MACHAKOS UNIVERSITY

University Examinations for 2016/2017

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

SECOND YEAR SECOND SEMESTER EXAMINATION FOR BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONICS ENGINEERING

EEE 209: ELECTRICAL ENGINEERING

DATE:16/6/2017 **TIME: 8.30-10.30 AM**

INSTRUCTIONS

1. This paper has **FIVE** questions.
2. Attempt Question **ONE (compulsory)** and any other **TWO** questions.
3. All workings must be clearly shown.

QUESTION ONE (COMPULSORY) (30 MARKS)

a) Enumerate the various parts of a dc generator explaining the purpose of each part (6 marks)

b) Derive the mathematical relationship between the secondary line voltage and the primary line voltage for the following three-phase transformer connections.

i) Star-Star connection

ii) Delta-Delta connection

iii) Delta-Star connection

iv) Star-Delta connection **[8 marks]**

c) State two advantages and two disadvantages of the three-phase induction motor. **[4 marks]**

d) State the characteristics of the various types of dc motors hence give two application areas for

each type. **[6 marks]**

e) A 12 pole, 50 Hz, 11 kV, three-phase induction motor delivers 250 kW at a slip of 2.5% and a power factor of 0.86 lagging. If the rotational losses are 2.5 kW and the motor efficiency is 95.6%, determine:

i) the rotor copper loss

ii) the stator losses

iii) the input line current **[6 marks]**

QUESTION TWO (20 MARKS)

a) In a 120 V compound dc generator, the resistances of the armature, shunt and series windings are 0.06, 20 and 0.04 respectively. The load takes 84 A at 120 V. Find the armature current, the induced e.m.f., and the machine efficiency when the machine is connected as:

i) long-shunt

ii) short shunt

Neglect the brush contact drop and ignore the armature reaction. (**8 marks]**

b) Explain how excitation is achieved in self-excited dc generators**2 marks]**

c) The following data refers to a 2000/120 V single-phase transformer:

primary resistance = 1.6Ω secondary resistance = 0.006Ω

primary reactance = 4.72Ω secondary reactance = 0.022Ω

core loss resistance = 85 k2Ω magnetizing inductance = 15.2kΩ

The transformer secondary supplies a 120V, 4.5 kW load at a power factor of 0.85 lag. Using the exact transformer equivalent circuit, determine:

i) the primary applied voltage

ii) the voltage regulation

iii) the primary power factor

iv) the transformer efficiency

[10 marks]

QUESTION THREE (20 MARKS)

a) The transformer is probably one of the most useful electrical devices ever invented. Give

reasons to support this statement. **[4 marks]**

b) Briefly explain why the Δ-Δ connection of three-phase transformers is far more common than the Y-Y connection. **[3 marks]**

c) An induction motor may be considered to be a transformer with a rotating short circuited secondary. Despite the similarities, there are a number of fundamental differences. Enumerate these differences. **[5 marks]**

d) A 200 V dc series motor takes 5 A at no-load when running at 2500 rpm. The armature and field resistances are 0.4 and 0.8 respectively. If the input power at full load is 5 kW, calculate:

i) the full load speed.

ii) the full load torque in N-m.

iii) the motor efficiency. (8 marks)

QUESTION FOUR (20 MARKS)

a) What is the significance of back e.m.f. in a dc motor? A dc motor connected to a 400V supply has an armature resistance of 0.12Ω Calculate:

i) the value of the back e.m.f. when the armature current is 120 A

ii) the value of armature current when the back e.m.f. is 380.8 V (4 marks)

b) A 280 V dc shunt motor has an armature current of 20 A when running at 1200 rpm against a full load torque. The armature resistance is 0.8Ω. Assuming that the flux remains constant and neglecting brush contact drop, calculate:

i) the resistance that must be inserted in series with the armature to reduce the speed to 800 rpm at the same torque and

ii) the speed of the motor if the load torque is halved with the resistance calculated in part (i) in the circuit . (6 marks)

c) A 6-pole, 400-V, 50-Hz, three-phase induction motor has a delta connected stator and a star connected slip-ring rotor with a stator phase voltage-to-rotor phase voltage transformation ratio of 5.2. The rotor resistance and standstill leakage reactance are 0.05Ω and 0.3Ω per phase respectively. Neglecting the stator impedance and magnetizing currents, determine:

i) the rotor current and power factor at start with slip-rings shorted

ii) the rotor current and power factor when running at 960 rpm with slip-rings shorted

iii) the external rotor resistance per phase required to obtain a starting current of 20 A in the stator supply lines. How much power is wasted in the starting resistance? (10 marks)

QUESTION FIVE (20 MARKS)

a) Clearly explain the principle of operation of a dc motor. (7 marks)

b) A three-phase induction motor runs at almost 998 rpm at no load and 912 rpm at full load when supplied from a 50-Hz, three-phase source.

i) How many poles does this motor have?

ii) What is the slip in percent at full load?

iii) What is the frequency of the rotor currents at full load?

iv) What is the speed of the stator field with respect to the rotor? With respect to the stator? (8 marks)

c) Explain the difference between a squirrel-cage and a slip-ring three-phase induction motor.

Which of the two is more widely used and give reasons why. (5 marks)