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	:	2024/25
Date	:	05th February 2026
Time	:	1330-1630h
Duration	:	3 hours

General instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **Five (5)** questions in **Four (4)** pages.
3. Answer **all** questions.
4. All questions carry equal marks.
5. Answer for each question should commence from a new page.
6. This is a Closed Book Test (CBT).
7. Any type of calculator is allowed to use.

Question 1

a. Discuss the advantages and disadvantages of star-delta(Y-Δ) over delta-star (Δ-Y) three-phase transformer connections. **(4 marks)**

b. Figure Q1 shows the windings of a three-phase two-winding transformer. Select any 'Yd' vector group winding connection of your choice and answer the following question.

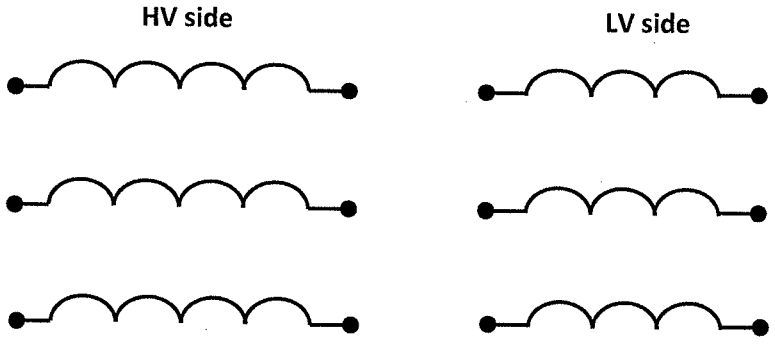


Figure Q1

i. Clearly draw the connection diagram in Figure Q1 including the polarity of each winding. You may use suitable symbols to identify the winding terminals.

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)**

c. A 50 kVA, 11 kV / 415 V, 50 Hz, three-phase transformer is tested to determine its equivalent circuit parameters and performance.

Open Circuit Test: 415 V, 8 A, 1.2 kW

Short circuit test: 900V, 2. 6 A, 1.8 kW

i. Determine the equivalent circuits parameters of the transformer referred to the HV side and the LV side.
ii. Draw the equivalent circuits of the transformer referred to HV and LV sides respectively with indicating all the parameters.
iii. Calculate the full-load efficiency of the transformer at 0.8 power factor lagging.
iv. Determine the percentage voltage regulation at full load and 0.8 power factor lagging. **(8 Marks)**

Question 2

a. Briefly explain armature reaction in a DC machine, using a neat, labelled diagram. Hence, discuss the effects of armature reaction on the performance of the machine. **(6 marks)**

b. Draw and explain the external characteristics of a DC series generator. **(4 marks)**

c. A DC series generator having a combined armature and filed resistance of 0.4 Ω is running at 1000 rpm and delivering 5.5 kW at a terminal voltage of 110 V. If the speed of the generator is increased to 1500 rpm and load adjusted to 10 kW, find the new current and terminal voltage. It is assumed that the machine is working on the straight line portion of the magnetization characteristic. **(10 marks)**

Question 3

a. DC shunt motors are commonly used in conveyor belt applications. Explain the reasons for selecting a DC shunt motor for this application, with reference to its speed–current and torque–current characteristic curves. **(5 marks)**

b. List two methods of speed controlling in DC shunt motors and discuss one of the methods. **(6 marks)**

c. A 230 V DC shunt motor draws a line current of 50 A. The shunt field resistance is 46 Ω and the armature resistance is 0.02 Ω. An external resistance of 0.6 Ω is connected in series with the armature. Under these conditions, the motor runs at a speed of 800 rpm. It is required to increase the motor speed to 850 rpm.

Determine the alteration that must be made to the motor circuit to achieve this increase in speed.

(9 marks)

Question 4

a. A three-phase wound-rotor (slip-ring) induction motor is commonly used in applications requiring high starting torque and controlled acceleration.

i. Explain the principle of speed control of a wound-rotor induction motor. Clearly describe how external resistance in the rotor circuit affects the motor speed and torque.

(4 marks)

ii. With the aid of clearly labelled torque–speed characteristic curves, explain the effect of increasing rotor resistance on:

- Starting torque
- Starting current
- Slip at maximum torque
- Operating speed under load

(4marks)

b. A three-phase 400 V, 50 Hz, 6 pole induction motor takes a power input of 30 kW at its full-load speed of 800 rpm. The stator copper loss is 1.2 kW. Stator core loss and the friction and windage losses are each accounted as 0.8 kW. Determine,

i. Slip of the motor
ii. rotor copper loss
iii. the mechanical power developed
iv. the output power
v. the efficiency of the motor

(12 marks)

Question 5

a) The capability curve (P-Q curve) of a cylindrical rotor synchronous generator provides insight into its maximum continuous and short-term overload capabilities across different operating conditions. Draw and explain this curve, highlighting each limitation.

(5 Marks)

b) In your laboratory experiments, dark lamp method was used to synchronize a synchronous machine with the power grid.
Explain the conditions that must be satisfied before synchronization, and describe the method of synchronization using dark lamp method. Support your answer with a diagram, where appropriate. **(7 marks)**

c) A three-phase synchronous generator is connected to a power grid and operates at constant speed. Explain how the excitation (field current) of the generator controls its reactive power output. Describe the operation of the generator under:

Under-excited condition

Normal excitation

Over-excited condition

In each case, indicate whether the generator is supplying or absorbing reactive power.

(8 marks)

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