

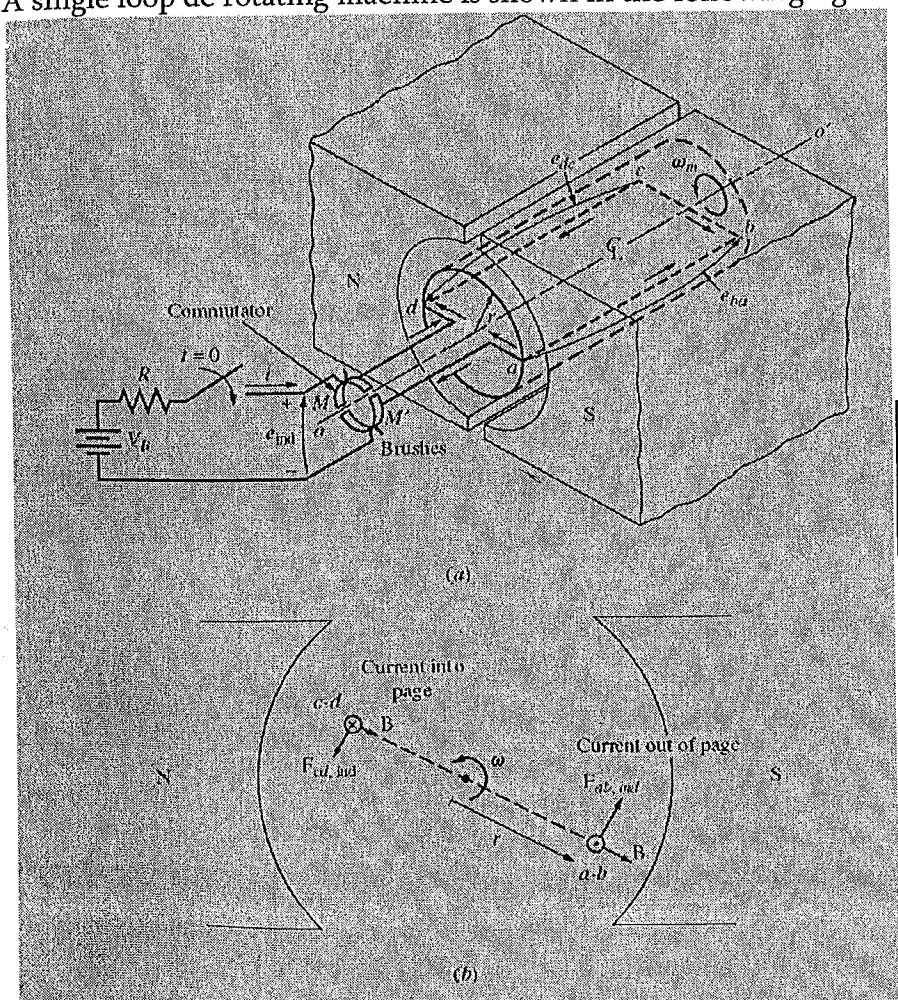
**Uva Wellassa University, Sri Lanka**  
**End Semester Examination – June/July 2009**  
**ENG 309-2 Electric Power and Machines**

Time: ~~One~~<sup>Two</sup> (02) hours

Total 04 Questions  
 Answer all questions  
 All questions carry equal marks

01)

A single loop dc rotating machine is shown in the following figure



$B =$  Magnetic flux density  
 $\omega =$  Angular Velocity of the loop

Figure 1

I. Prove that voltage induced in loop is  $e_{ind} = 2rlB\omega$

(5 marks)

- II. State three factors that affect induced voltage in a dc machine. (3 marks)
- III. Explain the mechanism that is used to get DC voltage out of a rotating loop. (2 marks)
- IV. The following information is given about the simple rotating loop shown in Figure 1

$$B = 0.8 \text{ T}$$

$$V_b = 24 \text{ V}$$

$$l = 0.5 \text{ m}$$

$$R = 0.4 \ \Omega$$

$$r = 0.125 \text{ m}$$

$$\omega = 250 \text{ rad/s}$$

- (a) Calculate induced voltage ( $e_{\text{ind}}$ ) in the above machine. Is this machine operating as a motor or a generator? Explain. (5 marks)
- (b) What is the current  $i$  flowing into or out of the machine? What is the power flowing into or out of the machine? (4 marks)
- (c) If the speed of the rotor were changed to 275 rad/s, what would happen to the current flow into or out of the machine? (3 marks)
- (d) If the speed of the rotor were changed to 225 rad/s, what would happen to the current flow into or out of the machine? (3 marks)

02)

- I. List major DC motor types? (5 marks)
- II. What is armature reaction and explain how it could affect torque speed characteristics of a DC motor. (5 marks)

III.

Following values are given for a shunt DC motor.

$$P_{\text{rated}} = 15 \text{ hp}$$

$$I_{L,\text{rated}} = 55 \text{ A}$$

$$V_T = 240 \text{ V}$$

$$N_F = 2700 \text{ turns per pole}$$

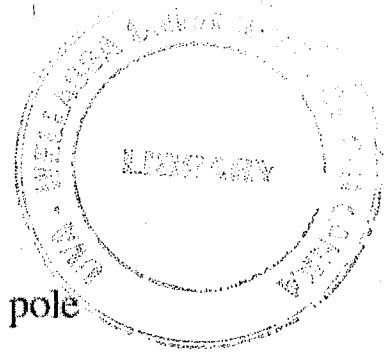
$$n_{\text{rated}} = 1200 \text{ r/min}$$

$$R_F = 100 \Omega$$

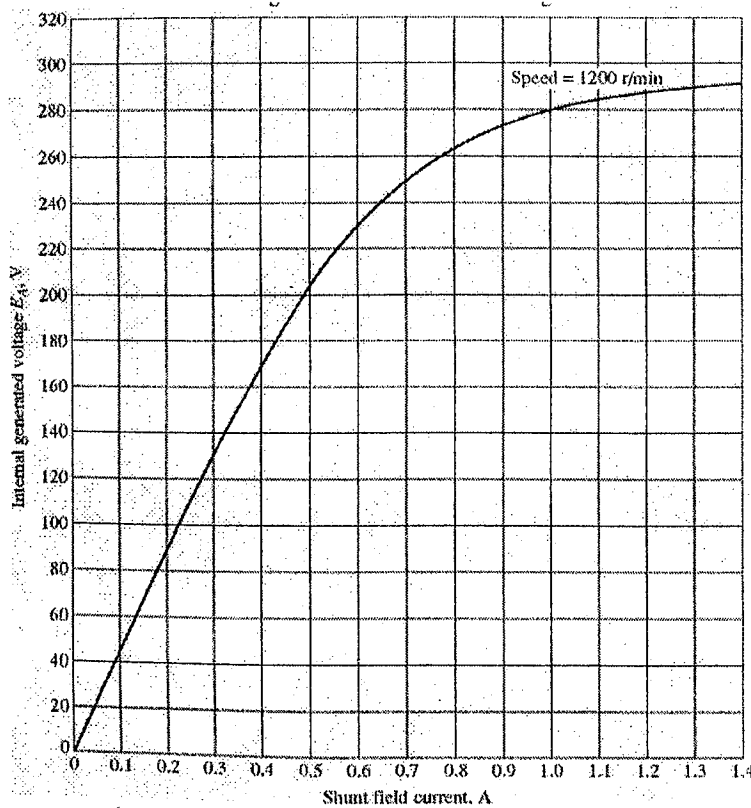
$$R_A = 0.40 \Omega$$

$$R_{\text{adj}} = 100 \text{ to } 400 \Omega$$

$$R_S = 0.04 \Omega$$



Magnetization curve of the motor is shown below



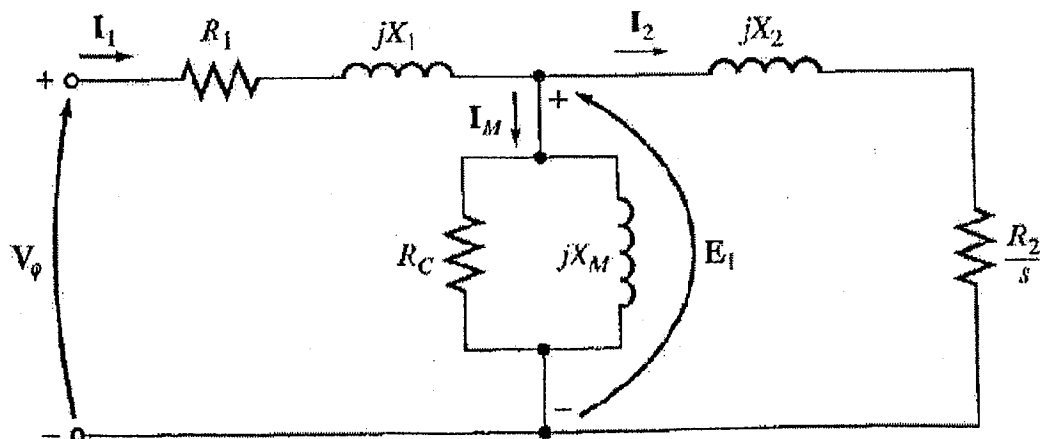
- a) Draw the equivalent circuit for a shunt DC Motor and name all the components in standard notation. (3 marks)
- b) If the resistor  $R_{\text{adj}}$  is adjusted to  $175 \Omega$ , what is the rotational speed of the motor at no-load conditions? (4 marks)

- c) Assume that the motor is operating at full load and that the variable resistor  $R_{adj}$  is  $175 \Omega$ . If the armature reaction is 1200 A turns at full load, what is the speed of the motor? (4 marks)
- d) If  $R_{adj}$  can be adjusted from 100 to  $400 \Omega$ , what are the maximum and minimum no-load speeds possible with this motor? (4 marks)

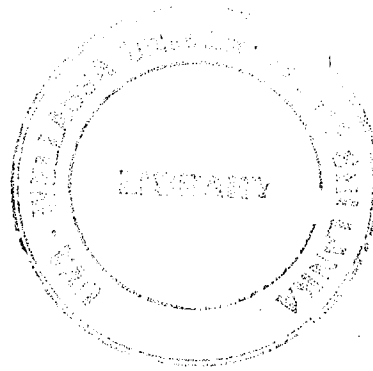
03)

- I. Draw the transformer model of an induction motor and in standard notation and name each component of the model. (5 marks)
- II. What are the main power losses that occur in an AC induction machine? Draw the power flow diagram and explain briefly. (5 marks)
- III. A 208-V, two-pole, 60-Hz Y-connected wound-rotor induction motor is rated at 15 hp. Its per phase equivalent Circuit components are

$$\begin{array}{lll}
 R_1 = 0.200 \Omega & R_2 = 0.120 \Omega & X_M = 15.0 \Omega \\
 X_1 = 0.410 \Omega & X_2 = 0.410 \Omega & \\
 P_{mech} = 250 \text{ W} & P_{misc} \approx 0 & P_{core} = 180 \text{ W}
 \end{array}$$



For a slip of 0.05, find



- (a) The line current  $I_L$  (3 marks)
- (b) The stator copper losses  $P_{SCL}$  (2 marks)
- (c) The air-gap power  $P_{AG}$  (2 marks)
- (d) The power converted from electrical to mechanical form  $P_{conv}$  (2 marks)
- (e) The induced torque  $\tau_{ind}$  (2 marks)
- (f) The load torque  $\tau_{load}$  (2 marks)
- (g) The overall machine efficiency (2 marks)

04)

- I. What are the main types of transformers? (5 marks)
- II. Draw the equivalent circuit model of a Transformer and explain how major power losses are modeled in the equivalent circuit. (5 marks)
- III. A 20-kVA 8000/480-V distribution transformer has the following resistances and reactances:

$$R_p = 32 \Omega$$

$$R_s = 0.05 \Omega$$

$$X_p = 45 \Omega$$

$$X_s = 0.06 \Omega$$

$$R_c = 250 \text{ k}\Omega$$

$$X_m = 30 \text{ k}\Omega$$

The excitation branch impedances are given referred to the high-voltage side of the transformer.

- a) Find the equivalent circuit of this transformer referred to the high-voltage side. (5 marks)
- b) Assume that this transformer is supplying rated load at 480 V and 0.8 PF lagging. What is this transformer's input voltage? (5 marks)
- c) Calculate core loss and copper loss of the above transformer. (5 marks)