3-phase AC circuits :-

→ 3ϕ system is a combination of 3 single phase systems.

→ In a balanced 3ϕ system, 3 voltages in phase by 120° electrical from each other in a particular sequence and they have equal magnitudes.

Advantages of 3ϕ system:-

(i) More efficient than 1ϕ system.

(ii) Transmission of same power, 3ϕ circuits require less conductor material than 1ϕ system.

(iii) 3ϕ motors self starting but 1ϕ motors are not self starting.

(iv) 1ϕ motors producing pulsating torque, but 3ϕ motor produces uniform torque.

(v) Generation, transmission & Distribution of 3ϕ system is cheaper.

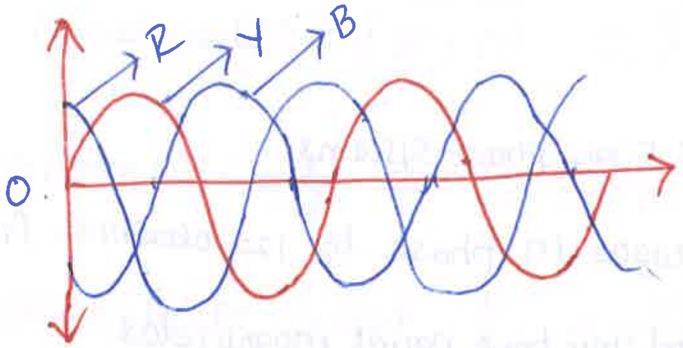
→ Consider 3 coils are R, Y, B which is displaced by 120° each other. According to faraday's law of electromagnetic induction emf induced in 3 coils are,

$$V_R = V_m \sin \omega t,$$

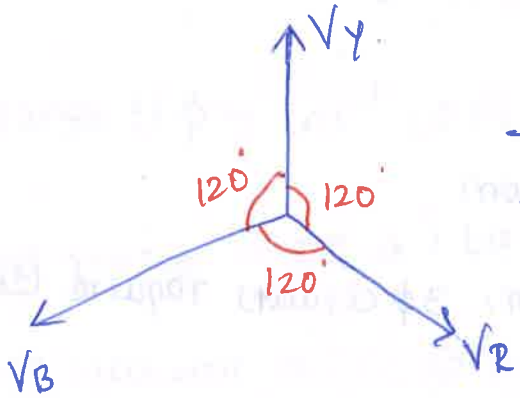
$$V_Y = V_m \sin(\omega t - 120^\circ)$$

$$V_B = V_m \sin(\omega t - 240^\circ).$$

→ All these 3 emf have the same ~~magnitude~~ Amplitude, Time period, frequency, but the starting and ending points are different.



→ In case emf induced in R phase is V_R be taken as reference, V_Y lags behind by 120 from V_R and V_B lags 240° from the V_R.



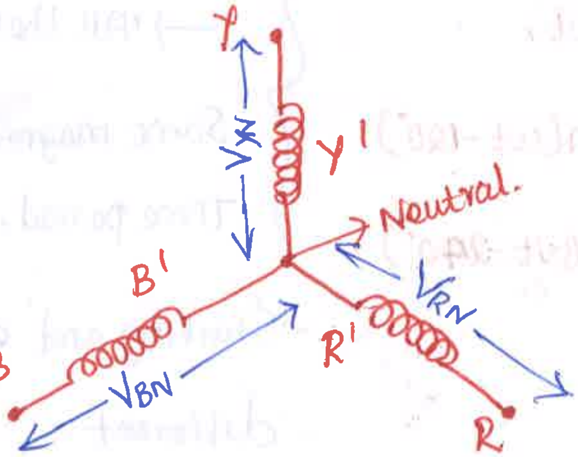
→ In order is which the different Phasors reach their respective maximum and minimum values is known as phase sequence.

→ which indicates the rotation of phasors in a particular direction.

Three phase connections :-

Star connection :-

→ In a star connection, the similar ends of different coils connected together to form a ~~~~ neutral point.



→ Voltage and current induced on each phase is known as phase voltage (V_{ph}) and phase current (I_{ph}).

→ potential different between 2 phase is known as line voltage (V_L).

from the diagram line voltages are,

$$\boxed{V_L = \sqrt{3}\, V_{ph}}$$

→ The current passing through any 2 phases are remains the same thus,

ie, Line current = phase current. $\boxed{I_L = I_{ph}}$

Power = 3 x phase power.

$$= 3(V_{ph} I_{ph} \cos\phi) = 3 \frac{V_L}{\sqrt{3}} \cdot I_L \cos\phi.$$

$$\boxed{P = \sqrt{3}\, V_L I_L \cos\phi \text{ Watts}}$$

Delta connection :-

→ If the 3 windings are connected as end of the one phase to the start of another. We get closed winding is known as delta connection.

→ In this case, there is only one winding is included between any two phases. hence, the voltage between 2 phase is equal to phase voltage.

i.e., $$\boxed{V_L = V_{ph} = V_{RY} = V_{BR} = V_{YB}}.$$

(

Y

|

B

Thus, $I_L = \sqrt{3} I_{ph}$.

Power = 3 x phase power $\Rightarrow 3 V_{ph} I_{ph} \cos\theta$.

$$= 3 V_L \left(\frac{I_L}{\sqrt{3}}\right) \cos\theta = \sqrt{3} V_L I_L \cos\theta.$$

$$\boxed{P = \sqrt{3} V_L I_L \cos\theta . \text{Watts}}$$

1) An inductive coil take 10A and dissipates 1000W. When connected to a supply at 250V, 25HZ. Calculate the impedance, the effective resistance, the reactance, the inductance & the power factor.

Soln:- $I = 10A$, $P = 1000W$ (actual power), $V = 250V$, $f = 25HZ$.

Inductive coil will also have certain resistance. So, it is equivalent to an R-L circuit.

$$\text{power} = VI\cos\phi \Rightarrow I^2 R = 1000$$

$$(10)^2 \times R = 1000$$

$$R = \frac{1000}{100} = 10\,\Omega.$$

$$\text{impedance}(Z) = \frac{V}{I} = \frac{250}{10} = 25\,\Omega.$$

$$= \sqrt{R^2 + X_L^2}, \quad X_L = \sqrt{Z^2 - R^2} = 22.91\,\Omega.$$

$$X_L = \omega L = 2\pi f L$$

$$22.91 = 2\pi f L \quad (f \to 25)$$

$$22.91 = 2\pi \times 25 \times L, \quad \boxed{L = 0.146 H.}$$

Powerfactor $\Rightarrow \cos\phi = \frac{R}{Z} = \frac{10}{25} = 0.4$ lagging.

Otherwise,

$$P = VI\cos\phi$$

$$1000 = 250 \times 10 \times \cos\phi$$

$$\boxed{\cos\phi = 0.4 \text{ lagging}}$$