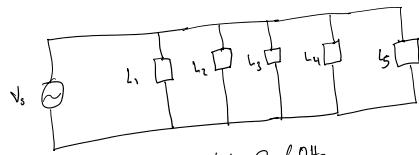


Single phase $V_{\text{rms}} = 116 \text{ V}$ source voltage

5 loads || connects



All loads operate @ 116V @ 60Hz

inducts motor

$$\textcircled{1} \quad L_1 \quad S_{L_1} = P_{L_1} + j Q_{L_1}$$

$$\theta_{L_1} = \tan^{-1} \left(\frac{Q_{L_1}}{P_{L_1}} \right) = \tan^{-1} \left(\frac{25}{40} \right)$$

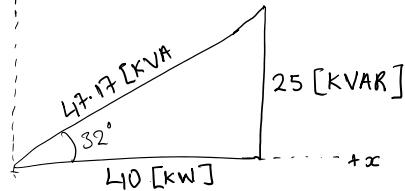
$$\theta_{L_1} = 32.0^\circ$$

$$|S_{L_1}| = \sqrt{40^2 + 25^2} [\text{kVA}]$$

$$|S_{L_1}| = 47.17 [\text{kVA}]$$

Power Triangle @ L_1

+y; 1st quadrant inductive load



$\textcircled{2} \quad L_2$ Synchronous motor with 30HP output
@ 80% efficiency & 0.95 pf leading

rate conversion rate for $\text{HP} \rightarrow \text{kW}$
 $1 \text{ HP} \rightarrow 0.746 \text{ kW}$

$$\begin{aligned} \text{real Power: } P &= 30 \text{ HP} \times 0.746 \frac{\text{kW}}{\text{HP}} \\ P &= 22.38 \text{ [kW]} \\ P_{L_2} &= \frac{P}{\text{efficiency}} = \frac{22.38 \text{ kW}}{0.8} \\ P_{L_2} &= 27.98 \text{ [kW]} \end{aligned}$$

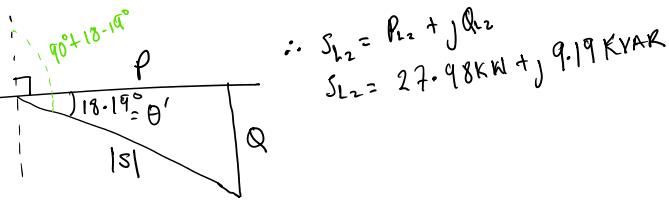
$$\text{Apparent Power: } |S_{L_2}| = \frac{P_{L_2}}{\text{pf}} = \frac{27.98 \text{ kW}}{0.95} \quad) \text{ kVA}$$

$$S_{L_2} = 29.45 \text{ kVA}$$

$$\begin{aligned} \text{Reactive Power } Q_{L_2} &= \sqrt{S_{L_2}^2 - P_{L_2}^2} = \sqrt{29.45^2 - 27.98^2} \text{ [kVAR]} \\ Q_{L_2} &= 9.19 \text{ [kVAR]} \end{aligned}$$

$$\begin{aligned} \text{pf} &= 0.95 \text{ leading} \\ \theta &= \cos^{-1}(0.95) + 90^\circ = 18.19^\circ + 90^\circ \\ \theta &= 108.19^\circ \end{aligned}$$

Reactive Power: Q_{L_2} first sketch the power triangle



$$S_{L2} = P_{L2} + jQ_{L2}$$

$$S_{L2} = 27.98 \text{ kVA} + j 9.19 \text{ kVAR}$$

② L₃ single phase transformer drawing primary current $I = 52 \angle -25^\circ \text{ A}$

for Transformer the primary side is where Input power comes through
we are interested in input power

$$\text{Vinput} = 416 \text{ V } @ 60 \text{ Hz}$$

$$\text{let } \phi_{V_{\text{input}}} = 0^\circ$$

$$\therefore V_{\text{input}} = 416 \cos(2\pi(60)t + 0^\circ)$$

$$V_{\text{input}} = 416 \cos(377t) = 416 \angle 0^\circ$$

$$I_{\text{primary}} = 52 \angle -25^\circ \text{ A} = 47.13 - j 21.98 \text{ [A]}$$

$$\text{real Power: } P_{L3} = |V||I| \cos(\phi_V - \phi_I)$$

$$P_{L3} = (416)(52) \cos(0 - (-25))$$

$$P_{L3} = 19.61 \text{ [kW]}$$

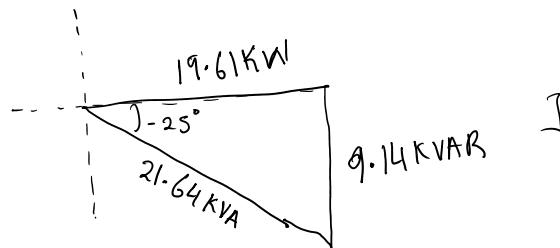
$$\text{Apparent Power: } S_{L3} = \frac{P_{L3}}{\cos(\theta)} = \frac{19.61}{\cos(25)}$$

$$S_{L3} = 21.64 \text{ [kVA]}$$

$$\text{Reactive power: } Q_{L3} = |V||I| \sin(\theta) = 416 \times 52 \sin(25)$$

$$Q_{L3} = 9.14 \text{ [kVAR]}$$

Power Triangle @ L₃



③ L₄ electronic ballast light drawing 22 kW real power
pf of 0.96 lagging

$$\text{Apparent Power: } |S_{L4}| = \frac{P_{L4}}{\text{p.f.}} = \frac{22 \text{ kW}}{0.96}$$

$$|S_{L4}| = 22.92 \text{ kVA}$$

Reactive Power: $Q_{L4} = \sqrt{S_{L4}^2 - P_{L4}^2}$

$$Q_{L4} = (\sqrt{22.92^2 - 22^2}) \text{ kVAR}$$

$$Q_{L4} = 6.42 \text{ [kVAR]} \quad \text{lagging}$$

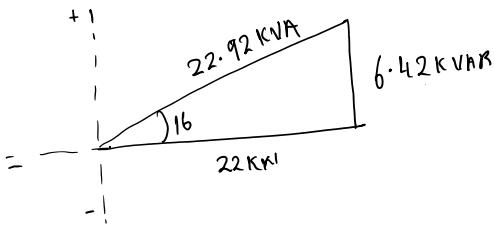
$$S_{L4} = P_{L4} + j Q_{L4}$$

$$S_{L4} = (22 + j 6.42) \text{ [kVA]}$$

$$\theta = \tan^{-1}\left(\frac{Q}{P}\right) = \tan^{-1}\left(\frac{6.42}{22}\right)$$

$$\theta = 16^\circ$$

Power Triangle @ L4



② L5 miscellaneous loads $|S_{L5}| = 12 \text{ kVA} \angle 20^\circ$

$$S_{L5} = P_{L5} + j Q_{L5}$$

$$P_{L5} = |S_{L5}| \cos \theta$$

$$P_{L5} = 12 \cos(20) \text{ [kW]}$$

$$P_{L5} = 11.28 \text{ [kW]}$$

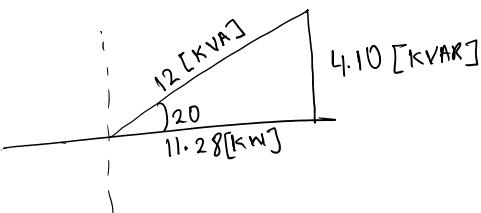
$$Q_{L5} = |S_{L5}| \sin \theta$$

$$Q_{L5} = 12 \sin(20) \text{ [kVAR]}$$

$$Q_{L5} = 4.10 \text{ [kVAR]}$$

$$S_{L5} = (11.28 + j 4.10) \text{ [kVA]}$$

Power triangle @ L5



$$P_T = P_1 + P_{L2} + P_{L3} + P_{L4} + P_{L5}$$

$$P_T = 40 \text{ kW} + 27.98 \text{ kW} + 19.61 \text{ kW} + 22 \text{ kW} + 11.28 \text{ kW}$$

$$P_T = 120.87 \text{ kW}$$

$$Q_T = Q_{L_1} + Q_{L_2} + Q_{L_3} + Q_{L_4} + Q_{L_5}$$

$$Q_T = 25 \text{ KVAR} + 9.19 \text{ KVAR} + 9.14 \text{ KVAR} + 6.42 \text{ KVAR} + 4.10 \text{ KVAR}$$

$Q_T = 53.83 \text{ KVAR}$

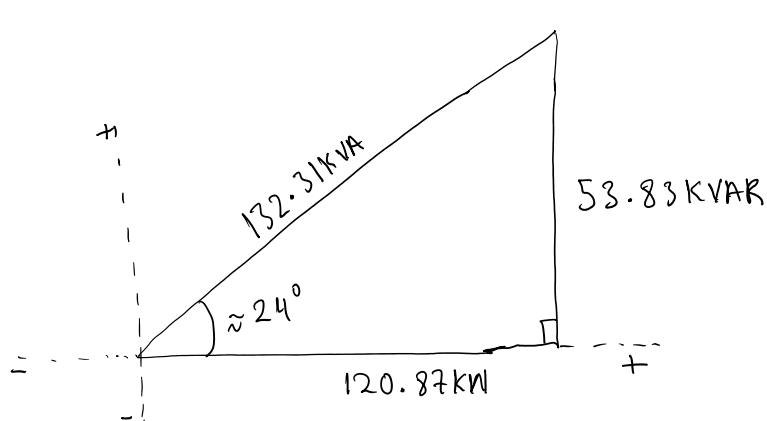
$$S_T = \sqrt{P_T^2 + Q_T^2} = \sqrt{120.87^2 + 53.83^2} \text{ [KVA]}$$

$S_T \approx 132.31 \text{ KVA}$

from above $S_T = \sum_{n=1}^5 S_{L_n} = 132.31 \text{ KVA}$

$$\theta = \tan^{-1} \left(\frac{Q_T}{P_T} \right) = \tan^{-1} \left(\frac{53.83}{120.87} \right)$$

$$\theta = 24^\circ$$



1d
Total Current delivered to the load $I_T = \frac{\text{Power delivered } (S_T)}{\text{Supplied Voltage}}$

$$I_T = \frac{132.31 \text{ KVA}}{416 \text{ V}}$$

$$I_T = 318.05 \text{ A}$$

1st phase 416V @ 60Hz $\Rightarrow V_0$

500kVA @ 0.75 lagging \Rightarrow load

desired p.f correction = 0.96 lagging or higher

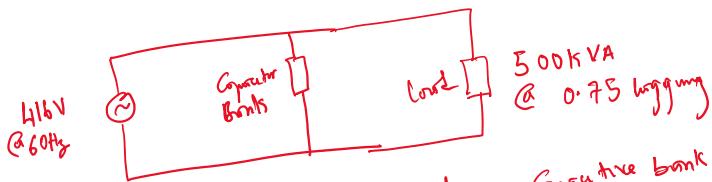
p.f Capacitive bank $\Rightarrow 0.25mF \times n$ $n = \# \text{ of Capacitors}$

\hookrightarrow || with the load

Target \hookrightarrow Determine the # of Capacitors needed to get to the desired p.f of 0.96 lagging

\hookrightarrow Actual p.f seen @ the load after all caps are switched ON

Step 1 Draw the circuit of Power triangle



Step 2 Determine power triangle without the capacitive bank

$$P_f_1 = \frac{P}{S_2} \quad \text{where } P.f_1 = 0.75 \text{ lagging}$$

$$S = 500 \text{ kVA}$$

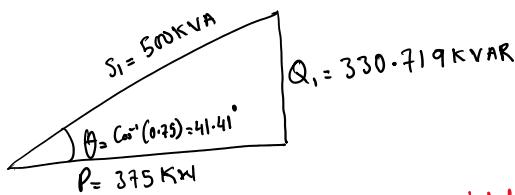
$$P = P_f_1 S$$

$$P = 0.75 \times 500 \text{ kVA} = 375 \text{ kW}$$

$$Q_1 = \sqrt{S^2 - P^2} = \sqrt{500^2 - 375^2} \text{ kVAR}$$

$$Q_1 = 330.719 \text{ kVAR}$$

Power Triangle 1



Step 3 use desired p.f to determine reactive power needed for the p.f correction

$$Q_b = \tan(\theta_2) \times P$$

$$\theta_2 = \cos^{-1}(P_f_t) = 16.26^\circ$$

$$Q_b = \tan(16.26^\circ) \times 375 \text{ kW}$$

$$Q_b = 109.375 \text{ kVAR}$$

$$Q_{\text{needed}} = Q_i - Q_b = 330.719 - 109.375 \text{ [kVAR]}$$

$$Q_{\text{needed}} = 221.344 \text{ kVAR}$$

$$Q = \frac{V_{rms}^2}{X_{CT}}$$

X_{CT} = total Capacitance of Capacitive Bank
 $V_{rms} = 416\text{ V}$

$$X_{CT} = \frac{(416)^2 \text{ V}}{221.344 \text{ KVAR}} = 0.782 \text{ } \Omega$$

$$Y_C = \frac{1}{j\omega C} = \frac{1}{\omega C} \quad \text{where } \omega = 2\pi f = 2\pi(60)$$

$$G_T = \frac{1}{\omega X_{CT}} = \frac{1}{2\pi(60)(0.782\Omega)}$$

$$G_T = 3.393 \text{ mF}$$

Assuming the Capacitors that make up the Capacitive Bank are in parallel

$$\# \text{ Capacitors} = \frac{C_T}{C} \quad C = 0.25 \text{ mF}$$

$$\# \text{ Capacitors} = \frac{3.393 \text{ mF}}{0.25 \text{ mF}} = 13.572 \text{ Capacitors}$$

$$\# \text{ Capacitors} \approx 1/4 \text{ Capacitors of } 0.25 \text{ mF}$$

Step 4 find p.f seen at the load after all capacitors are switched ON

$$P_{real \text{ power}} = 375 \text{ kW}$$

$$Q_{CT_f} = \frac{V_{rms}^2}{X_{CT_f}}$$

$$X_{CT_f} = \frac{1}{\omega C_{CT_f}} = \frac{1}{2\pi(60)(1/4 \times 0.25 \text{ mF})}$$

$$X_{CT_f} = 0.758 \text{ } \Omega$$

$$Q_{CT_f} = \frac{(416)^2 \text{ V}}{0.758 \text{ } \Omega} = 228.306 \text{ KVAR}$$

$$\therefore \text{Reactive power at Capacitive bank} = 228.306 \text{ KVAR}$$

Q_f = final Reactive power after all capacitors are turned ON

$$Q_f = Q_i - Q_{CT}$$

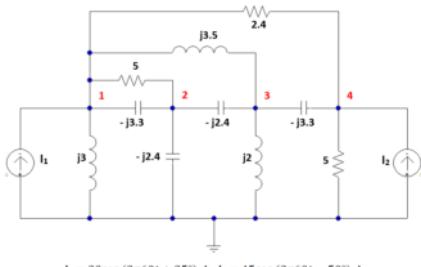
$$Q_f = 330.719 - 228.306 \text{ [KVAR]}$$

$$Q_f = 102.413 \text{ KVAR}$$

$$\text{p.f} = \cos \left[\tan^{-1} \left(\frac{Q_f}{P} \right) \right] \quad \text{since Real Power (P) for the system will stay the same}$$

$$\text{p.f} = \cos \left[\tan^{-1} \left(\frac{102.413 \text{ KVAR}}{375 \text{ kW}} \right) \right]$$

$$\text{p.f} = 0.965$$



$$I_1 = 30\cos(2\pi 60t + 35^\circ) A; I_2 = 45\cos(2\pi 60t - 50^\circ) A$$

$$\vec{V} = \vec{I} \cdot \vec{Z_K} \Rightarrow \vec{I} = \frac{\vec{V}}{Z_K} = \vec{I} = \vec{Y} \vec{V} \quad \vec{Y} = \frac{1}{Z_K}$$

Apply Nodal Analysis @ node 1

$$\begin{aligned} I_1 &= \frac{V_1}{j3} + \frac{V_1 - V_2}{-j3.3} + \frac{V_1 - V_3}{5} + \frac{V_1 - V_4}{j3.5} + \frac{V_1 - V_4}{2.4} \\ I_2 &= V_2 \left[\frac{1}{j3} - \frac{1}{j3.3} + \frac{1}{5} + \frac{1}{j3.5} + \frac{1}{2.4} \right] + V_3 \left[\frac{1}{j3.3} - \frac{1}{5} \right] + V_4 \left[\frac{-1}{j3.5} \right] + V_4 \left[\frac{-1}{2.4} \right] \end{aligned}$$

Using Matlab

$$I_1 = V_1 [0.6 - j0.316] + V_2 [-0.2 - j0.303] + V_3 [0 + j0.286] + V_4 [-0.417] \text{ in terms of impedance } Z_K$$

$$I_1 = 30A \angle 35^\circ$$

$$30A \angle 35^\circ = V_1 [1.305 + j0.687] + V_2 [-1.517 + j2.297] + V_3 [0 - j3.5] + V_4 [-2.4] \text{ in terms of admittance } Y = \frac{1}{Z_K}$$

Apply Nodal Analysis @ node 2

0 current @ summing junction

$$\begin{aligned} 0 &= \frac{V_2}{j2.4} + \frac{V_2 - V_1}{-j3.3} + \frac{V_2 - V_3}{5} + \frac{V_2 - V_4}{-j2.4} \\ 0 &= V_1 \left[\frac{1}{j3.3} - \frac{1}{5} \right] + V_2 \left[\frac{-1}{j2.4} - \frac{1}{j3.3} + \frac{1}{5} - \frac{1}{j2.4} \right] + V_3 \left[\frac{1}{j2.4} \right] \end{aligned}$$

Using Matlab

$$0 = V_1 [-0.2 - j0.303] + V_2 [0.2 + j1.136] + V_3 [0 - j0.417] \text{ in terms of impedance } Z_K$$

$$0 = V_1 [-0.2 - j0.303] + V_2 [0.2 + j1.136] + V_3 [0 + j2.4] \text{ in terms of admittance } Y$$

$$0 = V_1 [-1.517 + j2.299] + V_2 [0.150 - j0.854] + V_3 [0 + j2.4] \text{ in terms of admittance } Y$$

Apply Nodal Analysis @ Node 3

0 current @ summing junction

$$0 = \frac{V_3 - V_2}{-j2.4} + \frac{V_3}{j^2} + \frac{V_3 - V_1}{j^{3.5}} + \frac{V_3 - V_4}{-j^{3.3}}$$

$$0 = V_1 \left[\frac{-1}{j^{3.5}} \right] + V_2 \left[\frac{1}{j^{2.4}} \right] + V_3 \left[\frac{-1}{j^{2.4}} + \frac{1}{j^2} + \frac{1}{j^{3.5}} - \frac{1}{j^{3.3}} \right] + V_4 \left[\frac{1}{j^{3.3}} \right]$$

$$0 = V_1 [0 + j0.286] + V_2 [0 - j0.417] + V_3 [0 - j0.066] + V_4 [0 - j0.303] \text{ in terms of } Z_{th}$$

$$0 = V_1 [0 + j0.286] + V_2 [0 - j0.417] + V_3 [0 + j15.148] + V_4 [0 + j3.3] \text{ in terms of } Y$$

$$0 = V_1 [0 - j3.5] + V_2 [0 + j2.4] + V_3 [0 + j15.148] + V_4 [0 + j3.3]$$

Apply Nodal Analysis @ Node 4

$$I_2 = \frac{V_4 - V_1}{2.4} + \frac{V_4 - V_3}{-j^{3.3}} + \frac{V_4}{5}$$

$$I_2 = V_1 \left[\frac{-1}{2.4} \right] + V_3 \left[\frac{1}{j^{3.3}} \right] + V_4 \left[\frac{1}{2.4} - \frac{1}{j^{3.3}} + \frac{1}{5} \right]$$

$$I_2 = V_1 [-0.417] + V_3 [0 - j0.303] + V_4 [0.617 + j0.303]$$

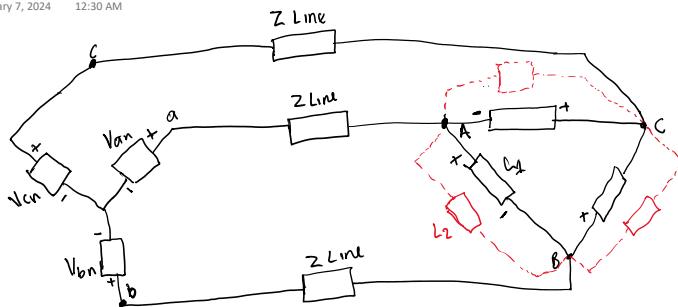
$$I_2 = 4.5A \angle 50^\circ$$

$$4.5A \angle 50^\circ = V_1 [-2.4] + V_3 [0 + j3.3] + V_4 [1.306 - j0.642]$$

4×4 Admittance Matrix

$$\vec{I} = \vec{Y} \cdot \vec{V}$$

$$\begin{bmatrix} 30A \angle 35^\circ \\ 0 \\ 0 \\ 4.5A \angle 50^\circ \end{bmatrix} = \begin{bmatrix} 1.305 + j0.687 & -1.517 + j2.299 & 0 - j3.5 & -2.4 \\ -1.517 + j2.299 & 0.150 - j0.854 & 0 + j2.4 & 0 \\ 0 + j3.5 & 0 + j2.4 & 0 + j15.148 & 0 + j3.3 \\ -2.4 & 0 & 0 + j3.3 & 1.306 - j0.642 \end{bmatrix} \cdot \begin{bmatrix} V_1 \\ V_2 \\ V_3 \\ V_4 \end{bmatrix}$$



$$Z_{line} = 2 + j \omega \quad V_S = 50 \text{ Hz}$$

$L_1 = \text{Inductive } 3\phi \ 8.66 \text{ kV} \quad S_{L1} = 750 \text{ kVA} @ 0.6 \text{ pf lagging}$

$L_2 = \text{Inductive } 3\phi \ 8.66 \text{ kV} \quad P_{L2} = 540 \text{ kW} @ \text{unity pf} \therefore \text{pf} = 1$

① $L_1 : V_{load} = 8.66 \text{ kV } 3\phi \Delta$ $S_{L1}/\phi = \frac{S_{L1}}{3} = \frac{750 \text{ kVA}}{3} = 250 \text{ kVA}$

$$V_{L-N} = \frac{V_{load}}{\sqrt{3}} \approx 5 \text{ kV}$$

$$P_{L1} = \text{pf} \times S_{L1} = 0.6 \times 750 \text{ kVA}$$

$$P_{L1} \approx 450 \text{ kW}$$

$$P_{L1}/\phi = \frac{P_{L1}}{3}$$

$$P_{L1}/\phi = 150 \text{ kW}$$

$$Q_{L1} = \sqrt{S_{L1}^2 - P_{L1}^2}$$

$$Q_{L1} = 600 \text{ kVAR}$$

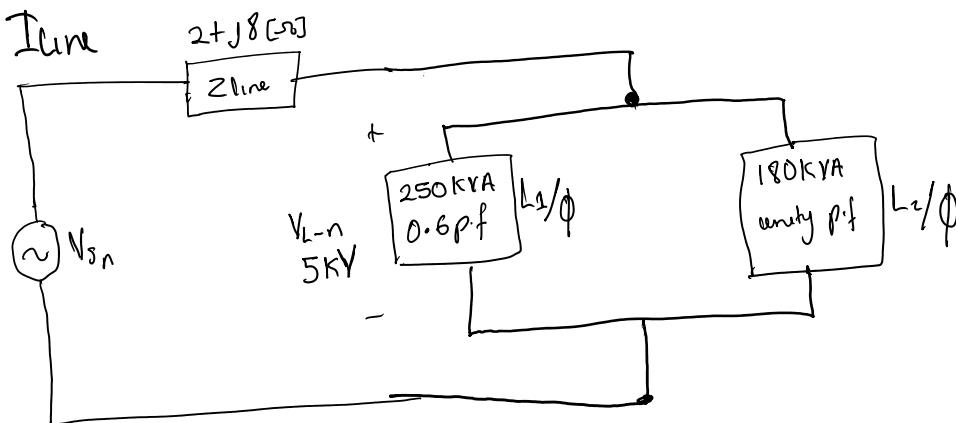
$$Q_{L1}/\phi = \frac{Q_{L1}}{3}$$

$$Q_{L1}/\phi = 200 \text{ kVAR}$$

② L_2 with unity p-f $S_{L2} = P_{L2} \neq Q_{L2} = 0$

$$P_{L2}/\phi = \frac{540 \text{ kW}}{3} = 180 \text{ kW}$$

$$S_{L2}/\phi = 180 \text{ kVA}$$



4b

Magnitude of line Current

$r_n \quad r_T \quad P_M \quad M \quad T$

(4b) Magnitude of line Current

$$I_{\text{line}} = \frac{S_T}{\sqrt{3} V_{\text{line}}} \quad \text{where } S_T = [P_{L_1} + P_{L_2}] + j [Q_{L_1} + Q_{L_2}]$$

$$S_T = [450 \text{Kw} + 540 \text{kVar}] + j [600 \text{kVA}]$$

$$S_T = 990 \text{Kw} + j 600 \text{kVar}$$

$$S_T = \sqrt{990^2 + 600^2} [\text{kVA}] \angle \tan^{-1} \frac{600}{990} \text{K}$$

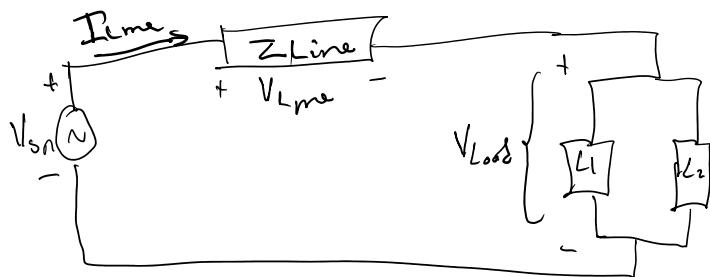
$$S_T = 1157.63 \text{kVA} \angle 31.22^\circ$$

$$|I_{\text{line}}| = \frac{1157.63 \text{kVA}}{\sqrt{3} \times 8.66 \text{kV}} = 77.18 \text{A}$$

Hc) $V_{\text{line}} = I_{\text{line}} \cdot Z_{\text{line}}$ where $I_{\text{line}} = 77.18 \text{A} \angle -31.22^\circ$ Current lags Voltage
 $Z_{\text{line}} = 2 + j 8 = 8.25 \Omega \angle 75.96^\circ$

$$V_{\text{line}} = 77.18 \text{A} \times 8.25 \Omega \angle -31.22^\circ + 75.96^\circ$$

$$V_{\text{line}} = 636.735 \text{V} \angle 44.74^\circ$$



$$V_{sn} = V_{loss} + V_{line}$$

$$V_{sn} = 5 \text{KV} \angle 0^\circ + 636.735 \text{V} \angle 44.74^\circ$$

$$V_{sn} \approx 5.45 \text{kV} + j 448.19 \text{[V]}$$

$$V_{sn} \approx 5.47 \text{kV} \angle 4.70^\circ \quad V_{s-n} @ \text{source}$$

$$V_{L-L} \approx \sqrt{3} V_{sn} = 9.47 \text{kV} \angle 4.7^\circ \text{[V]} \quad V_{L-L} @ \text{source}$$

$$4d) Z_L = 2 + j8$$

$$P_{Z_L} = |I_{\text{line}}|^2 \times Z_L(\text{real})$$

$$P_{Z_L} = 77.18^2 A \times 2$$

$$P_{Z_L} = 11.913 \text{ KW}$$

$$Q_{Z_L} = |I_{\text{line}}|^2 \times Z_L(\text{reactive})$$

$$Q_{Z_L} = 77.18^2 A \times 8$$

$$Q_{Z_L} = 47.654 \text{ KVAR}$$

$$S_{\text{line}} (\text{polar form}) = 49.12 \angle 75.96^\circ [\text{KVA}]$$

4e) 3φ power @ the source

$$S_{3\phi} = I_{\text{line}} \times V_{L-L} \times \sqrt{3} \text{ where } I_{\text{line}} = 77.18 A \angle -31.22^\circ$$

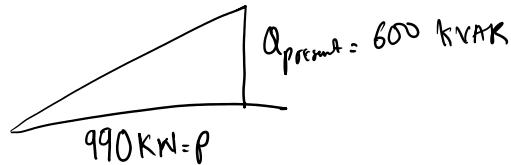
$$V_{L-L} = 9.47 \text{ KV} \angle 4.7^\circ$$

$$S_{3\phi} = 77.18 A \times 9.47 \text{ KV} \times \sqrt{3} \angle 32.22 + 4.7^\circ$$

$$S_{3\phi} = 1265.94 \angle 36.92^\circ [\text{KVA}]$$

$$S_{3\phi} = 1012.09 + j760.44 [\text{KVA}]$$

4f) Power triangle @ Delta load using $S_T = 990 + j 600 [\text{KVA}]$



at unity p.f $Q = 0 \text{ KVAR}$

Q_{needed} for unity p.f = $Q_{\text{present}} - Q_{\text{target}}$

$$Q_{\text{needed}} = 600 \text{ KVAR}$$

$$X_C = \frac{V_L^2}{Q_{\text{needed}}} = \frac{8.66^2 \text{ K}^2}{600 \text{ KVAR}} \checkmark$$

$$X_C = 124.99 \Omega$$

$$C_T = \frac{1}{2\pi f X_C} = \frac{1}{2\pi(60)124.99}$$

$$C_T = 2 \cdot 124 \times 10^{-5} \text{ F}$$

$$C_T = 21.24 \mu\text{F}$$

$$\text{for } 3\phi \text{ Delta correction } C_D = \frac{C_T}{3}$$

$$C_D = \frac{21.24 \mu F}{3}$$

$$C_D \approx 7.08 \mu F$$

(4g) $N_{\text{new}} I_{\text{line}} = \frac{N_{\text{new}} S_T}{\sqrt{3} V_{\text{line}}}$ where $N_{\text{new}} S_T = 990 \text{ kVA}$ since $\theta = 0$

$$N_{\text{new}} I_{\text{line}} = \frac{990 \text{ kVA}}{\sqrt{3} \times 8.66 \text{ KV}}$$

$$N_{\text{new}} I_{\text{line}} = 66.00 A \angle 0^\circ$$

$$Z_L = 8.25 \angle 75.96^\circ [\Omega]$$

$$\begin{aligned} \text{Power loss @ Line} &= (N_{\text{new}} I_{\text{line}})^2 \times Z_{\text{Line}} \\ &= (66.00)^2 \times 8.25 \Omega \angle 0^\circ + 75.96^\circ \\ &= 35.94 \angle 75.96^\circ [\text{kVA}] \\ &= 8.72 + j 34.86 [\text{kVA}] \end{aligned}$$

$$\begin{aligned} \% \text{ improvement in real power loss} &= \frac{11.913 - 8.72}{11.913} \times 100 \\ &= 26.80 \% \text{ improvement} \end{aligned}$$

4 Extra Credit

$$\text{Power Cost} = \$25/\text{MVA per hour} \times 1265.94 \text{ kVA} \times \frac{1 \text{ MVA}}{1000 \text{ kVA}} = 1.265 \text{ MVA}$$

$$\text{Generator Capacity Before unit pf correction} = 1265.94 \text{ kVA} \times 1.265 \text{ MVA} = \$31.63 \text{ per hour}$$

$$\text{Production Cost per hour} = \$\frac{25}{\text{MVA per hour}} \times 1.265 \text{ MVA} = \$31.63 \text{ per hour}$$

$$\text{Annual cost of production} = 365 \times 24 \text{ hours} \times \$31.63/\text{hour} = \$277078.80$$

After pf correction

$$S_{\text{ap}} = \text{New I}_{\text{line}} \times V_{\text{line}} \times \sqrt{3}$$

$$= 66 \times 9.47 \times \sqrt{3} \angle 47^\circ \\ = 1082 \angle 47^\circ [\text{kVA}] = \text{New capacity of generator}$$

$$\text{New hourly production cost} = \$\frac{25}{\text{MVA per hour}} \times 1.082 \text{ MVA} = \$27.05 \text{ per hour}$$

$$\text{New Annual production cost} = 365 \times 24 \text{ hours} \times \$27.05/\text{hours} = \$236958$$

$$\text{Annual savings after pf correction} = \$40120.8$$