An industrial plant consists of several three-phase induction motors and draws 300 kW at 0.6 PF lagging from the substation bus.

Find the kVAR (three-phase) rating of a capacitor bank to improve the PF to 0.9 lagging.

A final pf of .9 lagging is required, the total apparent power is require.

$$\text{acos}(.9) = 25.842\ \mathbf{deg} \qquad \text{acos}(.6) = 53.13\ \mathbf{deg}$$

$$S_{3\phi} := \frac{300\ \mathbf{kW}}{0.6}\left(.6 + j \cdot \sin\left(\text{acos}(.6)\right)\right) = (300 + 400\text{j})\ \mathbf{kVA}$$

$$S_{3\phi} = \left(5 \cdot 10^{5}\ \angle 53.13°\right)\ \mathbf{W}$$

$$Q_{old} := \text{Im}\left(S_{3\phi}\right) = 400\ \mathbf{kVAR}$$

$$Q_{new} := \text{Re}\left(S_{3\phi}\right) \cdot \tan\left(\text{acos}(.9)\right) = 145.297\ \mathbf{kVAR}$$

$$Q_c := Q_{old} - Q_{new} = 254.703\ \mathbf{kVAR}$$

A three-phase power system consists of a wye-connected generator connected to a wye-connected load through a transmission line having an impedance of 1.5 Ohms angle 75 degrees per phase. The load impedance is 20 Ohms angle 30 degrees per phase. The voltage at the load is 4,160 volts (line to line).

a) Draw the per phase equivalent circuit for phase a, using the phase a load voltage as reference.
b) Find the total complex power (3-phase) supplied by the generator.

(a)

The per -phase equivalent circuit is seen in Figure 1.

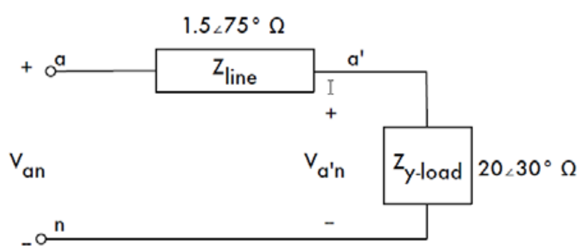

Figure 1: Circuit Diagram - Problem 2.20

$$V_{a'n} = V_{load}$$
$$Z_{line} := (1.5\angle 75°)\ \Omega$$
$$Z_{load} := (20\angle 30°)\ \Omega$$

$$V_{L\_load} := (4.16\angle 0)\ kV$$

$$V_{load} := \frac{V_{L\_load}}{\sqrt{3}} = 2.402\ kV \qquad I_{load} := \frac{V_{load}}{Z_{load}} = (104 - 60.044i)\ A$$

$$I_{load} = (120.089\angle -30°)\ A$$

The voltage at the generator is required.

$$V_{gen} := V_{load} + I_{load} \cdot Z_{line} = (2.529 + 0.127i)\ kV$$

$$S_{gen} := 3\ V_{gen} \cdot \overline{I_{load}} = (766.151 + 495.325i)\ kVA$$

$$S_{gen} = (912.323\angle 32.883°)\ kVA$$

A 345 kV three-phase line supplies 750 MVA at 0.8 PF lagging to a three-phase load which is delta connected.

a. Find the complex impedance per phase of load
b. Find the magnitudes of the line and phase currents

a. 5 pts

$S_{3\phi} := 750\ MVA$ $\quad pf := .8 \cdot lagging$ $\quad \theta := \mathrm{acos}(pf) = 0.644$

$\theta = 36.87\ deg$

$V_L := 345\ kV$

$$S_{1\phi} := \frac{S_{3\phi}}{3} = 250\ MVA$$

Assuming the line voltage is the reference, i.e. the angle of the line voltage is 0 radians. Also note that because the load is delta connected Vline=Vphase. Reall that per phase, S=VI* and V=IZ so:

$$V_\phi := V_L = 345\ kV$$

$$Z_\phi := \overline{\frac{{V_\phi}^2}{(S_{1\phi} \angle -\theta)}} = (380.88 - 285.66i)\ \Omega$$

$$Z_\phi = (476.1 \angle -36.87°)\ \Omega$$

a. 5 pts

The phase current:

$$I_\phi := \frac{S_{1\phi}}{V_\phi} = 724.638\ A$$

Then for a delta configured load:

$$I_L := \sqrt{3}\ I_\phi = (1.255 \cdot 10^3)\ A$$

The following three-phase, balanced loads are connected across a three-phase, wye-connected source (60 Hz and 480 V – line to line). The nature of the three loads are described below:

Load #1: Wye-connected load with 100 kVA (3-phase) at 0.9 PF lag;
Load #2: Wye-connected load with 60 kW (3-phase) at 0.7 PF lead;
Load #3: Delta-connected load, with 75 A phase current and 0.9 PF lag.

Calculate the magnitude of the total source line current

$pf_1 := 0.9 \cdot \mathbf{lagging}$ $\quad pf_2 := 0.7 \cdot \mathbf{leading}$ $\quad pf_3 := 0.9 \cdot \mathbf{lagging}$

$S_1 := 100 \left(pf_1 + j \cdot \sin\left(\operatorname{acos}\left(pf_1\right)\right)\right) \mathbf{kVA} = (90 + 43.589\mathrm{i})\ \mathbf{kVA}$ $\quad \operatorname{acos}\left(pf_1\right) = 25.842\ \mathbf{deg}$

$S_2 := \dfrac{60\ \mathbf{kW}}{pf_2} \left(pf_2 - j \cdot \sin\left(\operatorname{acos}\left(pf_2\right)\right)\right) = (60 - 61.212\mathrm{i})\ \mathbf{kVA}$ $\quad \operatorname{acos}\left(pf_2\right) = 45.573\ \mathbf{deg}$

$V_L := 480\ \mathbf{V}$ $\quad I_L := \sqrt{3} \cdot 75 \cdot \mathbf{A} = 129.904\ \mathbf{A}$ $\quad \operatorname{acos}\left(pf_3\right) = 25.842\ \mathbf{deg}$

$S_3 := \sqrt{3}\ V_L \cdot I_L \cdot \left(pf_3 + j \cdot \sin\left(\operatorname{acos}\left(pf_3\right)\right)\right) = (97.2 + 47.076\mathrm{i})\ \mathbf{kVA}$

$S_{total} := S_1 + S_2 + S_3 = (247.2 + 29.453\mathrm{i})\ \mathbf{kVA}$

$I_L := \dfrac{S_{total}}{\sqrt{3} \cdot V_L} = (297.335 + 35.426\mathrm{i})\ \mathbf{A}$

$\left|I_L\right| = 299.438\ \mathbf{A}$