



MACHAKOS UNIVERSITY

University Examinations for 2022/2023 Academic Year

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

THIRD/FOURTH YEAR SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (ELECTRICAL AND ELECTRONIC ENGINEERING)

EEE 538: ELECTRICAL MACHINE DESIGN

DATE:

TIME:

INSTRUCTIONS

- *This Paper Consists of FIVE Questions.*
- *Question ONE is Compulsory.*
- *Attempt ANY OTHER TWO of the remaining FOUR Questions.*
- *All solutions must be hand written.*

QUESTION ONE (COMPULSORY) (30 MARKS)

- Discuss *Five* factors that must be considered in Electrical Machine Design. (5 marks)
- No insulating material in practice satisfies all the desirable properties. Therefore, materials which satisfy most of the desirable properties must be selected. Based on the temperature withstanding ability, the insulating materials have been classified according to ISI (now BIS) – 1271, 1985, first revision. Discuss present and past of these classifications, giving specific examples in each case (7 marks)
- Explain the merits and demerits of using *double layer windings* in the design of Synchronous Machines. (6 marks)

- d) Discuss how the following phenomena affect the Induction Machine Design. Explain of such are affected in slot selection for the rotor.
- i) Cogging
 - ii) Crawling (5 marks)
- e) Discuss the Details that must be specified while ordering a DC machine or consumer's specification for a design of the same. (7 marks)

QUESTION TWO (20 MARKS)

A 250kW, 500V, 6pole, 600rpm, dc generator is built with an armature of 0.75m and core length of 0.3m. The lap connected armature has 720conductors. A similar machine is to be designed for a 350kW,440V,720 rpm,6pole dc generator. Assume a square pole face with ratio pole arc to pole pitch equal to 0.66, full load efficiency of 0.91 and internal voltage drop as 4% of rated voltage. The diameter of commutator is 0.7 times of the armature diameter. The pitch of the commutator segments should not be less than 4mm. The voltage between adjacent segments should not exceed 15V at no load. *Required: Armature diameter, core length, number of armature slots, armature conductors and commutator segments of the second machine. Apply the necessary checks.*

QUESTION THREE (20 MARKS)

A manufacturer catalogue has the B-H Curve for the magnetic circuit of a 440V, 6 pole, 3-phase Y-connected 50HZ induction motor shown in Table Q 3.1. Further, the machine has the particulars shown in Table Q 3.2. *Required: The magnetization current for the machine internal circuit.*

$B(T)$	0.5	0.7	1.0	1.2	1.4	1.6
$H(AT/m)$	95	110	200	300	600	2500

Particular	Value
Core length	0.15m
Stator teeth length	30mm
Stator Tooth width at 1/3 height from the narrow end	7mm
Rotor Tooth width at 1/3 height from the narrow end	10.5mm

Rotor teeth length	15mm
Stator bore diameter	0.4m
Effective airgap length	0.9mm
Stator and Rotor core depth	6.5mm
Mean 60° length of magnetic circuit per pole pair in stator	0.25m
Mean 60° length of magnetic circuit per pole pair in Rotor	0.16m
Number of stator slots	72
Conductors per stator slot	8
Rotor slots	49
Stacking factor	0.9

QUESTION FOUR (20 MARKS)

A 300 kVA, 6600/400V, delta-star, 50Hz, 3 phase core type transformer has the data shown in Table Q.4.

Table Q 4							
Flux Density(T)	0.75	1.0	1.15	1.25	1.3	1.35	1.4
AT/m	100	105	200	400	500	1000	1500
Core Loss/Kg (W/Kg)	0.7	1.25	1.75	2.1	2.3	2.6	2.8

Further, the number of turns per phase on the HV winding is 830 while the net iron area of each limb and yoke is 260cm^2 and 297cm^2 respectively. The mean length of the flux path in each limb and yoke are 55 cm and 86.9 cm respectively while the density of iron is 7.55g/cm^3 . *Required: The load current for the transformer steel and its various components .*

QUESTION THREE (20 MARKS)

A water wheel generator with power output of 4750 kVA, 13.8 kV, 50 Hz, 1000 rpm, working at a pf of 0.8 has a stator bore and gross core length of 112 cm and 98 cm respectively. For a machine made of same materials with 6250 kVA, 13.8 kV, 50 Hz, 750 rpm operating at a power factor of 0.85 is to be designed. *Required: Main dimensions, details of stator winding, size of the stator slot and copper losses in the stator winding of the second machine.*