



TECHNICAL UNIVERSITY OF MOMBASA

UNIVERSITY EXAMINATION FOR:

SCHOOL OF ENGINEERING AND TECHNOLOGY

ELECTRICAL ENGINEERING DEPARTMENT

Bachelor of Technology in electrical Engineering

EEE4310 ELECTRICAL MACHINES II

END OF SEMESTER EXAMINATION

SERIES: APRIL 2025

TIME: 2 HOURS

DATE: APRIL 2025

Instructions to Candidates

You should have the following for this examination

-Answer Booklet, examination pass and student ID

This paper consists of **five** Questions; Question ONE is compulsory. In addition attempt any Other TWO Questions.

Do not write on the question paper.

Question ONE (Compulsory 30 marks)

- (a) (i) With aid of a diagram describe the power stages of a 3phase induction motor **(4mks)**
- (ii) State the difference between gross torque and shaft torque of an induction motor **(2mks)**
- (iii) The input power to a 4 pole, 3phase, 50Hz motor is 53kW, its speed is 1200rpm. The stator losses are 1.9 KW, the windage and friction losses are 2.5kW. Calculate (i) The rotor Cu losses (ii) The efficiency of the motor **(4mks)**
- (b)(i) Explain the need of a startor when starring a 3phase induction motor **(2mks)**
- (ii) With aid of a sketch derive an expression for relationship between starting and full load torque for auto transformer starting method **(4mks)**
- (iii) The ratio of the maximum torque to full load torque in a 3phase induction motor is 4.5. Determine the ratio of the starting to full load torque for direct on line starting method, given that the rotor resistance and standstill reactance 0.08Ω and 04Ω per phase respectively **(4mks)**

(c) (i) Describe the following characteristics of a 3phase induction (i) Motor on load (ii) Motor on no load **(4mks)**

(ii) Show that $\frac{T_M}{T_f} = \frac{a^2 + s^2}{2as}$ for a 3phase induction motor **(2mks)**

(iii) A phase induction motor having a 6pole star connected stator winding runs on 240V, 50Hz supply. The rotor resistance and standstill reactance are 0.12Ω and 0.85Ω per phase respectively. The ratio of the stator to rotor turns is 1.8 and full load slip is 4%. Calculate the developed torque at full load, maximum torque and speed at maximum torque **(4mks)**

Question TWO

(a)(i) Describe what happens when a load is added to a 3phase induction motor **(3mks)**

(ii) Derive an expression for the maximum torque of a 3phase induction motor **(3mks)**

(iii) A 4pole, 50Hz, Induction motor at standstill has 120V induced across star connected rotor terminals. The rotor resistance and standstill reactance per phase are 0.2Ω and 0.1Ω respectively

(i) Calculate the rotor speed when the rotor is drawing a current a current of 16A, at a particular load

(ii) Find the speed at which the torque is maximum and the corresponding value of the rotor input power **(4mks)**

(b)(i) Describe the following characteristics of a 3phase induction motor (i) Speed regulation (ii) Power factor **(6mks)**

(ii) A 150kV, 3000V, 50Hz, 6pole star connected induction has a star connected slip ring rotor with a transformation ratio of 3.6. The rotor resistance is 0.1Ω per phase and it's per phase leakage inductance is $3.61mH$. The stator impedance may be neglected. Calculate the starting current on rated voltage with short circuited slip ring **(4mks)**

Question THREE

(a)(i) With aid of a sketch, describe speed control of an induction motor by changing the applied voltage **(3mks)**

(ii) With aid of a sketch describe the rotor resistance method for speed control of induction motors **(3mks)**

(iii) The rotor of a 4pole, 50Hz slip ring induction motor has a resistance of 0.3Ω per phase and runs at 1440rpm at full load. Determine the external resistance per phase which must be added to lower the speed to 1320rpm, the torque being the same as before **(4mks)**

(b) (i) With aid of a sketch describe the star-delta starting method for 3phase induction motor **(3mks)**

(ii) Derive an expression for the relationship between the starting torque and full load torque for (i) above **(3mks)**

(iii) A 4pole, 50Hz induction motor at standstill has 120V induced across its star connected rotor terminals. The rotor resistance and standstill reactance per phase are 0.2Ω and 0.1Ω respectively (i) Calculate the rotor speed when its drawing a current of 16A at a particular load (ii) Find the speed which the torque is maximum and the corresponding value of the rotor input **(4mks)**

Question FOUR

(a)(i) Describe the effect of slip on the rotor circuit of a three phase induction motor **(3mks)**

(ii) Show that $f^{(s)} = Sf$ where $f^{(s)}$ is the rotor current frequency **(3mks)**

(iii) A 6 pole 3phase induction motor is connected to 100Hz supply system. Calculate (i) synchronous speed (ii) The speed of the motor when slip is 2% (iii) The rotor current frequency when the motor runs at 750rpm **(4mks)**

(b)(i) Describe the relationship of slip and load on a 3phase induction motor **(3mks)**

(ii) Show that $T_s \propto V^2$ where T_s is the starting torque of a three phase induction motor **(3mks)**

(iii) A 460V, 3phase, 50Hz star connected induction motor has full load speed of 1560rpm. The motor has an impedance of $0.7\Omega + j7\Omega$ per phase and rotor/ starter turn ratio of 0.6. Its slip is 0.03. Determine

(i) The full load torque

(ii) Rotor current

(iii) Full load rotor Cu losses **(4mks)**

Question FIVE

(a)(i) With aid of a sketch describe the voltage and current relationship of star-star 3phase transformer configuration **(3mks)**

(ii) With aid of a sketch describe the star-delta current and voltage relationship for this configuration **(3mks)**

(iii) A 3phase step down transformer is connected to 6600V on the primary side. The ratio of turns per phase is 12 and the line current drawn from the mains is 20A. Calculate the line voltage in the secondary and current if the transformer is connected is Star-delta **(4mks)**

(b)(i) State TWO advantages and TWO disadvantages of building a 3 phase transformer from a common magnetic core **(4mks)**

(ii) With aid of a sketch describe the construction of a 3phase transformer from a bank of 3 single phase transformers **(3mks)**

(iii) A 3phase step down transformer is connected to 33000 on the primary side. The ratio of turns per phase is 16 and the line current drawn from the mains is 50A. Determine secondary line voltage and secondary line current when the transformer is connected in delta- delta configuration.(3mks)