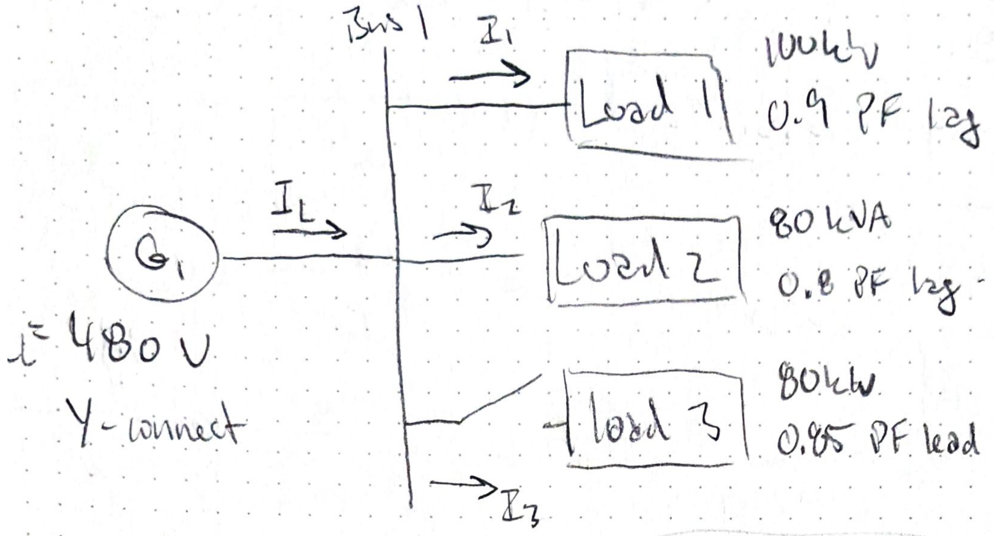
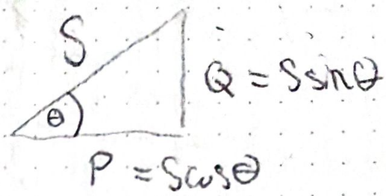
EE347 HW 1

Text 2-3





$$S = \frac{P}{\cos\theta} = \frac{Q}{\sin\theta}$$

$$Q = P\tan\theta$$

$$P = \frac{Q}{\tan\theta}$$

a) Load 1 Y-connect, What are phase voltages and currents for load?

$$V_{\phi_1} = \frac{480v}{\sqrt{3}} = \boxed{277\,v}$$

$$P = 3V_\phi I_\phi \underbrace{\cos\theta}_{PF}$$

$$I_{\phi_1} = \frac{P}{3V_{\phi_1}\cos\theta} = \frac{100kW}{3(277v)0.9} = \boxed{133.7\ A}$$

b) Load 2 Δ-connect, find φ voltage & current

$$\boxed{V_{\phi_2} = V_{LL} = 480v}$$

$$I_{\phi_2} = \frac{S}{3V_{\phi_2}} = \frac{80kVA}{3(480v)} = \boxed{55.6\ A}$$

c) $P_G = P_1 + P_2$ $Q_G = Q_1 + Q_2$ $S_G = \sqrt{P_G^2 + Q_G^2}$

$P_1 = 100kW$

$P_2 = (80kVA)(0.8)$

$$\boxed{P_G = 164\ kW}$$

$Q_1 = (100kW)\tan(\cos^{-1}(0.9))$
$= 48.4\ kVA_r$

$$\boxed{S_G = 190\ kVA}$$

$Q_2 = (80kVA)\sin(\cos^{-1}(0.8))$
$= 48\ kVA_r$

$$\boxed{Q_G = 96.4\ kVA_r}$$

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

$\theta = \tan^{-1}\left(\frac{Q_G}{P_G}\right) = 30.45^\circ$

$I_L = \frac{P_G}{\sqrt{3}\, V_{LL} \cos\theta}$

$P = 164\,kW$

$\cos\theta = 0.86$

$= \frac{164\,kW}{\sqrt{3}(480\,V)(0.86)}$

$= \boxed{228.8\ A}$

e) $P_3 = 80\,kW$ $PF = 0.85$ lead

$Q_3 = P_3 \tan(-\cos^{-1}(0.85))$ lead $= -49.6\ kVAr$ leading

$P_G = P_1 + P_2 + P_3 = \boxed{244\,kW}$

$Q_G = Q_1 + Q_2 + Q_3 = \boxed{46.8\ kVAr}$

$S_G = \sqrt{P_G^2 + Q_G^2} = \boxed{248.4\ kVA}$

f) $I_L = \frac{P_G}{\sqrt{3}\, V_{LL} \cos\theta}$

$\theta = \tan^{-1}\left(\frac{Q_G}{P_G}\right) = 10.86^\circ$

$\cos\theta = 0.982$

$I_L = \frac{244\,kW}{\sqrt{3}(480\,V)\cos(10.86^\circ)}$

$= \boxed{298.8\ A}$

8) Compare total I_L to $I_1 + I_2 + I_3$

$I_L = 298.8$ A

$$I_1 = \frac{P_1}{\sqrt{3}\, V_{LL}\, PF_1} = \frac{100kW}{\sqrt{3}(480v)(0.9)} = 133.6 \text{ A}$$

$$I_2 = \frac{S_1}{\sqrt{3}\, V_{LL}} = \frac{80kVA}{\sqrt{3}(480v)} = 96.2 \text{ A}$$

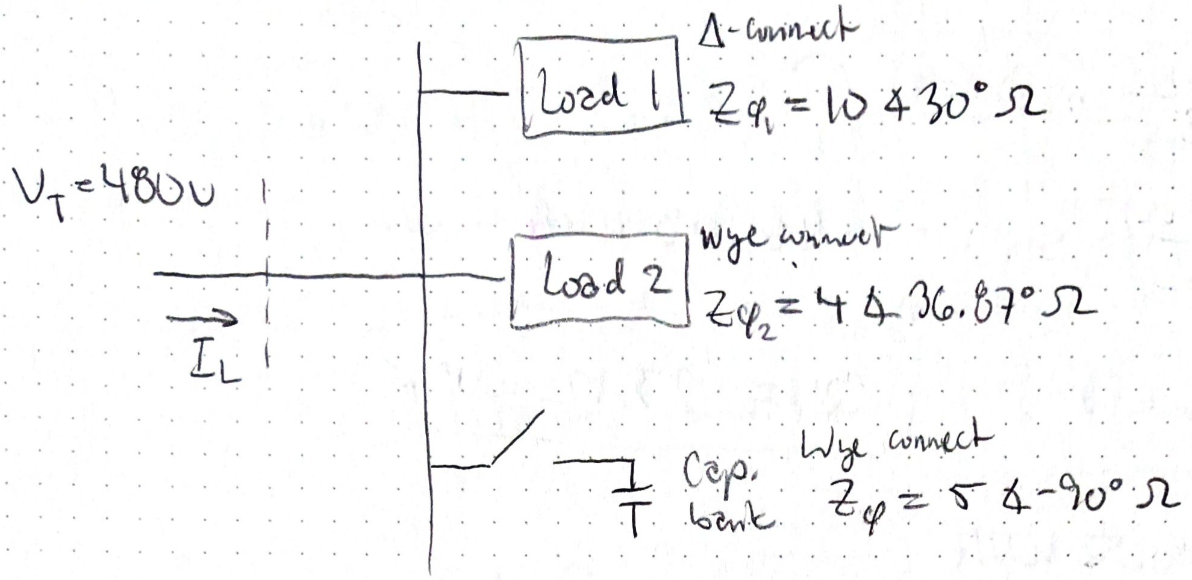
$$I_3 = \frac{P_3}{\sqrt{3}\, V_{LL}\, PF_3} = \frac{80kW}{\sqrt{3}(480)(0.85)} = 113.2 \text{ A}$$

$$I_1 + I_2 + I_3 = \boxed{343 \text{ A}}$$

is greater than $I_L = 299$ A

because each load is drawing current at a diffrent power factor angle, and the 3rd load has a leading current, opposing the other two.

2-6



a) open switch

$$P_1 = 3\frac{V_T^2}{Z_{\varphi_1}}\cos\theta_1 = 3\left(\frac{480v^2}{10\Omega}\right)\cos(30°) = 59.9\text{ kW}$$

$$Q_1 = 3\frac{V_T^2}{Z_{\varphi_1}}\sin\theta_1 = 3\left(\frac{480v^2}{10\Omega}\right)\sin(30°) = 34.6\text{ kVAr}$$

$$P_2 = 3\frac{(V_T/\sqrt{3})^2}{Z_{\varphi_2}}\cos\theta_2 = 46.08\text{ kW}$$

$$Q_2 = 3\frac{(V_T/\sqrt{3})^2}{Z_{\varphi_2}}\sin\theta_2 = 34.6\text{ kVAr}$$

$$P_T = P_1 + P_2 = \boxed{106\text{ kW}} \qquad Q_T = Q_1 + Q_2 = \boxed{69.2\text{ kVAr}}$$

$$S_T = \sqrt{P_T^2 + Q_T^2} = \boxed{126.6\text{ kVA}}$$

$$PF = \cos\left(\tan^{-1}\left(\frac{Q_T}{P_T}\right)\right) = 0.837 \text{ lag}$$

$$I_L = \frac{P_T}{\sqrt{3}\,V_T\,PF}$$

$$= \frac{106\text{kW}}{\sqrt{3}(480v)(0.837)}$$

$$= \boxed{152.3\text{ A}}$$

b) closed switch

$$P_3 = 3\frac{(V_T/\sqrt{3})^2}{Z_{\varphi_3}}\cos\theta = 0$$

$$Q_3 = 3\frac{(V_T/\sqrt{3})^2}{Z_{\varphi_3}}\sin\theta = -46.08\ kVAr$$

$$\boxed{P_T = 106\ kW} \qquad \boxed{Q_T = 23.12\ kVAr}$$

$$S_T = 108.5\ kVA$$

$$PF = \cos\left(\tan^{-1}\left(\frac{Q_T}{P_T}\right)\right) = 0.977$$

$$I_L = \frac{P_T}{\sqrt{3}V_T PF} = \boxed{130.5\ A}$$

c) The total current decreased since the resonance of the system is reduced and there is less reactive power

Prob. 1

$\bar{V}_S = 480v \angle 0°$

a) 1, 9 kW HID, PF = 1.0

b) 1, 5 tonne heat pump, COP = 1.75, $PF_b = 0.95$ lag

c) 2, 5 HP, $\eta = 90\%$ lathes, $PF_c = 0.79$ lags

d) 3, elec autoclaves, 10 kBTU/h, $\eta = 98\%$, PF = 0.97 lag

a) $\bar{S}_a = 9kW + j0 = \sqrt{3}\,\bar{V}_L \bar{I}_a^*$

$$\bar{I}_a = \frac{9kW + j0}{\sqrt{3}(480v \angle 0°)} = 10.8 \angle 0° \text{ A}$$

b) 3.5 kW / tonne thermal

$P_{therm} = (5 \text{ tonnes})(3.5 \text{ kW/tonne}) = 17.5 \text{ kW thermal}$

$$P_{elec} = \frac{P_{therm}}{COP} = 10 \text{ kW} = P_b$$

$\theta_b = \cos^{-1}(PF_b) = 18.2°$ $\qquad S_2 = \dfrac{P_b}{PF_b} = 10.5 \text{ kVA}$

$\bar{S}_b = 10.5 \text{ kVA} \angle 18.2° = \sqrt{3}\,\bar{V}_S \bar{I}^*$

$$\bar{I}_b = \frac{\bar{S}^*}{\sqrt{3}\,\bar{V}_S} = \frac{(10.5 \text{ kVA} \angle 18.2°)^*}{\sqrt{3}(480v \angle 0°)}$$

$$= 12.6 \angle 18.2° \text{ A}$$

c) $P_{mech_{kW}} = (0.746 \text{ kW/HP}) P_{mech HP} = 3.73 \text{ kW}$

$$P_{elec} = \frac{P_{mech kW}}{\eta} = 4.14 \text{ kW}$$

$$P_c = 2 P_{elec} = 8.3 \text{ kW}$$

$$S_c = \frac{P_c}{PF_c} = 10.5 \text{ kVA}$$

$$\theta_c = \cos^{-1}(PF_c) = 37.8°$$

$$\bar{I}_c = \frac{(10 \text{ kVA} \angle 37.8°)}{\sqrt{3}\,(480 \angle 0°)} = 12 \angle 37.8 \text{ A}$$

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d) 3 autoclaves 10 kBTU/h, $\eta = 98\%$, $PF_d = 0.97$ lag

$1 \text{ W} / 3.41 \text{ BTU/h} \rightarrow 10 \text{ kBTU/h} / 3.41 \text{ BTU/h/W} = 2.93 \text{ kW}_{thermal}$

$$P_{elec} = \frac{P_{thermal}}{\eta} = 2.96 \text{ kW}$$

$P_d = 3 P_{elec} = 8.88 \text{ kW}$ $\quad S_d = \frac{P_d}{PF_d} = 9.15 \text{ kVA}$

$$\theta_d = \cos^{-1}(PF_d) = 14°$$

$$\bar{I}_d = \frac{9.15 \text{ kVA} \angle 14°}{\sqrt{3}\,(480 \text{ V})} = 11 \angle 14° \text{ A}$$

Switch lighting system (a) with

- T8 fluorescent <u>25% less</u> consumption, $PF_f = 0.91$ lead

$P_f = 0.75\, P_a = (0.75)(9\text{ kW}) = 6.75\text{ kW}$

$S_f = \dfrac{P_f}{PF_f} = 7.4\text{ kVA}$ $\qquad \theta_f = \cos^{-1}(PF_f) = -24.5°$ leading

$\bar{S}_f = 7.4\text{ kVA} \measuredangle -24.5°$

$\bar{I}_f = \dfrac{\bar{S}_f}{\sqrt{3}\, V_s} = 8.9 \measuredangle -24.5°\text{ A}$ lead

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$\bar{S}_1 = \bar{S}_a + \bar{S}_b + \bar{S}_c + \bar{S}_d = 38 \measuredangle 18.3°\text{ kVA}$

$\bar{S}_2 = \bar{S}_f + \bar{S}_b + \bar{S}_c + \bar{S}_d = 35 \measuredangle 14.6°\text{ kVA}$

$I_1 = \dfrac{S_1}{\sqrt{3}\, V_s} = \dfrac{38\text{ kVA}}{\sqrt{3}(480\text{V})} = 45.7\text{ A}$

$I_2 = \dfrac{S_2}{\sqrt{3}\, V_s} = \dfrac{35\text{ kVA}}{\sqrt{3}(480\text{V})} = 42\text{ A}$

for 60°C rating w/ 40°C ambient,

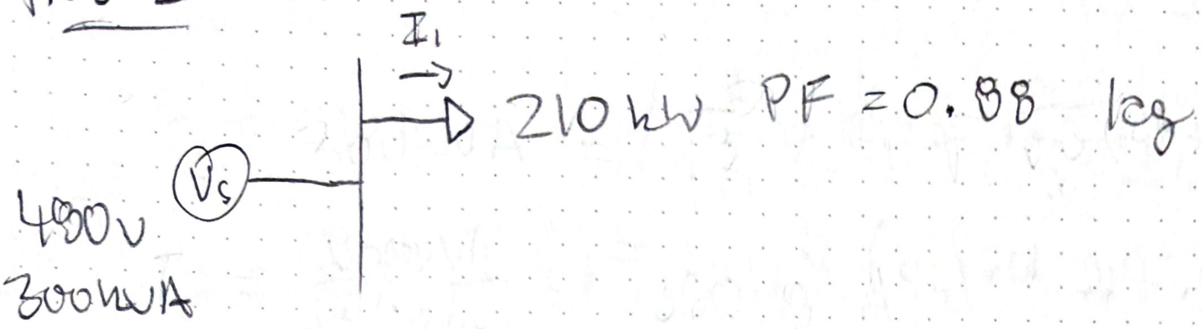
CF = 0.82 from Table 310.15(B)(2)(a)
for 40°C ambient, based on 30°C

Using Table 310.15(B)(16):

for 60°C, $(0.82) I_1 = 37\text{ A} \rightarrow$ AWG 8

$(0.82) I_2 = 34\text{ A} \rightarrow$ AWG 8

Prob 2



$$S_1 = \frac{P}{PF} = \frac{210\text{ kW}}{0.88} = 238.6\text{ kVA}$$

$$I_1 = \frac{S_1}{\sqrt{3}\,V_s} = \frac{238.6\text{ kVA}}{\sqrt{3}\,(480\text{ V})} = 287\text{ A}$$

Use CF from Table 310.15(B)(2)(a) for 30°C ambient

temp rating for Al THW = 75°C

ambient temp 36-40°C : CF = 0.88

$$I_1(0.88) = 253\text{ A}$$

Use Table 310.15(B)(16) for conductor gauge

Al THW   270 > 253 A

$\boxed{\text{400 kcmil gauge}}$

add <u>two</u> 12 HP lathes ($\eta = 90\%$, $PF = 0.87$ lag)

to same branch.

$$P_{mech\,kW} = (0.746\ kW/HP)\ P_{mech\,HP} = 8.95\ kW$$

$$P_{elec} = \frac{P_{mech\,kW}}{\eta} = 9.95\ kW$$

$$P = 2(P_{elec}) = 19.9\ kW$$

$$S = \frac{P}{PF} = 22.9\ kVA$$

$$S_2 = S_1 + S = 261.5\ kVA$$

$$I_2 = \frac{S_2}{\sqrt{3}\,V_S} = 314.5\ A$$

Using the same values from NFPA 70

$$I_2 CF = I_2(0.88) = 277\ A$$

$$\boxed{\text{277 A > 270 A max rating for 400 kcmil gauge conductor}}$$

FE Prob 1

$S = 2100\ \text{VA}$ w/ $PF = 0.85$ lagging, VAr is ...

$\theta = \cos^{-1}(PF) = 31.8^\circ$

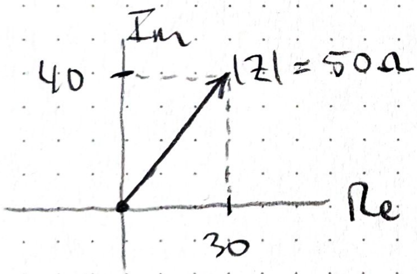
$Q = S\sin\theta = 1106.6\ \text{VAr}$

(A) $1100\ \text{VAr}$ since lag $\rightarrow +Q$

FE Prob 2

$\bar{Z} = 30\Omega + (-j50\Omega) + j90\Omega$

$= 30\Omega + j40\Omega$



(C)