higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T560**(E)**(A12)T

# NATIONAL CERTIFICATE

# ELECTRO-TECHNOLOGY N3

(11040343)

**12 August 2019 (X-Paper)**
**09:00–12:00**

**This question paper consists of 8 pages and a formula sheet of 3 pages.**

 

# DEPARTMENT OF HIGHER EDUCATION AND TRAINING
# REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE
ELECTRO-TECHNOLOGY
TIME: 3 HOURS
MARKS: 100

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**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 off ALL calculations to THREE decimal places.
6. Use the correct symbols and units.
7. ALL circuit diagrams and vector diagrams must be at least one third of a page and must be fully labelled.
8. Start each question on a NEW page.
9. Write neatly and legibly.

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## QUESTION 1

Give ONE term for each of the following descriptions by choosing a term from the list below. Write only the term next to the question number (1.1–1.10) in the ANSWER BOOK.

| |
|---|
| lap winding; air gap; laminated plates; field pole; commutation; bedding; pole shoe; yoke; bearings; brushes; commutator; wave winding |

1.1 Used to make an electrical connection between a stationary circuit and a rotating commutator

1.2 A process whereby a strip of emery paper is placed around the commutator

1.3 Type of armature winding that is suitable for a high-current, low-voltage application

1.4 The space between the stator and rotor of any machine

1.5 Used to minimise eddy-current losses in a DC machine

1.6 Part of the field system used to evenly distribute the main magnetic flux over the air gap or to increase the efficiency of the magnetic path

1.7 Armature winding of which the ends are connected to commutator segments that are far apart

1.8 The outer frame of a DC machine

1.9 Used to support a rotating armature

1.10 A process of reversing current flow in a DC generator

(10 × 1) **[10]**

## QUESTION 2

2.1 Separately excited generators are commonly used in DC motor speed control.

State the reason why these generators are used for this particular application. (2)

2.2 Draw on the same system of axes characteristic curves of a compound-wound generator, clearly showing terminal voltage against load current for the following machines:

(a) over-compounded

(b) level-compounded

(c) under-compounded (4)

2.3 A shunt-wound generator having a shunt field resistance of 175 Ω and an armature resistance of 0,2 Ω supplies 90 A at a terminal voltage of 300 V to a bank of batteries.

Calculate the following:

2.3.1 Armature current of the generator (2)

2.3.2 Magnitude of the generated emf (1)

2.3.3 Power delivered to the load. Express your answer in kW. (1)
**[10]**

## QUESTION 3

3.1 Indicate whether the following statements are TRUE or FALSE. Choose the answer and write only 'True' or 'False' next to the question number (3.1.1–3.1.3) in the ANSWER BOOK. Correct the statement if it is FALSE.

3.1.1 DC series motors are constant speed motors.

3.1.2 DC series motors produce reasonably low starting and operating torque.

3.1.3 DC series motors are used when the motor is permanently coupled to the load.
(5)

3.2 The armature of a certain eight-pole DC series motor has 44 slots and 6 conductors per slot. The armature is lap-wound and has a resistance of 0,3 Ω. The motor draws 32 A from a 400 V supply.

Calculate the speed at which the armature is rotating if the useful flux per pole is 66 mWb. (5)
**[10]**

## QUESTION 4

4.1 Certain applications require DC motors to rotate in both directions.

Show by means of neat, fully labelled circuit diagrams TWO methods used to reverse the direction of rotation of a series-wound motor. Begin by drawing a circuit diagram to show the original direction of rotation of the motor. Indicate the direction of current flow in all the diagrams. (6)

4.2 A 20 kW shunt-wound generator supplies a load at 400 V if the generator is operating at an efficiency of 92%.

Calculate the following:

4.2.1 Mechanical power input to the generator (1)

4.2.2 Total losses occurring in the machine (1)

4.2.3 Armature current if the shunt field current is 2,7 A (2)

**[10]**

**QUESTION 5**

5.1 Alternating quantities such as voltage and current are sinusoidal in nature and can be represented on a vector diagram.

Represent the following vectors on the same system of axes:

Use V as the reference vector.
$I_1$ is in phase with V.
$I_2$ leads V by an angle $\alpha$.
$I_3$ lags V by an angle $\beta$. (4)

5.2 A non-sinusoidal current waveform was plotted over half a cycle and the following mid-ordinates were extracted from the waveform:

$I_1 = 3$ A
$I_2 = 9$ A
$I_3 = 22$ A
$I_4 = 37$ A
$I_5 = 18$ A
$I_6 = 5$ A

Determine the following using these mid-ordinates:

5.2.1 The effective (rms) value of the wave

5.2.2 The average value of the wave

5.2.3 The form factor of the wave

(3 × 2) (6)

**[10]**

 

**QUESTION 6**

A circuit consists of a 30 Ω resistor, a 150 mH inductor and a 200 µF capacitor, all connected in parallel. This parallel combination is then connected across a 100 V, 50 Hz supply.

Calculate the following:

6.1 Current drawn by each component (5)

6.2 Current flowing through the circuit (2)

6.3 Phase angle of the circuit (1)

6.4 Apparent power of the circuit (2)
**[10]**

**QUESTION 7**

A 25 kW, three-phase induction motor is supplied from a 525 V, 50 Hz supply and it operates at a power factor of 0,8 lagging and an efficiency of 85%. This motor is started by means of a star-delta starter.

Calculate the following:

7.1 Phase voltage of the motor when its windings are connected in star (2)

7.2 Phase current of the motor when its windings are connected in star (3)

7.3 Phase voltage of the motor when its windings are connected in delta (1)

7.4 Phase current of the motor when its windings are connected in delta (2)

7.5 Reactive power of the motor (2)
**[10]**

 

## QUESTION 8

8.1 The efficiency of a transformer is very high because it has no moving parts and therefore no frictional losses.

Name TWO types of losses that occur in a transformer and state exactly in which part of the transformer each occurs. (2 × 2) (4)

8.2 A single-phase transformer has 1 250 primary turns and 400 secondary turns. The supply voltage is 240 V.

Calculate the following:

8.2.1 Secondary voltage

8.2.2 Secondary current if the transformer draws a current of 12 A

8.2.3 Rating of the transformer in kVA

(3 × 2) (6)
**[10]**

## QUESTION 9

9.1 Indicating type instruments measure the effective or root mean square values of alternating quantities.

Name the THREE mechanisms of these indicating type instruments. (3)

9.2 There are two types of moving-iron instruments, namely attraction types and repulsion types.

9.2.1 State TWO advantages of moving-iron instruments.

9.2.2 State TWO disadvantages of moving-iron instruments.

(2 × 2) (4)

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

Sketch a neat, fully labelled circuit diagram to show how a voltmeter is connected in a high voltage system. Also show the supply and the load. (3)
**[10]**

 

**QUESTION 10**

10.1 Electronic logic gates form the basic building blocks of digital systems.

Draw the switching circuit for a NOR gate. (4)

10.2 Every decimal number can be represented by its binary equivalent.

Convert $111011,011_2$ into its decimal equivalent. (4)

10.3 A diode will conduct electrical current when it is forward biased.

Explain what is meant by a *forward biased diode*. (2)

**[10]**

**TOTAL: 100**

## 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. $E = 2p\Phi \dfrac{ZN}{60_c}$

4. $N = \dfrac{V}{K\Phi}$

5. $T = \dfrac{0{,}318\, I_a \; Zp\,\Phi}{C}$

6. $Efficiency/Rendement = \dfrac{VI}{VI + I_a{}^2 R_a + I_s V + C} \times 100\,\%$

7. $Efficiency/Rendement = \dfrac{VI - (I_a{}^2 R_a + I_a V + C) \times 100\,\%}{VI}$

8. $Efficiency/Rendement = \dfrac{2\pi N(W - S)\, r}{60\, VI} \times 100\,\%$

9. $Efficiency/Rendement = \sqrt{\dfrac{I_1}{I_1 + I_2}} \times 100\,\%$

10. $E = Blv$

11. $e = E_m Sin 2\pi ft$

12. $i = I_m Sin 2\pi ft$

13. $e_{ave/gem}$ of/or $i_{ave/gem} = 0{,}637\; E_m$ or/of $I_m$

14. $e_{rms/wgk}$ or/of $i_{rms/wgk} = 0{,}707\; E_m$ or/of $I_m$

15. $\mathrm{E_{ave/gem}} = \dfrac{\mathrm{e_1 + e_2 + e_3 + ... + e_n}}{\mathrm{n}}$

or/of $I_{ave\,/\,gem} = \dfrac{i_1 + i_2 + i_3 + ... + i_n}{n}$

16. $$E_{rms/wgk} = \sqrt{\frac{e_1^2 + e_2^2 + e_3^2 + \ldots + e_n^2}{n}}$$

or/of $$I_{rms/wgk} = \sqrt{\frac{i_1^2 + i_2^2 + i_3^2 + \ldots + i_n^2}{n}}$$

17. $$Form\ factor/Vormfaktor = \frac{E_{rms/wgk}}{E_{ave/gem}}\ or/of\ \frac{I_{rms/wgk}}{I_{ave/gem}}$$

18. $$Crest\ factor/Kruinfaktor = \frac{E_m}{E_{rms/wgk}}\ or/of\ \frac{I_m}{I_{rms/wgk}}$$

19. $$I = \frac{V}{R}$$

20. $$X_L = 2\pi fL\ ;\ i = \frac{V}{X_L}$$

21. $$X_C = 2\pi fC\ ;\ i = \frac{V}{X_C}$$

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. $$VR = I \times R\ ;\ V_L = I \times X_L\ ;\ V_C = I \times X_C$$

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. $$P = VI\,\mathrm{Cos}\ \theta$$

29. $$\mathrm{Cos}\ \theta = \frac{R}{Z}\ ;\ Cos\,\theta = \frac{W\ or/of\ kW}{VA\ or/of\ kVA}$$

30. $$I_{active/aktief} = I\ Cos\,\theta$$
$$\mathrm{I}_{\mathrm{reactive/reaktief}} = \mathrm{I\ Sin}\ \theta$$

31. $P = VI\,Cos\ \theta$

$Q = VI\,Sin\ \theta$

32. $fr = \dfrac{1}{2\pi\sqrt{LC}}$

33. $I = \sqrt{I_R^2 + I_L^2}$ ; $Tan\,\theta = \dfrac{I_L}{I_R}$

34. $I = \sqrt{I_R^2 + I_C^2}$ ; $Tan\,\theta = \dfrac{I_C}{I_R}$

35. $I = \sqrt{I_R^2 + (I_L - I_C)^2}$ ; $Tan\,\theta = \dfrac{I_L - I_C}{I_R}$

36. $I = \sqrt{I_R^2 + (I_C - I_L)^2}$ ; $Tan\,\theta = \dfrac{I_C - I_L}{I_R}$

37. $Cos\,\theta = \dfrac{I_R}{I}$

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

42. $kVA = \dfrac{\sqrt{3}\,V_L I_L}{1\,000}$

43. $V_{shunt/sjunt} = V_{meter}$ ; $I_s R_s = I_m R_m$

44. $I_T = I_m + I_s$

45. $I_T = \dfrac{V_T}{R_T}$