higher education & training

Department:
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REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

ELECTRO-TECHNOLOGY N3

(11040343)

12 August 2021 (X-paper)
09:00–12:00

Drawing instruments and nonprogrammable calculators may be used.

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

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DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE
ELECTRO-TECHNOLOGY N3
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. Keep subsections of questions together.
6. Round off all calculations to THREE decimal places.
7. Use the correct symbols and units.
8. All circuit diagrams and vector diagrams must be at least ONE THIRD of a page and fully labelled.
9. Use only a blue or black pen.
10. Write neatly and legibly.

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QUESTION 1

1.1 Why should brushes used in DC machines be spring loaded? (2)

1.2 The armature assembly of a DC machine is the rotating part of the machine.

Name THREE components that make up the armature assembly. (3)

1.3 Regarding DC machines, state what is meant by the following terms:

1.3.1 Commutation (3)

1.3.2 Bedding of brushes (2)

[10]

QUESTION 2

2.1 Self-excited generators produce their own exciting currents.

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

2.2 In a compound-wound generator, the difference in terminal voltage between no load and full load should be minimal.

Draw a neat, fully labelled diagram of a short-shunt compound-wound generator, clearly showing all the currents, the input power and the output power. (4)

2.3 A compound generator could be either differential or cumulative compound.

What do you understand by a differential-compound generator? (2)

2.4 Compensating windings are used to improve commutation.

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

[10]

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QUESTION 3

3.1 The speed of a DC motor is inversely proportional to the main magnetic flux. State how the speed of a shunt-wound motor can be:

3.1.1 Increased above the normal speed

3.1.2 Decreased below the normal speed

(2 × 1) (2)

3.2 A 22 kW, 400 V, six-pole DC shunt-connected motor has a wave-wound armature with a resistance of 0,25 Ω. The motor runs at a full-load speed of 1 200 r/min with the useful flux per pole being 25 mWb.

Calculate for an efficiency of 85%:

3.2.1 The armature current if the shunt field resistance is 240 Ω (4)

3.2.2 The back emf induced in the armature (2)

3.2.3 The total number of conductors (2)

[10]

QUESTION 4

4.1 The efficiency of a DC motor was determined using the rope brake method. The following information was recorded:

Pulley diameter = 580 mm
Weights (W) = 28 kg
Spring balance reading = 120 N
Shaft speed = 900 r/min
Terminal voltage = 220 V
Current taken from mains = 21,25 A

Calculate the following:

4.1.1 The mechanical power output of the motor. Take g, as 9,8 m/s^2 (2)

4.1.2 The electrical power input of the motor (2)

4.1.3 The efficiency of the motor (1)

4.2 An overload relay is a protective device found in a manual face-plate starter.

Make a neat, fully labelled sketch of a simple oil dashpot-type OLR. (5)

[10]

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QUESTION 5

5.1 The output from an alternator is a sinusoidal wave.

Show, by using the definition of form factor, that the form factor of any sinusoidal wave is 1,11. (3)

5.2 An alternating emf has a maximum value of 500 V.

Calculate:

5.2.1 The average value of this emf

5.2.2 The RMS value of this emf

(2 × 2) (4)

5.3 Draw a sine wave and on it, represent the three values mentioned in QUESTION 5.2 above. (3)

[10]

QUESTION 6

A single-phase load draws 6,75 kW at a power factor of 0,85 lagging from a 220 V, 50 Hz supply.

Calculate:

6.1 The current drawn by this load (2)

6.2 The phase angle of the circuit (1)

6.3 The reactive power of the circuit (2)

6.4 The impedance of the load (2)

6.5 Draw a vector diagram to show the voltage and current vectors as well as the phase angle. (3)

[10]

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QUESTION 7

7.1 Copy the following table into your answer book and then fill in the blanks.

Symbol	Quantity	SI unit
P	True power	
	Apparent power	
	Reactive power	

(5)

7.2 A 60 kW, 525 V, three-phase, star-connected induction motor with a full-load efficiency of 95%, takes a phase current of 75 A from the supply.

Calculate the following:

7.2.1 The phase voltage of the motor (2)

7.2.2 The power factor at which the motor is operating (2)

7.2.3 The line current of the motor (1)

[10]

QUESTION 8

8.1 Autotransformers are used as voltage boosters to correct voltage drops in cables.

State TWO advantages of autotransformers. (2)

8.2 A 7,5 kVA single-phase transformer has 500 turns on the primary side and 1 500 turns on the secondary side. If the transformer is connected to a 240 V supply, calculate the following:

8.2.1 The current flowing through the primary winding

8.2.2 The secondary voltage on an open circuit

8.2.3 The current through the secondary winding during full load

8.2.4 The power delivered to the load in kW if the power factor is 0,8 lagging

(2 × 4) (8)

[10]

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QUESTION 9

9.1 Potential transformers are used to step down high voltages to values that are safe and practical to measure.

Draw a neat and fully labelled circuit diagram to show how a voltmeter is connected in a high-voltage system. (3)

9.2 In a dynamometer-type instrument, the main magnetic field is produced by a fixed coil instead of a permanent magnet.

State TWO advantages and TWO disadvantages of this type of instrument. (4)

9.3 A galvanometer with an internal resistance of 65 Ω gives full-scale deflection when 5 mA flow through it.

Calculate, by using a suitable circuit diagram, the value of a series resistor to be used with the meter so that the meter can measure a voltage of 100 V. (3)

[10]

QUESTION 10

10.1 A rectifier circuit is used to convert AC to DC. Make a neat and fully labelled sketch of a full-wave bridge rectifier circuit.

Also show the input and output voltage waveforms. (6)

10.2 Add the following binary numbers using the rules for binary addition:
101_2 and 111_2.

Convert your answer into its decimal equivalent. (4)

[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 = 2pΦ $\frac{ZN}{60c}$

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. $E_{ave/gem} = \frac{e_1 + e_2 + e_3 + e_4 + ... + e_n}{n}$

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

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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 $\theta = \frac{W \text{ or } kW}{VA \text{ or } kVA}$

30. $I_{active} = I\cos\theta$; $I_{reactive} = I\sin\theta$

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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 = $\frac{\sqrt{3} V_L I_L}{1\,000}$

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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