The Open University of Sri Lanka
Department of Electrical and Computer Engineering
Diploma in Technology
**ECX4238– Electrical Machines**
Final Examination-2013/2014
Duration: Three hours

Date: 04th September 2014 Time: 09.30-12.30 hrs

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

**(1)**

a. Describe the speed and torque characteristic of DC series motor. **[5 Marks]**

b. List the speed controlling methods of DC series motor and briefly explain one of the methods. **[5 Marks]**

c. A DC series motor runs at 600 rpm drawing 42 A from 440 V supply. Determine the value of external resistance to be added in series with the armature for the motor to run at 475 rpm. The load torque varies as the square of the speed. The armature resistance and series field resistance are 0.4 Ω and 0.3 Ω respectively. Assume linear magnetization. **[10 Marks]**

**(2)**

a. Explain the necessity of using a starter with a DC motor. **[3 Marks]**

b. A 240V DC shunt motor has an armature resistance of 0.2 Ω. Clearly stating any assumptions you made, Calculate,
   i. The value of resistance which must be introduced into the armature circuit to limit the starting current to 40 A
   ii. The EMF generated when the motor is running at a constant speed with this additional resistance in circuit and with an armature current of 30 A. **[8 Marks]**

c. A DC shunt generator driven by a belt from an engine runs at 800 rpm while feeding110 kW of electric power into 230 mains. When the belt breaks it continues to run as a motor drawing 8 kW from the mains. At what speed would it run? Given that armature and field resistances are 0.1 Ω and 120 Ω respectively. **[9 Marks]**

**(3)**

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

b. Draw power flow diagram of three-phase induction motor. **[2 Marks]**

c. A three-phase, 3 pole-pairs (6 poles), 50 Hz, 400 V induction motor has friction and windage losses of 2 kW. When running at 960 rpm, power input to the motor is 40 kW at 0.85 power factor lagging. The stator losses equal to rotor copper losses. Calculate following by clearly stating any assumptions you make.

i. Synchronous speed
ii. Slip
iii. Rotor copper loss
iv. Mechanical power developed by the motor
v. Motor input current
vi. Motor Efficiency **[15 Marks]**

**(4)**

a. Discuss the advantages and disadvantages of star-delta starting over DOL (Direct on line) starting of a squirrel cage induction motor. **[4 Marks]**

b. A three-phase, 6 pole, 50 Hz, 400 V induction motor develops maximum torque at a slip of 10%. In a particular application, it runs at 5% slip at rated voltage, driving a load whose torque demand is proportional to square of speed. What is the maximum value to which the supply voltage can drop, if the motor is not to decrease below 900 rpm? Neglect stator impedance drop. **[16 Marks]**

**(5)**

a. What are the main constraints of the amount of power delivered by synchronous generator? Draw a capability diagram (Capability curve) of a synchronous generator and clearly indicate limits and the safe operating area. (Assume armature resistance is negligible) **[5 Marks]**

b. A 2300 V 1000-kVA 0.8-PF-lagging 60-Hz two-pole Y-connected synchronous generator has a synchronous reactance of 1.1 Ω and an armature resistance of 0.15 Ω. At 60 Hz, its friction and windage losses are 24 kW, and its core losses are 18 kW. The field circuit has a dc voltage of 200 V, and the maximum Field current is 10 A. The resistance of the field circuit is adjustable over the range from 20 to 200 Ω. The OCC of this generator is shown in Figure Q5.

i. How much field current is required to make terminal voltage equal to 2300 V when the generator is running at no load?
ii. What is the internal generated voltage of this machine at rated conditions?
iii. How much field current is required to make terminal voltage equal to 2300 V when the generator is running at rated conditions?
iv. How much power and torque must the generator's prime mover be capable of supplying?
v. Construct a capability curve for this generator. **[15 Marks]**

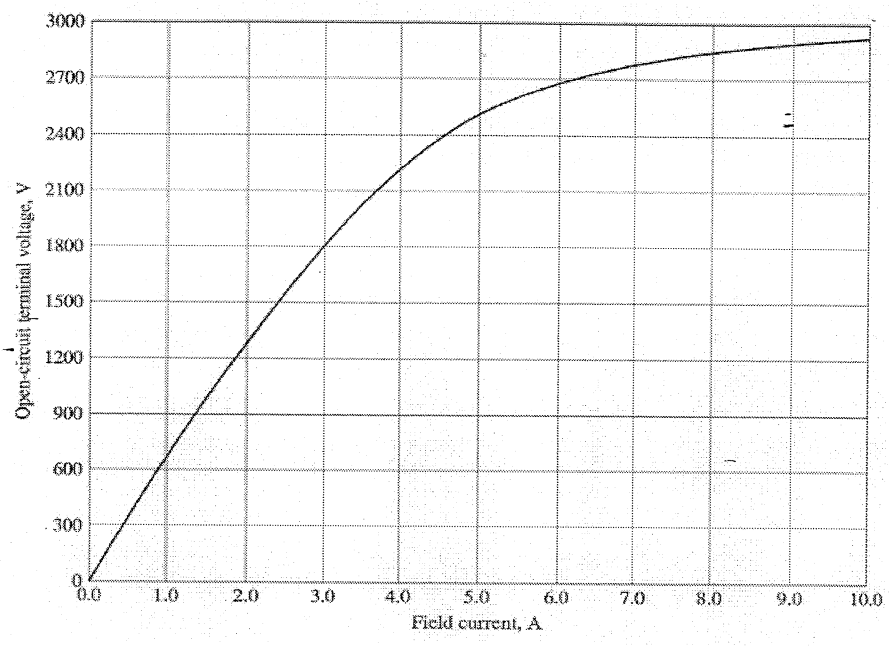


**Figure Q5: Open circuit characteristics**

**(6)**

a. Briefly explain the open circuit test and short circuit test of an alternator. **[4 Marks]**

b. The ac resistance of winding per phase of a three-phase star connected, 1000 kVA, 11 kV alternator is 0.45 Ω. The open circuit and short circuit test results of this alternator is given below.

OC Test: Field current =12.5 A, voltage between line = 422 V

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

Determine the full-load voltage regulation of the alternator at,

i. 0.8 power factor lagging
ii. 0.8 power factor leading **[16 Marks]**

**(7)**

a. Compare ONAF and OFAN cooling methods of transformer. **[2 Marks]**

b. A 200 kVA, 11000/400 V, 50 Hz, delta-star three phase distribution transformer gave the following test results.

OC test : 400V, 9 A, 1.5 kW
SC test : 350 V, Rated current, 2.1 kW

i. Draw the equivalent circuit of the transformer
   a. referred to LV side and
   b. referred to HV side inserting all the parameter values. **[6 Marks]**

ii. Calculate the efficiency of the transformer at 0.85 lagging load power factor at,
   a. full load.
   b. 75% of full load **[4 Marks]**

iii. At what load or kVA the transformer is to be operated for maximum efficiency? Also calculate the value of maximum efficiency at unity load power factor. **[5 Marks]**

iv. Determine the voltage regulation of the transformer at full load at 0.9 power factor lagging. **[3 Marks]**

**(8)**

a. Certain three-phase transformer has been labelled as 31Dy1.Explain what information you can obtain from above labelling? **[2 Marks]**

b. Sketch the winding connection and draw phasor diagram to show all voltages and currents of the transformer mentioned in (a) **[4 Marks]**

c. Figure Q8 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]**

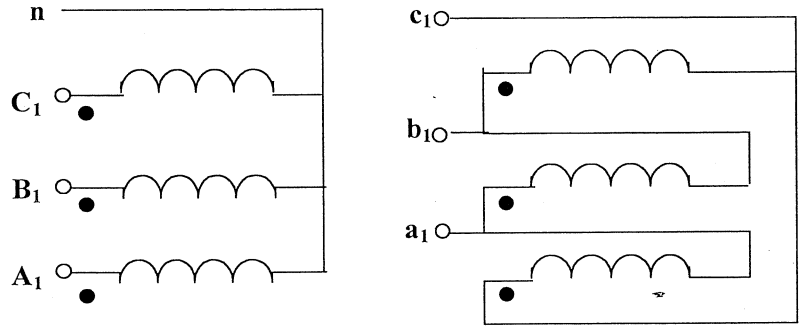


**Figure Q8**

d. 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 0.03 Ω per phase. Calculate the iron losses of the transformer at normal voltage and frequency if its full load efficiency be 95.5% at 0.8 power factor lagging. **[6 Marks]**