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Department:
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REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

ELECTROTECHNOLOGY N3

(11040343)

16 April 2020 (X-paper)
09:00–12:00

This question paper consists of 6 pages and one formula sheet of 3 pages.

278Q1A2016

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. Start each question on a new page.
5. Use only a black or blue pen.
6. Write neatly and legibly.

QUESTION 1

1.1 Why are the field poles and the armature cores of DC machines laminated? (2)

1.2 Friction losses occur in the bearings that support the rotating armature.

Name TWO types of bearings commonly used in DC machines. (2)

1.3 State the function of each of the following components that make up the field system of a DC machine:

1.3.1 Field coils

1.3.2 Pole shoes

(2 × 2) (4)

1.4 Choose the correct word(s) from those given in brackets. Write only the word (s) next to the question number (1.4.1–1.4.2) in the ANSWER BOOK.

1.4.1 (Wave-wound, Lap-wound, Armature winding) is for heavy- current machines

1.4.2 When the ampere-turns of the two windings oppose each other, the machine is said to be (cumulatively compounded, compound connected, differentially compounded).

(2 × 1) (2)

[10]

QUESTION 2

2.1 State Faraday's first law of electromagnetic induction. (2)

2.2 Name TWO methods used to improve commutation and to reduce sparking. (2)

2.3 A 200 V DC, shunt-wound generator produces an armature current of 42,75 A. The resistance of the shunt field and armature are 125 Ω and 0,15 Ω respectively.

Calculate the following:

2.3.1 Magnitude of the generated EMF (2)

2.3.2 Efficiency of the generator if it is driven by a prime-mover rated at 9,5 kW (4)

[10]

QUESTION 3

3.1 Briefly explain the term *armature reaction* as applicable to DC machines. (2)

3.2 A 400 V, 15 kW, six-pole DC shunt motor has a lap-wound armature. The armature has 100 slots and there are four conductors per slot. The motor operates at a full-load efficiency of 85%.

Calculate the useful flux per pole if the motor develops a full-load torque of 136 Nm. Take the resistance of the field circuit to be 275 Ω. (5)

3.3 Draw the characteristic curve of a shunt motor showing torque against armature current. (3)

[10]

QUESTION 4

4.1 Name TWO places in a DC machine where iron losses occur. (2)

4.2 An overload relay is a protective device used to guard a motor against the harmful effects of an overload.

Make a neat, fully labelled sketch of a simple thermal-type overload relay. Show and label the following parts in the relay:

Contacts
Bimetal strip
Heating element (4)

4.3 During a brake test on a DC motor the following information was recorded:

Effective load on the brake drum	=	310 N
Pulley diameter	=	250 mm
Speed of shaft	=	875 r/min
Current drawn from the supply	=	17,5 A
Terminal voltage	=	220 V

Determine the efficiency of the motor. (4)

[10]

QUESTION 5

5.1 State what is meant by the following terms with regards to a sinusoidal waveform:

5.1.1 Cycle

5.1.2 Frequency

(2 × 2) (4)

5.2 An alternating current is represented by the following equation:

$$i = 13{,}5 \sin (376{,}991t)$$

Determine the following:

5.2.1 Frequency of this current

5.2.2 Average value of this current

5.2.3 Instantaneous value of the current, 0,75 milliseconds after the commencement of a cycle

(3 × 2) (6)
[10]

QUESTION 6

A parallel circuit is supplied by a 90 V, 50 Hz voltage source. This parallel circuit comprises of a 40 Ω resistor, a 120 mH inductor and a 220 µF capacitor.

Calculate the following:

6.1 Current drawn by each component (5)

6.2 Total current flowing through the circuit (2)

6.3 Power factor of the circuit (1)

6.4 Reactive power of the circuit (2)
[10]

QUESTION 7

7.1 An alternating current circuit has three powers associated with it. Copy the following table into your ANSWER BOOK and fill in the blank spaces.

SYMBOL	QUANTITY	FORMULA	UNIT
	True power	$VI \cos \emptyset$	
	Apparent power	VI	
	Reactive power	$VI \sin \emptyset$	

(6)

7.2 Draw a neat, fully labelled circuit diagram to show how the windings of a three-phase induction motor are connected in delta and then to the supply. (3)

7.3 A large induction motor is started by means of a star-delta starter.

Determine the voltage across the stator windings of this 525 V induction motor while running at full-load speed. (1)

QUESTION 8

8.1 The losses occurring in a transformer can be classified as either constant or variable losses.

Name TWO types of constant losses that occur in a transformer. (2)

8.2 A three-phase distribution transformer has 800 turns on the primary side and 200 turns on the secondary side. For a primary voltage of 11 kV, calculate the secondary line voltage on open circuit if the transformer is connected in:

8.2.1 Delta-star

8.2.2 Star-delta

(2 × 4) (8)
[10]

QUESTION 9

9.1 A moving-coil instrument gives a full-scale deflection if 20 mA flows through it. The internal resistance of
coil is 85 Ω..

Determine the following:

9.1.1 The resistance required to use the instrument as an ammeter for a 6,2 A current flow. (3)

9.1.2 The series resistance required to use it as a voltmeter up to 150 V. (3)

9.2 Give the value of the following measuring instruments:

9.2.1 The usual full-scale deflection of an ammeter connected to a current transformer. (1)

9.2.2 Output voltage of a potential transformer. (1)

9.3 Name TWO mechanisms which are found in measuring instruments. (2)
[10]

QUESTION 10

10.1 Draw a fully labelled IEC symbol for a silicon-controlled rectifier (SCR). (4)

10.2 Determine the number of inputs required so that the gate can produce 16 outputs. (2)

10.3 Convert $15{,}8125_{10}$ into its binary equivalent. (4)
[10]

TOTAL: 100

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

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 x 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 x I; $P = I^2 R$; P = $\frac{V^2}{R}$

28. P = VICosθ

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

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