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(University of Choice)

MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY (MMUST)

MAIN CAMPUS

UNIVERSITY EXAMINATIONS
2022/2023 ACADEMIC YEAR

THIRD YEAR FIRST SEMESTER EXAMINATIONS

FOR THE DEGREE
OF
BACHELOR OF SCIENCE IN ELECTRICAL
AND
COMMUNICATION ENGINEERING

COURSE CODE: ECE 313

COURSE TITLE: ELECTRICAL MACHINES II

DATE: 7TH DECEMBER, 2022 **TIME:** 3: 00 PM – 5:00 PM

INSTRUCTIONS TO CANDIDATES

ANSWER QUESTION ONE AND ANY OTHER TWO QUESTIONS.
QUESTION ONE CARRIES 30 MARKS AND ALL OTHERS 20 MARKS EACH.

TIME: 2 Hours

MMUST observes ZERO tolerance to examination cheating

Question One (30 marks)

(a) Define a transformer. **[1 mark]**

(b) i) State the most commonly used three-phase transformer winding connections. **[2 marks]**

ii) State two problems of the Y-Y connection of a three-phase transformer. **[2 marks]**

(c) A three-phase induction motor is wound for 4 poles and is supplied from 50 Hz system. Calculate:

i) The synchronous speed, **[1 mark]**
ii) The rotor speed, when slip is 4%, **[1 mark]**
iii) Rotor frequency when rotor runs at 600 rpm. **[2 marks]**

(d) A 3.3 kV/110 V, 50 Hz, single-phase transformer is to have an approximate e.m.f. per turn of 22 V and operate with a maximum flux of 1.25 T. Calculate:

i) the number of primary and secondary turns, **[2 marks]**
ii) the cross-sectional area of the core **[2 marks]**

(e) A three-phase induction motor having star-connected rotor has an induced e.m.f of 80 V between slip-rings at standstill on open-circuit. The rotor has a resistance and reactance per phase of 1Ω and 4 Ω respectively. Calculate current/phase and power factor when:

i) slip-rings are short circuited, **[2.5 marks]**
ii) slip-rings are connected to a star-connected rheostat of 3Ω per phase. **[2.5 marks]**

(f) A transformer has 1200 primary turns and 200 secondary turns. The primary and secondary resistances are 0.2 Ω and 0.02 Ω respectively and the corresponding leakage reactances are 1.2 Ω and 0.05 Ω respectively. Calculate:

i) the equivalent resistance, reactance and impedance referred to the primary winding, and
ii) the phase angle of the impedance. **[6 marks]**

(g) Derive the e.m.f equation of a transformer. **[6 marks]**

Question Two (20 marks)

(a) i) Mention two instrument transformers. **[1 mark]**

ii) Explain the use of the transformers mentioned in (i). **[2 marks]**

iii) It is desired to measure a line current of the order 2000A to 2500 A. If a standard 5A ammeter is to be used along with a current transformer, find the turn ratio of the current transformer and determine by what factor should the ammeter reading be multiplied to get the line current in each case. **[4 marks]**

(b) i) A 2200/200 V transformer draws a no-load primary current of 0.6 A and absorbs 400 W. Find the magnetizing and iron loss currents. **[2 marks]**

ii) A 2200/250 V transformer takes 0.5 A at a power factor of 0.3 on open circuit. Find the magnetizing and working components of no-load primary current. **[2 marks]**

(c) A single-phase transformer has 400 primary and 1000 secondary turns. The net cross-sectional area of the core is 60 cm2. If the primary winding is connected to a 50-Hz supply at 520 V, calculate:

i) the peak value of flux density in the core,

ii) the voltage induced in the secondary winding. **[4 marks]**

(d) In a no-load test, an induction motor took 10 A and 450 W with a line voltage of 110 V. If the stator resistance/phase is 0.05 Ω and friction and windage losses amount to 135 W, calculate the exciting conductance and susceptance/ phase. **[5 marks]**

Question Three (20 marks)

(a) Mention three disadvantages of three-phase induction motors. **[3 marks]**

(b) A single-phase transformer has a voltage ratio of 6:1 and the high voltage winding is supplied at 540 V. The secondary winding provides a full load current of 30 A at a power factor of 0.8 lagging. Neglecting losses, find:

i) the rating of the transformer,
ii) the power supplied to the load,
iii) the primary current. **[5 marks]**

(c) Explain the working principle of an induction motor. **[6 marks]**

(d) The star-connected rotor of an induction motor has a standstill impedance of $(0.4 + j4)\ \Omega$ per phase and the rheostat impedance per phase is $(6 + j2)\ \Omega$. The motor has an induced emf of 80V between slip-rings at standstill when connected to its normal supply voltage. Find:

i) The rotor current at standstill with the rheostat in the circuit,
ii) The rotor current when the slip-rings are short-circuited and motor is running with a slip of 3%. **[6 marks]**

Question Four (20 marks)

(a) State two advantages of an autotransformer. **[2 marks]**

(b) Give two advantages and two disadvantages of $\Delta - \Delta$ three-phase transformer connections. **[4 marks]**

(c) A single-phase transformer is rated at 40 kVA. The transformer has full-load copper losses of 800 W and iron losses of 500 W. Determine:

i) the transformer efficiency at full-load and 0.8 power factor. **[4 marks]**

ii) the transformer efficiency at half full-load and 0.8 power factor. **[3 marks]**

(d) A 21.45-kVA, 3300/220-V distribution transformer is connected as a step-down autotransformer, with the load connected to the secondary windings. Draw the diagram for this combination and determine:

i) The primary winding voltage,
ii) The secondary winding voltage,
iii) The turn ratio,
iv) The nominal rating of the autotransformer. **[7 marks]**

Question Five (20 marks)

a) State four parameters that can be found using the blocked rotor test. **[2 marks]**

b) i) Write the formula for the starting torque of a motor. **[1.5 marks]**

ii) Draw a diagram showing the different stages of power development in an induction motor. **[3.5 marks]**

c) Explain the working principle of a star-delta starter. **[4 marks]**

d) A 1100 V, 50 Hz delta-connected induction motor has a star-connected slip-ring rotor with a phase transformation ratio of 3.8. The rotor resistance and standstill leakage reactance are 0.012Ω and 0.25Ω per phase respectively. Neglecting stator impedance and magnetizing current, determine:

i) the rotor current at start with slip-rings shorted, **[2.5 marks]**

ii) the rotor power factor at start with slip-rings shorted, **[0.5 marks]**

iii) the rotor current at 4% slip with slip-rings shorted, **[2.5 marks]**

iv) the rotor power factor at 4% slip with slip-rings shorted, **[0.5 marks]**

v) the external rotor resistance per phase required to obtain a starting current of 100 A in the stator supply lines. **[3 marks]**