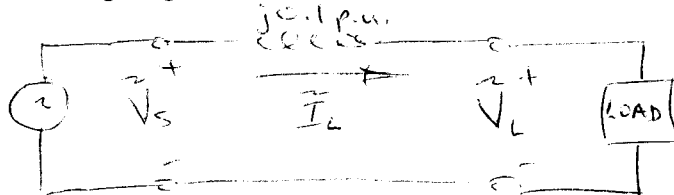
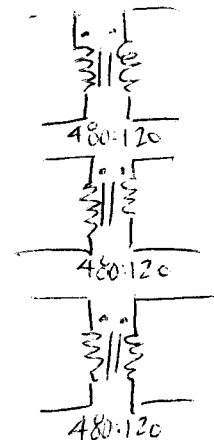


EE 5200 XFMR EXC.

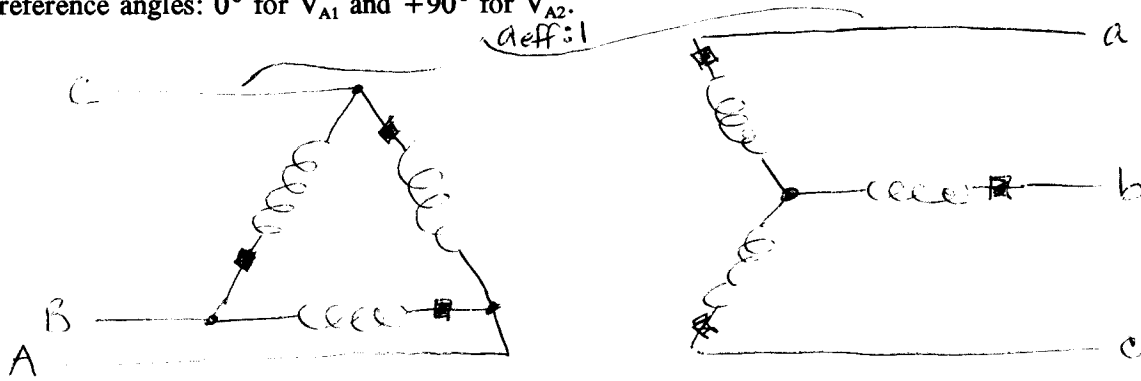
- 1) [15pts] A 3 ϕ transformer has a total series impedance of $j0.1$ pu. A balanced 3 ϕ source is connected to the primary and a balanced 3 ϕ load of $S = 1.0/-36.87^\circ$ pu is connected to the secondary. The terminal voltage at the load is $1.0/0^\circ$ pu. Using the per phase equivalent below, and leaving all quantities in per unit,
- Calculate the phasor value of the load current in per unit.
 - Calculate the phasor value of the source voltage in per unit.
 - Calculate the voltage regulation at the load terminals of the transformer.



- 2) [10 pts] It is desired to construct a 480 Δ -208Y volt 3 ϕ transformer from 3 single phase 480-120 volt transformers. Positive sequence LN voltages on the 480V side must lead the corresponding LN voltages on the secondary side by 90° . Labeling the 480-volt terminals as H1, H2 and H3 and the 208-volt terminals X1, X2 and X3,
- Sketch out the phase shift diagrams that would appear on the transformer nameplate.
 - Correctly connect the windings, labeling H1, H2, H3, X1, X2 and X3.



- 3) [20 pts] For the transformer shown, draw the closed phasor diagrams for positive and negative sequence voltages (both LL and LN) for the transformer shown. The effective turns ratio of the transformer is $a_{eff} = 5.0$. Use reference angles: 0° for V_{A1} and $+90^\circ$ for V_{A2} .



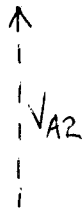
a) Positive sequence voltage for primary
 $(V_{A1}, V_{B1}, V_{C1}, V_{AB1}, V_{BC1}, V_{CA1})$

Positive sequence voltage for secondary
 $(V_{a1}, V_{b1}, V_{c1}, V_{ab1}, V_{bc1}, V_{ca1})$



b) Negative sequence voltages for primary
 $(V_{A2}, V_{B2}, V_{C2}, V_{AB2}, V_{BC2}, V_{CA2})$

Negative sequence voltages for secondary
 $(V_{a2}, V_{b2}, V_{c2}, V_{ab2}, V_{bc2}, V_{ca2})$



- c) What is the magnitude and phase relationship between V_{A1} and V_{a1} ? Between V_{A2} and V_{a2} ?

4) [10 pts] Answer both of the following short essay questions.

a) [5 pts] A coworker questions the calculations you performed when converting Z_{12} , Z_{13} and Z_{23} to Z_1 , Z_2 and Z_3 for a 3-winding transformer. He says that since Z_2 is negative, you've made a mistake. What do you tell him (be polite)?

b) [5 pts] A conceptual phase-shifting transformer is used in positive and negative sequence networks to represent the phase shift of the phase A voltages and currents from one side to the other. Ratios like $1/30^\circ$ or $1/-30^\circ$ are common. What effect do these phase shifting transformers have if you want to transfer an impedance from one side to the other?

5) [15 pts] A new 3 ϕ transformer has the following self-cooled (OA or ONAN) ratings:

Primary: Y-connected, 345 kV, 296 MVA
Secondary: Y-connected, 118 kV, 296 MVA
Tertiary: Δ -connected, 13.8 kV, 77 MVA

Binary short-circuit tests performed at the factory give the following results:

$Z_{12} = 6.21\%$ on 296-MVA 345-kV base.
 $Z_{13} = 55.9\%$ on 77-MVA 118-kV base.
 $Z_{23} = 42.1\%$ on 77-MVA 13.8-kV base.

Find the per unit impedances Z_1 , Z_2 and Z_3 on a base of 100 MVA, 118 kV. These must be provided to your systems studies engineers. It may be helpful to refer to section 2.8 of your text book.

6) [30 pts] A simple 3 ϕ power system consists of a generator, a transformer, a transmission line, and a large synchronous motor. Nameplate data for each piece of equipment is given below. The transformer has ANSI standard phase shift (high-voltage LN voltages lead the low-voltage LN voltages by 30 $^\circ$).

G1: 50MVA, 24kV, $X_0 = 5\%$, $X_1 = 20\%$, $X_2 = 10\%$, $X_N = 0.4\Omega$

T1: 100MVA, 24-13.8kV, $X_0 = 5\%$, $X_1 = X_2 = 10\%$

M1: 50MVA, 13.2kV, $X_0 = 5\%$, $X_1 = X_2 = 20\%$

T-Line: $X_0 = 1\Omega$, $X_1 = X_2 = 0.5\Omega$

$$\bar{Z}_{new} = \bar{Z}_{old} \left(\frac{\sqrt{S_{B,old}}}{\sqrt{S_{B,new}}} \right)^2$$

- a) [15 pts] Using a system base of 100MVA and 24kV at bus 1, determine the base impedance for both sections of the system and convert all impedances to per unit values on the common system base.
- b) [15 pts] Construct the zero, positive and negative sequence impedance diagrams. Label all impedances with their correct values in per unit. Include the effects of positive and negative sequence phase shift.

