# EE 30372, Spring 2008 <br> Exam 1 <br> 13 March, 2008 

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) $\qquad$

Problem 3 (20) $\qquad$

Problem 4 (35) $\qquad$

Total (100)

Name $\qquad$

1. Short Answers (5 pts each)
(a) A generator must supply line current of 200 Amps at line-to-line voltage of 600 V . If the machine is to be $\Delta$-connected, what are the V and A requirements of each individual phase of the generator?
(b) A load in a single-phase 60 Hz system consumes 2KVA at 100 volts with power factor 0.9 lagging. Find the size of a capacitor (in Farads) to connect in series with the load to correct the power factor to unity.
(c) A $240 / 480 \mathrm{~V}$ transformer with the configuration below ( $X=$ low side, $H=$ high side) has terminals $X_{2}$ and $X_{3}$ connected. if we apply 200 V across $H_{1}$ and $H_{2}$, what voltage do we measure across $X_{1}$ and $X_{4}$ ?

(d) We need to produce power in a $50 \mathrm{~Hz}, 3$-phase system using a 4-pole alternator. At what mechanical rotation speed do we set the engine to drive this alternator?
(e) If the secondary side of a $500 \mathrm{~V} / 100 \mathrm{~V}$ step-down transformer has impedance $(1+\mathrm{j} 2) \Omega$, and the primary has impedance $(2+\mathrm{j} 3) \Omega$, find the total equivalent impedance referred to the primary side.
2. A Y-connected, three-phase generator operating at $60 \mathrm{~Hz}, 480 \mathrm{~V}$ (line-line) has output impedance in each phase of $(0.05+\mathrm{j} 0.5) \Omega$.
(a) ( 10 pts .) The generator has to supply the system with 50 kVA at power factor 0.9 leading. In this state, find line current at the output terminals and the generator's internal voltage $\mathbf{E}_{A}$.
(b) (10 pts.) Sketch an accurate phasor diagram of the generator in this state, and compute its voltage regulation.

3. Above observe a one-line diagram for a three-phase power system.
(a) (10 pts) Convert the entire system to per-unit values, using $S_{\text {base }}$ of 200 kVA , and $V_{\text {base }}$ set by the generator's voltage. Draw the per-phase circuit in pu.
(b)(10 pts.) With given parameters, compute the actual power loss in the transmission line by using your pu system followed by conversion to "real" values.

4. (20 pts.) Above is the per-phase equivalent circuit model of the the 3-phase induction motor we used in class. It is $230 \mathrm{~V}, 60 \mathrm{~Hz}, 6$-pole, and is Y-connected. Suppose its per-phase parameters are $R_{1}=1.0 \Omega, X_{1}=3.0 \Omega, R_{2}=2.0 \Omega, X_{2}=3.0 \Omega, X_{M}=30 \Omega$. For this exercise, we will ignore core losses and assume mechanical and miscellaneous losses total a fixed 200 W . At full load, the motor is expected to deliver 1 HP to the shaft at 1140 rpm . At this full load speed, find (a) the air-gap power $P_{A G}$, (b) the stator copper losses, (c) the output torque and horsepower (compute HP out, and compare to rated HP), and (d) the machine's efficiency.

(b) (15 pts.) The wiring of this motor's stator is shown above, with configuration dependent on terminal voltage available ( 460 vs .230 ). At 230 V , we connect the two coils of each phase in parallel, while at 460 V , they are in normally in series (see page from EE Handbook). Suppose we're using 230V, but instead of the usual wiring, we connect terminals 4,5 and 6 together, connect the a,b,c leads to terminals 1,2 , and 3 , and leave $7,8,9$ unconnected. Using whatever physical principles and aspects of our models of the induction motor you need, present a detailed, complete argument (quantitative where possible) for how the torque/speed curve in this case will look relative to that of the normal 230 V wiring. (You may use the circuit model, go back to physical first principles, or use a combination of the two.)
