



**higher education
& training**

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE ELECTRO-TECHNOLOGY N3

16 August 2023

This marking guideline consists of 10 pages.

QUESTION 1

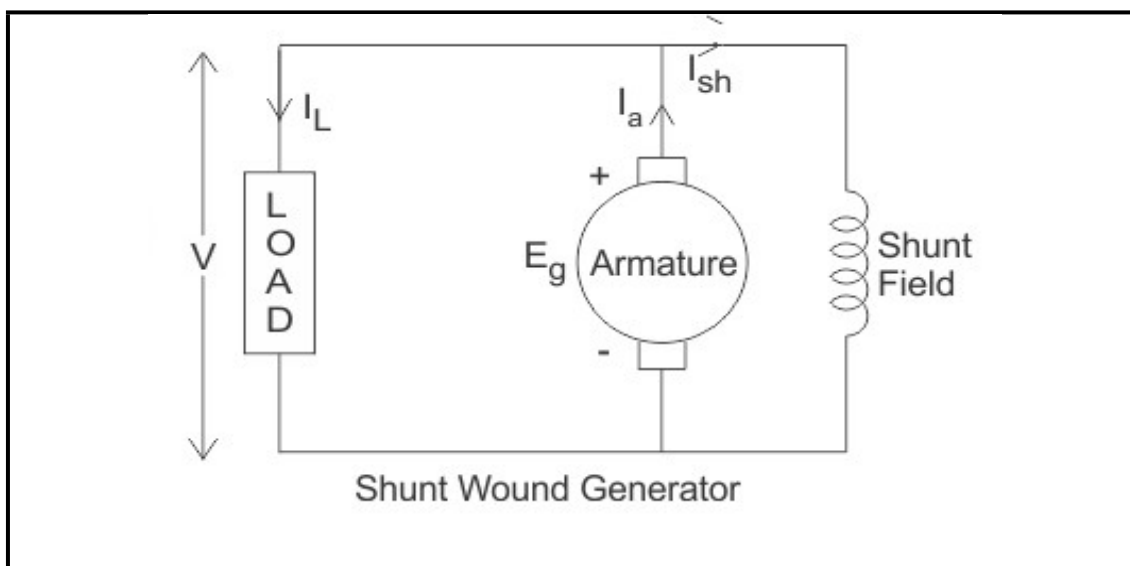
- 1.1 Air gap✓✓
 1.2 Centrifugal force✓✓
 1.3 Interpoles✓✓
 1.4 Instantaneous values✓✓
 1.5 Damping torque✓✓✓

(5 × 2) [10]

QUESTION 2

- 2.1 A generator in which the series and the shunt field coils are connected in such a way that the fields support each other✓ to produce more magnemotive force. ✓ (2)

2.2



(1 mark each for the armature, the shunt field and the load) (3 × 1)
 (1 mark for the correct sketch)

(3)
(1)

- 2.3 $p = 2$, $c = 2$, $V = 220 \text{ V}$, $I_a = 80 \text{ A}$, $R_a = 0,45 \Omega$, $Z = 680$ conductors,
 $\Phi = 20 \text{ mWb}$

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

$$E = V + I_a R_a$$

$$= 220 + (80)(0,45) \checkmark$$

$$= 256 \text{ V} \checkmark$$

$$N = \frac{60Ec}{2p\Phi Z}$$

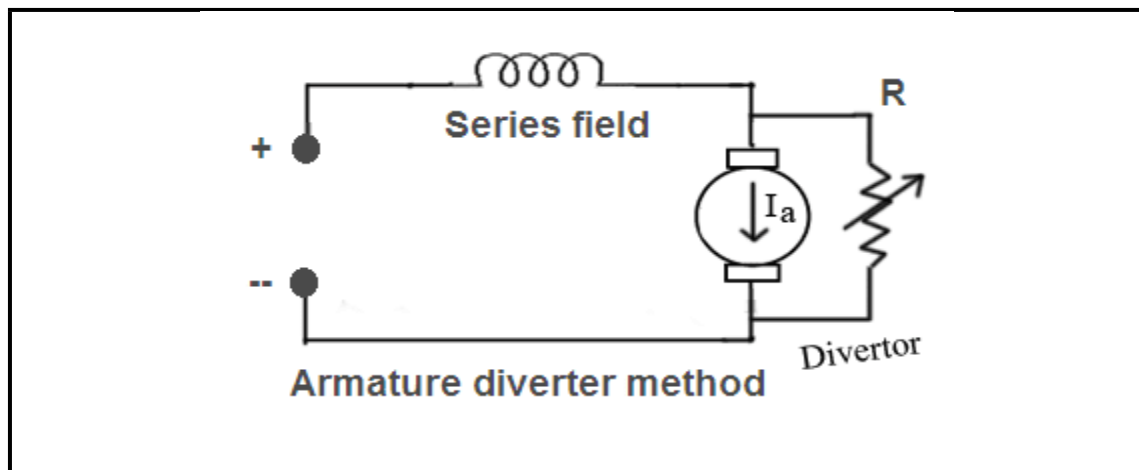
$$= \frac{60 \times 256 \times 2}{2 \times 2 \times 0,02 \times 680} \checkmark$$

$$= 564,706 \text{ r/min} \checkmark$$

(4)

QUESTION 3

- 3.1 Speed control of a series direct current motor by connecting a diverter across the armature.



(1 mark each for the field, armature and diverter) (3 × 1)
(1 mark for the correct sketch)

(3)
(1)

- 3.2 A no-volt relay ensures that the starting handle is replaced to the off position ✓ when the supply is cut off. ✓

OR

A no-volt relay automatically disconnects ✓ the motor from the supply in the event of the supply voltage dropping below ✓ the rated value.

(2)

- 3.3 $V = 200 \text{ V}$, $I_L = 50 \text{ A}$, $R_a = 0,25 \Omega$, $R_{se} = 0,4 \Omega$, $N = 890 \text{ r/min}$, $\Phi = 29 \text{ mWb}$
 $I_L = I_a = I_{se} = 50 \text{ A}$

$$\begin{aligned} E &= V - (I_a R_a + I_{se} R_{se}) \\ &= 200 - (50 \times 0,25) - (50 \times 0,4) \checkmark \\ &= 167,5 \text{ V} \checkmark \end{aligned}$$

$$N = \frac{E}{k \Phi}$$

$$k = \frac{E}{N \Phi}$$

$$= \frac{167,5}{(890)(0,029)} \checkmark$$

$$= 6,489 \checkmark$$

(4)
[10]

QUESTION 4

- 4.1 4.1.1 True
 4.1.2 False
 4.1.3 True
 4.1.4 True

(4 × 1) (4)

- 4.2 V = 250 V, I = 26A, (W-S) = 35 kg × 9.81 = 343,35 N
 N = 600 r/min, d = 550 mm, r = 275 mm = 0,275 m

4.2.1 $P_{in} = VI$
 $= (250)(26)✓$
 $= 6,5 \text{ kW}✓$ (2)

4.2.2 $P_o = \frac{2\pi Nr(W-S)}{60}$
 $= \frac{(2\pi)(600)(0,275)[(35 \times 9,81)]}{60}✓$
 $= 5,933 \text{ kW}✓$ (2)

4.2.3 $\eta = \frac{P_{out}}{P_{in}} \times 100\%$
 $= \frac{5,933 \times 1000}{6500} \times 100\% = 91,277\%$
 ✓

OR

$\eta = \frac{2\pi N(W-S) \times r}{60 VI} \times 100$
 $= \frac{2\pi \times 600 \times 343,25 \times 0,275}{60 \times 250 \times 26} \times 100$
 ✓
 = 91,272 % ✓ (2)

[10]

QUESTION 5

- 5.1 The effective value (r/min value) of an alternating current is the value of the alternating current that produces the same amount of heat✓ as its direct equivalent.✓ (2)

- 5.2 $e_1 = 3,6 \text{ V}$
 $e_2 = 10,5 \text{ V}$
 $e_3 = 16 \text{ V}$
 $e_4 = 18 \text{ V}$
 $e_5 = 10,5 \text{ V}$
 $e_6 = 2,7 \text{ V}$

- 5.2.1 The r/min value

$$= \sqrt{\frac{e_1^2 + e_2^2 + e_3^2 + e_4^2 + e_5^2 + e_6^2}{n}}$$

$$= \sqrt{\frac{3,6^2 + 10,5^2 + 16^2 + 18^2 + 10,5^2 + 2,7^2}{6}} \checkmark$$

$$= \sqrt{\frac{820,75}{6}} \checkmark$$

$$= 11,696 \text{ V} \checkmark \quad (3)$$

- 5.2.2 The average value

$$= \frac{e_1 + e_2 + e_3 + e_4 + e_5 + e_6}{n}$$

$$= \frac{3,6 + 10,5 + 16 + 18 + 10,5 + 2,7}{6} \checkmark \checkmark$$

$$= 10,217 \text{ V} \checkmark \quad (3)$$

- 5.2.3 The form factor (2)

$$\text{Form factor} = \frac{E_{rms}}{E_{avg}}$$

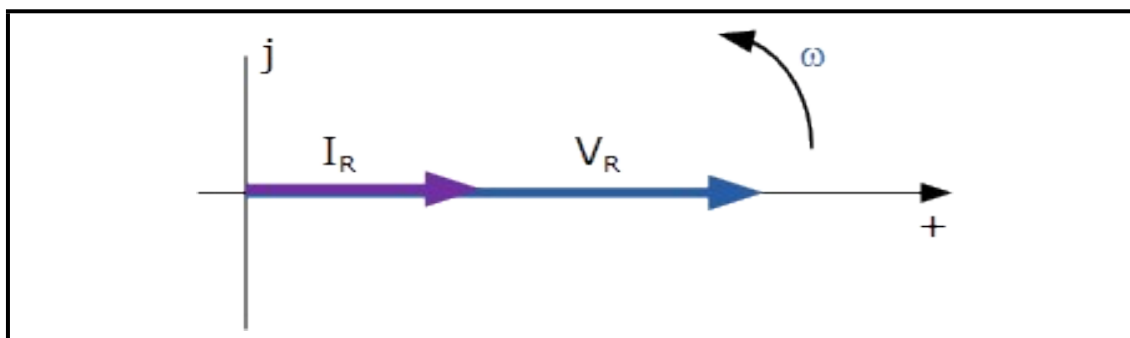
$$= \frac{11,696}{10,217} \checkmark$$

1,145✓

[10]

QUESTION 6

6.1



(1 mark each for the current and the voltage) (2 × 1)

(2)

6.2 R = 55 Ω, C = 160 μF, V = 150 V, F = 50 Hz

6.2.1 The current through the resistor

$$I_R = \frac{V}{R} = \frac{150}{55} \checkmark = 2,727 \text{ A} \checkmark \quad (2)$$

6.2.2 The current through the capacitor

$$X_C = \frac{1}{2\pi FC} = \frac{1}{(2\pi) \checkmark \checkmark} = 19,894 \Omega \checkmark$$

$$I_C = \frac{V}{X_C} = \frac{150}{19,894} \checkmark$$

$$= 7,54 \text{ A} \checkmark \quad (3)$$

6.2.3 The total current flowing in the circuit

$$I = \sqrt{I_R^2 + I_C^2}$$

$$= \sqrt{2,727^2 + 7,4^2} \checkmark$$

$$= 8,018 \text{ A} \checkmark \quad (2)$$

6.2.4 The impedance of the circuit

$$Z = \frac{V}{I_T} = \frac{150}{8,018} = 18,708 \Omega \checkmark \quad (1)$$

[10]

QUESTION 7

$I_L = 15 \text{ A}$, $V_L = 350 \text{ V}$, $\cos \theta = 0,8$ lagging

7.1 The voltage across each phase winding

$$V_{ph} = V_L = 350 \text{ V (delta connection)} \quad (1)$$

7.2 The current flowing in each phase winding

$$I_p = \frac{I_L}{\sqrt{3}} = \frac{15}{\sqrt{3}} = 8,66 \text{ A} \quad (2)$$

7.3 The power input to the motor

$$\begin{aligned} P &= \sqrt{3} V_L I_L \cos \theta \\ P &= \sqrt{3} (350)(15)(0,8) \\ &= 7\,274,613 \text{ W OR } 7,275 \text{ kW} \end{aligned} \quad (2)$$

7.4 The reactive power of the motor

$$\begin{aligned} \cos \theta &= 0,8 \\ \theta &= \cos^{-1} 0,8 \\ &= 36,87^\circ \\ Q &= \sqrt{3} V_L I_L \sin \theta \\ &= \sqrt{3} (350) (15) (\sin 36,869) \\ &= 5\,455,973 \text{ VAR OR } 5,456 \text{ kVAR} \end{aligned} \quad (3)$$

7.5 The full-load efficiency

$$P_o = 6 \text{ kW}$$

$$\begin{aligned} \eta &= \frac{P_o}{P_i} \times 100\% & \text{OR} & \quad \eta = \frac{P_{out}}{P_{in}} \times 100\% \\ &= \frac{6000}{7275} \times 100\% & & \quad = \frac{6000}{7274,613} \times 100\% \\ &= 82,474\% & & \quad = 82,479\% \end{aligned}$$

(2)

[10]

QUESTION 8

8.1 $S = 250 \text{ kVA}$, $V_{1(L)} = 5,5 \text{ kV}$, $V_{2(L)} = V_{2(ph)} = 350 \text{ V}$, $N_2 = 90 \text{ turns}$

8.1.1 The primary phase voltage

$$V_{1(p)} = \frac{V_{1(L)}}{\sqrt{3}} = \frac{5500}{\sqrt{3}} = 3,175 \text{ kV} \quad (1)$$

8.1.2 The secondary phase current

$$S = \sqrt{3} V_{2(L)} I_{2(L)} = \dot{I}$$

$$I_{2(L)} = \frac{S}{\sqrt{3} V_{2(L)}} = \frac{(250 \times 10^3)}{\sqrt{3} (350)} = 412,393 \text{ A}$$

$$I_{2(p)} = \frac{I_{2(L)}}{\sqrt{3}} = \frac{412,393}{\sqrt{3}} = 238,095 \text{ A} \quad (3)$$

8.1.3 The number of primary turns

$$N_1 = V_{1(p)} \frac{N_2}{V_{2(p)}} = 3175 \left(\frac{90}{350} \right) = 816 \text{ turns} \quad (2)$$

8.1.4 The output power if the load has a power factor of 0,86

$$P_o = \sqrt{3} V_L I_L \cos \phi = \sqrt{3} (350) (412,393) (0,86) = 214,99 \text{ kW}$$

OR

$$P_o = 3 V_p I_p \cos \phi = (3) (350) (238,095) (0,86) = 214,99 \text{ kW} \quad (2)$$

- 8.2
- Motor starters for large induction motors
 - Voltage boosters

(2)
[10]

QUESTION 9

- 9.1
- Attraction-type instrument
 - Repulsion-type instrument
- (2)

9.2

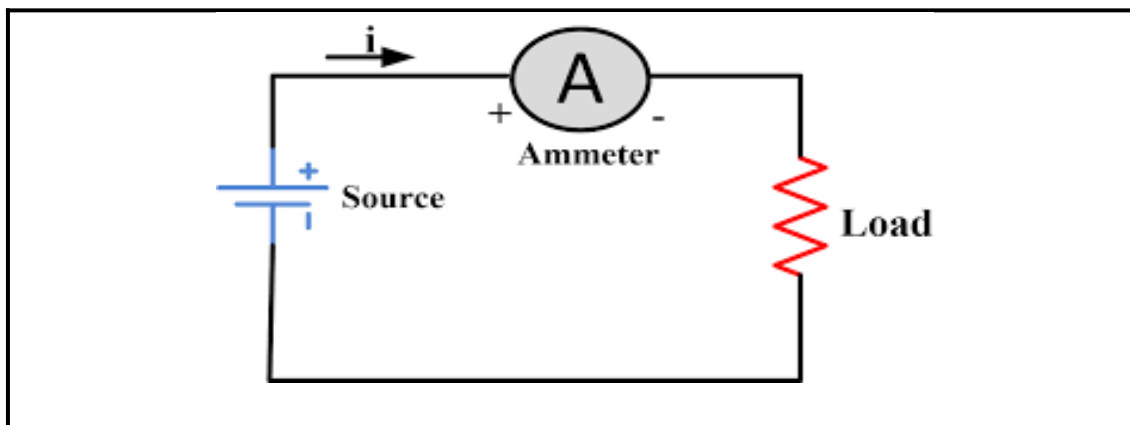
$$I_{sh} = I_T - I_m = 5,5 - 20 \times 10^{-3} = 5,48 \text{ A} \checkmark \checkmark$$

$$R_{sh} = \frac{I_m R_m}{I_{sh}} = \frac{(20 \times 10^{-3})(65)}{5,48} = 0,237 \Omega \checkmark \checkmark$$

(4)

- 9.3 The secondary side of instrument transformers must be earthed to ensure immediate discharge ✓ to the ground of any harmful energy. ✓ (2)

- 9.4 An ammeter connected to measure the current flow through the load



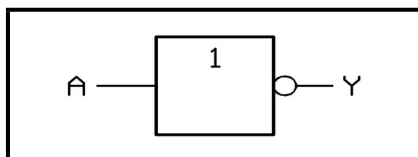
(1 mark each for the ammeter and the load) (2 × 1)

(2)
[10]

QUESTION 10

- 10.1
- The current gain is high
 - It has a very high input impedance and a low output impedance
 - Voltage gain is slightly less than 1 (Any 2 × 1) (2)

- 10.2 IEC symbol for a NOT gate



(1 mark each for the input and output terminals) (2 × 1) (2)
(1 mark for the correct sketch) (1)

- 10.3 Add the following binary numbers and convert the final answer to a decimal number.

1010_2 and 1101_2

$$\begin{array}{r} 1010 \\ + 1101 \\ \hline = 10111_2 \end{array}$$

✓ ✓ ✓ ✓ ✓ (½ a mark for each digit)

$$\begin{aligned} 10111_2 &= (1 \times 2^4) + (0 \times 2^3) + (1 \times 2^2) + (1 \times 2^1) + (1 \times 2^0) \checkmark \\ &= 16 + 0 + 4 + 2 + 1 \checkmark \\ &= 23_{10} \checkmark \end{aligned}$$

(5)
[10]

TOTAL: 100