Province of the
EASTERN CAPE
EDUCATION

NATIONAL SENIOR CERTIFICATE

GRADE 11

NOVEMBER 2022

ELECTRICAL TECHNOLOGY: POWER SYSTEMS MARKING GUIDELINE (EXEMPLAR)

MARKS: 200

This marking guideline consists of 12 pages.

INSTRUCTIONS TO MARKERS

1. All calculations with multiple answers imply that any relevant, acceptable answer should be considered.

2. Calculations:

   2.1 All calculations must show the formulae.

   2.2 Substitution of values must be done correctly.

   2.3 All answers MUST contain the correct unit to be considered.

   2.4 Alternative methods must be considered, provided that the correct answer is obtained.

   2.5 Where an incorrect answer could be carried over to the next step, the first answer will be deemed incorrect. However, should the incorrect answer be carried over correctly, the marker has to re-calculate the values, using the incorrect answer from the first calculation. If correctly used, the candidate should receive the full marks for subsequent calculations.

   2.6 Markers should consider that learners answers may deviate slightly from the marking guideline depending on how and where in the calculation rounding off was used.

3. These marking guidelines are only a guide with model answers.

4. Alternative interpretations must be considered and marked on merit. However, this principle should be applied consistently throughout the marking session at ALL marking centres.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

1.1	1.1	B ✓	(1)
	1.2	A ✓	(1)
	1.3	D ✓	(1)
	1.4	A ✓	(1)
	1.5	C ✓	(1)
	1.6	C ✓	(1)
	1.7	A ✓	(1)
	1.8	B ✓	(1)
	1.9	A ✓	(1)
	1.10	D ✓	(1)
	1.11	A ✓	(1)
	1.12	C ✓	(1)
	1.13	D ✓	(1)
	1.14	B ✓	(1)
	1.15	C ✓	(1)
			[15]

QUESTION 2: OCCUPATIONAL HEALTH AND SAFETY

2.1 2.1.1
- Seating position ✓
- Standing position
- Regular movement
- Organisation of work

(Any 1 x 1) (1)

2.1.2
- Temperature ✓
- Lighting
- Reflection and glare
- Humidity
- Noise
- Space

(Any 1 x 1) (1)

2.2 Inadequate lighting leads to decreased visibility and movement, ✓ which could lead to injury to yourself or others. ✓ (2)

2.3 It protects the worker ✓ from unnecessary or avoidable hazards. ✓ (2)

2.4 They are warning signs, ✓ that make people aware of potential hazards in an area. ✓ (2)

2.5 Regulations are necessary to control the conditions under which work is done ✓ in order to protect everyone in the workplace. ✓ (2)

[10]

QUESTION 3: TOOLS AND MEASURING INSTRUMENTS

3.1
- Clean regularly to remove any build-up of dust or dirt. ✓
- Check that connecting leads are in good working order. ✓
- Store safely in a dry place when not in use. ✓ (3)

3.2 3.2.1 $V_{max.}$ = V/div × no. of divisions ✓
$= 5 \times 3$ ✓
$= 15$ V ✓ (3)

3.2.2 T = T/div. × no. of divisions
$= 2 \times 10^{-3} \times 5$ ✓
$= 10 \times 10^{-3} s = 10$ ms ✓
$f = \frac{1}{T}$
$= \frac{1}{10 \times 10^{-3}}$ ✓
$= 100$ Hz ✓ (4)

[10]

QUESTION 4: DC MACHINES

4.1
- A generator has a mechanical input with an electrical output. ✓
- A motor has an electrical input with a mechanical output. ✓ (2)

4.2 To collect current from the commutator. ✓ (1)

4.3
- They have no brushes. ✓
- The permanent magnets are on the inside and rotate, while the coils are on the outside and are static. ✓
- The design of the rotor and stator is different.
- The motor can stay still in a certain position once it has rotated through a certain angle. (Any 2 x 1) (2)

4.4 The motor will accelerate to a very high speed, ✓ which will damage the motor. ✓ (2)

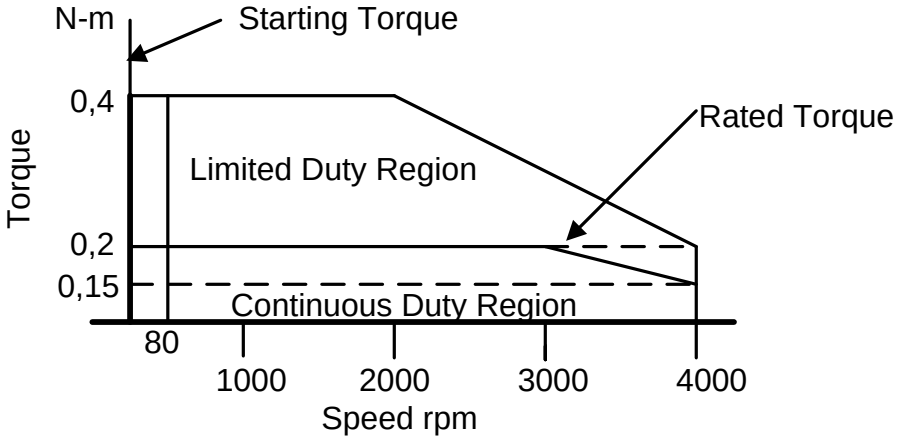
4.5 4.5.1 Compound wound motor ✓ (1)

4.5.2 A – armature ✓
B – series field ✓ (2)

4.5.3 It has the constant speed of a shunt machine ✓ and the high torques of a series machine. ✓ The speed stays virtually constant with an increase in load. ✓ (3)

4.5.4
- Continuous running mills ✓
- Stone crushers
- Electric locomotives (1)

4.6



Horizontal and vertical axis correctly numbered and labelled ✓
Starting torque correctly shown ✓
Rated torque correctly shown ✓
Limited duty region shown ✓
Continuous duty region shown ✓ (5)

4.7 4.7.1 They are windings that are placed in close proximity of the armature windings. ✓ They carry the same current as the armature but in the opposite direction. ✓ This neutralises the effects of armature reaction. ✓ (3)

4.7.2 These are smaller poles placed midway between the main poles on the geometric neutral axis. ✓ They have an equal and opposite mmf to that of the armature mmf. ✓ This neutralises the armature reaction at the brush axis. ✓ (3)

[25]

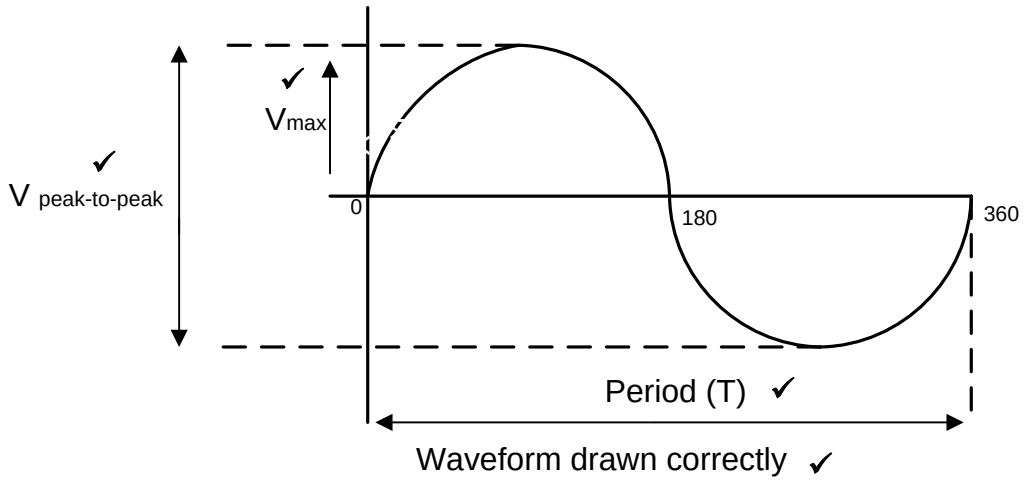
QUESTION 5: SINGLE PHASE AC GENERATION

5.1 5.1.1
- It is current that flows in one direction only. ✓
- Current that has a constant polarity. (Any 1 x 1) (1)

5.1.2 When there is relative movement between a conductor and a magnetic field, ✓ an electromotive force is induced in the conductor. ✓
Electromagnetic induction is the causing of a current to flow in a wire when it has a changing magnetic field across it. (2)

5.1.3 Place the thumb and first two fingers of the right hand mutually at 90° to each other. ✓ If the first finger points in the direction of the magnetic field, ✓ the second in the direction of current flow, ✓ then the thumb will indicate the direction of the movement or force. ✓ (4)

5.2



(4)

5.3 $f = \frac{1}{T}$ ✓

$= \frac{1}{10 \times 10^{-3}}$ ✓

$= 100$ Hz ✓ (3)

5.4 5.4.1 $V_{RMS} = V_{MAX} \times 0,707$

$V_{MAX} = \frac{V_{RMS}}{0,707}$ ✓

$= \frac{22,6}{0,707}$ ✓

$= 31,97$ V ✓ (3)

5.4.2 $V_{AVE} = V_{MAX} \times 0,637$ ✓

$= 31,97 \times 0,637$ ✓

$= 20,36$ V ✓ (3)

5.5 $V_{MAX} = 2\pi\beta AnN$ ✓

$= 2\pi \times 50 \times 10^{-3} \times 3\,000 \times 10^{-6} \times 50 \times 200$ ✓

$= 9,42$ V ✓

$v = V_{MAX} \sin\theta$

$= 9,42 \times \sin 75$ ✓

$= 9,1$ V ✓

OR

$v = V_{MAX} \sin\theta$ ✓

$= 2\pi\beta anN \sin 75$ ✓

$2\pi \times 50 \times 10^{-3} \times 3\,000 \times 10^{-6} \times 50 \times 200 \times \sin 75$ ✓

$= 9,1$ V ✓ (5)

[25]

QUESTION 6: SINGLE PHASE TRANSFORMERS

6.1
- The size of the current flowing ✓
- The number of turns on the coil ✓ (2)

6.2
- It consists of two coils, the primary and secondary coils. ✓
- The coils are wound around soft iron core. ✓ (2)

6.3 To improve the magnetic coupling ✓ and get maximum transfer of power from the primary to the secondary winding. ✓ (2)

6.4
- Eddy current losses ✓
- Hysteresis losses ✓ (2)

6.5 The AC voltage induces an alternating magnetic field in the primary winding. ✓ This magnetic field links electromagnetically with the secondary coil. ✓
As a result an AC voltage is induced in the secondary coil. ✓
The size of the voltage depends on the number of turns on the secondary winding. ✓ (4)

6.6 6.6.1 $\text{transformer ratio} = \frac{V_P}{V_S}$

$= \frac{240}{32}$ ✓

$= 7{,}5 : 1$ ✓ (2)

6.6.2 $S = V_S I_S$ ✓
$= 32 \times 15$ ✓
$= 480\ \text{VA}$ ✓ (3)

6.6.3 $S = V_P I_P$
$I_P = \frac{S}{V_P}$ ✓

$= \frac{480}{240}$ ✓

$= 2\ \text{A}$ ✓

OR

$\frac{I_S}{I_P} = \frac{7{,}5}{1}$
$I_P = \frac{I_S}{7{,}5}$ ✓
$= \frac{15}{7{,}5}$ ✓
$= 2\ \text{A}$ ✓ (3)

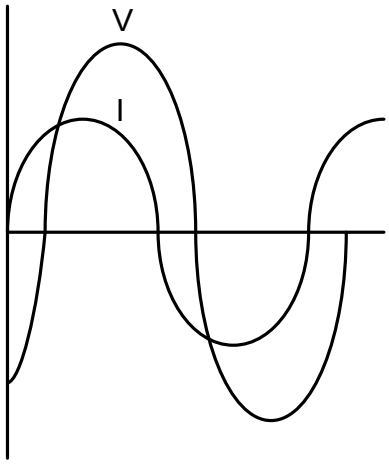
[20]

QUESTION 7: RLC CIRCUITS

7.1 The current leads the voltage. ✓ (1)

7.2 The inductive reactance will increase. ✓ (1)

7.3



- Shape of voltage waveform larger than current waveform ✓
- Phase difference showing current leading voltage ✓ (2)

7.4 It is the ratio ✓ of the real power to the apparent power in a circuit. ✓ (2)

7.5 The increase in frequency will cause a decrease in the capacitive reactance. ✓ This will cause a decrease in the impedance of the RC circuit, ✓ which will cause the current to increase. ✓ (3)

7.6
$$\cos\theta = \frac{P}{S}$$
$$P = S\cos\theta \checkmark$$
$$= 5 \times 0{,}75 \checkmark$$
$$= 3{,}75\ W \checkmark$$ (3)

7.7 7.7.1
$$X_C = \frac{1}{2\pi fC} \checkmark$$
$$= \frac{1}{2 \times \pi \times 100 \times 75 \times 10^{-6}} \checkmark$$
$$= 21{,}22\ \Omega \checkmark$$ (3)

7.7.2
$$Z = \sqrt{R^2 + (X_L - X_C)^2} \checkmark$$
$$= \sqrt{22^2 + (31{,}43 - 21{,}22)^2} \checkmark$$
$$= 24{,}25\ \Omega \checkmark$$ (3)

7.7.3
$$I = \frac{V}{Z} \checkmark$$
$$= \frac{110}{24{,}25} \checkmark$$
$$= 4{,}54\ A \checkmark$$ (3)

7.7.4 $S = VI$ ✓
$= 110 \times 4{,}54$ ✓
$= 498{,}97$ VA ✓ (3)

7.7.5 $X_L = 2\pi fL$
$L = \frac{X_L}{2\pi f}$ ✓
$= \frac{31{,}43}{2 \times \pi \times 100}$ ✓
$= 0{,}05$ H $= 50$ mH ✓ (3)

7.7.6 $\cos\theta = \frac{p}{s}$ ✓
$= \frac{400}{498{,}97}$ ✓
$= 0{,}8$ ✓ (3)
[30]

QUESTION 8: CONTROL DEVICES

8.1
- Overload conditions ✓
- Short circuits ✓
- Earth faults (Any 2 x 1) (2)

8.2 It is a re-settable electro-mechanical device ✓ that instantly breaks the circuit, ✓ once over currents or short circuits are detected. ✓ (3)

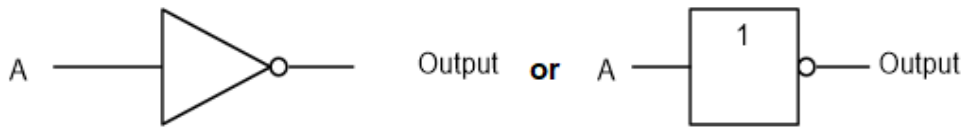
8.3 8.3.1 They provide a safe and convenient means ✓ of connecting and interrupting the circuit. ✓ (2)

8.3.2 To prevent the unexpected restarting of the circuit ✓ if the power is restored after an interruption of the power supply. ✓ (2)

8.3.3 There is a normally open relay contact ✓ connected in parallel with the start button ✓ that keeps the circuit energised. (2)

8.4 Software is the machine language that is installed on a PLC, ✓ that instructs it to interact with the input and output hardware. ✓ (2)

8.5



1 mark for symbol ✓
1 mark for labels ✓ (2)

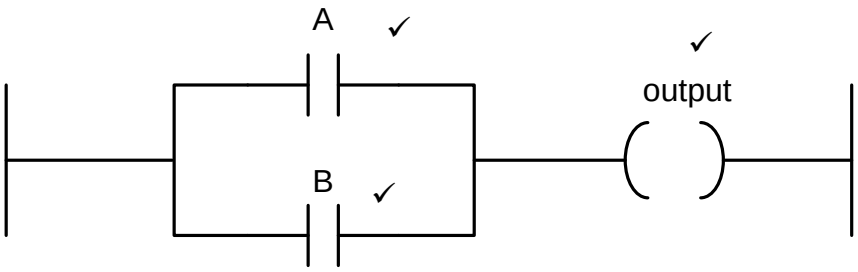
8.6 8.6.1 OR gate ✓ (1)

8.6.2

A	B	OUTPUT
0	0	0 ✓
0	1	1 ✓
1	0	1 ✓
1	1	1 ✓

1 Mark for both inputs and output correct per line (4)

8.6.3



(3)

8.7 These are a set of standard connecting cables ✓ used to connect PLC's or computers to each other when exchanging data. ✓ (2)

[25]

QUESTION 9: SINGLE-PHASE MOTORS

9.1 9.1.1 Split-phase motor ✓ (1)

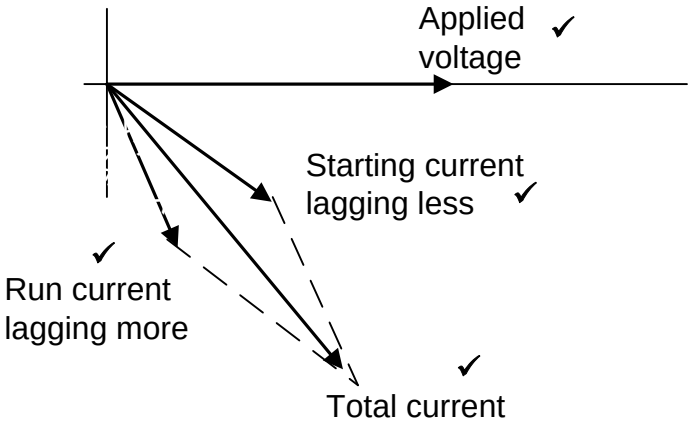
9.1.2 A – main (run) winding ✓
B – centrifugal switch ✓ (2)

9.1.3
- Fans ✓
- Washing machines ✓
- Domestic fridges
- Air conditioning fans
- Small machine tools

(Any 2 x 1) (2)

9.1.4 The start winding is positioned at right angles to the main winding. ✓
It is made of narrow, fine copper conductors ✓ to give it a high resistance to reactance ratio. ✓
Its main purpose is to provide the rotating magnetic field required for rotation (starting torque). ✓ (4)

9.1.5



(4)

9.2
- Robust and sturdy ✓
- Cheaper to build and maintain ✓
- Construction is simple ✓
- Very little maintenance is required
- Can be operated in hazardous conditions (Any 3 x 1) (3)

9.3 A single coil cannot produce the rotating magnetic field required ✓ to sweep across the conductive bars of the rotor. ✓ (2)

9.4 9.4.1 To ensure that there are no visible damages to any parts of the motor, ✓ and to check if there are any blockages due to dirt or foreign objects. ✓ (2)

9.4.2
- To check the continuity of the windings. ✓
- To check if the insulation resistance between the windings, and the windings and earth is acceptable. ✓
- To check if the frame is earthed and that all electrical connections are fastened and insulated. ✓ (3 x 1) (3)

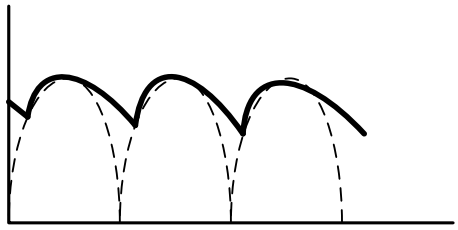
9.4.3
- To check if all bolts are secure and the frame is not cracked. ✓
- To check if the rotor and cooling fans are rotating freely. ✓ (2)

[25]

QUESTION 10: POWER SOURCES

10.1 10.1.1 A – AC mains input voltage ✓
B – rectifier ✓
C – regulator ✓ (3)

10.1.2



1 mark for dashed line showing pulsating waveform ✓
1 mark for ripple waveform ✓ (2)

10.1.3 The Zener diode holds the output voltage ✓ at a fixed value. ✓ (2)

10.2 Forward biasing occurs when a supply with a voltage larger than the junction voltage ✓ is connected to the diode with the positive lead to the P-region (anode) and the negative lead to the N-region (cathode). ✓ This allows the diode to conduct electricity freely. ✓ (3)

10.3
- Using a centre tap transformer and two diodes ✓
- Using four diodes as a bridge rectifier ✓ (2)

10.4 $\gamma = \frac{1}{2\sqrt{3}CfR_L}$

$R_L = \frac{1}{2\sqrt{3}Cf\gamma}$ ✓

$= \frac{1}{2 \times \sqrt{3} \times 100 \times 10^{-6} \times 50 \times 1,15}$ ✓

$= 50,2\ \Omega$ ✓ (3)
[15]

TOTAL: 200