MACHAKOS UNIVERSITY

University Examinations for 2023/2024 Academic Year

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

THIRD YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONICS ENGINEERING

EEE300 ELECTRICAL MACHINES II

DATE: **TIME:**

INSTRUCTIONS

1. This paper consists of **FIVE** questions.
2. Answer **QUESTION ONE** and any other **TWO** questions.
3. All workings must be clearly shown.

QUESTION ONE COMPULSORY (30 MARKS)

a) State TWO advantages of three phase transformers over single phase transformers. **[2 marks]**

b) Two 3-phase transformers A and B having the same no-load line voltage ratio $3{,}300/400-V$ supply a load of $750\ kVA$ at 0.707 lagging when operating in parallel. The rating of A is $500\ kVA$, its resistance is 2% and reactance 3%. The corresponding values of B are $250\ kVA$; 1.5% and 4% respectively. Assuming that both transformers have star-connected secondary windings, calculate: **[6 marks]**

(i) the load supplied by each transformer,

(ii) the power factor at which each transformer is working,

(iii) the secondary line voltage of the parallel circuit

c) Give TWO advantages of three-phase induction motors. **[2 marks]**

d) A 3-phase, 60 Hz induction motor has 2 poles. If the slip is 2% at a certain load, determine

i) the synchronous speed,

(iii) the speed of the rotor and

(ii) the frequency of the induced e.m.f.'s in the rotor. **[4 marks]**

e) With use of diagrams, explain the three modes of operation of induction motor **[3marks]**

f) A 440V, 60Hz, six-pole, 3Φ induction machine is taking 50kVA at 0.8 power factor and is running at a slip of 2.5%. The stator copper losses are 0.5kW and rotational losses are 2.5kW. Compute **[5 Marks]**

i) The total copper loss

ii) The shaft HP

iii) The efficiency

iv) The shaft torque

g) With the aid of a diagram, explain the principle of operation of a hysteresis motor. **[6marks]**

h) Determine the step angle of a variable-reluctance stepper motor with 12 teeth in the stator and 8 rotor teeth. **[2marks]**

QUESTION TWO (20 MARKS)

a) Explain the principle of operation of a transformer and hence, derive its e.m.f equation. **[5 marks]**

b) The following test results are obtained for a 3Φ, 280V, 60Hz, 6.5A, 500W induction machine,

Blocked-rotor test: 44V, 60Hz, 25A, 1250W

No-load test: 208V, 60Hz, 6.5A, 500W

The average resistance of measured by the dc bridge between two stator terminals is 0.54 Ohms.

i) Determine the no load rotational losses

ii) Determine the parameters of the equivalent circuit **[9marks]**

c) A 2000-kVA, 6,600/400-V, 3-phase transformer is delta-connected on the high voltage side and star-connected on the low-voltage side. Determine its % resistance and % reactance drops, % efficiency and % regulation on full-load 0.8 p.f. leading given the following data: **[6 marks]**

S.C. test; H.V. data: 400V, 175 A and 17kW

O.C. test; L.V. data: 400V, 150 A and 15kW

QUESTION THREE (20 MARKS)

a) Sketch the connection diagrams for star-delta and delta-star transformers, stating where such connections are applied. **[4marks]**

b) A three-phase transformer has 500 primary turns and 50 secondary turns. If the supply voltage is 2.4kV, find the secondary line voltage on no-load when the windings are connected

(i) star-delta,

[4marks]

(ii) delta-star.

c) A 3Φ, 280V, 60Hz, 20hp, 4-pole induction motor has the following equivalent circuit parameters.

$$R_1 = 0.12\ Ohms\ \ R'_2 = 0.1\ Ohm \quad X_1 = X'_2 = 0.25\ Ohm \ \text{ and } X_m = 10.0\ Ohms$$

The rotational loss is 400W. For a 5% slip, determine: **[12marks]**

i) The motor speed in rpm and radians per sec.

ii) The motor current.

iii) The stator Cu-loss.

iv) The air-gap power.

v) The rotor Cu-loss.

vi) The shaft power..

vii) The developed torque and the shaft torque.

viii) Determine the output horsepower at s=0.1.

ix) The efficiency of the motor.

QUESTION FOUR (20 MARKS)

a) With the aid of a diagram, explain the principle of operation of a three-phase induction motor. **[5marks]**

b) A 500kVA, 3-phase, 50Hz transformer has a voltage ratio (line voltages) of 33/11-kV and is delta/star connected. The resistances per phase are: high voltage 35 Ω, low voltage

0.876 Ω and the iron loss is 3050W. Calculate the value of efficiency at full-load and one-half of full-load respectively (a) at unity p.f. and (b) 0.8p.f. **[8marks]**

c) The frequency of the supply to the stator of an 8-pole induction motor is 50 Hz and the rotor frequency is 3 Hz. Determine (i) the slip, and (ii) the rotor speed. **[2marks]**

d) A $250W$, single-phase, $50Hz$, $220V$ universal motor runs at $2000\ rpm$ and takes $1.0\ A$ when supplied from a $220V$ dc. supply. If the motor is connected to $220V$ ac supply and takes $1.0\ A$ (r.m.s), calculate the speed, torque and power factor. Assume $R_a = 20\Omega$ and $L_a = 0.4H$.

[5marks]

QUESTION FIVE (20 MARKS)

a) Discuss any TWO methods of starting three phase squirrel-cage induction motors.

[4marks]

b) Give 4 disadvantages of 1-Φ induction motors as compared to 3-Φ induction motors (IM) motors**.** **[2marks]**

c) Using a diagram, discuss the principle of operation of a single phase Repulsion-Induction Motor.

[4marks]

d) A 415V, three-phase, 50 Hz, 4-pole, star-connected induction motor runs at 24 rev/s on full load. The rotor resistance and reactance per phase are 0.35Ω and 3.5 Ω respectively, and the effective rotor-stator turns ratio is 0.85:1. Calculate: **[10marks]**

i. the synchronous speed,
ii. the slip,
iii. the full load torque,
iv. the power output if mechanical losses amount to 770W,
v. the maximum torque,
vi. the speed at which maximum torque occurs, and
vii. the starting torque.