Power System Analysis I **Midterm II** **Fall** **09.12.2011**

SOLUTIONS

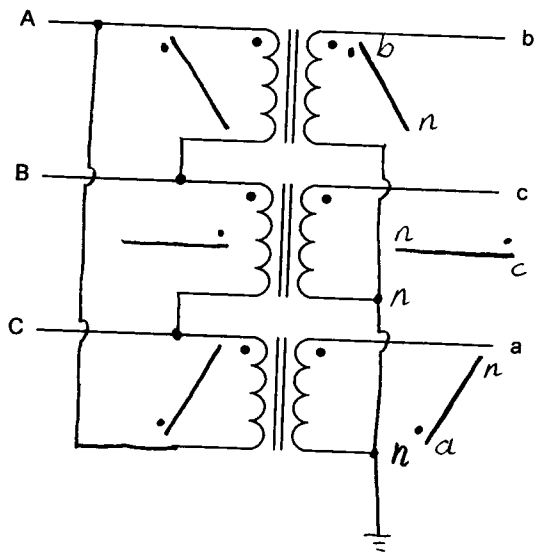
P1 (30): The following schematic shows three identical single-phase two-winding transformers. Using these single-phase transformers, we want to construct a three-phase transformer bank. Assume positive-sequence balanced three-phase system.

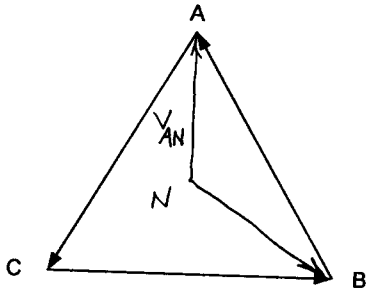
(5) **a)** Connect the high-voltage side as delta (Δ) and the low-voltage side as solidly grounded wye (Y).

(15) **b)** Assume that the phasor voltages shown below are applied to the high-voltage side windings, draw the phasor voltage diagram for the low-voltage side and find the phase shift between $\bar{V}_{AN}$ and $\bar{V}_{an}$.

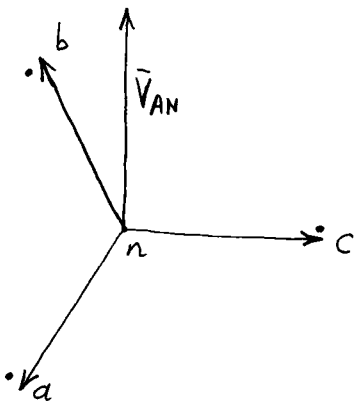
(10) **c)** For the same given input voltages, modify the low-voltage terminal connections and labeling so that $\bar{V}_{an}$ lags $\bar{V}_{AN}$ by 90°.

a)



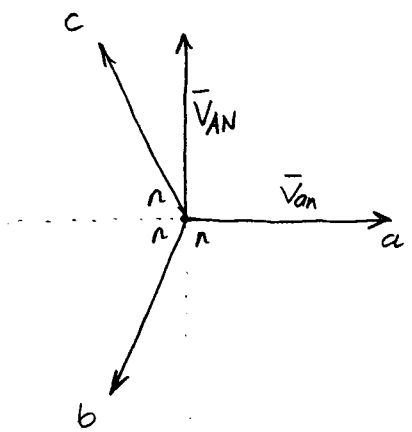


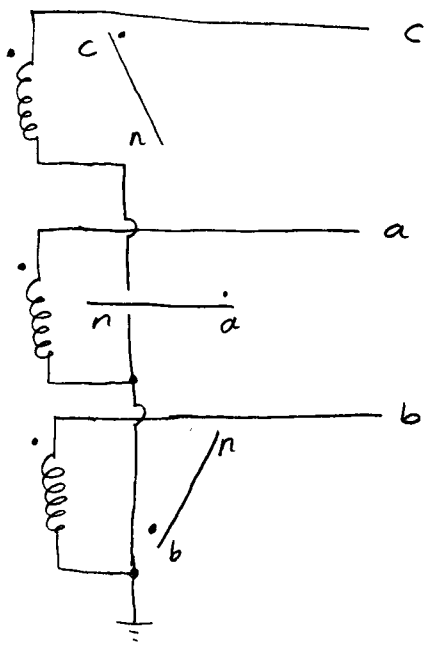
b)



$\bar{V}_{AN}$ lags $\bar{V}_{an}$ by 150°.

c)

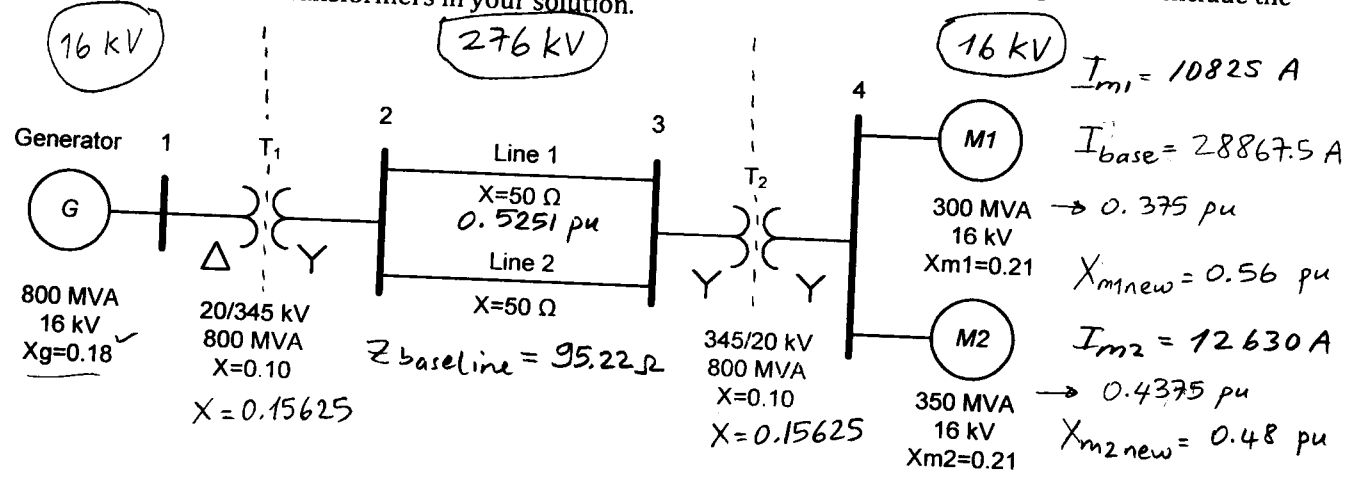




P2 (35): The figure below shows the one-line diagram of a three-phase power system.

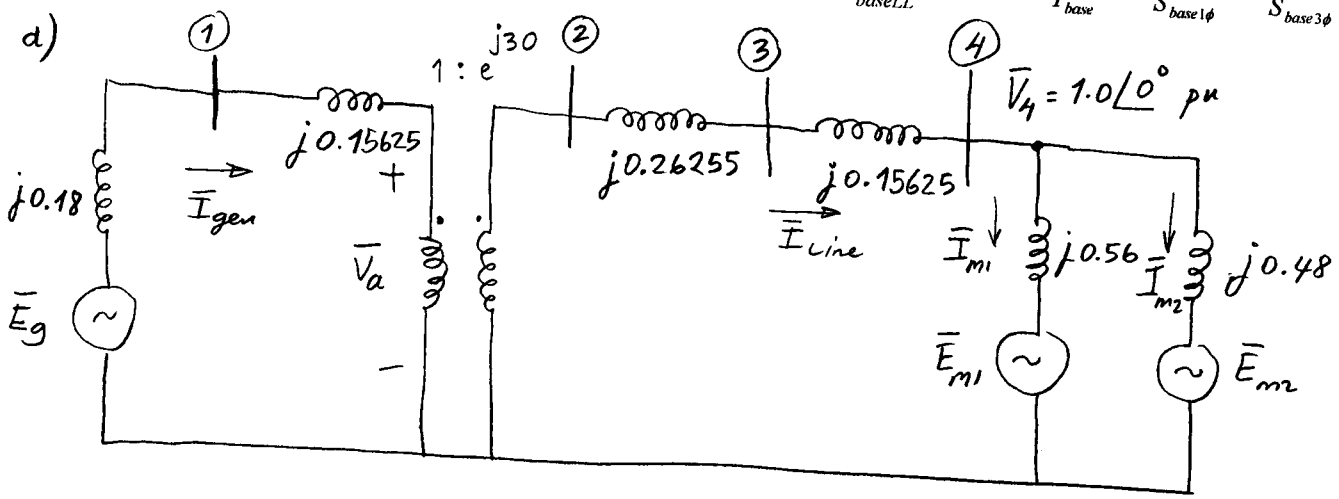
(20) **a)** Draw the per-unit impedance diagram of the system including the transformer phase shifts. Use the ratings of the generator as the base values.

(15) **b)** The motors are drawing their rated powers from the system at the unity power factor with the bus 4 voltage is at 16 kV. Determine the voltage at bus 1 and the current supplied by the generator. Include the phase shifts of the transformers in your solution.



$$Z_{new} = Z_{old}\left(\frac{V_{baseold}}{V_{basenew}}\right)^2\left(\frac{S_{basenew}}{S_{baseold}}\right) \qquad I_{base} = \frac{S_{base1\phi}}{V_{baseLN}} = \frac{S_{base3\phi}}{\sqrt{3}V_{baseLL}} \qquad Z_{base} = \frac{V_{baseLN}}{I_{base}} = \frac{V^2_{baseLN}}{S_{base1\phi}} = \frac{V^2_{baseLL}}{S_{base3\phi}}$$

a)



b) $\bar{I}_{m1} = 0.375$ pu, $\bar{I}_{m2} = 0.4375$ pu $\Big\}$ $\bar{I}_{line} = 0.8125$ pu

first find the voltage at bus 2

$$\bar{V}_2 = 1.0 + (0.8125)(0.4188\angle 90^\circ) = 1.0563\angle 18.792^\circ$$ (5)

$$\bar{V}_a = \bar{V}_2\angle -30^\circ = 1.0563\angle -11.208^\circ$$

Also $\bar{I}_{gen} = \bar{I}_{line}\angle -30^\circ = 0.8125\angle -30^\circ$ pu

$$\bar{V}_1 = 1.0563\angle -11.208^\circ + (0.8125\angle -30^\circ)(0.15625\angle 90^\circ) = 1.104\angle -4.96^\circ$$

$\bar{I}_{gen} = 0.8125\angle -30^\circ$ pu (5)

$\bar{V}_1 = 1.104\angle -4.96^\circ$ (5)