Province of the
EASTERN CAPE
EDUCATION

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NATIONAL SENIOR CERTIFICATE

GRADE 12

SEPTEMBER 2025

ELECTRICAL TECHNOLOGY: POWER SYSTEMS MARKING GUIDELINE

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 must 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 D ✓ (1)

1.2 C ✓ (1)

1.3 B ✓ (1)

1.4 D ✓ (1)

1.5 B ✓ (1)

1.6 A ✓ (1)

1.7 A ✓ (1)

1.8 C ✓ (1)

1.9 C ✓ (1)

1.10 D ✓ (1)

1.11 A ✓ (1)

1.12 A ✓ (1)

1.13 C ✓ (1)

1.14 C ✓ (1)

1.15 B ✓ (1)

[15]

QUESTION 2: OCCUPATIONAL HEALTH AND SAFETY

2.1 Always wear and apron ✓
Protective glasses are essential
Wear latex gloves (Any 1 x 1) (1)

2.2 Danger means anything that may cause injury to a person or cause damage to property. ✓ (1)

2.3
- Direct pressure to the wound ✓
- Direct and continual pressure to the pressure points ✓ (2)

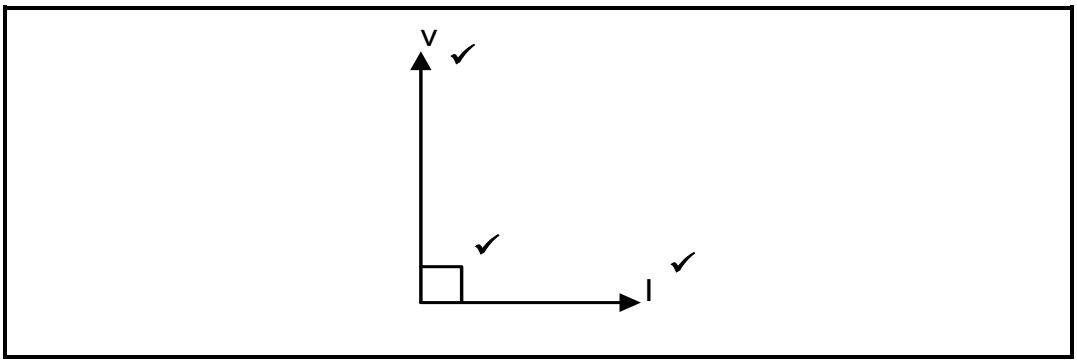
2.4
- To make employees conversant with the hazards to their health and safety attached to any work they have to perform. ✓
- To inform a health and safety representative of the occurrence of an accident in the workplace for which such representative has been designated. ✓ (2)

2.5 This is the maximum current that the body can withstand and still let go. ✓ A typical current value is around 7 mA. ✓ (2)

2.6 Employees with a good discipline stay focused on their goals ✓ and are determined to complete their assignments. ✓ (2)
[10]

QUESTION 3: RLC CIRCUITS

3.1



(3)

3.2 Current ✓ (1)

3.3 3.3.1 $X_L = 2\pi fL$ ✓
$= 2 \times \pi \times 50 \times 0,15$ ✓
$= 47,12\ \Omega$ ✓ (3)

3.3.2 $X_C = \frac{1}{2\pi fC}$ ✓
$= \frac{1}{2\times\pi\times50\times100\times10^{-6}}$ ✓
$= 31,83\ \Omega$ ✓ (3)

3.3.3 $Z = \sqrt{R^2 + (X_L - X_C)^2}$ ✓
$= \sqrt{29^2 + (47,12 - 31,83)^2}$ ✓
$= 32,78\ \Omega$ ✓ (3)

3.3.4 $I_T = \frac{V_T}{Z}$ ✓
$= \frac{13}{32,78}$ ✓
$= 0,40\ A$ ✓ (3)

3.4 Reactance is the opposition to current flow in an AC circuit ✓ offered by reactive components. ✓
Impedance is the total opposition to current flow in an AC circuit ✓ consisting of resistive and reactive components. ✓ (4)

3.5 $f_r = \frac{1}{2\pi\sqrt{LC}}$ ✓
$= \frac{1}{2\pi\times\sqrt{0,5\times100\times10^{-6}}}$ ✓
$= 22,51\ Hz$ ✓ (3)

3.6 3.6.1

$$I_R = \frac{V_T}{R} \checkmark$$
$$= \frac{100}{10} \checkmark$$
$$= 10\ A \checkmark$$
$$I_L = \frac{V_T}{X_L} \checkmark$$
$$= \frac{100}{28{,}23} \checkmark$$
$$= 3{,}54\ A \checkmark$$
$$I_C = \frac{V_T}{X_C} \checkmark$$
$$= \frac{100}{42{,}44} \checkmark$$
$$= 2{,}36\ A \checkmark$$

(9)

3.6.2

$$I_T = \sqrt{{I_R}^2 + (I_L - I_C)^2} \checkmark$$
$$= \sqrt{10^2 + (3{,}54 - 2{,}36)^2} \checkmark$$
$$= 10{,}07\ A \checkmark$$

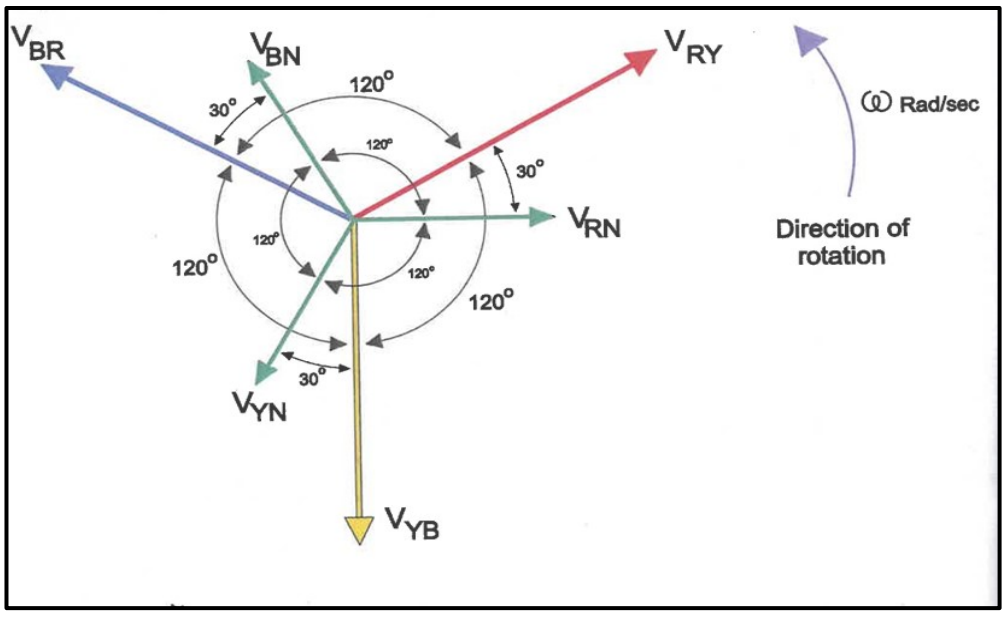
(3)

[35]

QUESTION 4: THREE-PHASE GENERATION

4.1 Supply of power is constant ✓
Uses less copper or aluminium in the conductors ✓
More economical ✓
Can be connected in star or delta
Balancing of loads and phasors can be done (3)

4.2



Line values and phasors correct ✓
Phase values and phasors correct ✓
Direction of rotation ✓
30° correct ✓
120° correct ✓ (5)

4.3 4.3.1 The generated electricity transported along overhead high voltage power lines. ✓ (1)

4.3.2 Self-contained units controlled from the main control centres. ✓ (1)

4.3.3 Network of over 25 000 km high voltage power lines to various bulk users. ✓ (1)

4.4 Mutual induction ✓ (1)

4.5
- Reduced current in supply conductors ✓
- Smaller supply conductors required ✓
- Reduced cost due to smaller conductors
- Longer lifespan
- Reduced maintenance (2)

4.6 4.6.1 $V_L = V_{PH}$ ✓
$= 240\ V$ ✓ (2)

4.6.2 $S = \sqrt{3}V_L I_L$ ✓
$I_L = \frac{S}{\sqrt{3}V_L}$
$= \frac{250\times10^3}{\sqrt{3}\times240}$ ✓
$= 601{,}41\ A$ ✓ (3)

4.6.3 $I_{PH} = \frac{I_L}{\sqrt{3}}$ ✓
$= \frac{601{,}41}{\sqrt{3}}$ ✓
$= 347{,}22\ A$ ✓ (3)

4.6.4 $P = \sqrt{3}V_L I_L \cos\theta$ ✓
$= \sqrt{3} \times 240 \times 601{,}41 \times 0{,}8$ ✓
$= 200\ 001\ W = 200\ kW$ ✓ (3)

4.7 $\tan\theta = \sqrt{3}\left[\frac{W_{BLUE}-W_{RED}}{W_{RED}+W_{BLUE}}\right]$ ✓
$= \sqrt{3}\left[\frac{8{,}5\times10^3-3\times10^3}{3\times10^3+8\times10^3}\right]$ ✓
$= 0{,}828$ ✓
$\theta = \tan^{-1} 0{,}828$ ✓
$= 39{,}6°$
$\cos 39{,}6° = 0{,}77$ ✓ (5)

4.8 wattmeter ✓ (1)

4.9
- It can measure both balanced and unbalanced loads. ✓
- The power consumption of each phase can be determined. (1)

[35]

QUESTION 5: THREE-PHASE TRANSFORMERS

5.1 5.1.1 Heavy industries where a high power is essential. ✓ (1)

5.1.2 Step-down transformer in high voltage supply lines. ✓ (1)

5.2
- Constant overloading ✓
- Insufficient ventilation ✓
- Transformer oil may be impure due to carbonisation ✓
- Transformer oil may be insufficient (3)

5.3 5.3.1 $P = \sqrt{3}V_{LS}I_{LS}\cos\theta$ ✓

$I_{LS} = \frac{P}{\sqrt{3}V_{LS}\cos\theta}$

$= \frac{85\times10^3}{\sqrt{3}\times450\times\cos36,87°}$ ✓

$= 136,32$ A ✓ (3)

5.3.2 $S = \sqrt{3}V_{LS}I_{LS}$ ✓

$= \sqrt{3}\times450\times136,32$ ✓

$= 106\,250,92\ VA = 106,25\ kVA$ ✓ (3)

5.3.3 $Q = \sqrt{3}V_{LS}I_{LS}sin\theta$ ✓

$= \sqrt{3}\times450\times136,32\times sin36,87°$ ✓

$= 63\,750,71\ VA_r = 63,75\ kVA_r$ ✓ (3)

5.3.4 $\eta = \frac{\text{OUTPUT}}{\text{OUTPUT+LOSSES}}\times100\%$ ✓

$= \frac{85\times10^3}{85\times10^3+12,5\times10^3}\times100\%$ ✓

$= 87,18\ \%$ ✓ (3)

5.4
- Oil Natural, Air Natural (ONAN) ✓
- Oil Natural, Air Forced (ONAF) ✓
- Oil Forced, Air Forced (OFAF) ✓
- Oil Forced, Water Forced (OFWF) (3)

5.5
- Core-type ✓
- Shell-type ✓ (2)

5.6
- Size ✓
- Frequency ✓
- Windings ratio
- Voltage
- Current
- Power
- Power factor
- Efficiency (Any 2) (2)

5.7
- Assemble or modify the circuit only when the supply is off. ✓
- Use short wires where possible and ensure that the wires are not loosely connected ✓
- Do not switch the circuit on before the educator has inspected it and is satisfied with it
- Never touch any bare electrical wire or terminal
- After the simulation, wait for the transformer to cool off before returning it to the storeroom
- Be careful of the secondary terminals of a live open circuit transformer (2)

5.8
- Heavy through-faults ✓
- Overloads ✓
- Switching surges
- Lightning (2)

5.9 If the load is increased the secondary current will increase ✓ resulting in an increase in the primary current due to the increased magnetic force ✓ (2)

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QUESTION 6: THREE-PHASE MOTORS AND STARTERS

6.1
- Two endplates ✓
- Stator ✓
- Stator windings ✓
- Rotor
- Fan blades
- A shaft on which the rotor is fixed
- A wiring box housing the stator winding ends (3)

6.2 To reduce the high starting current. ✓ (1)

6.3
$$n_s = \frac{60f}{p} \checkmark$$
$$= \frac{60\times50}{8} \checkmark$$
$$= 375 \text{ rpm} \checkmark$$ (3)

6.4
$$S = n_s - n_r \checkmark$$
$$= 3600 - 3420 \checkmark$$
$$= 180 \text{ rpm} \checkmark$$ (3)

6.5
- When a three-phase supply is connected to the stator winding, a rotating magnetic flux is produced. ✓
- This flux will cut the metal rod of the rotor, inducing an emf in it ✓which is responsible for the flow of current in the rotor. ✓
- This current will create a magnetic flux. ✓
- The stator and rotor magnetic flux will react to each other and a force will be produced. ✓
- The force will cause the rotor to rotate in the direction of the rotating magnetic flux. ✓ (6)

6.6
- Are mounting bolts tightened properly ✓
- Are the endplates securely fastened ✓
- Does the frame have any cracks
- Is there any play in the shaft
- Does the shaft turn freely
- Is the cooling fan intact (2)

6.7 The speed when maximum load is connected to the motor. ✓ (1)

6.8
- Power ✓
- Phase ✓
- Voltage
- Current
- Frequency
- Full load speed (2)

6.9
- It helps in the reduction of magnetic hum ✓
- Helps to avoid 'cogging' ✓
- Increase in effective ratio of transmission between stator and rotor
- Increased slip for a given torque (2)

6.10 6.10.1 N/C delta ✓ N/C star ✓ (2)

6.10.2 (a) To keep the circuit energised ✓ after the start button is released. ✓ (2)

(b) Prevents the timer and other contacts from being energised ✓ before MC_1 is energised. ✓ (2)

6.10.3
- When the start button is pressed, MC_1 will be energised, closing MC_1 (N/O_1) and MC_1 (N/O_2) ✓
- MC_2 will be energised opening the MC_2 (N/C) and the motor will run in star and prevent MC_3 from being energised and Timer T is energised ✓
- After a pre-set time, the energised timer will open T (N/C) and close T (N/O), ✓ de-energising MC_2 and MC_2 N/C will close again thus enabling MC_3 to be energised ✓
- MC3 will be energized, causing MC_3 (N/C) to open, and the motor will operate in delta mode. This sequence prevents MC_2 from being energized.
- The motor runs in delta mode until stopped or overloaded. ✓ (6)

[35]

QUESTION 7: PROGRAMMABLE LOGIC CONTROLLERS (PLCs)

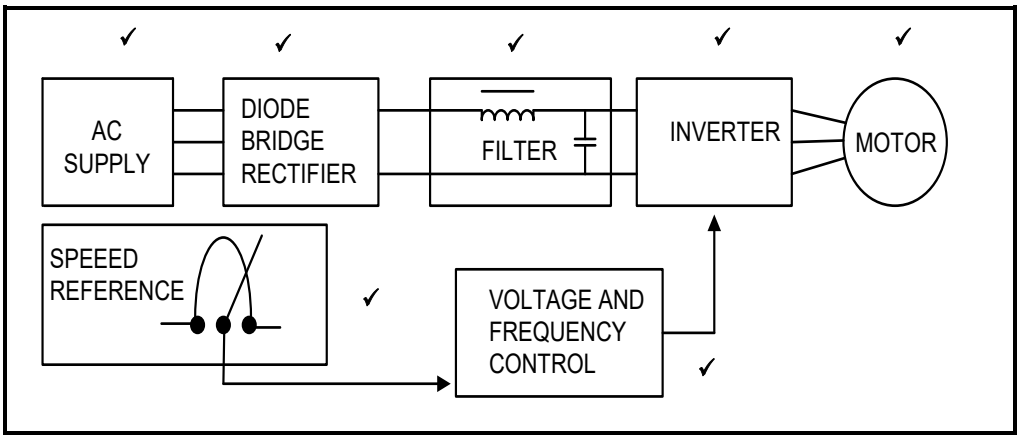
7.1 A semi-conductor device that uses light ✓ to transfer an electrical signal between circuits or elements of a circuit, ✓ while keeping them electrically isolated from each other. ✓ (3)

7.2 7.2.1 Digital devices which simply provide ON/OFF information, ✓ like pushbuttons and limit switches. ✓ (2)

7.2.2 Devices that continuously detect changing states ✓ and provide a value within a range. ✓ (2)

7.3 A device that converts a physical condition ✓ into an electrical signal that can be used by a PLC. ✓ (2)

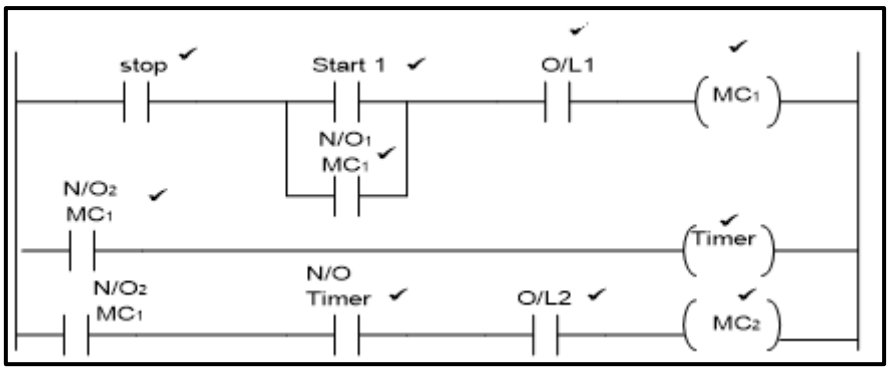
7.4



(7)

7.5 7.5.1 Sequence starter with timer ✓ (1)

7.5.2



(10)

7.5.3 The timer prevents MC_2 from being energised ✓until the preset time has elapsed. ✓ (2)

7.6 Installation must be done by qualified and experienced technicians. ✓
Electrical performance should be a main consideration ✓
Unnecessary losses should be eliminated ✓
Avoid high starting currents
An energy efficient motor should be considered (3)

7.7 They accelerate a motor from start to a region above the breakdown speed ✓
The normal restraints of fixed frequency, fixed voltage, fixed starting frequency and acceleration do not apply ✓
The starting current and torque are limited by the overload capability of the VSD and not restrained by the per unit slip characteristics of the motor ✓
The VSD can be designed to match the motor and load in such a way that results in the applicable starting torque characteristic. ✓ (4)

7.8 Variable air volume air conditioning systems ✓
Water pumping systems ✓
Exhaust air systems
Dust extractions
Paint shop exhaust systems
Fan systems
Heating systems for air and liquid applications (2)

7.9 Synchronous wound rotor motors ✓
Synchronous squirrel-cage induction motors ✓
Synchronous motors with a permanent magnet magnet stator
Synchronous motors with brushes or brushless (2)
[40]

TOTAL: 200