McGill

April 2009
Final Examination

ELECTRIC MACHINERY

ECSE 461 - 001

APRIL 24, 2009 – 9:00 AM

Examiner: Joos, Geza

Assoc Examiner: Galiana, Francisco

Student Name:		McGill ID:									

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**

McGill

Department of Electrical and Computer Engineering

ECSE 461 – Electric Machinery

Winter 2009

Final Examination

1. A single phase load is rated 5 kW, 0.75 power factor (lag), at 320 V, 60 Hz. Assume the load is a constant impedance load.
   (a) The voltage is reduced to 280 V. Compute the power and reactive power drawn by the load. Draw the V-I diagram for this case and the rated voltage case.
   (b) A power factor correction capacitor is connected in parallel with the load to increase the power factor to 0.95 for rated 320 V. Compute the reactive power and reactance in Ω of the capacitor. Give the line current. Draw the V-I diagram for this case and the uncompensated case. Indicate the real power consumed in both cases.

2. A three phase load is rated 15 kW, at a power of 0.75 (lag) when supplied from a 550 V, 60 Hz three phase feeder. The three single phase loads are connected in Δ. They are assumed to be constant impedance loads.
   (a) Compute the line current. Indicate the real and reactive power drawn by each phase. Draw the phasor diagram for the current and voltage in each phase.
   (b) The single phase loads are reconnected in Y. Compute the line current, and the real and reactive power drawn by the three-phase load. Indicate the change required in the load impedance to obtain the same power as for the Δ connection.

3. A 15 kVA, 8.7 kV / 320 V, 60 Hz single-phase distribution transformer has the following parameters, in Ω referred to the respective windings: primary side: R_p = 40.3, X_p = 139, R_c = 378 k, X_m = 102 k; secondary side: R_s = 0.055, X_s = 0.188.
   (a) Draw the equivalent circuit referred to the secondary side and indicate all values in Ω. Find the short circuit current on the secondary side, with rated voltage applied to the primary winding.
   (b) The transformer feeds an 11 kW inductive load, 0.75 power factor (lead). Assuming the load voltage is 320 V, find the input current and power factor. Compute the voltage at the primary side and the voltage regulation. Ignore the excitation branch.

4. A 14 pole, three-phase, 550 V, 50 kVA Y-connected synchronous generator has a synchronous impedance of 5.8 Ω per phase. All losses are neglected.
   a) The generator is driven by a water turbine and supplies a 550 V, 60 Hz, 40 kW, 0.8 power factor inductive load. Give the turbine speed and shaft torque. Compute the armature current, internal voltage and load angle. Draw the corresponding vector diagram. Draw the power/load angle curve and indicate the maximum power.
   b) The generator is synchronized to the ac mains and supplies 40 kW and 30 kVAr of reactive power. Compute the armature current, excitation voltage and load angle. Draw the corresponding vector diagram.

5. A 45 hp separately excited dc motor has the following parameters: armature resistance: 0.15 Ω, induced voltage at 1800 rpm and rated field current: 220 V, mechanical losses: 750 W at 1800 rpm, core losses at 1800 rpm: 500 W. The field current is assumed constant. The machine is not saturated.
   a) For a 230 V armature voltage, the armature current is 100 A. Find the motor speed, the electromagnetic power and torque, and the shaft power and torque. Draw the approximate speed/armature voltage curve, for an 100 A armature current, the voltage varying from 0 to 230 V, indicating the speed at 0, 120 and 230 V.
   b) The machine is driven at 1750 rpm and supplies 100 A to a resistive load. Compute the value of the load resistance and the power dissipated in this resistance. Find the shaft power and torque.

6. Tests on a 3 phase, 15 hp, 8 pole, 440 V, 60 Hz induction motor gave the following parameters, in Ω/phase at 60 Hz, seen from the stator:

   $R_1 = 0.52$ $X_1 = 1.15$ $X_m = 40.0$

   $R_2 = 0.63$ $X_2 = 1.15$

   Rotational and stray losses are equal to 340 W.
   a) The motor is fed at 440 V, 60 Hz. For a slip of 4 %, find the speed, electromagnetic torque, shaft torque and power. Find the input current and power factor. Find the input power and the motor efficiency.
   b) For a motor voltage of 300 V, 40 Hz, and a 4 % slip, find the speed, electromagnetic torque. Ignore the magnetizing branch. Draw the approximate torque-speed characteristics of the motor in the stable region, for a 60 Hz and a 40 Hz operation, using the values computed. Include synchronous speeds.

7. Tests on a 50 MVA, 8 kV / 78 kV, 60 Hz single-phase ideal transformer give the following results:

   With the high voltage side in open circuit, readings on the low voltage side give: 8 kV, 62.1 A, 206 kW

   With the high voltage side in short circuit, readings on the low voltage side give: 674 V, 6.25 kA, 187 kW

   (a) Calculate the equivalent series impedance, resistance and reactance as referred to the low voltage terminals. Draw the corresponding equivalent circuit.
   (b) Rated load at unit power factor is applied to the high voltage side, with the high side voltage assumed to be at rated value. Obtain the efficiency and voltage regulation. Draw the phasor diagram. Explain what happens to the regulation if the load power factor is decreased to 0.70, lag and lead.