EE 30372, Spring 2010
Exam 1
4 March, 2010

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 (30) _____

Problem 2 (15) _____

Problem 3 (20) _____

Problem 4 (20) _____

Problem 5 (15) _____

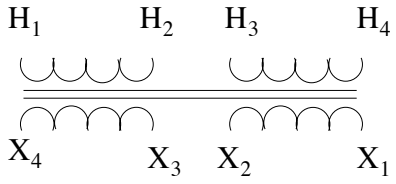
Total (100) _____

Name_____

1. Short Answers (5 pts each)
   (a) What is the reactive power into a single-phase load consuming 20 kW at terminal voltage 480 V rms and power factor 0.9 leading?

   (b) Sketch the fields of the rotor and stator inside a two-pole synchronous three-phase generator driving a load with impedance angle of 30 degrees. Indicate the direction of the fields' rotation.

   (c) A 240/480 V transformer with the configuration below (X = low side, H = high side) has terminals X_2 and X_4 connected. if we apply 120V across X_1 and X_3, what voltage do we measure across H_1 and H_2?

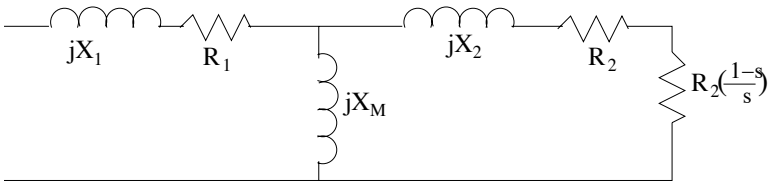


(d) A 13.5kV/135kV three-phase transformer rated at 100kVA has low-voltage side series phase impedance of $1 + j3$ and high-voltage side impedance of $5 + j10$ in Y-connection. Find the total equivalent impedance in per-unit.

(e) A three-phase, 12.4 kV (line-line) distribution line supplies apparent power of 200 kVA to your plant. What is the line current in this state?

(f) What is the output torque of a motor delivering 2 HP at 1200 rpm?

2. (15 pts.) A Δ-connected, three-phase generator operating at 60 Hz, 400 V (terminal voltage) has output impedance in each phase of $(0.3 + j2.1)\Omega$. The generator is supplying the system with 40kVA at power factor 0.9 lagging. Find line current at the output terminals and sketch an accurate phasor diagram of the generator's operation, including numerical values for all pertinent voltages and currents.



3. (20 pts.) Above is the *per-phase* equivalent circuit model of the a 3-phase induction motor, 230V, 60 Hz, 4-pole, Y-connected. Suppose its per-phase parameters are $R_1 = 1.0\Omega$, $X_1 = 3.0\Omega$, $R_2 = 2.0\Omega$, $X_2 = 2.0\Omega$, $X_M = 40\Omega$. For this exercise, we will ignore core losses and assume mechanical and miscellaneous losses total a fixed 300 W. At full load, the motor is expected to rotate at 1710 rpm. At this full load speed, find (a) the air-gap power P_{AG}, (b) the stator copper losses, (c) the output torque and horsepower

4. A series DC motor has field and armature resistances of 0.2Ω and 0.5Ω, respectively. Suppose that the motor's field flux is a linear function of field current. The motor is supplied with a terminal voltage of 200V.
(a) (10 pts.) The motor operates at 1000 rpm with input current of 40 A. What is the induced torque in this state?

(b) (10 pts.) Now we reduce the load on the motor, and input current drops to 10 A. What is the speed of the motor?

5. (15 pts.) Our 480V/240V transformer is again represented below. For this exercise, ignore winding resistance and leakage inductance, so that all four coils have the indentical, mutual flux through them. Suppose that the coil between H_1 and H_2 has measured impedance $j5$. What impedance will we see if we connect H_1 to X_3 and H_2 to X_4 and then again connect a source to H_1 and H_2? Explain your reasoning carefully, citing relevant physical principles.