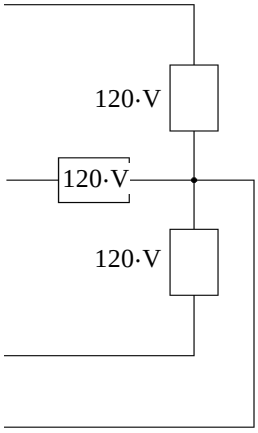
ECE 3600 Exam 2 given: Fall 17

(The space between problems has been removed.)

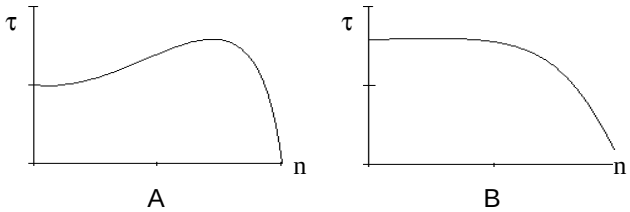
Write Legibly! This part of the exam is Closed book, Closed notes, No Calculator.

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. a) A 3-phase step-up transformer is usually wired in what way? Y - Y Y - Δ Δ - Y Δ - Δ
   circle one
   b) A 3-phase step-down transformer is usually wired in what way? Y - Y Y - Δ Δ - Y Δ - Δ
   circle one
   c) Is it desirable for at least one side of a 3-phase transformer to be wired in a certain way? yes no circle one
   If yes, which way and why?
6. To Bring a Synchronous Generator "On Line" you must do several things. Name at least 3. Be as specific as you can.
   1.
   2.
   3.
   4.
   5.
7. Name at least two tests or procedures performed on induction motors in order to determine the model parameters.
8. a) How many single-phase transformers are required to transform 3-phase power. Give the minimum number.
   b) Show how these single-phase transformers might be connected between the source (shown at left below) and a load (shown at right). Do not create an unbalanced load for the source.

   480V, 3-phase
   A _____
   B _____
   C _____
   N _____



   c) What is the required turns ratio of the transformers you showed above.
9. a) The torque-speed curves of 2 induction motors (A and B) are shown at right. Only one equivalent circuit parameter is different between the two. What is it?
   b) This parameter is bigger in which motor?
   c) The starting current is bigger in which motor?



Problems 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.

1. (23 pts) A $60\ Hz$, 6-pole, 3-phase, Y-connected, synchronous generator supplies $120\ kW$ of power to a $4.2\ kV$ bus. The synchronous reactance is $40\ \Omega$/phase. The generator emf is $3.4\ kV$. Find the following.
   a) The power angle, δ.
   b) The total reactive power generated.
   c) Find a new magnitude of the generator emf so that $Q := 48 \cdot kVAR$

ECE 3600 Exam 2 Fall 17 p2

2. (27 pts) A 3-phase, 208-V, Δ-connected, induction motor has the following equivalent circuit components: $R_1 := 0.3\cdot\Omega$ $R_2 := 0.6\cdot\Omega$ $R_C := \infty$ $X_1 := 0.4\cdot\Omega$ $X_2 := 1\cdot\Omega$ $X_M := 18\cdot\Omega$

   currently running at $n_m := 1140\cdot rpm$ mechanical, rotational losses: $P_{mech} := 500\cdot W$

   a) Draw the circuit model of one phase, and label the known parts and values.

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

   c) The line current (magnitude) Note: a number that may be helpful: $\dfrac{1}{\frac{1}{j\cdot X_M}+\frac{1}{\frac{R_2}{s}+j\cdot X_2}} = 7.699 + 5.81j\ \Omega = 9.645\ \Omega\ \angle 37.04^\circ$

   d) The stator copper losses

   e) The air-gap P_{AG}

   f) The power converted from electrical to mechanical form

   g) The rotor copper losses

   h) The overall machine efficiency

3. (22 pts) A 1/2-hp, 120-V, 60-Hz, single-phase, capacitor-run, induction motor has two different windings set 90° apart in the motor housing. At startup, the run winding uses 500W and 5.5A and the start winding (with an 80μF series capacitor) uses 250W and 4.8A.

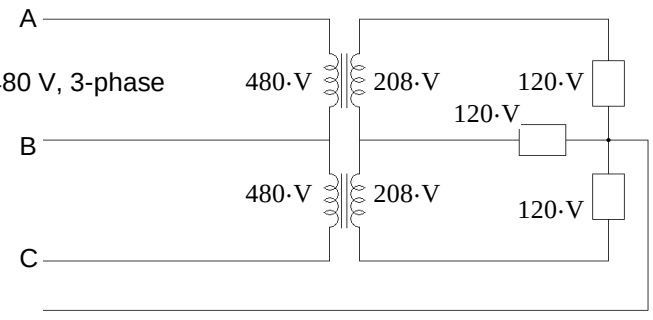
   a) Assume that the Q for the start winding with the capacitor is negative. Find the phase angle difference between the two currents.

   b) Find the impedance (R and X) of the start winding **without** the series capacitor. $C := 80\cdot\mu F$ excluded

Answers **Questions**

1. 12.47·kV 46·kV 138·kV 345·kV
2. Oil Oil is a better insulator than air Oil is used to keep the transformers cool
3. Oil filled (old) Gas (SF_6) filled (newer) 4. Relays in the control buildings
5. a) Δ - Y b) Y - Δ c) yes Δ, to reduce third-harmonic currents.
6. 1. Bring speed to the correct rpm so that the generator frequency matches the line frequency.
   2. Adjust the field current, I_f so that the generator voltage matches the line voltage.
   3. Readjust speed if necessary, check that the phases are in the correct sequence if necessary.
   4. Wait until the phases align (0 volts difference between generator terminal and the line phase). Connect to the line at just the right moment.
   5. Increase input torque to produce real electrical power and and field current to produce reactive power.

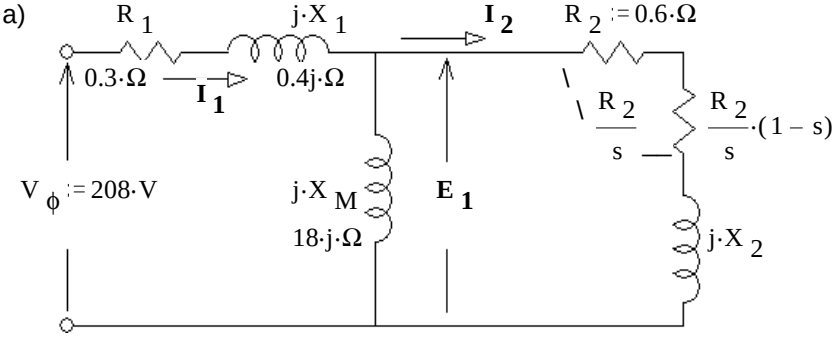
   at least 3 of these
7. Locked rotor test
   No-load test
   DC test
8. a) 2 b)



   c) $\frac{480\cdot V}{208\cdot V}$
9. a) R_2 or rotor resistance
   b) B c) A

Problems

1. a) 11.2·deg b) 165.6·kVAR c) 2769·V
2. a)



   b) 5·% c) 35.6·A
   d) 380·W e) 9.75·kW
   f) 9.26·kW g) 487·W
   h) P_{out} = 8.76·kW 86.5·%
3. a) 105·deg
   b) (10.85 + 10.63·j)·Ω