higher education & training

Department:
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NATIONAL CERTIFICATE

ELECTROTECHNOLOGY N3

(11040343)

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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
ELECTROTECHNOLOGY 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. Keep subsections of questions together.
5. Round ALL calculations off to THREE decimals.
6. Use the correct symbols and units.
7. Start each question on a NEW page.
8. ALL circuit diagrams and vector diagrams must be at least one third of a page and must be fully labelled.
9. Write neatly and legibly.

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QUESTION 1

1.1 The choice of armature windings is determined by the size and function of the machine.

State with regard to the nature of voltage and current the application of the following windings:

1.1.1 Lap winding

1.1.2 Wave winding

(2 × 2) (4)

1.2 The construction of a DC motor is similar to that of a DC generator.

Make a neat and fully labelled sketch of a two-pole DC machine. Show only the following labels:

- Yoke
- Field pole
- Pole shoe
- Field coil
- Armature

(6)
[10]

QUESTION 2

2.1 When a coil of wire is rotated inside a magnetic field, magnetic lines of flux are cut and an EMF is induced in the coil.

State THREE factors that will influence the magnitude of this EMF. (3)

2.2 Compound-wound generators are used to produce a nearly constant output voltage.

Draw a neat and fully labelled circuit diagram of a cumulative compound-wound generator and clearly show the following:

- All currents and their directions
- The input and output powers

(5)

2.3 Shunt-wound generators produce a relatively constant output voltage, provided the load current is below the maximum value.

State TWO uses of these generators. (2)
[10]

QUESTION 3

3.1 The method of controlling the speed of a shunt-wound motor is both easy and economical.

State how the speed of this motor can be:

3.1.1 Increased above normal speed

3.1.2 Decreased below normal speed

(2 × 2) (4)

3.2 The self-induced EMF in the armature of a DC motor makes the motor self-regulating.

Give another name by which this self-induced EMF is known. (2)

3.3 A series machine draws 45 amperes from a 250 V supply. The resistance of the series field and the armature are 0,1 ohm and 0,25 ohms respectively.

Determine the machine's constant if it runs at 1 000 r/min and the useful flux per pole is 25 milli-webers. (4)

[10]

QUESTION 4

4.1 Manual face-plate starters are used to limit the high starting currents of DC motors by introducing additional resistance into the armature circuit during starting.

Make a neat, fully labelled sketch of a manual face-plate starter used to start a shunt-wound motor. (7)

4.2 Two identical 200 V, 18 kW shunt-wound generators are tested simultaneously by means of the Hopkinson's back-to-back test. The current drawn from the supply is 12 amperes.

Determine the efficiency of each machine, assuming that full-load currents circulate between the machines. (3)

[10]

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QUESTION 5

5.1 A poor power factor will cost an industrial consumer a lot of money in maximum demand charges.

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

5.2 An alternating EMF is represented by the following equation:

$e = 420 \sin(628{,}319\ t)$ V.

Determine:

5.2.1 The time taken for this EMF to reach a value of 250 V for the first time after the commencement of a cycle

5.2.2 The time taken for this EMF to reach its maximum value

5.2.3 The instantaneous value of the EMF, 2 milliseconds after the commencement of a cycle

(3 × 2) (6)

5.3 State, with respect to an alternating waveform, what is meant by *frequency* of the wave. (2)

[10]

QUESTION 6

A series circuit consists of a 35 ohm resistor, a 60 mH inductor and a 200 µF capacitor. The circuit is connected across a 125 V, 50 Hz supply.

6.1 Calculate:

6.1.1 The total impedance of the circuit (3)

6.1.2 The total current flowing through the circuit (1)

6.1.3 The voltage drop across each of the three components (3)

6.2 Determine:

6.2.1 The algebraic sum of the three voltage drops (1)

6.2.2 The vector sum of the three voltage drops showing ALL your calculations (2)

[10]

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QUESTION 7

7.1 Unity power factor means that the current and voltage vectors are in phase.

Define *power factor*. (2)

7.2 A 22 kW, 380 V, star-connected, three-phase alternator supplies power to a certain load at a power factor of 0,8 lagging.

Calculate:

7.2.1 The phase voltage of the alternator (1)

7.2.2 The line current drawn by the load if the alternator is working at full load (2)

7.2.3 The phase current drawn by the load. (1)

7.2.4 The magnitude of the phase angle (1)

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

[10]

QUESTION 8

8.1 Autotransformers are used as motor starters to start large induction motors.

State THREE advantages of autotransformers. (3)

8.2 A three-phase distribution transformer has a delta-connected primary and a star-connected secondary winding. The transformer is supplied at 11 kV and if the secondary phase voltage is 500 V, calculate:

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 180 A per phase to the load (2)

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

[10]

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QUESTION 9

9.1 A moving-coil instrument with an internal resistance of 60 ohms, gives full-scale deflection when 15 mA flows through it.

Calculate the value of:

9.1.1 Shunt resistor to be used with the meter so that it will be able to measure a current of up to 9 A

9.1.2 Series resistor that the meter can be used as a voltmeter to measure a voltage up to 80 V

(2 × 3) (6)

9.2 An ammeter used with a current transformer gives full-scale deflection when 5 A flows through it.

9.2.1 State TWO safety precautions to be observed before removing the ammeter after a high current measurement. (2)

9.2.2 State the reason why all current transformers are earthed during operation. (1)

9.3 The two-wattmeter method was used to measure the power drawn by a balanced three-phase load. The readings on the two watt-meters were 18 kW and -4,7 kW respectively.

Determine the total power drawn by the load. (1)

[10]

QUESTION 10

10.1 State TWO functions of a transistor. (2)

10.2 A truth table shows the output of any circuit for every possible combination of inputs.

Determine the number of possible outputs of a logic gate having four inputs. (2)

10.3 Logic gates are used for switching purposes.

Draw the IEC symbol for a NOT gate. (3)

10.4 Subtract 110_2 from 1011_2, using the rules for binary subtraction. (3)

[10]

TOTAL: 100

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ELECTROTECHNOLOGY 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. $T = \frac{0,318 I_a Z p \Phi}{C}$
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. $e = E_m \text{Sin} 2\pi ft$
12. $i = I_m \text{Sin} 2\pi ft$
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 θ = $\frac{X_C}{R}$

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 θ = $\frac{X_L - X_C}{R}$; Tan θ = $\frac{X_C - X_L}{R}$

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

28. $P = VI\cos\theta$

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

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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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