Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2022/2023

COURSE NAME	:	ELECTRIC DRIVES
COURSE CODE	:	BEV 30703
PROGRAMME CODE	:	BEV
EXAMINATION DATE	:	JULY / AUGUST 2023
DURATION	:	3 HOURS
INSTRUCTION	:	1. ANSWERS **ALL** QUESTIONS. 2. THIS FINAL EXAMINATION IS CONDUCTED VIA **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) If you are working as a technical engineer in a company that involve motor and drive system installation, suggest **three (3)** benefits to your clients to upgrade the conventional drive system with the latest technology using a smart controller.

(6 marks)

(b) A drive system has two loads and a motor. Load 1 has rotational motion and coupled to the motor through a reduction gear ratio of 8 and efficiency of 95%. The moment of inertia and torque of Load 1 is 9 kg.m^2 and 9 Nm, respectively. While, Load 2 has translation motion and consist of 900 kg weight to be lifted up at uniform speed of 2 m/s. The coupling between Load 2 and the motor has efficiency of 80%. The inertia of the motor is 0.2 kg.m^2 and runs at constant speed of 1350 rpm.

(i) Sketch and label the drive system as mentioned above.

(4 marks)

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

(5 marks)

(iii) Calculate the output power of the motor.

(5 marks)

(c) A drive used in a hoist system to raise and lower weights of 400 kg at velocities of 2 m/s. The weight hangs from a cable that is wounded on a drum with radius of 0.4 m. The drum is driven by the drive motor through a gearbox that has an efficiency of 90%. The maximum speed of the motor is 1250 rpm.

(i) If the gear speed ratio is 1:N, propose the value of N to the nearest integer.

(4 marks)

(ii) Examine the actual motor speed in radians per minute (rpm) based on the result obtained in **Q1(c)(i)**.

(1 mark)

Q2 (a) (i) States **three (3)** methods in controlling DC motor speed.

(3 marks)

(ii) Briefly describes the *Armature Resistance Control* method in shunt DC motor and sketch the related circuits to support your explanation.

(5 marks)

(b) A 200 V compensated shunt DC motor drives a 650 Nm torque load when running at 1100 rpm. The combine armature compensating winding resistance is 0.06 Ω and shunt field resistance is 40 Ω. If the windage and friction losses are assumed to remain constant and the motor efficiency is 90%,

(i) Examine the output power of the motor.

(1 mark)

(ii) Determine the power drawn by the motor at its maximum capability.

(1 mark)

(iii) Find the current drawn by the motor.

(1 mark)

(iv) Examine the shunt field current and armature current if the equivalent circuit is shown in **Figure Q2(b)(iv)**.

(2 marks)

(v) Calculate the dynamic braking resistance when the torque and speed of the motor reach 370 Nm and 1000 rpm, respectively.

(5 marks)

(c) A 220 V series DC motor has 45 A armature current and deliver speed of 1450 rpm. The motor has armature resistance of 0.2 Ω.

(i) Determine the resistance to be added into the circuit to obtain rated torque condition.

(2 marks)

(ii) Examine the appropriate resistance if the speed reduces to 1200 rpm.

(5 marks)

Q3 (a) In DC drive system, controlled rectifiers can be used to provide variable DC voltage from a fixed voltage of AC source. Thyristors in the rectifier circuit only capable of conducting armature current of DC motor in single direction. With the aid of thyristor rectifier circuitry and its V-I plane DC motor quadrant operation, briefly describes the operating principle of,

(i) single-phase fully controlled rectifier, and

(4 marks)

(ii) single-phase half-controlled rectifier.

(4 marks)

(b) The speed of a 50 hp, 400 V, 1500 rpm, separately excited DC motor is controlled by a three phase 415 V, 50 Hz star connected supply. The rated armature current of the motor is 100 A, while the armature resistance and inductance of the motor is 0.09 Ω and 0.7 mH, respectively. If the motor constant and magnetic flux, $K_e\phi$ is 0.3, by neglecting the losses in the converter system,

(i) Determine no-load speed at firing angle, $\alpha = 30°$ and assumed the armature current is 10% of the rated current with continuous mode.

(7 marks)

(ii) Examine the firing angle to obtain rated speed of 1500 rpm.

(5 marks)

(iii) Calculate the speed regulation for the firing angle obtained in **Q3(b)(ii)**.

(5 marks)

Q4 (a) (i) State **three (3)** factors in controlling speed of induction motor for a drive system.

(3 marks)

(ii) Briefly explain the *plugging* of an induction motor drive.

(6 marks)

(b) A three-phase, star connected, 50 Hz, 4-pole induction motor has resistance and reactance of $R_s = R_r = 0.038\ \Omega$ and $X_s = X_r = 0.15\ \Omega$, respectively. The motor is controlled with a constant (V/f) ratio with rated slip of 3%. If the motor runs at the frequency of 25 Hz, calculate the operating slip of the motor.

(13 marks)

(c) The rotor resistance and standstill reactance of three-phase induction motor are respectively 0.015 Ω and 0.09 Ω per phase. At normal voltage, the full load slip is 3%. If the motor developed full-load torque at half-load speed,

(i) Determine the full load speed in radians per minute if the synchronous speed is 100 rpm.

(1 mark)

(ii) Calculate the operating motor slip at half-load speed.

(2 marks)

– END OF QUESTIONS –

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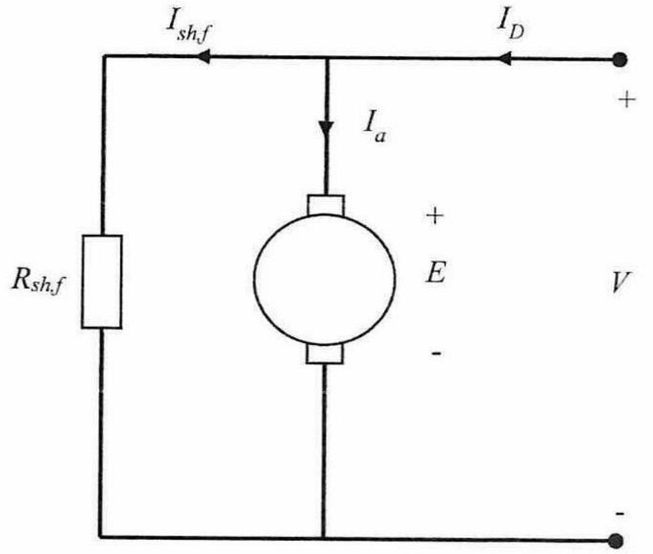

Figure Q2(b)(iv)

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FORMULA

$$F = mg$$

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

$$P = T\omega$$

$$E = K_e \emptyset \omega$$

$$T = K_e \emptyset I_a$$

$$T = K_e \emptyset I_a$$

$$\emptyset = K_f I_a$$

$$T = K_e K_f I_a^2$$

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

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

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

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

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

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