EE 30372, Spring 2011
Final Exam
11 May, 2011

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. As usual, three-phase voltages are given as line-to-line by default.

Problem 1 (35) ______

Problem 2 (20) ______

Problem 3 (15) ______

Problem 4 (30) ______

Problem 5 (20) ______

Total (120) ______

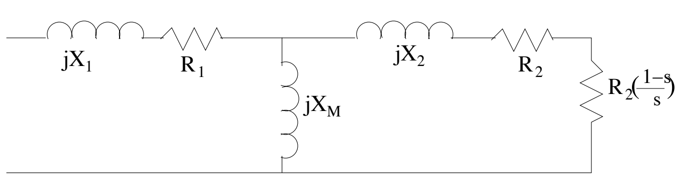
Name________________________________

1. Shorter exercises (5 pts. each):

(a) We may sometimes start a motor in a Y-configuration, and then run it in Δ. In steady-state, what is the difference in the power absorbed by the motor in these two wirings?

(b) If we're operating at 50 Hz, find the power factor of a load consisting of the parallel combination of a 10Ω resistor and a 100 milliHenry inductor.

(c) In the figure below, circle the inductor which you would expect to be the largest of the three if this represents the equivalent circuit of a well-designed induction motor.

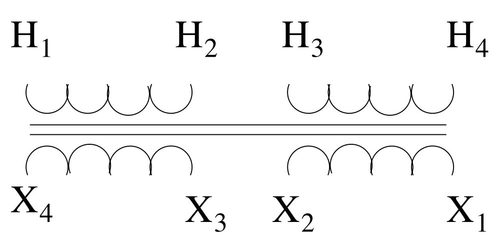


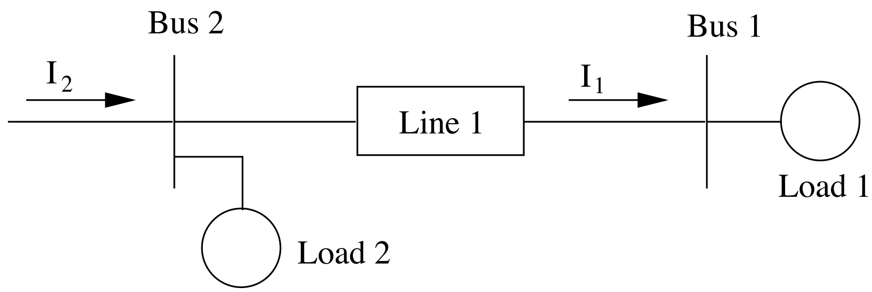
(d) At what speed (in rpm) should we rotate a 12-pole generator if we want to produce power at 60 Hz?

(e) Sketch accurately the phasor diagram of a transmission line which has voltage $1.0V_{pu}$ at its receiving end, where the load is consuming power of 1.0 p.u with power factor 1.0, and the line's impedance is $(1.0 + j1.0)\Omega_{pu}$.

(f) A three-phase system falls into a state in which A, B and C phase voltages are all $2.0\angle 10^o$. Find the symmetric component representation of these voltages.

(g) Draw connections among the terminals of our 2:1 transformer below (H = high side) to achieve a voltage boost from 50 to 75 volts AC. Clearly label the primary and secondary connections. Dots may be assumed to be at the higher-numbered index of each coil.





2. (20 pts.) Load 1 and Load 2 in the above three-phase system are each consuming 1 MW, with the former having power factor 0.9 lagging and the latter 0.7 lagging. The transmission line between them is medium-length, with parameters $R = 5\Omega$, $X = 40\Omega$ and $Y = 10^{-6}\mathrm{Siemens}$. At Bus 1, we hold line-line voltage 20 kV. Find the voltage at Bus 2, the losses in Line 1, and the currents I_1 and I_2.

3. (15 pts.) We have learned that when transmission lines are inductive, we need to advance the phase of a generator to deliver real power to the system. Using a two-bus system, with both busses having voltage magnitude 1.0, find the power which is transmitted from one of the busses when it has its phase advanced by 30 degrees, and the transmission line has impedance 1.0Ω (purely resistive).

4. Suppose we have the following per-unit bus admittance and impedance matrices for the three symmetric components of a 3-phase power system. The system has S_{base} = 100 MVA, and V_{baseLL} of 35 kV at all of the busses. Assume that in normal, balanced operation, the system behaves according to the positive-sequence parameters.

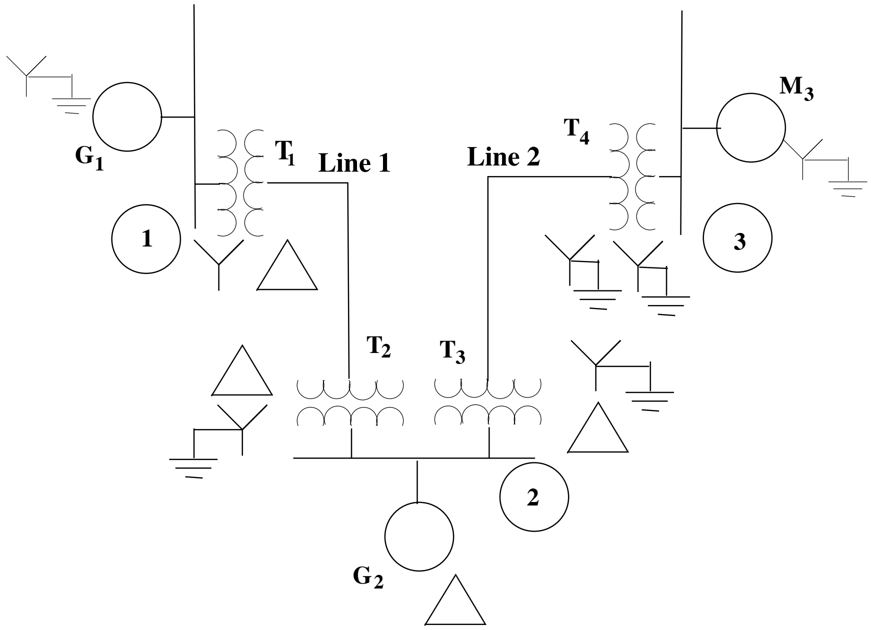
$$\mathbf{Y}_{bus0} = \begin{pmatrix} -j5 & 0 & 0 \\ 0 & -j8 & j4 \\ 0 & j4 & -j3 \end{pmatrix} \mathbf{Y}_{bus1} = \begin{pmatrix} -j5 & j2 & j1 \\ j2 & -j4 & j1 \\ j1 & j1 & -j4 \end{pmatrix} \mathbf{Y}_{bus2} = \begin{pmatrix} -j5 & j2 & j1 \\ j2 & -j6 & j4 \\ j1 & j4 & -j7 \end{pmatrix}$$

$$\mathbf{Z}_{bus0} = \begin{pmatrix} j0.2 & 0 & 0 \\ 0 & j0.38 & j0.5 \\ 0 & j0.5 & j1.0 \end{pmatrix} \mathbf{Z}_{bus1} = \begin{pmatrix} j0.29 & j0.18 & j0.12 \\ j0.18 & j0.38 & j0.14 \\ j0.12 & j0.14 & j0.31 \end{pmatrix} \mathbf{Z}_{bus2} = \begin{pmatrix} j0.33 & j0.23 & j0.18 \\ j0.23 & j0.43 & j0.28 \\ j0.18 & j0.28 & j0.33 \end{pmatrix}$$

(a) (10 pts.) A double line-to-ground fault (lines B and C) occurs at bus 1. Assuming that before the fault, all busses held voltage $1.0\angle 0^0$ in the A phase and all of the system was balanced, find the fault currents in all phases at bus 1 (in p.u.).

(b) (10 pts.) Compute the (real) voltage V_B at bus 3 during the fault of part (a).

(c) (10 pts.) Assuming that before the fault, the current between busses 1 and 3 was negligible, compute the power (in “real” Watts and VAR) being consumed in the line and transformers between busses 1 and 3 due to the fault.



5. The components of the power system above have the following ratings:

Generator 1(G_1):	100 MVA, 10.0 kV, X_1=0.2 pu, X_2=0.2 pu, X_{g0}=0.2pu
Generator 2(G_2):	100 MVA, 10.0 kV, X_1=0.1 pu, X_2=0.1 pu, X_{g0}=0.1pu
Motor 3 (M_3):	100 MVA, 10.0 kV, X_1=0.05 pu, X_2=0.1 pu, X_{g0}=0.1pu
All $Y-\Delta$ transformers:	100 MVA, 10/100 kV, X_1 = 0.05 pu,X_2=0.1 pu, X_0 = 0.05 pu
All $Y-Y$ transformers:	100 MVA, 10/100 kV,X_1 = 0.1 pu,X_2=0.1 pu, X_0 = 0.05 pu
All $\Delta-\Delta$ transformers:	100 MVA, 10/100 kV,X_1 = 0.1 pu,X_2=0.1 pu, X_0 = 0.05 pu
Line 1:	X = 10Ω
Line 2:	X = 20Ω

Regardless of transformer type, their high voltage sides will be connected to the transmission line.

(20 pts.) Find the zero-sequence bus impedance matrix for this system.

5. (repeated) (20 pts.) Find the zero-sequence bus impedance matrix for this system.