higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T500(E)(A4)T
APRIL EXAMINATION

NATIONAL CERTIFICATE

ELECTRO-TECHNOLOGY N3

(11040343)

4 April 2013 (X-Paper)
09:00–12:00

This question paper consists of 5 pages and a 3-page formula sheet.

DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE
ELECTRO-TECHNOLOGY 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 the subsections of questions together.
5. Rule off after the completion of each question.
6. Sketches and diagrams must be done in pencil.
7. The sketches/diagrams must be neat, reasonably large and fully labelled.
8. The answers must be worked to THREE decimal places after a comma.
9. Use the correct symbols and SI units for answers.
10. Write neatly and legibly.

QUESTION 1

Briefly explain the following terminology as applicable in the construction of a DC machine:

1.1 Flux

1.2 Main pole

1.3 Field winding

1.4 Yoke

1.5 Pole shoe

(5 × 2) **[10]**

QUESTION 2

2.1 The current through the field coils is determined by the supply voltage and the field resistance. Express this information by means of a formula. (2)

2.2 List THREE components of a DC motor circuit that can be affected by a high starting current if it is not limited. (3)

2.3 Define the term *residual magnetism* as applicable to a DC machine. (2)

2.4 Give ONE function of a no-volt device which is found in a series starter motor. (2)

2.5 Name ONE application of a differentially compounded generator. (1)
[10]

QUESTION 3

3.1 A 200 V, 8 kW shunt wound generator has an armature circuit resistance of 0,2 ohms and shunt field of 100 Ω.

Determine the following:

3.1.1 The shunt field current (1)

3.1.2 The line current (1)

3.1.3 The armature current (2)

3.1.4 The generated EMF at full load (3)

3.2 List THREE applications of a shunt generator. (3)
[10]

QUESTION 4

4.1 Draw a neat circuit diagram of a face-plate starter connected to a compound motor. (8)

4.2 Name the device found in a face-plate starter that protects the motor against an excessive current flow. (2)

[10]

QUESTION 5

5.1 Name THREE losses that can occur in a DC machine according to its classification. (3)

5.2 When tests were performed on two similar 380 V, 133 kW generators, it was found that the current between the machines is equal to the full-load current and in addition, 50 A are taken from the supply.

Calculate the approximate efficiency of each machine. (7)

[10]

QUESTION 6

When a particular coil was connected to a 160 V, DC supply a current of 4 A was drawn. The same coil was then connected to a 240 V, 60 Hz supply and the current drawn was 0,6 A.

Calculate the value of the coil in mH.

[10]

QUESTION 7

7.1 A 380 V, three-phase, star-connected motor is rated at 38 kW. The full load power factor is given as 0,8 and the efficiency as 85%.

Determine the following:

7.1.1 The line voltage for the motor when it runs at full load (1)

7.1.2 The phase voltage for the motor when it runs at full load (2)

7.1.3 The phase current for the motor when it runs at full load (5)

7.2 Name TWO advantages of a star connection. (2)

[10]

QUESTION 8

8.1 Briefly discuss *mutual induction* which occurs during the operation of a transformer. (4)

8.2 A three-phase transformer has a rating of 440 kVA and is connected in delta-star. The input line voltage is 2,4 kV and the output line voltage is 797 V. Ignore losses.

Determine the following:

8.2.1 The turn ratio (4)

8.2.2 The input line current (2)
[10]

QUESTION 9

9.1 A moving-coil instrument gives a full-scale deflection if 20 mA flows through it. The resistance of the coil is 5 Ω.

Determine the following:

9.1.1 Voltage across the meter (1)

9.1.2 Current through the shunt resistor when the instrument is used as an ammeter for a current flow of 1 A (1)

9.1.3 The value of the shunt resistance (2)

9.1.4 The series resistance required to use it as a volt-meter up to 8 V (3)

9.2 List THREE mechanisms which are found in measuring instruments. (3)
[10]

QUESTION 10

10.1 Change the following decimal numbers to the binary numbers:

10.1.1 $4{,}4375_{10}$ (2)

10.1.2 41_{10} (2)

10.1.3 $3{,}125_{10}$ (2)

10.2 Make a neat labelled mechanical sketch for an AND gate with three inputs. (4)
[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. $E = 2p\Phi \dfrac{ZN}{60C}$

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

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

6. $Efficiency = \dfrac{VI}{VI + Ia^2 Ra + IsV + C} \times 100$

7. $Efficiency = \dfrac{VI - (Ia^2 Ra + IsV + C) \times 100}{VI}$

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

9. $Efficiency = \sqrt{\dfrac{I_1}{I_1 + I_2}} \times 100$

10. $E = Blv$

11. $e = E_m Sin2\pi ft$

12. $i = I_m Sin2\pi ft$

13. $e_{ave/gem}$ *or* $i_{ave/gem} = 0{,}637\ Em\ or\ Im$

14. $e_{rms/wgk}$ *or/fr* $i_{rms/wgk} = 0{,}707\ Em\ or\ Im$

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

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

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

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

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

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

21. $X_C = \frac{1}{2\pi fC}\ ;\ i = \frac{V}{X_C}$

22. $Z = \sqrt{R^2 + X_L^2}\ ;\ Z = \sqrt{R^2 + X_C^2}\ ;\ I = \frac{V}{Z}$

23. $Tan\ \theta = \frac{X_L}{R}\ ;\ Tan\ \theta = \frac{X_C}{R}$

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. $\text{Tan}\ \theta = \frac{X_L - X_C}{R}\ ;\ Tan\ \theta = \frac{X_C - X_L}{R}$

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

28. $P = VI \text{ Cos } \theta$

29. $\text{Cos } \theta = \frac{R}{Z}\ ;\ Cos\ \theta = \frac{W\ or/of\ KW}{VA\ or/of\ KVA}$

30. $I_{active/aktief} = I\ cos\ \theta$

$I_{reactive/reaktief} = I \sin \theta$

31. $P = VI \cos \theta$

$Q = VI \sin \theta$

32. $fr = \frac{I}{2\pi\sqrt{LC}}$

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

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

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

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

37. $Cos\ \theta = \frac{I_R}{I}$

38. $V_L = V_P$; $I_L = \sqrt{3}\, Ip$

39. $V_L = \sqrt{3}\, Vp$; $I_L = I_p$

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. $KVA = \frac{\sqrt{3}\, V_L I_L}{1\,000}$

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

44. $I_T = I_m + I_s$

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

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MARKING GUIDELINE

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4 APRIL 2013

This marking guideline consists of 8 pages.

QUESTION 1

1.1 FLUX – are **magnetic fields or lines** which are moving between **two main poles of different charges** namely north and south.

1.2 MAIN POLE – is **moulded with or bolted** to the yoke or stator and **holds the field coils in position.**

1.3 FIELD WINDING – are **wound around** the poles/armature core for **excitation to supply the field flux.**

1.4 YOKE – is the **outer casing of the machine or protects the inner parts** and **supports the main field** system.

1.5 POLE SHOE – **holds the field coils in position** and **increases the efficiency of the magnetic path.**

(5 × 2) **[10]**

QUESTION 2

2.1 $I_R = \frac{V_S}{R}$ Answer (2)

2.2
- Protection fuses
- Starting equipment
- Motor
- Circuit breaker

Any 3 (3)

2.3 RESIDUAL MAGNETISM – is the **magnetism which remains in the iron** or material even after the **current has been switched off** (2)

2.4 NO VOLT PROTECTION – to ensure that the **starting handle is replaced to an off position** when **the supply is cut off.** (2)

2.5 DIFFERENTIALLY COMPOUNDED GENERATOR – welding generators or carbon arc searchlight generators. (1)
[10]

QUESTION 3

3.1 Given:- V = 200 V; Power = 8 kW = 8 000 W; $R_a = 0{,}2\ \Omega$; R_{SH} = 100 Ω

3.1.1 $$R_{SH} = \frac{V_{SH}}{I_{SH}}$$

$$I_{SH} = \frac{200\ V}{100\ \Omega} = 2\ A \longrightarrow \text{Answer} \checkmark$$

(1)

3.1.2 $$I_L = \frac{P}{V_L} = \frac{8\,000\ W}{200\ V} = 40\ A \longrightarrow \text{Answer} \checkmark$$

(1)

3.1.3 $$I_a = I_L + I_{SH} = 40\ A + 2\ A = 42\ A \longrightarrow \text{Answer} \checkmark\checkmark$$

(2)

3.1.4 $$EMF = V + I_a R_a = 200\ V + (42\ A \times 0{,}2\Omega) \checkmark\checkmark$$

$$= 208{,}4\ V \longrightarrow \text{Answer} \checkmark$$

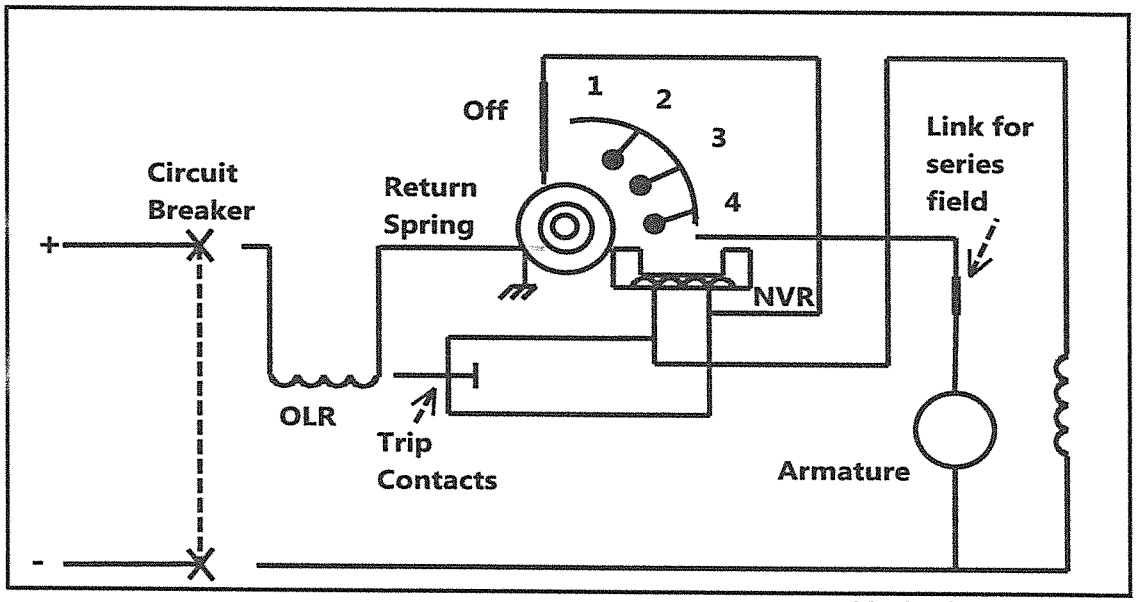
(3)

3.2
- Supply excitation to AC generator ✓
- The distance from the generator to its load is short. ✓
- Charging battery ✓

(3)
[10]

QUESTION 4

4.1 STARTER FOR SHUNT MOTOR



Marks for labelling (4)
Marks for sketch (4)

4.2 Overload relay. ✓✓ (2)

[10]

QUESTION 5

5.1
- Electrical losses ✓
- Iron losses. ✓
- Mechanical losses ✓

(3)

5.2 $I_L = \frac{Power}{Voltage} = \frac{133\,000}{380\,V}$ ✓

= 350 A ⟶ Answer ✓

Approximate efficiency = $\sqrt{\frac{I_L}{I_L + I_1}} \times 100\%$

= $\sqrt{\frac{350}{350+50}} \times 100\%$ ✓✓

= 0,93541 × 100% ✓

= 93,54% ⟶ Answer ✓✓

(7)

[10]

QUESTION 6

Resistance of the circuit: $R = \frac{V_t}{I_t} = \frac{160\,V}{4\,A}$ ✓

= 40 Ω ⟶ Answer ✓

Impedance of the circuit: $Z = \frac{V_s}{I_t} = \frac{240\,V}{0{,}6A}$ ✓

= 400 Ω ⟶ Answer ✓

Since $Z = \sqrt{R^2 + X_L{}^2}$

$X_L = \sqrt{400^2 - 40^2}$ ✓

= $\sqrt{158\,400}$ ✓

= 397,995 Ω ⟶ Answer ✓

$X_L = 2\,\pi fL$

$L = \frac{397{,}995\,\Omega}{2 \times 3{,}142 \times 60\,Hz}$ ✓

= 1,056 H ✓

= 1 056 mH ⟶ Final answer ✓ **[10]**

QUESTION 7

7.1 Given: V = 380 V; Star-connected; Power = 38 kW; Power factor = 0,8; Efficiency = 85%

7.1.1 Line voltage $[V_L] = 380\,V$ ⟶ Answer ✓ (1)

7.1.2 Phase voltage $[V_{PH}] = \frac{V}{\sqrt{3}} = \frac{380\,V}{\sqrt{3}}$ ✓

= 219,393 V ⟶ Answer ✓ (2)

7.1.3 Line current $[I_L] = \frac{P}{\sqrt{3}V_L Cos\theta\eta} = \frac{38\,000\,W}{\sqrt{3} \times 380\,V \times 0{,}8 \times 0{,}85}$ ✓ ✓

= 84,905 A ✓

But $I_L = I_{PH}$ (Star Connection) ✓

$\therefore I_{PH} = 84{,}905\,A$ ⟶ Answer ✓ (5)

7.2
- Two voltages are available e.g. Line voltage and phase voltage ✓
- By earthing the neutral, leakage protection is simplified. ✓ (2)

[10]

QUESTION 8

8.1
- Coil A carries supply voltage is placed near to another coil B ✓
- An EMF is induced to coil B and no electrical connection ✓
- The EMF into coil B is in opposition to the force producing ✓
- Mutual induction is EMF induced in coil B. ✓ (4)

8.2 Given: Power rating = 440 kVA; $V_{1(L)} = 2{,}4\ kV$; $V_{1(P)} = 2{,}4\ kV$; $V_{2(L)} = 797\ V$

8.2.1 Turns ratio: $V_{2((P)} = \frac{V_{2(L)}}{\sqrt{3}} = \frac{797\ V}{1{,}732}$ ✓

= 460,162 V ⟶ Answer ✓

$$\frac{N_1}{N_2} = \frac{V_1}{V_2}$$

$$\frac{N_1}{N_2} = \frac{2\,400\ V}{460{,}162\ V}$$ ✓

$N_1 : N_2$ = 5,216; 1 ⟶ Final answer ✓ (4)

8.2.2 The Input line current:$[I_L]$ = $\frac{kVA}{\sqrt{3}\ V} = \frac{440\,000}{1{,}732 \times 2\,400\ V}$ ✓

= 105,851 A

But $I_L = I_P$ (Star connection)

= 105.851 A ⟶ Answer ✓ (2)

[10]

QUESTION 9

9.1 Given: $I_M = 20\ mA; R_m = 5\ \Omega$;

9.1.1 $V_m = I_m \times R_m$
= 0,02 A X 5 Ω
= 0,1 V ⟶ Answer ✓ (1)

9.1.2 $I_{sh} = I_L - I_m$
= 1 – 0,02
= 0,98 A ⟶ Answer ✓ (1)

9.1.3 $R_s = \frac{V_s}{I_s} = \frac{0,1\ V}{0,98\ A}$
= 0,102 Ω ⟶ Answer ✓ ✓ (2)

9.1.4 $R_t = \frac{V_t}{I_t} = \frac{8\ V}{0,02\ A}$

= 400 Ω ⟶ Answer ✓

$R_{series} = R_t - R_m$
= (400 – 5) Ω
= 395 Ω ⟶ Final answer ✓ ✓ (3)

9.2
- Deflecting mechanism ✓
- Controlling Mechanism ✓
- Damping Mechanism ✓ (3)

[10]

QUESTION 10

10.1 10.1.1

2	4 remainder 0
2	2 remainder 0
2	1 remainder 1

0,4375 x 2 = 0
0,835 x 2 = 1
0,75 x 2 = 1
0,5 x 2 = 1

Shown Steps ✓
$4,4375_{10} = 100,0111_2$ ⟶ Answer ✓ (2)

10.1.2

2	41 remainder 1
2	20 remainder 0
2	10 remainder 0
2	5 remainder 1
2	2 remainder 0
2	1 remainder 1

Shown steps✓

$41_{10} = 101001_2$ ⟶ Answer✓ (2)

10.1.3

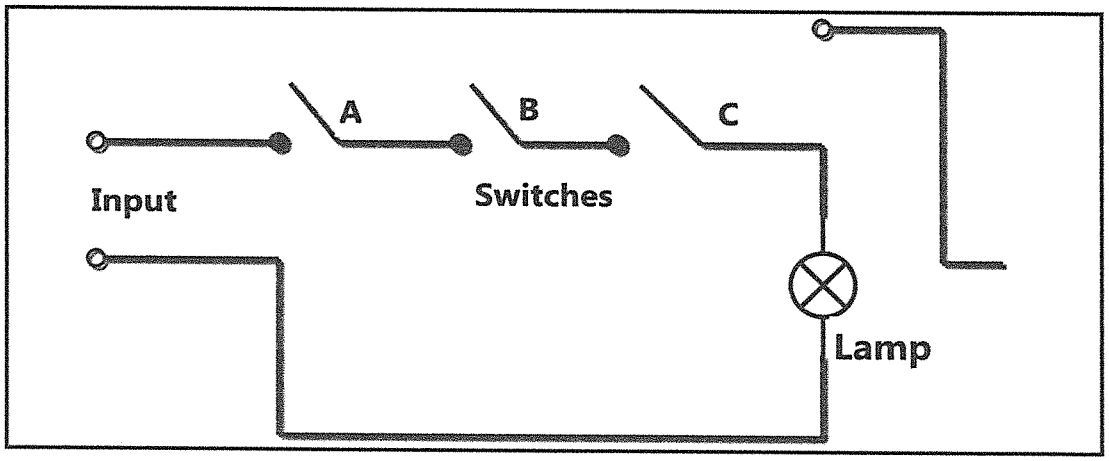
2	3 remainder 1
2	1 remainder 1

0,125 x 2 = 0
0,25 x 2 = 0
0,5 x2 = 1

Shown steps✓

$3{,}125_{10} = 11{,}001_2$ ⟶ Answer✓ (2)

10.2 Mechanical switch for AND gate with THREE inputs



Correct diagram✓✓✓✓ (4)
[10]

TOTAL: 100