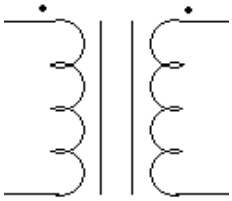
ECE 3600 Exam 2 given: Fall 15

(The space between problems has been removed.)

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

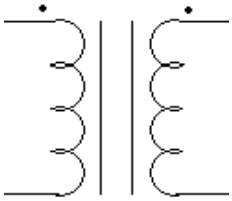
(28 pts) Questions If I can't read what you've written or you answer is ambiguous, I'll assume you don't know.

1. a) You have a 320/80-V, 640-VA transformer. Can you use this transformer to transform 320 V to 240 V? If yes, show the connections and compute the new VA rating.



   b) Could this transformer also be used to transform 240 V to 180 V ? If yes, what is the maximum real power that could be transformed at these voltages?

2. a) You have a 360/120-V, 7.2-kVA transformer. Show the necessary connections to use this transformer to transform 120 V to 480 V. Also show the 120-V source and the load.



Also show the 120-V source and the load.

   b) the power flows from right to left / left to right in my drawing above.

(circle one of the options)

3. List at least 3 different synchronous motor speeds in the US, in rpm.

4. You have a very simple single-phase power system with two regions. Region 1 operates at 480 V and is connected to region 2 by a 480/120 V, 2.4 kVA transformer. You wish to make calculations using the per-unit system. Find:

   a) All the necessary bases for region 1 (Select the most reasonable numbers for bases where needed).

   b) All the necessary bases for region 2.

5. a) Consider a 3-phase synchronous-machine **phasor diagram**. To increase the real output power (watts), what is the primary thing that should change in the **phasor diagram**? (All other changes in the phasor diagram will follow from this change.) Say what should change and whether it should increase or decrease.

   b) How can the power plant operator make that happen?

   c) To increase the real reactive power (VARs), what is the primary thing that should change in the **phasor diagram**? (All other changes in the phasor diagram will follow from this change.) Say what should change and whether it should increase or decrease.

   d) How can the power plant operator make that happen?

6. Name at least two tests or procedures performed on induction motors in order to determine the model parameters.

The following problems were handed out to the student after finishing the closed-book part.

This part of the exam is open book, open notes. You MUST show work to get credit. Show the correct units for each value. Assume voltage and current values are RMS and $f := 60 \cdot Hz$. Assume normal abc sequence and balanced conditions for all 3ϕ.

I SUGGEST: DO THE EXAM BACKWARDS, Problem 3 first, then 2, then 1

1. (30 pts) A 3-phase, synchronous generator is not electrically connected to anything. The prime mover is spinning the generator at $3600\ \text{rpm}$. The input torque is $50\ \text{Nm}$. When the field current is $10\ \text{A}$, DC, the terminal voltage is $1100\ \text{V}$.
   The field current is raised to $20\ \text{A}$, and the terminal voltage goes up to $2200\ \text{V}$.
   The generator is now Y-connected to a $3.6\ \text{kV}$, $60\ \text{Hz}$, bus. The line current is measured at $3.8\ \text{A}$.

   a) Find the synchronous reactance. X_S = ?

   If you can't find X_S, or doubt your value, mark here ____ and use $X_S = 30\ \Omega$ for the rest of the problem.
   If it still doesn't seem like you have enough information to answer the following parts, come ask.
   I will answer questions for points.

   b) Find the total reactive power generated.

   c) The prime mover torque in increased to $\tau_{in} := 450 \cdot \text{N} \cdot \text{m}$ Find the generated electrical power P = ?

   The prime mover torque is held at this value for the rest of the problem.
   d) Find the power angle. δ = ?

   e) Find the total reactive power generated.

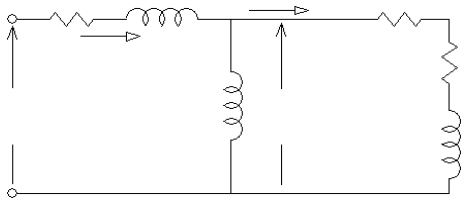
   f) The generator operator is told to produce $36\ \text{kVAR}$, no change in power.
   What does the operator change and to what value.

   h) Did the power angle change with the the previous change?
   If yes, say whether it increased or decreased. No calculation is required.

   g) Did the generated power change with the the previous change?
   If yes, say whether it increased or decreased. No calculation is required.

2. (21 pts) The following information is for a 3-phase, Y-connected, induction motor:
   $X_M := 400 \cdot \Omega$ $R_C := \infty$ $n_m := 1728 \cdot \text{rpm}$ Shaft torque: $\tau_{shaft} := 50 \cdot \text{N} \cdot \text{m}$
   $|\mathbf{E_1}| = E_1 := 260 \cdot \text{V}$ $|\mathbf{I_2}| = I_2 := 13 \cdot \text{A}$ $P_{RCL} := 390 \cdot \text{W}$

   a) Below is a drawing the circuit model of one phase.
   Label **all** the parts and arrows and add known values.

   b) Find the slip. Make a reasonable assumption as necessary.

   c) Find R_2

   d) Find X_2

   e) The magnitude of the line current. I advise you to assume the phase angle of E_1 is 0^o.

   f) The air-gap power

   g) The power converted from electrical to mechanical form.

   h) Find the mechanical power losses (all lumped together).

3. (21 pts) The parameters of a 5:1 step-down transformer are shown below. **ECE 3600 Exam 2 Fall 15 p3**
The transformer is loaded with $\mathbf{Z}_L := (2.5 + 0.8\cdot j)\cdot\Omega$ and the secondary voltage is $V_2 := 42\cdot V$

$R_m := 1\cdot k\Omega$ $R_s := 2\cdot\Omega$ $X_m := 800\cdot\Omega$ $X_s := 6\cdot\Omega$

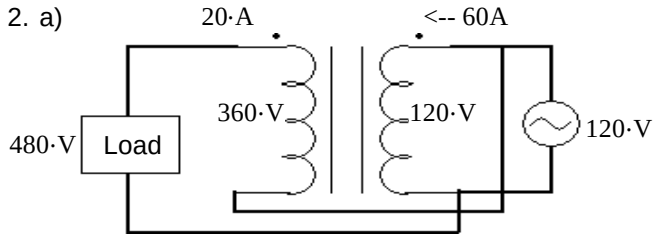
a) Find the primary, source voltage. Magnitude only. $|\mathbf{V}_S|$ = ? As part of your answer, make a useful drawing or schematic.

b) If this load were considered "full load", find the voltage regulation as defined in your notes. %VR = ?

c) Find the efficiency of the transformer.

Answers **Closed-book part**

1. a) <-- 6A 2·A 8·A 8A -->
320·V 320·V 80·V + 240·V
+ 6A --> <-- 8A
1.92·kVA
b) same connection 1.44·kW

2. a)


b) right to left

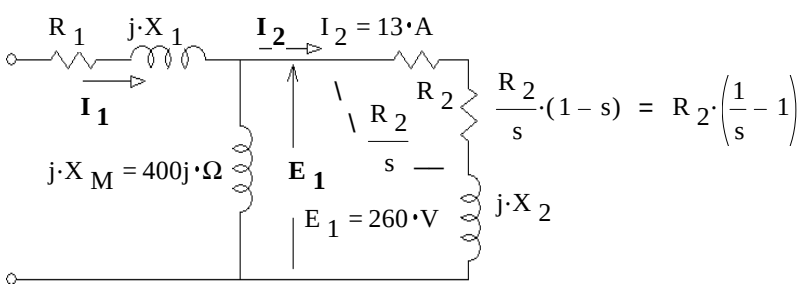
3. $\frac{3600\cdot rpm}{any\_integer}$ 3600·rpm 1800·rpm 1200·rpm 900·rpm 720·rpm etc..

4. a) $S_{base} := 2400\cdot VA$ $V_{base} := 480\cdot V$ $I_{base} := 5\cdot A$ $Z_{base} := 96\cdot\Omega$
b) $S_{base} := 2400\cdot VA$ $V_{base} := 120\cdot V$ $I_{base} := 20\cdot A$ $Z_{base} := 24\cdot\Omega$

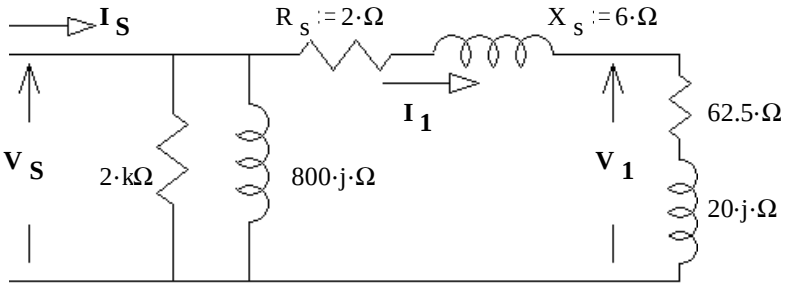
5. a) Increase the power or torque angle, δ b) Increase the mechanical input power (the steam input to the turbine)
c) Increase the induced EMF, E_A d) Increase the DC field current, I_F

6. 2 of these: Locked rotor test No-load test DC test

Open-book part 1. a) 32.0·Ω b) 23.7·kVAR c) 151·kW d) 20.6·deg e) - 3.69·kVAR
f) The operator changes the field current to: 21.8·A h) decreased g) NO

2. a)


b) 0.04
c) 0.769·Ω
d) 5.49·Ω
e) 13.2·A
f) 9.75·kW
g) 9.36·kW
h) 312·W

3.


a) 222.5·V
b) 5.98·%
c) 90.1·%