Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2023/2024

COURSE NAME	:	ELECTRIC DRIVES
COURSE CODE	:	BEV 30703
PROGRAMME CODE	:	BEV
EXAMINATION DATE	:	JULY 2024
DURATION	:	3 HOURS
INSTRUCTIONS	:	1. ANSWER ALL QUESTIONS 2. THIS FINAL EXAMINATION IS CONDUCTED VIA ☐ Open book ☒ Closed book 3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK

THIS QUESTION PAPER CONSISTS OF **SIX (6)** PAGES

Q1 (a) In an electric drive system, several main components need to be considered for its operation. Please sketch a block diagram illustrating a complete electric drive system. Each block should be explained accurately.

(8 marks)

(b) One of the important components in an electric drives system is the power modulator. Identify three main classifications of power modulators. Explain and provide examples the principles of each category.

(6 marks)

(c) A motor drives two loads,

Load-1 has rotational motion and couple to the motor through a reduction gear with a gear ratio a = 0.1 and an efficiency of 90%. This load has a moment of inertia of 10 kg-m2 and torque of 10 Nm.

Load-2 has translational motion and consists of 1000 kg weight to be lifted up at a uniform speed of 1.5 m/s. The coupling between this load and the motor has an efficiency of 85%. The motor has an inertia of 0.2 kg-m2 and runs at a constant speed of 1420 rpm.

(i) Sketch a block diagram of the motor load system showing the complete system and label it accordingly.

(3 marks)

(ii) Determine an equivalent inertia referred to the motor shaft.

(4 marks)

(iii) Calculate power developed by the motor.

(4 marks)

Q2 (a) Closed-loop speed control scheme is widely used in electric drives system. From the control scheme, sketch a block diagram illustrating the complete closed-loop speed control scheme system. Explain the system operation accurately.

(8 marks)

(b) A DC series motor operates at a voltage of 220 V and runs at 1000 rpm in the clockwise direction. It requires an armature current of 100 A when driving a load with constant torque. The resistances of the armature and field windings are 0.05 ohms, respectively. Assume a linear magnetic circuit.

(i) Sketch an equivalent circuit of the DC series motor based on the given specifications. Label the equivalent circuit accordingly.

(4 marks)

(ii) Determine the magnitude of the motor speed and armature current if the motor terminal voltage is reversed and the number of turns in field winding is reduced to 80%.

(11 marks)

(iii) Determine the direction of the motor.

(2 marks)

Q3 (a) Describe briefly the following DC Motor Speed Control strategy.

(i) Armature voltage control.

(2 marks)

(ii) Field flux control.

(2 marks)

(iii) Armature resistance control

(2 marks)

(b) Auto-transformer and un-controlled rectifier can be used to have variable voltage in DC Motor Drive. Summarize the operating concept and features of this voltage control method with the aid of suitable diagram.

(6 marks)

(c) An AC source of 230 V, 50 Hz fed to a single-phase fully controlled rectifier to control speed of a separately excited DC Motor. The motor rated parameter are 200 V, 1000 rpm, and 100 A. If the rectifier is operated in continuous conduction mode and the motor has armature resistance of 0.05 Ω,

(i) Calculate firing angle at the rated motor torque and speed of 800 rpm.

(5 marks)

(ii) Determine the new firing angle of the rectifier when the motor rotates in reverse direction with the speed of 600 rpm at rated torque condition.

(4 marks)

(iii) Propose a method to improve DC signal of output rectifier.

(4 marks)

Q4 (a) Differentiate between constant torque region and constant power region in Volts/Hertz (*V/f*) control strategy of induction motor drive.

(8 marks)

(b) A 2200 V, 2.6 kW, 735 rpm, 50 Hz, 8-pole, three-phase delta connected squirrel-cage induction motor has following parameters referred to the stator:

$$R_s = 0.075\ \Omega$$
$$R_r' = 0.1\ \Omega$$
$$X_s = 0.45\ \Omega$$
$$X_r' = 0.55\ \Omega$$

(i) Find slip of the motor at rated operation.

(2 marks)

(ii) Examine full load line current.

(3 marks)

(iii) Calculate the full load torque.

(2 marks)

(iv) Calculate maximum line current at starting condition.

(2 marks)

(v) Determine starting torque of the motor.

(1 mark)

(c) A 3 hp, 415 V, 4 pole, 50 Hz, delta connected squirrel cage induction motor is used to run a fan load at rated speed of 1400 rpm and its rated voltage. The motor has parameters of 1.5 Ω stator resistance, 3.5 Ω rotor resistance, stator and rotor reactance is 4.8 Ω and 4.0 Ω, respectively, and magnetization reactance of 70 Ω. The motor torque and slip at full load is 60 Nm and 0.07, respectively. All parameters are referred to the stator of the motor. The load torque is given by

$$T_L = K(1-s)^2$$

where K and s is motor constant and slip, respectively.

Calculate terminal voltage parameter, when the motor running at the speed of 1200 rpm.

(7 marks)

- END OF QUESTIONS -

APPENDIX A

FORMULA

$$J = J_o + a_1^2 J_1$$

$$T_l \omega_m = T_{lo} \omega_m + \frac{T_{l1} \omega_{m1}}{\eta_1}$$

$$T_l \omega_m = T_{lo} \omega_m + \frac{F_1 v_1}{\eta_1}$$

$$F = mg$$

$$\text{Kinetic Energy} = \frac{1}{2} J \omega^2$$

$$P = T\omega$$

$$V_a = \frac{2V_m}{\pi} cos\alpha$$

$$E = K_e \emptyset \omega$$

$$T = K_e \emptyset I_a$$

$$\emptyset = K_f I_a$$

$$T = K_e K_f I_a^2$$

$$s = \frac{\omega_s - \omega_m}{\omega_s}$$

$$P_{cu} = 3I^2 R$$

$$P_c = 3\frac{V_m^2}{R_m}$$

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APPENDIX A

FORMULA

$$I_r' = \frac{V_s}{\left[\left(R_s + \frac{R_r'}{s}\right)^2 + (X_s + X_r')^2\right]^{\frac{1}{2}}}$$

$$T_d = \frac{3R_r'V_s^2}{s\omega_s\left[\left(R_s + \frac{R_r'}{s}\right)^2 + (X_s + X_r')^2\right]}$$

$$T_{start} = \frac{3R_r'}{\omega_s}\frac{V_s^2}{[(R_s + R_r')^2 + (X_s + X_r')^2]}$$

$$SR = \frac{N_{NL} - N_{FL}}{N_{NL}} \times 100$$

$$s = \frac{\omega_s - \omega_r}{\omega_s}$$

$$s_{max} = \frac{R_r'}{\sqrt{R_s^2 + K^2(X_s + X_r)^2}}$$

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