University of KwaZulu-Natal

Discipline of Electrical, Electronic and Computer Engineering

Examinations: October 2025

Subject, Course & Code: ELECTRICAL MACHINES 4 – ENEL4MBH2

DURATION: 2 HOURS TOTAL MARKS: 100

Examiners: Dr. Rudiren Sarma (Internal)

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Instructions: Answer ALL Questions. **Start answering each question on a fresh page of the answer booklet.**

The use of scientific calculators is permitted but their memories must be cleared.

Question 1 Equivalent circuit and Phasor diagram [26 Marks]

A 10 hp, 460 V, 60 Hz, 4-pole, three-phase, star-connected induction machine has the following parameters in ohms per phase referred to the stator.

R_C = 1410 Ω **R_1 = 0.54 Ω** **R_2' = 0.488 Ω**

X_M = 51.12 Ω **X_1 = 2.093 Ω** **X_2' = 3.209 Ω**

The friction and windage may be assumed to be constant at 200 W.

For a slip of 2.0 %, and using the **approximate equivalent circuit** determine:

(a) The rotor and stator current per phase. [10]

(b) Draw the phasor diagram of the induction motor at this operating point. [8]

(c) The starting current and starting torque for this motor [8]

Question 2 Braking of Induction Motors [20 Marks]

The Induction machine in Question 1 is to be braked from the above operating point of 2.0 % slip by changing the stator connections and inserting an external rotor circuit resistance, which referred to the stator side is 1.6 Ω/phase. Using the **approximate equivalent circuit**, determine the initial value of the braking torque:

(a) When the stator is disconnected from the AC supply and a DC current is applied through two stator phases; the DC current is adjusted to give the same air gap flux. [10]

(b) When two stator leads from the AC supply are interchanged. [10]

Question 3 Induction Generator [24 Marks]

The Induction machine in Question 1 is to be operated as a generator with a slip of -2.0 %. Using the **approximate equivalent circuit**, determine the stator and rotor currents per phase and draw a diagram to show the flow of real power in the machine inserting all values in the diagram.

Question 4 Double-cage Induction Motor [25 Marks]

The above machine design in Question 1 was modified to a double cage rotor design using the same stator such that:

$R_C = 1410\ \Omega$	$R_1 = 0.54\ \Omega$	$R_2' = 0.573\ \Omega$	$R_3' = 4.80\ \Omega$
$X_M = 51.12\ \Omega$	$X_1 = 2.093\ \Omega$	$X_2' = 4.65\ \Omega$	$X_3' = 3.75\ \Omega$

Using the **approximate equivalent circuit**, calculate:

(a) The motor's starting torque. [8]

(b) The percentage increase in the starting torque for the double cage design as compared to a single cage design in Question 1. [2]

(c) The motor's torque when operating at a slip of 2%. [8]

(d) Compare the starting current for the double cage design to that of a single cage design in Question 1. [7]