EE 30372, Spring 2012
Exam 1
7 March, 2012

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. For full credit, simplify your answers as much as possible. You may use calculators for numerical evaluations but no programming capabilities. This exam is closed-book.

Remember that when three-phase voltages are given, they will be line-to-line by default.

Problem 1 (25) _____

Problem 2 (25) _____

Problem 3 (20) _____

Problem 4 (30) _____

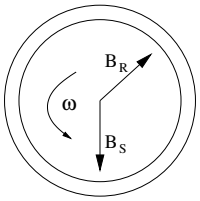
Total (100) _____

Name_____

1. Short Answers (5 pts each)
   (a) Two generators, G_1 and G_2, are connected by a line having impedance $j10\Omega$. Each holds voltage magnitude 6kV, but G_2 has its output phase advanced by 3 degrees relative to $G1$. What is the total complex power output into the line by G_2?

   (b) What is the line current for a three-phase load at 480V consuming 10 Hp at power factor 0.8 lagging?

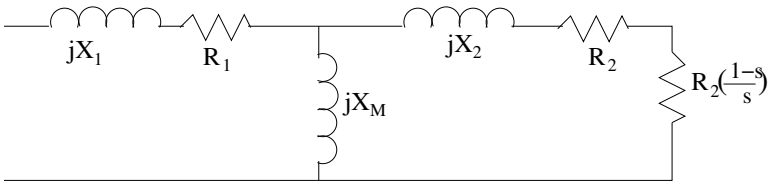
   (c) A synchronous machine has rotor and stator fields as illustrated, rotating at speed



   ω in the direction indicated. Is this machine functioning as a generator or as a motor?

(d) A Δ-connected, three-phase load with impedance of 30+j40 Ohms in each phase is connected to a 400V supply. What is the total real power absorbed by the load?

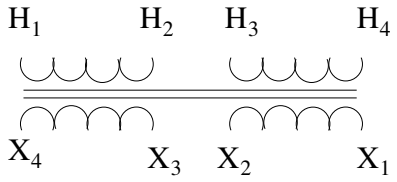
(e) Suppose the two-phase (90 degrees apart) source at 250 volts line-to-neutral is supplying a two-phase load with impedance of 20+j15 Ohms in each phase. Find the RMS value of the current in the neutral line.



2. (25 pts.) Above is the *per-phase* equivalent circuit model of a 3-phase induction motor somewhat similar to the one we've used in class, running at 208V, 60 Hz, 6-pole, Y-connected. Suppose its per-phase parameters are $R_1 = 2.0\Omega$, $X_1 = 4.0\Omega$, $R_2 = 1.0\Omega$, $X_2 = 4.0\Omega$, $X_M = 40\Omega$. Core losses (modeled in stator) are 150W and mechanical losses total a fixed 75 W. At full load, the motor is expected to rotate at 1140 rpm. At this full load speed, find (a) line current into the motor, (b) the converted power P_{conv}, (c) efficiency and (d) the output horsepower and torque.

3. (20 pts.) Generators A and B have power/frequency slopes of 1.0 MW/Hz and 2.0 MW/Hz, respectively. Both have no-load speeds set to 61 Hz. Their reactive power/voltage slopes are both 20 kVAR/volt. These two machines are to be set to supply equal parts of the reactive power to a load of 4.0 MVA, power factor 0.7 lagging, at 4kV. Find the no-load voltage settings for each of the two generators, and the system frequency.

4. Below is a 7.2kV/240V transformer, which could supply your home. H is the high-voltage side, and X is the low-voltage. Low-side impedances are 0.1Ω and $j0.3\Omega$ and high-side are 10Ω and $j20\Omega$, in both cases for the series-connected coils. You may ignore the shunt impedances.



(a) (20 points) If your house is drawing its rated maximum of 200A at 240V, with power factor 0.9 lagging, find the voltage regulation of the transformer and sketch an *accurate* phasor diagram, referenced to the low-voltage side, with voltage drops across resistive and inductive components of the equivalent circuit graphed and identified separately.

(b) (10 pts.) As you get older, you become paranoid, join various paramilitary groups, and decide to get off the power grid. On E-bay, you buy two windmills, one of which outputs 4kV AC at 60 Hz, and the other of which outputs 3.2kV at 60 Hz. They are magically kept in phase. Opening the junction box on the transformer, you find that all the 8 terminals in the figure of the previous page are accessible, with the neutral/ground wire for the service entrance to your house connected to both X_2 and X_3, and the X_1 and X_4 lines to connected to the two 120V circuits. Being well-versed in electric power, you imitate the usual distribution line by disconnecting H_2 from H_3, and connecting the leads from one windmill across H_1 and H_2, and the other across H_3 and H_4, to supply the primary with the usual 7.2 kV. How's that work for you? Discuss. If you see any problems, propose a better way to connect the system if you're so damned smart. Show also what you would do for electrical connections if you can afford only one of the two windmills.