higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T460(E)(J23) T

AUGUST EXAMINATION

NATIONAL CERTIFICATE

ELECTRO-TECHNOLOGY N3

(11040343)

23 July 2014 (Y-Paper)
13:00–16:00

This question paper consists of 6 pages and 3 formula sheets.

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 subsections of questions together, for example QUESTION 1. 1.1, 1.2, et cetera.
5. Rule off on completion of each question.
6. The correct information must be copied from the question paper and substituted for the correct symbol.
7. Sketches and diagrams must be done in pencil and must be neat, reasonably large and fully labelled.
8. You will be penalised for untidy and illegible work.
9. Answers must be rounded off to THREE decimal places after the comma.
10. Use the correct units for answers.
11. Write neatly and legibly.

QUESTION 1

1.1 State THREE purposes of the yoke as applicable to the DC machine. (3)

1.2 Draw a sketch of a four- pole DC machine. Indicate the following components on the sketch: pole core, flux, field winding and pole shoe. (7)
[10]

QUESTION 2

2.1 Name the type of brush which is relatively cheap and is used in motors with a low current density. (1)

2.2 Briefly explain the following terms as applicable to DC machines:

2.2.1 Armature reaction (2)

2.2.2 Commutation (2)

2.3 State ONE disadvantage of the brush shifting method in order to achieve optimal commutation. (2)

2.4 State THREE methods, except the one mentioned in QUESTION 2.3, which can be employed to counter the effects of the armature reaction. (3)
[10]

QUESTION 3

3.1 A DC motor is connected to a supply voltage of 230 V. The armature current is 45 A and the armature resistance is 250 mΩ.

If the useful flux per pole is 25 mWb and all the constant value is 33,2, determine the speed of the motor in r/min. (4)

3.2 State the main reason why a starting resistor is connected in series with the armature during the starting process. (2)

3.3 The torque of an eight-pole lap-wound DC motor is 320 N.m.

If the armature current is 160 A and the number of armature conductors is 560, determine the useful flux per pole in mWb. (4)
[10]

QUESTION 4

4.1 A shunt generator delivers an output voltage of 240 V at a current of 90 A. The armature and field resistances are 0,025 Ω and 80 Ω respectively.

If the no-load current is 3,09 A, determine the efficiency of the generator. (7)

4.2 Name TWO methods which are used in a friction test to calculate efficiency. (2)

4.3 Give another name for friction test. (1)
[10]

QUESTION 5

5.1 The following ordinate points were read from the full cycle of an alternating quantity: $e_1 = 23$ V; $e_2 = 45$ V; $e_3 = 86$ V; $e_4 = 123$ V; $e_5 = 98$ V; $e_6 = 38$ V; $e_7 = 22$ V.

Determine the following using the above data:

5.1.1 What type of alternating quantity is mentioned above? (1)

5.1.2 Actual value (3)

5.1.3 Average value (3)

5.1.4 Form factor (1)

5.1.5 What type of wave form is deduced from the value of the crest factor, if the crest factor is 1,414? (1)

5.2 Define *maximum value.* (1)
[10]

QUESTION 6

A series circuit comprises of a coil having a resistance of 16 Ω, an inductive reactance of 30 Ω and a capacitive reactance of 45 Ω. The circuit is connected across a 220 V, 60 Hz supply.

Determine the following:

6.1 The impedance of the circuit (2)

6.2 The total current flowing in the circuit (2)

6.3 Current flowing through the capacitor (1)

6.4 Voltage drop across the inductor (2)

6.5 Draw a phasor diagram to show the relationship between the resistor, inductive reactance and capacitive reactance. (3)
[10]

QUESTION 7

7.1 A 76 kW, 380 V, three-phase AC motor has a power factor of 0,84 and an efficiency of 85%.

Calculate the line current of the motor in kA. (4)

7.2 A 160 kW, three-phase AC motor is connected in delta and the supply voltage is 400 V if the power factor is 0,86.

Determine the following:

7.2.1 Phase voltage in kV (2)

7.2.2 Phase current of the motor in kA (4)
[10]

QUESTION 8

8.1 A 400 KVA, three-phase transformer has a delta-connected primary and a star-connected secondary. The input voltage is 3,3 kV and the secondary voltage is 380 V.

Determine the following:

8.1.1 The secondary phase voltage (1)

8.1.2 The maximum allowable secondary phase current (3)

8.1.3 The maximum power output at a power factor of 0,8 (3)

8.2 State the function of a conservator. (2)

8.3 Give the colour of silica gel as it absorbs moisture. (1)
[10]

QUESTION 9

9.1 An ammeter has an internal resistance of 20 Ω and a full-scale deflection when 30 mA flows through it. The instrument is used to measure 15 VDC.

Show the necessary calculations to do the conversion from an ammeter to a voltmeter. (4)

9.2 Explain *mutual inductance* as applicable to a single-phase transformer. A sketch is not necessary as a part of the explanation. (4)

9.3 Name TWO control mechanisms used in electrical instruments. (2)
[10]

QUESTION 10

10.1 What is the main purpose of horizontal and vertical plates in a cathode ray? (1)

10.2 Draw a fully labelled sketch of an OR gate with THREE inputs using mechanical switches. (3)

10.3 State TWO applications of a silicon-controlled rectifier in electronic circuits. (2)

10.4 Subtract the following binary numbers and convert the answer to a decimal number:

$1111{,}0010_2 - 1011{,}0111_2$ (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. $Efficiency/Rendement = \dfrac{VI}{VI + Ia^2 Ra + IsV + C} \times 100$

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

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

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 $i_{ave/gem} = 0{,}637$ Em or/of Im

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$\text{I}_{\text{reactive/reaktief}} = \text{I}\sin\theta$

31. $P = VI\,\text{Cos}\ \theta$

$Q = VI\,\text{Sin}\ \theta$

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

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

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

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MARKING GUIDELINE

NATIONAL CERTIFICATE

AUGUST EXAMINATION

ELECTRO-TECHNOLOGY N3

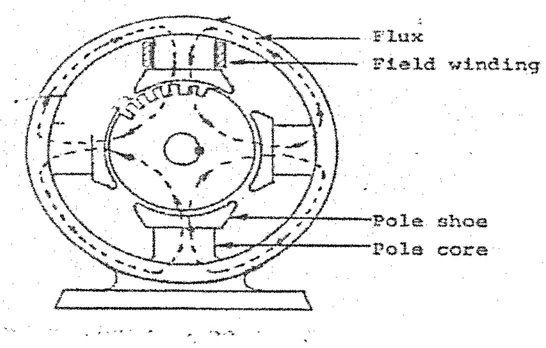
23 JULY 2014

This marking guideline consists of 9 pages.

QUESTION 1

1.1
- It forms the outer casing of the machine. ✓
- It supports the main field system. ✓
- It forms the magnetic circuit of the main poles. ✓ (3)

1.2 (3 marks for correct sketch)



(4 marks for indicating parts and labelling)

A FOUR–POLE DC MACHINE√ (7)
[10]

QUESTION 2

2.1 Carbon brush ✓ (1)

2.2 2.2.1 Armature reaction – is the distortion of the main flux entering and leaving the armature caused by the flux set up by armature conductors when they carry current. ✓ ✓
OR It is the effect of the armature ampere-turns upon the value and distribution of the magnetic flux entering and leaving the armature core. (2)

2.2.2 Commutation – is the reversal of the EMF and current in the short✓circuited coil during its transfer from one commutator segment to the next. ✓ (2)

2.3 Disadvantage of brush shifting: The brushes have to be moved each time the current changes. ✓✓ (2)

2.4 Increase the field flux **OR** Increase the brush contact resistance. ✓
Interpoles ✓
Compensating winding ✓ (3)
[10]

QUESTION 3

3.1 Given: V = 230 V; I_a = 45 A; R_a = 250 mΩ = 0,25Ω; Φ = 25 mWb = 0,025 Wb.
K = 33,2.; N = ?

EMF = V - $I_a R_a$
= 230 V – (45 x 0,25) ✓
= 218,75 V ✓ (One mark for correct answer and unit)

Speed N = $\frac{E}{k\phi}$

$= \frac{218{,}75V}{33{,}2 \times 0{,}025Wb}$ ✓

= 263,554 r/min ✓ (4)

3.2 In order to limit a very high starting current from the supply; ✓ which can damage the armature windings, commutator and brushgear. ✓ (2)

3.3 Given: C = 2p; T = 320 N.m; I_a = 160 A; Z = 560; p = 4

$$T = \frac{0{,}318 I_a Zp\phi}{C}$$

$$\Phi = \frac{320 \times 2 \times 4}{0{,}318 \times 160 \times 560 \times 4}$$ ✓✓

= 0,0225 Wb ✓
= 22,5 mWb ✓ (4)

[10]

QUESTION 4

4.1 Given: Output voltage = 240 V; I = 90 A; $R_a = 0{,}025\ \Omega$; $R_s = 80\ \Omega$;
$I_{no} = 3{,}09$ A

No load losses = VI_{no}
= 240 x 3,09
= 741,6 W ✓

Shunt field loss = VI_{sh} But $I_{sh} = \dfrac{240}{80} = 3$ A
= 240 x 3
= 720 W ✓

Full load armature losses = $I_a^2 R_a$ but $I_a = I_L + I_{sh}$
= $(93)^2\, 0{,}025$ = 90 +3
= 216,225 W ✓ = 93 A

Total losses = 7 41,6 + 216,225 + 720
= 1 677,825 W

Output power = 240 x 90 W
= 21 600 W ✓

Input power = 1 677,825 W + 21 600 W
= 23 277,825 W ✓

Efficiency = $\dfrac{Output}{Input} \times 100\%$ **OR** Efficiency = $\dfrac{VI}{VI + I_a^2 R_a + I_s V + I_{no} V}$ x 100%

$= \dfrac{21\,600\,W}{23\,277{,}825} \times 100\%$ ✓ $= \dfrac{21\,600\,W}{21\,600 + 216{,}225 + 741{,}6 + 720}$

= 92,79 % ✓ = 92,79 % (7)

4.2 Rope brake ✓
Prony brake ✓ (2)

4.3 Direct method ✓ (1)
[10]

QUESTION 5

5.1 Given: $e_1 = 23$ V; $e_2 = 45$ V; $e_3 = 86$ V; $e_4 = 123$ V; $e_5 = 98$ V; $e_6 = 38$ V; $e_7 = 22$ V.

5.1.1 Alternating voltage ✓ (1)

5.1.2 Actual $[E_{RMS}] = \sqrt{\dfrac{e_1^2 + e_2^2 + e_3^2 + e_4^2 + e_5^2 + e_6^2 + e_7^2}{n}}$

$$= \sqrt{\frac{23^2 + 45^2 + 86^2 + 123^2 + 98^2 + 38^2 + 22^2}{7}} \checkmark$$

$$= \sqrt{\frac{36611}{7}} \checkmark$$

$$= \sqrt{5230{,}143}$$

$$= \underrightarrow{72{,}320\ \text{V}} \checkmark$$

(3)

5.1.3 Average value $[E_{AVE}] = e_1 + e_2 + e_3 + e_4 + e_5 + e_6 + e_7 / 7$

$$= (23 + 45 + 86 + 123 + 98 + 38 + 22)/7 \checkmark$$

$$= 435/7 \checkmark$$

$$= \underrightarrow{62{,}143\ \text{V}} \checkmark$$

(3)

5.1.4 Form factor $= E_{RMS}/E_{AVE} = 72{,}320\ V/62{,}143\ V$ ✓

$$= \underrightarrow{1{,}164\ \text{V}} \checkmark$$

(1)

5.1.5 Sine wave / peak wave / sinusoidal wave ✓ (1)

5.2 Maximum value – is the maximum or peak value of an alternating voltage or current. ✓ (1)

[10]

QUESTION 6

6.1 Given: R = 16 Ω ; X_L = 30 Ω; X_C = 40 Ω ; V_s = 220 V/60 Hz.

$$Z = \sqrt{R^2 + (X_C - X_l)^2}$$
$$= \sqrt{16^2 + (45-30)^2} \checkmark$$
$$= \sqrt{481}$$
$$= 21{,}932\ \Omega \checkmark$$

(2)

6.2 $$I_t = \frac{V_t}{Z} = \frac{220\,V}{21{,}932\,\Omega} \checkmark$$
$$= 10{,}031\ A \checkmark$$ (2)

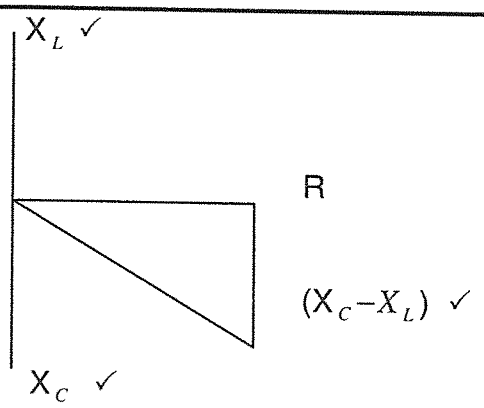
6.3 $I_t = I_C$ [connected in series]
I_C = 10,031 A ✓

(1)

6.4 Voltage drop across the inductor $V_L = I_L \times X_L$ but $I_L = I_t = I_c$ connected in series

$= 10{,}031\ A \times 30\ \Omega$ ✓
$= 300{,}930\ V$ ✓ (2)

6.5



(3)
[10]

QUESTION 7

7.1 Given: Power = 76 kW; V_L = 380 V; Power factor = 0,84; Efficiency = 85%

$$\text{Power (P)} = \sqrt{3}V_L I_L Cos\theta \times \eta$$
$$I_L = \frac{76\,000}{\sqrt{3} \times 380\,V \times 0{,}84 \times 0{,}85} \checkmark\checkmark$$
$$= 161{,}723\ A \checkmark$$
$$= 0{,}162\ kA \checkmark$$

(4)

7.2 Given: Power = 160 kW; V_L = 400 V; Power factor = 0,86

7.2.1 In delta:
$V_P = V_L$
$V_P = 400\,V$ ✓
V_P = 0,4 kV ✓
(2)

7.2.2 Power (P) = $\sqrt{3}\,V_L I_L Cos\theta$

$I_L = \dfrac{160\times10^3}{\sqrt{3}\times400\,V\times0{,}86}$ ✓

= 268,535 A ✓

but $I_L = \sqrt{3}I_P$ in delta connection

$I_P = \dfrac{268{,}535A}{\sqrt{3}}$ ✓

= 155,039 A

= 0,155 kA ✓
(4)
[10]

QUESTION 8

8.1 Given: Rating = 400 kVA; Delta-connected primary; Star-connected secondary; Input voltage = 3,3 kV; Output voltage = 380 V

8.1.1 Secondary phase voltage [V_{ph}] = $\dfrac{380}{\sqrt{3}}$

= 219,393 V ✓
(1)

8.1.2 Maximum allowable secondary phase current: $I_{2L} = \dfrac{S}{\sqrt{3}\,V_{2L}}$

$= \dfrac{400\,000}{\sqrt{3}\times380\,V}$ ✓✓

= 607,737 A ✓
(3)

8.1.3 Maximum power output at a power factor:

P = $\sqrt{3}\,V_{2L}L_{2L}Cos\theta$	**OR** S x Cosθ ✓
= $\sqrt{3}\times380\times607{,}737\times0{,}8$	**OR** 400 000 x 0,8 ✓
= 319 999,93 W	**OR** 320 000 W ✓
= 320 kW Answer	**OR** 320 kW

(3)

8.2 A conservator makes allowances for the expansion and contraction when temperature changes. ✓✓
(2)

8.3 Silica gel turns pink as it absorbs moisture. ✓
(1)
[10]

QUESTION 9

9.1 Given : $R_m = 20\ \Omega$; $I_m = 30\ mA = 0{,}03\ A$; $V_t = 15\ V$

As a voltmeter: $R_t = \frac{V_t}{I_t}$

$= \frac{15V}{0{,}03A}$ ✓

$= 500\ \Omega$ ✓

Therefore: $R_t = R_m + R_{series}$

$R_{series} = (500 - 20)\ \Omega$ ✓

$= 480\ \Omega$ ✓ (4)

9.2
- Two coils are brought together namely primary (input) and secondary windings (output). ✓ The supply is connected to input windings.
- The voltage forms a magnetic field between the primary and secondary winging. ✓
- The variation of magnetic field induces an EMF of mutual inductance into the secondary winding. ✓
- There is no electrical connection between the two coils, only magnetic connection. ✓

(4)

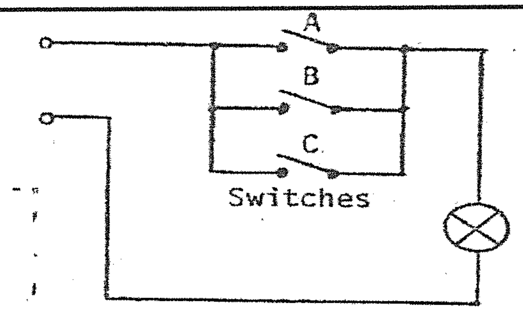
9.3
- Gravity control ✓
- Control spring ✓

(2)
[10]

QUESTION 10

10.1 Horizontal and vertical plates are used to control the path of the electrons ✓ (1)

10.2



(3 marks for correct diagram) (3)

OR gate with THREE inputs

10.3
- Motor speed control
- Time delay circuits
- Battery charger
- Heater control
- Relay circuit
- Regulated power supplies
- Static switches

  Phase controls

(Any 2 x 1mark) (2)

10.4

$$\begin{array}{l} 1111{,}0010 \\ \underline{1011{,}0111} \\ 0011{,}1011_2 \longrightarrow \checkmark \end{array}$$

$$0011{,}1011_2 = 2^1 + 2^0 + 2^{-1} + 0 + 2^{-3} + 2^{-4} \checkmark$$

$$= 2 + 1 + 0{,}5 +) + 0{,}125 + 0{,}0625 \checkmark$$

$$= \underrightarrow{3{,}6875_{10}} \checkmark$$

(4)

[10]

TOTAL: 100