



higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

ELECTROTECHNICS N4

25 March 2025

This marking guideline consists of 9 pages.

QUESTION 1: PRINCIPLES OF ELECTRICITY

- 1.1 1.1.1 Atom: The smallest particle of a chemical element that can exist. ✓✓
- 1.1.2 Ampere: The current which is maintained in two straight parallel conductors of infinite length of negligible cross-sectional area, ✓ and placed 1 metre apart in a vacuum would produce between the conductors a force of 2×10^{-7} newtons per metre of length. ✓
- 1.1.3 Resistance: Opposition offered to the flow of current, ✓✓ or Is that resistance in which a current of 1 ampere flowing for 1 second generates 1 joule of thermal energy.
- 1.1.4 Potential difference: An electric pressure which causes the current to flow between two points in a circuit. ✓✓
- 1.1.5 Temperature coefficient of resistance: Is the increase in unit resistance of a substance, per unit rise in temperature from 0°C . ✓✓
(2 × 5) (10)

- 1.2 Data:
 $l = 100 \text{ m}$
 $I_T = 20 \text{ A}$
 $V_S = 240 \text{ V}$
 $V_D = (5\%)V_S$
 $\rho = 0,028 \mu\Omega \text{ m}$

$$V_D = \left(\frac{5}{100}\right) 240 = 12 \text{ V} \checkmark$$

$$R_T = \frac{V_D}{I_T} = \frac{12}{20} = 0,6 \Omega \checkmark \checkmark$$

$$l = 100 + 100 = 200 \text{ m} \checkmark$$

NOTE: This is the resistance of two conductors (Positive and Negative)

$$\begin{aligned} A &= \frac{\rho l}{R} \\ &= \frac{(0,028 \times 10^{-6})(200)}{0,6} \checkmark \\ &= 9,33 \times 10^{-6} \text{ m}^2 \checkmark \end{aligned}$$

$$\begin{aligned} d &= \sqrt{\frac{4A}{\pi}} \\ &= \sqrt{\frac{4 \times 9,33 \times 10^{-6}}{\pi}} \checkmark \end{aligned}$$

$$= 3,446 \times 10^{-3} \text{ m or } 3,446 \text{ mm} \checkmark \quad (8)$$

1.3 Data:

$$\begin{array}{lll} E_1 = 120 \text{ V}, & E_2 = 60 \text{ V}, & R_L = 20 \Omega \\ r_1 = 0,4 \Omega, & r_2 = 0,2 \Omega, & V_L = ? \\ I_1 = ?, & I_2 = ?, & I_1 + I_2 = ? \end{array}$$

Consider Loop ACDEA:

$$\begin{aligned} E_1 &= I_1 r_1 + (I_1 + I_2) R \\ 120 &= 0,4 I_1 + 20 I_1 + 20 I_2 \\ 120 &= 20,4 I_1 + 20 I_2 \dots \dots \dots (1) \checkmark \checkmark \end{aligned}$$

Consider Loop BCDEB:

$$\begin{aligned} E_2 &= I_2 r_2 + (I_1 + I_2) R \\ 60 &= 0,2 I_2 + 20 I_1 + 20 I_2 \\ 60 &= 20 I_1 + 20,2 I_2 \dots \dots \dots (2) \checkmark \checkmark \end{aligned}$$

$$(1) \times 20, 2: \quad 2424 = 412,08 I_1 + 404 I_2 \dots \dots \dots (3) \checkmark$$

$$(2) \times 20: \quad 1200 = 400 I_1 + 404 I_2 \dots \dots \dots (4) \checkmark$$

$$\begin{aligned} (3) - (4): \quad 1224 &= 12,08 I_1 \\ I_1 &= 101,325 \text{ A } \checkmark \checkmark \end{aligned}$$

Substitute I_1 into (1)

$$\begin{aligned} 120 &= 20,4 I_1 + 20 I_2 \\ 120 &= (20,4 \times 101,325) + 20 I_2 \\ I_2 &= -97,352 \text{ A } \checkmark \checkmark \end{aligned}$$

$$\begin{aligned} \therefore (I_1 + I_2) &= (101,325 - 97,352) = 3,973 \text{ A} \\ V_L &= (I_1 + I_2) R \\ &= 3,973 \times 20 \\ &= 79,46 \text{ V } \checkmark \checkmark \end{aligned}$$

(12)
[30]

QUESTION 2: DC MACHINES

2.1 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)

Or

Is the process in which alternating current generated in the armature windings of a DC machine is converted to a pulsating direct current by the use of a commutator, which is a mechanical rectifier.✓✓

2.2

- a) Loose brush connections✓
- b) Dirty brushes/commutator✓
- c) Low alternator speed✓
- d) Incorrect field winding connection✓
- e) Incorrect armature direction of rotation✓
- f) No residual magnetic flux in the field system✓
- g) Field winding resistance greater than shunt field critical resistance✓

Any relevant answer (1 × 3)

(3)

2.3

Data:

$$V = 240 \text{ V}$$

$$p = 3$$

$$c = 6 \text{ (lap)}$$

$$\phi = 50 \text{ mWb}$$

$$R_{sh} = 30 \Omega$$

$$R_a = 0,1 \Omega$$

$$Z = 850$$

2.3.1

$$I_L = 50 \text{ A}$$

$$I_{sh} = \frac{V}{R_{sh}} = \frac{240}{30} = 8 \text{ A}✓$$

$$I_{a(G)} = I_L + I_{sh} = 50 + 8 = 58 \text{ A}✓$$

$$E_{(G)} = V + I_a R_a = 240 + (58 \times 0,1)✓ = 245,8 \text{ V}✓$$

$$N_{(G)} = \frac{60EC}{2pZ\phi} = \frac{60 \times 245,8 \times 6}{2 \times 3 \times 850 \times 50 \times 10^{-3}}✓ = 347,011 \text{ r/min}✓$$

(6)

2.3.2 $I_L = 50 \text{ A}$

$$I_{a(M)} = I_L - I_{sh}$$

$$= 50 - 8 = 42 \text{ A} \checkmark$$

$$E_{(M)} = V - I_a R_a$$

$$= 240 - (42 \times 0,1) \checkmark$$

$$= 235,8 \text{ V} \checkmark$$

$$N_{(M)} = \frac{60EC}{2pZ\phi}$$

$$= \frac{60 \times 235,8 \times 6}{2 \times 3 \times 850 \times 50 \times 10^{-3}} \checkmark$$

$$= 332,894 \text{ r/min} \checkmark$$

(5)

2.4 Data:

$$V = 230 \text{ V}$$

$$R_a = 0,5 \text{ A}$$

$$I_{a(st)} = 25 \text{ A}$$

$$R_{st} = ?$$

$$I_{st} = \frac{V}{R_a + R_{st}}$$

$$25 = \frac{230}{0,5 + R_{st}} \checkmark$$

$$25(0,5 + R_{st}) = 230 \checkmark$$

$$25R_{st} = 230 - (25 \times 0,5) \checkmark$$

$$R_{st} = 8,7 \Omega \checkmark$$

(4)

[20]

QUESTION 3: AC THEORY

3.1 a) True/Real/Active power ✓

b) Apparent power ✓

c) Reactive power ✓

(3)

3.2 a) Using power banks in parallel with the supply ✓

b) Using synchronous motor instead of induction motors ✓

c) Using phase advancers ✓

(3)

3.3

Data:

$$V = 240 \text{ V}$$

$$P_o = 12,5 \text{ Kw}$$

$$\eta = 88\%$$

$$\cos \phi = \text{pf} = 0,75 \text{ lagging}$$

3.3.1

$$P_i = \frac{P_o}{\eta}$$

$$= \frac{12,5}{0,88}$$

$$= 14,205 \text{ kW} \checkmark$$

$$I = \frac{P_i}{V \cdot \cos \phi}$$

$$= \frac{14,205 \times 10^3}{240 \times 0,75}$$

$$= 78,917 \text{ A} \checkmark$$

(2)

3.3.2

$$\cos \phi = 0,75$$

$$\therefore \phi = 41,41^\circ \checkmark$$

$$\text{Active Component} = I \cos \phi$$

$$= 78,917 \times 0,75 = 59,188 \text{ A} \checkmark$$

$$\text{Reactive Component} = I \sin \phi$$

$$= 78,917 \cdot \sin 41,41^\circ = 52,199 \text{ A} \checkmark$$

(3)

3.3.3

$$S = VI$$

$$= 240 \times 78,917 = 18,94 \text{ kVA} \checkmark$$

$$Q = VI \cdot \sin \phi$$

$$= 240 \times 78,917 \cdot \sin 41,41^\circ = 12,409 \text{ kVA}_r \checkmark$$

(2)

3.4

Data:

$$V = 240 \text{ V}$$

$$f = 50 \text{ Hz}$$

$$R = 12 \Omega$$

$$X_L = 27 \Omega$$

$$P = 1,3 \text{ kW}$$

3.4 $P = I^2 R$

$$I = \sqrt{\frac{P}{R}}$$

$$= \sqrt{\frac{1300}{12}}$$

$$= 10,408 \text{ A} \checkmark$$

$$Z_t = \frac{V}{I} = \frac{240}{10,408} = 23,059 \Omega \checkmark$$

$$(Z_t)^2 = R^2 + (X_c - X_L)^2$$

$$X_c - X_L = \sqrt{(Z_t)^2 - R^2}$$

$$= \sqrt{23,059^2 - 12^2} = 19,691 \Omega \checkmark \checkmark$$

$$X_c + X_L = 19,691 + 27 = 46,691 \Omega \checkmark$$

$$X_c = \frac{1}{2\pi f C} = 46,691 \Omega \checkmark$$

$$C = \frac{1}{2\pi f X_c}$$

$$= \frac{1}{2\pi \times 50 \times 46,691} = 68,174 \mu\text{F} \checkmark$$

(7)
[20]

QUESTION 4: TRANSFORMERS

- 4.1
- a) Cooling fins ✓
 - b) Buchholz relay ✓
 - c) Conservator/expansion tank ✓
 - d) Breather ✓
 - e) Transformer tank (Oil-filled housing) ✓
 - f) Terminal box ✓
 - g) Bushings ✓
 - h) Radiator/Cooling tubes ✓
 - i) Laminated core ✓
 - j) Windings ✓
 - k) Tap changer ✓

Any relevant answer (1 × 4) (4)

4.2 Data:

$$\begin{aligned} V_1 &= 8\,880\text{ V} = E_1 \\ V_2 &= 400\text{ V} = E_2 \\ I_0 &= 10\text{ A} \\ pf &= \cos\phi_0 = 0,1 \\ N_1 &= 40\text{ Turns} \\ f &= 50\text{ Hz} \end{aligned}$$

$$\begin{aligned} 4.2.1 \quad \phi_m &= \frac{E_1}{4,44fN_1} \\ &= \frac{8\,880}{4,44 \times 50 \times 40} \checkmark \\ &= 1\text{ Wb} \checkmark \end{aligned} \quad (2)$$

$$\begin{aligned} 4.2.2 \quad P_0 &= V_1 I_0 \cos\phi_0 \\ &= 8\,880 \times 10 \times 0,1 \checkmark \\ &= 8\,880\text{ W} \checkmark \\ I_c &= \frac{P_0}{V_P} \\ &= \frac{8\,880}{8\,880} = 1\text{ A} \checkmark \\ I_M &= \sqrt{(I_0)^2 - (I_c)^2} \\ &= \sqrt{10^2 - 1^2} = 9,950\text{ A} \checkmark \end{aligned}$$

(4)
[10]

QUESTION 5: AC MACHINES

- A: Foot piece/Mounting feet ✓
- B: Stator winding ✓
- C: Bearing/s ✓
- D: Shaft ✓
- E: End shield ✓
- F: Terminal box ✓
- G: Fan ✓
- H: Fan cover ✓
- I: Stator/Cooling fins ✓
- J: Rotor ✓

(10 × 1) [10]

QUESTION 6: GENERATION AND SUPPLY OF AC POWER AND MEASURING INSTRUMENTS

- 6.1 6.1.1 Coal power station✓
 6.1.2 Nuclear power station✓
 6.1.3 Wind power station/farm✓
 6.1.4 Hydro power station (Pumped storage scheme)✓
 6.1.5 Solar power station✓

(1 × 5) (5)

6.2 Data:

$$R_m = 200 \, \Omega$$

$$I_m = 20 \, \text{mA}$$

$$I_t = 10 \, \text{A}$$

$$V = 100 \, \text{V}$$

$$6.2.1 \quad I_{sh} = I_t - I_m$$

$$= 10 - 20 \times 10^{-3}$$

$$= 9,98 \, \text{A}✓$$

$$R_{sh} = \frac{I_m R_m}{I_{sh}}$$

$$= \frac{(20 \times 10^{-3})(200)}{9,98}✓$$

$$= 0,4 \, \Omega✓$$

(3)

$$6.2.2 \quad R_{se} = \frac{V}{I_m} - R_m$$

$$= \frac{100}{20 \times 10^{-3}} - 200✓$$

$$= 4\,800 \, \Omega✓$$

(2)

[10]

TOTAL: 100