EE 372, Spring 2005
Final Exam
4 May, 2005

Show all your work and your answers clearly on the test pages. In any plots and sketches, label and include units (if possible) on anything that might be of interest. You are each allowed one two-sided 8.5 by 11 inch page of formulae for reference. Calculators may be used only for simple trigonometric and (complex variable) arithmetic operations. For full credit, simplify your answers as much as possible.

Problem 1 (35) ______

Problem 2 (30) ______

Problem 3 (25) ______

Problem 4 (20) ______

Total (110) ______

Name______________________________

1. Short answers (5 pts. each):

(a) You need to provide cable to run a 20 hp, three-phase motor at 480V (line-to-line). The motor has power factor 0.8. For safety, you'll size the cable for double the rated horsepower. How many amps must you allow for in each of the three cables? You may use 1hp = 750W.

(b) If $\mathbf{V_A} = \mathbf{V_B} = \mathbf{0}$ and $\mathbf{V_C} = \mathbf{1.0\angle 30^o}$, what are all the symmetric component voltages ($\mathbf{V_{A1}}, \mathbf{V_{A2}}, \ldots, \mathbf{V_{C1}}, \ldots$, etc.)?

(c) Due to the ice load on lines resulting from a winter storm in South Bend on May 5, a transmission tower collapses, leaving a spectacular line-to-line (lines A and B) and single line-to-ground (line C) fault at the same point. Write the equations for what we know immediately of currents and voltages at the fault, without solving through symmetric components.

(d) A transformer has the following parameters:
R = 0.01pu, X = 0.1pu, 13.8/135kV, 50MVA
Convert the parameters to pu for S_{base} of 100 MVA, and V_{base} values of 12.4/121.3kV.

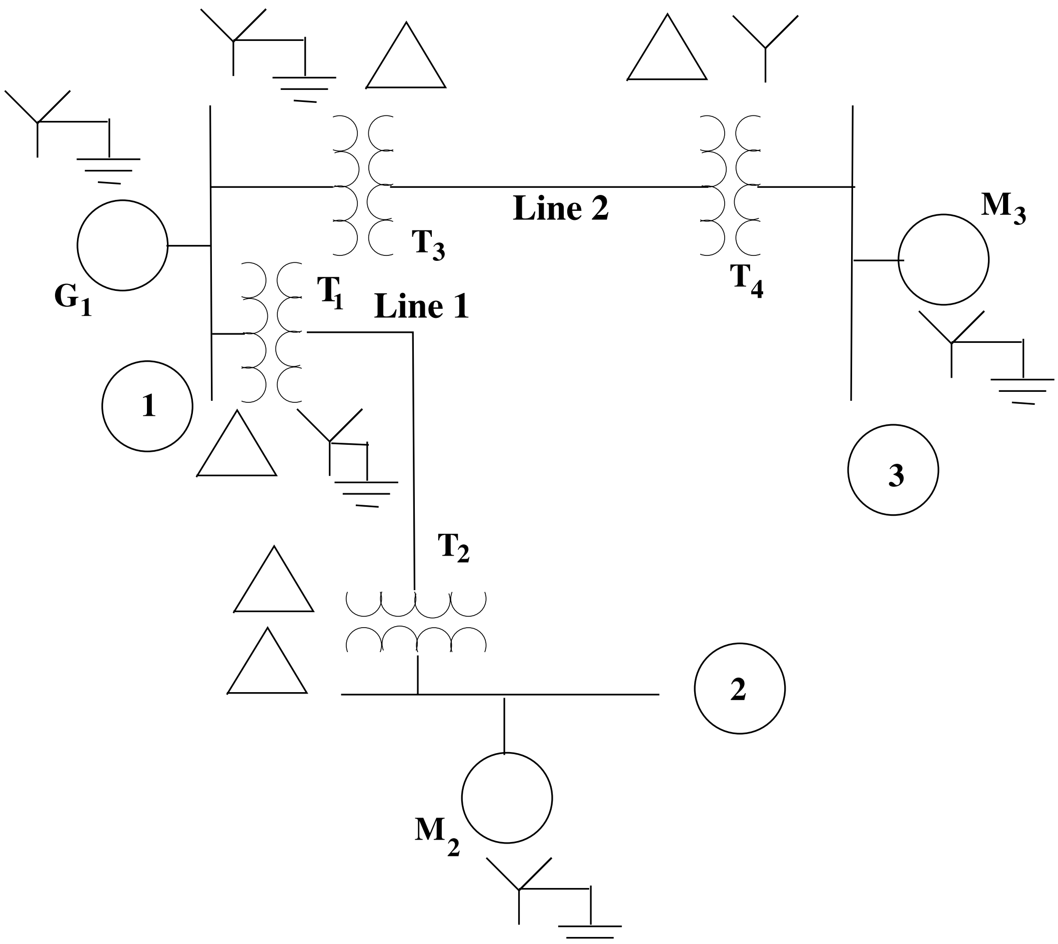
(e) In order to increase the capacity of a transmission line with bundled conductors, we double the number of identical cables in each bundle and double the radius of each bundle from 0.25m to 0.5m. What changes result in the resistive and inductive impedance of the line? You may use the approximation that each bundle behaves as a "pipe" of the given radius, and that the cross section of the 3 lines' arrangement is an equilateral triangle with each side 8 meters.

(f) If $\mathbf{V_A} = 5\angle 20^o V$ and $\mathbf{V_C} = 1\angle 260^o$, find $\mathbf{V_{AC}}$, the voltage between them.

(g) Assume the sketch below is distribution-level power at 12.4 kV. and the transformer produces single-phase 240V at the secondary. The power is out due to the ice storm mentioned in the previous problem. Your neighbor fires up his single-phase, 120V gasoline powered generator and, without disconnecting his house from the power grid, attaches the two leads to his circuit breaker box, equivalent to connecting to points A and B in the sketch. Down the street, an unsuspecting lineman is working on the three-phase lines. What voltage will he see on the three lines relative to ground? Assume the lines are isolated to only the local connections and are unloaded for this problem.

2. You knew this was coming. The components of the power system below have the following ratings:

Generator 1(G_1):	100 MVA, 13.8 kV, X_1=0.2 pu, X_2=0.2 pu, X_{g0}=0.2pu
Motor 2(M_2):	100 MVA, 13.8 kV, X_1=0.1 pu, X_2=0.1 pu, X_{g0}=0.1pu
Motor 3 (M_3):	100 MVA, 13.8 kV, X_1=0.05 pu, X_2=0.1 pu, X_{g0}=0.1pu
All $Y - \Delta$ transformers:	100 MVA, 13.8/138 kV, $X_1 = 0.05$ pu,X_2=0.1 pu, $X_0 = 0.05$ pu
All $Y - Y$ transformers:	100 MVA, 13.8/138 kV,$X_1 = 0.1$ pu,X_2=0.1 pu, $X_0 = 0.05$ pu
All $\Delta - \Delta$ transformers:	100 MVA, 13.8/138 kV,$X_1 = 0.1$ pu,X_2=0.1 pu, $X_0 = 0.05$ pu
Line 1:	X = 10Ω
Line 2:	X = 20Ω



(a)(10 pts.) Find and sketch the equivalent circuit in pu for the zero sequence component for analysis of this system under $S_{base} = 100$MVA, and $V_{base} = 13.8$kV at generator 1.

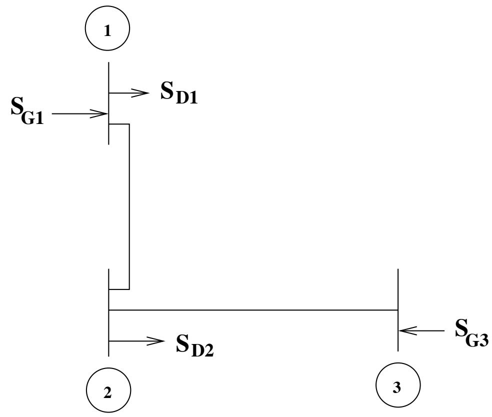
(b)(10 pts.) Find the value of the first element (1,1) in the Z_{bus0} matrix for symmetric components analysis.

(c) (10 pts.) Suppose we have the following bus impedance matrices for the system (these are NOT correct for the parameters given at the beginning of the problem):

$$Z_{bus0} = \begin{pmatrix} j0.3 & 0 & j0.1 \\ 0 & j0.3 & j0.1 \\ j0.1 & j0.1 & j0.3 \end{pmatrix} Z_{bus1} = \begin{pmatrix} j0.3 & j0.1 & j0.1 \\ j0.1 & j0.2 & j0.2 \\ j0.1 & j0.2 & j0.3 \end{pmatrix} Z_{bus2} = \begin{pmatrix} j0.2 & j0.05 & j0.05 \\ j0.05 & j0.1 & j0.1 \\ j0.05 & j0.1 & j0.3 \end{pmatrix}$$

The system is initially stable with all bus voltages (V_A) approximately equal to $1\angle 0^o$ pu V. A line-to-line (lines B and C) fault then occurs at bus 1. Find the voltages of the three phases at bus 3 during the fault.

3. For the system in the figure below, $S_{G1} = 0.1 + j0.1$, $S_{D1} = 0.2 - j0.4$, $S_{D2} = 0.4 + j0.2$ and $V_3 = 1.0\angle 0^o$. All lines have impedance j0.1 pu.



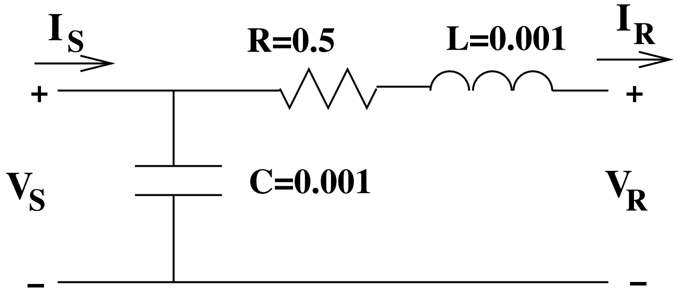
(a) (10 pts.) Find the bus admittance matrix which will be appropriate for solving power flow for the system.

(b) (5 pts.) Identify each bus according to our standard notation as load, slack or generator bus in the equations.

(c) (10 pts.) What would the solution to the power flow equations look like in the limit as the impedances of all the lines went to zero? Give values for all the unknown variables for this asymptotic case.

4. Below is the equivalent circuit of a 60Hz system, perhaps a transformer or transmission line. We need to describe this two-port network in terms of the equation

$$\begin{pmatrix} \mathbf{V_S} \\ \mathbf{I_R} \end{pmatrix} = \begin{pmatrix} \mathbf{A} & \mathbf{B} \\ \mathbf{C} & \mathbf{D} \end{pmatrix} \begin{pmatrix} \mathbf{V_R} \\ \mathbf{I_S} \end{pmatrix}$$



(a) (10 pts.) Find the values of $\mathbf{A}, \mathbf{B}, \mathbf{C}, \mathbf{D}$.

(b) (10 pts.) Compute the necessary numerical values and draw an accurate phase diagram for this system when a load attached to the V_R terminals is receiving 75 kW at 600 Volts, 60 Hz, with load power factor 0.9 lagging.