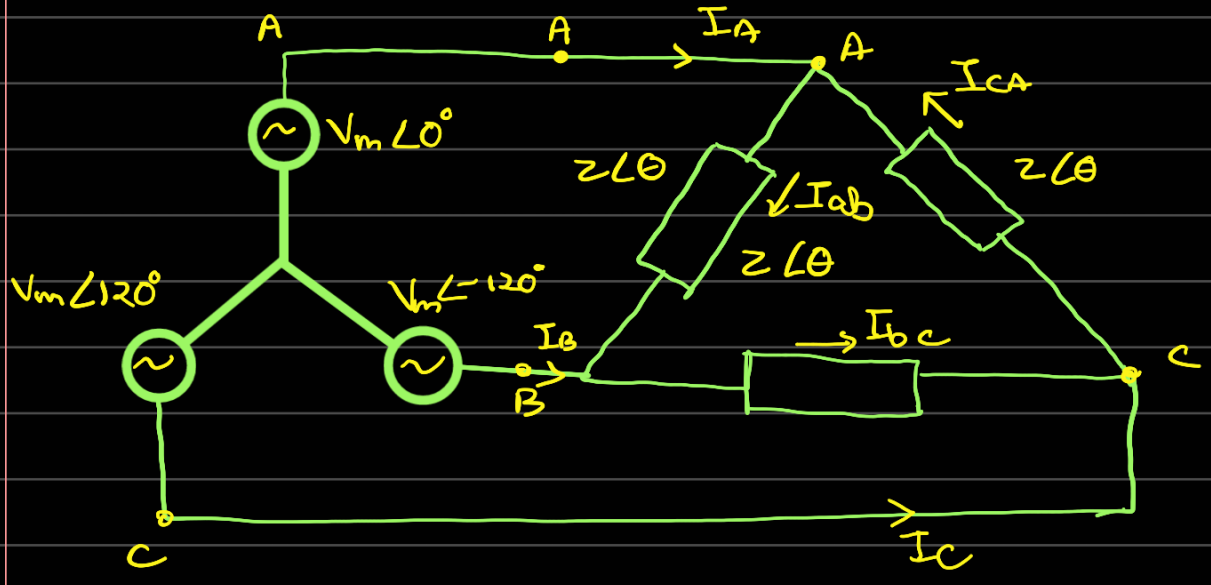
Day-11



$$V_{an} = V_m \sin \omega t$$
$$V_{bn} = V_m \sin(\omega t - 120°)$$
$$V_{cn} = V_m \sin(\omega t + 120°)$$

↓ peak

$$V_{ab} = V_{an} - V_{bn} = \sqrt{3} V_m \sin(\omega t + 30°)$$
$$V_{bc} = \sqrt{3} V_m \sin(\omega t - 90°) = V_{ab} \angle -120°$$
$$V_{ca} = \sqrt{3} V_m \sin(\omega t + 150°) = V_{ab} \angle 120°$$

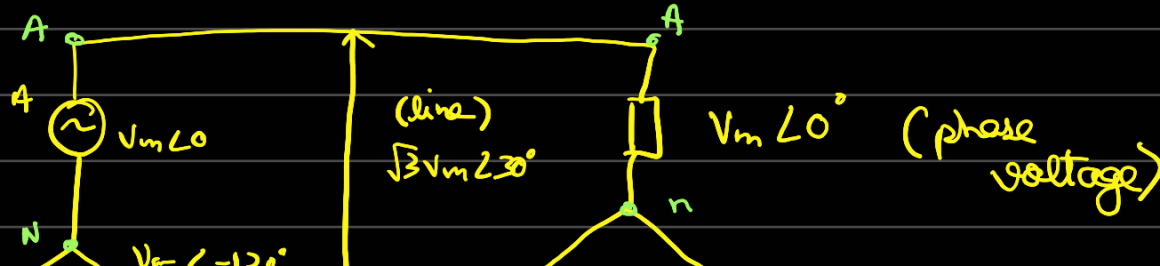
$$V_{ab} = \sqrt{3} V_{an} \angle 30°$$

$$I_A = \sqrt{3} I_{ab} \angle -30°$$

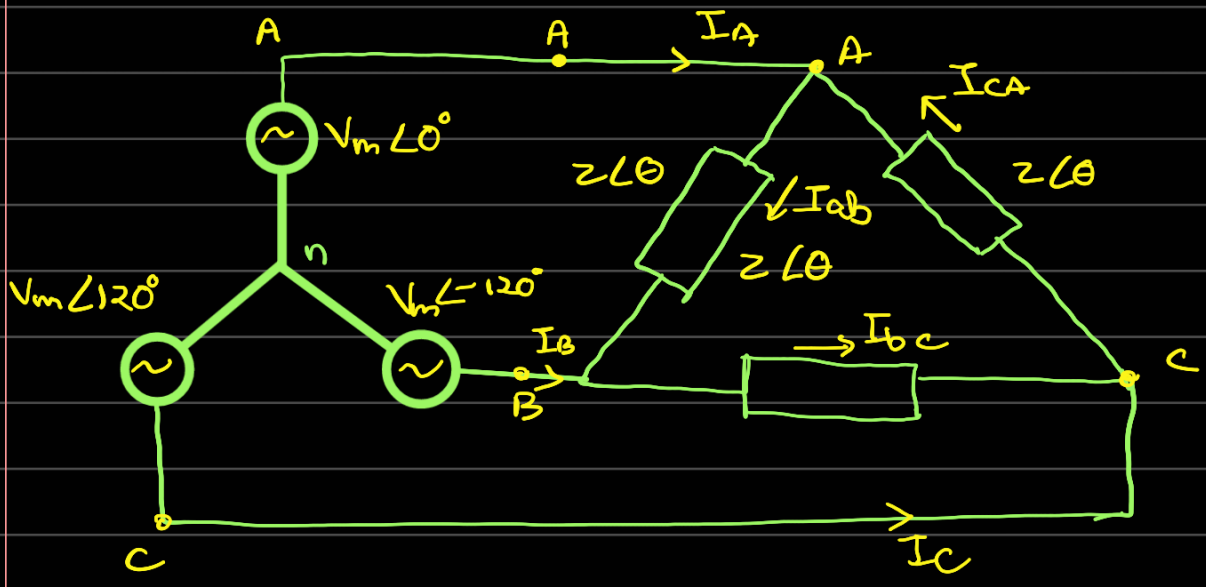
$$I_{CA} = I_{AB} \angle 120°$$

So $$I_A = I_{AB} - I_{CA}$$

$$= \sqrt{3} I_{AB} \angle -30°$$



1.)



$V_{an} = 100 \angle 0°$

$Z = 8 + 4j$ Find I_{ab}, I_{bc}, I_{CA}, I_a, I_b, I_c

(Ans) $$I_{ab} = \frac{\sqrt{3}\, V_{an} \angle 30°}{4\sqrt{5} \angle 26.565}$$

$$= 25\sqrt{\frac{3}{5}} \angle 3.435°$$

$$= 19.365 \angle 3.435° \quad A$$

$$I_{bc} = I_{ab} \angle -120°$$

$$= 19.365 \angle -116.565° \quad A$$

$$I_{ca} = I_{ab} \angle 120°$$
$$= 19.365 \angle 123.435°$$

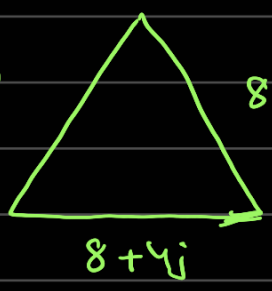
$$I_a = \sqrt{3}\, I_{ab} \angle -30°$$

$= 33.541 \angle -27.565^\circ \text{ A}$

$I_b = \sqrt{3}\, I_{bc} \angle -30^\circ = 33.541 \angle -146.565^\circ$

$I_c = \sqrt{3}\, I_{ca} \angle -30^\circ = 33.541 \angle 93.435^\circ$

2.)



(Same as Q.1)

$$I_{AB} = \frac{100\sqrt{3}}{8} \angle 30^\circ = 21.65 \angle 30^\circ$$

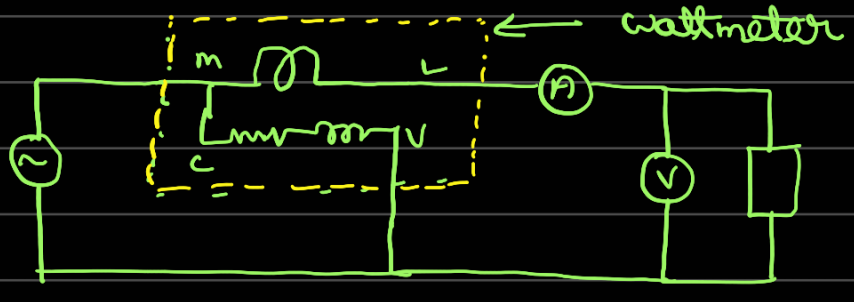
$$I_{BC} = \frac{100\sqrt{3} \angle -90^\circ}{8+4j} = 19.365 \angle -116.565^\circ$$

$$I_{CA} = \frac{100\sqrt{3} \angle 150^\circ}{8-4j} = 19.365 \angle 176.565^\circ$$

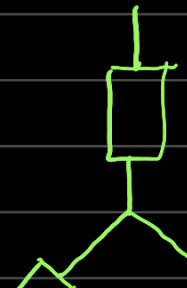
$I_A = I_{AB} - I_{CA}$

3) (H.W.)

2 wattmeters are sufficient to measure 3-phase power in a circuit. Explain how.



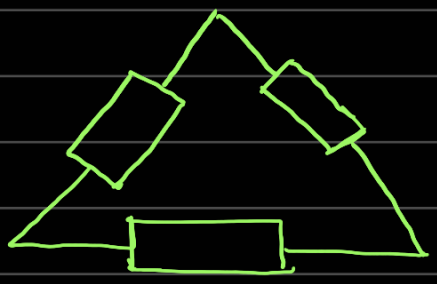
→ 3-phase power:



$P = 3V_p I_L \cos\theta$

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

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



$$P = \frac{3 V_L I_L \cos\theta}{\sqrt{3}}$$

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

Active power in 3-phase circuit is $\sqrt{3} V_L I_L \cos\theta$

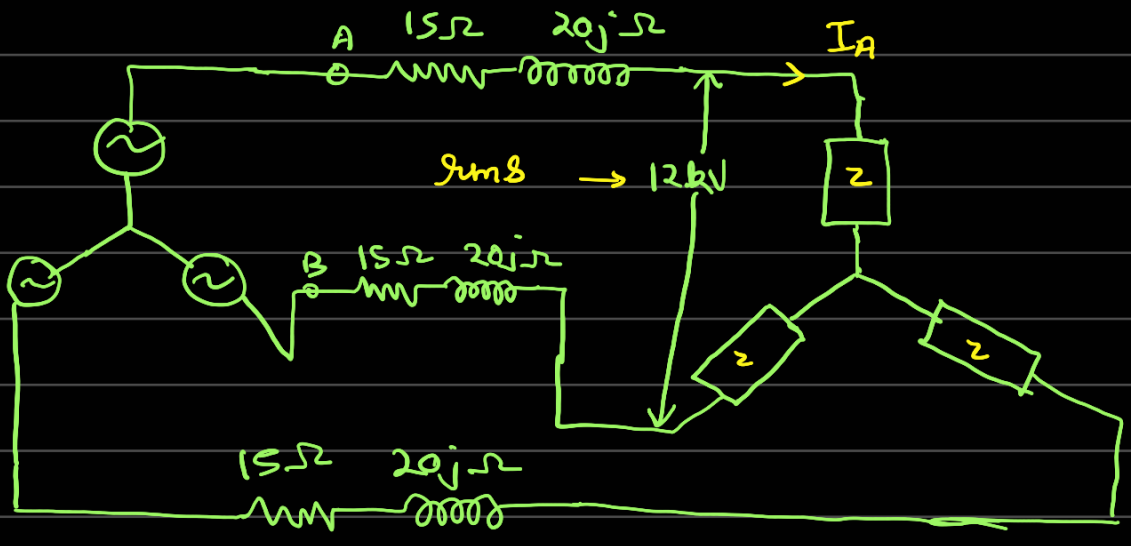
$P = \sqrt{3} V_L I_L \cos\theta$
$Q = \sqrt{3} V_L I_L \sin\theta$
$S = \sqrt{3} V_L I_L$

4.) Each transmission line of 3-wire 3-phase system has $Z = 15 + 20j\ \Omega$. System delivers $P_{Total} = 160$ KW at 12 kV to a balanced 3-phase star connected load with a lagging p.f. = 0.86.

a.) Determine $|V_{AB}|$

b.) Find p.f. of total load as seen by source.

c.) Efficiency of transmission?



Ans.) a.) $I_A\ (rms) = \frac{160/3}{\quad} = 8.95\ A$

$12/\sqrt{3} \times 0.86$

$$Z = \frac{12/\sqrt{3}}{8.95} \angle -\cos^{-1} 0.86 \times 1000 \ \Omega$$

$$= 774.1 \angle -30.68^\circ \ \Omega$$

$$Z_T = 774.1 \angle -30.68 + 25 \angle 53.13^\circ$$
$$= 680.726 - 375.019\,j$$
$$= 777.19 \angle -28.85^\circ$$

$$|V_{AB}| = \sqrt{3} \times 8.95 \times 777.19 \times 10^{-3} \ kV \quad (rms)$$
$$= 12.05 \ kV$$

b.) $p.f.\ (Total) = \cos(-28.85^\circ) = 0.876$

c.) $$\text{Efficiency} = \frac{160}{\sqrt{3} \times 12.05 \times 8.95 \times 0.876} = 0.9778 \simeq 97.78\%.$$