

UNIT-2

AC CIRCUITS

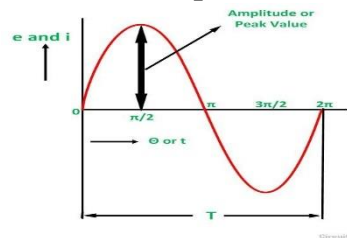
1. What is RMS (Root Mean Square) Value ?

The RMS (Root Mean Square) value (also known as effective or virtual value) of an alternating current (AC) is the value of direct current (DC) when flowing through a circuit or resistor for the specific time period and produces same amount of heat which produced by the alternating current (AC) when flowing through the same circuit or resistor for a specific time.

2. Define Peak Value

The maximum value attained by an alternating quantity during one cycle is called its **Peak value**. It is also known as the maximum value or amplitude or crest value. The sinusoidal alternating quantity obtains its peak value at 90 degrees as shown in the figure below.

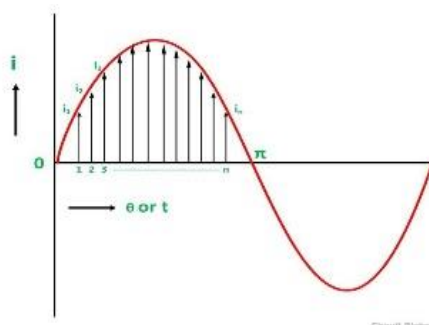
3. Define line currents and phase currents?



- The currents flowing in the lines are called as line currents
- The currents flowing through phase are called phase currents

4. Remember the term Average Value

Definition: The average of all the instantaneous values of an alternating voltage and currents over one complete cycle is called **Average Value**. If we consider symmetrical waves like sinusoidal current or voltage waveform, the positive half cycle will be exactly equal to the negative half cycle. Therefore, the average value over a complete cycle will be **zero**.



5. What is the effective value of a waveform?

The effective value of a sine wave is more commonly known as the **Root Mean Squared** or simply RMS value as it is calculated as the square root of the mean (average) of the square of the voltage or current.

6. Recall the term Waveform.

The waveform **describes the shape of one cycle of the voltage or current**. Current can be generated as an alternating current (AC), where the direction of the current flow alternates around zero with positive and negative direction

7. Define line voltage and phase voltage?

The voltage across one phase and neutral is called line voltage & the voltage between two lines is called phase voltage

8. What is meant by Real power?

Real power means the useful power transfer from source to load. Unit is watts.

9. What is meant by apparent power?

Apparent power is the product of voltage and current and it is not true power. Unit is VA

10. What is reactive power?

If we consider the circuit as purely inductive the output power is reactive power. Its unit is VAR

11. What are the advantages and disadvantages of a 3-phase circuit?

The single-phase circuits are easier to implement but are less efficient than three-phase circuits. On the other hand, **a three-phase circuit's design and setup are costly**. However, the operation cost will be much lower because of its power transfer efficiency.

12. Define power factor.

The power factor is the ratio between Real Power and Apparent Power.

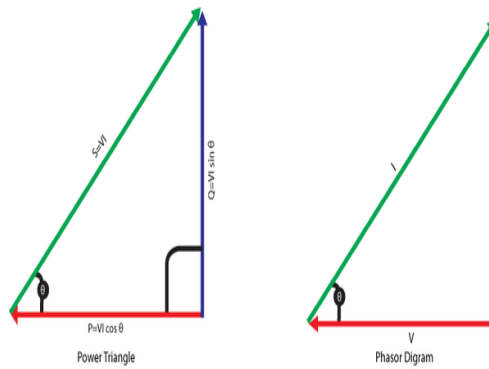
$$\text{Power Factor} = \frac{\text{Real Power (kW)}}{\text{Apparent Power (kVA)}} = \frac{\text{Beer}}{\text{Beer + Foam}}$$

13. What is a Power Triangle?

The power triangle is a right-angle triangle where Hypotenuse is the apparent power or true power (S), the Opposite side is the reactive power (Q) and the leftover Adjacent side is the active power or real power (P). These three parameters of AC circuits follow the Pythagoras' theorem as $S^2 = P^2 + Q^2$. The angle between P and S gives the Power Factor (or $\cos \theta$).

14. Define Leading Power Factor.

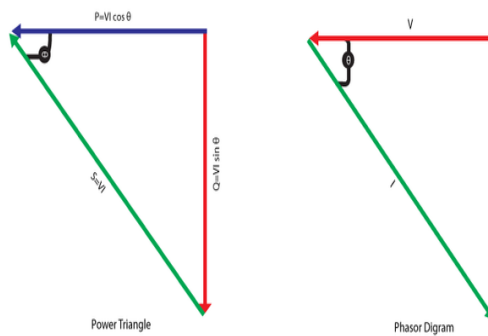
When the load is largely capacitive, leading power factor arises, resulting in a phase angle (θ) of less than 90 degrees between P and S.



Leading Power Factor

15. Define Lagging Power Factor

When the load is largely inductive, lagging power factor happens, resulting in a phase angle (θ) of greater than 90 degrees between P and S.



Lagging Power Factor

16. Draw the Power Triangle of AC circuits

In AC Circuits there are three types of power

- Apparent power (S)
- Active power (P)
- Reactive power (Q)

Let , V = R.M.S. value of applied Voltage , I = R.M.S. value of current flowing in AC circuit and θ = angle between voltage V and current I (= $\theta_v - \theta_i$)

17.what is Apparent Power (S)

It is the product of the R.M.S. value of the applied voltage and circuit current. It is also known as wattless or idle power .

$$S = V.I \text{ (Volt-Ampere or VA)}$$

18.Write formula for Active Power (P)

It is the power which is developed in the circuit resistance.

$$P = V \cdot I \cdot \cos \theta = V \cdot I \cdot \left(\frac{R}{Z} \right) \quad (\text{Watt}) \quad = \left(\frac{V}{Z} \right) \cdot I \cdot R = I \cdot I \cdot R = I^2 R$$

19. Tell about Reactive Power (Q)

It is the power which is developed in the circuit reactance.

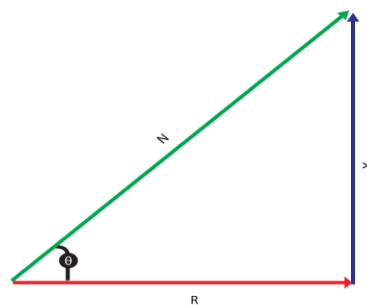
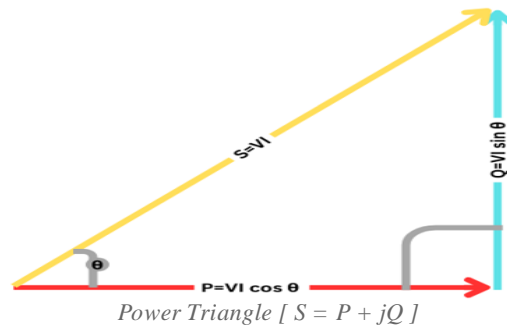
$$Q = V \cdot I \cdot \sin \theta = V \cdot I \cdot \left(\frac{X}{Z} \right) \quad (\text{Volt-Ampere-Reactive or VAR}) = \left(\frac{V}{Z} \right) \cdot I \cdot X = I \cdot I \cdot X = I^2 X$$

There is a relation between S, P and Q.

$$P^2 + Q^2 = (V \cdot I \cdot \cos \theta)^2 + (V \cdot I \cdot \sin \theta)^2 \quad [\cos^2 \theta + \sin^2 \theta = 1] \\ = (V \cdot I)^2 = S^2 \quad \text{Therefore, } P^2 + Q^2 = S^2 \text{ and } S = \sqrt{P^2 + Q^2}$$

Impedance (Z) is basically resistance of AC circuits and X_L and X_C is called inductive reactance and capacitive reactance which is the resistance offered by Inductors and Capacitors individually.

$$\text{Inductive Reactance } (X_L) = 2\pi f L \quad \text{Capacitive Reactance } (X_C) = \frac{1}{2\pi f C} \\ \text{Impedance } (Z) = \sqrt{R^2 + (X_L - X_C)^2} \quad \text{Here } X_L < \theta \text{ and } X_C > \theta$$



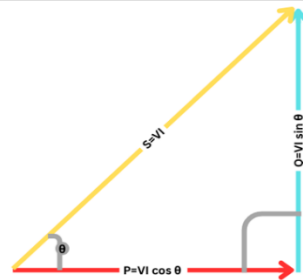
Impedance Triangle [$Z = R + jX$]

$$Z = \sqrt{R^2 + (X_L - X_C)^2} = \frac{V}{I} = \frac{V_{rms}}{I_{rms}} = \frac{V_{rms}}{I_{rms}} \angle (\theta_v - \theta_i) \quad I = \frac{V}{ZS} \\ = I_{2rms} \quad ZP = I_{2rms} R \quad Q = I_{2rms} X$$

Power Factor of AC circuits

Power Factor , $\cos \theta$, is an essential component of an AC circuit . It is defined as the ratio of real power (P) to apparent power (S) which is generally a decimal value .It lies in the range 0 to 1 , for example 0.95 or 95%.It also defines the phase angle between V and I

$$\text{Power Factor} = P/S = VI \cos \theta / VI = \cos \theta$$



Power Factor ($\cos \theta$)