MACHAKOS UNIVERSITY

University Examinations for 2019/2020Academic Year

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

SECOND YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (MECHANICAL ENGINEERING)

EMM 214: ELECTRICAL ENGINEERING II

DATE: 15/12/2020 **TIME: 8:30 – 10:30 AM**

INSTRUCTIONS

Answer Question One and Any Other Two Questions

QUESTION ONE (30 MARKS) (COMPULSORY)

a) Give two types of DC machines and draw their equivalent circuit. (2 marks)

b) A four-pole dc machine has an armature of radius 12.5cm and an effective length of 25cm. The poles cover 75% of the armature periphery. The armature winding consists of 33 coils each having seven turns. The coils are accommodated in 33 slots. The average flux density under each pole is 0.75T: If the armature is lap wound,

i. Determine the value of K_a. (2 marks)

ii. Determine the induced armature voltage when the armature rotates at 1000 rpm . (3 marks)

iii. Determine the current in the coil and the electromagnetic torque developed when the armature current is 400A. (3 marks)

iv. Determine the power developed by the armature. (3 marks)

c) Explain the functions of the following parts of a DC machine. (5 marks)

i. The commutator,

ii. The brushes,

iii. The electric circuit of the motor,

iv. The magnetic circuit,

v. Why is the rotor/stator laminated?

d) A single-phase transformer with a ratio of 6600/600V has a load impedance of (4+j3) Ohms connected across the terminals LV side. Calculate the kW delivered to the load neglecting the losses. (4 marks)

e) A six-pole lap connected generator has a useful flux/pole of 0.045Wb. If the no load voltage at 400rpm is 300V, find the conductors on the armature periphery. (4 marks)

f) With aid of a diagram, show the power flows and losses in an induction motor from the three phase power supply to the shaft power. (4 marks)

QUESTION TWO (20MARKS)

a) Tests are performed on a 1∅, 10kVA, 2200/220V; 60Hz transformer and the following data in table 2a were obtained.

Table 2a

	Open-Circuit Test (HV side open)	**Short-Circuit Test (LV side shorted)**
Voltmeter	220V	150V
Ammeter	2.5A	4.55A
Wattmeter	100W	215W

i. Derive the parameters for the approximate equivalent circuits referred to the low-voltage side and high-voltage side. (12 marks)

ii. Express the excitation current as a percentage of the rated current. (2 marks)

iii. Determine the power factor for the no load and short-circuit test. (2 marks)

b) An ideal transformer has 1000 turns on its primary and 500 turns its secondary. The driving voltage on the primary side is 100V and the load resistance is 5$\boldsymbol{\Omega}$. Calculate V_2, I_1 and I_2. (4 marks)

QUESTION THREE (20MARKS)

a) Give four different types of transformers. (2 marks)

b) With the aid of a diagram, show how transformers are connected in parallel. (2 marks)

c) Three 1φ, 50kVA, 2300/230V, 60Hz transformers are connected to form a 3φ, 4000/230 V transformer bank. The equivalent impedance of each transformer referred to low voltage is 0.012 + j0.016 Ω. The 3φ transformer supplies a 3φ, 120kVA, 230V, 0.85 PF (lag) load.

i. Draw a schematic diagram showing the transformer connection (2 marks)

ii. Determine the transformer winding currents (2 marks)

iii. Determine the primary voltage (line-line) required. (3 marks)

iv. Determine the voltage regulation. (2 marks)

d) A 10kW, 100V, 1000 rpm dc machine has R_a = 0.1 Ω and is connected to a 100V dc supply.

i. Determine the starting current if no starting resistance is used in the armature circuit. (2 marks)

ii. Determine the value of the starting resistance if the starting current is limited to twice the rated current. (2 marks)

iii. This dc machine is to be run as a motor, using a starter box. Determine the values of resistances required in the starter box such that the armature current I_a is constrained within 100 to 200% of its rated value (i.e., 1 to 2 pu) during start-up. (3 marks)

QUESTION FOUR (20MARKS)

a) A 4500/16000V, 1500kVA, 50Hz transformer has the following parameters:

$R_1 = 0.03\Omega; R_2 = 0.44\Omega,\ R_0 = 1688\Omega;\ X_1 = 0.092\Omega;\ X_2 = 1.34\Omega;\ X_0 = 256\Omega$:

The transformer is supplying full load at a power factor of 0.8 lagging. Using the equivalent circuit, find the input current. (10 marks)

b) A 3φ, 230V, 27kVA, 0.9p.f (lag) load is supplied by three 10kVA, 1330/230V, 60Hz transformers connected in Y-Δ by means of a common 3φ feeder whose impedance is 0.003 + j0.015Ω per phase. The transformers are supplied from a 3φ source through a 3φ feeder whose impedance is 0.8 + j5.0Ω per phase. The equivalent impedance of one transformer referred to the low-voltage side is 0.12 + j0.25 Ω. Determine the required supply voltage if the load voltage is 230V. (10 marks)

QUESTION FIVE (20MARKS)

a) Derive the equation of the developed torque in a dc machine. (10 marks)

b) Give the names of two types of induction motors based on their rotor structure. (1 mark)

c) A three phase, 460V, 100hp, 60Hz, 6-pole induction machine operates at 3% slip (positive) at full load.

i. Determine the speeds of the motor and its direction relative to the rotating field. (2 marks)

ii. Determine the rotor frequency (1 mark)

iii. Determine the speed of the stator field. (1 mark)

iv. Determine the speed of the rotating airgap field. (1 mark)

v. Determine the speed of the rotor relative to

I. The rotor structure. (1 mark)

II. The stator structure (1 mark)

III. The stator rotating field (1 mark)