Chapter 11: Balanced Three-Phase CirCuits

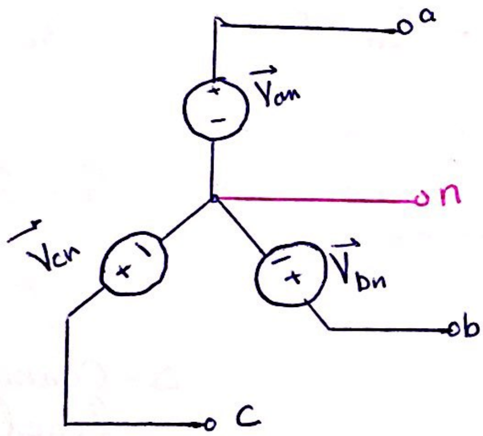
Three phase circuit : three sources having the same amplitude and frequency but out of phase by 120°

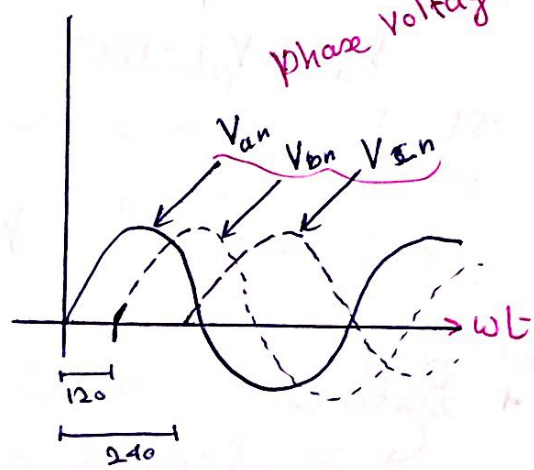
1- • The instant-aneous power ⟶ Constant

2- • P_{loss} in 3-phase.sys $= \frac{1}{2} P_{loss}$ in 1-phase.sys

* Possible Configurations of 3.p.S :-

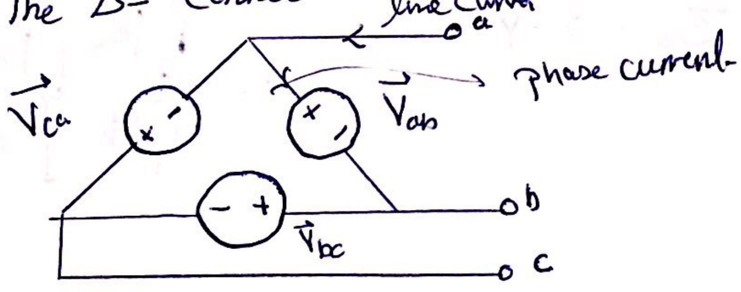
1- The Y- Connected Source





• V_{ab}, V_{bc}, V_{ca} are line-to line Voltages

2- The Δ- Connected Source



* The phase Sequence

1- abc sequence (positive sequence)

2- acb sequence (negative sequence)

1- (+) Sequence:-

لعكس الريش للتيار

$$V_{an} = V_p \angle 0^\circ$$
$$V_{bn} = V_p \angle -120$$
$$V_{cn} = V_p \angle +120$$

مع عقارب الساعة

line to line voltage → line to line Vol

$$\vec{V}_{ab} = \sqrt{3}\ \vec{V}_{an} \angle +30^\circ$$
$$\vec{V}_{bc} = \sqrt{3}\ \vec{V}_{bn} \angle +30^\circ$$
$$\vec{V}_{ca} = \sqrt{3}\ V_{cn} \angle +30^\circ$$

I_{ab}, I_{bc}, I_{ca} are phase currents

2- (-) sequence

$$V_{an} = V_p \angle 0^\circ$$
$$V_{bn} = V_p \angle 120^\circ$$
$$V_{cn} = V_p \angle -120^\circ$$

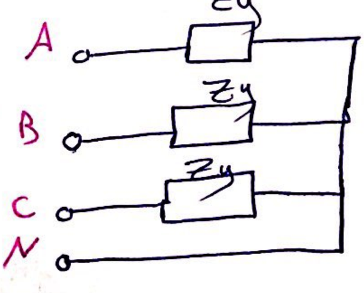
عكس عقارب الساعة

$$\vec{V}_{ab} = \sqrt{3}\ \vec{V}_{an} \angle -30^\circ$$
$$\vec{V}_{bc} = \sqrt{3}\ \vec{V}_{bn} \angle -30^\circ$$
$$\vec{V}_{ca} = \sqrt{3}\ \vec{V}_{cn} \angle -30^\circ$$

Balanced set: $V_{an} + V_{bn} + V_{cn} = 0$

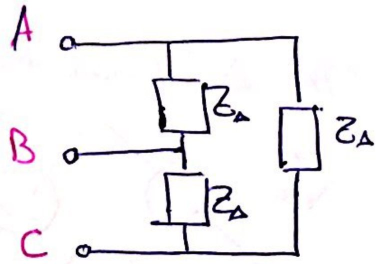
* Balanced Three phase loads:-
  ↳ Z is equal on all phases:

Y-Connected load



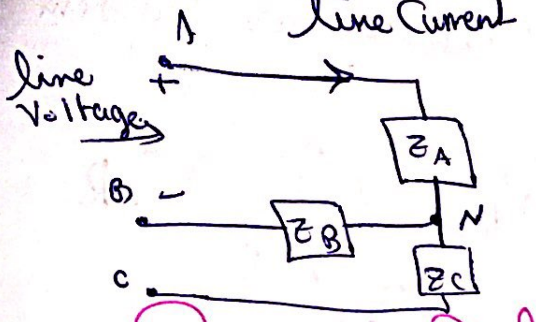
$$Z_\Delta = 3 Z_Y$$

Δ-Connected load



- We Connect the three phase Source with the the phase load by: Y-Y or Y-Δ or Δ-Y or Δ-Δ

Note:



فرق بين الـ Phase current و الـ line current

line current ← التيار اللي عبر بين A و N او B و N

Phase current ← التيار اللي عبر باللود

V_{CN} is phase voltage (voltage across a single phase)

/ V_{AB} is line to line voltage (voltage across any pair of lines)

* Power in Balanced System

- $P_{instantaneous}$ is Constant
- $P_T = 3 V_p I_p \cos\theta$

loads

Y-load

- P_{av} :-

$P_A = P_B = P_C = P_T$

$P_T = \sqrt{3} V_L I_L \cos\theta$

$V_{AN} = \frac{V_L}{\sqrt{3}}$

$I_{ct} = I_L$

- Q

$Q_T = \sqrt{3}\, V_L I_L \sin\theta$

- Complex: $\vec{S}_T$

$S_T = \sqrt{3}\, V_L I_L \angle\theta$

Δ-load

- P_{av}:

$P_T = \sqrt{3}\, V_L I_L \cos\theta$

- Q:-

$Q_T = \sqrt{3}\, V_L I_L \sin\theta$

- Complex $\vec{S}$

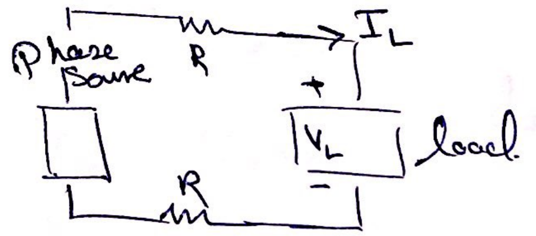
$\vec{S}_T = \sqrt{3}\, V_L I_L \angle\theta$

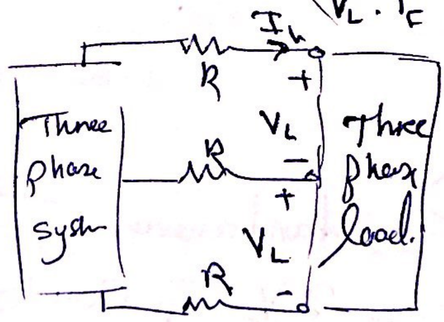
* Comparing Power loss:

Single phase System

Three-phase System

$$P_{loss} = \left(\frac{P_L}{V_L \cdot P_F}\right)^2 (2R) \quad >>> \quad P_{loss} = \left(\frac{P_L}{V_L \cdot P_F}\right)^2 \cdot R$$

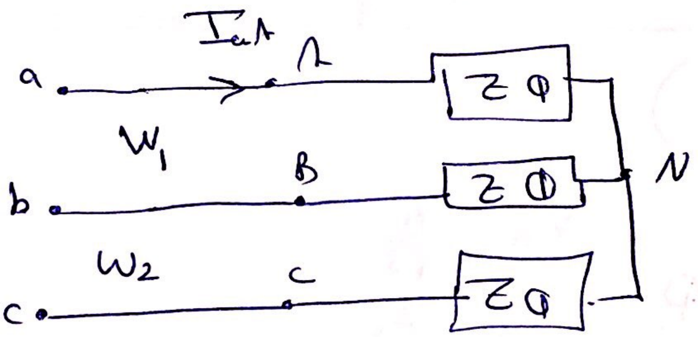




* Measuring Pav in 3Φ system

$$W_1 = V_L I_L \cos(\theta_z + 30^\circ)$$

Impedance angle



$$W_2 = V_L I_L \cos(\theta_z - 30^\circ)$$

$$P_{Total} = W_1 + W_2 = \sqrt{3}\, V_L I_L \cos\theta_z$$