MACHAKOS UNIVERSITY

University Examinations 2023/2024 Academic Year

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF BUILDING AND CIVIL ENGINEERING

THIRD YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING

EMM 214 ELECTRICAL ENGINEERING II

DATE **TIME**

Instructions: This paper contains **Five** questions attempt *question **One** and any other **Two***

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

b) b) A transformer has 600 primary turns and 150 secondary turns. The primary and secondary resistances are 0.25Ω and 0.01 Ω respectively and the corresponding leakage reactances are 1.0 Ω and 0.04Ω respectively. Determine **[7 marks]**

(i) the equivalent resistance referred to the primary winding,
(ii) the equivalent reactance referred to the primary winding,
(iii) the equivalent impedance referred to the primary winding, and
(iv) the phase angle of the impedance.

c) Give TWO advantages of three-phase squirrel cage induction motors over slip-ring induction motor. **[2 marks]**

d) Sketch the power flow diagram of an induction motor. **[3 marks]**

e) 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 **[5marks]**

i) The total copper loss
ii) The shaft HP
iii) The efficiency

iv) The shaft torque

f) A $220\,V, 7\,hp$ series motor is mechanically coupled to a fan and draws $25A$ and runs at $300rpm$ when connected to a $220\,V$ supply with no external resistance connected to the armature circuit (i.e.$R_{se} = 0$). The torque required by the fan is proportional to the square of the speed. $R_a = 0.6\Omega$ and $R_{sr} = 0.4\Omega$. Neglect armature reaction and rotational loss.

[6marks]

i. Determine the power developed to the fan and the torque developed by the machine.

ii. The speed is to be reduced to 200rpm by inserting a resistance (R_{se}) in the armature circuit. Determine the value of this armature resistance and the power delivered to the fan.

g) A shunt generator supplies a $20kW$ load at $200\,V$ through cables of resistance, $R = 100m\Omega$, as shown in Fig. Q1f. If the field winding resistance, $R_f = 50\,\Omega$ and the armature resistance, $R_a = 40m\Omega$ determine **[5 marks]**

i. the terminal voltage,

ii. the e.m.f. generated in the armature,

iii. the efficiency of the generator at full load, assuming the iron, friction and windage losses amount to $1.2kW$.

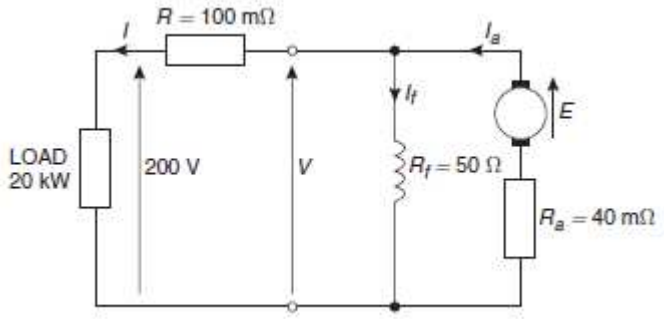

Fig.Q 1f.

QUESTION TWO (20 MARKS)

a) Explain the principle of operation of a transformer and hence, derive its e.m.f equation.

[7 marks]

b) A 400kVA transformer has a primary winding resistance of $0.5\,\Omega$ and a secondary winding resistance of $0.001\,\Omega$. The iron loss is 2.5kWand the primary and secondary voltages are 5kV and 320V respectively. If the power factor of the load is 0.85, determine the efficiency of the transformer (a) on full load, and (b) on half load. Determine also, the maximum efficiency for this transformer assuming the power factor remains unchanged.

[10marks]

c) A 100V D.C. generator supplies a current of 15A when running at 1500 rev/min. If the torque on the shaft driving the generator is 12 Nm, determine (a) the efficiency of the

generator and (b) the power loss in the generator. **[3marks]**

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 250V series motor draws a current of $40A$. The armature resistance is 0.15 Ω and the field resistance is 0.05 Ω. Determine the maximum efficiency of the motor. **[4 marks]**

d) The power supplied to a three-phase induction motor is 32kW and the stator losses are 1200W. If the slip is 5%, determine (i) the rotor copper loss, (ii) the total mechanical power developed by the rotor, (iii) the output power of the motor if friction and windage losses are 750W, and (iv) the efficiency of the motor, neglecting rotor iron loss. **[4 marks]**

e) A separately-excited generator develops a no-load e.m.f. of $150V$ at an armature speed of $20\ rev/s$ and a flux per pole of $0.10Wb$. Determine the generated e.m.f. **[4marks]**

(i) the speed increases to $25\ rev/s$ and the pole flux remains unchanged,

(ii) the speed increases to $24\ rev/s$ and the pole flux is decreased to $0.01Wb$.

QUESTION FOUR (20 MARKS)

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

b) 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]**

c) Outline THREE principal losses of a dc machine. **[3 marks]**

d) A series motor has an armature resistance of 0.2 Ω and a series field resistance of 0.3 Ω. It is connected to a $240V$ supply and at a particular load runs at 24 rev/s when drawing 15 A from the supply. **[6 marks]**

i. Determine the generated e.m.f. at this load.

ii. Calculate the speed of the motor when the load is changed such that the current is increased to 30 A. Assume that this causes a doubling of the flux.

iii. Sketch and explain the speed/current characteristic curve for the motor.

e) A 500V shunt motor runs at its normal speed of $10\ rev/s$ when the armature current is 120A. The armature resistance is $0.2\ \Omega$. **[4 marks]**

i. Determine the speed when the current is 60A and a resistance of $0.5\ \Omega$ is connected in series with the armature, the shunt field remaining constant.

ii. Determine the speed when the current is 60A and the shunt field is reduced to 80% of its normal value by increasing resistance in the field circuit.

QUESTION FIVE (20 MARKS)

a) Discuss any TWO methods of starting three phase squirrel-cage induction motors. **[4marks]**

b) 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 $3.5\ \Omega$ 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.

c) i Explain the electromechanical energy conversion in a D.C. machine.

ii) The armature of a D.C. machine has a resistance of $0.25\ \Omega$ and is connected to a $300V$ supply. Calculate the e.m.f. generated when it is running: (a) as a generator giving $100A$, and as a motor taking $80A$. **[4marks]**

d) What is armature reaction and how is it minimized in a DC machine? **[2 marks]**