THE MOMBASA POLYTECHNIC UNIVERSITY COLLEGE

Faculty of Engineering and Technology

DEPARTMENT OF ELECTRICAL & ELECTRONIC ENGINEERING

DIPLOMA IN TECHNOLOGY
Electrical Power Engineering

UNIT CODE_____

ELECTRICAL MACHINES III

END OF SEMESTER EXAMINATIONS

SERIES: FEBRUARY 2011 SERIES

TIME: 2 HOURS

Instructions to Candidates:

1. You are required to have the following for this examination;
   - Answer booklet
   - Scientific calculator
   - SMP Tables

2. Attempt Question **ONE (COMPULSORY)** and any other **TWO** Questions.

3. Q1 carries 30 marks while each of the remaining questions carry 20 marks each

(COMPULSORY)

Question ONE

a) i) State TWO main reasons why variable speed drives are applied. (2 marks)

ii) Sketch and label the circuit symbols for six power electronic devices most commonly used in variable speed drives. (3 marks)

iii) Explain the distinguishing features of any devices in (a) (ii) above. (6 marks)

b) i) Using a labelled circuit diagram, describe the principle of operation of the following circuits.

I) Chopper controlled DC machine

II) Thyristor converter Drive. (6 marks)

ii) Draw the typical waveforms at the input and output for the drives in (b) (i) above. (4 marks)

c) i) Explain the following terms as applied in stepper motor drives.

I) Step angle

II) Halt – step

III) Full step (2 marks)

ii) A 500rev/min permanent magnet stepper motor has 18 poles on the stator and 15 on the rotor. Calculate:

I) Step angle

II) No of steps made in 1hour. (3 marks)

d) List and distinguish the TWO main types of Refrigeration systems applied today. (4 marks)

Question TWO

a) Describe with relevant circuits the following techniques applied in DC motor speed control for locomotive industry.

i) Regenerative braking

ii) Plugging (4 marks)

b) i) Show that in DC motor speed control

I) $T = KIa$ for shunt motor circuit

II) $T = Kia^2$ for series motor. (5 marks)

ii) Calculate the power output of a DC shunt motor with the following parameters / characteristics.

- Number of Armature conductors = 960
- Type of winding = wave wound
- Number of poles = 8

- Reluctance per pole = 120Ω
- Field winding resistance = 1mΩ
- Number of Field winding Turns = 100
- Normal speed of Rotation = 300 rev/minute
- Supply voltage = 210V
- Armature Resistor = 0.5Ω (6 marks)

c) The DC motor in (b) (ii) above was connected to a 240V, 50H supply through a Thyristor converter drive and was found to perform the same with firing angle $\propto = 0^0$. Calculate:

i) Percentage change of speed when $\propto$ suddenly adjusted to $\frac{\pi}{3}$ with the field kept constant.

ii) Corresponding new torque and new power output. (5 marks)

Question THREE

a) Draw the circuits for any ONE of the following 3∅ induction motor drives and explain how it works.

i) Voltage source inverter circuit

ii) Current source inverter circuit

iii) Cydo converter circuit. (9 marks)

b) Sketch the input/output waveform of any ONE circuit in Q 3 (a) above. (4 marks)

c) A 440V, 3 phase, 6 pole, 50Hz delta connecter induction motor has the following equivalent circuit parameters at normal frequency.

R_1 = 0.2Ω/phase X_1 = X_2^1 = 0.58Ω/phase

R_2^1 = 0.18Ω/phase

Calculate:

i) Starting torque and current with normal voltage and frequency.

ii) Starting torque at 10% of rated frequency and 14% of normal voltage. (7 marks)

Question FOUR

a) Compare and contrast between any ONE:

i) Synchronous and induction motor drives

ii) Reluctance and permanent magnet stepper motors. (4 marks)

b) i) With a construction and wiring diagram, show how the stepper motor can be configured to be driven by:

I) Single phase Bipolar pulses

II) Three phase Unipolar pulses (5 marks)

c) The block diagram below shows transfer functions of various blocks of vector controlled induction motor drives. The damping factor G = 0.4 and PI controller gain K = 8.

i) Determine the:
   I) Open loop transfer function
   II) Settling to within 5% of final value
   III) Damped frequency of oscillation (9 marks)

Question FIVE

a) i) With the aid of a well labelled diagram describe how the vapour compression system in refrigeration and air conditioning works. (5 marks)

ii) Draw the refrigeration cycle and indicate where each component in (a) (i) above lies. (3 marks)

b) Sketch a domestic refrigerator power circuit consisting of the following elements:
   i) Hermelically sealed sulphase induction motor compression.
   ii) Thermocouple heat sensor
   iii) Pressure bellow sensor
   iv) Fridge Door contact Sensor (5 marks)

c) i) A certain refrigerant had the following properties when applied in a commercial building refrigeration system.

   $Q = 20$

   $Cp = 0.01 \times 10^3$

   $Ti = -15^0C$

   $To = 10^0C$

   Pumping power = 2 kW.

   Calculate:
   I) Tonnes of refrigeration
   II) Specific power consumption carnot. (5 marks)

   iii) Calculate the coefficient of performance for the refrigeration in C (i) if the mean evaporator temperature was -13^0C and that of compression was 25^0C. (2 marks)