## EE 30372, Spring 2013 Exam 1 6 March, 2013

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. Voltage and current values are, unless otherwise noted, in rms.

Problem 1 (35)

Problem 2 (25)

Problem 3 (20)

Problem 4 (20)

Total (100)

Name\_

## 1. Short Answers (5 pts each)

(a) Two single-phase generators,  $G_1$  and  $G_2$ , are connected by a line having impedance 5 $\Omega$ .  $G_1$  has voltage (1000+j20)V and  $G_2$  has voltage 1kV. What is the total complex power output into the line by each of  $G_1$  and  $G_2$ ?

(b) What is the line current magnitude for a three-phase load at 480V consuming 15 Hp at power factor 0.7 lagging?

(c) On our oscilloscope, we measure the voltage between the A and B lines of a threephase supply as  $200 \cos(100\pi t + 45^0)$ . In phasor notation, what would the voltage  $\mathbf{V}_{AN}$  be, if N is the neutral terminal? (d) Convert this load into a simple Y-connected configuration, with a single complex impedance  ${\bf Z}$  in each branch.



(e) A 50Hz induction motor has operating speed of 570 rpm. How many poles does it have in its windings?

(f) If a 60 Hz, two-pole induction motor is operating at slip of 2%, what is the electrical frequency on any conductor bar in the rotor?

(g) You have a 30 HP, 600V, 3-phase, 60 Hz motor operating at PF 0.7 lagging, and you would like to correct that power factor to 1.0. What size capacitor would you put in parallel with each of the  $\Delta$ -connected segments of the motor?

2. A Y-connected, three-phase generator operating at 60 Hz, 2400 V (line-line terminal voltage) has output impedance in each phase of  $(1.0 + j6.0)\Omega$ .

(a) (15 pts.) The generator is supplying, at its terminals, 300kVA at power factor 0.9 lagging. Find line current at the output terminals and the generator's voltage regulation. Sketch an accurate phasor diagram of its operation, including numerical values for all pertinent voltages and currents.

(b) (10 pts.) With the field current fixed as in part (a), what is the maximum real power the generator can deliver? (You may ignore the machine's internal resistance,  $R_A$ , for this part.) Sketch the phasor diagram for this state, and compute the reactive power the generator is supplying or consuming.



3. Above is the *per-phase* model of a 3-phase transformer. The parameters are  $N_p/N_s = 5$ ,  $X_p = 10\Omega$ ,  $R_p = 5\Omega$ ,  $X_s = 1\Omega$ ,  $R_s = 0.5\Omega$ . We neglect shunt impedances. The load has impedance  $(20 + j15)\Omega$ .

(a) (10 pts.) Find the equivalent circuit, with all entities referenced to the primary.

(b) (10 pts.) We apply 6kV at the primary. What is the complex power actually delivered to the 3-phase load?

4. Generators 1 and 2 have power/frequency slopes of 20.0 MW/Hz and 30.0 MW/Hz, respectively. Their reactive power characteristics are 0.5 MVAR/V and 1.0 MVAR/V, respectively. We broke the controls for the field currents, with generator 1 stuck at 1230V and generator 2 at 1180V terminal voltage. We plan to connect them to an "infinite" bus which is operating at 60 Hz and 1200V, and would like to extract from each of them equal parts of a total delivery of 100 MW to the system.

(a) (10 points) Find the no-load speeds we should set on each generator before connecting them to the bus.

(b) (10 pts.) Find the power factor (with leading/lagging specification) at which each of the generators is operating when they're connected to the bus.