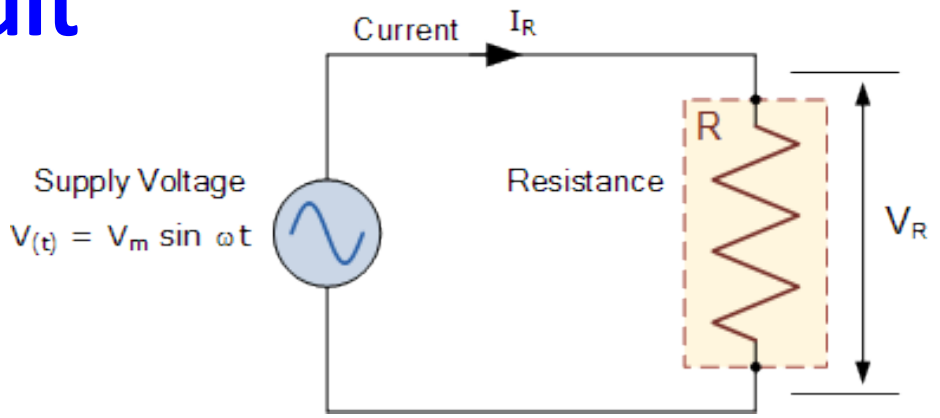


(a) y_2 leads y_1 by ϕ



(b)

Pure resistive circuit



The instantaneous voltage across the resistor, V_R is equal to the supply voltage

$$V_R = V_{max} \sin \omega t$$

The instantaneous current flowing in the resistor is

$$I_R = \frac{V_R}{R} = \frac{V_{max}}{R} \sin \omega t = I_{max} \sin \omega t$$

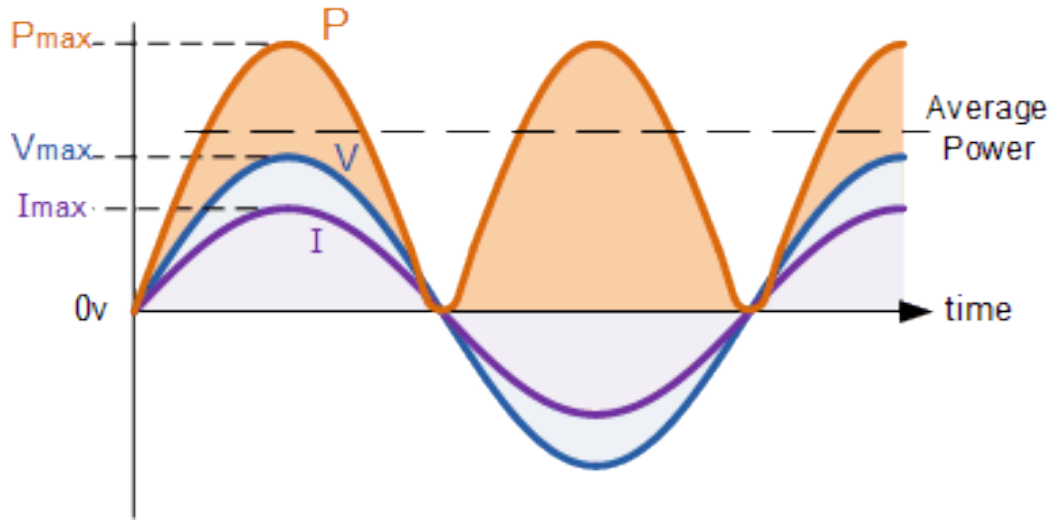
- The voltage across a resistor is given as $V_R = I.R$
- The instantaneous voltage across the resistor

$$V_R = I_{max} R \sin \omega t$$

- For resistors in AC circuits the phase angle ϕ between the voltage and the current is zero
- The power factor of the circuit is given as $\cos 0^o = 1.0$.
- **Note: Power factor is defined as the cosine of the phase angle between voltage and current**

- In AC circuits, the ratio of voltage to current depends upon the frequency and phase difference or phase angle (ϕ) of the supply. So the term **Impedance**, symbol **Z** is generally used

AC impedance Z = R



Average power

- The power in the circuit at any instant in time can be found by multiplying the voltage and current at that instant.
- $P_{av}=V_{rms}\ I_{rms}$

Power factor

- Cosine of the phase angle between voltage and current
- Power factor = cos0 = 1 (unity)

Pure Inductive Circuit

- Impedance $Z = X_L$
- Waveforms
- Phasor representation
- Average power
- Power factor

Pure Inductive Circuit

Pure Capacitive Circuit

- Impedance $Z = X_C$
- Waveforms
- Phasor representation
- Average power
- Power factor

Note: Derive all above parameters