The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Electrical and Computer Engineering

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	: 2023/2024
Date	: 14th February 2025
Time	: 1400-1700 hrs
Duration	: **3 hours**

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 handwriting.
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. **[03 marks]**

b) A 11 KV, 200 MVA, 50Hz Cylindrical rotor synchronous generator has the following parameters.

Xd=1.4 PU
Xd'=0.4 PU
Xq''=0.2 PU
Td'=0.5 PU
Td''=0.03 PU
Ta=0.2 PU

There is a sudden three phase short circuit at the terminals of the generator while it is on steady no-load condition with rated voltage across terminals. The generator breaker will trip if it operates in 6 cycles following the fault. Write down an expression to calculate the instantaneous phase current (in p.u) at phase-A (no need to obtain the final value, an expression with numerical values is sufficient). **[06 marks]**

c) Briefly explain the two main speed control modes available in the synchronous motor drives. **[04 marks]**

d) Briefly explain the significance of synchronous motor V-curves. **[03 marks]**

e) Which type of motor is employed in domestic pump systems among synchronous motors and induction motors? Provide justification for your answer. **[04 marks]**

Question 02

a) Explain how a BLDC motor maintains rotation of the rotor without brushes? **[3 marks]**

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

c) Write a short description about the materials that can be used for BLDC motor rotor construction considering different applications. **[3 marks]**

d) List two rotor position sensing techniques available for a BLDCM. **[2 marks]**

e) A BLDCM has the following parameters.

Rotor radius = 8cm
Rotor axial length = 30cm
Airgap flux density due to rotor magnets = 0.9T
Number of turns per phase = 36 turns
Stator resistance per phase = 0.6 Ω
Stator Inductance per phase = 12 mH
Friction Torque = 1 Nm for all speeds

It was found that the steady state speed of the motor is 1141.5 rpm when delivering a load of load-torque 65Nm. Calculate the DC supply voltage at the input terminals. State assumptions you made. **[08 marks]**

Question 03

a) Suppose you are an engineer at a company designing a cost-effective automated window blind system, and your task is to select an appropriate motor for smooth, precise, and controlled movement of the blinds. You have three motor options: DC motor, stepper motor, and BLDC motor. Which motor would you recommend for this application, and how would you justify your choice based on performance, cost, and ease of control? **[6 marks]**

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

c) How does the static position error occur in the stepper motor drives? **[2 marks]**

d) Draw the cross-section of a variable-reluctance stepper motor with four rotor poles and six stator poles and calculate the basic step angle of that stepper motor. **[4 marks]**

e) With the aid of a suitable diagram, briefly explain Pull-out Torque Characteristics/Slewing characteristics of a stepper motor. **[4 marks]**

Question 04

A separately excited dc motor is required to be controlled by a four quadrant DC motor drive with bipolar voltage control. The motor parameters are as follows,

Motor torque constant = 1.6Nm/A
Armature resistance = 0.5Ω
Armature Inductance = 2mH

A 300V DC source is available to power up the DC drive system. You can assume the friction torque as 1Nm for all the speeds.

a) Draw the power circuit of your proposed DC drive system incorporating all the necessary components. **[3 marks]**

b) If the operating switching frequency of the drive is 20kHz, determine the duty factor which is required to set motor speed at 1400rpm, while driving a load of load torque 50Nm. Also calculate the percentage peak-peak current ripple under this condition. **[8 marks]**

c) Calculate the initial rate of deceleration, in case you reduce the existing duty factor (calculated in part (b)) by 15%, stepwise. Note that the moment of inertia of the motor and its connected load is 1kg m^2. What will be the final steady state speed with new duty factor? **[9 marks]**

Question 05

a) Briefly explain why the induction motor rotor should rotate at a slower speed than the revolving magnetic field. **[04 marks]**

b) In the induction motor drives, in order to obtain the best possible torque per ampere, it is required to maintain the airgap flux as a constant at its rated value. Briefly explain the way of achieving constant airgap flux in practice. **[05 marks]**

c) A three-phase induction motor has the following parameters,

Parameter	Value
Number of poles	4
Rated Frequency	50Hz
Rated Power	15kW
Rated Voltage	400V
Rated Current	20A
Full Load Slip	5%
Breakdown Slip	10%

The motor is used in a variable speed drive covering a speed range from 0 to 6000 rpm. Determine the speed ranges corresponding to constant torque, constant power and high-speed regions. **[08 marks]**

d) Define the term 'temperature rise' in electric machines. What are the factors responsible for temperature rise in electrical machines? **[03 marks]**