

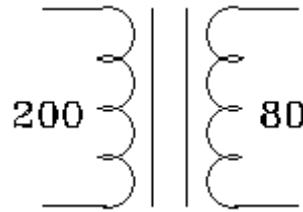
## ECE 3600 Exam 2 given: Fall 09

(The space between problems has been removed.)

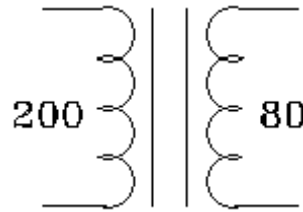
**Write Legibly!** This part of the exam is **Closed book, Closed notes, No Calculator.**

(33 pts) Questions If I can't read what you've written or your 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 obviously 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 photovoltaic solar panels that could argue for their use in cities like Phoenix. Give at least 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

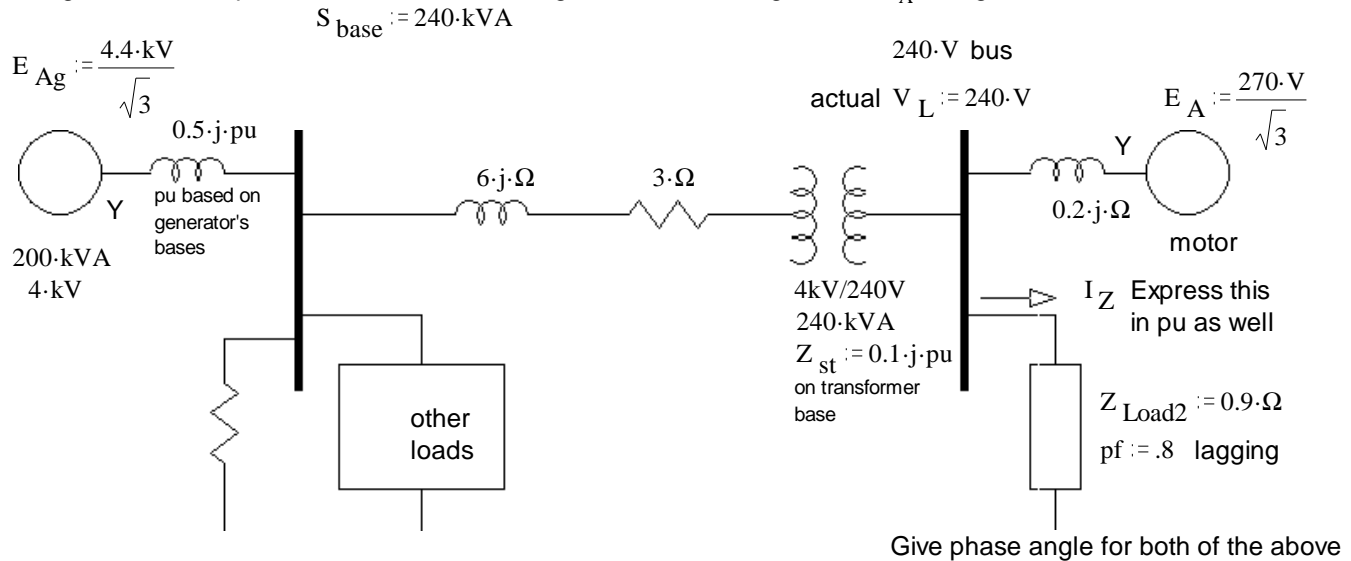
Pages 3&4 \_\_\_\_\_ of a possible 33 pts

Questions \_\_\_\_\_ of a possible 33 pts

Total \_\_\_\_\_ of a possible 100 pts

You MUST show work to get credit. Show the correct units

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.  $E_A$  voltages are line-to-neutral.



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

$N_{poles} := 4$	$R_1 := 0.20 \cdot \Omega$	$R_2 := 0.12 \cdot \Omega$	
	$X_1 := 0.40 \cdot \Omega$	$X_2 := 0.40 \cdot \Omega$	$X_M := 15 \cdot \Omega$
	$P_{mech} := 300 \cdot \text{W}$	$P_{misc} := 0 \cdot \text{W}$	$P_{core} := 0 \cdot \text{W}$

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

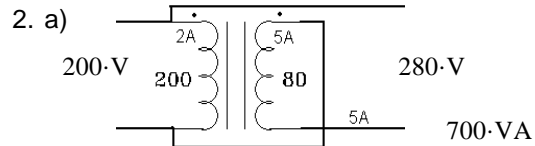
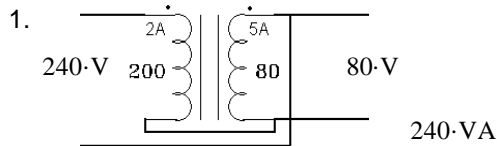
$E_1 = 101.49 - 13.961j \cdot \text{V}$        $|E_1| = 102.446 \cdot \text{V}$       The line current:  $|I_L| = 52 \cdot \text{A}$

Find the following:

- The stator copper losses
  - The air-gap  $P_{AG}$
  - The power converted from electrical to mechanical form
  - The motor speed in revolutions per minute and radians per second
  - The induced torque  $\tau_{ind}$
  - The load torque  $\tau_{load}$
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  $\Omega$ /phase.
- Find the magnitude of the generator emf so that  $Q := 9 \cdot \text{MVAR}$
  - Find the power angle,  $\delta$ .
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  $\Omega$ /phase and that losses are negligible.

Note:  $1 \cdot \text{hp} = 745.7 \cdot \text{W}$

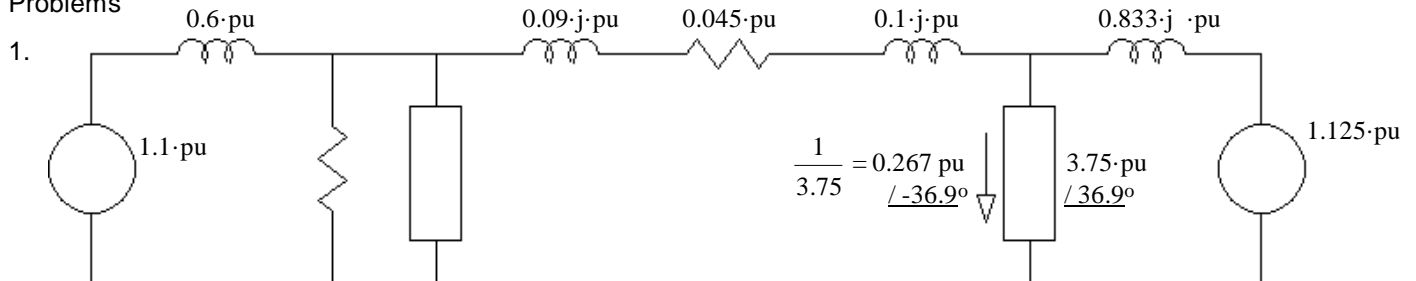
**Answers**  
Questions



b)  $pf = 1$

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,  $\delta$
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. Photovoltaic 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 nighttime power generation from the river flow.  
2. Power extraction from ocean waves.

Problems



2. a) 1.622-kW      b) 15.14-kW      c) 14.23-kW      d)  $177.2 \frac{\text{rad}}{\text{sec}}$       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  $\Delta$ -connected      480·V      61·A      514·V