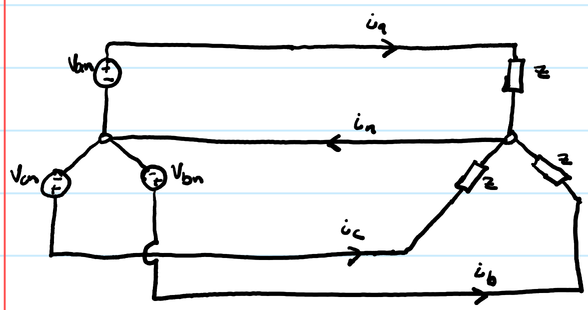
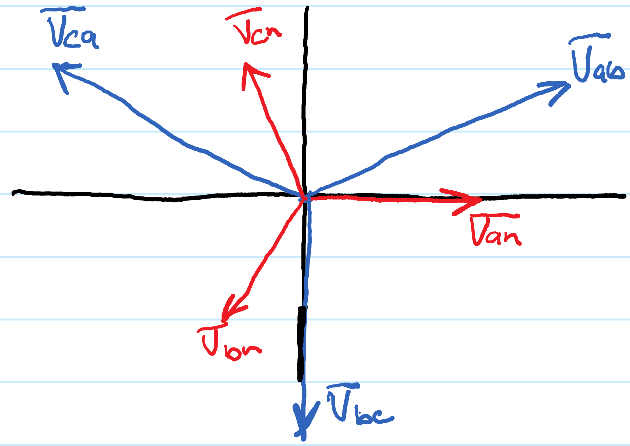
2018-09-07-1

$\bar{V}_{an} = V_\phi \angle 0^\circ$

$\bar{V}_{bn} = V_\phi \angle -120^\circ$

$\bar{V}_{cn} = V_\phi \angle 120^\circ$





What is voltage from a-b?

$\bar{V}_{ab} = \bar{V}_{an} - \bar{V}_{bn} \Rightarrow \bar{V}_{ab} = \bar{V}_{an} + (-\bar{V}_{bn})$

$= V_\phi \angle 0^\circ + (V_\phi \angle -120^\circ + 180^\circ)$

$= V_\phi + V_\phi \cos(60^\circ) + jV_\phi \sin(60^\circ)$

$= V_\phi\left(\frac{3}{2}\right) + jV_\phi\left(\frac{\sqrt{3}}{2}\right)$

$|\bar{V}_{ab}| = V_\phi\sqrt{\frac{9}{4}+\frac{3}{4}} \Rightarrow |\bar{V}_{ab}| = V_\phi\sqrt{3}$

$\theta_{ab} = \tan^{-1}\left(\frac{\sqrt{3}/2}{3/2}\right) \Rightarrow \theta_{ab} = \tan^{-1}\left(\frac{\sqrt{3}}{3}\right) \Rightarrow \theta_{ab} = 30^\circ$

$\boxed{\bar{V}_{ab} = V_\phi\sqrt{3}\angle 30^\circ}$

Can verify: $\boxed{\begin{array}{l}\bar{V}_{bc} = V_\phi\sqrt{3}\angle -90^\circ \\ \bar{V}_{ca} = V_\phi\sqrt{3}\angle 150^\circ\end{array}}$

$\boxed{\text{Line to line Voltage (aka line voltage): } V_L = V_\phi\sqrt{3}}$

What are the currents in each phase/line?

$\bar{Z} = Z\angle\theta$

$\bar{I}_a = \dfrac{V_{an}\angle 0^\circ}{Z\angle\theta} \Rightarrow \bar{I}_a = \dfrac{V_{an}}{Z}\angle -\theta \Rightarrow \bar{I}_a = I_\phi\angle -\theta \Rightarrow \boxed{\bar{I}_a = I_L\angle -\theta}$

Can verify: $\boxed{\begin{array}{l}\bar{I}_b = I_L\angle -120^\circ - \theta \\ I_c = I_L\angle 120^\circ - \theta\end{array}}$

$\bar{I}_n = \bar{I}_a + \bar{I}_b + \bar{I}_c \Rightarrow \bar{I}_n = I_L\left(\cos(-\theta) + j\sin(-\theta) + \cos(-\theta-120^\circ) + j\sin(-\theta-120^\circ) + \cos(-\theta+120^\circ) + j\sin(-\theta+120^\circ)\right)$

$= I_L\left(\cos(\theta) + 2\cos(120^\circ)\cos(\theta) + j\left(\sin(-\theta) - 2\cos(120^\circ)\sin(\theta)\right)\right)$

$= I_L\left(\cos(\theta) - \cos(\theta) + j(-\sin(\theta) + \sin(\theta))\right)$

$\boxed{\bar{I}_n = 0}$

* For balanced loads, $\bar{I}_n = 0$. So, can get rid of wire.

2018-09-07-2

Complex power:

$\bar{S} = \bar{S}_a + \bar{S}_b + \bar{S}_c + \bar{S}_n$

$\bar{S}_n = 0$ because $\bar{I}_n = 0$

$\bar{S} = \bar{S}_a + \bar{S}_b + \bar{S}_c$

$\bar{S} = \bar{V}_{an} \bar{I}_a^* + \bar{V}_{bn} \bar{I}_b^* + \bar{V}_{cn} \bar{I}_c^*$

$= V_\phi I_L \angle\theta + V_\phi I_L \angle -120^\circ + \theta + 120^\circ + V_\phi I_L \angle 120^\circ + \theta - 120^\circ$

$\boxed{\bar{S} = 3 V_\phi I_L \angle\theta}$

* 3x power as 1ϕ

* $\frac{3}{2}$x wires of 1ϕ (3 vs. 2) Better than 2ϕ (3 vs. 4)

$V_L = V_\phi\sqrt{3} \Rightarrow V_\phi = \frac{V_L}{\sqrt{3}}$

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

Ex Wye connected load

$P = 24$ kW $\quad$ PF= 0.8 lag $\quad$ $V_L = 480V$

Find: a) I_ϕ and V_ϕ

b) $\bar{S}_{total}$

a) $V_\phi = \frac{V_L}{\sqrt{3}} \Rightarrow \boxed{V_\phi = 277.13V}$

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

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

b) $\theta = \cos^{-1}(PF) \Rightarrow \theta = 36.87^\circ$

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

$$\boxed{\begin{aligned} \bar{S}_{tot} &= 30{,}000 \angle 36.87^\circ \text{ VA} \\ &= 24{,}000 + j18{,}000 \text{ VA} \end{aligned}}$$