OCD087

UNIVERSITY OF GREATER MANCHESTER

OFF CAMPUS DIVISION

WESTERN INTERNATIONAL COLLEGE, RAS AL KHAIMAH

BENG (HONS) ELECTRICAL AND ELECTRONIC ENGINEERING

SEMESTER TWO EXAMINATION 2024/2025

ELECTRICAL MACHINES AND POWER ELECTRONIC DRIVES

MODULE NO: EEE6011

Date: Saturday, 24 May 2025 **Time: 10:00 am – 12:30 pm**

INSTRUCTIONS TO CANDIDATES:

There are FIVE (5) questions on this paper.

Answer any FOUR (4) questions.

All questions carry equal marks.

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QUESTION 1

a) A 25 kVA, single phase transformer has 250 turns on the primary winding and 40 turns on the secondary winding. The primary is connected to a 1500 V, 50 Hz AC supply. Based on this data, determine the full load primary and secondary currents, the secondary induced electromotive force (emf), and the maximum magnetic flux in the core.

(7 marks)

b) A 750 kVA distribution transformer has full load copper loss of 6.5 kW and iron loss of 4.2 kW. Calculate the all-day efficiency of the transformer if the transformer operates for 24 hours a day with varying load conditions as given in the table below.

No. of hours	Loading in kW	Power Factor
8	500	0.85
6	400	0.8
6	250	0.75
4	0	-

(10 marks)

c) In a no-load test conducted on a single-phase transformer, the following data were recorded:

The primary voltage: 220 V,

The secondary voltage:110 V,

The no load primary current: 0.5 A,

The input power: 30 W

Calculate the turns ratio of the transformer, the magnetising component of the no load current, the working (or loss) component of the no load current, and the iron loss in the transformer. The resistance of the primary winding is given as 0.6 Ω.

(8 marks)

[TOTAL 25 MARKS]

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QUESTION 2

a) A DC motor takes an armature current of 110 A at 480 V. The armature circuit resistance is 0.2 Ω. The machine has 6 poles, and the armature is lap connected with 864 conductors. The flux per pole is 0.05 Wb. Calculate the speed, the gross torque developed by the armature and the efficiency of the motor assuming only armature copper loss.

(16 marks)

b) Explain how the armature voltage control method influences the speed of a DC shunt motor. Using this method, calculate the new speed of a DC shunt motor when the armature voltage is reduced from 220 V to 180 V. The motor initially runs at 1000 rpm and draws an armature current of 30 A. Given that the armature resistance is 0.5 Ω and the load torque remains constant.

(9 marks)

[TOTAL 25 MARKS]

QUESTION 3

a) A 440 V, shunt motor has armature resistance of 0.8 Ω and field resistance of 200 Ω. Determine the back emf, when giving an output of 7.46 kW at 85 % efficiency.

(6 marks)

b) A 25 kW, 250 V, DC shunt generator has armature and field resistances of 0.06 Ω and 100 Ω respectively. Determine the total armature power developed when working as a generator delivering 25 kW output and as a motor taking 25 kW input.

(10 marks)

c) Explain three different methods used to control the speed of a DC motor.

(9 marks)

[TOTAL 25 MARKS]

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QUESTION 4

a) A 4 pole, 3 phase induction motor operates on a 50 Hz power supply. Calculate the synchronous speed at which the stator's magnetic field rotates, the rotor speed when the slip is 0.04, the frequency of the rotor currents when the slip is 0.03, and the frequency of the rotor currents when the motor is at standstill.

(6 marks)

b) A 100 kW, 3300 V, 50 Hz, 3 phase, star connected induction motor has a synchronous speed of 500 rpm. The full load slip is 1.8 % and full load power factor 0.85. Stator copper loss is given as 2440 W. Iron loss is 3500 W. Rotational losses is 1200 W. Calculate the rotor copper loss, the line current and the full-load efficiency.

(12 marks)

c) State and briefly explain any two starting methods used for single-phase induction motors with the help of diagrams.

(7 marks)

[TOTAL 25 MARKS]

QUESTION 5

a) A 75 kW, 3 phase, Y connected, 50 Hz, 440 V cylindrical rotor synchronous motor operates at rated condition with 0.8 p.f. leading. The motor efficiency excluding field and stator losses, is 95 % and Xs = 2.5 Ω. Calculate mechanical power developed, the armature current, the back e.m.f., the power angle and the maximum or pull-out torque of the motor.

(12 marks)

Question 5 continued over the page…

Question 5 continued…

b) A hybrid variable reluctance (VR) stepping motor is constructed with 8 main stator poles, each castellated to have 5 teeth, giving a total of 40 stator teeth. The rotor has 50 teeth. Calculate the stepping angle of the motor in degrees, the resolution of the motor in terms of steps per revolution. Also determine the number of steps required for the motor shaft to complete 25 full revolutions.

(6 marks)

c) A half wave rectifier circuit uses an SCR, which is adjusted to have a gate current of 1 mA. The SCR's forward breakdown (triggering) voltage is 100 V when the gate current is 1 mA. If the circuit is supplied with a sinusoidal voltage of 200 V peak, determine the firing angle of the SCR, the conduction angle and the average load current. Assume the load resistance is 100 Ω, and the holding current is zero.

(7 marks)

[TOTAL 25 MARKS]

END OF QUESTIONS

PLEASE TURN THE PAGE FOR EQUATION SHEET

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EQUATION SHEET

TRANSFORMERS:

$$E_1 = 4.44\, f\, N_1\, \emptyset_m = 4.44\, f\, N_1\, B_m A$$

$$E_2 = 4.44\, f\, N_2\, \emptyset_m = 4.44\, f\, N_2\, B_m A$$

$$\text{transformation ratio K} = \frac{V_2}{V_1} = \frac{N_2}{N_1} \quad \text{transformation ratio K} = \frac{V_2}{V_1} = \frac{N_2}{N_1} = \frac{I_1}{I_2}\,\frac{I_1}{I_2}$$

DC motors

$$T_a \alpha\, \emptyset\, I_a$$

$$N \alpha \frac{E_b}{\emptyset}$$

$$E_b = V - I_a R_a$$

$$E_b = \frac{\emptyset Z N}{60} * \frac{P}{A}$$

$$T_a = 0.159\, \emptyset\, z\, I_a \frac{P}{A}$$

$$T_{sh} = 9.55\, \frac{Output}{N} Nm$$

$$T_{sh} = F * r$$

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$$I_{sh} = \frac{V}{R_{sh}}$$

$$Power\ Factor = \frac{kW}{KVA}$$

$$\eta = \frac{x * full\ load\ KVA * P.f}{x * full\ load\ KVA * P.f + W_{cu} + W_i}$$

$$\text{Horse Power} = \frac{\text{Power}}{740} \text{Horse Power} = \frac{\text{Power}}{740}$$

Slip speed $N_s = \frac{120*f}{p} N_s = \frac{120*f}{p}$

$$\text{Percentage slip } = \frac{Syn\ speed - Rotor\ speed}{Syn\ speed} * 100\ \%$$

$$\text{Rotor speed} = \frac{120 * f\ (1 - S)}{P}$$

AC Machines

Synchronous Speed, $N_S = \frac{120f}{p}$

Slip, S= $\frac{N_S - N}{N_S}$ * 100%

Slip, S= $\frac{Rotor\ Copper\ Loss}{Rotor\ Input}$ *100%

Frequency of the induced e.m.f.'s in the rotor = S*f

Mechanical power developed by the rotor= Rotor input power – Rotor copper losses

Output power of the motor=
Mechanical power developed by the rotor - Friction or windage losses(if any)

Efficiency of the motor = $\frac{Output\ power}{Input\ power}$ *100%

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Duty cycle of the PWM signal = $\frac{Average\ voltage\ across\ motor}{supply\ voltage}$ *100%

RMS voltage across the motor = Supply Voltage * $\sqrt{Duty\ Cycle}$

Effective voltage applied across motor = Effective RMS Voltage - Back E.M.F

Peak voltage of an AC Voltage = $\sqrt{2}$ * V_{rms}

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