ECE 3600 Final given: Fall 08

(The space between problems has been removed.)

Write Legibly! If I can't read what you've written or you answer is ambiguous, I'll assume you don't know.

(50 pts) Questions This part of the exam is Closed book, Closed notes, No Calculator.

1. Give the two largest sources of energy used to produce electricity in the US. List the largest first.

2. a) The Gadsby power plant (which we visited) uses what source of energy?

   b) Is the Gadsby power plant is used to supply base load or peak load?

3. Give the approximate efficiencies of each type of power plant:

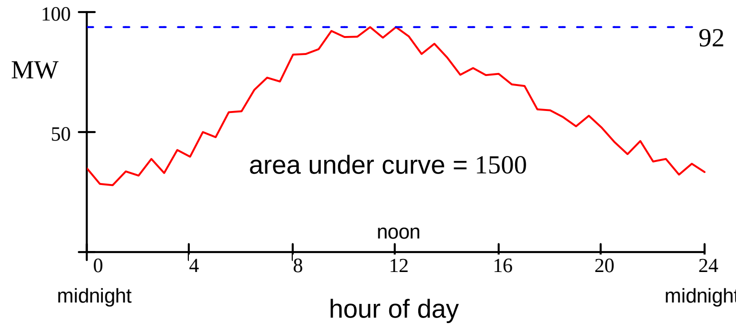
   a. Hydroelectric

   b. Rankin-cycle steam turbine plants, regardless of the source of heat. (coal, oil, gas-steam, nuclear, solar-steam, geothermal)

   c. Single-cycle gas turbine

   d. Combined-cycle gas turbine

4. A load curve for a city is shown at right. The units of the area are not shown, so you will have to figure out what they must be.



   a) What is the load factor for this city. (Since you don't have a calculator, you may answer with a mathematical expression.)

   b) 100 MW is the maximum capacity of the distribution system in this city. If electric vehicles became popular in this city, could they be accommodated without increasing the capacity of the power distribution system?

   c) If yes, how?

5. a) ____ is the letter used for Magnetic Flux Density

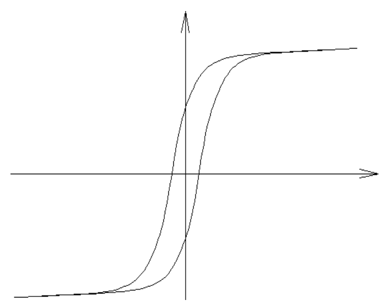
   b) ____ is the letter used for Magnetic Field Intensity

   c) ____ is the letter used for Magnetic Permeability

   d) How are these three things related to one another (give an equation)?

   e) Name the common magnetic curve shown at right.

   f) Label the axes on the figure shown at right.



6. What insulates the wires from one another in an overhead transmission line?

7. a) What is bundling?

   b) What is the main reason for bundling?

8. Is it OK to load a transmission line above the surge impedance loading for long periods of time?

9. When accounting for the non-ideal characteristics of a power transformer, which of the following is the most important (least often neglected)?

   magnetization reactance core losses winding losses leakage reactance

   circle one

10. A single-phase transformer is rated at 240 kVA, 12kV/240V . The transformer is operated at its rated voltages.

    a) What is the rated current in the primary?

    b) What is the rated current in the secondary?

    c) How are these ratings affected if the transformer is operated at half the rated voltages?

    d) What is the turns ratio of this transformer? (Two possible answers)

11. If a short occurs between lines b and c of a 3-phase transmission line, the zero-sequence circuit can be ignored in the analysis, why?

12. Draw a set of negative-sequence voltages, labeling $\mathbf{V}_{a2}$, $\mathbf{V}_{b2}$, and $\mathbf{V}_{c2}$.

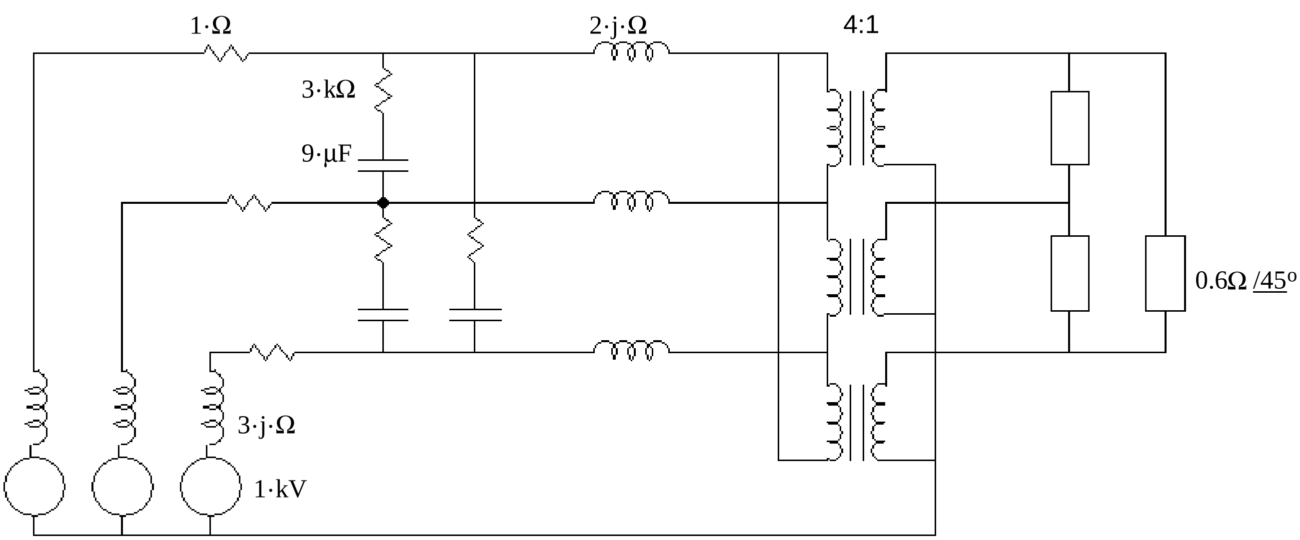
Open book

This part of the exam is open book, open notes. You MUST show work to get credit.

Show the correct units for each value. Assume $f := 60 \cdot Hz$ for all problems and normal abc sequence for all 3ϕ

1. (28 pts) A 3-phase system delivers 208-V, 60-Hz 3-phase power of 12 kW to a load with a 70% lagging power factor. Each line has a resistance of 0.5 Ω. ("delivers" means those are the values at the load.)
   a) Three Y-connected sources supply the power. What voltage do they each supply (magnitude)?
   b) Find the total power lost in the lines and the overall efficiency of the system.
   c) Three capacitors are Y-connected at the load to correct the power factor. Find the capacitor value(s).
   d) The source voltage is adjusted so that the load power remains 12 kW.
      What is the new efficiency of the system with the capacitors of part c).

2. (14 pts) Draw a per-phase drawing of for the balanced 3-phase, 60-Hz system shown. You may neglect phase issues introduced by Y-Δ and Δ-Y connections. You may need to modify the turns ratio of the transformer to reflect Y-Δ and Δ-Y connections. Be sure to show values of the source, passive components and turns ratio on your drawing.



3. (33 pts) A 138 kV transmission line is 240 km long and has the following line parameters. $S := \text{siemens}$

$$len := 240 \cdot km \qquad R := 0.1 \cdot \frac{\Omega}{km} \qquad \omega L := 0.4 \cdot \frac{\Omega}{km} \qquad G := 0 \cdot \frac{S}{km} \qquad \omega C := 3.4 \cdot 10^{-6} \cdot \frac{S}{km}$$

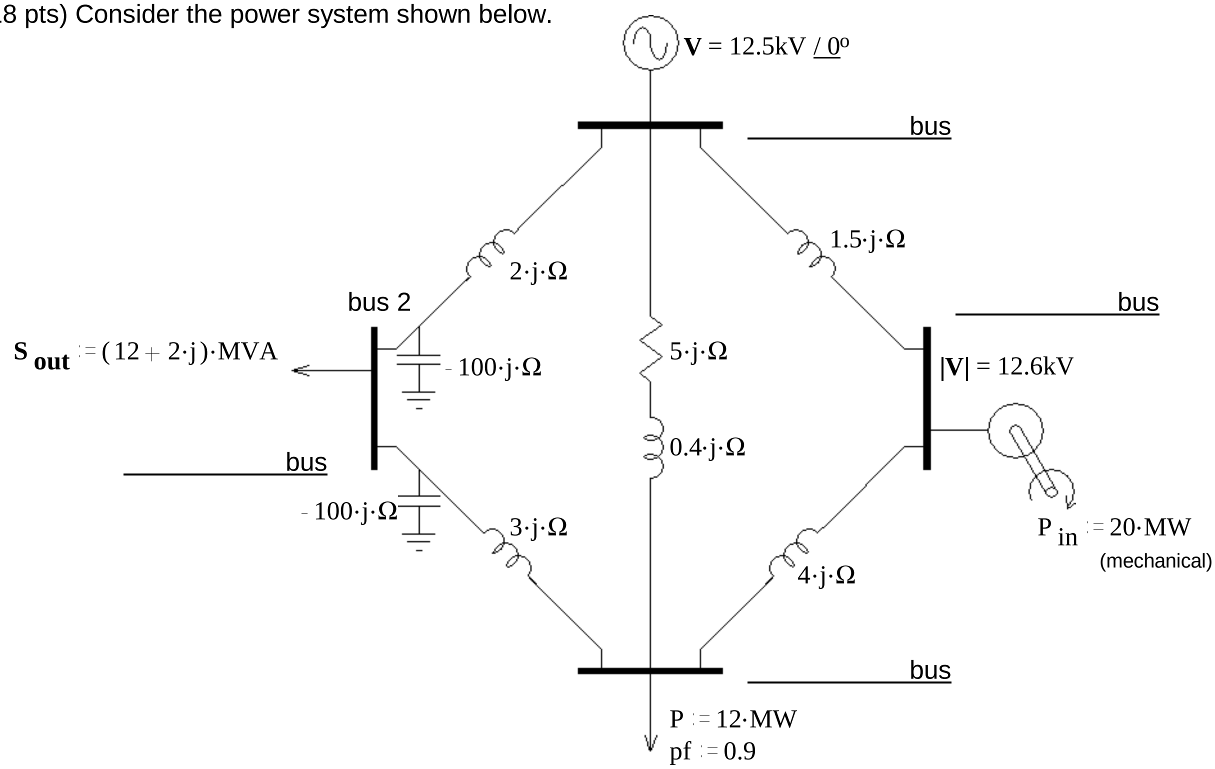
   a) Choose the most appropriate model for this transmission line and draw it, including the impedance and/or admittance value(s).
   b) A source is connected to one end of the line and a load of 400Ω is connected to the other end. The load power factor is 1. The line-to-line voltage at the source is 138 kV. Assume the source voltage, $\mathbf{V_S}$, phase is /0°. Find the line current, $\mathbf{I_{Line}}$ (not $\mathbf{I_S}$) in any form. NOTE: Read carefully, esp."source" and "load"

      $\mathbf{I_{Line}}$ = ?

   c) Same load and conditions as part b). Find the load phase voltage, $\mathbf{V_R}$, magnitude and phase. $\mathbf{V_R}$ = ?
   d) What is the line voltage at the load (magnitude)?
   e) How much total power is delivered to the load?
   f) Express this load in terms of SIL.

Problems 4 and 5 are no longer covered in this course

4. (18 pts) Consider the power system shown below.



a) Identify each bus as "slack", "load", or "generator".

b) Number the slack bus as "bus 1". I have labeled bus 2. Label the other two on the drawing.

c) Show $\mathbf{V_1}$, $\mathbf{V_2}$, $\mathbf{V_3}$, and $\mathbf{V_4}$ on the drawing.

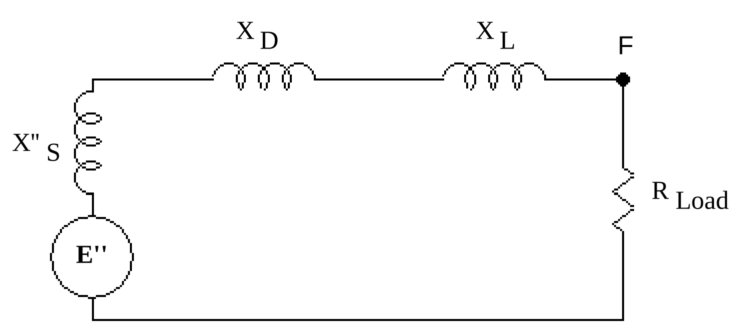
d) Show $\mathbf{I_1}$, $\mathbf{I_2}$, $\mathbf{I_3}$, and $\mathbf{I_4}$ on the drawing and draw arrows to indicate the direction of each.

e) Find elements **A** and **B** in the matrix below.

f) What is this matrix called?

$$\begin{bmatrix} \mathbf{I_1} \\ \mathbf{I_2} \\ \mathbf{I_3} \\ \mathbf{I_3} \end{bmatrix} = \begin{bmatrix} \_ & \mathbf{A} & \_ & \_ \\ \_ & \mathbf{B} & \_ & \_ \\ \_ & \_ & \_ & \_ \\ \_ & \_ & \_ & \_ \end{bmatrix} \cdot \begin{bmatrix} \mathbf{V_1} \\ \mathbf{V_2} \\ \mathbf{V_3} \\ \mathbf{V_3} \end{bmatrix}$$

5. (17 pts) One phase of a balanced 3-phase system is shown below.



A fault occurs point F. It is a short between lines b and c with an impedance of $\mathbf{Z_f}$.

a) Draw the circuit you would have to analyze to find the fault current. Identify the parts and Include the component voltages and currents at the fault.

b) Set up a mathematical expression (or expressions) for the fault current.
(don't forget j & that the fault current is NOT $\mathbf{I_{a1}}$)

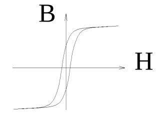
ECE 3600 Final Fall 08 p3

1. 1. Coal 2. Nuclear (Natural Gas has become #2 since Fall 08) 2. a) Natural Gas b) peak

3. a. ≥ 90% b. 35 - 40% c. ~ 38% d. 55 - 60%

4. a) 0.679 b) yes c) The vehicles should be charged during off-peak hours.

5. a) B b) μ c) H d) $B = \mu \cdot H$ e) B-H curve or Hysteresis curve f)



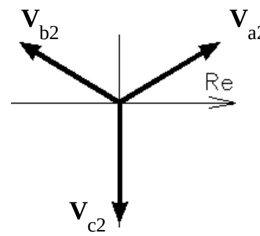
6. Air (and distance)

7. a) Multiple wires per phase b) Reduce corona discharge

8. Yes, the surge impedance loading does not set the power limit. 9. leakage reactance

10. a) 20 b) 1000 c) NOT affected d) 50 or 50:1

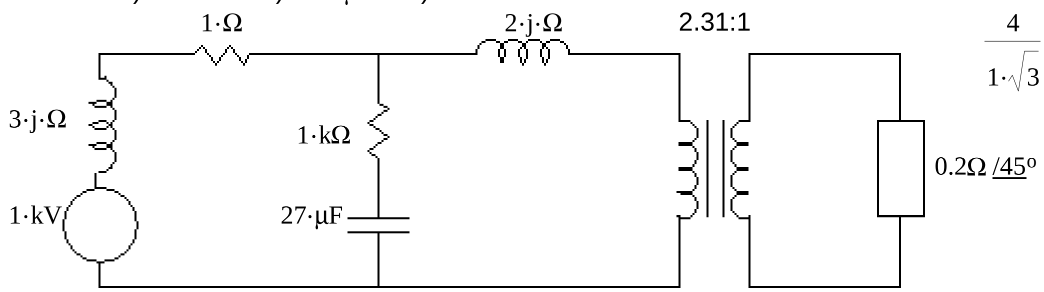
11. No connection to ground means no zero-sequence current can flow. Since there is no zero-sequence voltage source, no current means no voltage as well. 12.



Open Book

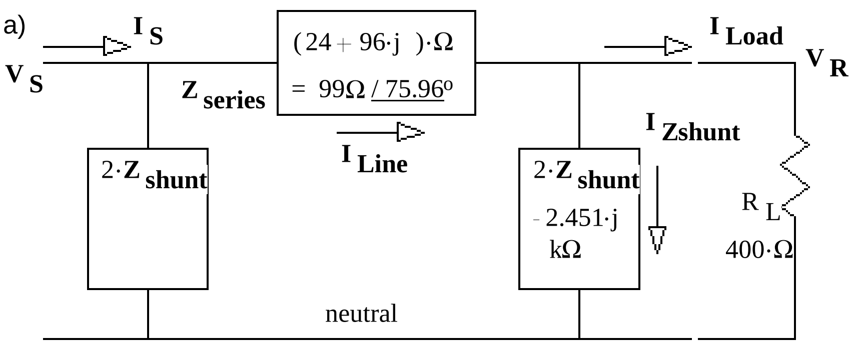
1. a) $137.8 \cdot V$ b) $77.9 \cdot \%$ c) $751 \cdot \mu f$ d) $87.8 \cdot \%$

2.



$$\frac{4}{1 \cdot \sqrt{3}} = 2.309$$

3. a)



b) $(191.4 - 15 \cdot j) \cdot A$ = 192A / -4.48°

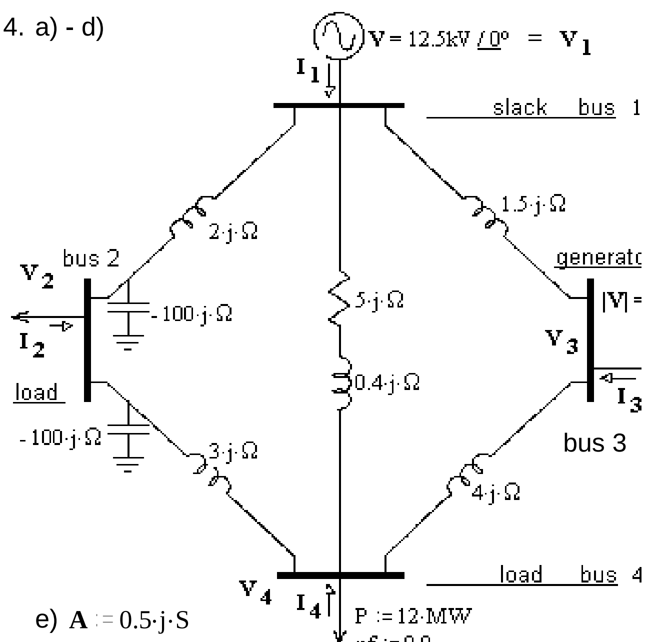
c) 75.8kV / -13.75°

d) $131.3 \cdot kV$

e) $43.1 \cdot MW$

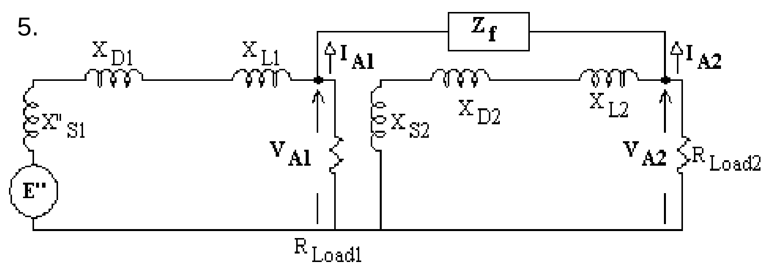
f) 0.857 SIL

4. a) - d)



e) $\mathbf{A} := 0.5 \cdot j \cdot S$
$\mathbf{B} := -0.813 \cdot j \cdot S$

5.



define $$\mathbf{Z_X} = \mathbf{Z_f} + \frac{1}{\dfrac{1}{(X_{S2} + X_{D2} + X_{L2}) \cdot j} + \dfrac{1}{R_{Load2}}}$$

$$\mathbf{I_S} = \frac{\mathbf{E''}}{(X''_{S1} + X_{D1} + X_{L1}) \cdot j + \left(\dfrac{1}{R_{Load1}} + \dfrac{1}{\mathbf{Z_X}}\right)}$$

$$\mathbf{V_{A1}} = \mathbf{I_S} \cdot \frac{1}{\left(\dfrac{1}{R_{Load1}} + \dfrac{1}{\mathbf{Z_X}}\right)} \qquad \mathbf{I_{A1}} = \frac{\mathbf{V_{A1}}}{\mathbf{Z_X}}$$

$$\mathbf{I_{fault}} = \mathbf{I_B} = a^2 \cdot \mathbf{I_{A1}} + a \cdot \mathbf{I_{A2}} = (a^2 - a) \cdot \mathbf{I_{A1}}$$