higher education & training

Department:
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REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

ELECTROTECHNICS N4

(8080074)

19 November 2024 (X-paper)
09:00–12:00

Drawing instruments and non-programmable calculators may be used.

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

020Q1E2419

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DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE
ELECTROTECHNICS N4
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. Use only a black or blue pen.
5. Write neatly and legibly.

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QUESTION 1: PRINCIPLES OF ELECTRICITY

1.1 Complete the following sentences by writing only the missing word or words next to the question number (1.1.1–1.1.10) in the ANSWER BOOK.

1.1.1 To gain insight into the nature of electric currents, it is necessary to consider the … of the atom.

1.1.2 The coil produces the magnetisation of the circuit, and this property of the coil is called its … force.

1.1.3 Since the … of the magnetic circuit is low, the self-inductance of the primary winding is large compared with its resistance.

1.1.4 The capacitance of a capacitor is … proportional to the area of the plates and inversely proportional to the distance between them.

1.1.5 When two magnets are placed close to each other, unlike poles … each other.

1.1.6 Since the reluctance of the magnetic circuit is low, the … of the primary winding is large compared with its resistance.

1.1.7 The ratio between the … and the applied voltage is always called the capacitance.

1.1.8 An atom is the smallest particle of a … element that can exist.

1.1.9 Primary and secondary cells are the … sources of EMF.

1.1.10 A capacitor comprises plates and an insulating material, referred to as a …

(10 × 1) (10)

1.2 A resistor of unknown value X is connected in parallel to a 20 Ω resistor. This combination is then connected in series to another parallel combination with a 30 Ω and a 50 Ω resistor. The circuit is supplied from a 110 V supply.

Calculate the value of the unknown resistor if the current through the 50 Ω resistor is 2 A. Also, calculate the energy dissipated by the unknown resistor in 36 seconds. (9)

1.3 A 90 µF capacitor is connected in parallel with a 40 µF capacitor. This parallel combination is then connected in series with another parallel combination of a 70 µF and 35 µF capacitor. If the circuit is connected across a 110 V DC supply, calculate:

1.3.1 The total capacitance of the circuit. (4)

1.3.2 The potential difference across each parallel branch. (3)

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1.3.3 The charge across each capacitor. (4)

[30]

QUESTION 2: DC MACHINES

2.1 Name THREE applications of a DC series motor. (3)

2.2 State the function of each of the following relays in a manual faceplate starter for a DC motor:

2.2.1 No-volt relay (NVR)

2.2.2 Overload relay (OLR)

(2 × 2) (4)

2.3 A six-pole, 300 V, shunt-connected machine takes a current of 25 A from the supply. The armature is lap-wound and has a resistance of 0,2 Ω. The shunt field resistance is 100 Ω and the useful flux per pole is 20 mWb.

Calculate the number of armature conductors per slot if the armature has 75 slots and rotates at 1 300 r/min. (8)

2.4 A 400 V, four-pole, wave-wound DC shunt motor has 470 armature conductors. The shunt field resistance is 150 Ω.

Calculate the torque developed by the motor if the useful flux per pole is 25 mWb and the motor draws a current of 55 A from the supply. (5)

[20]

QUESTION 3: AC THEORY

Refer to FIGURE 1 below, and determine the magnitude of the current flowing through each branch. Leave your answer in a polar form.

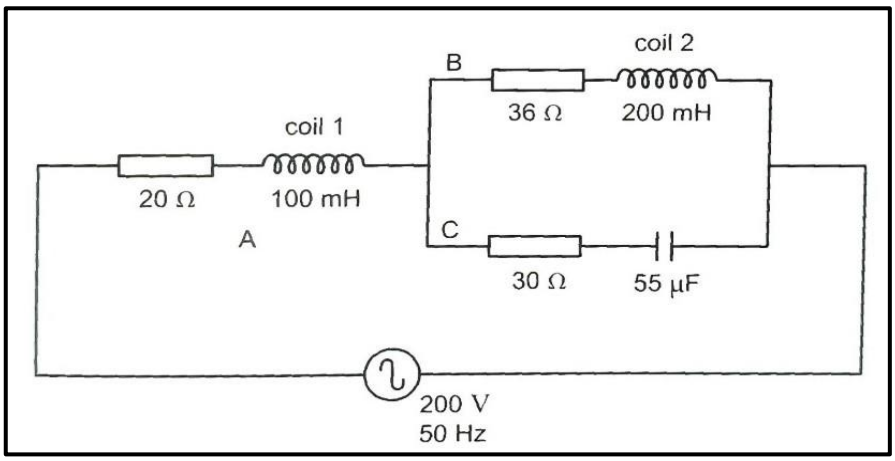


FIGURE 1 **[20]**

QUESTION 4: TRANSFORMERS

4.1 Show using a two single-phase configuration, how a star-delta transformer is connected for a three-phase, four-wire system. (6)

4.2 A single-phase 222/2 220 V, 50 Hz transformer has a net area of 100 cm² and 200 turns on the primary windings.

Calculate the maximum flux density in Tesla and the number of turns in the secondary windings. (4)

[10]

QUESTION 5: AC MACHINES

5.1 A three-phase, six-pole induction motor rotates at 400 r/min while being supplied from a 410 V, 50 Hz source.

Calculate:

5.1.1 The percentage slip at which the rotor of the induction motor is operating. (3)

5.1.2 The per-unit slip at which the rotor is operating. (1)

5.2 Briefly explain how to reverse the direction of rotation of the following motors:

5.2.1 Three-phase induction motor

5.2.2 Single-phase induction motor

5.2.3 Universal motor

(3 × 2) (6)

[10]

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QUESTION 6: GENERATION AND SUPPLY OF AC POWER AND MEASURING INSTRUMENTS

6.1 An overhead, three-phase grid network is used to interconnect power stations and bulk consumers.

Study FIGURE 2 below which represents the electrical reticulation network mainly used in South Africa, and answer the question that follow.

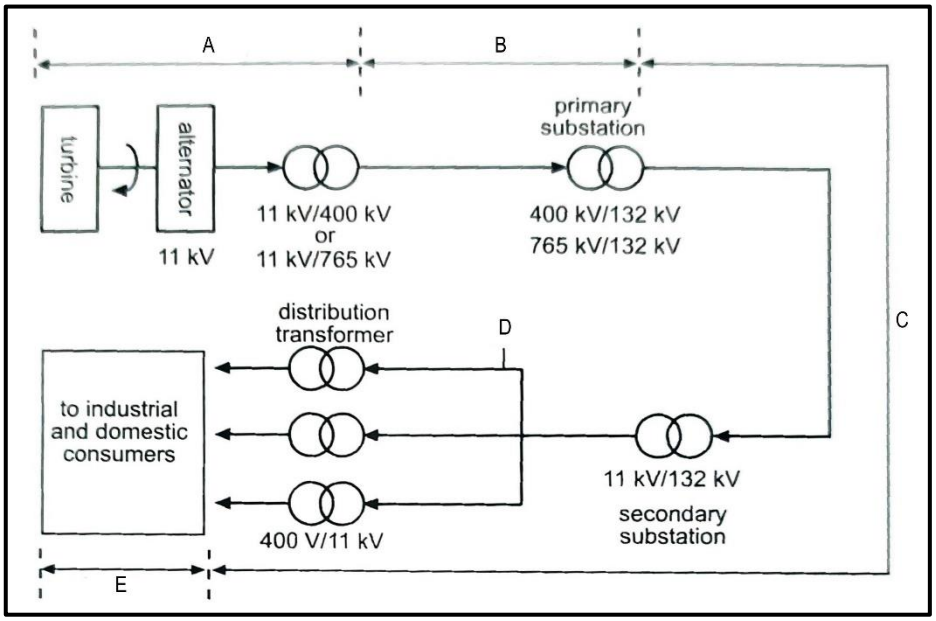


FIGURE 2

Name the FIVE stages, as represented by the letters A, B, C, D and E. Write only the answer next to the letter (A–E) in the ANSWER BOOK. (5)

6.2 Choose a term from COLUMN B that matches a description in COLUMN A. Write only the letter (A–F) next to the question number (6.2.1–6.2.5) in the ANSWER BOOK.

COLUMN A		COLUMN B	
6.2.1	An instrument used for measuring electric current in a circuit	A	voltmeter
6.2.2	An instrument used for measuring electrical potential difference between two points in an electric circuit	B	long resistor
6.2.3	An instrument used to detect and measure very small direct currents	C	ohmmeter
6.2.4	A low-resistance resistor used with a meter when measuring currents bigger than the range of the meter	D	ammeter
6.2.5	A high-resistance resistor used with a meter when measuring voltages bigger than the range of the meter	E	shunt resistor
		F	galvanometer

(5 × 1) (5)

[10]

TOTAL: 100

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ELECTROTECHNICS N4

FORMULA SHEET

Any applicable formula may also be used.

PRINCIPLES OF ELECTRICITY

1. $E = V + I\,r$

2. $V = IR$

3. $R_T = R_{se} = R_1 + R_2 + R_3 + ...R_n$

4. $\frac{1}{R_T} = \frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + ...\frac{1}{R_n}$

5. $P = V\ I = I^2R = \frac{V^2}{R}$

6. $\eta = \frac{\boldsymbol{P}_0}{\boldsymbol{P}_{in}} \times 100$

7. $R = \rho\frac{l}{A}$

8. $A = \frac{\pi d^2}{4}$

9. $\frac{R_1}{R_2} = \frac{1+\alpha_0 T_1}{1+\alpha_0 T_2}$

10. $R_t = R_\theta[1+\alpha_\theta(t-\theta)]$

11. $R_T = R_1 + \frac{R_2\ x\ R_3}{R_2 + R_3}$

12. $I_{SC} = I_N = \left[\frac{R_2}{R_2 + R_3}\right] I_T$

13. $R_{SC} = R_N = R_3 + \frac{R_1\ x\ R_2}{R_1 + R_2}$

14. $I_L = \left[\frac{R_N}{R_N + R_2}\right] I_N$

15. $\phi = \frac{mmf}{S} = \frac{IN}{S}$

16. $H = \frac{IN}{l}$

17. $F = BlI$

18. $E = Blv$

19. $B = \frac{\phi}{a}$

20. $E = \frac{\Delta\phi}{\Delta t}.N$

21. $E = \frac{L\Delta I}{\Delta t}$

22. $L = \frac{\Delta\phi}{\Delta l}.N$

23. $Q = VC$

24. $V = \frac{Q}{C}$

25. $Q_{se} = Q_1 = Q_2 = Q_3 ... = Q_n$

26. $Q_p = Q_1 + Q_2 + ...Q_n$

27. $C_{se} = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + ...\frac{1}{C_n}}$

28. $C_p = C_1 + C_2 + ...C_n$

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DIRECT CURRENT MACHINES

29. $E = \frac{2ZNp\phi}{60c}$

30. $E = kN\phi$

31. $c = 2a$

32. $E = I_{sh}R_{sh} + L\frac{\Delta I}{\Delta t}$

33. $R_{start} = \frac{(V - E)}{I_a} - R_a$

34. $I_{a_{start}} = \frac{V}{R_a + R_{start}}$

35. $E_{gen} = V + I_a R_a$

36. $E_{mot} = V - I_a R_a$

ALTERNATING CURRENT THEORY

37. $E_m = 2\pi BANn$

38. $e = E_m \sin(2\pi f.t.57,3)^0$

39. $E_{rms} or I_{rms} = 0,707 E_m or I_m$

40. $E_{ave} or I_{ave} = 0,637 I_m or I_m$

41. $T = \frac{1}{f}$

42. $f = \frac{Np}{60}$

43. $\omega = 2\pi f$

44. $Z = \sqrt{R^2 + X^2}$

45. $\cos\phi = \frac{R}{Z}$

46. $\tan\phi = \frac{X}{R}$

47. $Z_L = R + j\omega L$

48. $Z_C = R - j\frac{1}{\omega C}$

49. $P = V\ I\ Cos\phi = I^2 R$

50. $pf = Cos\phi = \frac{R}{Z}$

51. $\boldsymbol{S} = \boldsymbol{V}\ \boldsymbol{I}$

52. $Q = V\ I\ Sin\phi$

TRANSFORMERS

53. $E = 4,44\, f\, \phi_m N$

54. $k_t = \frac{N_1}{N_2} = \frac{V_1}{V_2} = \frac{E_1}{E_2} = \frac{I_2}{I_1}$

ALTERNATING CURRENT MACHINES

55. $\mathrm{Ns} = \frac{f}{p}$

56. $s = \frac{Ns - Nr}{Ns}$

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MEASURING INSTRUMENTS

57. $$\boldsymbol{R_{sh} = \frac{I_m R_m}{I_{sh}}}$$

58. $$R_x = \frac{V}{I} - R_a$$

59. $$R_{se} = \frac{V_t}{I_t} - R_m$$

60. $$R_x = \frac{V}{I - I_v}$$

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