Drives and Traction & Electromagnetic Compatibility

ASSIGNMENT 1

Section A

Answer ALL questions in this section.

A1. a) The armature of a 6-pole DC generator has 30 slots and in each slot there are 8 conductors. The flux per pole is 0.0174Wb. When the speed of the armature is 1200 rev/min. Calculate the value of the EMF generated if the armature is:

i) Wave wound, and (3 marks)

ii) Lap wound. (3 marks)

b) Motor is machine converse electrical energy to mechanical energy as shown in Figure A1b, describe basic construction of a DC motor. (2 marks)

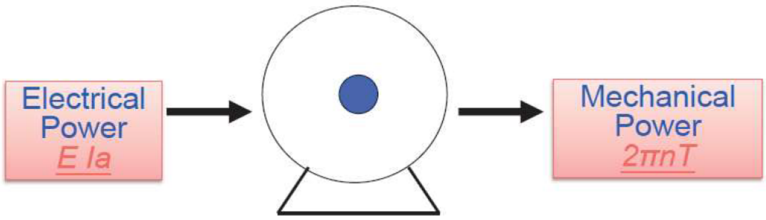

Figure A1b

A2. When an induction motor is connected to a 3-phase supply, current flows in the primary circuit. There are four kinds of power losses. With the aim of Fig. A2, describe the meanings of:

a) Stator copper loss, P_{cu1} ; (2 marks)

b) Iron loss, P_i; (2 marks)

c) Rotor copper loss, P_{cu2} ; (2 marks)

d) Mechanical loss; P_{loss}. (2 marks)

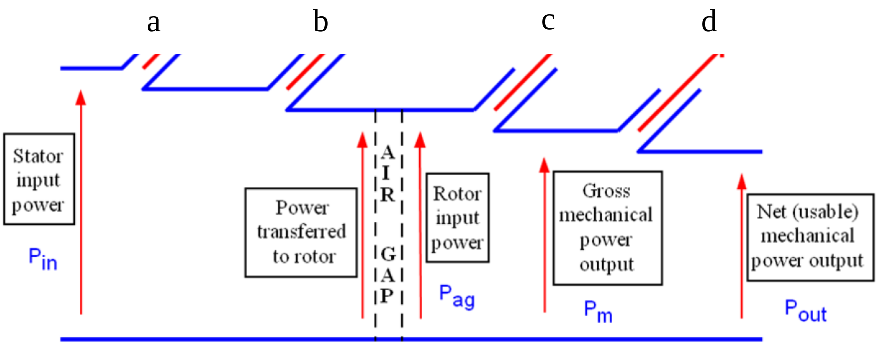

Fig.A2

A3. a) A 4-pole, 50 Hz, 3-phase induction motor is running at a slip of 3 % on the full-load condition, determine:

i) the synchronous speed; (2 marks)

ii) the motor speed; (2 marks)

b) Describe two approaches to reduce the Electromagnetic Interference (EMI) effect. (4 marks)

A4. a) Draw the connection circuit diagrams of the following self-excited d.c. motors.

i) The shunt motor; (2 marks)

ii) The compound motor. (2 marks)

b) Regarding traction motors to drive a train, describe two kind of resistive forces for a train needed to overcome. (4 marks)

A5. A 400V DC shunt motor shown in Figure A5, it runs at no load at 1500 rpm with input 1000W. The shunt field current is 1A and the armature resistance is 0.2Ω. Find:

(1 mark)

i) Line current at no load,

(1 mark)

ii) Armature current at no load,

iii) Armature copper loss at no load, (2 marks)

iv) Line current at which maximum efficiency occurs, and (2 marks)

v) The value of maximum efficiency (2 marks)

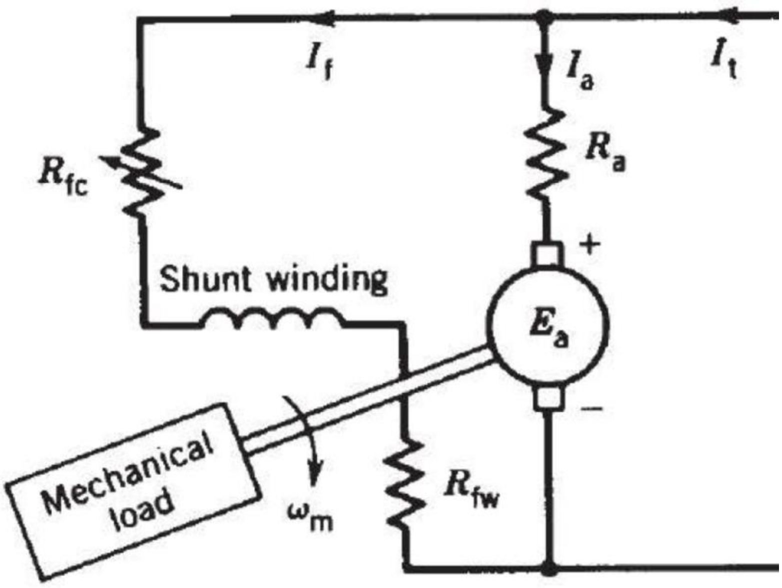

Figure A5

Section B

Choose ALL questions from this section. Each question carries equal marks.

B1. (a) Suggest method to maximize the starting torque of induction motor. (6 marks)
A typical torque versus slip of a cage type induction motor is shown in Fig. B1a.

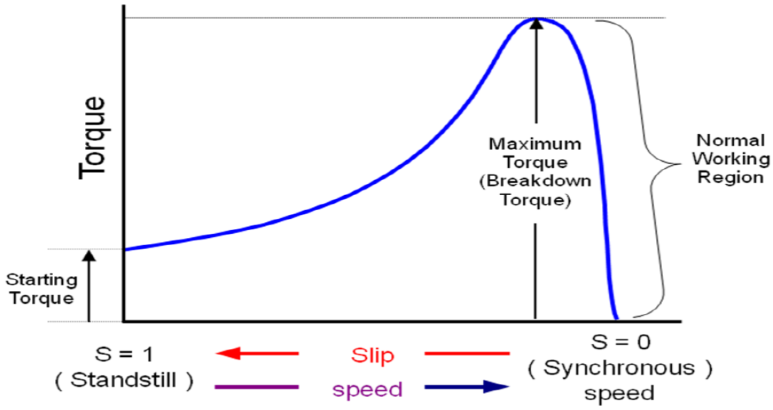

Fig.B1a

(b) Fig. B1b shows a direct on line motor start control circuit. The circuit has 3-phase power wire connected with a motor and a control circuit.

(i) How the contactor circuit start the motor; (5marks)

(ii) List the function of the circuit. (5marks)

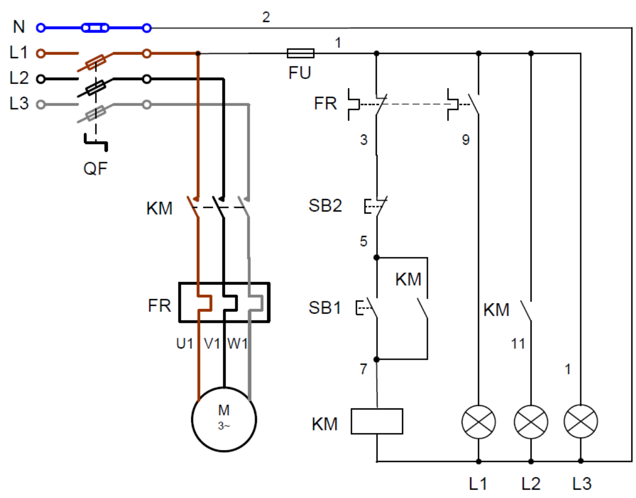

Fig. B1b

(c) Explain why Permanent Magnet Synchronous Motor (PMSM) save more energy compare to induction motor. (4 marks)

B2 (a) Describe the operation principle of below electronic component use in motor drive:

(i) Diode, (3marks)

(ii) IGBT. (3marks)

· (b) There are 5 parts in EN50121, which is Electromagnetic compatibility standard. Describe each part regarding EN50121.

i) Part 1 General introduction, (2marks)

ii) Part 2 Interface between the railway system and the outside world, (3marks)

iii) Part 3 The train and complete vehicle, train-borne apparatus, (3marks)

iv) Part 4 signaling and telecommunication (3marks)

v) Part 5 Power supply (3marks)

B3. (a) Explain the necessity for using a starter with a d.c. motor. (6 marks)

(b) During regenerative braking, motor become a generator. A d.c. shunt generator as shown in Fig. B4 has the following characteristics: (6 marks)

- 125 kW rated power
- 375 V rated voltage
- 1210 rpm rated speed
- power loss of the armature circuit at full load is 8 kW
- power loss of the field circuit at full load is 2 kW

At full load, calculate:

i. The output current, I_t; (2 marks)
ii. The field circuit current, I_f; (2 marks)
iii. The armature current, I_a; (2 marks)
iv. The resistance of armature circuit, R_a; (2 marks)
v. The resistance of field circuit, R_f; (3 marks)
vi. The driven torque. (3 marks)

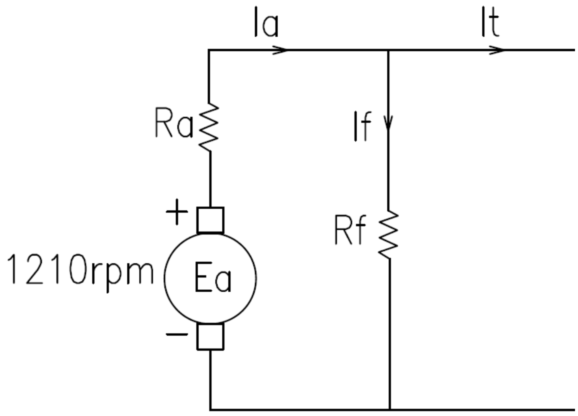

Fig. B3

- End of Questions -

Useful Formulae:

The symbols used in the following formulas correspond to their usual meanings.

DC Machines:

Parallel path (c)	Lap winding = 2p ; Wave winding = 2	Induced voltage	$E = \frac{Z}{c} \times (\frac{2pN\phi}{60})$ $E = K\phi N$
Motor armature voltage	$V = E + I_a R_a$	Generator armature voltage	$V = E - I_a R_a$
Motor torque	$P = EI_a = T\omega = T(\frac{2\pi N}{60})$ $T = K\phi I_a$	Power on no load test (P_{NO})	$P_{NO} = P_W + I_f^2 R_f + I_a^2 R_a$
Total loss	$P_L = P_o + I_f^2 R_f + I_a^2 R_a$ Where at no load test: $P_o = VI_o$	Starting resistance,	$R_S = \frac{V}{I_S} - R_a$
Shunt motor: Efficiency,	$\eta = \frac{P_{in} - P_L}{P_{in}} = \frac{V(I_a + I_f) - P_L}{V(I_a + I_f)}$	*Shunt generator: Efficiency*	$\frac{P_{out}}{P_{out} + P_L} = \frac{V(I_a - I_f)}{V(I_a - I_f) + P_L}$

Induction Motors:

Rotor Frequency	$f_R = s f$	Synchronous Speed N_S	$N_s = 60 f/p$
Rotor reactance per phase	$X_r = 2\pi f_r L = 2\pi s f L = sX_o$	Slip	$s = \frac{N_S - N_R}{N_S} \times (100\%)$
Starting current	$I_o = \frac{E_o}{Z_o} = \frac{E_o}{\sqrt{R^2 + X_o^2}}$	Rotor impedance per phase	$Z_R = \sqrt{R^2 + (sX_o)^2}$
Ratio of power	$P_{AG} : P_{CU2} : P_M = 1 : s : (1-s)$	Running current	$I_R = \frac{E_R}{Z_R} = \frac{sE_o}{\sqrt{R^2 + (sX_o)^2}}$
Torque- Slip	$T = \frac{3E_2}{2\pi n_S} \times \frac{sR_2}{R_2^2 + s^2 X_2^2}$	Max. Torque Slip Equation	$s_m = \frac{R_2}{X_2}$
Efficiency	$\eta = \frac{P_{out}}{P_{out} + P_L}$		

Synchronous Machine:

Voltage regulation	$E = \sqrt{\left[(V\cos\phi + IR)^2 + (V\sin\phi \pm IXs)^2\right]}$ $VR = \frac{E - V}{V} \times 100\%$	

*** End ***