EE 455, Quiz 1, Spring 2005, Dr. McCalley

SOLUTIONS: QUIZ #1

1. (30 pts) A 12.47kV feeder provides service to an unbalanced delta-connected load consuming the following power:
   - Phase ab: 1500 kVA, 0.95 lagging
   - Phase bc: 1000 kVA, 0.85 lagging
   - Phase ca: 950 kVA, 0.9 lagging

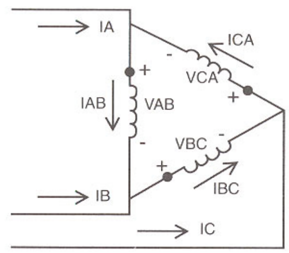
   Give the following expressions (no need to calculate – just give expressions):

   a. The currents in each phase.

$$\bar{I}_{ab} = \left[\frac{1500\angle(\cos^{-1}0.95)^\circ}{12.47\angle 0^\circ}\right]^* \text{ Amps}$$

$$\bar{I}_{bc} = \left[\frac{1000\angle(\cos^{-1}0.85)^\circ}{12.47\angle -120^\circ}\right]^* \text{ Amps}$$

$$\bar{I}_{ca} = \left[\frac{950\angle(\cos^{-1}0.90)^\circ}{12.47\angle 120^\circ}\right]^* \text{ Amps}$$



   b. The matrix $\underline{A}$, where A is defined in the equation to the right ➔.

$$\begin{bmatrix} I_a \\ I_b \\ I_c \end{bmatrix} = \underline{A} \begin{bmatrix} I_{ab} \\ I_{bc} \\ I_{ca} \end{bmatrix}$$

   Using KCL at each node

$$\bar{I}_A = \bar{I}_{ab} - \bar{I}_{ca}$$

$$\bar{I}_B = \bar{I}_{bc} - \bar{I}_{ab}$$

$$\bar{I}_C = \bar{I}_{ca} - \bar{I}_{bc}$$

$$\begin{bmatrix} \bar{I}_A \\ \bar{I}_B \\ \bar{I}_C \end{bmatrix} = \begin{bmatrix} 1 & 0 & -1 \\ -1 & 1 & 0 \\ 0 & -1 & 1 \end{bmatrix} \begin{bmatrix} \bar{I}_{ab} \\ \bar{I}_{bc} \\ \bar{I}_{ca} \end{bmatrix}$$

   c. Are the *line currents* balanced in this case?

   No, the unbalanced load will result in unbalanced line currents. If you carry out all calculations you will find that $\bar{I}_A + \bar{I}_B + \bar{I}_C = 0\angle 0^\circ$. This will always be the case in the delta connection as there is no neutral wire to carry current.

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2. (25 pts) The table below gives the time interval and kVA demand of the four customers fed by a single 75kVA transformer during a particular time period.

Time	Cust#1	Cust#2	Cust#3	Cust#4
3:00-3:30	10	0	10	5
3:30-4:00	20	25	15	20
4:00-4:30	5	30	30	15
4:30-5:00	0	10	20	10
5:00-5:30	15	5	5	25
5:30-6:00	15	15	10	10
6:00-6:30	5	25	25	15
6:30-7:00	10	50	15	30

Determine:
a. 30 minute maximum kVA demand
b. Noncoincident maximum kVA demand
c. Load factor
d. Diversity factor
e. Utilization factor (assume 0.9 pf)
You need not perform any long division here (i.e., where appropriate, you may leave answers as ratios).

a: $10+50+15+30=105 \text{ kVA}$

b: $20+50+30+30=130 \text{ kVA}$

c: $\dfrac{\text{Avg Demand}}{\text{Max Demand}}=\dfrac{\frac{500/2}{4}}{105}=\dfrac{\frac{500}{8}}{105}\approx 0.5952$ Average Demand is Total Energy (in kVAh) / Hours

d: $\dfrac{\text{Max Noncoincident Demand}}{\text{Max Diversified Demand}}=\dfrac{130}{105}\approx 1.2381$

e: $\dfrac{\text{Max kVA Demand}}{\text{XFMR kVA Demand}}=\dfrac{105}{75}=1.4$ (Notice we don't use the p.f. as the demands are kVA not kW)

3. (20 pts) You receive the following data from a manufacturer regarding a new three phase transformer:

Ratio of line-line voltages:	69kV/34.5kV
Power rating:	5 MVA
Per unit reactance on base of transformer ratings:	0.10 pu

You are considering replacement of an existing transformer in your three-phase system with this new one, and you want to see how it would affect the currents.
(a) Give the expression to convert the per unit reactance given above to the per unit reactance on a 10 MVA base.
(b) In what way is the value of the per unit reactance expressed in part (a) influenced by whether it is computed on the 69 kV side or the 34.5 kV side?

$$Z_{\text{pu new}}=Z_{\text{pu old}}\cdot\left(\frac{V_{\text{base old}}}{V_{\text{base new}}}\right)^2\cdot\left(\frac{S_{\text{base new}}}{S_{\text{base old}}}\right)$$

$$=0.10\cdot\left(\frac{69\text{ kV}}{69\text{ kV}}\right)^2\cdot\left(\frac{10\text{ MVA}}{5\text{ MVA}}\right)=0.2\text{ p.u.}$$

or

$$=0.10\cdot\left(\frac{34.5\text{ kV}}{34.5\text{ kV}}\right)^2\cdot\left(\frac{10\text{ MVA}}{5\text{ MVA}}\right)=0.2\text{ p.u.}$$

Notice it makes no difference which side of the XFMR the per unit reactance is computed on.

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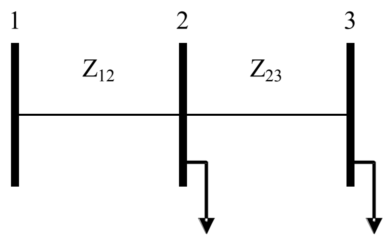
4. (25 pts) In the following system that we dealt with in class, the forward sweep generated currents I_{23} and I_{12}, and resulted in a voltage at node 1 of 7376 volts. The desired voltage at node 1 was 7200 volts. Describe the backwards sweep, and show the calculations that you would make in performing it.



Using V1 voltage as 7200 together with the current I12 and impedance Z12, find V2

$$\overline{V}_2 = \overline{V}_1 - \overline{I}_{12} \cdot \overline{Z}_{12}$$

I2 = I12 – I23, and I3 = I23

Now use V2 voltage together with I23 and Z23 to find V3

$$\overline{V}_3 = \overline{V}_2 - \overline{I}_{23} \cdot \overline{Z}_{23}$$

Now begin a new forward sweep to determine the next iteration currents.