



KIMATHI UNIVERSITY COLLEGE OF TECHNOLOGY

UNIVERSITY EXAMINATIONS 2010/2011

THIRD YEAR FIRST SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE IN TELECOMMUNICATION AND INFORMATION TECHNOLOGY

EEE2306 : ELECTRICAL MACHINES II

DATE: 13TH APRIL 2011

TIME: 11.00AM – 1.00PM

INSTRUCTION

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

QUESTION 1

- a) Explain the principle of operation of a three phase induction motor. Giving details of how rotating magnetic field is developed in the air gap. **(8 marks)**
- b) With reference to the three phase induction motor define the following terms and state what causes them.
- i) Crawling
 - ii) Cogging **(4 marks)**
- c) Describe what singlephasing is, its causes and state how a three phase induction motor can be protected against single phasing. **(4 marks)**
- d) A 100,000-kVA 230/115-kV Δ - Δ three-phase power transformer has a per-unit resistance of 0.02 pu and a per-unit reactance of 0.055 pu. The excitation branch elements are $R_C = 110$ pu and $X_m = 20$ pu
- i) If this transformer supplies a load of 80 MVA at 0.85 PF lagging, draw the phasor diagram of one phase of the transformer.
 - ii) What is the voltage regulation of the transformer bank under these conditions?
 - iii) Sketch the equivalent circuit referred to the low-voltage side of one phase of this transformer.
 - iv) Calculate the entire transformer impedances referred to the low-voltage side. **(9 marks)**

- e) Using cross field theory, and with the help of diagrams, Explain the operation of a single phase induction machine **(5 Marks)**

QUESTION 2

- a) Show that the frequency of induced emf in the rotor is given by the following expression

$$F_r = s f_s \quad \text{Where } F_r = \text{rotor frequency}$$

$$s = \text{slip}$$

$$f_s = \text{synchronous frequency} \quad \text{(3Marks)}$$

- b) A 6-pole, 60Hz, Star connected, three phase induction motor has the following parameters per phase $R_1 = 0.5\Omega$, $R_2 = 0.25\Omega$, $X_1 = 0.75\Omega$, $X_2 = 0.5\Omega$, $X_m = 100\Omega$. and $R_c = 500\Omega$. The friction and windage losses are 150W. Determine the efficiency of the motor at its rated slip of 2.5%. **(8 marks)**

- c) A 208-V, 60 Hz, six-pole Y-connected 25-hp design class B induction motor is tested in the laboratory, with the following results:

No load:	208 V,	22.0 A,	1200 W,	60 Hz
Locked rotor:	24.6 V,	64.5 A,	2200 W,	15 Hz
DC test:	13.5 V,	64 A		

Find the equivalent circuit of this motor, and plot its torque-speed characteristic curve.

(7 marks)

- d) Differentiate between the slip ring and Squirrel cage motor **(2 marks)**

QUESTION 3

- a) A 20-kVA 8000/480-V distribution transformer has the following resistances and reactances:

$$R_p = 32 \Omega \quad R_s = 0.05 \Omega$$

$$X_p = 45 \Omega \quad X_s = 0.06 \Omega$$

$$R_c = 250 \text{ k}\Omega \quad X_M = 30 \text{ k}\Omega$$

The excitation branch impedances are given referred to the high-voltage side of the transformer.

- Find the equivalent circuit of this transformer referred to the high-voltage side.
- Find the per-unit equivalent circuit of this transformer.
- Assume that this transformer is supplying rated load at 480 V and 0.8 PF lagging. What is this transformer's input voltage? What is its voltage regulation?
- What is the transformer's efficiency under the conditions of part (iii) above? **(12 marks)**

- b) A Delta-Delta bank consisting of three 20kVA, 2300/230V transformers supplies a load of 40kVA. If one transformer is removed, find for the resulting V-V connection
- kVA load carried by each transformer
 - per cent of rated load carried by each transformer
 - total kVA rating of the V-V bank
 - ratio of V-V bank to Delta- Delta Bank transformer rating **(5 marks)**
- c) List the factors that must be considered when selecting a transformer for a given load in a specific location **(3 Marks)**

QUESTION 4

- a) A 240-V, 50Hz, 1/3hp, 4 pole, single phase induction motor has the following circuit parameter: $R_1=2.5\Omega$, $X_1 = 1.25\Omega$, $R_2 = 3.75\Omega$, $X_2 = 1.25\Omega$, and $X_m = 65\Omega$. The motor runs at speed of 1425rpm and has a core loss of 25W. The friction and windage loss is 2W. Determine the shaft torque and the efficiency of the motor. **(10 marks)**
- b) With special reference to the single phase induction motor, explain the following.
- Principle of operation of split phase motor. **(2 marks)**
 - reversing direction of capacitor start motor **(1 mark)**
 - Why universal motor operates better on dc than ac supply. **(2 marks)**
 - Why we disconnect auxiliary winding in split phase motor. **(1 mark)**
- c) A 115-V, 60Hz, 4pole, Single phase induction motor is rotating in the clockwise direction at a speed of 1710rpm. determine its per unit slip
- in direction of rotation
 - in the opposite direction
 - If the rotor resistance at standstill is 12.5Ω , determine the effective rotor resistance in each direction. **(4 marks)**

QUESTION 5

- a) A 460-V 100-hp four-pole Δ -connected 60-Hz three-phase induction motor has a full-load slip of 5 percent, an efficiency of 92 percent, and a power factor of 0.87 lagging. At start-up, the motor develops 1.9 times the full-load torque but draws 7.5 times the rated current at the rated voltage. This motor is to be started with an autotransformer reduced voltage starter.
- What should the output voltage of the starter circuit be to reduce the starting torque until it equals the rated torque of the motor?
 - What will the motor starting current and the current drawn from the supply be at this voltage? **(6 marks)**

b) State the conditions that must be met before three phase transformers are connected in parallel to serve a common load. **(2 marks)**

c) With a brief explanation, what type of single motor would you select to perform each of the following jobs?

- i). Vacuum cleaner
- ii). Refrigerator
- iii). Air conditioner fan
- iv). Variable-speed sewing machine
- v). Clock

(5 marks)

d) i) Name three ways of starting a three phase induction motor

(2 mark)

ii) Draw the power circuit and the control circuit of a Star Delta starter and give a brief explanation

(5 Marks)