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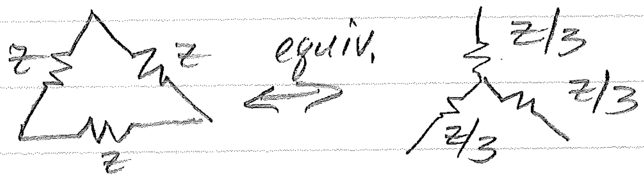
2.42

Draw the wye-equivalent one-line diagram



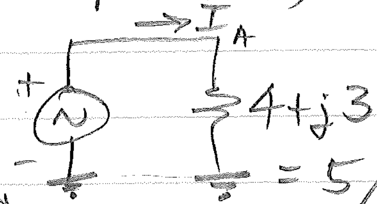
$\frac{12+j9}{3} = 4+j3$

$208 V_{LL} \div \sqrt{3} = 120 V_{LN}$

RMS Line-to-Line

RMS Line-to Neutral

One line (phase A)



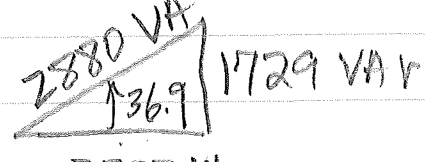
$\tilde{I}_A = \frac{120\angle 0}{5\angle 36.9} = 24\angle -36.9^\circ$ A_{RMS}

$S_A = \tilde{V}_{AN}\tilde{I}_A^* = (120\angle 0)(24\angle -36.9)^* = (120\angle 0)(24\angle +36.9)$

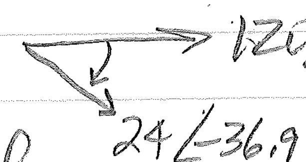
$= 2880\angle 36.9$ VA $= 2303 + j1729$

W VAr

Power Triangle



$\tilde{V}_{AN}, \tilde{I}_A$ phasors



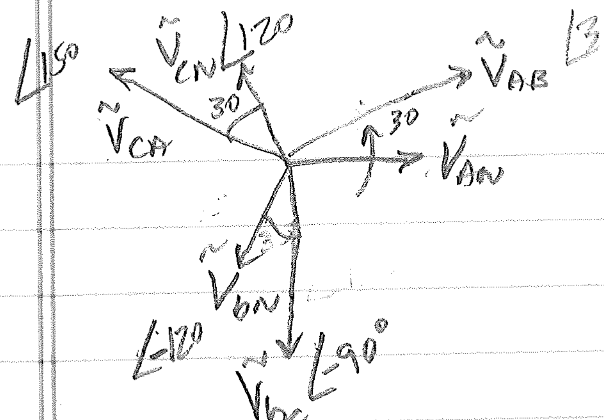
Angles negated

Load receives P and positive Q

lagging $\tilde{I}$

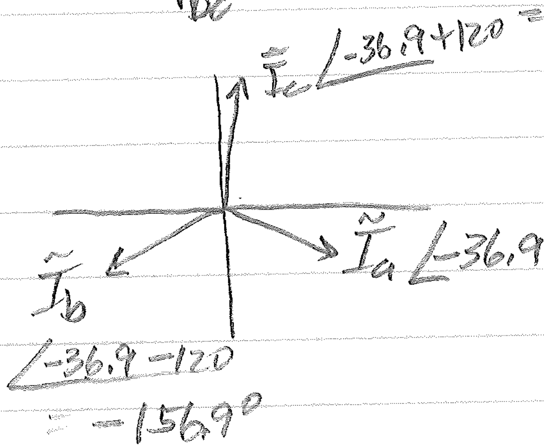
Phases b & c have same P, Q. $\tilde{V}_{bn}, \tilde{I}_b$ lag by 120°

V_{cn}, I_c lead by 120



V_{L-L} leads L-N by 30°

V_{LL} is $\sqrt{3}$ larger

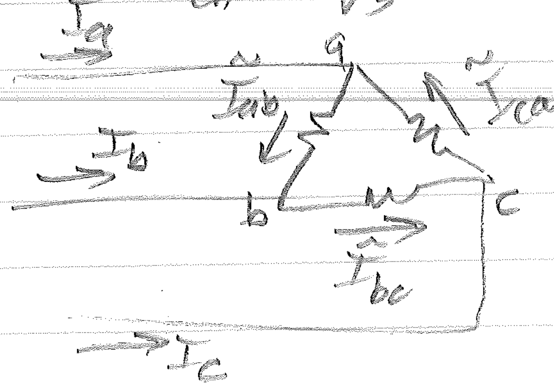


$\hat{I}_{ab}$ leads I_a by 30°, and is $\sqrt{3}$ smaller

$$\tilde{I}_{ab} = \frac{24}{\sqrt{3}} \angle -36.9 + 30^\circ$$

$$\hat{I}_{bc} = \frac{24}{\sqrt{3}} \angle -156.9 + 30^\circ$$

$$\tilde{I}_{CA} = \frac{24}{\sqrt{3}} \angle 83.1 + 30^\circ$$



If you want VAB to be $\angle 0$, then take away 30° from every V & I angle

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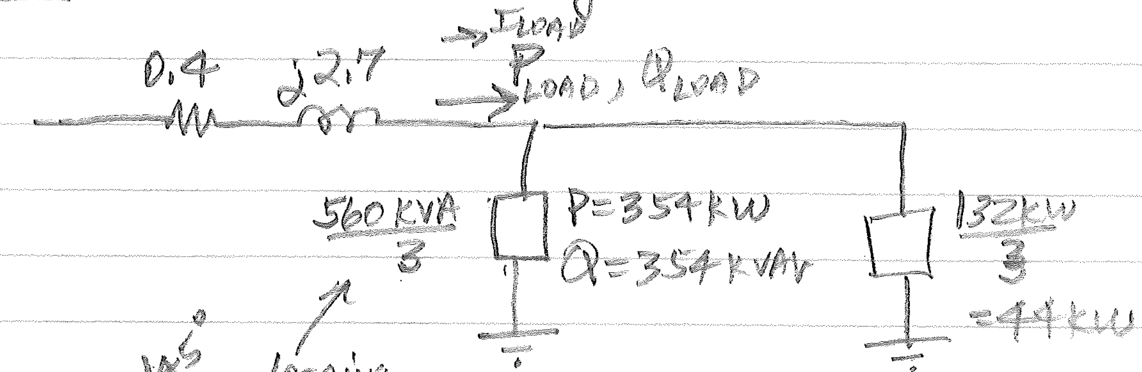
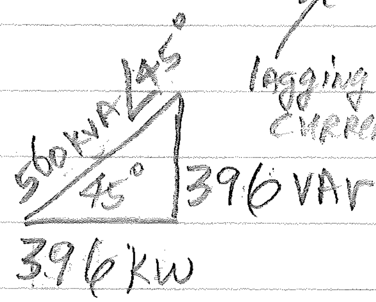
2.44 DRAW ONE-LINE DIAGRAM





LN voltage at load is $\frac{2200\sqrt{3}}{\sqrt{3}} = 2200\ V_{RMS}$

Conservation of power

$$P_{LOAD\,3\phi} = (396 + 132) = 528\ KW$$

$$Q_{LOAD\,3\phi} = (354 + 0) = 354\ KVAr$$

$$S_{LOAD} = 636\angle 33.8\ KVA_{3\phi}$$

$$V_{LOAD} = 2200\angle 0$$

$$V_{LOAD} I^*_{LOAD} = S_{LOAD}, \quad I^*_{LOAD} = \frac{\frac{636000}{3}\angle 33.8}{2200}$$

$$I_{LOAD} = 96.4\angle -33.8\ A$$

$$V_{SOURCE} = \underbrace{(0.4 + j2.7)(96.4\angle -33.8)}_{\underbrace{2.73\angle 81.6 \cdot 96.4\angle -33.8}_{263\angle 47.8}} + 2200$$

$$= 176.7 + j194.8 + 2200$$

$$= 2377 + j194.8 = 2385\angle 4.7°$$

2.44, cont.

Source Power ?

$$V_{source} I^*_{source} = (2385\angle 4.7)(96.4\angle -33.8)^* \quad 1\phi$$

$$= \underset{\text{KVA}}{230\angle 38.5} = \underset{\substack{\text{KW} \\ 1\phi}}{180} + j\underset{\substack{\text{KVAr} \\ 1\phi}}{143}$$

Load P was 528 KW 3ϕ = 176 KW 1ϕ

Q 354 KVAr 3ϕ = 118 KVAr 1ϕ

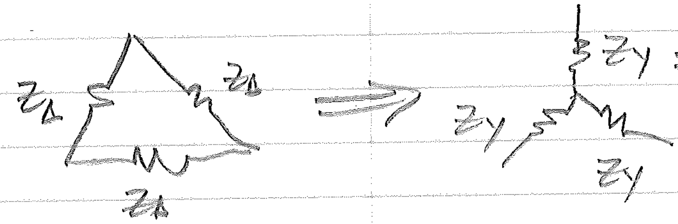
$$|I|^2 R = (96.4)^2 (0.4) = 3.72 \text{ KW } 1\phi$$

$$|I|^2 X = (96.4)^2 (2.7) = 25.1 \text{ KVAr } 1\phi$$

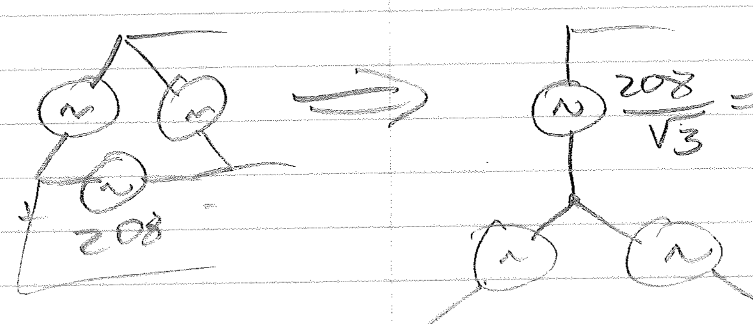
	P	Q
LOAD	176	118
LOSS	+ 3.7	25
Source	180 KW 1ϕ	143 KVAr 1ϕ

Checks !

2.46. Balanced, Convert Δ's to Y's

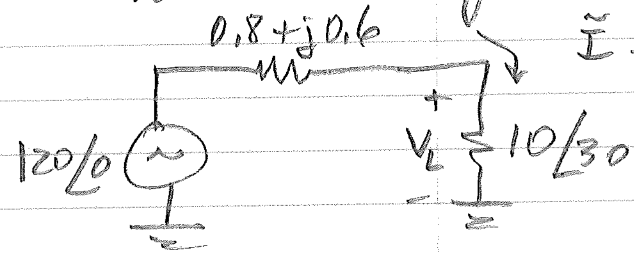


$$Z_Y = \frac{Z_\Delta}{3} = 10\angle 30^\circ\ \Omega$$



$$\frac{208}{\sqrt{3}} = 120V$$

One-line diagram for phase a.



$$\tilde{I} = \frac{120}{(0.8+j0.6)+(8.66+j5.0)}$$

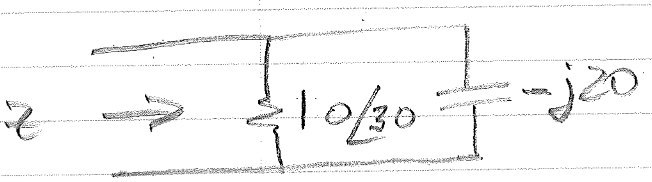
$$\tilde{I} = \frac{120}{(9.46+j5.6)} = 11\angle 30.6$$

$$\tilde{I} = 10.92\angle -30.6^\circ\ A$$

$$\tilde{V}_L = (10.92\angle -30.6)(10\angle 30) =$$

$$\boxed{\tilde{V}_L = 109.2\angle -0.6\ V}$$ Line to neutral

Cap bank $Z_\Delta = -j60\Omega$, Wye equiv. $= -j20\Omega$



$$Z = \frac{(10\angle 30)(20\angle -90)}{10\angle 30 - j20}$$

$$Z = \frac{200\angle -60}{(8.66+j5.0-j20)} = \frac{200\angle -60}{8.66-j15} = \frac{200\angle -60}{17.32\angle -60}$$

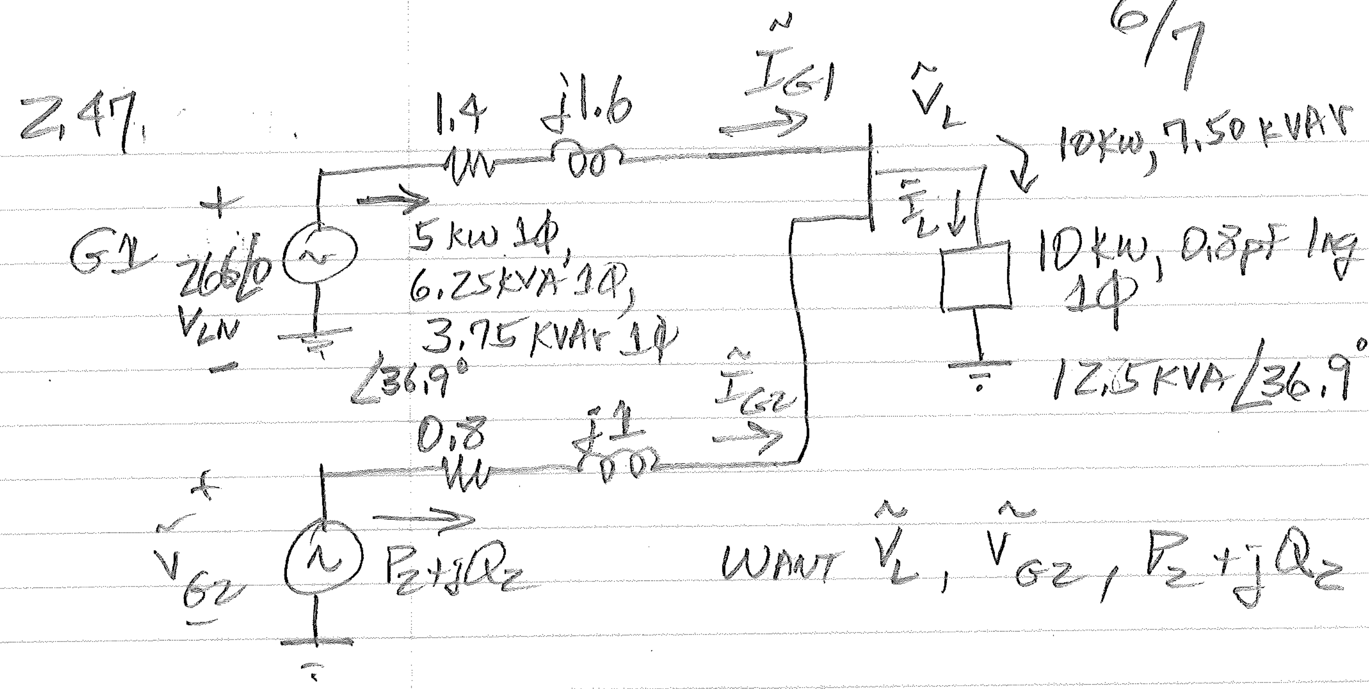
Less drop to load

$Z = 11.55\angle 0^\circ$ (perfect power factor correction)

$$V_{LOAD} = 120\angle 0\left[\frac{11.55}{(0.8+j0.6)+11.55}\right] = 120\angle 0\left[\frac{11.55}{12.36\angle 2.8}\right] = 112.1\angle -2.8$$

Line-to-neutral

2.47



WANT $\tilde{V}_L$, $\tilde{V}_{G2}$, $P_2 + jQ_2$

Strategy to solving this puzzle – start with what u know:

Conditions at G1 allow you to get $\tilde{I}_{G1}$

Voltage drop on line 1 gets you $\tilde{V}_L$

$\tilde{V}_L$ and $P_L + jQ_L$ gets you I_L

$\tilde{I}_L + \tilde{I}_{G1}$ gets you $\tilde{I}_{G2}$

$I_{G2}^2(0.8)$ gets you $P_{LOSS\,2}$

$\quad(1)$ " " $Q_{LOSS\,2}$

Voltage drop on line 2 gets you $\tilde{V}_{G2}$

$\tilde{V}_{G2}\,\tilde{I}_{G2}^*$ gets you $P_2 + jQ_2$

$\tilde{V}_{G1}\,\tilde{I}_{G1}^* = 6250\angle 36.9$, $\tilde{I}_{G1} = \dfrac{6250\angle 36.9}{266} = \boxed{\begin{matrix} I_{G1} \\ 23.5\angle -36.9^\circ \text{ A}\end{matrix}}$

$\tilde{V}_{drop\,1} = (23.5\angle -36.9)\underbrace{(1.4 + j1.6)}_{2.13\angle 48.8} = 50.0\angle 11.9^\circ$ V

$= 48.9 + j10.3$ V

2.47, CONT

$$\hat{V}_{LOAD} = \tilde{V}_{G1} - \tilde{V}_{drop} = 266 - 48.9 - j10.3 = 217.1 - j10.3$$

$$\hat{V}_{LOAD} = 217.3\angle -2.7 \text{ V}$$

$$I^*_{LOAD} = \frac{12500\angle 36.9}{217.3\angle -2.7} = 57.5\angle 39.6, \quad \tilde{I}_{LOAD} = 57.5\angle -39.6 \text{ A}$$

$$\tilde{I}_{G2} = \tilde{I}_L - \tilde{I}_{G1} = (44.3 - j36.7) - (18.79 - j14.11)$$

$$= 25.5 - 22.6 = \overset{I_{G2}}{34.1\angle -41.5^\circ}$$

$$\tilde{V}_{G2} = \hat{V}_L + \tilde{I}_{G2}(0.8 + j1) = 217.3\angle -2.7 + \underbrace{(34.1\angle -41.5)(1.281\angle 51.3)}_{43.7\angle 9.8^\circ}$$

$$= (217.1 - j10.24) + (43.1 + j7.44)$$

$$\tilde{V}_{G2} = 260 - j2.8 = 260\angle -0.6^\circ \text{ V}$$

$$V_{G2} I^*_{G2} = (260\angle -0.6)(34.1\angle 41.5) = 8666\angle 40.9 \text{ VA}$$

$$= 6550 \text{ W}, 5674 \text{ W}$$

Power Check

Input	P	Q
G1	5000	3750
G2	6550	5674
	11550	9424

Load	P	Q
	10000	7500

Loss	P	Q
Line 1	$(23.5)^2(1.4) = 773$	$(23.5)^2(1.6) = 884$
Line 2	$(34.1)^2(0.8) = 930$	$(34.1)^2(1) = 1163$

Load + Loss	P	Q
	10000	7500
	773	884
	930	1163
	11703	9547 ?

Round off?