

# 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,  $\Delta$ -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  $\Omega$ , a series-field resistance of 0.005  $\Omega$ , 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.

8 Marks

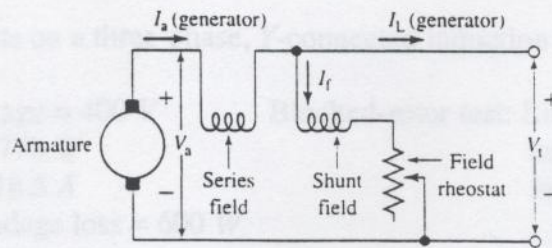


Fig. 1 Long-shunt compound generator connections.

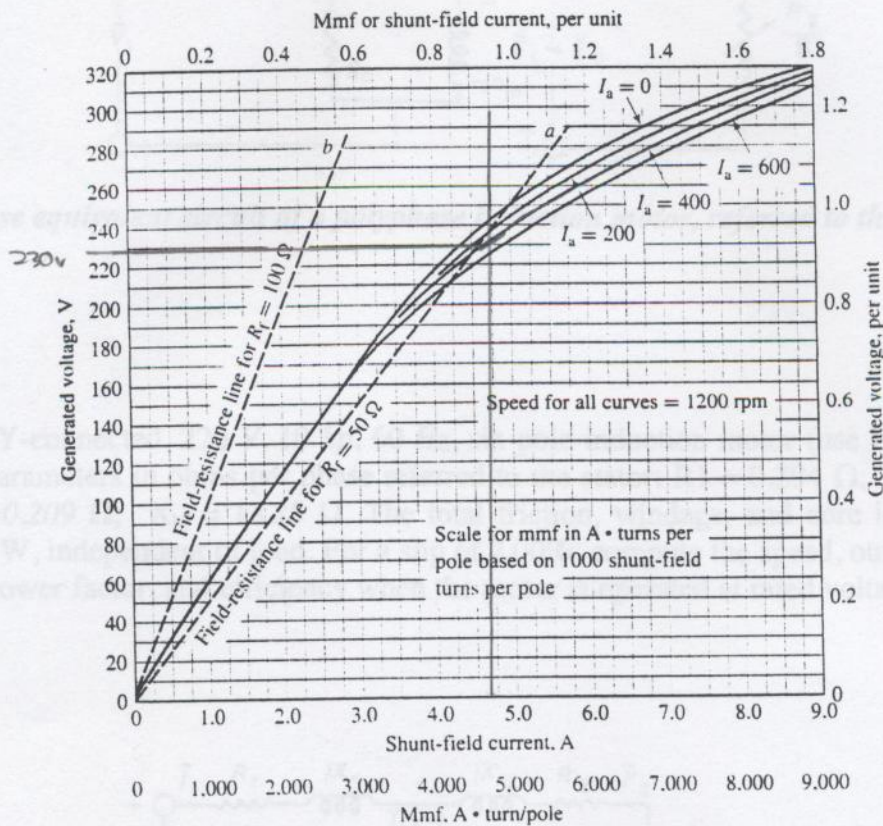


Fig. 2 Magnetization curves for a 250-V, 1200 rpm dc machine.

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-field 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  $X_{l1} = X'_{l2}$ .

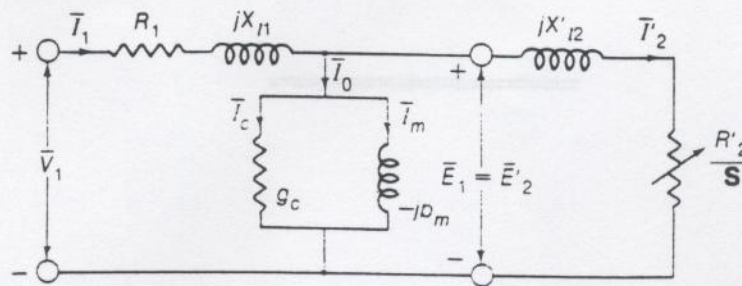


Fig. 3 Per-phase equivalent circuit of a polyphase induction motor, referred to the stator.

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:  $R_1 = 0.294 \Omega$ ;  $R'_2 = 0.144 \Omega$ ;  $X_{l1} = 0.503 \Omega$ ;  $X'_{l2} = 0.209 \Omega$ ;  $X_M = 13.25 \Omega$ . 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.

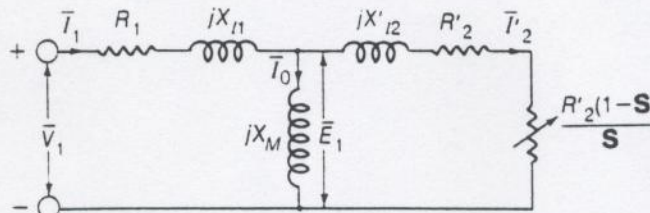


Fig. 4 Per-phase equivalent circuit of polyphase induction motor for use in problem . 5

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**

