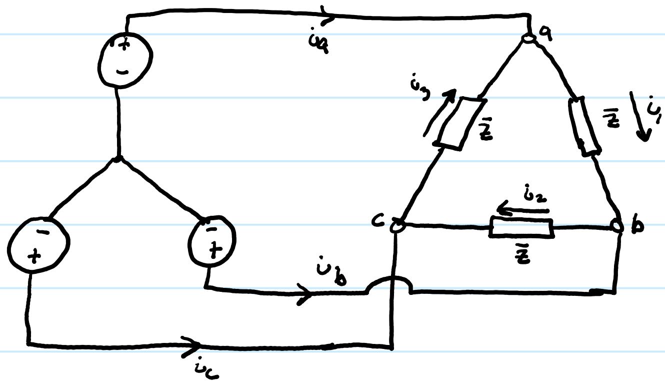
2018-09-10-1

*Section 2.5 in textbook

Wye- Delta Connection

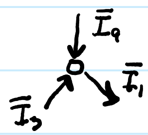


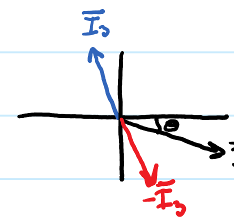
* How does i_a relate to i_1? or, how does line current relate to phase current?

$$\bar{I}_1 = \frac{\bar{V}_{ab}}{\bar{Z}} \Rightarrow \bar{I}_1 = \frac{V_L \angle 0}{Z \angle \theta} \Rightarrow \bar{I}_1 = \frac{V_L}{Z} \angle -\theta \Rightarrow \bar{I}_1 = I_\phi \angle -\theta$$

$$\bar{I}_2 = I_\phi \angle -120° - \theta$$

$$\bar{I}_3 = I_\phi \angle 120° - \theta$$





$$\bar{I}_a = \bar{I}_1 - \bar{I}_3 \Rightarrow \bar{I}_a = \bar{I}_1 + (-\bar{I}_3)$$

$$-\bar{I}_3 = I_\phi \angle 120° - \theta + 180° \Rightarrow -\bar{I}_3 = I_\phi \angle -60° - \theta$$

$$\bar{I}_a = I_\phi \angle -\theta + I_\phi \angle -60° - \theta$$

$$= I_\phi \left(\cos(\theta) - j\sin(\theta) + \cos(60° + \theta) - j\sin(60° + \theta) \right)$$

$$= I_\phi \left(\cos(\theta) + \cos(60°)\cos(\theta) - \sin(60°)\sin(\theta) + j\left(-\sin(\theta) - \sin(60°)\cos(\theta) - \cos(60°)\sin(\theta)\right)\right)$$

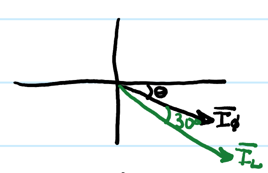
$$= I_\phi \left(\frac{3}{2}\cos(\theta) - \frac{\sqrt{3}}{2}\sin(\theta) + j\left(-\frac{3}{2}\sin(\theta) - \frac{\sqrt{3}}{2}\cos(\theta)\right)\right)$$

$$\bar{I}_a = I_\phi \left(\left[\frac{3}{2}\cos(\theta) - \frac{\sqrt{3}}{2}\sin(\theta)\right] - j\left[\frac{3}{2}\sin(\theta) + \frac{\sqrt{3}}{2}\cos(\theta)\right]\right)$$

$$|\bar{I}_a| = I_\phi \sqrt{\left[\frac{3}{2}\cos(\theta) - \frac{\sqrt{3}}{2}\sin(\theta)\right]^2 + \left[\frac{3}{2}\sin(\theta) + \frac{\sqrt{3}}{2}\cos(\theta)\right]}$$

$$= I_\phi \sqrt{\frac{9}{4} + \frac{3}{4}}$$

$$|\bar{I}_a| = I_\phi \sqrt{3}$$



$$\theta_L = \tan^{-1}\left(\frac{-\left(\frac{3}{2}\sin(\theta) + \frac{\sqrt{3}}{2}\cos(\theta)\right)}{\frac{3}{2}\cos(\theta) - \frac{\sqrt{3}}{2}\sin(\theta)} \right)$$

$$= \tan^{-1}\left(\frac{-\left(\frac{\sqrt{3}}{2}\sin(\theta) + \frac{1}{2}\cos(\theta)\right)}{\frac{\sqrt{3}}{2}\cos(\theta) - \frac{1}{2}\sin(\theta)} \right) \Rightarrow \theta_L = \tan^{-1}(\tan(-\theta - 30°)) \Rightarrow \boxed{\begin{array}{c} |\bar{I}_L| = I_\phi\sqrt{3} \\ \theta_L = \angle -30° - \theta \end{array}}$$

* can verify others are 120° apart.

Complex Power:

$\bar{S} = \bar{S}_{ab} + \bar{S}_{bc} + \bar{S}_{ca}$

$= \bar{V}_{ab}\bar{I}_1^* + \bar{V}_{bc}\bar{I}_2^* + \bar{V}_{ca}\bar{I}_3^*$

$= (V_L \angle 0)(I_\phi \angle \theta) + (V_L \angle -120°)(I_\phi \angle 120° + \theta) + (V_L \angle 120°)(I_\phi \angle \theta - 120°)$

$\boxed{\bar{S} = 3 V_L I_\phi \angle \theta}$

$I_\phi = \frac{I_L}{\sqrt{3}}$

$$\boxed{\begin{aligned} \bar{S} &= \sqrt{3} V_L I_L \angle \theta \\ P &= \sqrt{3} V_L I_L \cos(\theta) \\ Q &= \sqrt{3} V_L I_L \sin(\theta) \end{aligned}}$$

* Same as for wye connected load!!

Ex Delta connected load

$P = 24$ kW $\quad PF = 0.8$ lag

$V_L = 480$ V

Find: a) I_L and I_ϕ

b) $\bar{S}$

Solution: a) $P = \sqrt{3} V_L I_L (PF)$

$I_L = \frac{P}{\sqrt{3} V_L (PF)} \Rightarrow \boxed{I_L = 36.08\text{A}}$

$I_L = I_\phi \sqrt{3}$

$I_\phi = \frac{I_L}{\sqrt{3}} \Rightarrow \boxed{I_\phi = 20.83\text{A}}$

b) $\cos(\theta) = 0.8$

$\theta = 36.87°$

$\bar{S} = \sqrt{3} V_L I_L \angle 36.87°$

$$\boxed{\begin{aligned} \bar{S} &= 30{,}000 \angle 36.87° \text{ VA} \\ \bar{S} &= 24{,}000 + j\,18{,}000 \text{ VA} \end{aligned}}$$

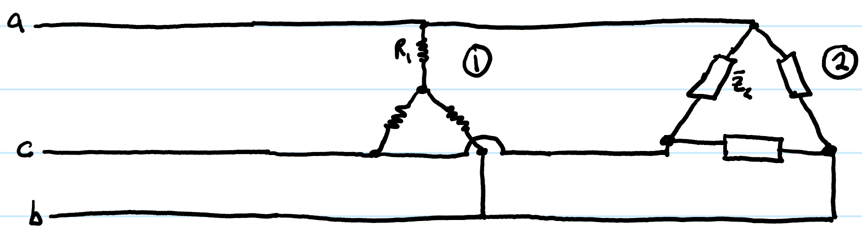
* This is the same as the wye load

* For balanced loads, I_L and $\bar{S}_{tot}$ don't change if P and PF don't change.

2018-09-10-3

Ex Problem 2.23

$S_{TOT} = 1000\ kVA$ $\quad V_L = 4160V$ $\quad PF = 0.8$ lag



$P_1 = 200\ kW$

Find: a) $\bar{S}_2$

b) $\bar{Z}_2$

a) $\bar{S}_{TOT} = \bar{S}_1 + \bar{S}_2$

$\bar{S}_2 = \bar{S}_{TOT} - \bar{S}_1$

$\bar{S}_2 = 1000\ kVA(0.8 + j0.6) - (200\ kW + j0)$

$\bar{S}_2 = 800 + j600 - 200\ \ VA$

$$\boxed{\begin{aligned}\bar{S}_2 &= 600 + j600\ kVA \\ &= 600\sqrt{2}\angle 45°\ kVA\end{aligned}}$$

b) Single Phase Power in Delta load

$\bar{S}_{1\phi} = \dfrac{\bar{S}_2}{3}$

$\bar{S}_{1\phi} = \dfrac{V_L^2}{\bar{Z}^*} \Rightarrow \bar{Z} = \dfrac{V_L^2}{\bar{S}_{1\phi}^*}$

$\bar{Z} = \dfrac{3V_L^2}{\bar{S}_2^*} \Rightarrow \bar{Z} = \dfrac{4160^2(3)}{600\sqrt{2}\angle -45°\ kVA} \Rightarrow \boxed{\begin{aligned}\bar{Z} &= 61.2\angle 45°\ \Omega \\ \bar{Z} &= 43.3 + j43.3\ \Omega\end{aligned}}$