



**higher education
& training**

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE ELECTROTECHNICS N4

28 June 2022

This marking guideline consists of 8 pages.

QUESTION 1: PRINCIPLES OF ELECTRICITY

- 1.1 1.1.1 The electric pressure which causes the current to flow between two points in a circuit.
- 1.1.2 It is that amount of magnetic flux which, when cut at a uniform rate by a conductor in 1 second, generates an emf of 1 volt.
- 1.1.3 A measure of the resisting power of a specified material to the flow of an electric current.
- 1.1.4 The ease with which a magnetic field can be established in a material compared to the ease with which the same magnetic field can be established in air.
- 1.1.5 The opposition offered to the establishment of magnetic lines of force in a magnetic circuit.

(2 × 5) (10)

1.2 Given:

$I_T = 250A$	$I_T = 250A$
$d_{cu} = 20mm$	$d_{al} = ?$
$I_{cu} = 80A$	$I_{al} = ?$
$l_{cu} = 2,5km$	$l_{al} = ?$
$\rho_{cu} = 0,017 \mu\Omega m$	$\rho_{al} = 0,028 \mu\Omega m$

$$R = \frac{\rho}{A}$$

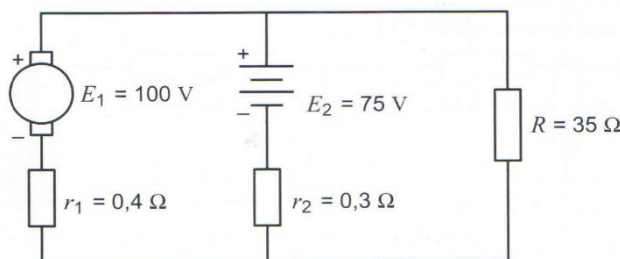
$$A = \frac{\rho}{R} \checkmark$$

$$\frac{\pi d^2}{4} = \frac{\rho}{R} \checkmark$$

$$d = \sqrt{\frac{4\rho}{\pi R}} \checkmark$$

(3)

1.3 1.3.1



correct circuit (1 mark)

generator and internal resistance (1 mark)

battery and internal resistance (1 mark)

load resistor (1 mark)

(4)

1.3.2

Find I_N :

$$I_1 = \frac{E_1}{r_1} = \frac{100}{0,4} = 250 \text{ A} \checkmark$$

$$I_2 = \frac{E_2}{r_2} = \frac{75}{0,3} = 250 \text{ A} \checkmark$$

$$I_{SC} = I_N = I_1 + I_2 = 250 + 250 = 500 \text{ A} \checkmark$$

Find R_N :

$$R_{SC} = R_N = \frac{r_1 \times r_2}{r_1 + r_2} = \frac{[(0,4)(0,3)]}{[0,4 + 0,3]} = 0,171 \Omega \checkmark \checkmark$$

Find I_L :

$$I_L = \left[\frac{R_N}{R_N + R_L} \right] I_N = \left[\frac{0,171}{0,171 + 35} \right] (500) = 2,431 \text{ A} \checkmark \checkmark$$

Find V_L :

$$V_L = I_L R_L = 2,431 \times 35 = 85,085 \text{ V} \checkmark \checkmark$$

(9)

1.4

Given:

$$l = 50 \text{ cm}$$

$$V = 8 \text{ m/s}$$

$$B = 0,3 \text{ Wb/m}^2$$

$$I = 600 \text{ mA}$$

1.4.1

$$E = Blv$$

$$= 0,3 \times 50 \times 10^{-2} \times 8 \checkmark$$

$$= 1,2 \text{ V} \checkmark$$

(2)

1.4.2

$$F = BIl$$

$$= 0,3 \times 50 \times 10^{-2} \times 600 \times 10^{-3} \checkmark$$

$$= 90 \text{ mH} = 0,09 \text{ N} \checkmark$$

(2)

[30]

QUESTION 2: DC MACHINES

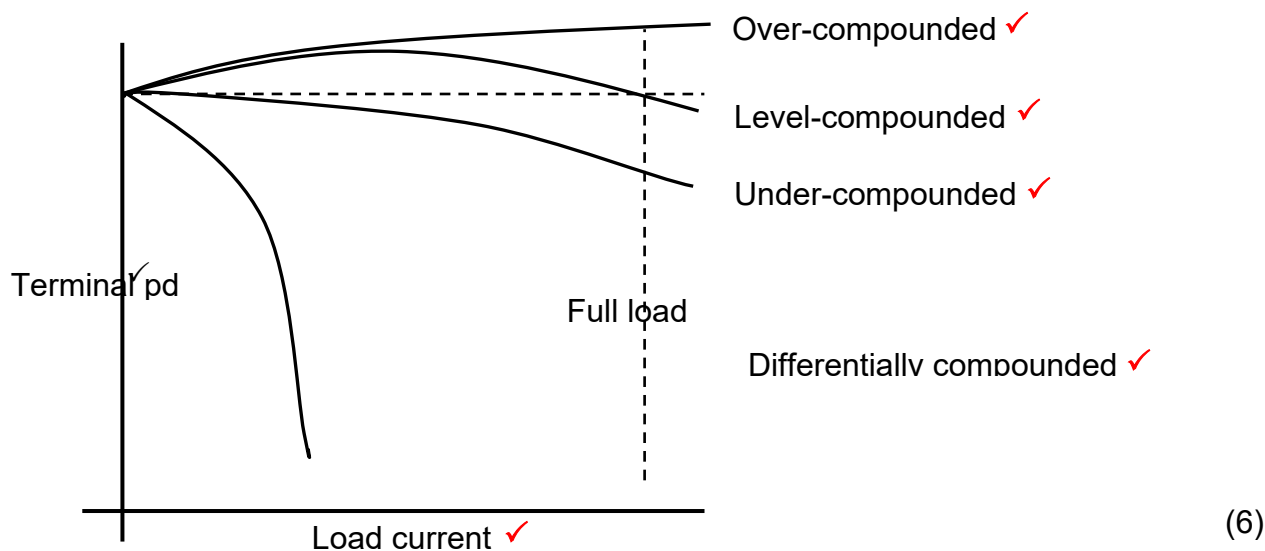
2.1 It is to strengthen the magnetic field. (2)

2.2

- Interpoles
- Shifting the brushes
- Compensating windings
- Increasing the brush contact resistance

(4)

2.3



2.4 **Given:**

$$R_{start} = ?$$

$$P = 15 \text{ KW}$$

$$R_a = 0,62 \Omega$$

$$V = 400 \text{ V}$$

$$I_{start} = 1,8 I_a$$

$$R_f = 148 \Omega$$

$$I_L = \frac{P}{V} = \frac{15000}{400} = 37,5 \text{ A} \quad \checkmark$$

$$I_f = \frac{V}{R_f} = \frac{400}{148} = 2,703 \text{ A} \quad \checkmark$$

$$I_a = I_L - I_f = 37,5 - 2,703 = 34,797 \text{ A} \quad \checkmark$$

$$I_{start} = 1,8 I_a = 1,8 \times 34,797 = 62,635 \text{ A} \quad \checkmark \checkmark$$

$$V = E + I_a (R_a + R_{start})$$

But $E_{start} = 0$ at standstill

$$400 = 0 + 62,635(0,62 + R_{start}) \quad \checkmark \checkmark$$

$$R_{start} = 5,766 \Omega \quad \checkmark$$

(8)
[20]

QUESTION 3: AC THEORY**Solution:**

$$X_{C_A} = \frac{1}{2\pi fC}$$

$$j \frac{1}{2\pi(50)(75 \times 10^{-6})} = 42,441 \Omega \checkmark$$

$$Z_A = 0 - jX_C$$

$$j 0 - j 42,441 = 42,441 \angle -90^\circ \Omega \checkmark$$

$$X_{L_B} = 2\pi fL$$

$$j 2\pi(50)(160 \times 10^{-3}) = 50,265 \Omega \checkmark$$

$$Z_B = R + jX_L$$

$$j 25 + j 50,265 = 56,139 \angle 63,556^\circ \Omega \checkmark$$

$$X_{L_C} = 2\pi fL$$

$$j 2\pi(50)(60 \times 10^{-3}) = 18,85 \Omega \checkmark$$

$$Z_C = R + jX_L$$

$$j 10 + j 18,85 = 21,338 \angle 62,054^\circ \Omega \checkmark$$

$$Z_A \times Z_B = (42,441 \angle -90^\circ)(56,139 \angle 63,556^\circ)$$

$$j 2382,595 \angle -26,444^\circ \Omega \checkmark$$

$$Z_A + Z_B = (0 - j 42,441) + (25 + j 50,265) = 25 + j 7,724$$

$$j 26,196 \angle 17,378^\circ \Omega \checkmark$$

$$Z_{//} = \frac{Z_A \times Z_B}{Z_A + Z_B}$$

$$j \frac{2382,595 \angle -26,444^\circ}{26,196 \angle 17,378^\circ} = 90,953 \angle -43,822^\circ$$

$$j 65,622 + j 62,978 \Omega \checkmark \checkmark$$

$$Z_T = Z_{//} + Z_C$$

$$j65,622 + j62,978 + 10 + j18,85$$

$$j75,622 - j44,128$$

$$j87,556 \angle -30,265^\circ \Omega \checkmark \checkmark$$

$$V_T = 240 \angle 0^\circ V = 240 + j0 \checkmark$$

$$I_T = I_C = \frac{V_T}{Z_T}$$

$$j \frac{240 \angle 0^\circ}{87,556 \angle -30,265^\circ} = 2,741 \angle 30,265^\circ A \checkmark$$

$$V_2 = I_T Z_C$$

$$j(2,741 \angle 30,265^\circ)(21,338 \angle 62,054^\circ)$$

$$j58,487 \angle 92,319^\circ = -2,367 + j58,439 V \checkmark$$

$$V_1 = V_T - V_2$$

$$j(240 + j0) - (-2,367 + j58,439)$$

$$j242,367 - j58,439 = 249,313 \angle -13,556^\circ V \checkmark$$

$$I_A = \frac{V_1}{Z_A}$$

$$j \frac{249,313 \angle -13,556^\circ}{42,441 \angle -90^\circ} = 5,874 \angle 76,444^\circ \checkmark \checkmark$$

$$I_B = \frac{V_1}{Z_B}$$

$$j \frac{249,313 \angle -13,556^\circ}{56,139 \angle 63,556^\circ} = 4,441 \angle -77,112^\circ \checkmark \checkmark$$

[20]

QUESTION 4: TRANSFORMERS**Given:**

$$\begin{array}{ll}
 V_1 = 250 \text{ V} & A = 0,035 \text{ m}^2 \\
 f = 50 \text{ Hz} & d = 2,5 \text{ mm} \\
 B = 1,66 \text{ T} & I / \text{mm}^2 = 4 \text{ A}
 \end{array}$$

4.1 $\phi_m = BA$

$$\begin{aligned}
 & \checkmark (1,66)(0,035) \checkmark \\
 & \checkmark 0,058 \text{ Wb} \checkmark
 \end{aligned}$$

$$N_1 = \frac{E_1}{4,44 f \phi_m}$$

$$\begin{aligned}
 & \checkmark \frac{250}{(4,44)(50)(0,058)} \checkmark \\
 & \checkmark 19,416 = 20 \text{ turns} \checkmark
 \end{aligned}$$

(4)

4.2

$$A = \frac{\pi d^2}{4}$$

$$\begin{aligned}
 & \checkmark \frac{\pi (2,5)^2}{4} \checkmark \\
 & \checkmark 4,909 \text{ mm}^2 \checkmark
 \end{aligned}$$

$$I = (I / \text{mm}^2) A$$

$$\begin{aligned}
 & \checkmark (4)(4,909) \checkmark \\
 & \checkmark 19,636 \text{ A} \checkmark
 \end{aligned}$$

$$S = V_1 I_1$$

$$\begin{aligned}
 & \checkmark (250)(19,636) \checkmark \\
 & \checkmark 4909 \text{ VA} \checkmark
 \end{aligned}$$

(6)

[10]**QUESTION 5: AC MACHINES**

5.1 The energy is transferred entirely magnetically, by means of induced emf ✓ in the rotor conductors by the rotating magnetic field, ✓ which is set up by the stator windings. ✓ (3)

5.2

- Star
- Delta

(2)

5.3

- Capacitor-start, capacitor-run motor
- Capacitor-start, induction-run motor
- Resistance-start, induction-run motor

(3)

- 5.4
- The direction of rotation of a universal motor can be reversed by changing the polarity across the armature or the field coils.
 - It can be achieved by interchanging the connections to the brush holders.
- (Any relevant answer 2 × 1)

(2)
[10]

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

- 6.1
- 6.1.1 Medupi and/or Kendal power station
- 6.1.2 Koeberg power station
- 6.1.3 Cookhouse and/or Jeffreys Bay power station
- 6.1.4 Drakensberg pumped-storage scheme
- 6.1.5 Sasol Gas Engine Power Plant (GEPP)

(1 × 5) (5)

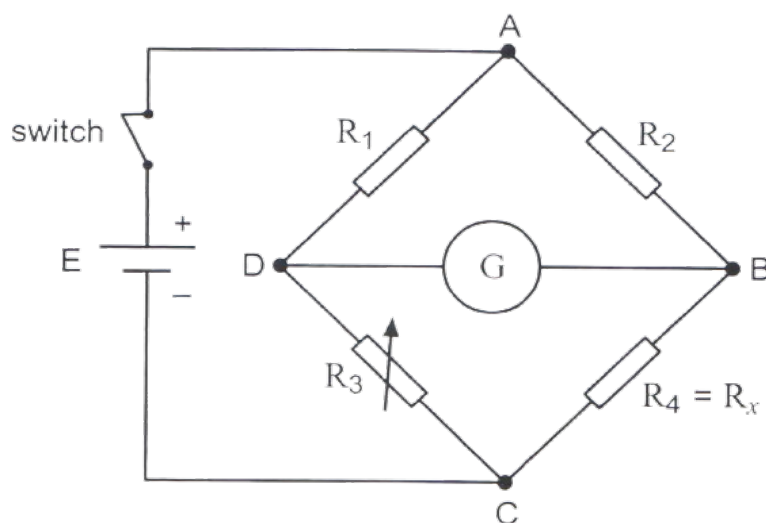
6.2 **Given:**

$$R_1 = 80 \Omega$$

$$R_2 = 800 \Omega$$

$$R_3 = 500 \Omega$$

$$R_4 = R_x = ?$$



$$R_1 R_4 = R_2 R_3$$

$$R_4 = R_x = \frac{R_2 R_3}{R_1}$$

$$= \frac{(800)(500)}{80} \checkmark$$

$$= 5000 \Omega \checkmark$$

Correct circuit diagram (3 marks)

Calculation (2 marks)

(5)
[10]**TOTAL: 100**