EE 455, HW1, Spring 2005, Dr. McCalley
Due Friday, January 21, 2005

SOLUTIONS: Problems #2 & #3

#2.

Part a)

XFMR #1:

Max Noncoincident Demand

$$12.4 + 13.4 + 16.1 + 12.9 + 11.9 = \boxed{66.7 \text{ kW}}$$

Max Coincident Demand

$$\frac{\text{Max Noncoincident Demand}}{\text{Diversity Factor (5 Customers)}} = \frac{66.7}{2.20} = \boxed{30.3 \text{ kW}}$$

Max kVA_{T1} Demand

$$\frac{\text{Max Coincident Demand}}{\text{Power Factor}} = \frac{30.3}{0.9} = \boxed{33.6}$$

XFMR #2:

Max Noncoincident Demand

$$10.1 + 12.9 + 13.8 + 14.2 + 16.3 + 14.3 = \boxed{81.6 \text{ kW}}$$

Max Coincident Demand

$$\frac{\text{Max Noncoincident Demand}}{\text{Diversity Factor (6 Customers)}} = \frac{81.6}{2.30} = \boxed{35.5 \text{ kW}}$$

Max kVA_{T1} Demand

$$\frac{\text{Max Coincident Demand}}{\text{Power Factor}} = \frac{35.5}{0.9} = \boxed{39.4}$$

XFMR #3:

Max Noncoincident Demand

$$17.0 + 15.1 + 16.7 + 18.3 + 17.3 + 16.1 + 17.0 = \boxed{117.5 \text{ kW}}$$

Max Coincident Demand

$$\frac{\text{Max Noncoincident Demand}}{\text{Diversity Factor (7 Customers)}} = \frac{117.5}{2.40} = \boxed{49.0 \text{ kW}}$$

Max kVA_{T1} Demand

$$\frac{\text{Max Coincident Demand}}{\text{Power Factor}} = \frac{48.9}{0.9} = \boxed{54.4}$$

SOLUTIONS: Problems #2 & #3

#2 Cont.

Part b)

Segment N1-N2: (Segment sees all 18 customers)

Max Noncoincident Demand

$$66.7 + 81.6 + 117.5 = \boxed{265.8\text{ kW}}$$

Max Coincident Demand

$$\frac{\text{Max Noncoincident Demand}}{\text{Diversity Factor (18 Customers)}} = \frac{265.8}{2.86} = \boxed{92.9\text{ kW}}$$

Segment N2-N3: (Segment sees 13 customers

Max Noncoincident Demand

$$81.6 + 117.5 = \boxed{199.1\text{ kW}}$$

Max Coincident Demand

$$\frac{\text{Max Noncoincident Demand}}{\text{Diversity Factor (13 Customers)}} = \frac{199.1}{2.74} = \boxed{72.6\text{ kW}}$$

Segment N3-N4: (Segment sees 7 customers)

Max Noncoincident Demand

$$\boxed{117.5\text{ kW}}$$

Max Coincident Demand

$$\frac{\text{Max Noncoincident Demand}}{\text{Diversity Factor (7 Customers)}} = \frac{117.5}{2.40} = \boxed{48.9\text{ kW}}$$

Notice this segment see the same demands as XFMR #3.

#3

Given 0.9 pf lagging and that the kW flow is equal to the Max Coincident Demand, the following complex power flows are found to be:

Segment N1-N2: $S_{12} = 92.94 + j45.01$ kVA
Segment N2-N3: $S_{23} = 72.66 + j35.19$ kVA
Segment N3-N4: $S_{34} = 48.96 + j23.71$ kVA
XFMR T1: $S_{T1} = 30.32 + j14.68$ kVA
XFMR T2: $S_{T2} = 35.48 + j17.18$ kVA
XFMR T3: $S_{T3} = 48.96 + j23.71$ kVA

SOLUTIONS: Problems #2 & #3

#3 Cont

Convert the per-unit XFMR data to ohms referred to the high-voltage side:

$$Z_{base} = \frac{V^2_{LL\ base}}{VA_{3\phi\ base}} \qquad Z_{actual} = Z_{base} \times Z_{per\text{-}unit}$$

$$\text{XFMR \#1: } Z_{base} = \frac{2400^2}{25{,}000} = 230.4\ \Omega$$

$$Z_{T1} = (0.01379 + j0.01157) \cdot 230.4 = 3.18 + j2.67\ \Omega$$

$$\text{XFMR \#2: } Z_{base} = \frac{2400^2}{37{,}500} = 153.6\ \Omega$$

$$Z_{T1} = (0.01343 + j0.01343) \cdot 153.6 = 2.06 + j2.06\ \Omega$$

$$\text{XFMR \#2: } Z_{base} = \frac{2400^2}{50{,}000} = 115.2\ \Omega$$

$$Z_{T1} = (0.01286 + j0.01532) \cdot 153.6 = 1.48 + j1.77\ \Omega$$

The line impedances are found as follows:

$$\text{N1-N2: } Z_{12} = (0.3 + j0.6) \cdot \frac{5000}{5280} = 0.2841 + j0.5682\ \Omega$$

$$\text{N2-N3: } Z_{23} = (0.3 + j0.6) \cdot \frac{500}{5280} = 0.0284 + j0.0568\ \Omega$$

$$\text{N3-N4: } Z_{34} = (0.3 + j0.6) \cdot \frac{750}{5280} = 0.0426 + j0.0852\ \Omega$$

The current flowing in line segment N1-N2:

$$I_{12} = \cdot \frac{(92.94 + j45.01)^*}{2.4\angle 0^\circ} = 43.0\angle -25.84^\circ\ \text{A}$$

Calculating the voltage at N2:

$$V_2 = V_1 - Z_{12} \cdot I_{12}$$
$$= (2400\angle 0^\circ) - (0.2841 + j0.5682) \cdot (43.0\angle -25.84^\circ)$$
$$= 2378.4\angle -0.4^\circ\ \text{V}$$

Calculating the current flowing into XMFR #1:

$$I_{T1} = \cdot \frac{(30.32 + j14.68)^*}{2.378\angle -0.4^\circ} = 14.16\angle -26.24^\circ\ \text{A}$$

SOLUTIONS: Problems #2 & #3

Calculating the secondary voltage referred to the high side:

$$\begin{aligned} V_{T1} &= V_2 - Z_{T1} \cdot I_{T1} \\ &= (2378.4\angle -0.4°) - (3.18 + j2.67) \cdot (14.16\angle -26.24°) \\ &= 2321.5\angle -0.76° \text{ V} \end{aligned}$$

Calculating the secondary voltage by using the turns ratio:

$$V_{\text{low T1}} = \frac{2321.5\angle -0.76°}{10} = \boxed{232.15\angle -0.76° \text{ V}}$$

The current flowing in line segment N2-N3:

$$I_{23} = \cdot \frac{(72.66 + j35.19)^*}{2.378\angle -0.4°} = 33.95\angle -26.24° \text{ A}$$

Calculating the voltage at N3:

$$\begin{aligned} V_3 &= V_2 - Z_{23} \cdot I_{23} \\ &= (2378.4\angle -0.4°) - (0.0284 + j0.0568) \cdot (33.95\angle -26.24°) \\ &= 2376.7\angle -0.43° \text{ V} \end{aligned}$$

Calculating the current flowing into XMFR #2:

$$I_{T2} = \cdot \frac{(35.48 + j17.18)^*}{2.3767\angle -0.43°} = 16.59\angle -26.27° \text{ A}$$

Calculating the secondary voltage referred to the high side:

$$\begin{aligned} V_{T2} &= V_3 - Z_{T2} \cdot I_{T2} \\ &= (2376.7\angle -0.43°) - (2.06 + j2.06) \cdot (16.59\angle -26.27°) \\ &= 2331.3\angle -0.82° \text{ V} \end{aligned}$$

Calculating the secondary voltage by using the turns ratio:

$$V_{\text{low T2}} = \frac{2331.3\angle -0.82°}{10} = \boxed{233.13\angle -0.82° \text{ V}}$$

The current flowing in line segment N2-N3:

$$I_{34} = \cdot \frac{(48.96 + j23.71)^*}{2.3767\angle -0.43°} = 22.89\angle -26.27° \text{ A}$$

SOLUTIONS: Problems #2 & #3

Calculating the voltage at N4:

$$\begin{aligned} V_4 &= V_3 - Z_{34} \cdot I_{34} \\ &= (2376.7\angle -0.43°) - (0.0426 + j0.0852) \cdot (22.89\angle -26.27°) \\ &= 2375.0\angle -0.47° \text{ V} \end{aligned}$$

Calculating the current flowing into XMFR #3:

$$I_{T3} = \cdot \frac{(48.96 + j23.71)^*}{2.375\angle -0.47°} = 22.91\angle -26.31° \text{ A}$$

Calculating the secondary voltage referred to the high side:

$$\begin{aligned} V_{T3} &= V_4 - Z_{T3} \cdot I_{T3} \\ &= (2375.0\angle -0.47°) - (1.48 + j1.77) \cdot (22.91\angle -26.31°) \\ &= 2326.9\angle -1.0° \text{ V} \end{aligned}$$

Calculating the secondary voltage by using the turns ratio:

$$V_{\text{low T3}} = \frac{2326.9\angle -1.0°}{10} = \boxed{232.69\angle -1.0° \text{ V}}$$

The percent voltage drop to the secondary of XFMR T3 is:

$$V_{\text{drop}} = \frac{|V_1| - |V_{T3}|}{|V_1|} \cdot 100 = \frac{2400 - 2326.9}{2400} \cdot 100 = \boxed{3.045\%}$$