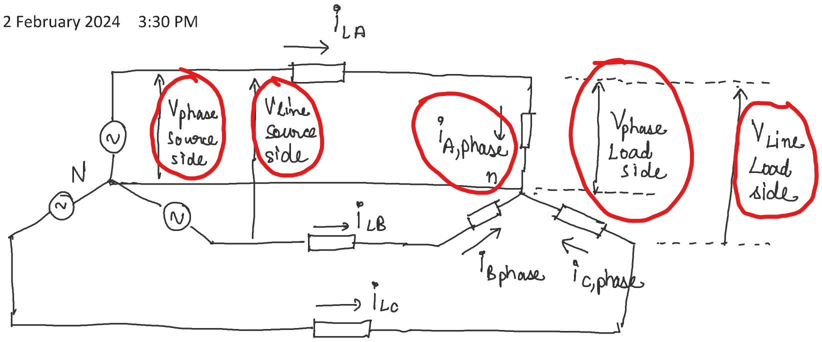
# Lecture 7

Friday, 2 February 2024 3:30 PM




Fig(i)

Balanced means that everything is same but the theta values are different.

Most of our formulas are for ideal or particular cases and so learn the concepts and not the formulas.

When doing these questions, first make a rough diagram and deduce all the circuit related properties and then start solving the question. Write the required variables in terms of the known ones. Take time but do correctly.

Phase voltage and current can be defined for load side and source side.

In the above figure with star connected load

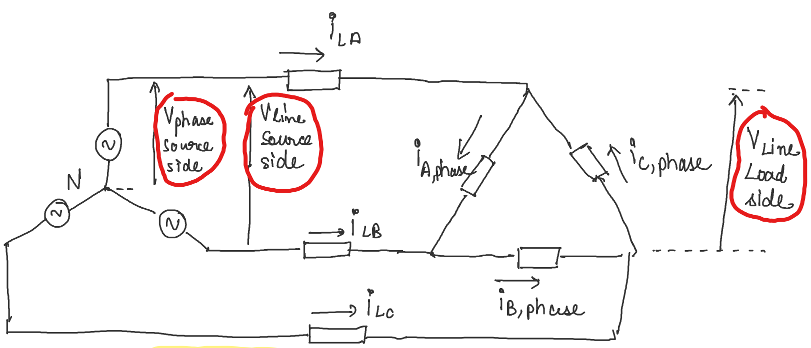
(i) Line current = Load side phase current

$\checkmark$ $\bar{I}_{A,phase} = \bar{I}_{LA}$

(ii) And at load side

$$\sqrt{3}\ \bar{V}_{phase,An} \angle 30^\circ = \bar{V}_{AB} \checkmark$$

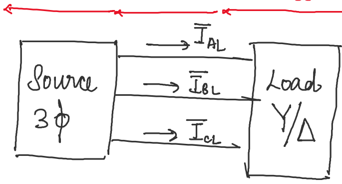
In delta connected loads :-

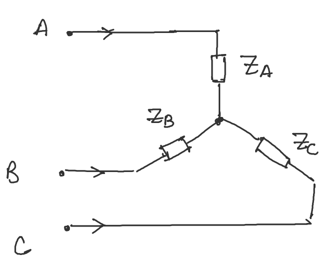


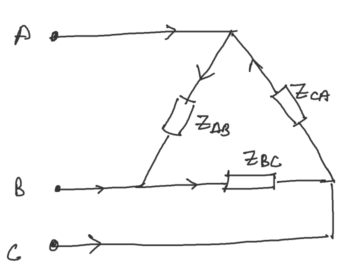

(i) $\boxed{\bar{V}_{line\,(load\,side)} = \bar{V}_{phase\,(load\,side)}}$

(ii) $\boxed{\bar{I}_{LA} = \bar{I}_{A,phase} - \bar{I}_{c\,phase}}$

* Conversion from star load to delta load & vice-versa:-



Impedance b/w AB in Y $= Z_A + Z_B$

Impedance b/w AB in $\Delta = \dfrac{Z_{AB}(Z_{BC}+Z_{CA})}{Z_{AB}+Z_{CA}+Z_{BC}}$

$$\Rightarrow \quad Z_A + Z_B = \frac{Z_{AB}(Z_{BC}+Z_{CA})}{Z_{AB}+Z_{CA}+Z_{BC}} \quad \text{—— (i)}$$

Similarly

$$Z_B + Z_C = \frac{Z_{BC}(Z_{AB}+Z_{CA})}{Z_{AB}+Z_{BC}+Z_{CA}} \quad \text{—— (ii)}$$

&

$$Z_C + Z_A = \frac{Z_{CA}(Z_{AB}+Z_{BC})}{Z_{AB}+Z_{BC}+Z_{CA}} \quad \text{—— (iii)}$$

Using the above three-equations :-

$$\boxed{Z_A = \frac{Z_{AB}\,Z_{CA}}{Z_{AB}+Z_{BC}+Z_{CA}}}$$

$$\boxed{Z_{AB} = \frac{Z_A Z_B + Z_B Z_C + Z_C Z_A}{Z_C}}$$

Source can be star or delta too.

* Total complex power $\quad S_{3\phi} = S_A + S_B + S_C$

$(P + jQ)$

In case of a balanced system $S_A = S_B = S_C$

$$\boxed{S_{3\phi} = 3S_A}$$

$S_{A\text{-source}} = \overline{V_{AN}}\ \overline{I_A}^{*}$

$P_{A\text{-source}} = |\overline{V_{AN}}| \times |\overline{I_A}| \cos\theta$

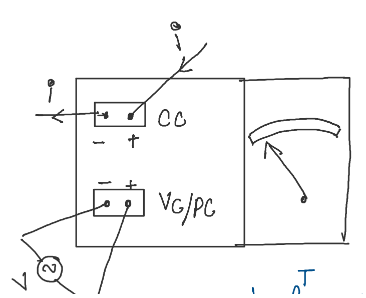
where $\theta$ is the angle b/w phase voltage & line current

$P_{3\phi} = 3 V_{ph} I_L \cos\theta$

$$\boxed{P_{3\phi} = \sqrt{3}\, V_L I_L \cos\theta}$$

Why not only delta ?

* Wattmeter :-



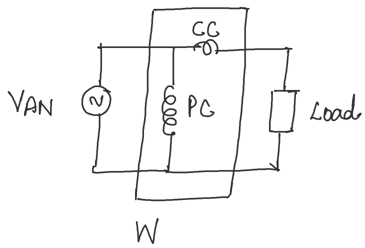

CC – current coil

VC – voltage coil

PC – potential coil

$$W = \frac{1}{T}\int_0^T vi\,dt$$

$$= V_{rms} I_{rms} \cos\theta$$

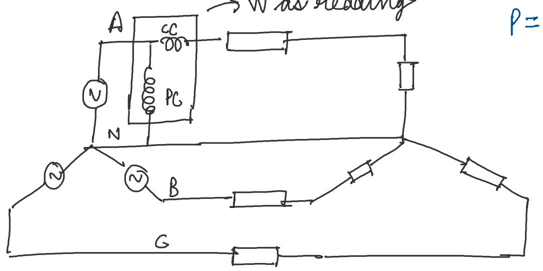



* How do you measure in a 3-phase circuit??

Case 1:- 4 wire balanced system

→ W as reading

$P = 3W$

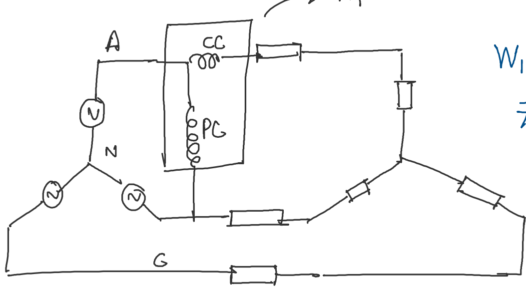



Case 2 :- 4-wire unbalanced system

We will need 3 wattmeters to measure power in each phase and then add them all together.

Case 3 :- 3 wire-balanced system

→ $W_1$

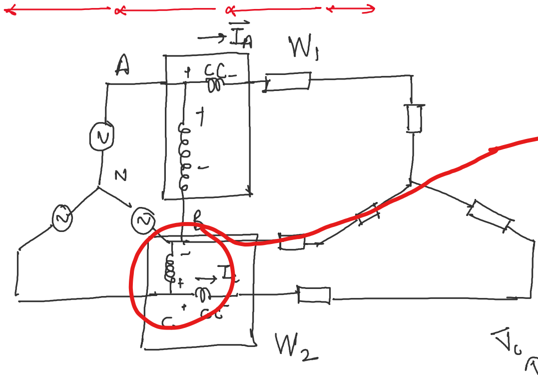



$W_1 = |V_{AB}||I_A| \cos(30+\theta)$

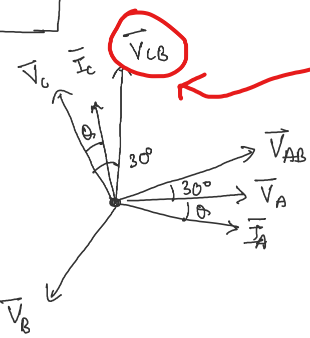
$\neq |V_{AN}||I_A| \cos\theta$

We can't measure using a single wattmeter. We will not be able to connect potential coil to $V_{AN}$. as neutral is not accessible. If we connect as shown in figure above and divide the reading $\sqrt{3}$, then too the $\theta$ will be between line voltage & line current & not between phase voltage & line current

## * 2 Wattmeter method :-




Lookout for the polarity of the terminals. As in case of Vbc and Vcb.




$$W_1 = |V_{AB}||I_A| \cos(30+\theta)$$

$$W_2 = |V_{CB}||I_C| \cos(30-\theta)$$

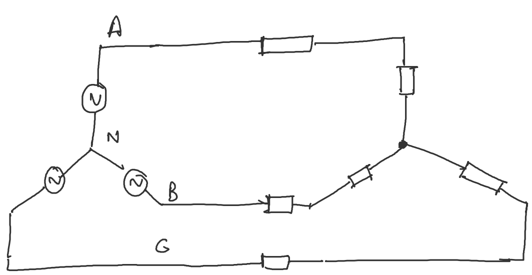
Assuming a balanced system

$$W_1 + W_2 = |V_{AB}||I_A| \left[\cos(30+\theta) + \cos(30-\theta)\right]$$

$$= |V_{AB}||I_A|\, 2 \cos 30 \cos\theta$$

$$= \boxed{\sqrt{3}\, |V_{AB}||I_A| \cos\theta = P_{3\phi}}$$

Case 4: 3 wire unbalanced system




$$W_1 = \frac{1}{T} \int v_{ab}\, i_a \, dt$$

$$W_2 = \frac{1}{T} \int v_{cb}\, i_c \, dt$$

$$W_1 + W_2 = \frac{1}{T} \int \left[ (v_{an} - v_{bn}) i_a + (v_{cn} - v_{bn}) i_c \right] dt$$

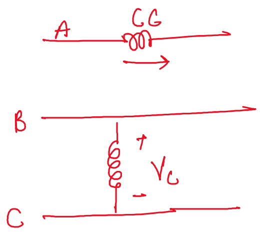
$$= \frac{1}{T} \int \left[ v_{an} i_a + v_{cn} i_c + v_{bn} i_b + \left( - v_{bn} i_a - \cancel{v_{bn} i_c} - v_{bn} i_b \right) \right] dt$$

$$= \frac{1}{T} \int \left( v_{an} i_a + v_{bn} i_b + v_{cn} i_c \right) dt = P_{3\phi}$$

Q1. Prove for a balanced 3-$\phi$, 3 wire system

$$Q_{3\phi} = \sqrt{3}\,(W_2 - W_1)$$

Q2.




Is the power measured by one wattmeter connected in this manner relate to total real power or reactive power of the balanced system?