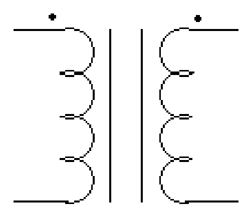
ECE 3600 Exam 2 given: Fall 16

(The space between problems has been removed.)

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

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

1. When we visited Terminal substation, we saw three different yards at three different line voltages. Power was also distributed locally at yet another line voltage. List as many of these voltages as you can remember.
2. Large power transformers are filled with ________________ for two main reasons. Give both reasons.
   fill in blank
3. The breakers used in substations come in two main types, list them and indicate which type was newer technology.
4. What devices control these breakers and where are they located?
5. These control devices utilize voltage and current information. What devices in the substation provide that information?
6. You saw several capacitor banks at Terminal substation. We've talked in class about adding capacitors to correct power factor, but people in the power industry usually talk about the effects of adding capacitors differently. What do they say they add capacitors for?
7. The generators at Gadsby (like most generators) are filled with what gas? For what reason?
8. a) You have a 400/100-V, 800-VA transformer. Can you use this transformer to transform 500 V to 400 V? If yes, show the connections and compute the new VA rating.



   b) Show the 500-V source and the load.
   c) Could this transformer also be used to transform 480 V to 384 V ? If yes, what is the maximum real power that could be transformed at these voltages?

Problems

1. (35 pts) A 3-phase, synchronous generator is not electrically connected to anything. The prime mover is spinning the generator at 3600 rpm. The input torque is 20 Nm.
   The generator E_A perfectly matched to the grid voltage and is then Y-connected to a 4.8 kV, 60 Hz, bus.

   a) The prime mover torque in increased to $\tau_{in} := 600 \cdot N \cdot m$ Find the generated electrical power P = ?

   The prime mover torque is held at this value for the rest of the problem.

   b) The line current is measured at: $I_L := 28 \cdot A$ Find the total reactive power generated.
   I suggest you draw a phasor diagram with $|E_A| = |V_\phi|$, such as in SG1, problem 2.

   c) Find the power angle. δ = ? Hint: Remember the special conditions when $|E_A| = |V_\phi|$.

   d) Find the synchronous reactance. X_s = ?

   If you can't find X_S, or doubt your value, mark here ____ and use $X_S = 70\ \Omega$ for the rest of the problem.

   e) The generator operator is told to produce 60 kVAR , no change in power. Find the new E_A

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

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

2. (41 pts) A 3-phase, Δ-connected, induction motor is rated at 50-hp, 1134-rpm, 480-V, 60-Hz. At rated conditions, it has an overall efficiency of 92.265%, a power factor of 0.80, and total rotational losses (mechanical) of 415W.

   Also know are: $X_1 := 0.4\cdot\Omega$ $R_C := \infty$ $R_2 := 0.9\cdot\Omega$ $1\cdot hp = 745.7\cdot W$

   a) Make a drawing the circuit model of one phase. Label **all** the parts and add known values as you work the problem.

   All values below are for rated conditions. Find the following:

   b) The slip. Make a reasonable assumption as necessary.

   c) The power converted from electrical to mechanical form.

   d) Find the magnitude of I_2 Note, you may want to find the next two parts first.

   e) The power transformed from the stator to the rotor (the air-gap power).

   f) The rotor copper loss.

   g) The stator copper loss. Hint: The input power is the sum of two or three different powers.

   h) The magnitude of the line current. (Remember, it's Δ-connected)

   i) Find R_1

   j) The total $Q_{X2} := 2.926\cdot kVA$ Find: X_2

   k) Find: X_m Note: This will require the calculation of several numbers you probably don't have yet.
   Hint: The input Q is the sum of several different Qs.

Answers **Questions**

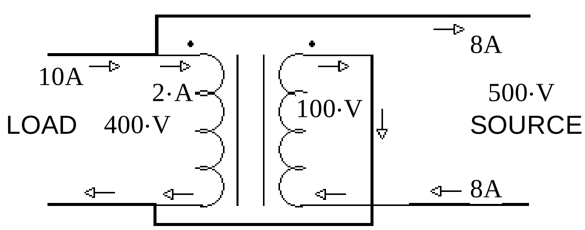
1. $12.47\cdot kV$ $46\cdot kV$ $138\cdot kV$ $345\cdot kV$ 2. Oil Electrical insulation Thermal cooling

3. Oil filled (old) Gas (SF_6) filled (newer) 4. Relays in the control buildings

5. Current transformers (CTs) Voltage or Potential Transformers (VTs or PTs) 6. To increase the voltage

8. a) $4\cdot kVA$ c) Same connections as a) $3.84\cdot kVA$

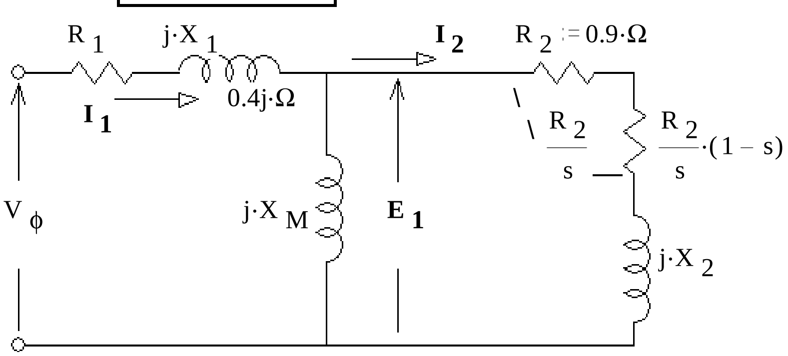
   b)



Problems

1. a) $218.7\cdot kW$ b) $-79.9\cdot kVAR$ c) $40.1\cdot deg$ d) $67.9\cdot\Omega$ e) $3.72\cdot kV$ g) decreased h) NO

2. a)



b) $5.5\cdot\%$ c) $37.7\cdot kW$

d) $28.5\cdot A$ e) $39.9\cdot kW$

f) $2.19\cdot kW$ g) $517\cdot W$

h) $60.8\cdot A$ i) $0.14\cdot\Omega$

j) $1.2\cdot\Omega$ k) $25.3\cdot\Omega$