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UNIVERSITY EXAMINATIONS 2024/2025

THIRD YEAR, FIRST SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING

EET 3316: ELECTRICAL MACHINES

DATE: JANUARY 2025 **TIME: 2 HOURS**

INSTRUCTIONS: Answer Question ONE and any other TWO questions.

QUESTION ONE (30 MARKS)

(a) Differentiate D.C. machines from transformers. [3 Marks]

(b) Explain why Kenya Power and Lighting Company (KPLC) may choose to use a bank of three separate single-phase transformers rather than one three phase distribution transformer unit. [3 Marks]

(c) Using the principle of electromagnetic induction and aid of diagram, explain how a 10kW, 50Hz, 0.85 p.f. ac 3-phase motor in the Engineering Workshop block, receives 415V, from a 11kV, 90MVA, pole mount mini-substation. [5 Marks]

(d) A 12-pole DC shunt generator has 50 slots on its armature with 12 conductors per slot with wave winding. The armature and field winding resistance is 0.5Ω and 60Ω respectively. The generator is supplying a resistive load of 15Ω at terminal voltage of 300 V when running at a speed of 625rpm. Draw the circuit and determine generated flux per pole. [5 Marks]

(e) In a 120 V compound dc generator, the resistances of the armature, shunt, and series windings are 0.06 Ω, 20 Ω and 0.04 Ω, respectively. The load current at 120 V is 84 A. Neglecting the

brush contact drop and the armature reaction, draw the circuit and calculate the armature current, the induced e.m.f., and the generator efficiency when it is connected as long-shunt.

[4 Marks]

(f) An 8/78kV, 50MVA, 60 Hz single-phase transformer to be installed at the Engineering Complex Block B gave the following test readings:

Open Circuit Test: 8 kV, 61.9 A and 136 kW

Short Circuit Test: 650 V, 6.25 kA and 103 kW.

Determine the efficiency and voltage regulation if the transformer is operating at rated voltage and a load of 0.9 p.f. lagging. [10 Marks]

QUESTION TWO (15 MARKS)

(a) Define the induction motor slip speed and highlight its mathematical formulation.

[2 Marks]

(b) A solenoid with 900 turns has a total flux of 1.33×10^{-7}Wb through its air core when the coil current is 100mA. If the flux takes 75ms to grow from zero to its maximum level, calculate the inductance of the coil. Also, calculate the induced e.m.f. in the coil during the flux growth.

[5 Marks]

(c) A shunt generator delivers 195 A at terminal p.d. of 250 V. The armature resistance and shunt field resistance are 0.02 Ω and 50 Ω respectively. The iron and friction losses equal to 0.95 kW. Calculate:

i). E.m.f. generated.

ii). Copper losses.

iii). Output of the prime mover.

iv). Mechanical and electrical efficiency. [8 Marks]

QUESTION THREE (15 MARKS)

(a) Highlight two similarities and two differences between D.C. generators and D.C motors.

[4 Marks]

(b) A single-phase 50Hz transformer has 80 turns on the primary winding and 400 turns on the secondary winding. The net cross-section area of the core is 200cm^2. If the primary winding is connected to a 240V, 50 Hz supply, determine:

i. The emf induced in the secondary winding.

ii. The maximum value of the flux density in the core. [6 Marks]

(c) A 3-phase, 10 HP squirrel cage induction motor is wound for 6 poles. When the motor is connected to 230 V, 50 Hz supply, at full-load, it operates at 4% slip.

Determine

i) full load speed.

ii) full load torque in Nm.

iii) frequency of rotor current under this condition.

[5 Marks]

QUESTION FOUR (15 MARKS)

(a) Differentiate core type from shell type transformers. [3 Marks]

(b) Power to an induction motor is supplied by a 12 pole, 3-phase, 500 rpm generator. The full load speed of the motor is 1440 rpm Find the percentage slip and number of poles in the motor. [5 Marks]

(c) A 3-phase transformer, ratio 33/6.6-kV, Δ/Y, 2000 kVA has a primary resistance of 8Ω per phase and a secondary resistance of 0.08Ω per phase. The percentage impedance is 7%. Calculate the secondary voltage with rated primary voltage and hence the regulation for full-load 0.75 p.f. lagging conditions. [7 Marks]

QUESTION FIVE (15 MARKS)

(a) State any three conditions that define an ideal transformer. [3 Marks]

(b) A 30 kVA, 2.4/0.12 kV, 50 Hz transformer has a high voltage winding resistance of 0.1 Ω and a leakage reactance of 0.22Ω. The low voltage winding resistance is 0.035 Ω and the leakage reactance is 0.012Ω. Find the equivalent winding resistance, reactance and impedance referred to the: high voltage side and low voltage side.

[6 Marks]

(c) A long-shunt dynamo running at 1000 r.p.m supplies 22 kW at a terminal voltage of 220 V. The resistances of armature, shunt field and series field are 0.05 Ω, 110 Ω and 0.06 Ω respectively. The overall efficiency at the above load is 88%. Calculate:

i). Total copper losses.

ii). Iron and friction losses.

iii). Torque exerted by the prime mover.

[6 Marks]