Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2022/2023

COURSE NAME	:	ELECTRIC DRIVES
COURSE CODE	:	BEV 30703
PROGRAMME CODE	:	BEV
EXAMINATION DATE	:	FEBRUARY 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) There are **TWO (2)** types of variable impedance in power modulator of electric drive system. State the type of variable impedance and summarize the function of each type.

(6 marks)

(b) A simple drive system consists of single motor coupled with a load as shown in **Figure Q1(b)**. Describes the system based on fundamental torque equation and rewrite the equation when the drive with constant inertia is zero.

(4 marks)

(c) A motor drives the winch drum through a reduction gear with a gear tooth ratio of 0.1 as shown in **Figure Q1(c)**. The friction torque at winch shaft is 15 Nm and at the motor shaft is 10 Nm. At the motor speed of 1500 rpm, the winch complete one rotational cycle in 11 s.

(i) Calculate the equivalent moment of inertia of the drive referred to the motor shaft.

(5 marks)

(ii) Determine the motor torque if the gear has an efficiency of 90%.

(5 marks)

(iii) Find total power of the motor.

(3 marks)

(iv) Determine the moment of inertia expression when a motor coupled with series of loads and through gear in a drive system.

(2 marks)

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 7.46 kW, 220 V, 900 rpm shunt DC motor has a full-load efficiency of 88%, an armature resistance of 0.08 Ω and shunt field current of 2 A. If the speed of this motor is reduced to 450 rpm after inserting a resistance in the armature circuit, and the load torque remains constant,

(i) Calculate the motor armature current.

(2 marks)

(ii) Examine the appropriate external resistance to be included in the circuit.

(8 marks)

(c) A 240 V series DC motor has 40 A armature current and deliver speed of 1500 rpm. The motor has armature resistance of 0.3 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 1000 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.

(4 marks)

(ii) single-phase half-controlled rectifier.

(4 marks)

(b) Summarise the concept of fully controlled rectifier DC drive in continuous and discontinuous conduction modes by providing related circuitries, voltage and current conduction waveforms.

(7 marks)

(c) A 220 V, 950 rpm, 120 A DC separately excited motor has an armature resistance of 0.05 Ω. The motor is fed from a single phase fully controlled rectifier with an AC voltage source of 230 V, 50 Hz. If the rectifier operated at continuous conduction mode,

(i) Determine a proper firing angle at the rated motor torque condition and speed of 865 rpm.

(4 marks)

(ii) Suggest a new firing angle when the motor rotates in reverse direction with the speed of 350 rpm at rated torque condition.

(3 marks)

(iii) Predict the effect on the motor speed and torque when an additional inductance is added in series with the armature circuit.

(3 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 230 V, 6-pole, three-phase, 50 Hz, 15 kW induction motor drives a constant torque load at rated frequency, rated voltage and rated output power and it has a speed of 980 rpm and efficiency of 93%.

(i) Calculate the new operating speed if there is a 10% of voltage drop and 5% of frequency drop.

(8 marks)

(ii) Find a new output power if the losses are constant.

(3 marks)

(c) A 440 V, 50 Hz, 4-pole three-phase squirrel cage induction motor develops a torque of 100 Nm at speed of 1200 rpm. If the stator supply frequency is reduced by half,

(i) Determine the stator supply voltage for maintaining the same flux in the motor.

(1 mark)

(ii) Calculate a new speed at 100 Nm of torque.

(4 marks)

– END OF QUESTIONS –

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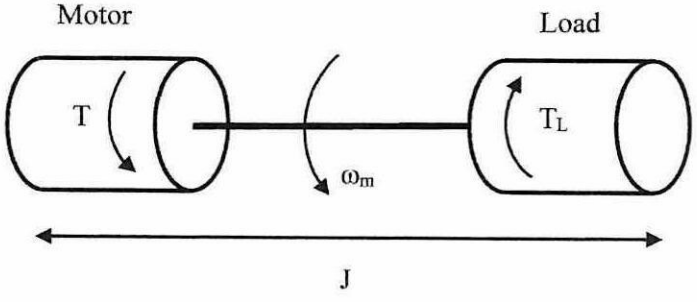

Figure Q1(b)

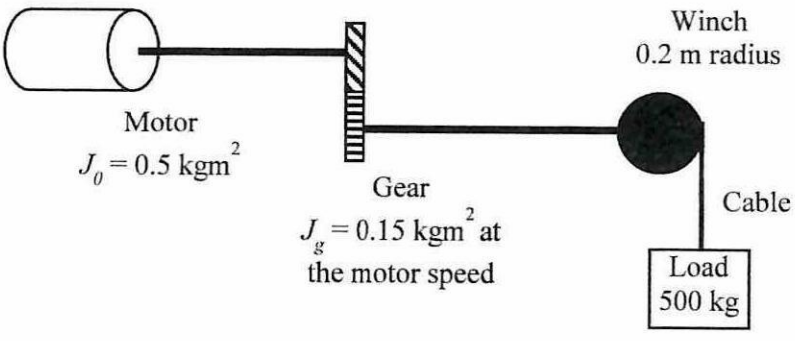

Figure Q1(c)

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FORMULA

$$F = mg$$

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

$$P = T\omega$$

$$E = K_e \emptyset \omega$$

$$T = K_e \emptyset I_a$$

$$T = K_e \emptyset I_a$$

$$\emptyset = K_f I_a$$

$$T = K_e K_f I_a^2$$

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

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

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

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

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

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