EE 30372, Spring 2011
Exam 1
10 March, 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. 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 (20) _____

Problem 3 (15) _____

Problem 4 (20) _____

Problem 5 (20) _____

Total (100) _____

Name_____

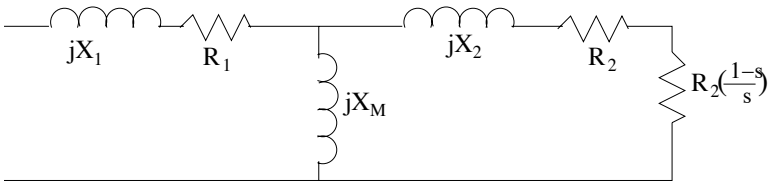
1. Short Answers (5 pts each)
   (a) A load is consuming 20 kW at power factor 0.7 lagging. Express its power consumption as the complex **S**.

   (b) Sketch the circuit(s) and stator for a single-phase induction motor with a capacitor used in the auxiliary phase for starting. Show physical placement of primary and auxiliary windings.

   (c) The line-to-neutral voltage of the a phase in a balanced three-phase system is $120\angle 15^o$ V in our usual phasor notation. What is the precise form of $v_{bc}(t)$, the time-function voltage between lines b and c?

(d) How many horsepower are being delivered by a motor turning at 1750 rpm, with torque of 20 ft-lbs?

(e) A three-phase, 14.0 kV distribution line supplies apparent power of 300 kVA to your jacuzzi. What is the line current in this state? Extra credit: How many people are likely to fit into a 300kVA jacuzzi?



2. (20 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 480V, 60 Hz, 6-pole, Y-connected. Suppose its per-phase parameters are $R_1 = 2.0\Omega$, $X_1 = 3.0\Omega$, $R_2 = 1.0\Omega$, $X_2 = 2.0\Omega$, $X_M = 50\Omega$. Core losses (modeled in stator) are 200W and mechanical losses total a fixed 250 W. At full load, the motor is expected to rotate at 1150 rpm. At this full load speed, find (a) the air-gap power P_{AG}, (b) efficiency and (c) the output horsepower.

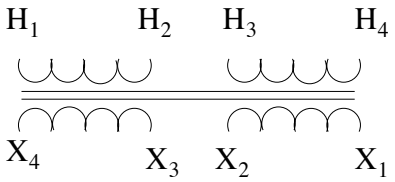
3. (15 pts.) A Y-connected, three-phase generator operating at 60 Hz, 1200 V (terminal voltage) has output impedance in each phase of $(1.0 + j4.0)\Omega$. The generator is supplying, at its terminals, 200kVA at power factor 0.9 leading. Find line current at the output terminals and the generator's voltage regulation, and sketch an accurate phasor diagram of the its operation, including numerical values for all pertinent voltages and currents.

4. Generators A and B have power/frequency slopes of 1.0 MW/Hz and 3.0 MW/Hz, respectively.

(a) (10 pts.) Choose no-load frequency settings for the governors on A and B if we want to operate them in parallel at 60 Hz, with each generator supplying half of the power to a 3.0 MW load. Sketch the house diagram for this setting.

(b) (10 pts.) If we now add another 1MW to the load with the settings from (a), what is the system frequency, and how much power is each generator providing?

The wiring of our 1 kVA, 480V/240V transformer is shown below. H is the high-voltage side, and X is the low-voltage.



(a) (8 pts.) We connect the following pairs of terminals together: X_2 and X_3, H_2 and H_3, and H_1 and H_4. We then perform a short-circuit test of the transformer in this higher-voltage (480V/240V) configuration. With an applied 60 Hz rms voltage of 50 V to X_1 and X_4, we observe an input current of 4.0 A and power of 50 W being absorbed in the transformer. What parameters have we measured, and what are their values in our equivalent circuit model? What would be the values resulting from a short circuit test in the transformer's lower voltage, parallel configuration?

(b) (7 pts.) Suppose the short-circuit test in (a) yielded impedance of $(5+j10)\Omega$ (these numbers are not the correct values for (a)). Find values for the H side and X side impedances which match this result and sketch the equivalent circuit.

(c) (8 pts.) Now let the transformer be ideal. Show, in a wiring diagram with primary and secondary voltages clearly labeled, how you would use it as an autotransformer to raise voltage from 400V ot 500V. Find the kVA rating for your autotransformer configuration.