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	**: EEX4448 Electrical Machines**
Academic Year	: 2023/2024
Date	: 13th February 2025
Time	: 1330-1630hrs
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(3)** pages.
3. Answer all five questions. All questions carry equal marks.
4. Answer for each question should commence from a new page.
5. No charts/ codes are provided.
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) Briefly explain four main winding connection types of three-phase transformers indicating the special features of each. **[04Marks]**

b) Compare and contrast the Dy11 and Yy0 vector groups in terms of phase shift, load handling, and harmonic suppression. **[04 Marks]**

c) In one of your laboratory experiments you carried out the winding insulation test for a transformer. Briefly discuss the importance of this test and the procedure followed by indicating the connection diagram. **[04 Marks]**

d) Figure 1 shows the windings of a three-phase two-winding transformer. Select any 'Dy' vector group winding connection of your choice and answer the following question.

i. Clearly draw the connection diagram in Figure 1 including the polarity of each winding.
ii. Identify the phase shift of the winding connection drawn in part (i) using phasor diagram.
iii. Draw the phase difference in a clock face.
iv. What is the vector group of the transformer given in part (i)? **[8 Marks]**

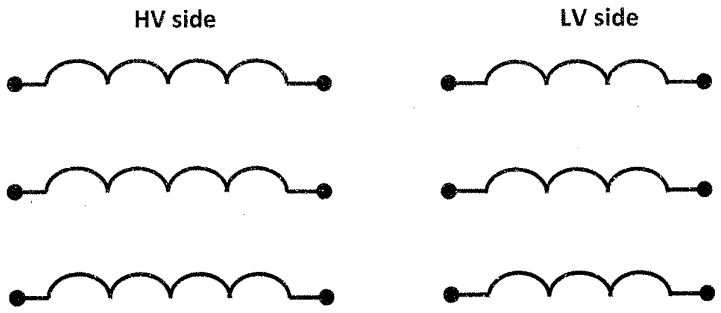


Figure 1

Hint: In the Dy winding connection, transformer HV winding should be connected in delta and LV winding should be connected in the star configuration.

Question 02

a) Why do self-excited DC machines require a residual magnetism to start? What happens if residual magnetism is lost? **[04 Marks]**

b) Draw the external characteristics of a DC separately excited generator and a DC shunt-excited generator. Which of the two exhibit a more pronounced voltage drop (drooping characteristic) with the increasing load current? Explain the reason for this behavior.

[08 Marks]

c) A 4-pole, lap wounded shunt generator delivers a current of 40 A at 230 V. The armature resistance is 0.1 Ω and field resistance is 115 Ω. Brush contact drop is 1 V per brush. Calculate,

i. Current in each conductor of armature
ii. Generated EMF **[08 Marks]**

Question 03

a) DC series motors are commonly used in traction applications. Explain why they are preferred for this purpose by analyzing their key characteristics. Support your explanation by deriving the relevant speed-torque and current-torque characteristics from the fundamental DC machine equations. **[06 Marks]**

b) A 500 V DC shunt motor has armature resistance including that of brushes of 0.2 Ω and the field resistance of 500 Ω. The motor draws 4 A from the main supply on no load. When the motor draws 20 A from the supply, determine,

i. the output power of the motor.
ii. the efficiency of the motor. **[06 Marks]**

c) A DC series motor runs at 500 rpm drawing 40 A from 600V supply. The armature resistance is 0.3 Ω and the field resistance is 0.2 Ω. Determine the value of the external resistance to be connected in series with the armature for the motor to run at 450 RPM. The load torque is proportional to the square of the speed. Assume linear magnetization.

[08 Marks]

Question 04

a) The rotor of an induction motor cannot run at synchronous speed. Explain the reason.

[04 Marks]

b) How does the construction and operational principle of a squirrel cage induction motor differ from that of a wound rotor induction motor?
Describe the implications of these differences on performance, starting characteristics, and industrial applications. **[04 Marks]**

c) A 400 V, 50 Hz, three-phase induction motor has 4 poles and, stator windings are star-connected. The rotational loss of the motor is 800 W and the core loss is negligible. The motor has the following parameters of its equivalent circuit model referred to the stator side.

$R_1 = 1.2\ \Omega$; $X_1 = 1.16\ \Omega$; $X_m = 35\ \Omega$; $R_2' = 0.4\ \Omega$; $X_2' = 1.16\ \Omega$

When the induction motor runs at 1440 rpm, determine,

i. input current and power factor
ii. output torque of the motor
iii. motor efficiency
iv. maximum torque and the corresponding slip **[12 Marks]**

Question 05

a) Explain the key differences between salient pole rotor and cylindrical rotor synchronous generators. How do the design features of each type influence their operation and applications? **[04 marks]**

b) In a synchronous generator, explain how the excitation system regulates voltage under varying load conditions and the effects of under-excitation and over-excitation on performance **[04 Marks]**

c) Describe how synchronous machines are used to correct the power factor in electrical systems. **[05 Marks]**

d) Derive the capability curve of a cylindrical rotor synchronous generator by starting from the basic phasor diagram when the generator is supplying power to a lagging load. Clearly explain the steps involved in the derivation and illustrate the capability curve, highlighting key factors that influence the generator's operation. State any assumptions you made during the derivation. **[07 Marks]**