The Open University of Sri Lanka

Faculty of Engineering Technology

Department of Electrical & Computer Engineering

061

Study Programme	: Bachelor of Science Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	**: EEX5348**
	Electrical Machines and Drives
Academic Year	: 2022/2023
Date	: 30th January 2024
Time	: 0930-1230hrs

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **Five (5)** questions in **Three (03)** pages.
3. Answer **all questions**, All the questions carry **equal marks**.
4. Answer for each question should commence from a new page.
5. Relevant figures and tables are provided with the question paper
6. This is a Closed Book Test **(CBT).**
7. Answers should be in clear hand writing.
8. Do not use red colour pen.

Question 01

a) Sketch typical line current waveform produced by a synchronous generator, following a sudden three-phase short circuit at its terminals (at the time t=0), indicating all the necessary details. Assume the generator was operating at no-load condition prior to the short circuit. **[3 marks]**

b) For the short-circuited synchronous generator in (a) above, write down an expression for the instantaneous current in phase A. Define all the terms in your expression. **[3 marks]**

c) What are the main categories of synchronous motor drives based on the control strategy, compare the mentioned synchronous drive types based on their control mechanism. **[5 marks]**

d) What is the significance of synchronous motor V-curves? Draw the variation of V curves with the increasing load and show the locus of unity power factor. **[4 marks]**

e) Which type of motor is employed in domestic pump systems among synchronous motors and induction motors? Provide justification for your answer. **[5 marks]**

Question 02

a) Sketch the internal structure of the BLDCM and briefly explain how the motor operates. **[4 marks]**

b) Briefly describe available rotor position sensing techniques for a BLDCM. **[2 marks]**

c) Briefly explain four (4) advantages of BLDC over the brushed DC motors **[4 marks]**

d) A BLDCM has following data.

Rotor radius = 8cm
Rotor axial length = 25cm
Airgap flux density due to rotor magnets = 0.7T
Number of turns per phase = 36 turns
Stator resistance per phase = 0.4 Ω
Stator Inductance per phase = 1 mH

The DC supply voltage at input terminals is 320V. Determine the motor **speed** and **efficiency** when delivering a load of load-torque 65Nm. State any assumptions you made. **[7 marks]**

e) Define the term 'temperature rise' in electric machines. What are the factors responsible for temperature rise in electrical machines? **[3 marks]**

Question 03

a) Suppose you're employed at a toy company and your expertise is requested in choosing a motor for an affordable toy doll capable of moving its arms through various steps. If you have three options to consider: DC motor, stepper motors, and servo motors, which motor would you recommend for this application, and how would you justify your choice with valid arguments? **[5 marks]**

b) What is the difference between full switching sequence and half switching sequence of stepper motors? **[4 marks]**

c) Draw the basic circuit configuration of a typical 4/2-pole, 4-phase, single-stack, variable reluctance stepper motor including the basic step angle. **[3 marks]**

d) With the aid of a suitable diagram briefly explain the significance of Torque Angle/Displacement Characteristics of stepper motor **[4 marks]**

e) How does the static position error occur in the stepper motor drives? With an aid of suitable diagrams, briefly explain a way of determining static position error. **[4 marks]**

Question 04

A separately excited dc motor is required to be controlled only in the forward motoring mode. The motor parameters are as follows,

Motor torque constant = 1.5Nm/A
Armature resistance = 0.4Ω
Armature Inductance = 9mH

Suppose a 350V DC source is available to power up the DC drive system. A step down chopper should be used for the driving purposes. You can assume the friction torque as 2Nm for all the speeds

a) Draw the power circuit of your proposed DC drive system including all the necessary components **[5 marks]**

b) How does the inductor in a DC chopper contribute to ensuring continuous current conduction? **[3 marks]**

c) If the proposed drive system should ensure continuous armature current for all the times, calculate the minimum switching frequency which is required to ensure that condition. **[4 marks]**

d) If the operating switching frequency of the drive is 10kHz, determine the duty factor of your drive system in order to set the motor speed at 1250rpm, while driving a load of load torque 50Nm. **[5 marks]**

e) Determine the peak-peak current ripple under the conditions mentioned in question (d). **[3 marks]**

Question 05

a) Briefly explain why the three phase induction motors are self-starting but single-phase induction motors are not? **[2 marks]**

b) With an aid of suitable diagram, briefly explain about the stable working region of an induction motor considering Torque/Speed characteristics. **[4 marks]**

c) A three phase 400V, 50Hz four pole induction motor runs on no-load at 1455rpm at rated voltage and frequency. The initial voltage boost is 10% of the rated voltage. If the load is constant for all speeds, determine the voltage and frequency combination required to drive the load at 200rpm. **[4 marks]**

d) Recalculate the voltage frequency combination in the section (c) if the load is required to be rotated at 2000rpm. **[5 marks]**

e) A three-phase induction motor has following data,

Number of poles = 6
Rated Frequency = 50Hz
Rated Power = 15kW
Rated Voltage = 400V
Rated Current = 20A
Full Load Slip = 4%
Breakdown Slip = 10%

The motor is used in a variable speed drive covering a speed range from 0 to 6500rpm. Determine the speed ranges corresponding to constant torque, constant power and high-speed regions. **[5 marks]**