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

Study Programme	: Bachelor of Technology Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	**: EEX4448 -Electrical Machines**
Academic Year	: 2020/21
Date	: 13th February 2022
Time	: 1400-1700 hrs
Duration	: **3 hours**

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **Eight (8)** questions in **four (4)** pages.
3. Answer any **Five (5)** questions only. All questions carry equal marks.
4. Answer for each question should commence from a new page.
5. This is a Closed Book Test (CBT).
6. Answers should be in clear hand writing.
7. Do not use Red colour pen.

Q1

a) Briefly explain how a voltage is induced in the secondary winding of a transformer.

[04 Marks]

b) Explain why low voltage side is short circuited during transformer's short circuit test?

[03 Marks]

c) In a large factory 500 kVA, 69 kV/ 4.16 kV, 60 Hz single phase transformer is used to step down the voltage as required by the production process. The open circuit test and short circuit test results of this transformer is as follows:

OC test data (HV side terminals are open circuited and equipment connected to LV side)	4160 V	2 A	5000 W
SC test data (LV side terminals are short circuited and equipment connected to HV side)	2600 V	4 A	2400 W

Determine,

i. Winding resistance and leakage reactance of the transformer, referred to the HV side.
ii. The values of R_m and X_m of the transformer referred to the HV side.
iii. The efficiency of the transformer when it supplies a load of 250 kVA at 0.8 lagging power factor.

[13 Mark]

Q2

a) An ideal transformer having 90 turns on the primary and 2250 turns on the secondary is connected to a 200 V, 50 Hz source. The load across the secondary draws a current of 2 A at a power factor of 0.8 lagging. Calculate;

i. The peak value of the magnetic flux linked by the secondary winding
ii. The effective value of the primary current
iii. Draw the phasor diagram to show induced emfs, currents and magnetic flux during transformer operation.

[6 Marks]

b) Discuss the advantages and limitations of three single phase transformers connected in a bank over a single three phase transformer. **[4 Mark]**

c) Explain briefly the problems that arise with magnetization and unbalanced loading of Yy connected three-phase transformers. Explain why these problems are not present in Yd transformers? **[4 Mark]**

d) A three phase, delta-star connected 11kV/400 V, 50 Hz transformer takes a line current of 5 A ,when secondary load of 0.8 lagging power factor is connected. Determine currents of each windings and output power of the transformer. **[6 Mark]**

Q3

a) Draw external characteristics of separately excited and shunt -excited DC generators and explain more drooping nature in one over other with proper reasoning. **[4 Mark]**

b) Draw and explain magnetic characteristics, internal characteristics and external (load) characteristics for DC Series generator in the same graph. **[4 Mark]**

c) Explain the term "critical load resistance" in a DC generator. **[2 Mark]**

d) How you obtain critical load resistance from the graph you have drawn in part b)? Indicate your selection in the same graph drawn in part b). **[4 Mark]**

e) A DC series generator having a combined armature and field 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 is raised to 1500 rpm find the new current and terminal voltage when load is adjusted to 10 kW.
Clearly state assumptions that you made. **[6 Marks]**

Q4

a) Draw torque-speed characteristics of following motors.
   i. DC series motor,
   ii. DC shunt motor
   iii. DC compound wound motor
   iv. Induction motor (single phase) **[4 Marks]**

b) Vacuum cleaners, Washing Machines, Air conditioners, Grinders and mixers are some of household electrical appliances which consists of different types of electric motors in it. Briefly explain the type of electric motor(s) used in each appliance clearly stating the reason(s) considering the characteristics drawn in part b). **[8 Marks]**

c) A DC shunt motor draws an armature current of 125 A from 440V supply. The motor drives a load at 1245 rpm and has armature resistance of 0.2 Ω. The motor is subjected to reduction of its excitation by 75% of its initial value while keeping constant torque in two situations. Calculate new speed of the motor. **[8 Marks]**

Q5

a) "An induction motor cannot operate at synchronous speed". Explain this statement. **[4 Marks]**

b) Draw and explain the torque-slip characteristic of a typical three-phase induction motor. Mark the starting torque and maximum torque and explain how the starting torque and maximum torque vary with rotor circuit resistance. **[8 Marks]**

c) A 400 V, 4 pole, 50 Hz, three-phase star-connected induction motor has per phase rotor resistance and reactance of 0.01Ω and 0.1 Ω respectively. Ratio of stator to rotor turns is 4. Determine,
   i. maximum torque and the corresponding slip
   ii. the full-load slip and the power output if maximum torque is twice the full-load torque **[8 Marks]**

Q6

a) Identify the type of induction motors, rotors of which are shown in Figure Q6-a and Figure Q6-b. **[2 Marks]**

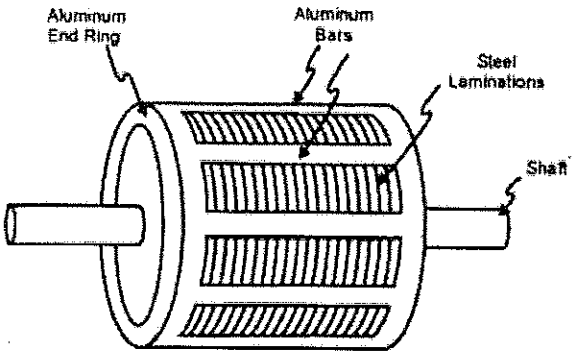


Figure Q6-a

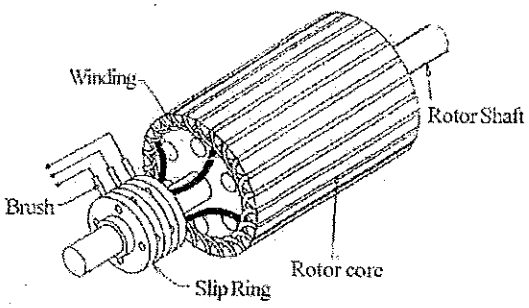


Figure Q6-b

b) Compare advantages and disadvantages of induction motors mentioned in part a). **[4 Marks]**

c) What is the necessity of short-circuited rotor conductors in motor shown in FigureQ6-a? **[2 Marks]**

d) Draw the power flow diagram of a three-phase induction motor and show the flow of power from the electrical source to mechanical load at the motor shaft. Based on the diagram, show that

$$P_g: P_{cu}: P_m = 1: s: (1-s)$$

Note that P_g, P_{cu}, P_m and s are usual notations. **[6 Marks]**

d) The power input to a three-phase induction motor is 50 kW and the corresponding stator losses are 2 kW. Slip of the motor is 3% and the friction and windage losses are 1 kW. Calculate;

i. rotor copper loss
ii. mechanical power developed
iii. shaft power
iv. efficiency of the motor

[6 Marks]

Q7

a) Explain the Open Circuit test and Short Circuit test of an alternator. How voltage regulation can be calculated by the use of results of these two tests. **[8 Marks]**

b) A 1000 kVA, 11 kV, 50 Hz, three-phase star connected alternator has rated current of 52.5 A and armature resistance of 0.45 Ω per phase. A field current of 12.5 A produces a short circuit current of 52.5 A and an open-circuit emf of 422 V line-to-line. Calculate the full-load voltage regulation of the alternator on

i. 0.8 power factor lagging
ii. 0.8 power factor leading

[12 Marks]

Q8

a) Draw the phasor diagram of a cylindrical rotor synchronous generator on lagging load. You may assume negligible armature resistance. **[4 Marks]**

b) Derive expressions for real power output and reactive power output of the generator from the phasor diagram drawn in part a). **[2 Marks]**

c) What is the term "capability curve of a synchronous generator"? Explain the limits of the curve briefly. **[4 Marks]**

d) Draw the capability curve of synchronous generator with the help of a phasor diagram drawn in part a). **[6 Marks]**

e) A synchronous generator is connected to an infinite bus and is running at no load. Explain briefly how to increase its real and reactive power outputs. **[4 Marks]**