The Open University of Sri Lanka
Department of Electrical and Computer Engineering
Diploma in Technology
ECX4238– Electrical Machines
Final Examination-2014/2015
Duration: Three hours **Closed Book**

Date: 27th August 2015 **Time: 09.30-12.30 hrs**

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

Question 1

a. Why it is not possible to obtain speed of a DC shunt motor above normal by armature resistance control? **[4 Marks]**

b. A belt driven 100 kW DC shunt generator running at 300 rpm on 230 V bus-bar, continues to run as a motor when the belt breaks and taking 10 kW power from supply. The armature and field resistances are 0.03 Ω and 60 Ω respectively. The brush contact drop under each brush equals to 1 V. Determine speed of the machine when it is operating as the motor. State any assumptions you make **[10 Marks]**

c. A DC motor runs at 900 rpm when it is connected to 460 V supply. Calculate the approximate speed, when the supply of the machine is 200 V. Assume that the new flux to be 0.7 of the flux when it was connected to 460 V **[6 Marks]**

Question 2

a. What are the methods used to control the speed of a DC shunt motor above and below its base speed? **[4 Marks]**

b. A 200 V DC series motor takes 40 A from the supply when it is running at the speed of 700 rpm. Armature and field resistance of the machine are 0.15 Ω and 0.1 Ω respectively. Now, the field winding is shunted by a resistance equivalent to the resistance of the field winding, and the torque is increased by 50%. Determine new speed of the machine and current taken from the supply **[16 Marks]**

Question 3

a. Explain briefly why the large three-phase induction motors need special starting arrangements. **[3 Marks]**

b. A three-phase, 4 pole, star connected, 400 V, 50 Hz squirrel cage induction motor has the following equivalent circuit parameters per phase in Ω. (All parameters are referred to the stator side and indicated with usual notations)

$R_1=0.25$ $X_1=1.4$
$R_2^1=0.50$ $X_2^1=1.0$ $X_m=40$

Total fixed (core, friction and windage) losses are 1275 W. If the machine operates at a slip of 4%, calculate the following by clearly stating the assumptions make.

i. Rotor speed **[4 Marks]**
ii. Stator current **[6 Marks]**
iii. Shaft torque **[7 Marks]**

Question 4

a. Compare the merits and demerits of Squirrel cage induction motor and Wound rotor induction motor. **[3 Marks]**

b. A three-phase, 50 Hz, 6 pole, 400 V 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 **[4 Marks]**
ii. Rotor copper loss **[4 Marks]**
iii. Shaft power **[4 Marks]**
iv. Shaft torque **[2 Marks]**
v. Motor Efficiency **[3 Marks]**

Question 5

a. Draw an equivalent circuit of a cylindrical rotor synchronous generator and obtain an expression for maximum power output. Assume that the armature resistance of the synchronous generator is neglected. **[4 Marks]**

b. A three phase, 22 kV, star connected turbo alternator with a synchronous impedance of j1.3 Ω/phase is delivering 230 MW at unity power factor to 22 kV grid.

i. With the turbine power remaining constant, the alternator excitation is increased by 30%. Determine machine current and power factor based upon linearity assumption. **[8 Marks]**
ii. At the new excitation, the turbine power is now increased till the machine delivers 275 MW. Calculate the new current and power factor **[8 Marks]**

Question 6

a. What type of alternators are used for i) hydro turbines ii) steam turbines as prime movers? Give reasons. **[4 Marks]**

b. A three phase 1500kVA, star connected, 50 Hz, 2300V alternator has a resistance between each pair of terminals as measured by direct current is 0.16 Ω. Assume that the effective resistance is 1.5 times the ohmic resistance. A field current of 70A produces a short circuit current equal to full-load current of 376A in each line. The same field current produces an emf of 700V on open circuit.

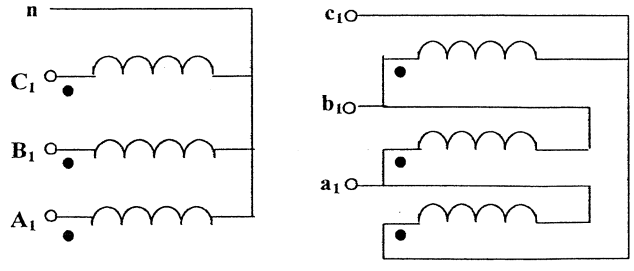
i. Determine the synchronous reactance of the machine **[8 Marks]**
ii. Determine the full load regulation at 0.8 power factor lagging **[8 Marks]**

Question 7

a. Certain three-phase transformer has been labelled as 41Dy11.Explain what information you can obtain from above 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



[8 Marks]

Figure Q7

d. A three-phase, delta-star connected 11 kV/ 400 V , 50 Hz transformer takes a line current of 5 A , when secondary load of 0.8 p.f lagging is connected. Determine each coil current and power output of transformer **[6 Marks]**

Question 8

a. Compare ONAF and OFAN cooling methods of transformer. **[3 Marks]**

b. A 100 kVA, 3300/400 V, 50Hz, three-phase transformer is delta connected on the high voltage side and star connected on the low voltage side. The resistance of the HV winding is 4 Ω per phase and that of the LV winding is 0.04 Ω per phase. Calculate the iron losses of the transformer at normal voltage and frequency if its full load efficiency be 95% at 0.85 power factor lagging **[8 Marks]**

c. A 120 kVA, 6000/400 V, Y-Y connected, 50Hz, three-phase transformer has an iron loss of 1800 W. The maximum efficiency occurs at 75 % of the full-load. Find the efficiency of the transformer at

i. Full load and 0.8 power factor **[5 Marks]**

ii. The maximum efficiency at unity power factor **[4 Marks]**