ECE 3600 Exam 2 given: Fall 12

(The space between problems has been removed.)

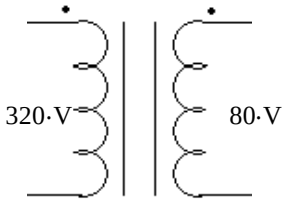
Write Legibly! This part of the exam is Closed book, Closed notes, No Calculator.

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

1. The voltage regulation of a transformer is often specified as %VR. Of the four values given below, circle the best %VR that could be a specification for a transformer.

   a) 120% b) 98% c) 50% d) 2%

2. 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.



3. When accounting for the non-ideal characteristics of a power transformer, which of the following is the most important (least often neglected)?

   magnetization reactance core losses winding losses leakage reactance

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

   b) When analyzing a power system, which, if any, of these bases should be constant throughout the system?

   c) For those bases that change from place to place throughout the system, which is the primary one that changes and what type of part causes the changes?

   d) Show how to find the remaining bases from those listed in parts b) and c).

5. The power angle of a synchronous generator is limited to what range of values?

6. a) List up to 3 different synchronous motor speeds in the US, in rpm.

   b) How are typical induction motor rated speeds related to the synchronous motor speeds?

   c) When the power is first turned on to an induction motor, what is the slip? s = ?

   d) When an induction motor is operated at its rated output, what is a typical slip? s = ?

7. An induction motor is operated with a variable-frequency drive.

   a.1) How is the motor operated at slower-than-normal speeds?

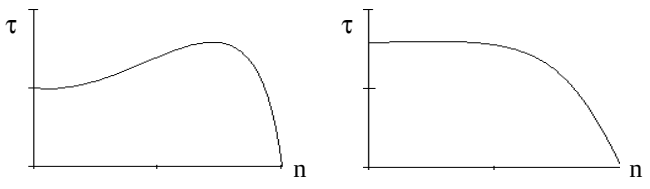
   a.2) Is there something else which must also be reduced? If yes, what and why?

   b) How is the motor operated at higher-than-normal speeds?

8. a) The torque-speed curves of 2 induction motors 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?



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

1. (25 pts) The parameters of a 3:1 step-down transformer are shown below. The primary voltage is $V_S := 110 \cdot V$

   The transformer is loaded with $\mathbf{Z_L} = R_L + jX_L$ and the secondary current is $I_2 := 2.4 \cdot A$

   $R_m := 1.5 \cdot k\Omega$ $R_s := 5 \cdot \Omega$ $X_m := 500 \cdot \Omega$ $X_s := 10 \cdot \Omega$

   a) The primary, source voltage provides 50 VARs $Q_S := 50 \cdot VAR$ Find X_L

   If you can't find X_L, mark here ___ , use $X_L = 4\Omega$ and move on.

   b) Find R_L

   If you can't find R_L, mark here ___ , use $R_L = 15\Omega$ and move on.

   c) Find the efficiency of this transformer.

2. (30 pts) A 3-phase induction motor is Y-connected to a 480-V bus. It draws 12kW of real power and has a power factor of 0.9 . Some more knowns:

   $X_M := 100 \cdot \Omega$ $R_C := \infty$ Input power: $P_{in} := 12 \cdot kW$ at $pf := 0.9$

   $\mathbf{E_1} := (250 - j \cdot 25.5) \cdot V$ $n := 1720 \cdot rpm$ Rotor copper loss: $P_{RCL} := 505 \cdot W$

   The output shaft torque: $\tau_{load} := 58 \cdot N \cdot m$ Stator copper loss: $P_{SCL} := 640 \cdot W$

   DON'T FORGET: Your powers are for the whole motor and your model is only for ONE phase.

   a) Draw the model for this motor. This will be your working drawing, so you may want to add information from above. Leave room on your drawing for current, voltage, and component values to be added later.

   b) Find the line current. $\mathbf{I_L}$ = ?

   c) Find R_1

   d) Find $|\mathbf{I_2}|$

   e) Find P_{AG}

   f) Find s

   g) Find R_2

   h) Find the shaft output power

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

   j) Find the overall machine efficiency η

3. (20 pts) A 60 Hz, 6-pole, 3-phase synchronous generator supplies 120 kW of power to a 4.2 kV bus. The synchronous reactance is 40 Ω/phase. The generator emf is 3.6 kV. Find the following.

a) The power angle, δ.

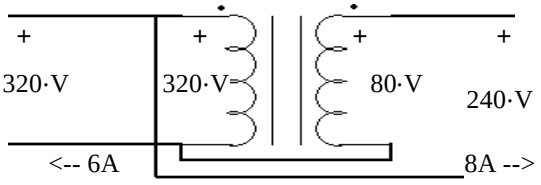
b) The total reactive power generated.

c) Find a new magnitude of the generator emf so that $Q := 45 \cdot kVAR$

Answers

Closed-book part 1. d)

2. 6A --> 2·A 8·A <-- 8A 1920·VA



3. leakage reactance

4. a) S_{base} V_{base} I_{base} Z_{base}

b) S_{base} c) V_{base} Transformers

d) $I_{base} = \frac{S_{base}}{V_{base}}$ $Z_{base} = \frac{V_{base}}{I_{base}}$

5. $0^o < \delta < 90^o$ 6. a) $\frac{3600 \cdot rpm}{any\_integer}$ 3600·rpm 1800·rpm 1200·rpm 900·rpm 720·rpm etc..

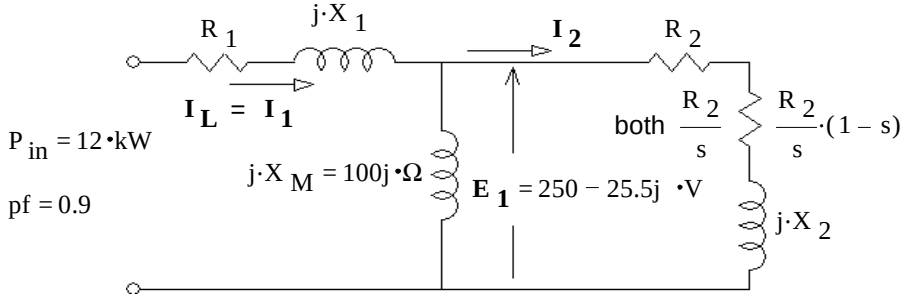
b) A little less (about 5% less) c) 1 d) $0.05 = 5 \cdot \%$

7. a.1) The frequency is less than 60Hz. a.2) The voltage must be reduced to prevent saturation of the core.

b) The frequency is greater than 60Hz. 8. a) R_2 or rotor resistance b) right-most c) left-most

Open-book part 1. a) $3.37 \cdot \Omega$ b) $14.1 \cdot \Omega$ c) $87.8 \cdot \%$

2. a) $P_{SCL} = 640 \cdot W$ $P_{RCL} = 505 \cdot W$



b) 16.04 A /-25.84° c) 0.829·Ω

d) 15.36 A /-17.0° e) 11.36·kW

f) 4.44·% g) 0.713·Ω

h) 10.45·kW i) 408·W

j) 87.1·%

3. a) 10.56° b) 202.6·kVAR c) 2.75·kV