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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	: 2019/20
Date	: 2nd August 2020
Time	: 1330-1630hrs
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. No charts/ codes are provided.
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) Draw the phasor diagram of an ideal transformer with secondary connected inductive load as shown in Figure Q1. State the assumptions made in obtaining the properties of an ideal power transformer? **[05 Marks]**

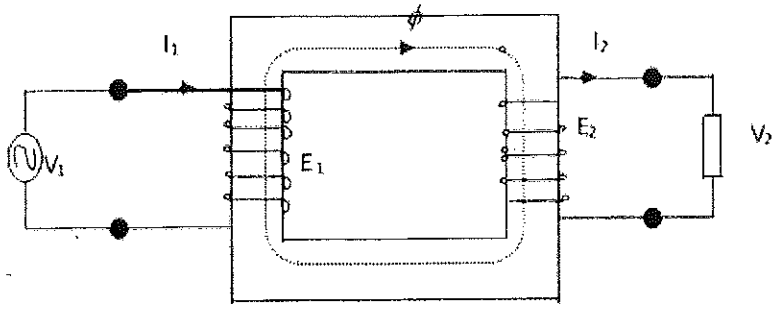


Figure Q1

b) What are the losses in power transformer? **[02 Marks]**

c) A 20 kVA, 50 Hz, 2000/200 V single phase distribution transformer was subjected to open circuit and short circuit tests. The results of the tests are given bellow:

OC test: 200 V, 4 A, 120 W
SC test: 60 V, 10 A, 300 W

i. Calculate equivalent circuit parameters of the transformer
ii. Draw the equivalent circuit of the transformer referred to LV side with indicating all the parameters.
iii. Calculate the full load efficiency of the transformer at 0.8 lagging power factor.
iv. Determine the voltage regulation of the transformer at 0.8 lagging power factor.
v. What is the load at maximum efficiency? Determine maximum efficiency of the transformer at 0.8 lagging power factor. **[13 Marks]**

Question 02

a) The Group connection of a certain transformer is 41Dy -11. What does this term mean? **[03 Marks]**

b) Explain briefly the purpose of instrument transformers? **[03 Marks]**

c) A load of 100 kVA is to be supplied at 460 V from 2300 V mains supply by an autotransformer. Determine the current and voltage rating for each of the two windings. What would be the kVA rating of the transformer, if it were used as a two-winding transformer **[6 Marks]**

d) A three-phase step-down transformer is connected to 6.6 kV mains supply and takes 10 A. The ratio of turns per phase is 12. Calculate the secondary line voltage, line current and output for following connections. Neglect losses.

i. delta/star
ii. star/delta **[8 Marks]**

Question 03

a) Briefly describe the two types of armature winding in DC machines. **[03 Marks]**

b) A six pole DC machine has an armature with 90 slots having 8 conductors per slot and runs at 1000 rpm. The flux per pole is 0.05 Wb. Determine the induced emf if winding is

i. Lap connected

ii. Wave connected **[04 Marks]**

c) Explain with suitable diagram, the armature reaction in DC machines. Describe methods of compensating the armature reaction. **[04 Marks]**

d) Draw and discuss the external characteristic of a dc shunt generator **[03 Marks]**

e) The open circuit characteristic of a shunt wound DC generator at 800 rpm gives:

Field current (A)	0	0.5	1.0	2.0	3.0	4.0	5.0
Induced emf (V)	10	50	100	175	220	245	262

Determine graphically the critical resistance of shunt field circuit. If the field circuit resistance is changed to 75 Ω, what will be the critical speed for the machine to build up. **[06 Marks]**

Question 04

a) Derive expression for speed -torque characteristic of a DC shunt motor from the basic equation and draw the characteristic **[03 Marks]**

b) A 400 V shunt motor while running at 1500 rpm takes an armature current of 30 A and delivers an output of 15 hp, the load torque varies as square of the speed. Armature resistance is 0.2 Ω. Calculate the value of resistance to be connected in series with the armature for reducing the motor speed to 1300 rpm. **[08 Marks]**

c) A 230 V DC series motor take 30 A when giving its rated output at 1500 rpm. The resistance of the motor is 0.3 Ω. Determine additional resistance required to obtain the rated torque;

i. at starting of the motor

ii. at the speed of 1000 rpm **[09 Marks]**

Question 05

a) Briefly explain the working principle of a three-phase induction motor. **[03 Marks]**

b) Why does an induction motor never run on synchronous speed? **[02 Marks]**

c) A 400 V, 50 Hz, three-phase induction motor has 4 poles and stator windings are star connected. Per phase rotor resistance and standstill reactance of the motor are 0.1 Ω and 1.0 Ω respectively. The full load slip is 4% and the stator to rotor turn ratio is 2:1. Calculate:

i. torque developed by the motor at full-load

ii. speed at the maximum torque

iii. Maximum torque **[15 Marks]**

Question 06

a) Briefly explain purpose and experimental procedure of locked rotor test of an induction motor. **[03 Marks]**

b) The reactance of the rotor of an induction motor varies greatly between starting and running conditions. Explain the reason. **[03 Marks]**

c) A 400 V, 50 Hz, 6 pole, three-phase induction motor takes a power input of 35 kW at its full-load speed of 890 rpm. The stator losses are 1 kW and friction and windage losses are 1.5 kW. Calculate;

i. Slip of the motor
ii. Rotor ohmic loss
iii. Shaft power
iv. Shaft torque
v. Efficiency **[14 Marks]**

Question 07

a) List three advantages of using a stationary armature in large synchronous generators? **[03 Marks]**

b) Briefly explain the open circuit test and short circuit test of an alternator **[06 Marks]**

c) A 1200 kVA, 3300 V, 50 Hz, three-phase star connected alternator has armature resistance of 0.25 Ω per phase. A field current of 40 A produces a short circuit current of 200 A and an open-circuit emf of 1100 V line-to-line. Calculate the voltage regulation on

i. Full-load, 0.8 p.f. lagging
ii. Full-load, 0.8 p.f. leading **[11 Marks]**

Question 08

a) Explain constructional differences between salient pole and cylindrical rotor synchronous machines. Why is cylindrical rotor machine used in thermal power plant and salient pole machine in hydro power plant? **[05 Marks]**

b) With the help of phasor diagrams explain the effect of armature reaction to the terminal voltage of an alternator for the following loads.

i. Inductive load
ii. Purely resistive load
iii. Capacitive load **[06 Marks]**

c) A 36 MVA, 20.8 kV, three-phase alternator has a synchronous reactance of 9 Ω and a nominal current of 1 kA. The no load saturation curve giving the relationship between E_0 and I_x is given in figure Q8. If the excitation is adjusted so that the terminal voltage remains fixed at 21 kV, calculate the exciting current required and draw the phasor diagram for the following conditions.

i. no-load
ii. resistive load of 36 MW
iii. capacitive load of 12 Mvar **[09 Marks]**

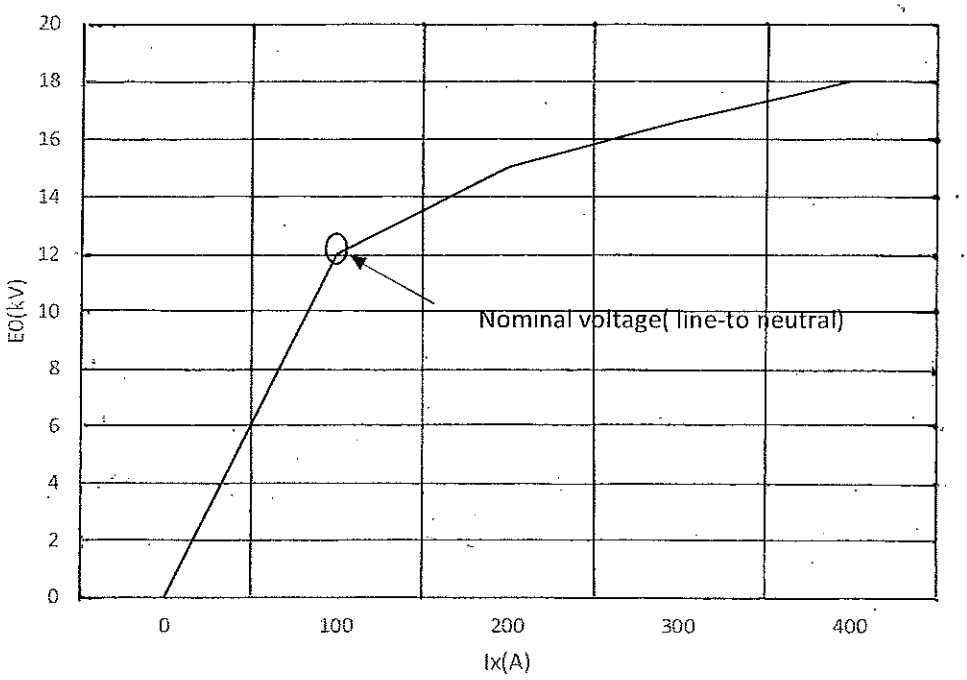


Figure Q8