higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE (VOCATIONAL)

ELECTRICAL PRINCIPLES AND PRACTICE
NQF LEVEL 4

(12041004)

21 November 2023 (X-paper)
09:00–12:00

Calculators may be used.

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

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DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE (VOCATIONAL)
ELECTRICAL PRINCIPLES AND PRACTICE
NQF LEVEL 4
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

1.1 State Kirchhoff's current law as used to solve electrical network circuits: (2)

1.2

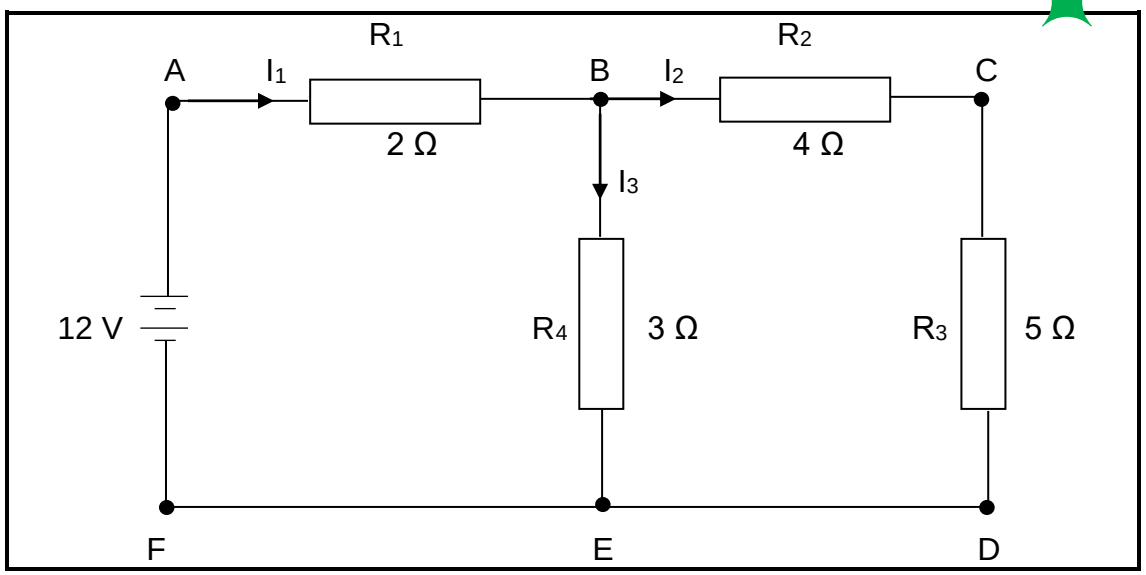
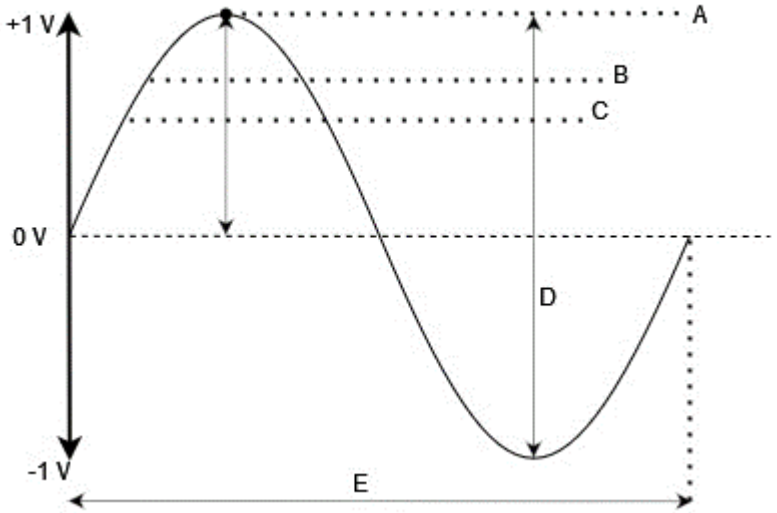


FIGURE 1

Apply Kirchhoff's laws to FIGURE 1 to determine I_1, I_2 and I_3. Use loop ABEFA and loop BCDEB. (12)

1.3 FIGURE 2 below represent a sinusoidal wave form of an alternating voltage.

Identify the terms used on the sine wave. Write only your answer next to the letter (A–E) in the ANSWER BOOK.



(5)

FIGURE 2

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1.4 The resistance of an unknown resistor R_x between A and D needs to be determined using a Wheatstone bridge circuit. The resistance of R_1 between A and B is 1000 Ω, the resistance of R_2 between B and C is 1200 Ω and the variable resistor R_3 with the value of 10 kΩ, which is located between C and D, has to be adjusted to ensure that the galvanometer reading is zero. This circuit is supplied by 12 V DC.

Draw the circuit diagram as described above, showing clearly the positions of the components described. (6)

1.5 With the alternating current circuit theory, the resistance and reactants are measured in Ohms.

1.5.1 What is the difference between resistance and reactance? (2)

1.5.2 What is the relationship of the resistance, reactance and impedance in a RLC circuit? (2)

1.5.3 Express the relationship mentioned above in 1.5.2 in a mathematical formula. (1)
[30]

QUESTION 2

2.1 There are more than THREE resources that are mainly used for generating electrical energy in South Africa. One of then is thermal energy.

Describe step by step how electricity is generated from thermal energy. (5)

2.2 A three-phase motor is connected in star across a 380 V supply, and it draws a current of 12 A at a power factor of 0,8 lagging.

Calculate the input power of the motor and give your answer in kW (2)

2.3 Aluminium conductors are used in overhead transmission lines.

Name THREE types of aluminium conductors. (3)

2.4 State TWO factors that must be considered when selecting fuses to protect electrical circuits. (2)

2.5 Lightning arrestors protect the power system against the harmful effects of voltage surges.

Name THREE types of lighting arrestors that are commonly used with overhead lines. (3)
[15]

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QUESTION 3

3.1 Complete the following sentences by writing only the missing word or words next to the question number (3.1.1–3.1.6) in the ANSWER BOOK.

3.1.1 A current that flows to earth in an electrically undamaged circuit is called …….

3.1.2 A current that results from an insulation failure or from the bridging of insulation is called …

3.1.3 The consumer's earth terminal is earthed by connecting it to the … earth terminal.

3.1.4 A bonding conductor shall have a nominal cross-sectional area of at least … copper

3.1.5 In case of metallic roofs, gutters, down pipes and waste pipes, the resistance of the earth continuity shall not exceed …

(5 × 1) (5)

3.2 Describe step by step how to carry out the earth fault loop impedance test as stated in the SANS 10142-1, The wiring of premises book. (5)

3.3 The international standard IEC 60364, names three groupings of earthing systems and uses the two-letter codes TN, TT and IT.

3.3.1 What does the first letters T and I indicate? (2)

3.3.2 Name THREE types of TN systems. (3)

[15]

QUESTION 4

4.1 All transformers operate on the principle of electromagnetic induction.

Briefly explain the operation of a simple single-phase step-down transformer. (3)

4.2 A three-phase transformer is connected to a 3,3 kV supply and has 550 turns on the primary winding and 55 turns on the secondary winding.

Calculate the secondary line voltage when the windings are connected in:

4.2.1 Star-delta

4.2.2 Delta-star

(2 × 4) (8)

4.3 Indicate whether the following statements are TRUE or FALSE. Choose the answer and write only 'True' or 'False' next to the question number (4.3.1–4.3.5) in the ANSWER BOOK.

4.3.1 The open-circuit test gives the core parameters of a transformer.

4.3.2 The impedance test is used to determine the copper loss.

4.3.3 The primary and the secondary windings of a transformer are electrically coupled.

4.3.4 At no loss, the output power of a transformer will be equal to the input power.

4.3.5 Hysteresis loss can be overcome by choosing the proper core material when designing the transformer.

(5 × 1) (5)

4.4 You are given THREE single phase transformers to construct a three-phase transformer. Upon testing the windings resistance of each transformer, the following readings (values) were obtained:

Name of the transformer	Winding type	Windings resistance test results
Transformer 1	Primary winding	75 Ω
	Secondary winding	10 Ω
Transformer 2	Primary winding	75 Ω
	Secondary winding	11Ω
Transformer 3	Primary winding	75 Ω
	Secondary winding	∞

4.4.1 Are all THREE transformers suitable to construct the three-phase transformer? (1)

4.4.2 Justify your answer in QUESTION 4.4.1 (3)

[20]

QUESTION 5

5.1 The three phase induction motors can be differentiated by their rotors.

5.1.1 Name the TWO types of rotors (2)

5.1.2 Describe in detail the difference in construction of the two rotors named above in 5.1.1 (6)

5.2 You are required to conduct an open-circuit test on an induction motor.

Name TWO parameters that can be determined using an open-circuit test on an induction motor. (2)

5.3 You have been employed as a design engineer by a company manufacturing DC machines.

Explain what you understand by each of the following:

5.3.1 Under-compounded generator

5.3.2 Cumulatively compounded generator

(2 × 1) (2)

5.4 Explain the purpose of *a thermal overload protection device*. (1)

5.5 A six-pole, 330 V DC motor has a wave-wound armature. The useful flux per pole is 55 mWb. The motor operates at a speed of 800 r/min.

Calculate the following:

5.5.1 The total number of conductors if the EMF induced is 300 V (3)

5.5.2 The torque developed by the motor if the armature current is 17 A (2)

5.6 A 60 Hz, three-phase induction motor is running at a synchronous speed of 1 200 r/min.

Calculate the number of poles that this motor has. (2)

[20]

TOTAL: 100

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FORMULA SHEET

1. $\boldsymbol{Cos\phi = \frac{R}{Z}}$

2. $\boldsymbol{P = V\ I\ Cos\phi}$

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

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

5. $V_1 = \left(\frac{R_1}{R_t}\right) V_T$

6. $\boldsymbol{I_1 = \left(\frac{R_2}{R_1 + R_2}\right) I_T}$

7. $R_T = R_1 + R_2 + R_3 + \cdots + R_n$

8. $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots + \frac{1}{R_n}$

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

10. $V_L = \sqrt{3}\, V\ p\ h$

11. $\boldsymbol{E = V - I_a\ R_a}$

12. $n_s = \frac{f}{p}$

13. $S = \frac{N_s - N_r}{N_s}$

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

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

16. $\tan\boldsymbol{\phi} = \sqrt{3}\left(\frac{\boldsymbol{W_1 - W_2}}{\boldsymbol{W_1 + W_2}}\right)$

17. $E = V + I\ r$

18. $\boldsymbol{V = I\ R}$

19. $R = \frac{p\ l}{A}$

20. $\boldsymbol{R_t = R_0(1 + \alpha t)}$

21. $R_t = R_0[1 + \propto_0 (t - \emptyset)]$

22. $P = V\ I$

23. $E = I^2\ R\ t$

24. $\boldsymbol{\eta = \frac{P_0}{P_{in}} \times 100}$

25. $\boldsymbol{X_L = 2\pi\ f\ L}$

26. $X_C = \frac{1}{2\pi\ f\ C}$

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

28. $Mmf = N\ I$

29. $H = \frac{Mmf}{l}$

30. $B = \frac{\Phi}{A}$

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31. $F = B\ I\ l$

32. $E = -L\frac{di}{dt}$

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

34. $E = \frac{1}{2}\ C\ V^2$

35. $Q = C\ V$

36. $F = 2\times10^{-7}\times\frac{I_1\ I_2}{d}$

37. $I = \frac{Emf}{R_T + r_T}$

38. $L = N\frac{\Delta\ \phi}{\Delta\ I}$

39. $v = V_m \sin(\omega t\ \pm\ \emptyset)$

40. $Z = \frac{V}{I}$

41. $I_T = \sqrt{I_R^2 + (I_L - I_C)^2}$

42. $tan\emptyset = \frac{X_L - X_C}{R}$

43. $I_{sh} = \frac{V + I_{se}R_{se}}{R_{sh}}$

44. $T = \frac{0{,}318 I_a Zp\emptyset}{c}$

45. $E = V - I_a(R_a + R_{se})$

46. $E = B\ l\ v$

47. $E = -N\ \frac{d\emptyset}{dt}$

48. $E = \frac{V}{d}$

49. $E = \frac{1}{2}LI^2$

50. $Q = It$

51. $C_T = C_1 + C_2 + C_3 + \cdots + C_n$

52. $\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \cdots + \frac{1}{C_n}$

53. $L_T = L_1 + L_2 + L_3 + \cdots + L_n$

54. $\frac{1}{L_T} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} + \cdots + \frac{1}{L_n}$

55. $tan\emptyset = \frac{I_L - I_C}{I_R}$

56. $E = V + I_a R_a$

57. $I_{sh} = \frac{V - I_{se}R_{se}}{R_{sh}}$

58. $E = V + I_a(R_a + R_{se})$

59. $E = V + I_a R_a + IR_{se}$

60. $E = V - I_a R_a - IR_{se}$

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61. $E = \frac{2p\emptyset ZN}{60\ c}$

62. $V_T = \sqrt{V_R^2 + (V_L - V_C)^2}$

63. $V_L = IX_L$

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

65. $N = \frac{V}{k\emptyset}$

66. $E = 4{,}44\ f\emptyset_m N$

67. $V_C = IX_C$

68. $E_{ave} or\ I_{ave} = 0{,}637\ E_m\ or\ I_m$

69. $P = \sqrt{3}\ V_L I_L\ cos\theta$

70. $S = \sqrt{3}\ V_L I_L$

71. $Q = \sqrt{3}\ V_L I_L\ sin\theta$

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