# ECE 3600 Exam 2 given: Fall 09   (The space between problems has been removed.)

Write Legibly!   This part of the exam is Closed book, Closed notes, No Calculator.

(33 pts) Questions   If I can't read what you've written or you answer is ambiguous, I'll assume you don't know.

1. You have a 200/80-V, 400-VA transformer.
   Can you use this transformer to transform
   120 V to 80 V? If yes, show the connections
   and compute the new VA rating.
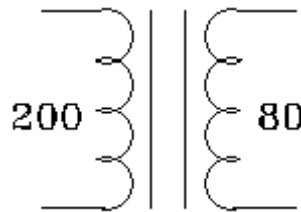
2. You have a 200/80-V, 400-VA transformer.
   a) Can you use this transformer to transform
   100 V to 140 V? If yes, show the connections
   and compute the maximum power that can
   be transformed at these voltages.
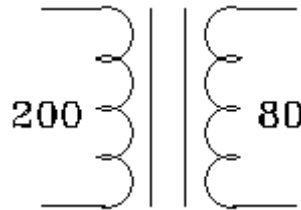
   Wire as a 200/280-V transformer and
   simply use it at half its rated voltages.

   b) What condition must be met by the load to transform this maximum power?

3. a) If your power system did not have any _____ , then there would be no good reason to use the per-unit system.

   b) What do these things do that justify the use of the per-unit system?

   c) List the bases of a per-unit system.

   d) Which, if any, of these bases should be uniform throughout the power system?

4. In a synchronous machine, how is E_{af} (E_A) controlled?

5. In a synchronous-machine phasor diagram, the shaft torque affects which variable most directly?

6. A motor is rated at 10hp, 208V, 60Hz, 1140rpm.

   a) What type of motor is this (most likely).

   b) How many poles does it have?

   c) What is the full-load slip of this motor?

7. The secondary of a current sensing transformer must always be connected in what way? (Think back to our substation field trip.)

8. Rocky Mountain power maintains two large systems involving lots of electrical engineering. One is obvously the power system itself. What is the other?

9. During his lecture to our class, Kent Udell mentioned a couple of side benefits to using photovoltic solar panels that could argue for their use in cities like Pheonix. Give at leats one.

10. Name at least one of the electrical-power-related projects that seniors in the mechanical engineering department are involved in.

ECE 3600   Exam #2   Arn Stolp
Scores:
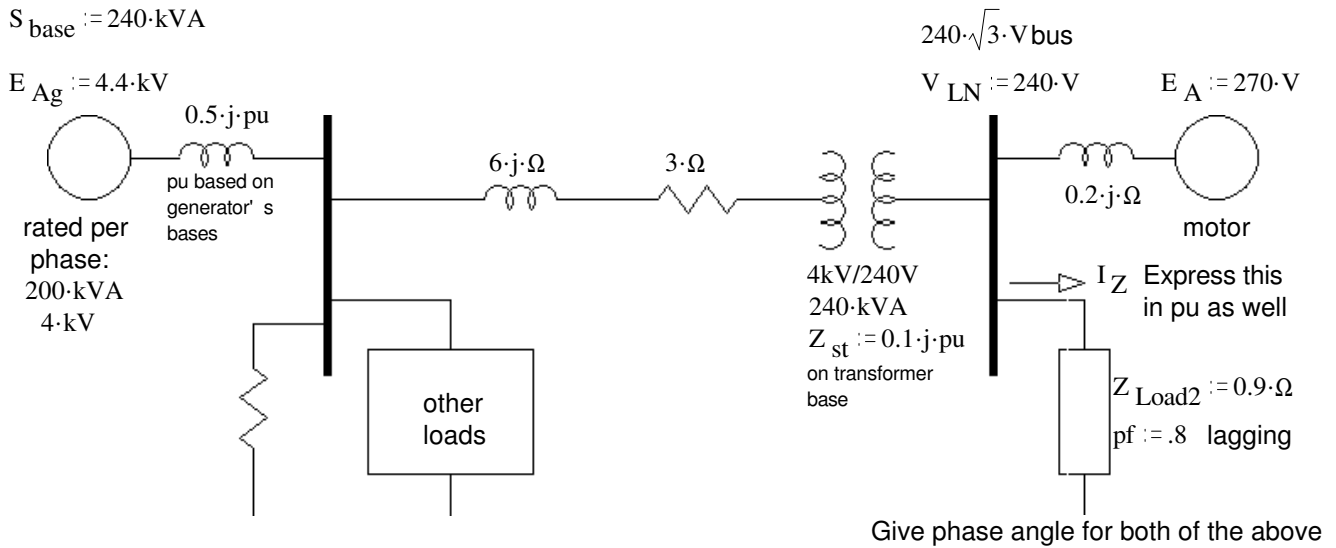   Pages 1&2 _____ of a possible 34 pts

   Pages 3&4 _____ of a possible 33 pts

   Questions _____ of a possible 33 pts

   Total _____ of a possible 100 pts

1. (18 pts) A one-line, per-phase diagram is shown below. Using the S_{base} given, draw a per-phase, per-unit diagram. Include pu values for all the values given in the drawing below. All voltages are line-to-neutral.

$S_{base} := 240 \cdot kVA$

$E_{Ag} := 4.4 \cdot kV$

$0.5 \cdot j \cdot pu$

pu based on generator' s bases

rated per phase:
$200 \cdot kVA$
$4 \cdot kV$

$6 \cdot j \cdot \Omega$　　$3 \cdot \Omega$

other loads

$240 \cdot \sqrt{3} \cdot V$ bus

$V_{LN} := 240 \cdot V$　　$E_A := 270 \cdot V$

$0.2 \cdot j \cdot \Omega$

motor

4kV/240V
$240 \cdot kVA$
$Z_{st} := 0.1 \cdot j \cdot pu$
on transformer base

I_Z Express this in pu as well

$Z_{Load2} := 0.9 \cdot \Omega$

$pf := .8$ lagging

Give phase angle for both of the above

2. (16 pts) A 208-V. four-pole, 60-Hz, Y-connected, induction motor is rated at 20 hp.
   Its equivalent circuit components are

   $N_{poles} := 4$　　　$R_1 := 0.20 \cdot \Omega$　　　　$R_2 := 0.12 \cdot \Omega$

   　　　　　　　　　　$X_1 := 0.40 \cdot \Omega$　　　　$X_2 := 0.40 \cdot \Omega$　　　　$X_M := 15 \cdot \Omega$

   　　　　　　　　　　$P_{mech} := 300 \cdot W$　　　$P_{misc} := 0 \cdot W$　　　$P_{core} := 0 \cdot W$

   For a slip of 0.06, the following values have been calculated for you:

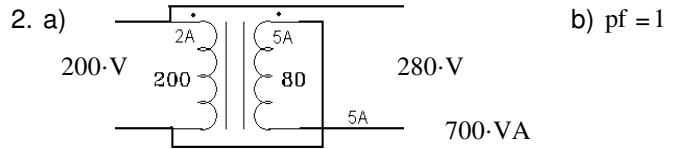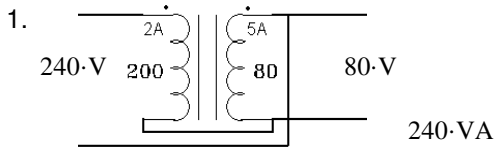 $E_1 = 101.49 - 13.961j \cdot V$　　　　$|E_1| = 102.446 \cdot V$　　　　The line current: $|I_L| = 52 \cdot A$

   Find the following:

   a) The stator copper losses

   b) The air-gap P_{AG}

   c) The power converted from electrical to mechanical form

   d) The motor speed in revolutions per minute and radians per second

   e) The induced torque τ_{ind}

   f) The load torque τ_{load}

3. (12 pts) A 60 Hz, 2-pole, Y-connected, 3-phase synchronous generator supplies 18 MW of power to a 18 kV bus.
   The synchronous reactance is 6 Ω/phase.

   a) Find the magnitude of the generator emf so that $Q := 9 \cdot MVAR$

   b) Find the power angle, δ.

4. (21 pts) An industrial plant is powered from a 480-V, 3-phase bus and currently draws 60 kW at a power factor of 0.8 lagging. A new mill is to be added at the plant. This mill requires a shaft torque of 600 Nm at 1200 rpm. Your job is to specify a motor which will run the mill and correct the plant power factor at the same time. Be sure to specify the type of motor including the number of poles. Tell me how the motor should be connected to the bus (This is an arbitrary decision here, but it will affect many of your other answers). Specify its minimum hp, voltage, and current ratings. Tell me what the back emf should be. You may assume the synchronous reactance is 1 Ω/phase and that losses are negligible.

Note:　$1 \cdot hp = 745.7 \cdot W$

Questions

1.

240·V　200　　80　　80·V

240·VA

2. a) 　　　　　　　　　　　b) pf = 1

200·V　200　　80　　280·V

700·VA

3. a) Transformers　　　b) What do these things do that justify the use of the per-unit system?

   c) S_{base}　　V_{base}　　I_{base}　　Z_{base}　　　　d) S_{base}

4. The field or rotor current　　5. The power or torque angle, δ

6. a) 3-phase induction motor　　b) 6　　c) 5·%

7. The secondary of current sensing transformer must always shorted.

8. The information or telemetry system

9.　1. The greatest power generation also occurs at the time of greastest need, the middle of hot summer days.

　　2. Photovoltic solar panels convert some solar radiation to electricity which would otherwise be converted to heat. This helps lower the total heat-load.

10. 1. Electrically powered rubber raft with nightime power generation from the river flow.

　　2. Power extraction from ocean waves.

Problems

1.
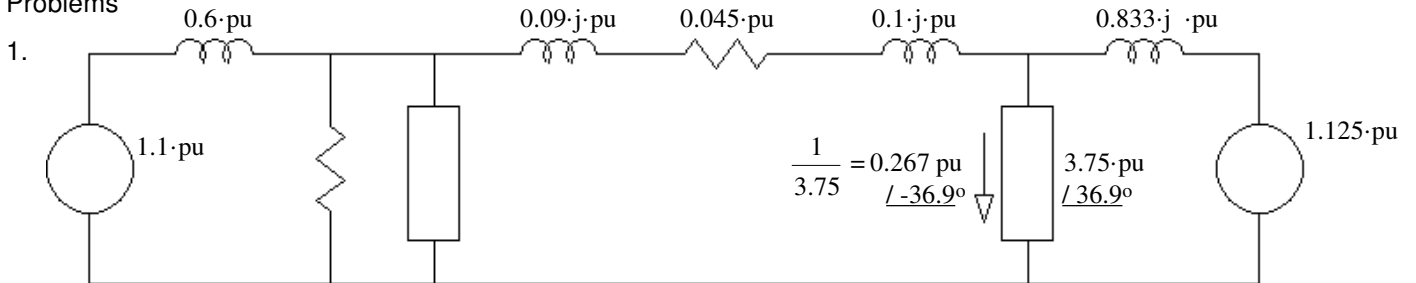
2. a) 1.622·kW　　b) 15.14·kW　　c) 14.23·kW　　d) $177.2 \cdot \dfrac{rad}{sec}$　　e) 80.31·N·m　　f) 78.61·N·m

3. a) 12.6·kV　　b) 15.95·deg　　4. Use a 6-pole synchronous motor of at least　101.2·hp

　　　　　　　　　　　　　　　If you select Y-connected　　277·V　　106·A　　343.4·V

　　　　　　　　　　　　　　　If you select Δ-connected　　480·V　　61·A　　514·V

Study guide for exam 2

　Homework 9 - 17 p.2　　　　　Labs 2 & 3　　　　　　　Field trip to Rocky Mountain Power Dispatch Center

　Subjects

　　　Auto-transformers

　　　per-unit, per-phase

　　　Synchronous motors and generators

　　　3-phase induction motors excluding tests