PP1

TECHNICAL UNIVERSITY OF MOMBASA

SCHOOL OF ENGINEERING AND TECHNOLOGY

ELECTRICAL AND ELECTRONICS ENGINEERING

UNIVERSITY EXAMINATION FOR:

DEGREE

EEE 4507: ELECTRICAL MACHINES V.

END OF SEMESTER EXAMINATION

SERIES: MAY 2025

TIME: 2 HOURS

DATE: May 2025

Instructions to Candidates

You should have the following for this examination

-Answer Booklet, examination pass and student ID

This paper consists of FIVE questions. Attempt Question 1, Compulsory and any other Two Questions.

Do not write on the question paper.

QUESTION ONE

a. Using diagrams and equations explain the principle of operation of a repulsion motor **[4MARKS]**

b. A 230 ,50HZ, 4 pole repulsion motor with two identical stator windings has the following parameters:

Mutual reactance referred to stator=60Ω

Resistance of each stator winding =0.5Ω

Leakage reactance of each stator winding=2.3Ω

Resistance of armature referred to stator=2.5Ω

Leakage reactance of armature referred to stator=3Ω

Copper loss=35W

Calculate the line current, power factor and the efficiency of the motor when running at 2100rpm **[4 MARKS]**

c. A 3300/250V, 50HZ single phase transformer has 80 turns on the secondary winding. Assuming an ideal transformer , calculate

i. Value of maximum flux density

ii. Number of turns on the HV side[6]

d. Name and describe four types of tests performed on single phase AC motors **[4 MARKS]**

e. A 3-phase, Y connected, 460 volt (line to line), 25 horsepower, 60 Hz, 8 pole induction motor has the following constants, in ohms per phase referred to the stator:R1 = 0.342, X1 = 0.561, Z1 = 0.342 + j0.561, R2 = 0.164, X2 = 0.265, Z2 = (0.164 / 0.02) + j0.265 = 8.20 + j0.265, Xx = Zx = 14.75. The Friction, windage and stray load losses = 265 Watts. For a slip of 2.00% (0.02), calculate **[8 MARKS]**

i. speed,
ii. stator current,
iii. power factor,
iv. output
v. torque
vi. power
vii. efficiency

QUESTION TWO

a. Using appropriate equivalent circuit diagrams derive the expression of the net output power of a single phase AC motor **[6MARKS]**

b. A 125W,4 poles ,50HZ single phase induction motor delivers rated output at a slip of 6%. The total copper loss at full load is25W. Calculate the full load efficiency and rotor copper loss caused by the backward field. Neglect stator copper losses **[4 MARKS]**

c. A 230 ,50HZ, 4 pole repulsion motor with two identical stator windings has the following parameters:

Mutual reactance referred to stator=60Ω

Resistance of each stator winding =0.5Ω

Leakage reactance of each stator winding=2.3Ω

Resistance of armature referred to stator=2.5Ω

Leakage reactance of armature referred to stator=3Ω

Copper loss=35W. Calculate the line current, power factor and the efficiency of the motor when running at 2100rpm **[4 MARKS]**

d. A 3φ, 15 hp, 460 V, four-pole, 60 Hz, 1728 rpm induction motor delivers full output power to a load connected to its shaft. The windage and friction loss of the motor is 750 W. Determine the **[6 MARKS]**

i. Mechanical power developed.
ii. Air gap power.
iii. Rotor copper loss.

QUESTION THREE

a. Using diagrams and equations explain the principle of operation of a repulsion motor **[4 MARKS]**

b. Using appropriate phasor and equivalent circuits derive the current and voltage equations of a transformer at no load **[5 MARKS]**

c. A three-phase, 460 V, 1740 rpm, 60 Hz, four-pole wound-rotor induction motor has the following parameters per phase:

R1 =0:25 ohms, R02 =0:2 ohms X1 =X02 =0.5 ohms, Xm =30 ohms. The rotational losses are 1700 watts. With the rotor terminals short-circuited, find **[11 MARKS]**

i. Starting current when started direct on full voltage.
ii. Starting torque.
iii. Full-load slip.
iv. Full-load current.
v. Ratio of starting current to full-load current.
vi. Full-load power factor.
vii. Full-load torque.
viii. Internal efficiency and motor efficiency at full load.
ix. Slip at which maximum torque is developed.
x. Maximum torque developed
xi. How much external resistance per phase should be connected in the rotor circuit so that maximum torque occurs at start?

QUESTION FOUR

a) Explain the principle of operation of a rotary converter **[8 MARKS].**

b) A 3 phase ,250kW synchronous converter develops 250V on the armature and is supplied from a 2200V,3 phase network through three single phase transformers Delta connected on the HV side and WYE connected on the LV side. The converter operates on full load at 0.9 lag and with an efficiency of 91%. Determine the voltage and current rating of both sides of the transformer, neglecting its losses **[6 MARKS]**

Using a well labled diagram of a single phase synchronous AC motor, deduce the expression of the total air gap power

Explain the construction and principle of operation of a synchro- transformer **[6 MARKS]**

QUESTION FIVE

a. The primary of an ideal transformer draws 1A at a power factor of 0.4lag when connected across a 230V supply and the secondary is on open circuit. The number of turns in the primary is twice that of the secondary. A load taking 50A at a lagging power factor of 0.8 is now connected across the secondary. Calculate the primary current and primary power factor **[4 MARKS].**

b. A 220V, single phase induction motor gave the following tests:

No load=220V, I=6.15A, W=348W

Locked rotor-126V, I=15A, W=577W

Stator winding resistance=1.5Ω

Determine the parameters of the equivalent circuit of the machine **[6 MARKS]**

c. Using well labeled diagrams explain the principle of operation of a servo motor **[4 MARKS]**

d. A three-phase variable-reluctance stepper motor has the following parameters: Rw =1Ω,Lw =30 mH ,I=3 A. Design a simple unipolar drive circuit such that the electrical time constant is 2 msec at phase turn-on and 1 msec at turnoff. The stepping rate is 300 steps per second. **[6 MARKS]**