University of Saskatchewan

Department of Electrical Engineering
EE 341.3 Electric Machines I (Term 2)
Final Examination (Total Duration: 3 hrs)

Dated: April 15, 2004 **Time: 9:00am – 12:00 pm**
Instructor: Dr. Ramakrishna (Rama) Gokaraju **Total Marks: 50**

Instructions:

1) This examination paper consists of 6 problems and 4 pages in total.
2) This is a closed-book examination. Two-page formula sheet is allowed. Solved examples are not allowed in the formula sheet.
3) Your solutions should be methodical. Write the steps of your numerical computations clearly. You will be severely penalized if your solutions are illegible.
4) Mark allotted for each problem is shown on the right margin.
5) You are advised not to spend more than 30 minutes on any given problem.

Problem 1

A 50 *kVA*, 13,800/208 *V*, *Δ-Y* distribution transformer has a resistance of 0.02 *pu* and a reactance of 0.08 *pu*.

a. What is the transformer's phase impedance referred to the high-voltage side?
b. Calculate this transformer's voltage regulation at full load and 0.9 *pf* leading, using the calculated high-side impedance.
c. Calculate this transformer's voltage regulation under the same conditions, using the per-unit system.

8 Marks

Problem 2

A 100 *kW*, 250 *V*, 400 *A*, long-shunt compound generator (Fig. 1) has an armature resistance (including brushes) of 0.025 Ω, a series-field resistance of 0.005 Ω, and the magnetization curve of Fig. 2. There are 1000 shunt-field turns per pole and three series-field turns per pole. The series field is connected in such a fashion that positive armature current produces direct-axis flux (mmf) which adds to that of the shunt field.

Compute the terminal voltage at rated terminal current when the shunt-field current is 4.7 *A* and the speed is 1150 *rpm*. **Neglect the effects of armature reaction.**

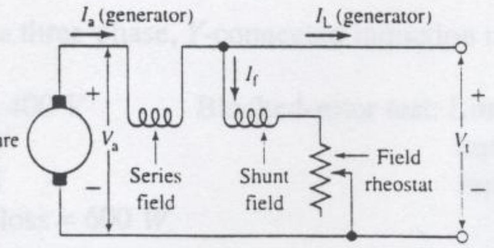

Fig. 1 Long-shunt compound generator connections.

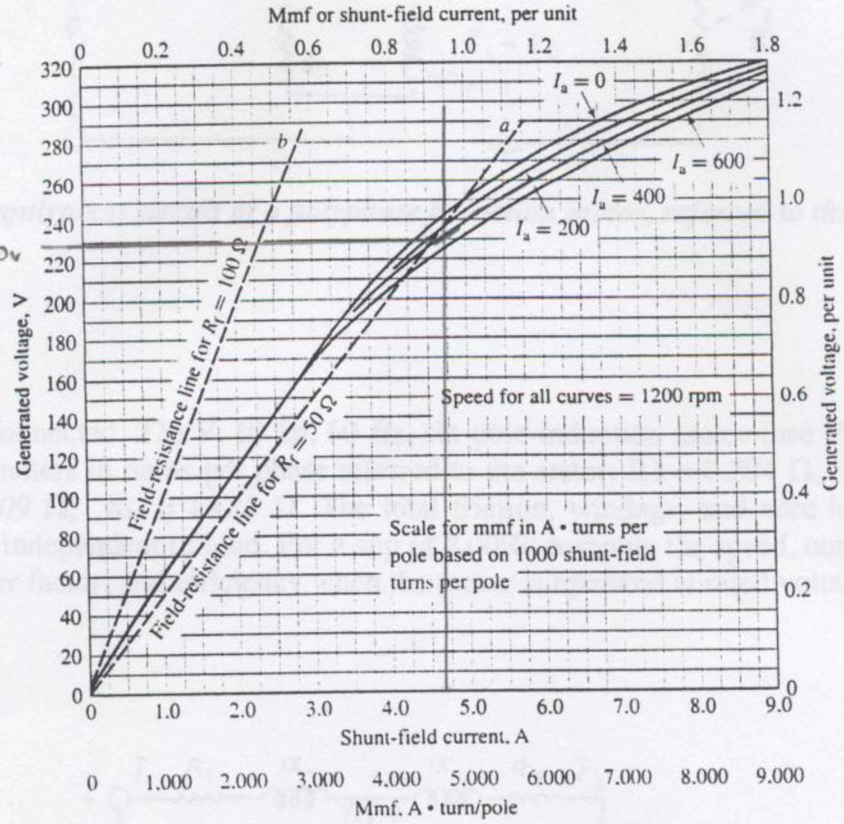

Fig. 2 Magnetization curves for a 250-V, 1200 rpm dc machine.

8 Marks

Problem 3

A dc series motor is connected to a load. The torque varies as the square of the speed. With the diverter-circuit (a rheostat connected across the series field winding) open, the motor takes 20 A and runs at 500 rpm. Determine the motor current and speed when the diverter-circuit resistance is made equal to the series-filed resistance. ***Neglect saturation and the voltage drop across the series-field resistance, as well as the armature resistance.***

8 Marks

Problem 4

No-load and blocked-rotor tests on a three-phase, *Y*-connected induction motor yield these results:

No-load test: Line-to-line voltage = 400 *V*
Input power = 1770 *W*
Input current = 18.5 *A*
Friction and windage loss = 600 *W*

Blocked-rotor test: Line-to-line voltage = 45 *V*
Input power = 2700 *W*
Input current = 63 *A*

Determine the parameters of the equivalent circuit of Fig. 3, assuming $R_1 = R'_2$ and $X_{l1} = X'_{l2}$.

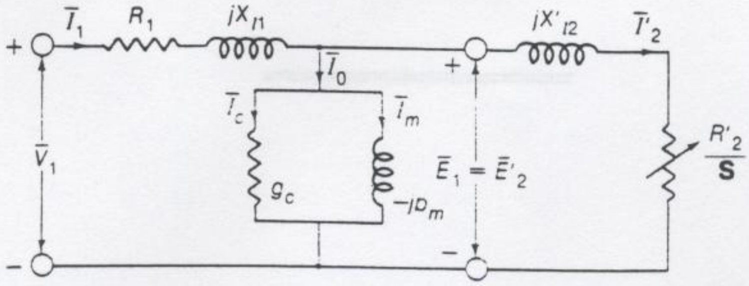

Fig. 3 Per-phase equivalent circuit of a polyphase induction motor, referred to the stator.

8 Marks

Problem 5

A three-phase, Y-connected, 220 *V*, 10 *hp*, 60 *Hz*, six-pole induction motor (use Fig. 4 for notation) has the following parameters in ohms per phase referred to the stator: R1 = 0.294 Ω; $R'_2 = 0.144$ Ω; $X_{l1} = 0.503$ Ω; $X'_{l2} = 0.209$ Ω; $X_M = 13.25$ Ω. The total friction, windage, and core losses can be assumed constant at 403 W, independent of load. For a slip of 2.00%, compute the speed, output torque and power, stator current, power factor, and efficiency when the motor is operated at rated voltage and frequency.

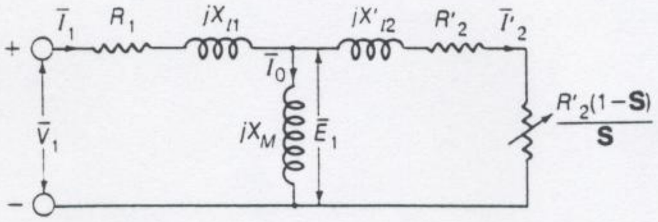

Fig. 4 Per-phase equivalent circuit of polyphase induction motor for use in problem 5

8 Marks

Problem 6

A 3-phase squirrel-cage induction motor has a starting torque of 1.75 *pu* and a maximum torque of 2.5 *pu* when operated at rated voltage and frequency. The full-load torque is considered as 1 *pu*. Neglect stator resistance.

(a) Determine the slip at maximum torque and the slip at full-load torque.
(b) Determine the rotor current at starting in *pu*. Consider the full-load rotor current as 1 *pu*.

10 Marks

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