higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T480(E)(M30)T
APRIL EXAMINATION

NATIONAL CERTIFICATE

ELECTRO-TECHNOLOGY N3

(11040343)

30 March 2015 (Y-Paper)
13:00–16:00

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

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 to be substituted for the correct symbol.
7. Sketches and diagrams must be done in pencil and must be neat, reasonably large and fully labelled.
9. The 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 Name and explain THREE methods which are employed to improve commutation. (3 × 2) (6)

1.2 Briefly explain and give the function of the following terms as applicable in DC machines:

1.2.1 Lap-wound

1.2.2 Wave-wound

(2 × 2) (4)
[10]

QUESTION 2

2.1 Define the term *armature reaction.* (2)

2.2 Briefly explain how the windings are connected in a long shunt compound motor. (2)

2.3 State the purpose of commutation in the following machines.

2.3.1 A motor

2.3.2 A generator

(2 × 1) (2)

2.4 A 6-pole machine has a wave-wound armature with conductors per slot. The flux per pole is 18 mWb and the EMF generated at 660 r/min is 109,33 V.

Determine the total number of conductors in the armature. (4)
[10]

QUESTION 3

3.1 Name ONE application of the following types of DC generators.

3.1.1 Differential-compound generator

3.1.2 Compound generator

(2 × 1) (2)

3.2 Draw a circuit diagram of the following DC motors and clearly show the directions of the current flow through the circuit.

3.2.1 A long-shunt compound motor

3.2.2 A short-shunt compound motor

(3 × 2) (6)

3.3 A 220 V, DC generator has an armature resistance of 0,4 Ω.

Determine the generated EMF when the armature current is 35 A. (2)

[10]

QUESTION 4

4.1 Draw a neat, labelled sketch of a face plate starter for a shunt motor. (6)

4.2 Determine the back EMF (in kV) generated in the armature of a 440 V, DC motor which has an armature circuit resistance 0,2 Ω and a load current of 80 A. (4)

[10]

QUESTION 5

An output voltage of 210 V, at a current of 130 A, is delivered by a shunt generator. The armature and field resistances are 0,085 Ω and 70 Ω respectively. The no-load current is 3,545 A.

Determine the following:

5.1 Shunt current (2)

5.2 Armature current (2)

5.3 Efficiency of generator (6)

[10]

QUESTION 6

The following ordinate points are read from the even wave of an alternating quantity:

$i_1 = 16\ A$; $i_2 = 38\ A$; $i_3 = 58A$; $i_4 = 79A$; $i_5 = 98\ A$; $i_6 = 116\ A$; $i_7 = 104\ A$; $i_8 = 91A$; $i_9 = 72\ A$;

$i_{10} = 52\ A$; $i_{11} = 31\ A$; $i_{12} = 14\ A$.

Determine the following:

6.1	Average value	(3)
6.2	RMS value	(4)
6.3	What is the maximum value of the alternating quantity?	(1)
6.4	Form factor	(1)
6.5	Crest factor	(1)
		[10]

QUESTION 7

A 300 kW, three-phase, AC motor is connected in delta and the supply voltage is 380 V. The power factor is 0,96.

Determine the following:

7.1	The phase voltage	(2)
7.2	The line current of the motor	(3)
7.3	The phase current of the motor in kA	(3)
7.4	What is the value of the angle in degrees?	(2)
		[10]

QUESTION 8

8.1 What is the colour of silica gel when it is dry? (2)

8.2 Name TWO types of components where energy losses occur in a transformer. (2)

8.3 A single-phase transformer has 55 turns on the secondary winding and is connected to a 210 V supply. The output voltage is 70 V and the primary current is 300 mA.

Determine the following:

8.3.1 Primary number of turns

8.3.2 Secondary current in amperes

8.3.3 Secondary VA, if ALL losses are ignored

(3 × 2) (6)
[10]

QUESTION 9

9.1 Give the value of the following measuring instruments:

9.1.1 The usual full-scale deflection of an ammeter connected to a current transformer

9.1.2 Output voltage of a potential transformer

(2 × 1) (2)

9.2 Draw a neat, labelled sketch, showing how TWO wattmeters can be used to measure a three-phase circuit. (2)

9.3 A current of 75 mA gives a full-scale reading on an ammeter with a resistance of 15 Ω

Determine the resistance values of the shunts to be used if:

9.3.1 3 A flows through the circuit

9.3.2 1 A flows through the circuit

(3 × 2) (6)
[10]

QUESTION 10

10.1 Briefly name ONE function of the following components:

10.1.1 Transistor

10.1.2 Diode

10.1.3 Silicon-controlled rectifier

(3 × 1) (3)

10.2 Briefly explain a positive ion. (2)

10.3 Give TWO functions of the cathode-ray oscilloscope. (2)

10.4 Determine the number of possibilities for the following:

10.4.1 A four-input gate

10.4.2 An eight-input gate

10.4.3 A three-input gate

(3 × 1) (3)
[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 = 2pΦ $\dfrac{ZN}{60c}$

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

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

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

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

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

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

10. E = Blv

11. e = E_m Sin2цft

12. i= I_m Sin2цft

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

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

15. $E_{ave} = \dfrac{e_1 + e_2 + e_3 + e_4 + \ldots + e_n}{n}$

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

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

$I_{rms} = \sqrt{\dfrac{i_1^{\ 2} + i_2^{\ 2} + i_3^{\ 2} + \ldots + i_n^{\ 2}}{n}}$

17. Form factor = $\dfrac{E_{rms}}{E_{ave}}$ or $\dfrac{I_{RMS}}{i_{AVE}}$

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

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

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

21. $X_C = 2цfC$; $i = \dfrac{V}{X_C}$

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

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

26. $\tan\theta = \dfrac{X_L - X_C}{R}$; $\tan\theta = \dfrac{X_C - X_L}{R}$

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

28. $P = VI\cos\theta$

29. $\cos\theta = \dfrac{R}{Z}$; $\cos\theta = \dfrac{W}{VA}$

30. $I_{active} = I\cos\theta$; $I_{reactive} = I\sin\theta$

31. P = VI Cos θ

    Q = VI Sin θ

32. $f_r = \frac{1}{2\pi\sqrt{LC}}$

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

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

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

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

37. Cos θ = $\frac{I_R}{I}$

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

42. $kVA = \frac{\sqrt{3} V_L I_L}{1000}$

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

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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30 MARCH 2015

This marking guideline consists of 8 pages.

QUESTION 1

1.1 INCREASING THE BRUSH CONTACT RESISTANCE/CARBON BRUSH ✓
By using carbon brushes the contact resistance is increased and commutation improved✓

SHIFTING THE BRUSHES✓
To improve commutation either in generator or motor, the brushes will be moved forwards or backwards.✓

INTERPOLES✓
Small poles placed between main poles are used to ensure sparkless commutation at any load.✓

COMPENSATION WINDINGS ✓
Are connected in series with the armature and ampere turns vary with the load but this is an expensive method.✓

(Any 3 × 2) (6)

1.2 1.2.1 Lap-wound is an overlap or parallel windings with two ends of each coil connected to adjacent commutator segments.✓

FUNCTION – is used to carry high/heavy current or low voltage.✓ (2)

1.2.2 WAVE-WOUND – is not connected to adjacent commutator segments but to segments a certain distance apart✓

OR

Wave windings are such that only two parallel circuits are formed.

FUNCTION – is used where low/medium current or high voltages are required✓ (2)

[10]

QUESTION 2

2.1 It is the distortion of the main magnetic field ✓as a result of the current flowing in the armature conductors.✓

OR

It is the effect of the armature ampere-turns upon the value and the distribution of the magnetic flux entering and leaving the armature core. (2)

2.2 A long-shunt compound motor is when a series field coil is connected in series with an armature and connected in parallel to a shunt field coil.✓ (2)

2.3 2.3.1 A motor commutation is to provide a difference in polarity between the armature and the field in order to produce motion.✓

2.3.2 A generator commutation – is to produce a steady voltage which remains constant.✓

(2 × 1) (2)

2.4 Given: P = 3; C = 2; Φ = 20 mWb = 0,018 Wb; N = 660 r/m; E = 109,33 V
Total number of conductors in armature = ?

$$E = \frac{2p\Phi ZN}{60C}$$

$$Z = \frac{E \times 60C}{2p\Phi N}$$ ✓ (Making Z the subject of the formula)

$$= \frac{109{,}33\,V \times 60 \times 2}{2 \times 3 \times 0{,}018 \times 660}$$ ✓✓

= 184,057 conductors✓ (4)

[10]

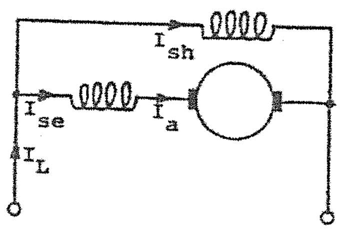
QUESTION 3

3.1 3.1.1 Differential-compound generator – is used as a welding generator✓
OR
Carbon arc search light generator

3.1.2 Compound generator – is used in a generating station which is a distance from the load.✓

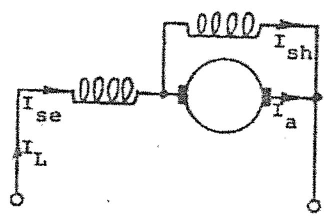
(2 × 1) (2)

3.2 3.2.1



LONG-SHUNT COMPOUND MOTOR
(1 mark for correct direction of current; 2 marks for sketch) (3)

3.2.2



SHORT-SHUNT COMPOUND MOTOR
(1 mark for correct directions of current; 2 marks for sketch) (3)

3.3 EMF [E] = $V + I_a R_a$

$= 220\text{ V} + (35\text{ A} \times 0{,}04)$

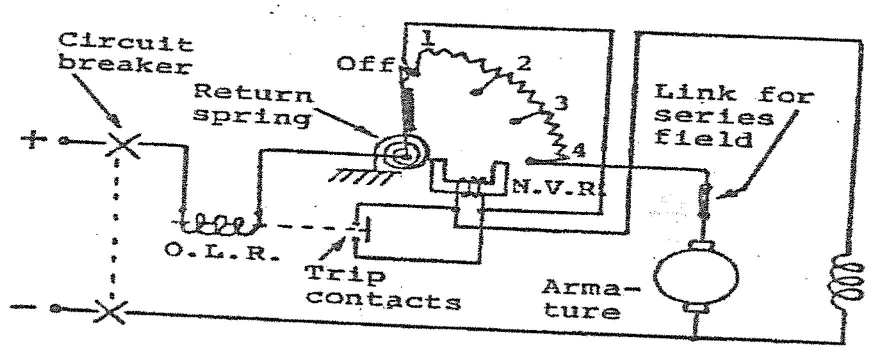
$= 220\text{ V} + 1{,}4\text{ V}$✓

$= 221{,}4$ Volts✓

(2)
[10]

QUESTION 4

4.1



A FACE PLATE STARTER FOR SHUNT MOTOR
(4 marks for labels and 2 marks for sketch) (6)

4.2 Back EMF [E] = $V - I_a R_a$✓

$= 440\text{ V} - (0{,}2\ \Omega \times 80\text{ A})$✓

$= 424\text{ V}$✓

$= 0{,}424\text{ kV}$✓

(4)
[10]

QUESTION 5

5.1 $I_{sh} = \frac{V}{R_{sh}} = \frac{210\ V}{70\ \Omega}$ ✓

$= 3\text{ A}$ ✓

(2)

5.2 $I_a = I_L + I_{sh} = 130\text{ A} + 3\text{ A}$✓

$= 133\text{ A}$✓

(2)

5.3 Efficiency [η] = $\frac{VI}{VI + I_a{}^2 R_a + I_{sh}V + I_0 V} \times 100$

$= \frac{210\ V \times 130}{((210\ V \times 130\ A) + ((133)^2 \times 0{,}085) + (3 \times 210) + (3{,}545 \times 210))} \times 100$ ✓

$= \frac{27\ 300\ W}{27\ 300\ W + 1\ 503{,}565 + 630 + 744{,}45} \times 100$ ✓✓

$= \frac{27\ 300\ W}{30\ 178{,}015} \times 100$ ✓

= 0,90463 × 100✓

= 90,463%✓

(6)

[10]

QUESTION 6

6.1 Average value [i_{ave}] = $\frac{i_1 + i_2 + i_3 + \ldots + i_n}{n}$

$= \frac{(16 + 38 + 58 + 79 + 98 + 116 + 104 + 91 + 72 + 52 + 31 + 14)A}{12}$ ✓

$= \frac{769}{12}$ ✓

= 64,083 A✓

(3)

6.2 RMS value [i_{rms}] = $\sqrt{\frac{i_1{}^2 + i_2{}^2 + i_3{}^2 + \ldots + i_n{}^2}{n}}$

$= \sqrt{\frac{16^2 + 38^2 + 58^2 + 79^2 + 98^2 + 116^2 + 104^2 + 91^2 + 72^2 + 52^2 + 31^2 + 14^2}{12}}$ ✓

$= \sqrt{\frac{62\ 507}{12}}$ ✓

$= \sqrt{5\ 208{,}917}$ ✓

= 72,173 A✓

(4)

6.3 116 A✓ (1)

6.4 Form factor = $\frac{I_{rms}}{I_{ave}}$

$= \frac{72{,}178A}{64{,}083A}$ ✓

= 1,126✓

(1)

6.5 Crest factor = $\frac{I_{\max}}{I_{rms}}$

$= \frac{116A}{72{,}178A}$ ✓

$= 1{,}607$ ✓

(1)

[10]

QUESTION 7

7.1 In delta: $V_L = V_P$ (In delta connection)✓

$V_P = 380$ V✓ (2)

7.2 The line current of the motor: Power = $\sqrt{3}V_L I_L Cos\theta$

$I_L = \frac{300\,000}{\sqrt{3} \times 380\,V \times 0{,}96}$ ✓✓

$= 474{,}795$ A✓ (3)

7.3 The phase current of the motor: $I_P = \frac{I_L}{\sqrt{3}}$

$= \frac{474{,}795A}{\sqrt{3}}$ ✓

$= 274{,}123$ A✓

$= 0{,}274$ kA✓ (3)

7.4 Angle in degrees: $\theta = \frac{360^\circ}{3}$ (Three-phase alternating quantity) ✓

$\Theta = 120^\circ$✓ (2)

[10]

QUESTION 8

8.1 Blue✓✓ (2)

8.2
- Winding losses✓
- Core losses✓

(2)

8.3 8.3.1 $\frac{N_1}{N_2} = \frac{V_1}{V_2}$

Primary number of turns $N_1 = 55 \times \frac{210\,V}{70\,V}$ ✓

$= 165$ turns✓ (2)

8.3.2 $\frac{V_1}{V_2} = \frac{I_2}{I_1}$

$I_2 = \frac{210\,V \times 0{,}3\,A}{70\,V}$ ✓

$= 0{,}9$ A✓

(2)

8.3.3 Secondary volt-ampere = VI
= 70 volts x 0,9 A✓
= 63 VA✓

(2)
[10]

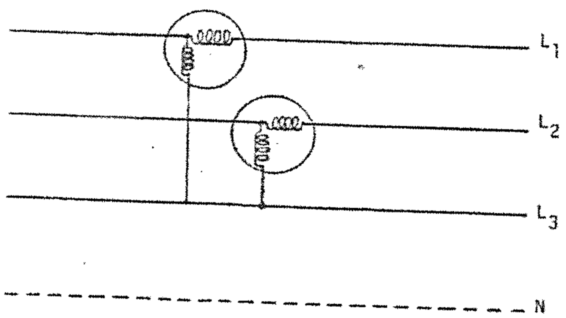
QUESTION 9

9.1 9.1.1 Current transformer = 5 A✓

9.1.2 Potential transformer = 110 V✓

(2 × 1) (2)

9.2



TWO WATTMETER INSTRUMENT IN THREE-PHASE CIRCUIT
(2 marks for correct diagram and wattmeters) (2)

9.3 9.3.1 $V_s = V_m$

$I_s R_s = I_m R_m$

$R_s = \frac{0{,}075 \times 15}{3 - 0{,}075}$ ✓

$= \frac{1{,}125\,V}{2{,}925\,A}$ ✓

$= 0{,}385\ \Omega$✓

9.3.2 $R_s = \frac{I_m R_m}{I_s}$

$= \frac{0{,}075 \times 15}{1 - 0{,}075}$ ✓

$= \frac{1{,}125\,V}{0{,}925}$ ✓

$= 1{,}216\ \Omega$✓

(2 × 3) (6)
[10]

QUESTION 10

10.1 10.1.1 Transistor – as an amplifier OR switch✓ (1)

10.1.2 Diode – as a rectifier✓ (1)

10.1.3 Silicon-controlled rectifier – (as speed control, time-delay circuit, battery charge, heater controls, relay controls, regulated power supplies, static switch and phase control) (Any 1 × 1) (1)

10.2 POSITIVE ION – is when an atom lost one or more electron(s)✓✓ (2)

10.3
- To study wave shape of alternating current and voltage
- To measure quantities such as voltage, current, power and frequency
- To diagnose and monitor electrical and electronic systems (Any 2 × 1) (2)

10.4 10.4.1 A four-input gate has $N = 2^4$
$= 16$ combinations

10.4.2 An eight-input gate has $N = 2^8$
$= 256$ combinations

10.4.3 A three-input gate has $N = 2^3$
$= 8$ combinations

(3 × 1) (3)
[10]

TOTAL: 100