The Open University of Sri Lanka
Department of Electrical and Computer Engineering
Advanced Diploma in Technology
ECX4238– Electrical Machines
Final Examination-2015/2016
Duration: Three hours **Closed Book**

Date: 26th November 2016 **Time: 09.30-12.30 hrs**

The paper contains eight (8) questions. Answer any (5) questions. All questions carry equal marks.

Q1)

a. Explain the necessity of a starter for a DC motor. Describe one of the methods of controlling the speed of a DC motor? **[6 Marks]**

b. A 230 V, DC series motor drives a load; the torque of which varies as the square of the speed. The motor takes a current of 15 A when the speed is 600 rpm. Calculate the speed and current when the motor field winding is shunted by a divertor of equal resistance as that of the field winding. Neglect all motor losses. State any assumptions you make. **[14 Marks]**

Q2)

a. Sketch the torque vs armature current, speed vs armature current and speed vs torque characteristics for the DC shunt motor? **[3 Marks]**

b. What do you mean by the term critical field resistance as applicable to the DC shunt generator? Why are the shunt generators said to be ' self -protected' under accidental short circuit situations? Justify your answer with the help of characteristic curves. **[5 Marks]**

c. A DC shunt motor drives a centrifugal pump whose torque varies as the square of the speed. The armature and field resistances of the motor are 0.1 Ω and 100 Ω respectively. The motor is fed from a 230 V supply and takes 45 A when running at 1000 rpm. What resistance must be inserted in the armature circuit to reduce the speed to 800 rpm? **[12 Marks]**

Q3)

a. Briefly explain the tests carried out to experimentally determine per phase parameters of three phase induction motor **[3 Marks]**

b. A three-phase, 400 V, 50 Hz, 4 pole, star connected squirrel cage induction motor has the following per-phase equivalent circuit parameters as referred to stator

$R_1 = 0.6\ \Omega$ $X_1 = 1.1\ \Omega$

$R_2' = 0.3\ \Omega$ $X_2' = 0.5\ \Omega$ $X_m = 25\ \Omega$

The mechanical losses are 1000 W and stator core loss is 500 W. If the machine operates at a slip of 3%, Determine

i. Rotor speed
ii. Stator current and power factor
iii. Mechanical power developed
iv. Output torque
v. Motor efficiency **[17 Marks]**

Q4)

a. The exciting current in a transformer is about 2% to 5% of the rated current whereas in three-phase induction motor it is about 40% to 50% of the rated current. Explain the reason **[3 Marks]**

b. The starting and maximum torques of a three-phase induction motor are 1.5 times and 2.5 times of the full load torque (respectively). Determine the percentage change in rotor circuit resistance to obtain a full load slip of 0.03. Neglect the stator impedance. **[7 Marks]**

c. A three-phase, 50 Hz, 400 V induction motor has 4 pole star-connected stator winding. Rotor resistance and standstill reactance per- phase are 0.1 Ω and 1.0 Ω respectively. The full load slip is 4 %. Stator to rotor turn ratio is 2:1. Calculate,

i. Total torque developed
ii. The horse power developed
iii. Maximum torque
iv. The speed at maximum torque

[10 Marks]

Q5)

a. What are the conditions for parallel operation of alternators? **[4 Marks]**

b. Two 50 MVA three-phase alternators operate in parallel. The settings of the governors are such that the rise in speed from full-load to no-load is 2% in one machine and 3% in the other, the characteristics being straight lines in both cases. If each machine is fully loaded when the total load is 100 MW, what would be the load on each machine when the total load is 60 MW? **[16 Marks]**

Q6)

a. When the load on an alternator is varied, its terminal voltage is also found to be varied. What can be the reason? Explain your answer? **[4 Marks]**

b. Explain briefly open circuit and short circuit tests of an alternator. How voltage regulation can be calculated by using the results of above tests. **[4 Marks]**

c. A three phase 1000 kVA, star connected, 50 Hz, 11 kV alternator has rated current of 52.5 A. The AC per-phase winding resistance is 0.45 Ω. The test results are given below:

OC test: Field current =12.5 A, line to line voltage =422 V

SC test: Field current=12.5 A, line current=52.5 A

Determine the full load voltage regulation of the alternator, when the alternator is operated

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

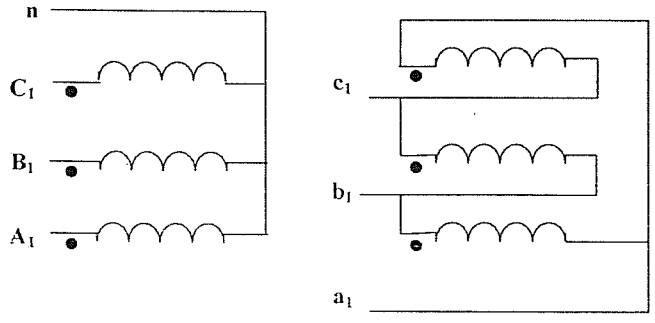
[12 Marks]

Q7)

a. Certain three-phase transformer has been labelled as 32Yd1.Explain what information you can obtain from this labelling? **[3 Marks]**

b. Sketch the winding connection and draw phasor diagram to show all voltages and currents of the transformer mentioned in (a) **[3 Marks]**

c. Figure Q7 shows the winding connections of a three phase transformer. Draw the phasor diagram to show the EMFs in windings and determine the phase shift between primary and secondary EMFs



[6 Marks]

Figure Q7

d. A three-phase 120 kVA, 6000V/400V, 50 Hz, star-star transformer has iron loss of 1800W. The maximum efficiency occurs at ¾ of the full-load. Find the efficiency of the transformer at
   i. Full-load at 0.8 power factor
   ii. The maximum efficiency at unity power factor **[8 Marks]**

Q8)

a. Briefly explain the methods of transformer connections when setting a three-phase transformer using three single-phase transformers. **[3 Marks]**

b. Compare OFWF and ODAF cooling methods of transformer. **[3Marks]**

c. Consider a three -phase 100 kVA, 3300/400 V, 50 Hz delta-star connected transformer. The per-phase resistance of the HV winding is 3.5 Ω and that of the LV winding is 0.02 Ω. Calculate the iron losses of the transformer at nominal voltage and frequency if its full-load efficiency be 95.8% at 0.8 power factor lagging. **[8 Marks]**

d. A three-phase 500 kVA, 6000 V/400 V, 50 Hz, delta-star transformer is delivering 300 kW at 0.8 power factor lagging to a balanced three-phase load connected to the LV side. The HV side is supplied from 6000 V, three-phase supply. Calculate the line current and current through the windings of both sides of the transformer. Assume that the transformer is ideal. **[6 Marks]**