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ECE 476
HW 2
Fall 2012

out of 29 points total

5 + 15 + 9

Problem 1: Minimize real power line losses:

5 points

$Q_{cap} = 4.0$ MVAR

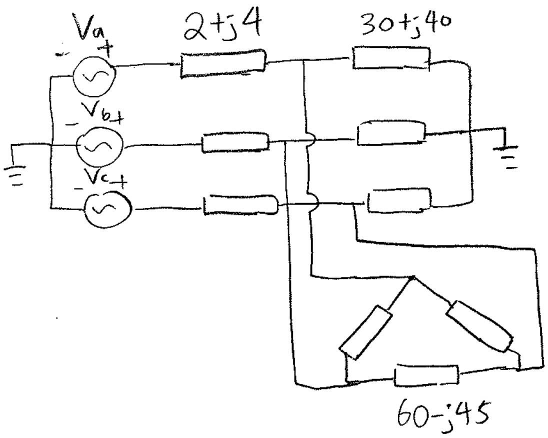
2 points per correct answer, 0.5 points per labelling of units

Minimize MVA power flow into feeder:

$Q_{cap} = 4.5$ MVAR

Problem 2:

15 points



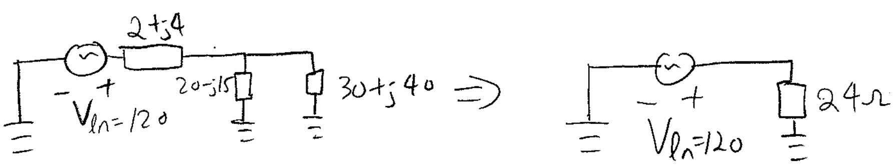
$V_{ll} = 120\sqrt{3}$

3 points, one point per answer, - 0.5 points for no units

1. Balanced load ⇒ Analyze each phase separately

First use Δ-Y transformation to turn delta load into Y- load

$Z_\Delta = 60 - j45 \Rightarrow Z_Y = \frac{Z_\Delta}{3} = 20 - j15\ \Omega$



Assume phase 'a' has voltage angle 0°.

Problem 2:

1. Using KVL: $\bar{I}_\phi = \frac{120\angle 0}{24} = \boxed{5A}$ or $5\angle 0° A$

$S_\phi = V_\phi I_\phi^* = 120 \cdot 5 = 600\ VA$

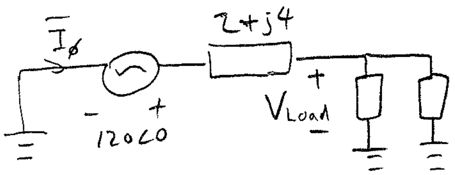
$S_{Tot} = 3 \cdot 600 = 1800\ VA$

$\boxed{P = 1800\ W}$, $\boxed{Q = 0\ VAR}$

2\.

2 points

1 point for magnitude, 1 point for phase angle, work must be shown to earn credit



$\bar{V}_{Load} = \bar{V}_\phi - \bar{I}_\phi (2+j4)$

$\bar{V}_{Load} = 120\angle 0 - 5\angle 0 \cdot (2+j4)$

$= 110 - j20$

$= 111.8 \angle -0.18$

Assuming phase a line to neutral has phase 0°,

$\bar{V}_{ll}$ for phase a is:

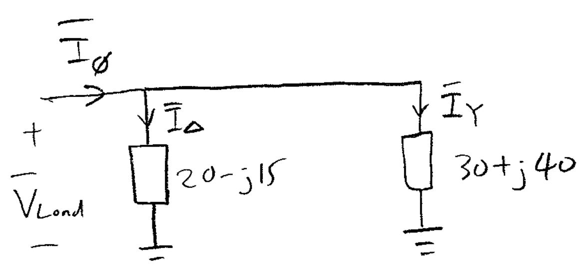
$\bar{V}_{ll} = \sqrt{3}\, \bar{V}_{Load}\, e^{j(\pi/6)}$

$= \boxed{193.6 \angle 0.34}\ V$

↑ 19.68°

3\.

4 points; two points per answer

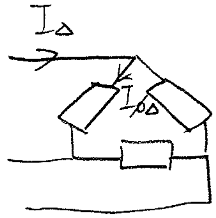


$\bar{I}_\Delta = \frac{V_{Load}}{20-j15} = \frac{111.8\angle -0.18}{20-j15} = 4+j2 = 4.47\angle 0.46$

Since $\bar{I}_\Delta$ is current of equivalent Y load for the actual Δ load; we need the phase current through each load of Δ connection

Problem 2

3.



$$\bar{I}_{\phi\Delta} = \frac{\bar{I}_\Delta}{\sqrt{3}} \cdot e^{j(\pi/6)}$$

$$= \boxed{2.58\angle 0.983 \text{ A}}$$

($0.983 \to 56.57°$)

The angle will have diff. values depending on which phase is chosen and how the phase current is labeled. The magnitude must be 2.58.

$$\bar{I}_Y = \frac{\bar{V}_{Load}}{30+j40} = \frac{111.8\angle -0.18}{30+j40} = 1-j2 = \boxed{2.23\angle -1.107 \text{ A}}$$

($-1.107 \to -63.43°$)

6 points 4. Δ Load: $\bar{S}_\Delta = 3\cdot(111.8\angle -0.18)(4.47\angle 0.46)^*$

$$= 1200 - j900$$

$$\therefore \boxed{\bar{P}_\Delta = 1200 \text{ W}, \quad \bar{Q}_\Delta = -900 \text{ VAR}}$$

Y Load: $\bar{S}_Y = 3\cdot(111.8\angle -0.18)(2.23\angle -1.107)^*$

$$= 450 + j600$$

$$\therefore \boxed{\bar{P}_Y = 450 \text{ W}, \quad \bar{Q}_Y = 600 \text{ VAR}}$$

Line: $\bar{S}_{Line} = 3\cdot\frac{|\bar{V}_{drop}|^2}{Z^*_{Line}} = 3\cdot\frac{|120\angle 0 - 111.8\angle -0.18|^2}{2-j4}$

$$= 150 + j300$$

$$\therefore \boxed{\bar{P}_{Line} = 150 \text{ W}, \quad \bar{Q}_{Line} = 300 \text{ VAR}}$$

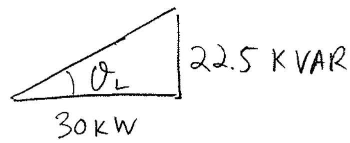
Note: $\bar{I}\bar{I}^* = |\bar{I}|^2$ and $\bar{I} = \frac{\bar{V}}{\bar{Z}}$, $\bar{I}^* = \frac{\bar{V}^*}{\bar{Z}^*}$

Also, notice $\bar{S}_\Delta + \bar{S}_Y + \bar{S}_{Line} = 1800 \text{ W}$ (sanity check ☺)

Problem 3

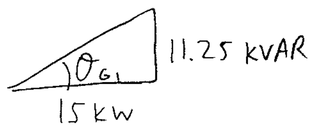
(9 points)

Load:



$\theta_L = \cos^{-1}(0.8) = 0.64$ rad

G1:



$\theta_{G_1} = 0.64$ rad

Doesn't matter if Load is Δ or Y since we're using per phase equivalent

460 V Line-Line ⇒ $\frac{460}{\sqrt{3}}$ V Line-Neutral

↑ Let this be 0° phase reference.
Of course we can also make life hard by letting this have a 30° phase shift.

Current of G1 Line: $\bar{I}_{G_1} = \left(\frac{\bar{S}_{G_1}}{3\bar{V}_{G_1}}\right)^* = \frac{15 - j11.25}{3\left(\frac{460}{\sqrt{3}}\right)}$ ← in KVA

(per phase →)

$= 18.83 - j14.11$ A

$= \boxed{23.53\angle -0.643 \text{ A}}$

↳ $-36.84°$

3 points — 1. Voltage at Load terminals:

Using KVL: $\frac{460}{\sqrt{3}}\angle 0 = \bar{I}_{G_1} \cdot (1.4 + j1.6) + \bar{V}_{Load}$

$\bar{V}_{Load} = 216.6 - j10.37$ V

$= \boxed{216.89\angle -0.047 \text{ V}}$ Line-Neutral

↳ $-2.74°$

or $375.6\angle 27.26°$ V Line-Line

Problem 3

3 points 2. $\bar{I}_{Load} = \left(\frac{\bar{S}_{Load}/3}{\bar{V}_{Load}}\right)^* = \frac{10-j7.5}{216.6+j10.37} = 44.41 - j36.75 \text{ A}$

$\bar{I}_{G2} = \bar{I}_{Load} - \bar{I}_{G1} = 44.41 - j36.75 - (18.83 - j14.11)$

$= 25.58 - j22.64 \text{ A}$

$\bar{V}_{G2} = \bar{V}_{Load} + \bar{I}_{G2}(0.8 + j1)$

$= 216.6 - j10.37 + (25.58 - j22.64)(0.8 + j1)$

$= 259.7 - j2.9 \text{ V}$

$= \boxed{259.7 \angle -0.011 \text{ V}}$

↳ $-0.64°$

3 points 3. $\bar{S}_{G2} = 3 \cdot \bar{V}_{G2} \bar{I}_{G2}^*$

$= 3(259.7 \angle -0.011)(25.58 + j22.64)$

$= \boxed{20.13 + j17.4 \text{ kVA}}$

↑ P ↑ Q