UNIVERSITY OF RUHUNA

Faculty of Engineering

Mid-Semester 3 Examination in Engineering: June 2014

Module Number: EE3304 **Module Name: Electrical Machines**

[Two Hours]

[Answer all questions, each question carries 5 marks]

Q1 a) Briefly explain the four basic principles which describe the fundamentals in electrical machines' operation.

[1.0 Mark]

b) What are the types of losses take place in a ferromagnetic core? What precautionary actions can be taken to minimize the above losses?

[1.0 Mark]

c) Figure Q1 shows a static magnetic field rotating at an angular speed of ω, in the center of a rectangular shape ($2r$ width, l length) stationary coil.

i) Show that the induced voltage of the coil is given by,

$$e_{ind} = N_c(2Brl)\omega \sin \omega t$$

where,

N_c - Number of turns in the coil
t - Time
B - Flux density

ii) The flux density and the rate of rotation of the rotating magnetic field mentioned in part c) (i), is 0.3 Wb/m^2 and 1200 rpm, respectively. The coil length is 0.4 m and the width is 0.5 m. If the coil consists of 15 turns, express the induced voltage as a function of time and hence calculate the rms voltage of the coil.

[3.0 Marks]

Q2. a) The transformer model parameters can be adequately approximated using the open circuit and the short circuit tests for a given transformer. Briefly explain the method of performing these tests.

[1.5 Marks]

b) A 2 kVA, 230/115 V transformer has been tested to determine its equivalent circuit. The results of the tests are shown below

Open Circuit Test	Short Circuit Test
I_{oc} = 0.45 A	V_{sc}= 19.1V
P_{oc}= 30W	P_{sc}= 42.3W

All data given were taken from the primary side of the transformer.

i) Find the equivalent circuit of this transformer referred to the law-voltage side.

ii) Determine the voltage regulation and the efficiency of the transformer at rated conditions and 0.8 power factor lagging.

[3.5 Marks]

Q3. a) What are the types of losses take place in an induction motor? Draw the power flow diagram indicating how the power flows through an induction motor.

[1.0 Mark]

b) A 208 V, two-pole, 60 Hz Y-connected wound-rotor induction motor is rated at 15 hp. The motor operates a load with the speed of 3420 rpm. The rotational and the core loses of the machine are 250 W and 180 W, respectively Its equivalent circuit parameters are

$R_1 = 0.20\ \Omega$ $R_2' = 0.12\ \Omega$ $X_m = 15\ \Omega$

$X_1 = 0.41\ \Omega$ $X_2' = 0.41\ \Omega$

Note that all the notations have their usual meanings.

i) Find the air gap power (P_{AG}).

ii) Calculate the induced torque (τ_{ind}) and the load torque (τ_{load}).

iii) Calculate the overall efficiency of the machine.

[4.0 Marks]

Q4. a) Briefly explain the rotor resistance starting method for a wound rotor induction motor.

[1.0 Mark]

b) Consider the induction motor given in Q3 part b)

i) Calculate the speed at which the induction motor gives its maximum torque.

ii) How much additional resistance would be necessary to add to the rotor circuit to make the maximum torque occur at starting condition?

[4.0 Marks]

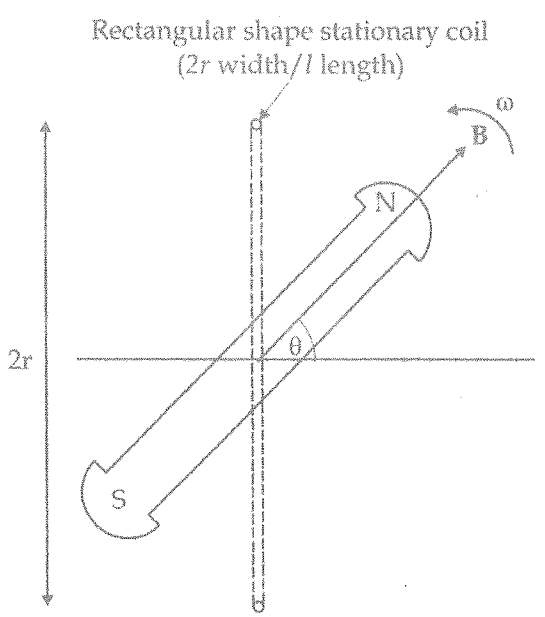

Figure Q1