00060

The Open University of Sri Lanka
Department of Electrical and Computer Engineering
Bachelor of Technology Honors in Engineering
ECX4248– Electrical Machines
Final Examination-2016/2017
Duration: Three hours

Closed Book

Date: 18th November 2017

Time: 09.30-12.30 hrs

This paper contains two sections: Section A and Section B. Section A consist of six (6) questions. Answer any four (4) questions from section A. Section B consist of two (2) questions which are MCQ type. Answer one (1) question from section B. No penalty marks allocated for MCQs.

Section A

(80 Marks)

Q1

a. Compare ONWF and OFWF cooling methods of a transformer **[2 Marks]**

b. Explain "cooling curve" related to electrical machines and describe its mathematical relationship **[2 Marks]**

c. Figure Q1-c 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 **[4 Marks]**

d. A 2000/200 V, 20 kVA single phase two winding transformer is connected as a step-up autotransformer as shown in figure Q1-d in which AB is 200 V winding and BC is 2000 V winding. The 200 V winding has enough insulation to withstand 2200 V to ground. Calculate

   i. LV and HV side voltage ratings of the autotransformer
   ii. autotransformer kVA rating
   iii. efficiency of the autotransformer at 0.8 p.f. when iron and full load Cu losses are equal to 120 W and 300W(respectively). **[6 Marks]**

e. A three-phase 120 kVA, 6000/400 V, 50 Hz, star/star transformer has core loss of 1700 W. The maximum efficiency occurs at two third (2/3) of the full-load. Find the efficiency of the transformer at

   i. full-load at 0.85 power factor
   ii. the maximum efficiency at unity power factor **[6 Marks]**

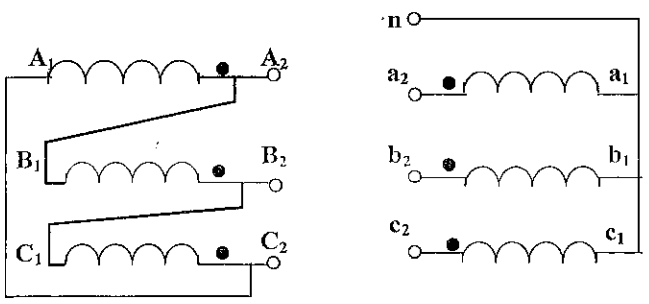

Figure Q1-c

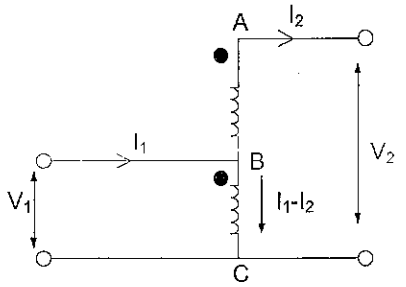

Figure Q1-d

Q2

a. Compare speed-torque characteristics of DC series motor with DC shunt motor. List the applications of each motor considering their speed-torque characteristics **[3 Marks]**

b. Explain diverter field control method used to control the speed of DC series motor **[3 Marks]**

c. A four pole series wound fan motor draws an armature current of 50 A, when running at 2000 rpm on 230 V DC supply with four field coils connected in series. The four field coils are now connected in two parallel groups of two coils in series. Assuming the flux/pole to be proportional to the exciting current and load torque proportional to the square of speed, find the new speed and armature current. Armature resistance is 0.2 Ω and resistance of each field coil is 0.05 Ω. Assume that the losses are negligible. **[14 Marks]**

Q3

a. What are the factors need to be considered before starting of DC shunt motor? **[2 Marks]**

b. A DC shunt motor runs at 1200 rpm on no-load drawing 5A from 230 V mains. Armature and field resistance of the motor are 0.25 Ω and 115 Ω respectively. When the motor is loaded it draws 62 A from the mains. The armature reaction demagnetizes the field to the extent of 5%.

i. Calculate the speed of the motor?
ii. Calculate the internal torque developed at no-load and on load.
iii. What is motor shaft torque at load?

[10 Marks]

c. A DC shunt generator driven by a belt from an engine runs at 750 rpm while feeding 100 kW of electric power into 230 V mains. When the engine shuts down DC shunt generator continuous to run as a motor drawing 8 kW from the mains. At what speed would it run? Armature and field resistances are 0.08 Ω and 115 Ω respectively. **[8 Marks]**

Q4

a. Describe no-load test and blocked-rotor test for induction motor **[4 Marks]**

b. A three-phase, star-connected ,400 V, 50 Hz, 4 pole induction motor has the following constants in ohms (per phase) referred to stator:
$R_1=0.3$ $R'_2=0.15$ $X_1=0.5$ $X'_2=0.21$ $X_m=13.25$
The core loss is 350 W and frictional and windage loss is 1000 W. For a slip of 2% compute,

i. Rotor speed
ii. Stator current and its power factor
iii. Output torque
iv. Efficiency of the motor

[8 Marks]

c. A 440 V, 4 pole, three-phase, 50 Hz star connected induction motor has a rotor resistance and reactance per phase of 0.01 Ω and 0.1 Ω respectively. If maximum torque is twice the full-load torque and ratio of stator to rotor turns is 4, determine;

i. maximum torque and the corresponding slip
ii. the full-load slip and power output

[8 Marks]

Q5

a. Draw an equivalent circuit of a cylindrical rotor synchronous generator with corresponding phasor diagram. Assume that the armature resistance of the synchronous generator can be neglected and inductive load is connected to its output terminal. **[8 Marks]**

b. A three-phase star connected alternator is rated at 1600 kVA, 13 kV. The per phase armature resistance and synchronous reactance are 1.5 Ω and 30 Ω respectively. The alternator is connected to a load of 1280 kW at 0.85 p.f. lagging.

i. Sketch the phasor diagram
ii. Calculate voltage regulation **[12 Marks]**

Q6

a. Derive an expression for output power of a cylindrical rotor synchronous generator and draw the power-load angle characteristics **[6 Marks]**

b. Briefly explain the capability curve (operating chart) of a cylindrical rotor synchronous generator including all limits. **[6 Marks]**

c. Explain three excitation methods used in alternators with relevant figures. **[8 Marks]**

Section B
(20 marks)

Q1 Underline the most suitable answer in the separate answer sheet provided.

i. Transformer is a device which .....
   a. can step up or step down the level of voltage
   b. its working without changing the power
   c. work through on electric induction
   d. all of these

ii. Total core loss of the transformer is also called as .....?
   a. eddy current loss
   b. hysteresis loss
   c. magnetic loss
   d. copper loss

iii. Thin laminations are used in a machine in order to reduce
   a. eddy current loss
   b. hysteresis loss
   c. both a and b
   d. copper loss

iv. Autotransformer makes effective saving on copper and copper losses, when its transformation ratio is equal to
   a. very low
   b. less than one
   c. greater than one
   d. approximate to one

v. An Isolation Transformer Has Primary to Secondary turns ratio of_____.
   a. 2 : 1
   b. 1 : 2
   c. 1 : 1
   d. Can be any ratio

vi. In Single Phase Transformer, The Primary Current and Primary Voltage is 4.55 and 11kV respectively. The Rating of the transformer would be_____?
   a. 50 kVA
   b. 86 kVA
   c. 100 kVA
   d. 150 kVA

vii. If the primary power of an ideal transformer having a 2:1 voltage ratio is 100 W, the secondary power is
   a. 100 W
   b. 50 W
   c. 75 W
   d. 200

viii. In an auto transformer, the primary and secondary are.....coupled.
   a. only magnetically
   b. only electrically
   c. magnetically as well as electrically
   d. none of the above

ix. Transformer action requires a
   a. constant magnetic flux
   b. increasing magnetic flux
   c. alternating magnetic lux
   d. alternating electric flux

x. For an ideal transformer the winding should have
   a. maximum resistance on primary side and least resistance on secondary side
   b. minimum resistance on primary side and maximum resistance on secondary side
   c. equal resistance on primary and secondary side
   d. no ohmic resistance on either side

xi. R_1 is the resistance of the primary winding of the transformer. The turn ratio in terms of primary to secondary is K. Then the equivalent resistance of the primary referred to secondary is
   a. R_1/K
   b. K^2R_1
   c. R_1/K^2
   d. KR_1

xii. What does the use the of height flux density value in transformer design lead to?
   a. Increase in weight/kVA.
   b. Decrease in weight/kVA.
   c. Reduced copper loss.
   d. Reduced iron loss.

xiii. Dissolve gas analysis of transformer oil is carried out to determine
   a. condition of transformer oil.
   b. condition of transformer.
   c. condition of bushings.
   d. condition of bushing stud.

xiv. The main purpose of providing tertiary winding in a three phase transformer is
   a. to suppress harmonic and unbalance in voltage.
   b. to interconnect three voltage systems.
   c. to carry extra load
   d. none of the above.

xv. When operating, two or more transformers in parallel, % impedance of these transformers should be
   a. inversely proportional to MVA rating of transformers.
   b. proportionate to MVA rating of transformers.
   c. same.
   d. such that actual impedance of all transformers would be same.

xvi. Tap changer is generally provided in
   a. current transformer.
   b. power transformer.
   c. voltage transformer.
   d. earthing transformer

[1.25*16 Marks]

Q2 Underline the most suitable answer in the separate answer sheet provided.

i. Induction motor operation depends on
   a. rotating magnetic field
   b. stationary magnetic field
   c. either of these
   d. none of the above

ii. Slip ring induction motor has
   a. Low starting torque
   b. medium starting torque
   c. high starting torque
   d. none of these

iii. A 3-phase 440 V, 50 Hz induction motor has 4% slip. The frequency of rotor e.m.f. will be
   a. 200 Hz
   b. 50 Hz
   c. 2 Hz
   d. 0.2 Hz

iv. The number of slip rings on a squirrel cage induction motor is usually
   a. two
   b. three
   c. four
   d. none

v. In case the air gap in an induction motor is increased
   a. the magnetizing current of the rotor will decrease
   b. the power factor will decrease
   c. Speed of motor will increase
   d. the windage losses will increase

vi. The frequency of rotor current in an induction motor is
   a. slip times the frequency of stator current
   b. slip times the frequency of supply
   c. one by slip times the frequency of stator current
   d. one by slip times the frequency of supply

vii. Slip of an induction motor increases with
   a. increase in current and decrease in torque
   b. increase in current and torque
   c. decrease in current and torque
   d. decrease in current and increase in torque

viii. Slip ring induction motor are employed only for
   a. Speed control
   b. High starting torque
   c. Both a and b
   d. None of these

ix. What is the shunt resistance component of the equivalent circuit obtained by no load test of an induction motor representative of?
   a. windage and friction loss
   b. core loss only
   c. both a and b
   d. Copper loss

x. Find the number of poles required, when the frequency is 50Hz and speed of the motor is 500 rpm?
   a. 5
   b. 10
   c. 12
   d. 24

xi. The sequence of induction motor is RYB, then the direction of induction motor can be changed by which of the following sequence?
   a. BYR
   b. RBY
   c. BRY
   d. All of the above

xii. A 4 pole 50 Hz induction motor is running at 1470 rpm. What is the slip value?
   a. 0.2
   b. 0.02
   c. 0.04
   d. 0.4

xiii. At stand still condition the value of slip is
   a. 1
   b. 0
   c. Infinite value
   d. Finite value

xiv. When maximum starting torque is obtained, rotor power factor is
   a. unity
   b. zero
   c. 0.707 lagging
   d. 0.5 lagging

xv. The condition for maximum running torque is
   a. R = X
   b. R = S.X
   c. R = X/2
   d. R = S.X/2

xvi. The motor operate in stable region at which of the following slip?
   a. low slip region
   b. high slip region
   c. both a and b
   d. unity slip

[1.25*16 Marks]

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Registration no: .....

Use this sheet to answer the MCQs in section B. Attach this sheet with your answer book. Clearly write the selected question number in the space given below.

Question no: .....

i.	a	b	c	d
ii.	a	b	c	d
iii.	a	b	c	d
iv.	a	b	c	d
v.	a	b	c	d
vi.	a	b	c	d
vii.	a	b	c	d
viii.	a	b	c	d

ix	a	b	c	d
x	a	b	c	d
xi	a	b	c	d
xii	a	b	c	d
xiii	a	b	c	d
xiv	a	b	c	d
xv	a	b	c	d
xvi	a	b	c	d