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FACULTY OF ENGINEERING & TECHNOLOGY

Electrical Machine-1

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Relationship of Line and Phase Voltages and Currents in a Star Connected System

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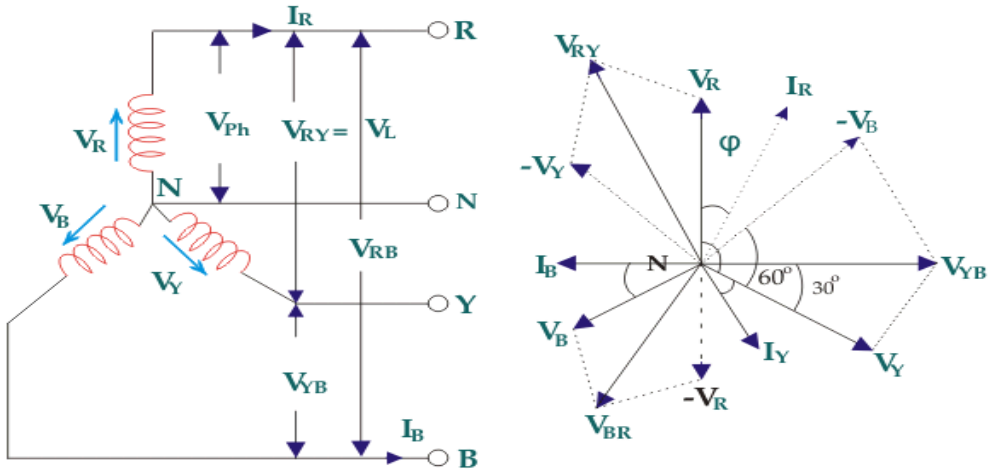

Suppose due to load impedance the current lags the applied voltage in each phase of the system by an angle ϕ. As we have considered that the system is perfectly balanced, the magnitude of current and voltage of each phase is the same. Let us say, the magnitude of the voltage across the red phase i.e. magnitude of the voltage between neutral point (N) and red phase terminal (R) is V_R.

Similarly, the magnitude of the voltage across yellow phase is V_Y and the magnitude of the voltage across blue phase is V_B. star system, magnitude of phase voltage in each phase is V_{ph}.

$$V_R = V_Y = V_B = V_{ph}$$

THREE PHASE TRANSFORMER

We know in the star connection, line current is same as phase current. The magnitude of this current is same in all three phases and say it is I_L.

$\therefore I_R = I_Y = I_B = I_L$, Where, I_R is line current of R phase, I_Y is line current of Y phase and I_B is line current of B phase.

Again, phase current, I_{ph} of each phase is same as line current I_L in star connected system.

$\therefore I_R = I_Y = I_B = I_L = I_{ph}$.

Now, let us say, the voltage across R and Y terminal of the star connected circuit is V_{RY}.

The voltage across Y and B terminal of the star connected circuit is V_{YBBR}.

From the diagram, it is found that

$V_{RY} = V_R + (-V_Y)$

Similarly, $V_{YB} = V_Y + (-V_B)$

And, $V_{BR} = V_B + (-V_R)$

Now, as angle between V_R and V_Y is 120°(electrical), the angle between V_R and $-V_Y$ is $180^o - 120^o = 60^o$(electrical).

$$V_L = |V_{RY}| = \sqrt{V_R^2 + V_Y^2 + 2V_R V_Y \cos 60^o}$$

$$= \sqrt{V_{ph}^2 + V_{ph}^2 + 2V_{ph}V_{ph} \times \frac{1}{2}}$$

$$= \sqrt{3}V_{ph}$$

$$\therefore V_L = \sqrt{3}V_{ph}$$

THREE PHASE TRANSFORMER

Thus, for the star-connected system line voltage = √3 × phase voltage.

Line current = Phase current

As, the angle between voltage and current per phase is φ, the electric power per phase is

$$V_{ph} I_{ph} cos\phi = \frac{V_L}{\sqrt{3}} I_L \cos\phi$$

So the total power of three phase system is

$$3 \times \frac{V_L}{\sqrt{3}} I_L \cos\phi = \sqrt{3} V_L I_L \cos\phi$$