McGill

Department of Electrical and Computer Engineering

ECSE 461 – Electric Machinery

Winter 2009

Sample Final Examination

INSTRUCTIONS:

- Attempt 6 out of the 7 questions.
- All 6 questions answered carry equal weight.
- This is an OPEN BOOK examination.
- CRIB SHEETS, NOTES AND ASSIGNMENTS are permitted.
- STANDARD CALCULATOR permitted ONLY.
- This examination consists of 7 questions, of a total of 3 pages, including the cover page.
- This examination is PRINTED ON BOTH SIDES of the paper
- This examination paper MUST BE RETURNED

1. A single phase load is rated 120 V, 60 Hz, 1.2 kW, 0.82 power factor (lagging). It is connected to a 120 V, 60 Hz, ac source. Assume a series connected R-L circuit.
   (a) Compute the load current, and the power and reactive power drawn by the load. Draw the V-I and power diagrams.
   (b) A long cable, of a total resistance 1.5 Ω and inductance of 8 mH (in series), connects the load to the source. Find the load current, power, reactive power and power factor. Draw the V-I vector diagram.

2. Three single phase, 208 V, 60 Hz, 2 kW, 0.75 (lagging) power factor loads are supplied from a three-phase 208 V, 60 Hz, 3 wire system.
   a) Draw the three phase load connection diagram. Draw the phasor diagram, showing the current and voltage for each load, the line current and the voltage. Compute the load and line currents. Give the total power absorbed and reactive power. Give the power factor.
   d) The three loads are connected in a Y configuration. Find the power consumed by each load. Compute the line current, total power and reactive power.

3. A 4600/600 V, 30 kVA single phase transformer equivalent circuit parameters in ohms are 0.10 resistive and 0.80 inductive, referred to the low voltage side. The magnetizing current is assumed negligible. The transformer turns ratio is assumed to be the ratio of primary (high voltage) to secondary voltages.
   (a) Draw the equivalent circuit referred to the low voltage side, including all impedances and rated voltages and currents. Compute the parameters of the equivalent circuit referred to the high voltage side, and draw the equivalent circuit.
   (b) Find the current and voltage (amplitude and phase) on the primary side for a rated voltage on the secondary side and a 30 kVA, 0.70 pf (lagging) load. Compute the voltage regulation.

4. A short circuit test on a single phase 575/120 V, 2.5 kVA, 60 Hz transformer yields the following measurements with 36 V applied to the high side: 50 W, 4.3 A. The open circuit test for 120 V applied to the low voltage side gives: 40 W, 0.7 A.
   a) Draw the approximate equivalent circuit referred to the low side, indicating the impedance values. Compute the short circuit current on the low voltage side, with 575 V applied to the high side.
   b) For a 2.5 kVA inductive load, 0.7 power factor (lagging) connected to the low voltage winding, compute the input voltage on the high side, assuming the load voltage is 120 V. Compute the voltage regulation. Find the efficiency.

5. An 8 pole, 550 V, 45 hp, 60 Hz three-phase squirrel cage induction motor has the following parameters, in Ω/phase:

   $R_1 = 0.15$ $X_1 = 1.00$ $X_m = 35$

   $R_2 = 0.20$ $X_2 = 0.90$

   Mechanical and core losses amount to 1800 W for rated operating conditions. The motor is connected directly to the 600 V, 60 Hz mains.
   a) Compute the starting torque, current and power factor. Give the % starting current compared to rated current.
   b) Find the motor slip, electromagnetic torque, shaft torque, efficiency and power factor for a speed of 870 rpm. Draw the approximate torque/speed curve, indicating starting, running and rated torques.

6. A 4 pole, three-phase, 120 kVA, 440 V, Y-connected synchronous generator has a synchronous reactance of 1.5 Ω per phase. All losses are neglected.
   a) The generator is driven by diesel engine and is connected to the 440 V, 60 Hz ac mains. It supplies 100 kW and the load angle is 35^o. Compute the armature current, internal voltage per phase and power factor. Find the reactive power. Draw the vector diagram, relating voltages and current, indicating all angles. Draw the power/load angle curve and compute the maximum power.
   b) The generator excitation current is kept constant. The shaft power is reduced to 0. Find the total reactive power supplied by the machine. Compute the armature current and load angle. Draw the corresponding vector diagram.

7. A 15 hp, 440 V, 1160 rpm separately excited dc motor has an armature resistance of 0.80 Ω and field losses are equal to 620 W. The field current is kept constant. The rotational losses are equal to 1750 W.
   a) For armature voltage of 440 V and armature current of 31 A, the speed is 1160 rpm. Find the internal voltage, electromagnetic power, shaft power, shaft torque and efficiency.
   b) The armature voltage is decreased to 200 V, and the current remains at 31 A. Find the motor speed and electromagnetic torque. Draw the approximate torque-speed characteristics for 440 and 200 V.