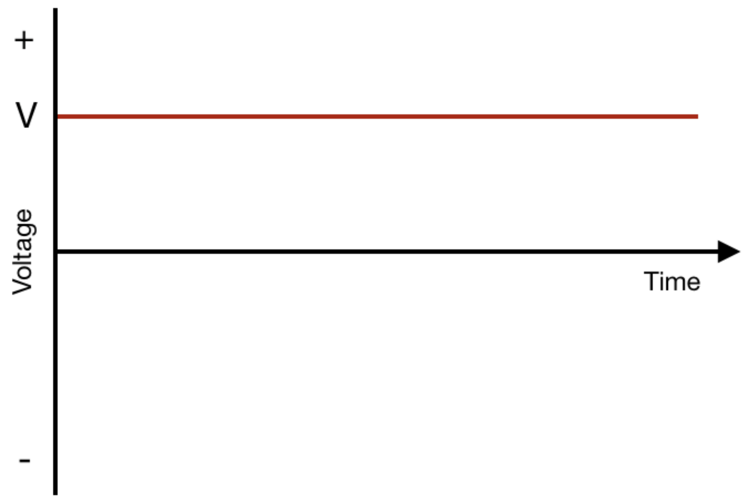
ELECTRICAL CIRCUIT

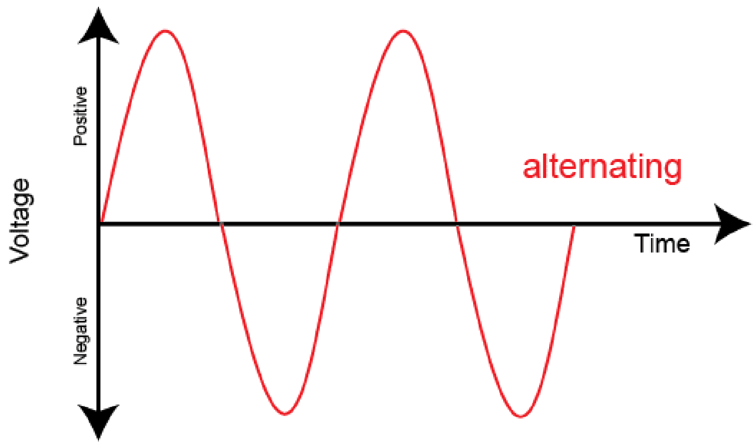
Differentiate between **DIRECT CURRENT (DC)** and **ALTERNATING CURRENT (AC)**

- DIRECT CURRENT (DC)



- Flow of electrical charge is only in one direction.
- Source:
    - Dry cell battery
    - Solar cell

- ALTERNATING CURRENT (AC)



- The movement of electrical charge periodically reverses directions.
- Source:
    - Alternating current generator

Faraday’s Law & Lenz’s Law:

- FARADAY’S LAW
  - Any change in the magnetic environment of a coil of wire will cause a voltage (emf) to be induced in the coil.

- LENZ’S LAW
  - There is induced current in a closed conducting loop if and only if the magnetic flux through the loop is changing.

Equation Of a Sinusoidal Waveform

$$e = Em \sin\ (wt + \theta)$$

Em = Peak voltage

w = Angular frequency (unit: radians per second)

t = Time (unit: second)

θ = The phase

Equation Of Frequency

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

Equation Of Time

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

RMS Value

V rms = 0.707 Vp

I rms = 0.707 Ip

0.707 = $1/\sqrt{2}$

Average Value

$$\text{Vavg} = 0.637\ \text{Vp} \ @\ 2/\pi\ \text{Vp}$$

$$\text{Iavg} = 0.637\ \text{Ip} \ @\ 2/\pi\ \text{Ip}$$

Form Factor

$$\frac{Rms\ value}{Average\ value} = 1.11$$

Peak Factor

$$\frac{Peak\ value}{rms\ value} = 1.414$$

Convert Radians to Degrees

$$rad = \frac{2\pi\ rad}{360°}\ @\ \frac{\pi}{180°}\ x\ degree$$

Convert Degrees to Radians

$$\deg = \frac{360°}{2\pi\ rad}\ @\ \frac{180°}{\pi}\ x\ rad$$

Velocity Of Rotation (Angular Velocity)

$$\omega = 2\pi f$$

Kirchoff's Current Law

$$i_2 + i_3 = i_1 + i_4$$

Kirchoff's Voltage Law

$$v_1 + v_2 + v_3 + v_4 = 0$$

Inductive Reactance, XL

$$X_L = \frac{V_L}{I_L} = 2\pi f L$$

Capacitive Reactance, XC

$$X_c = \frac{V_C}{I_C} = \frac{1}{2\pi f C}$$

Series RL Circuit

- The Impedance (Z)

$$Z = \sqrt{R^2 + X_L^2}$$

- The Phase Angle (θ)

$$\theta = \tan^{-1}(\frac{X_L}{R})$$

- Ohm's Law

$$V = IZ$$

$$I = \frac{V}{Z}$$

$$Z = \frac{V}{I}$$

- Source Voltage

$$V_S = \sqrt{V_R^2 + V_L^2}$$

Parallel RL Circuit

- Impedance (Z)

$$Z = \frac{RX_L}{\sqrt{R^2 + X_L^2}}$$

- The Phase Angle

$$\theta = \tan^{-1}(\frac{R}{X_L})$$

- The Total Current

$$I_{tot} = \sqrt{I_R^2 + I_L^2}$$

- The Phase Angle Between The Resistor Current & Voltage Phasor

$$\theta = \tan^{-1}(\frac{I_L}{I_R})$$

RC Series Circuit

- Impedance (Z)

$$Z = \sqrt{R^2 + X_C^2}$$

- The Phase Angle

$$\theta = \tan^{-1}(\frac{X_C}{R})$$

- Source Voltage

$$V_S = \sqrt{V_R^2 + V_C^2}$$

- The Phase Angle Between The Resistor Voltage & The Source Voltage

$$\theta = \tan^{-1}(\frac{V_C}{V_R})$$

Parallel RC Circuit

- Impedance

$$Z = \frac{RX_C}{\sqrt{R^2 + X_C^2}}$$

- The Phase Angle

$$\theta = \tan^{-1}(\frac{R}{X_C})$$

- Current Total

$$I_{tot} = \sqrt{I_R^2 + I_C^2}$$

- The Phase Current Values

$$\theta = \tan^{-1}(\frac{I_C}{I_R})$$

RLC Series Circuit

When XL > XC

- Total Resistance

$$X_{tot} = |X_L - X_C|$$

- Total Impedance

$$Z_{tot} = \sqrt{R^2 + (X_L - X_C)^2}$$

- The Phase Angle

$$\theta = \tan^{-1}(\frac{X_{tot}}{R})$$

When XC > XL

- Total Resistance

$$X_{tot} = |X_C - X_L|$$

- Total Impedance

$$Z_{tot} = \sqrt{R^2 + (X_C - X_L)^2}$$

- The Phase Angle

$$\theta = \tan^{-1}(\frac{X_{tot}}{R})$$

RLC Parallel Circuit

- Impedance

$$Z_{LR} = \sqrt{R^2 + X_L^2}$$

$$\therefore Z_T = \frac{Z_{LR}X_C}{\sqrt{(Z_{LR})^2 + (X_C)^2}}$$

- Current

$$I_{LR} = \frac{V}{Z_{LR}} \text{ and } I_C = \frac{V}{X_C}$$

- Circuit Impedance

$$Z = \frac{V}{I}$$

- Phase Angle

$$\frac{V_L}{V_R} = \frac{X_L}{R}$$

Power

$$P = VI = I^2R = \frac{V^2}{R}\ watts$$

True Or Active Power

$$P = VI\ \cos\theta\ watts\ (W)$$

Reactive Power

$$Q = VI\ \sin\theta\ \ vars\ (var)$$

Apparent Power

$$S = VI\ voltamperes\ (VA)$$

Power Factor

$$power\ factor = \frac{P}{S} = \frac{VI\ \cos\theta}{VI}$$

Resonance

- Resonance is a circuit condition that occurs when the Inductive Reactance (XL) is EQUAL to the Capacitive Reactance (XC) have been balanced.

$$X_L = X_C$$

$$2\pi f L = \frac{1}{2\pi f C}$$

Series RLC Circuit (RESONANT FREQUENCY)

$$X_L = X_C \rightarrow 2\pi f L = \frac{1}{2\pi f C}$$

$$f^2 = \frac{1}{2\pi L \; x \; 2\pi C} = \frac{1}{4\pi^2 LC} \rightarrow f = \sqrt{\frac{1}{4\pi^2 LC}}$$

$$\therefore fr = \frac{1}{2\pi\sqrt{LC}} \text{ (Hz)}$$

Quality Factor (Q Factor)

$$Q = \frac{1}{R}\sqrt{\frac{L}{C}}$$

Bandwidth (BW)

$$BW = \frac{f_r}{Q}$$

Or

$$BW = f_H - f_L$$

Or

$$BW = \frac{R}{L} \text{ (rads)}$$

Or

$$BW = \frac{R}{2\pi f L} \text{ (Hz)}$$

Turn Ratio

$$\frac{E_S}{E_P} = \frac{N_S}{N_P}$$

Where:

N_P= Number of turns in the primary

E_P= Voltage applied to the primary

N_S= Number of turns in the secondary

E_S= Voltage applied to the secondary

Current

$$\frac{E_P}{E_S} = \frac{N_P}{N_S} = \frac{I_S}{I_P}$$

Where:

I_P= Primary Current

I_S= Secondary Current

Efficiency Of a Transformer

$$\eta = \frac{output\ power}{input\ power} = \frac{input\ power - losses}{input\ power}$$

$$\eta = 1 - \frac{losses}{input\ power}$$

Full Load Output Power

$$IV\ \cos\theta$$

Copper Loss

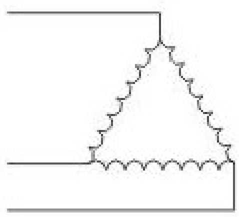
$$I_P^2 R_P + I_S^2 R_S$$

Total Losses

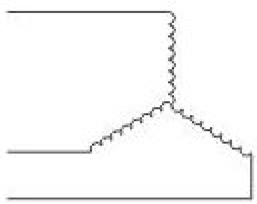
$$copper\ loss + iron\ loss$$

STAR VS DELTA CONNECTION

Sl. No.	Star (Y) Connected System	Delta (Δ) Connected System
1.	In star connected system there is common point known as neutral 'n' or star point. It can be earthed.	There is no neutral point in delta connected system
2.	In star connected system we get 3-phase, three wire system and also 3-phase, 4 wire system is taken out.	Only 3-phase, 3 wire system is possible in delta connected system
3.	Line voltage $V_L = \sqrt{3}\, V_{ph}$ or, $V_{ph} = \frac{1}{\sqrt{3}} V_L$	Line voltage = Phase voltage $V_L = V_{ph}$
4.	Line current = Phase current $I_L = I_{ph}$	Line current $I_L = \sqrt{3}\, I_{ph}$ $I_{ph} = \frac{1}{\sqrt{3}} I_L$
5.	Three phase power $= \sqrt{3}\, V_L I_{ph} \cos\phi$ $= 3\, V_{ph} I_{ph} \cos\phi$	Three phase power $= \sqrt{3}\, V_L I_L \cos\phi$ $= 3\, V_{ph} I_{ph} \cos\phi$



Delta



Star