higher education & training

Department:
Higher Education and Training
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NATIONAL CERTIFICATE

ELECTRO-TECHNOLOGY N3

(11040343)

21 April 2021 (X-paper)
09:00–12:00

This question paper consists of 7 pages and a formula sheet of 3 pages.

278Q1A2121

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TIME: 3 HOURS
MARKS: 100

INSTRUCTIONS AND INFORMATION

1. Answer all the questions.
2. Read all the questions carefully.
3. Number the answers according to the numbering system used in this question paper.
4. Start each question on a new page.
5. Use only blue or black ink.
6. Write neatly and legibly.

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QUESTION 1

Complete the following sentences by choosing words from the list below. Write only the answer next to the question number (1.1–1.10) in the ANSWER BOOK.

torque; motor; rotor; roller bearing; soldering; ball bearing; commutator; eddy current losses; pole shoes; lap windings; copper losses; wave windings, field winding

1.1 The armature assembly of a DC machine is also known as a …

1.2 … is minimised by laminating the field poles and armature cores.

1.3 … is a type of bearing used for heavy-duty applications.

1.4 … is a method used to attach the armature conductors to the commutator segments.

1.5 … is a twisting force that results in angular motion.

1.6 A/An … is a DC machine used to convert electrical energy into mechanical energy.

1.7 A/An … is made up of hard-drawn, wedge-shaped copper segments insulated from each other by thin mica sheets.

1.8 … are used to hold the field coils securely in position.

1.9 … are also known as overlap or parallel windings.

1.10 The ends of … are connected to commutator segments that are far apart.

(10 × 1) **[10]**

QUESTION 2

2.1 Name THREE types of self-excited generators. (3)

2.2 Draw a fully labelled circuit diagram of a shunt generator. Clearly show all the currents. (4)

2.3 Define an *under-compounded generator*. (2)

2.4 Interpoles are smaller poles found midway between the main poles and they are used to improve commutation.

Name the current that flows through these windings. (1)

[10]

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QUESTION 3

3.1 Draw a neat, fully labelled sketch of a manual face-plate starter used to start a shunt motor. (6)

3.2 A 12 kW, 300 V DC series-wound motor has a full-load efficiency of 93%.

Calculate the full-load speed of the motor if its series field and armature resistances are 0, 15 Ω and 0, 2 Ω respectively. Take the motor's constant to be 15 and the useful flux per pole to be 36 mWb. (4)

[10]

QUESTION 4

4.1 A 15 kW, DC shunt generator supplies its load at a terminal voltage of 400 V. The generator has an armature and shunt field resistance of 0, 25 Ω and 160 Ω respectively.

Calculate the following:

4.1.1 The armature current (3)

4.1.2 The armature copper loss (2)

4.1.3 The shunt field copper loss (1)

4.1.4 The efficiency of the machine if the iron, friction and windage losses amount to 550 W (2)

4.2 The magnitude of losses occurring in a DC machine determines its efficiency.

Name the method used to determine the efficiency of the following:

4.2.1 A large shunt or compound-wound machine

4.2.2 Two large identical shunt or compound-wound machines tested simultaneously.

(2 × 1) (2)

[10]

QUESTION 5

5.1 State TWO methods that can be used to improve the power factor of a plant. (2)

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5.2 An alternating emf is represented by the following expression:
$e = 240 \sin(1\,570t)$.

Determine the following:

5.2.1 The time taken for this emf to reach a value of 199, 75 V for the first time after the commencement of a cycle (3)

5.2.2 The time taken for this emf to reach its maximum value (3)

5.2.3 The instantaneous value of the emf 0,5 milliseconds after the commencement of a cycle (2)
[10]

QUESTION 6

A 200 V, 50 Hz, single-phase supply is used to supply a load which draws 4,5 A at a power factor of 0,9 lagging.

6.1 Draw a suitable vector diagram to show the voltage vector, current vector and phase angle. (3)

6.2 Calculate the magnitude of the phase angle. (1)

6.3 Calculate the true power drawn by the load. (2)

6.4 Calculate the reactive power needed by the load. (2)

6.5 Is this load an inductive or capacitive load? Give a reason for your answer. (2)
[10]

QUESTION 7

7.1 Three powers are associated with an alternating current circuit.

Give the formulae for calculating each power using the following values if efficiency is not given

7.1.1 Line values

7.1.2 Phase values

(3 × 2) (6)

7.2 Show by means of a neat, fully labelled circuit diagram how the terminals of the three-phase motor are connected in star and to the supply. (3)

7.3 Give another name for a mesh connection. (1)
[10]

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QUESTION 8

8.1 Draw a neat, labelled sketch of a step-down auto transformer. (3)

8.2 A three-phase distribution transformer has a star-connected primary and a delta-connected secondary. The transformer is supplied at 3,3 kV and the secondary phase voltage is 240 V.

Calculate the following:

8.2.1 The primary phase voltage (1)

8.2.2 The turns ratio of the transformer (2)

8.2.3 The primary line current if the transformer delivers a line current of 145 A (2)

8.2.4 The full-load rating of the transformer in kVA (2)
[10]

QUESTION 9

9.1 Indicating type instruments have THREE important mechanisms.

What is the function of the following mechanisms?

9.1.1 Deflecting mechanism

9.1.1 Controlling mechanism

9.1.1 Damping mechanism

(3 × 1) (3)

9.2 9.2.1 State TWO advantages of moving-iron instruments.

9.2.2 State TWO disadvantages of moving-iron instruments.

(2 × 2) (4)

9.3 The two-wattmeter method is used to measure the total power drawn by a balanced three-phase load.

Make a neat sketch to show how this method is used to measure the total power delivered to a balanced load. (3)
[10]

QUESTION 10

10.1 A silicon-controlled rectifier (SCR) is a type of thyristor.

State THREE uses of an SCR. (3)

10.2 A rectifier circuit is used to convert an alternating current into a direct current.

Make a neat, fully labelled sketch of a half-wave rectifier circuit and show the input and output waveforms. (4)

10.3 Add 1111_2 to 11010_2 by using the rules for binary addition. (3)

[10]

TOTAL: 100

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ELECTRO-TECHNOLOGY N3

FORMULA SHEET

Any applicable formula may also be used

1. $E = V - I_a R_a$
2. $E = V + I_a R_a$
3. $E = 2p\Phi \frac{ZN}{60c}$
4. $N = \frac{V}{K\Phi}$
5. $T = \frac{0,318 I_a Zp\Phi}{C}$
6. Efficiency = $\frac{VI}{VI + I_a{}^2 R_a + I_s V + C} \times 100\%$
7. Efficiency = $\frac{VI - (I_a{}^2 R_a + I_s V + C)}{VI} \times 100\%$
8. Efficiency = $\frac{2\pi N(W - S)r}{60VI} \times 100\%$
9. Efficiency = $\sqrt{\frac{I_1}{I_1 + I_2}} \times 100\%$
10. E = Blv
11. e = E_m Sin2πft
12. i= I_m Sin2πft
13. $e_{ave/gem}$ or $i_{ave/gem}$ = 0,637 E_m or I_m
14. $e_{rms/wgk}$ or $i_{rms/wgk}$ = 0,707 E_m or I_m
15. $E_{ave/gem} = \frac{e_1 + e_2 + e_3 + e_4 + ... + e_n}{n}$

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Or $I_{ave/gem} = \frac{i_1 + i_2 + i_3 + ... + i_n}{n}$

16. $E_{rms/wgk} = \sqrt{\frac{e_1^2 + e_2^2 + e_3^2 + ... + e_n^2}{n}}$

Or $I_{rms/wgk} = \sqrt{\frac{i_1^2 + i_2^2 + i_3^2 + ... + i_n^2}{n}}$

17. Form factor = $\frac{E_{rms/wgk}}{E_{ave/gem}}$ or $\frac{I_{RMS/WGK}}{i_{AVE/GEM}}$

18. Crest factor = $\frac{E_m}{E_{rms/wgk}}$ or $\frac{I_m}{I_{rms/wgk}}$

19. $I = \frac{V}{R}$

20. $X_L = 2\pi fL$; $I = \frac{V}{X_L}$

21. $X_C = \frac{1}{2\pi fC}$; $I = \frac{V}{X_C}$

22. $Z = \sqrt{R^2 + X_L^2}$; $Z = \sqrt{R^2 + X_C^2}$; $I = \frac{V}{Z}$

23. Tan $\theta = \frac{X_L}{R}$; Tan $\theta = \frac{X_C}{R}$

24. $V_R = I \times R$; $V_L = I \times X_L$; $V_C = I \times X_C$

25. $Z = \sqrt{R^2 + (X_L - X_C)^2}$; $Z = \sqrt{R^2 + (X_C - X_L)^2}$

26. Tan $\theta = \frac{X_L - X_C}{R}$; Tan $\theta = \frac{X_C - X_L}{R}$

27. $P = V \times I$; $P = I^2 R$; $P = \frac{V^2}{R}$

28. $P = VI\cos\theta$

29. Cos $\theta = \frac{R}{Z}$; Cos $\theta = \frac{W \text{ or } kW}{VA \text{ or } kVA}$

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30. $I_{active} = ICos\theta$; $I_{reactive} = ISin\theta$

31. P = VI Cos θ

    Q = VI Sin θ

32. $f_r = \frac{1}{2\pi\sqrt{LC}}$

33. $I = \sqrt{I_R{}^2 + I_L{}^2}$; Tan θ = $\frac{I_L}{I_R}$

34. $I = \sqrt{I_R{}^2 + I_C{}^2}$; Tan θ = $\frac{I_C}{I_R}$

35. $I = \sqrt{I_R{}^2 + (I_L - I_C)^2}$; Tan θ = $\frac{I_L - I_C}{I_R}$

36. $I = \sqrt{I_R{}^2 + (I_C - I_L)^2}$; Tan θ = $\frac{I_C - I_L}{I_R}$

37. Cos θ = $\frac{I_R}{I}$

38. $V_L = V_p$; $I_L = \sqrt{3}I_p$

39. $V_L = \sqrt{3}V_p$; $I_L = I_p$

40. $W = \sqrt{3}V_L I_L Cos\theta \times \eta$

41. $\frac{V_1}{V_2} = \frac{N_1}{N_2} = \frac{I_2}{I_1}$

42. kVA = $\frac{\sqrt{3}V_L I_L}{1000}$

43. $V_{shunt} = V_{meter}$; $I_s R_s = I_m R_m$

44. $I_T = I_m + I_s$

45. $I_t = \frac{V_t}{R_t}$

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