

UNIT 2

AC CIRCUITS

Lecture #1

OUTLINE

- Single phase AC circuits
- Three phase AC circuits

Single phase AC circuits

- Sinusoidal voltage
 - Peak value
 - Average value
 - RMS value
- Phasor Representation
- Power factor
- Single phase RC,RL & RLC circuits
- Complex power

Three phase AC circuits

- Line and Phase values
- Power measurement

Single phase AC circuits

What is AC?

What is the Difference between AC & DC?

What is sinusoidal voltage?

DC vs. AC

- ✓ Direct current or Voltage (**DC**) flows in the circuit only in **one direction**
- ✓ Alternating current or Voltage (**AC**) flows first in one direction then in the opposite direction

Definition of AC

- ✓ When the current or voltage flowing in the circuit varies in **magnitude** as well as **direction** periodically, it is called alternating current or voltage
- ✓ The circuits in which alternating currents flow are called AC circuits

Applications & Advantages

- Large scale power generation
- Transmission & Distribution

Advantages:

- ✓ Voltage can be Step up or step down using transformers
- ✓ Alternating current motors are cheaper, simple in construction, efficient

A.C Terminology

- ✓ *Waveform*
- ✓ *Alternating Waveform*
- ✓ *Sinusoidal Waveform*
- ✓ *Cycle*
- ✓ *Time period*
- ✓ *Frequency*
- ✓ *Amplitude*
- ✓ *Phase & Phase Difference*

A.C Terminology

Waveform:

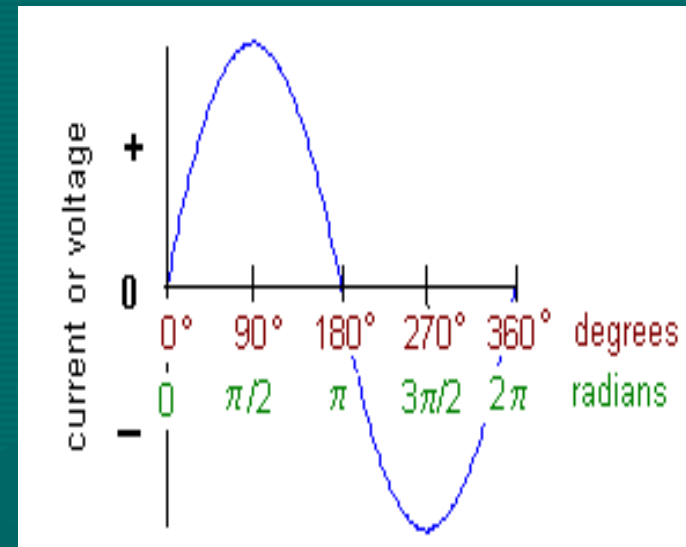
Plotting the instantaneous values Vs Time

Alternating Waveform:

The Waveform which reverses its direction regularly

Sinusoidal Waveform

- Alternating waveform in which **sine law** is satisfied
- **The Sinusoidal AC Waveform** The most common AC waveform is a *sine* (or *sinusoidal*) waveform.
- The **vertical axis** represents the **amplitude** of the AC current or voltage, in amperes or volts.
- The **horizontal axis** represents the **angular displacement** of the waveform. The units can be degrees or radians.



Sinusoidal Waveform

- The sine waveform is accurately represented by the **sine function** of plane trigonometry: $y = r \sin q$
- where:
 - y = the instantaneous amplitude
 - r = the maximum amplitude
 - q = the horizontal displacement

Sinusoidal Waveform

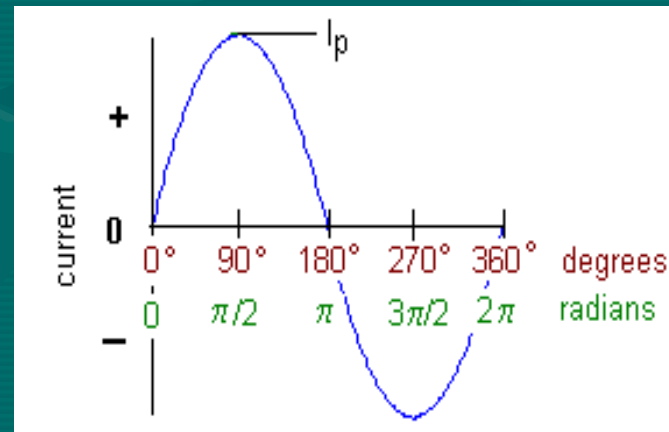
- **Instantaneous Current**

$i = I_p \sin q$ where

i = instantaneous current in amperes

I_p = the maximum, or peak, current in amperes

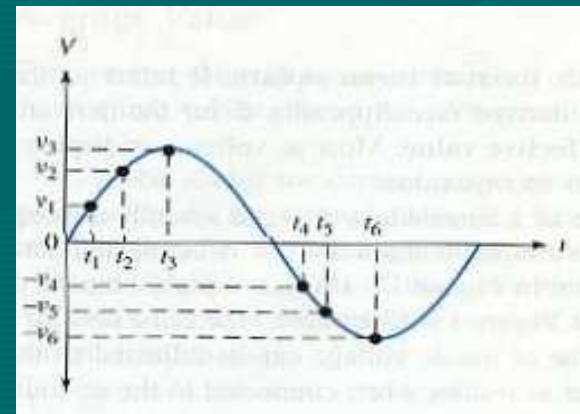
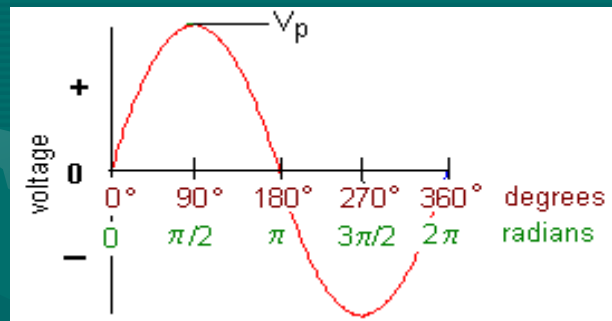
q = the angular displacement in degrees or radians



Sinusoidal Waveform

Instantaneous Voltage

- $v = V_p \sin q$ where
 - $v =$ instantaneous voltage in volts
 - $V_p =$ the maximum, or peak, voltage in volts
 - $q =$ the angular displacement in degrees or radians

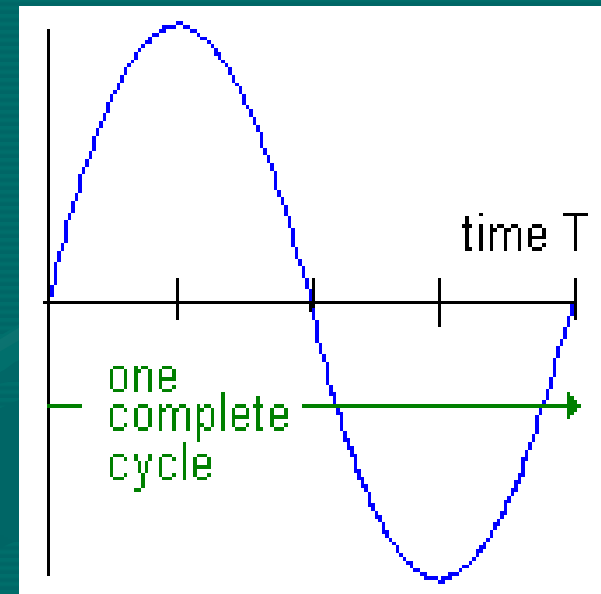


Sinusoidal Waveform

- Period of a waveform :

The **period** of a waveform is the time required for completing one full cycle.

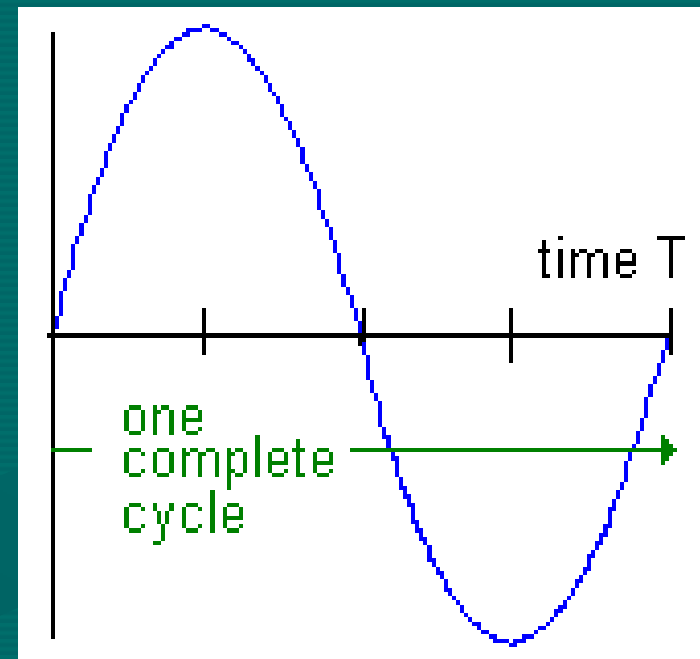
- Math symbol: T
Unit of measure: seconds
(s)



Sinusoidal Waveform

Period of a waveform :

- One period occupies exactly 360° of a sine waveform.
- The usual units of measure are:
 - seconds (s)
 - milliseconds (ms)
 - microseconds (μ s)

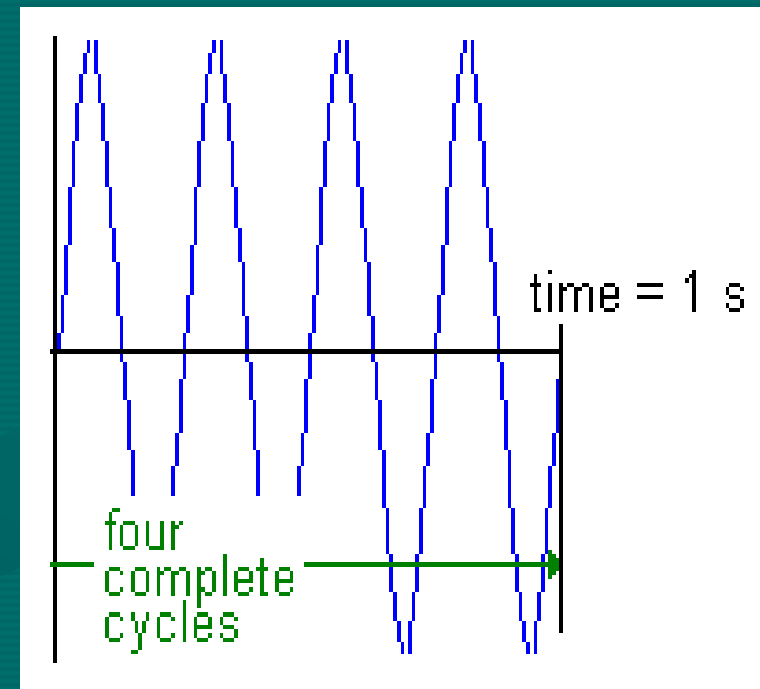


Sinusoidal Waveform

Frequency of a Waveform

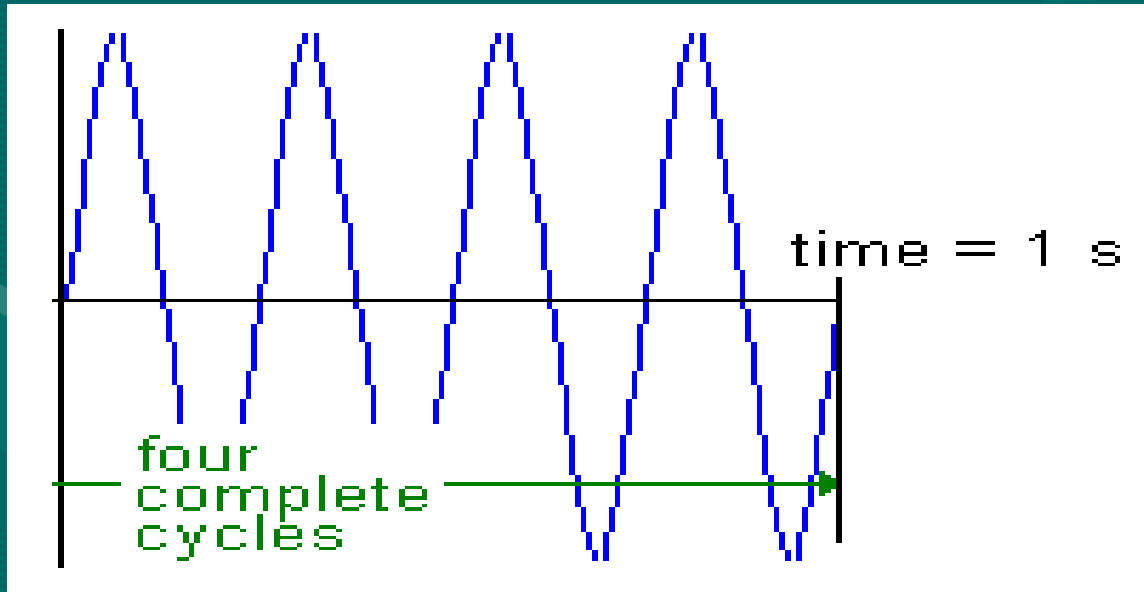
The **frequency** of a waveform is the number of **cycles** that is completed each **second**.

Math symbol: f
Unit of measure: hertz
(Hz)



Sinusoidal Waveform

- This example shows four cycles per second, or a waveform that has a frequency of **4 Hz**.



Sinusoidal Waveform

- Frequency to Period $T = 1/f$
- Period to Frequency $f = 1/T$

Sinusoidal Waveform

- A certain sine waveform has a frequency of 100 Hz. What is the period of this waveform?

Ans: 10 ms

- What is the frequency of a waveform that has a period of 200 ms?

Ans: 5 kHz

Sinusoidal Waveform

$$V = V_m \sin \omega t$$

$$I = I_m \sin \omega t$$

Angular velocity:

= Angle turned / time taken

$$= 2\pi / T$$

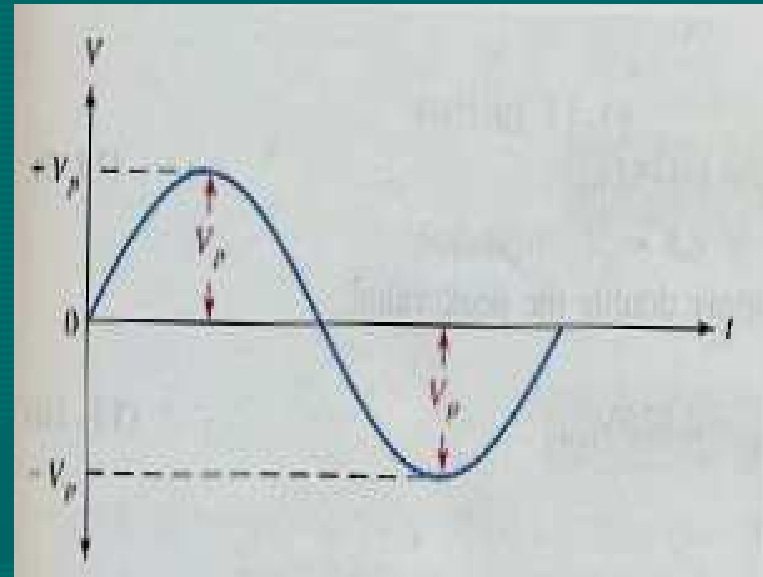
$$\omega = 2\pi F$$

Magnitude of sinusoidal waveform

- ✓ Peak value
- ✓ Average value (or) Mean value
- ✓ RMS value (or) Effective Value

Peak Voltage

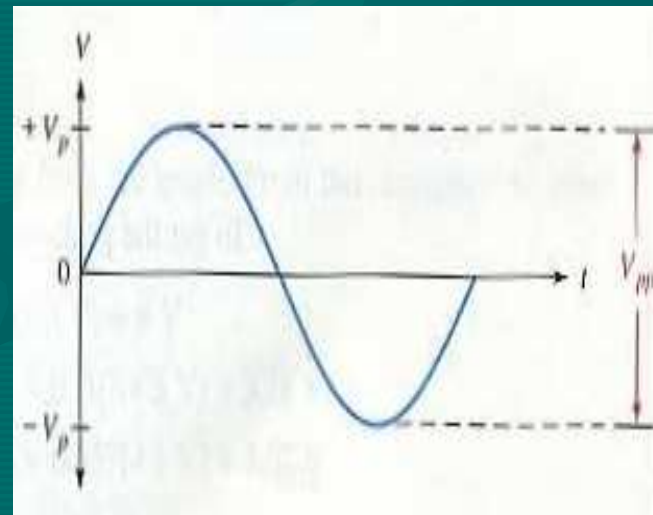
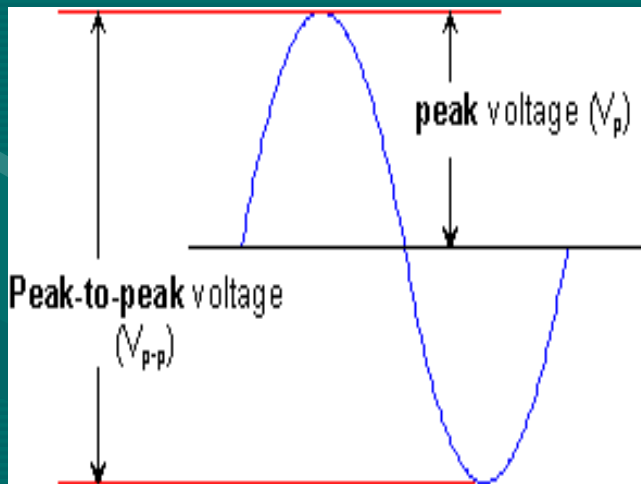
- **Peak voltage** is the voltage measured from the baseline of an ac waveform to its maximum, or peak, level. Unit: Volts Symbol: V_p
- For a typical sinusoidal waveform, the positive peak voltage is equal to the negative peak voltage
- Peak voltages are expressed without + or - sign.



Peak-to-peak voltage

Peak-to-peak voltage is the voltage measured from the maximum positive level to the maximum negative level.

Symbol: V_{p-p}



Peak-to-peak voltage

- For a typical sinusoidal waveform, the peak-to-peak voltage is equal to 2 times the peak voltage
- Peak and peak-to-peak values are most often used when measuring the amplitude of ac waveforms directly from an oscilloscope display

Peak-to-peak voltage

- Convert V_p to V_{p-p} :
- $V_{p-p} = 2 V_p$
- Convert V_{p-p} to V_p :
- $V_p = 0.5V_{p-p}$
- What is the peak-to-peak value of a sinusoidal waveform that has a peak value of 12 V?
 - Ans: 24
- V_p What is the peak value of a sine wave that has a peak -to-peak value of 440 V?
 - Ans: 220 V_p

Average value

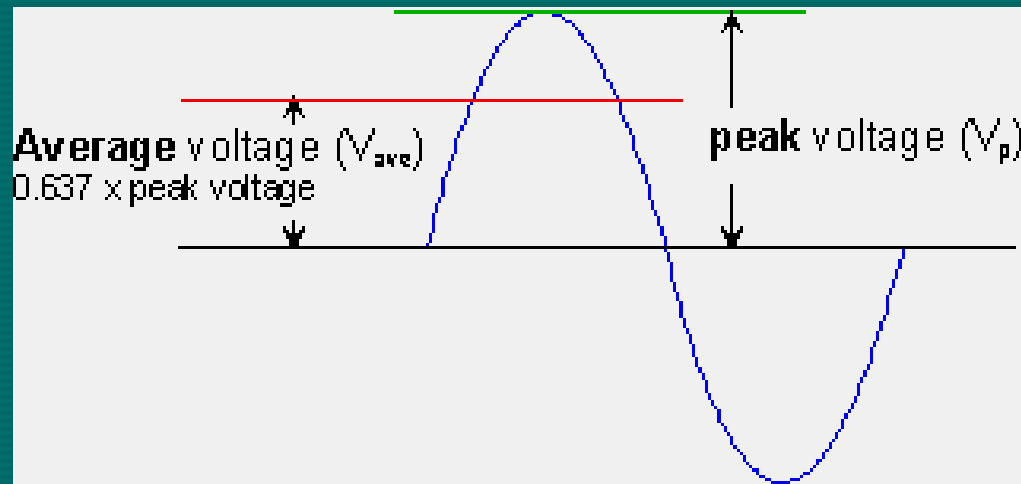
The arithmetic mean of all the instantaneous values of alternating quantity over one cycle is called its average value

Avg value = area under the curve / Base length

Average value

- If the waveform is symmetrical, then avg value is zero
- The average voltage is determined from just one half-cycle of the waveform because the average value of a full cycle is zero.
- The average voltage of a sinusoidal waveform is equal to 0.637 times its peak value.
- $V_{ave} = 0.637V_p$

Average value



Average value

Why Alternating current is not used for charging the Batteries?

RMS Value

- Each ac cycle consist of an identical positive and negative half cycles.
- The values of ac quantity changes from instant to instant. It becomes maximum at certain instant only.
- To specifying ac cycle, peak value is rarely used.

RMS Value

- RMS value is extensively used to express ac quantity.
- When current passes thro' a resistor, heat is produced.
- Let the heat produced by an AC of max value say I_{max} \neq the heat produced by an DC of I_{max}

RMS Value

- The effective value of an alternating current is that value of DC current which produces the same amount of heat as that produced by the AC when passed thro' the same resistance for the same amount of time
- $I_{dc} = \text{RMS value of } I_{ac}$

Phasor representation of Alternating quantity

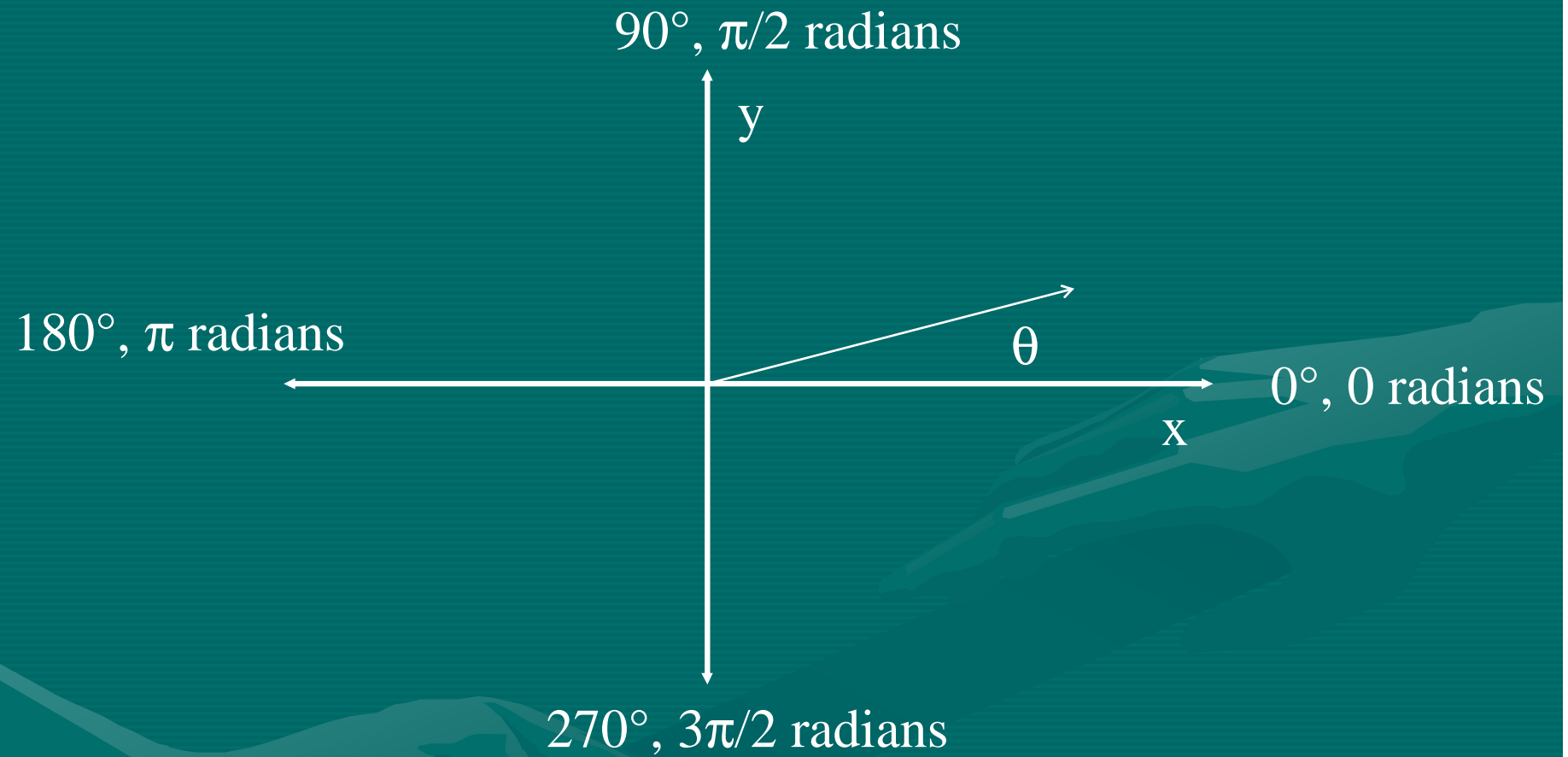
- Alternating Voltage or current can be represented in three forms
 - ✓ Waveforms
 - ✓ Equations
 - ✓ Phasors

phasor

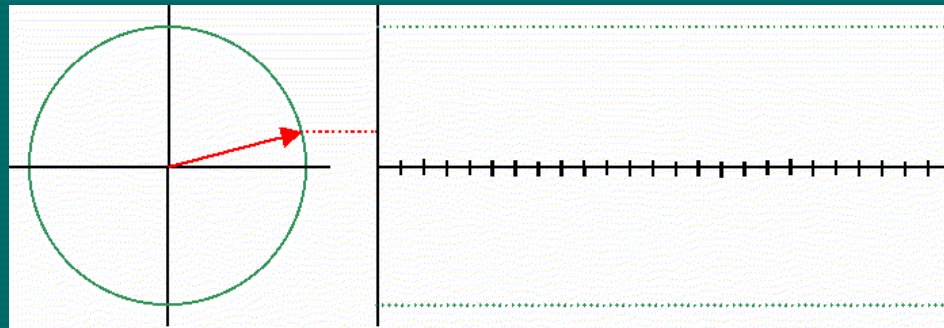
- A *phasor* is a **complex number** that represents the **magnitude** and **phase** of a sinusoidal voltage or current
- Represented by Line of Definite length rotating in anticlockwise direction at angular velocity ω . This rotating line is called PHASOR

Phasor representation of Alternating quantity

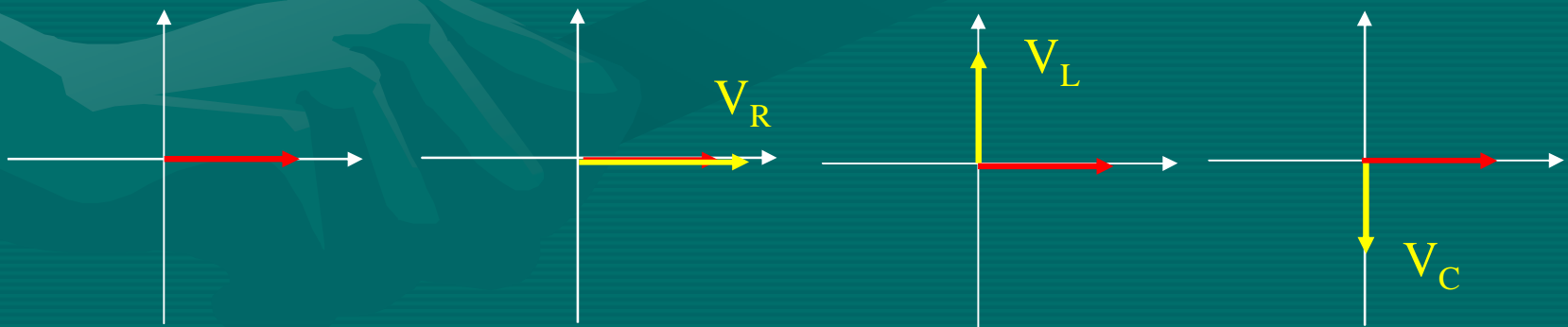
- The length of phasor equal to peak value of Alternating quantity



AC Circuits – Phasor Diagrams



Physlet simulation of phasors



D.ELANGO VAN
Current

Resistor AC Circuits

Inductor

Capacitor³⁸