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L-2/T-1/IPE

Date: 01/09/2025

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-1 B.Sc. Engineering Examinations 2023-2024

Sub: EEE 271 (Electrical Machines and Electronics)

Full Marks: 210

Time: 3 Hours

The figures in the margin indicate full marks

USE SEPARATE SCRIPTS FOR EACH SECTION

### SECTION – A

- There are FOUR questions in this section. Answer to Question no. 1 is compulsory. Answer any TWO questions from Questions 2 – 4. The corresponding Course Outcomes (COs) of each part of Question 1 are mentioned on the right most column below the marks. The COs of the course are mentioned at the end of the question paper.
- All the symbols have their usual meanings.
- Assume reasonable values for missing data.

1. (a) Discuss the various speed control methods of a shunt DC motor using the torque-speed relation. Explain why no single method is suitable for controlling speed across the entire range. Support your explanation with appropriate plots showing maximum torque and maximum power versus speed.

15  
(CO1)

(b) A shunt DC motor of Fig1. for Q. 1(b) initially has  $R_{adj} + R_F = 50 \Omega$ . It was operating with the terminal characteristic as shown in Plot-1 of Fig2. for Q. 1(b), with no-load speed = 1200 r/min. The rheostat has now adjusted to modify its terminal characteristic as shown in Plot-2 of Fig2. for Q. 1(b), with no-load speed = 1300 r/min.

20  
(CO3)

- (i) Estimate the percentage reduction in flux to modify the characteristic plot as mentioned above. If the motor is operating in linear region of magnetization curve ( $\phi \propto I_F$ ), find the modified value of  $R_{adj} + R_F$  too.
- (ii) The load on the motor is now increased and it is operating on point 'A' of Plot-2 of Fig2. for Q. 1(b). Find the induced voltage, armature current, line current and induced torque of the motor at point 'A'.

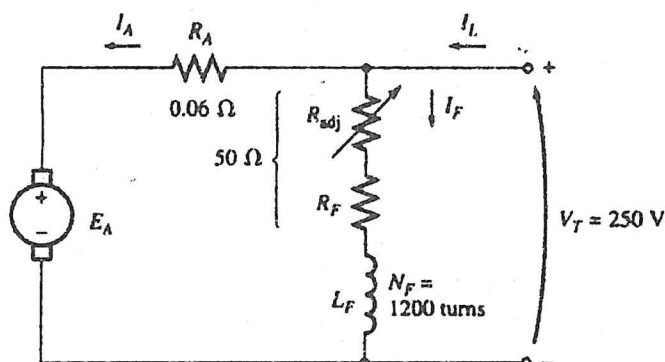
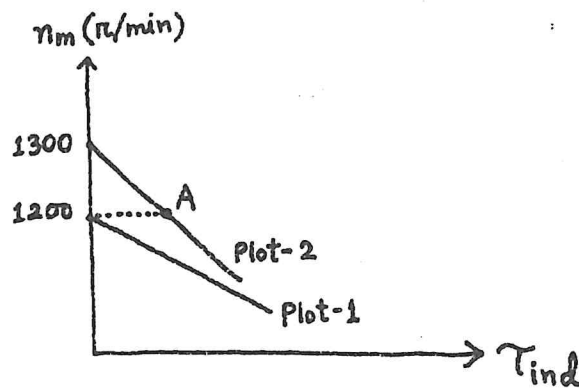


Fig1. for Q. 1(b)

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**Contd... Q. No. 1(b)**



**Fig2. for Q. 1(b)**

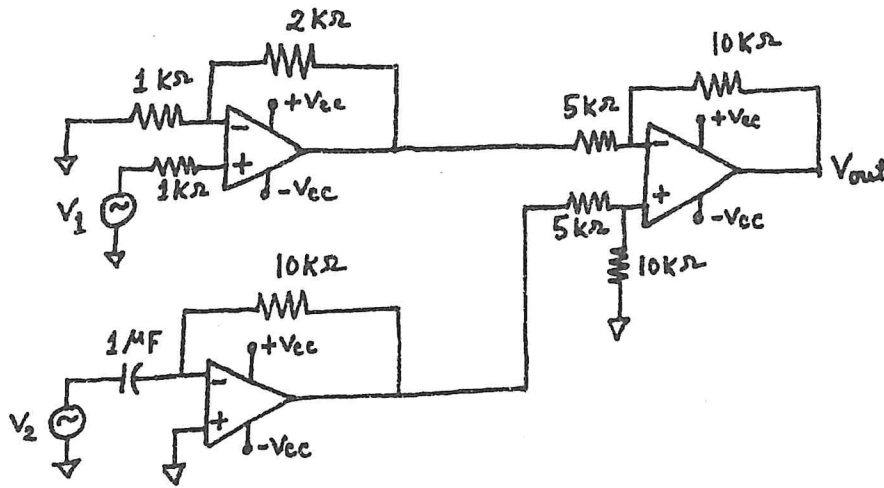
2. (a) Derive the torque-speed relation and characteristic plot of a series DC motor. Compare the advantages and disadvantages of series DC motor over shunt DC motor. (10)
- (b) With neat sketches, derive the expression of induced voltage in the rotating loop of a two pole DC machine. (8)
- (c) A 50-hp, 1200 r/min DC motor with compensating windings has an armature resistance (including the brushes, compensating windings, and interpoles) of  $0.06 \Omega$ . The armature and field circuit has been separately excited with two different DC sources of 250V. Its field circuit has a total resistance  $R_{adj} + R_f$  of  $50 \Omega$ , which produces a *no-load* speed of 1200 r/min. (17)
- (i) Find the speed of this motor when its armature current is 100 A.
- (ii) Suppose the load is increased so that armature current is now 200 A. Now find the speed of this motor.
- (iii) Now with the same load as (ii), the input voltage of the armature circuit is reduced to 200V. Find the speed of the motor with this reduced voltage.
- (iv) Estimate the torque of the three above cases. Now, draw a free-hand sketch of the torque-speed characteristic plot of this motor and show the three operating points of (i), (ii), (iii).
3. (a) An Op-Amp has a triangular input at its non-inverting terminal and a DC input at its inverting terminal. The Op-Amp is operating without feedback, produces a square wave of 30% duty cycle. Draw the circuit diagram and waveform of the two inputs properly to get the output. You must mention the peak value and period of the triangular input and the value of the DC input. (10)
- (b) Design a circuit with Op-Amps that has four inputs  $v_1, v_2, v_3, v_4$  and produces output,  $v_0$  such that, (12)

$$v_0 = 3(v_1 - v_2) + 2 \frac{dv_3}{dt} + 0.5 \int v_4 dt$$

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**Contd... Q. No. 3**

(c) In the circuit shown in Fig. for Q. 3(c),  $v_1 = 2 \sin(100t)$ ,  $v_2 = 5 \sin(100t)$  and  $V_{cc} = 15V$ . If the output  $v_{out} = A \sin(100t + \theta)$ , find the values of  $A$  and  $\theta$ . (13)



**Fig. for Q. 3(c)**

4. (a) Using the I-V characteristic and two-transistor model, explain how applying gate pulse turns on a thyristor. (10)
- (b) Derive the expression of rms output voltage of a single-phase half-wave controlled rectifier circuit with a resistive load. (8)
- (c) Deduce the relation between Gauge Factor and Poisson's ratio for a resistance wire strain gauge. (17)  
 A resistance wire strain gauge with Poisson's ratio of +0.5 is bonded to a steel structural member subjected to a stress of  $100 \text{ MN/m}^2$ . The modulus of elasticity of steel is  $200 \text{ GN/m}^2$ . Calculate the percentage change in the value of the gauge resistance due to the applied stress.

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**SECTION – B**

There are **FOUR** questions in this section. Answer to Question No. 5 is **COMPULSORY**.

Answer any **TWO** questions from Questions 6 - 8.

5. (a) 3-phase, 230-V, 50-Hz, 100-hp, six-pole induction motor has an efficiency of (20)  
91% (at rated conditions) and draws a line current of 24.8 A. Its core loss, stator cu (102)  
loss, and rotor cu loss are 1697 W, 2803 W, and 1549 W, respectively. Find its  
(i) input power  
(ii) total loss,  
(iii) air gap power,  
(iv) shaft speed,  
(v) power factor,  
(vi) Friction and Stray Loss combined,  
(vii) shaft torque.
- (b) Analyze the torque-speed characteristics of a three-phase induction motor. How (15)  
do the characteristics of this motor vary with line frequency? Explain with necessary (103)  
equations.
6. A 208 V, four pole , 50Hz, Y-connected induction motor supplies 13kW to a load at (35)  
a speed of 1460 r/m. Its equivalent circuit components are  
 $R_1 = 0.1 \Omega$   
 $X_M = 20 \Omega$   
 $X_1 = X_2 = 0.21 \Omega$   
All the mechanical losses are negligible.
- What is the motor's slip?
  - What is the induced torque of the motor in N-m under these conditions?
  - What will be the operating speed if the motor's torque is doubled?
  - How much power will be supplied by the motor if the torque is doubled?
  - Find the value of rotor resistance during the condition described in Q 6 (iv)
  - Find the speed at which maximum torque occurs

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7. A 240 V, Y connected synchronous motor is drawing 55A at unity pf from a 240V power system. The field current flowing under these conditions is 3.5A. Its synchronous reactance is  $2.6\Omega$ . Friction and windage loss, core loss are negligible. Assume a linear open circuit characteristic. (35)
- i) Find  $V_\phi$  and  $E_A$  for these conditions.
  - ii) Find initial torque angle.
  - iii) How much field current is required to make the motor operate at 0.8pf leading?
  - iv) What is new torque angle ?
  - v) How much power the motor is supplying?
  - vi) Sketch the phasor diagram before and after changing the field current in the same axis.
  - vii) After changing the field current now the load is increase3d by 35%. What will be the new power factor and torque angle?

8. (a) A 1000 VA 230/115 V single-phase transformer has been tested to determine the approximate equivalent circuit. The results of the tests are shown in Table for Q 8. (35)

Table for Q8

| Open circuit test | Short circuit test |
|-------------------|--------------------|
| $V_{OC} = 115V$   | $V_{SC} = 17.10 V$ |
| $I_{OC} = 0.11 A$ | $I_{SC} = 4.35A$   |
| $P_{OC} = 4.0 W$  | $P_{SC} = 38.50 W$ |

- i. According to the given data, on which side the open circuit test was performed? Justify your answer.
- ii. According to the given data, on which side the short circuit test was performed? Justify your answer
- iii. Find the parameters of the approximate equivalent circuit referred to the HT side and draw the approximate equivalent circuit.
- iv. Find the voltage regulation at rated load and 0.85 pf leading.
- v. Find the transformer efficiency at rated load and 0.85 pf lagging.

| Course Outcomes of EEE 271: Electrical Machines and Electronics |  |
|---|--|
| COs   | CO Statement   |
| CO1   | Explain the operation and working principles of electronic devices, equipment and electrical machineries.                |
| CO2   | Apply knowledge to solve problems relevant to the operation of electronic devices, equipment and electrical machineries. |
| CO3   | Analyse the operation of electronic devices, equipment and electrical machineries.                                       |
| CO4   | Design control circuits for electrical machines such that specified performance characteristics are attained             |