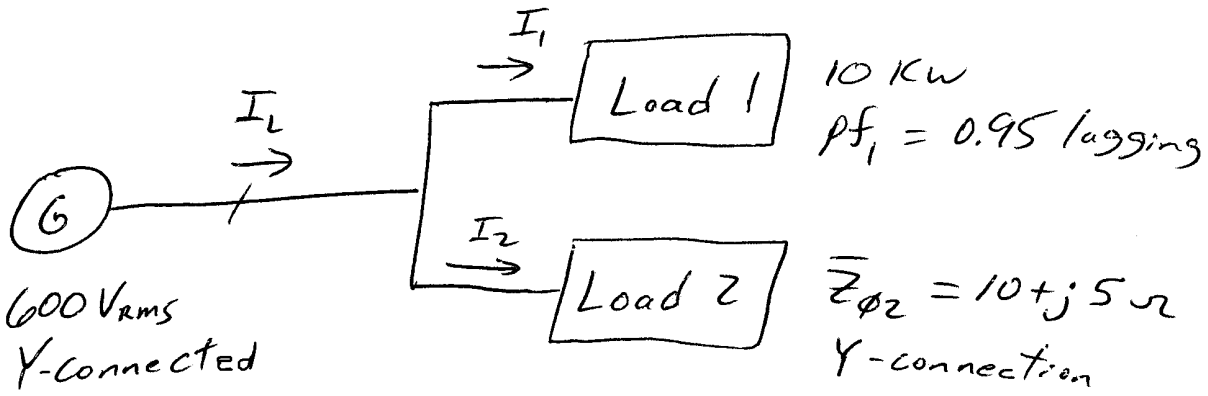
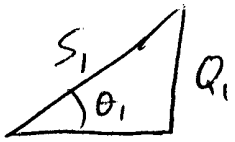
One-line, Three-Phase Power Example

ex.



Find voltage, currents, powers, reactive powers, and pfs.

Load 1



$pf_1 = \cos\theta_1 = 0.95$ lagging $\Rightarrow \theta_1 = \cos^{-1} 0.95$

$\theta_1 = +18.195°$

$$S_1 = \frac{P_1}{\cos\theta_1} = \frac{10\,KW}{0.95} = 10.526\ KVA$$

$$Q_1 = S_1 \sin\theta_1 = (10.526\,KVA)(\sin 18.195°)$$

$$Q_1 = 3.2868\ KVAR$$

Knowing $V_{LL} = 600\ V_{rms}$, the line current I_1 is found using (A-29) $P = \sqrt{3}\, V_{LL} I_L \cos\theta$

$$I_1 = \frac{P_1}{\sqrt{3}\, V_{LL} \cos\theta_1} = \frac{10 \times 10^3}{\sqrt{3}(600)0.9}$$

$$I_1 = 10.692\ A_{rms}$$

Load 2 (Y-configs)

$\bar{Z}_{\phi 2} = 10 + j5\ \Omega = 11.18 \angle 26.565^\circ\ \Omega$

$\Rightarrow \bar{Z}_{\Delta 2} = 3\bar{Z}_{\phi 2} = 30 + j15\ \Omega = 33.541 \angle 26.565^\circ\ \Omega$

$pf_2 = \cos\theta_2 = \cos 26.565^\circ$

$pf_2 = 0.89443$ lagging (inductive reactance)

For Δ-conf.

Using V_{LL} & $\bar{Z}_{\Delta 2}$, $I_{\phi 2} = \frac{600\ V_{rms}}{33.541} = 17.888554\ A_{rms}$

$P_2 = 3V_{\phi_2} I_{\phi_2} \cos\theta_2 = 3(600)(17.88855)\cos 26.565^\circ$

$P_2 = 28{,}800\ W = 28.8\ KW$

$Q_2 = 3V_{\phi 2} I_{\phi 2} \sin\theta_2 = 14{,}400\ VAR = 14.4\ KVAR$

$S_2 = 32{,}200\ VA = 32.2\ KVA = \sqrt{P_2^2 + Q_2^2}$

$I_{L2} = \frac{P_2}{\sqrt{3}\, V_{LL} \cos\theta_2} = \frac{28{,}800}{\sqrt{3}(600)\cos 26.565^\circ}$

$I_{L2} = 30.984\ A_{rms} = \sqrt{3}(17.888554)$

← double-check

Ex. cont.

Total Powers & line current

$P = P_1 + P_2 = 10\,kW + 28.8\,kW = \underline{38.8\,kW}$

$Q = Q_1 + Q_2 = 3.2868\,kVAR + 14.4\,kVAR = \underline{17.6868\,kVAR}$

$S = \sqrt{P^2+Q^2} = \underline{42.6411\,kVA}$

$pf = \frac{P}{S} = \frac{38.8}{42.6411} = \underline{0.9099\ lagging\ (Q>0)}$

Also, $\theta = \theta_V - \theta_I = \cos^{-1} 0.9099 = \underline{24.5^\circ}$

$P = \sqrt{3}\, V_{LL} I_L \cos\theta = \sqrt{3}\, V_{LL} I_L\, pf$

$\hookrightarrow I_L = \frac{38{,}800}{\sqrt{3}\,(600)0.9099} = \underline{41.0314\ A_{rms}}$