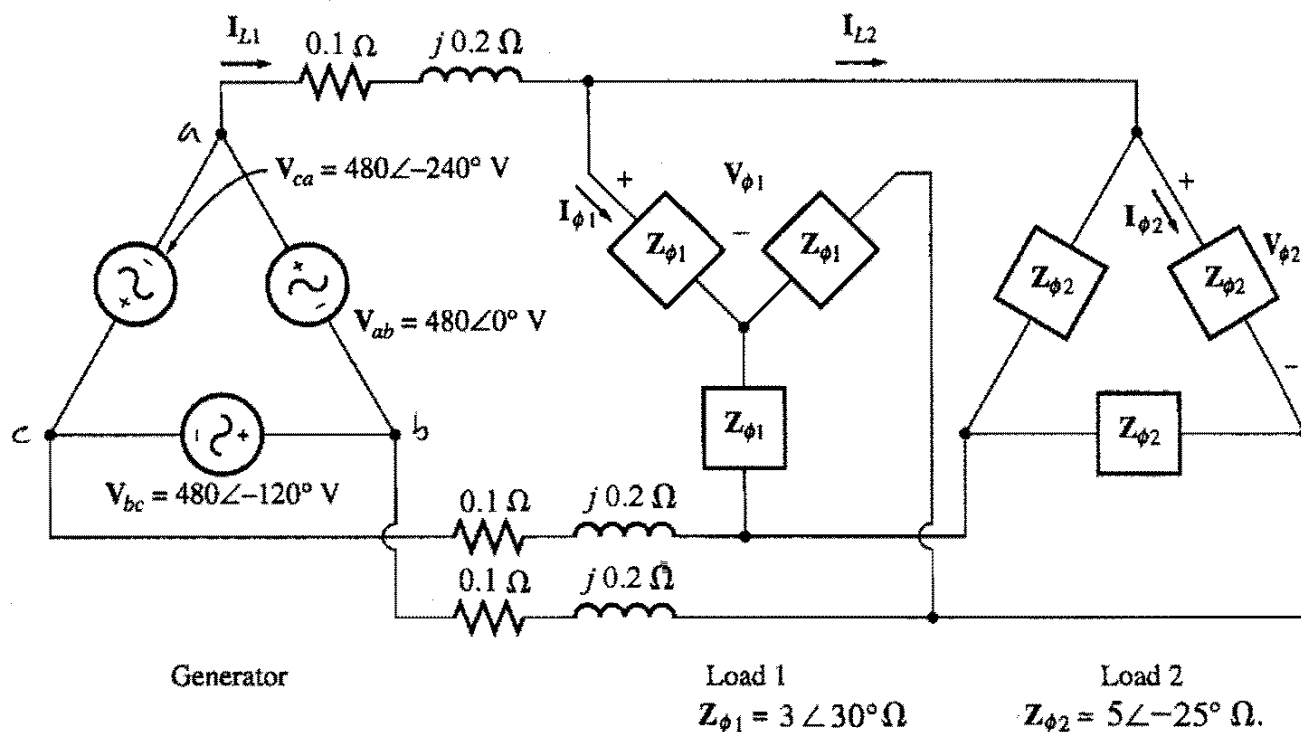


2-2 Figure P2-1 shows a three-phase power system with two loads. The Δ -connected generator is producing a line voltage of 480 V, and the line impedance is $0.1 + j0.2 \Omega$. Load 1 is Y connected, with a phase impedance of $3 \angle 30^\circ \Omega$ and load 2 is Δ connected, with a phase impedance of $5 \angle -25^\circ \Omega$.

Figure P2-1 | The system in Problem 2-2.



- What is the line voltage of the two loads?
- What is the voltage drop on the transmission lines?
- Find the real and reactive powers supplied to each load.
- Find the real and reactive power losses in the transmission line.
- Find the real power, reactive power, and power factor supplied by the generator.

➤ **modified** so $\bar{Z}_{\text{line}} = 0.1 + j0.2 \Omega$, $\bar{Z}_{\phi 1} = 3 \angle 30^\circ \Omega$, and $\bar{Z}_{\phi 2} = 5 \angle -25^\circ \Omega$.

① Convert Δ -source and Δ -load to Y-configuration

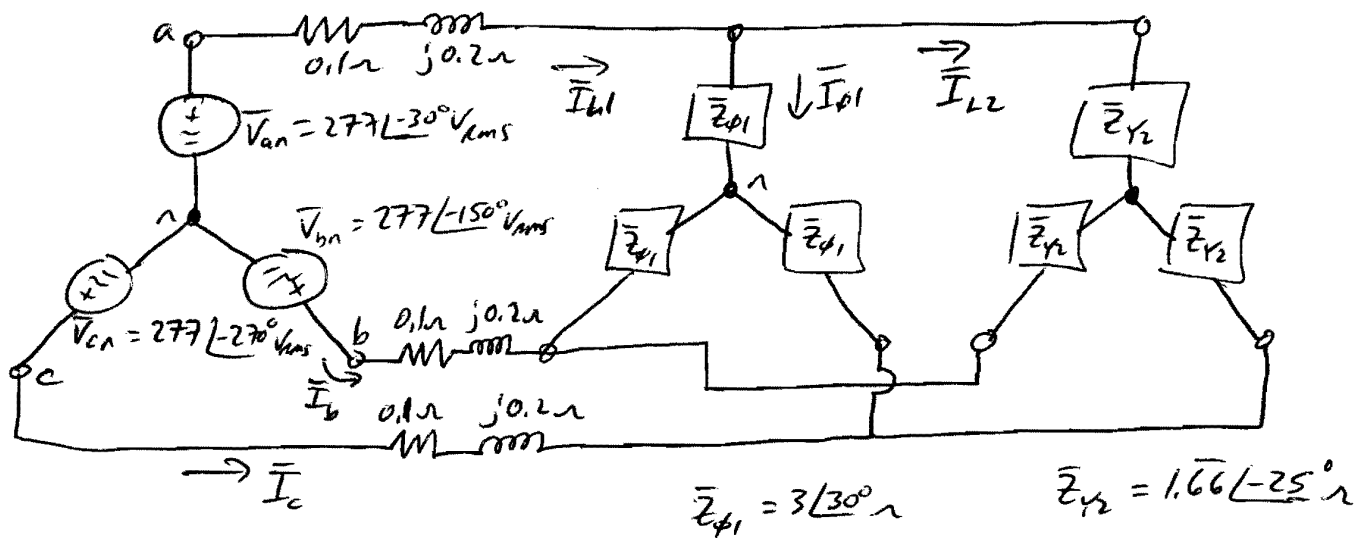
$$\bar{Z}_{Y2} = \frac{\bar{Z}_{\phi 2}}{3} = \frac{5 \angle -25^\circ}{3} = 1.66 \angle -25^\circ \Omega \quad \text{per Fig 2-12}$$

$$\text{Per (2-11) \& notes: } \bar{V}_{an} = \frac{V_L}{\sqrt{3}} \angle -30^\circ = \frac{480}{\sqrt{3}} \angle -30^\circ \text{ V}_{rms} = 277.13 \angle -30^\circ \text{ V}_{rms}$$

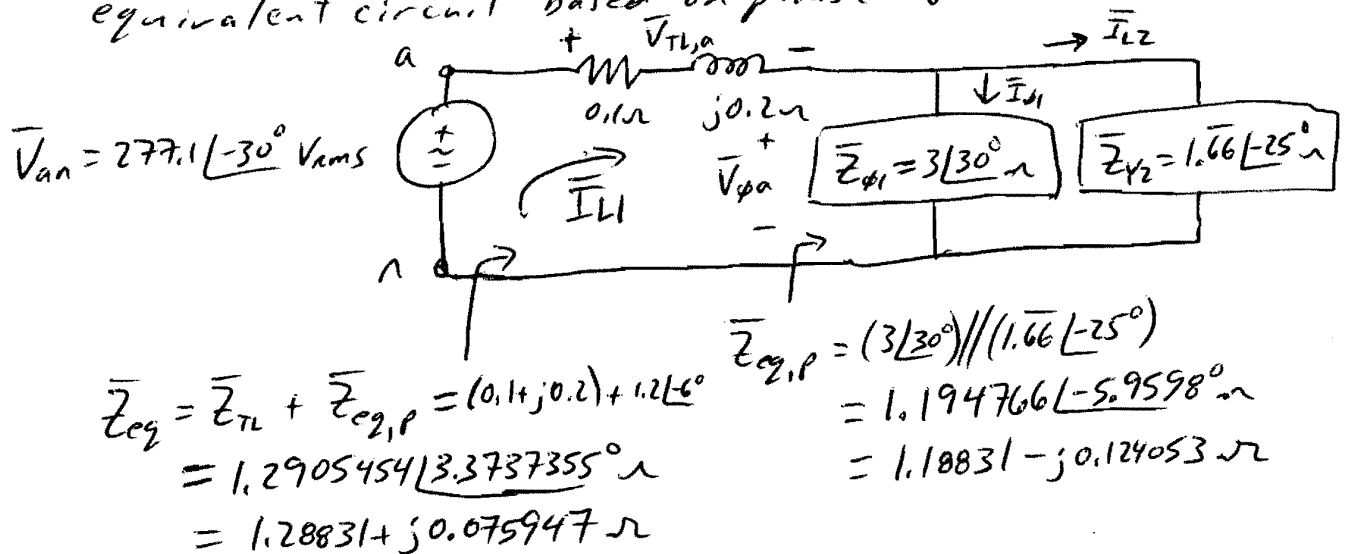
$$\bar{V}_{bn} = \frac{V_L}{\sqrt{3}} \angle -150^\circ = 277.13 \angle -150^\circ \text{ V}_{rms}$$

$$\bar{V}_{cn} = \frac{V_L}{\sqrt{3}} \angle -270^\circ = 277.13 \angle -270^\circ \text{ V}_{rms}$$

3 ϕ all Y-config. equivalent circuit



- (2) Since all loads, lines, + sources are balanced, we can analyze the 3 ϕ circuit using a per-phase equivalent circuit based on phase a.



a) Find V_{LL} for loads

By voltage division $\bar{V}_{\phi a} = \bar{V}_{an} \frac{\bar{Z}_{eq,p}}{\bar{Z}_{eq}} = \frac{(277.1\angle -30^\circ)(1.2\angle -6^\circ)}{1.29\angle 3.37^\circ}$

$= 256.5608\angle -39.3335^\circ \text{ V}_{rms}$

Per (2-11) $V_{LL} = \sqrt{3} V_{\phi a} = \sqrt{3} (256.56) = \underline{\underline{444.376 \text{ V}_{rms}}}$

b) Find voltage drop on lines V_{TL}

$$\text{By KVL } \bar{V}_{TL,a} = \bar{V}_{an} - \bar{V}_{\phi a} = (277.13 \angle -30^\circ) - (256.56 \angle -39.33^\circ) \\ = 48.0166 \angle 30^\circ \text{ Vrms}$$

$$\underline{\underline{V_{TL} = 48.02 \text{ Vrms}}}$$

c) Find P & Q for each load.

$$\text{Load 1 } \bar{I}_{\phi 1} = \frac{\bar{V}_{\phi a}}{\bar{Z}_{\phi 1}} = \frac{256.5608 \angle -39.3335^\circ}{3 \angle 30^\circ} = 85.52027 \angle -69.3335^\circ \text{ Arms}$$

$$\text{Per (2-23) } P_1 = 3 V_{\phi 1} I_{\phi 1} \cos \theta_1 = 3(256.56)(85.52) \cos 30^\circ$$

$$P_1 = 57,004.8 \text{ W} = \underline{\underline{57.00 \text{ KW}}}$$

$$\text{Per (2-24) } Q_1 = 3 V_{\phi 1} I_{\phi 1} \sin \theta_1 = 3(256.56)(85.52) \sin 30^\circ$$

$$Q_1 = 32,911.7 \text{ VAR} = \underline{\underline{32.91 \text{ KVAR}}}$$

$$\text{Load 2 } \bar{I}_{\phi 2} = \frac{\bar{V}_{\phi a}}{\bar{Z}_{\phi 2}} = \frac{256.5608 \angle -39.3335^\circ}{1.66 \angle -25^\circ} = 153.93648 \angle -14.3335^\circ \text{ Arms}$$

$$P_2 = 3(256.56)(153.9365) \cos(-25^\circ)$$

$$= 107,381.34 \text{ W} = \underline{\underline{107.38 \text{ KW}}}$$

$$Q_2 = 3(256.56)(153.9365) \sin(-25^\circ)$$

$$= -50,072.7 \text{ VAR} = \underline{\underline{-50.07 \text{ KVAR}}}$$

d) Find P & Q for the transmission line

$$\bar{I}_{L1} = \frac{\bar{V}_{un}}{\bar{Z}_{eq}} = \frac{277.1 \angle -30^\circ}{1.2883 + j0.07595} = 214.73722 \angle -33.373736^\circ \text{ A}_{rms}$$

$$\begin{aligned} \bar{S}_{TL} &= 3 \bar{V}_{TL,a} \bar{I}_{L1}^* = 3(48.0166 \angle 30.06^\circ)(214.737 \angle +33.374^\circ) \\ &= 30933 \angle 63.435^\circ \text{ VA} = 13834.2 + j27666.9 \text{ VA} \end{aligned}$$

$$\underline{\underline{P_{TL} = 13.834 \text{ KW}}}$$

$$\underline{\underline{Q_{TL} = 27.667 \text{ KVAR}}}$$

e) Find P , Q , & PF for the generator

By conservation of power -

$$P_{gen} = P_1 + P_2 + P_{TL} = 57.00 + 107.38 + 13.834$$

$$\underline{\underline{P_{gen} = 178.22 \text{ KW}}}$$

$$Q_{gen} = Q_1 + Q_2 + Q_{TL} = 32.91 - 50.07 + 27.667$$

$$\underline{\underline{Q_{gen} = 10.506 \text{ KVAR}}}$$

$$PF = \cos \theta_{eq} = \cos 3.3737355^\circ = \underline{\underline{0.9983 \text{ lagging}}}$$