KIMATHI UNIVERSITY COLLEGE OF TECHNOLOGY

SCHOOL OF ENGINEERING

BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONICS ENGINEERING

University Examination 2010/2011

THIRD YEAR FIRST SEMESTER

EEE 2306: ELECTRICAL MACHINES II

INSTRUCTION DATE: AUGUST 2011

This paper contains five questions. **A**nswer **QUESTION 1(COMPULSORY)** and any other two Questions.

QUESTION 1

a) With the aid of a circuit diagram and phasor, explain how a split phase single phase induction motor develops the starting torque. **(4 marks).**

b) State the advantages and disadvantages of a polyphase induction motor over other type of motors that are used as drive systems. **(4 marks)**

c) With the aid of a diagram explain the star / delta starting of a three phase induction motor stating its disadvantages. **(6 marks)**

d) Using relevant diagrams and equations discuss the various power stages in an induction motor and give the expression for the efficiency. **(8 marks)**

e) A load of 1200kVA at a power factor of 0.9397 lagging is supplied by two transformers in parallel, each of 800kVA capacity. The transformation ratio is the same at 6600/415V Delta/Star. if the equivalent impedances referred to secondary are $(0.004 + j0.02)\Omega$ and $(0.01 + j\ 0.025)\Omega$ per phase respectively. calculate

i). power of each transformer,

ii). Power factor of each. **(8 marks)**

QUESTION 2

a) Explain the following terms, with respect to a three phase induction motor

i). Plugging

ii). Single phasing

iii). cogging

iv). crawling **(4 marks)**

b) A 50-kW, 440-V, 50-Hz, six-pole induction motor has a slip of 6 percent when operating at full-load conditions. At full-load conditions, the friction and windage losses are 300 W, and the core losses are 600W. Find the following values for full-load conditions:

i). The shaft speed n_m

ii). The output power in watts

iii). The load torque τ_{load} in newton-meters

iv). The induced torque τ_{ind} in newton-meters **(4 marks)**

c) A three-phase Y-connected 220-V (line-to-line) 7.5-kW 60-Hz six-pole induction motor has the following parameter values in Ω/phase referred to the stator:

$$R_1 = 0.294 \quad R_2 = 0.144$$

$$X_1 = 0.503 \quad X_2 = 0.209 \quad X_m = 13.25$$

The total friction, windage, and core losses may be assumed to be constant at 403 W, independent of load. For a slip of 2 percent, compute

i). the speed,

ii). output torque and power,

iii). stator current,

iv). power factor, and

v). Efficiency when the motor is operated at rated voltage and frequency. **(6 marks)**

d) Using a 6 coil machine, explain how speed control can be obtained on a three phase induction machine (use both parallel and series connections). **(6 marks)**

QUESTION 3

a) Explain how rotational torque is developed in a capacitor start motor **(2 marks)**

b) Using double field revolving theory and with the help of diagrams explain the operation of Single phase induction machines **(6 marks)**

c) For a 230V, 1-phase induction motor, the parameters of the equivalent circuit are $R_1 = R_2' = 8\ \Omega$, $X_1 = X_2' = 12\ \Omega$, and $X_m = 200\ \Omega$. At a slip of 4%, calculate

i) Input current

ii) Input power

iii) Developed power

iv) Developed torque at rated voltage. The motor speed is 1728rpm. **(6 marks)**

d) A resistance split phase motor rated at 0.25hp (187W), 115V, 60Hz. When the rotor is locked, a test at reduced voltage on the main and auxiliary windings yield the following results

	main winding	**auxiliary winding**
applied voltage	$E = 23$ V	$E = 23$ V
current	$I_m = 4$ A	$I_a = 1.5$ A
active power	$P_m = 60$ W	$P_a = 30$ W

Calculate

i) the phase angle between I_a and I_s

ii) The locked rotor current drawn from the line at 115V. **(6 marks)**

QUESTION 4

a) Derive the equation for starting torque in a 3 phase induction machine and the condition for the maximum torque. **(4 marks)**

b) A 250W, 230V, 50Hz capacitor start motor has the following constants for the main and auxiliary windings: Main windings $Z_m = (4.5 + j3.5)ohms$ and the auxiliary $Z_a = (9.5 + j3.5)ohms$. Determine the value of starting capacitor that will place the main and auxiliary winding current in quadrature at starting. **(5 marks)**

c) A three-phase, 60-Hz induction motor runs at 890 r/min at no load and at 840 r/min at full load.
   i) How many poles does this motor have?
   ii) What is the slip at rated load?
   iii) What is the speed at one-quarter of the rated load?
   iv) What is the rotor's electrical frequency at one-quarter of the rated load? **(4 marks)**

d) A 15-kVA, 8000/230V distribution transformer has impedance referred to the primary of $(80 + j300)\Omega$. The components of the excitation branch referred to the primary side are given as $R_C = 350k\Omega$ and $X_M = 70\ k\Omega$.
   i) If the primary voltage is 7967 V and the load impedance is $Z_L = 3.2 + j1.5\ \Omega$, calculate the secondary voltage of the transformer
   ii) Calculate the voltage regulation of the transformer in (i) above.
   iii) If the load is disconnected and a capacitor of $-j3.5\ \Omega$ is connected in its place, calculate the secondary voltage of the transformer.
   iv) What is its voltage regulation under the conditions in (iii) above? **(7 marks)**

QUESTION 5

a) Define voltage regulation in a transformer and state how power factor affects it. **(2 marks)**

b)
   i) With the aid of a diagram explain how speed reversal can be achieved in a single phase induction motor **(3 marks)**
   ii) Explain why a universal motor operates better on DC than on AC **(2 marks)**
   iii) Explain why auxiliary windings are disconnected upon starting. **(1 mark)**

c) A universal series motor has resistance of 30Ω and inductance of 0.5H. When connected to a 250V d.c supply, and loaded to take 0.8A, it runs at 2000rpm. Estimate is speed and power factor, when connected to a 250V, 50Hz ac supply and loaded to the same current. **(5 marks)**

d) Discuss the different speed control methods that are used in speed control of three phase induction motors **(7 marks)**