



Province of the
EASTERN CAPE
EDUCATION

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NATIONAL SENIOR CERTIFICATE

GRADE 12

SEPTEMBER 2026

ELECTRICAL TECHNOLOGY: POWER SYSTEMS MARKING GUIDELINES

MARKS: 200

This marking guideline consists of 11 pages.

INSTRUCTIONS TO MARKERS

1. All questions with multiple answers imply that any relevant, acceptable answers should be considered.
2. Calculations:
 - 2.1 All calculations must show the formula.
 - 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 recalculate 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 guidelines, 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.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

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

QUESTION 2: OCCUPATIONAL HEALTH AND SAFETY

- 2.1 Horseplay ✓
Running in the workshop ✓
Throwing things
Placing bags, stools, or other items in walkways
Intentionally leaving spills or messes unattended (2)
- 2.2 An employer is anyone who hires or provides work for another person ✓ and pays or agrees to pay them, except as defined otherwise by the Labour Relations Act, 1995 (Act 66 of 1995). ✓ (2)
- 2.3 They create direct hazards, ✓ increase risks ✓ and could lead to injury or damage property. ✓ (3)
- 2.4 Third-degree burns occur when all layers of skin have been burned, causing permanent skin damage, ✓ affecting fat, muscle tissue and even bone. ✓
Charring of tissue ✓
Difficulty in breathing
Severe symptoms of shock (3)
- [10]**

QUESTION 3: RLC CIRCUITS

3.1 A phasor diagram is a graphical representation ✓ of a sinusoidal alternating current or voltage in an RLC circuit. ✓ (2)

3.2 3.2.1 Lagging ✓ because the circuit is inductive, ✓ the inductive voltage is greater than the capacitive voltage, the voltage leads the current. (2)

$$\begin{aligned}
 3.2.2 \quad V_T &= \sqrt{V_R^2 + (V_L - V_T)^2} \quad \checkmark \\
 &= \sqrt{150^2 + (180 - 90)^2} \quad \checkmark \\
 &= 174,93 \text{ V} \quad \checkmark
 \end{aligned}
 \quad (3)$$

$$\begin{aligned}
 3.2.3 \quad Z_T &= \sqrt{R^2 + (X_L - X_C)^2} \quad \checkmark \\
 &= \sqrt{10^2 + (14 - 8)^2} \quad \checkmark \\
 &= 11,66 \, \Omega \quad \checkmark
 \end{aligned}
 \quad (3)$$

$$\begin{aligned}
 3.2.4 \quad I_T &= \frac{V_T}{Z_T} \quad \checkmark \\
 &= \frac{174,93}{11,66} \quad \checkmark \\
 &= 15 \text{ A} \quad \checkmark
 \end{aligned}
 \quad (3)$$

3.3 $R = Z$ ✓
 Phase angle = 0° ✓
 Inductive voltage equals to capacitive voltage ✓
 Capacitive reactance equals inductive reactance
 Current is at maximum
 Impedance is minimum (3)

3.4 Capacitive reactance is the opposition to an alternating current ✓ by the reactive components of a capacitor. ✓ (2)

$$\begin{aligned}
 3.5 \quad 3.5.1 \quad I_T &= \frac{V_T}{R} \quad \checkmark \\
 &= \frac{220}{20} \quad \checkmark \\
 &= 11 \text{ A} \quad \checkmark
 \end{aligned}
 \quad (3)$$

$$\begin{aligned}
 3.5.2 \quad V_L &= I_T \times X_L \quad \checkmark \\
 &= 11 \times 50 \quad \checkmark \\
 &= 550 \text{ V} \quad \checkmark
 \end{aligned}
 \quad (3)$$

$$\begin{aligned}
 3.5.3 \quad Q &= \frac{V_L}{V_T} \text{ or } = \frac{X_L}{R} \text{ or } = \frac{X_C}{R} \quad \checkmark \\
 &= \frac{550}{220} = \frac{50}{20} = \frac{50}{20} \quad \checkmark \\
 &= 2,5 \quad \checkmark
 \end{aligned}
 \quad (3)$$

3.6 The phase angle would be zero because inductive reactance ✓ equals the capacitive reactance. ✓
 The circuit is at resonance. (2)

- 3.7 3.7.1 Phasor diagram of a parallel RLC circuit at resonance. ✓ (1)
- 3.7.2 The voltage drops across the components in a parallel circuit is the same ✓
Applied voltage is common across all components. (1)
- 3.7.3 In a parallel resonant circuit impedance is at maximum and the total current is at minimum. ✓ (1)
- 3.8 $f_r = \frac{1}{2\pi\sqrt{LC}}$ ✓
 $= \frac{1}{2\pi\sqrt{50 \times 10^{-3} \times 75 \times 10^{-6}}}$ ✓
 $= 82,19 \text{ Hz}$ ✓ (3)

[35]**QUESTION 4: THREE-PHASE AC GENERATION**

- 4.1 4.1.1 Measures the relationship of the real power to the apparent power. ✓ (1)
- 4.1.2 Measures the amount of electrical energy consumed. ✓
Measures the amount of power consumed over a certain time. (1)
- 4.1.3 A device that measures the power consumed by an application ✓ (1)

4.2

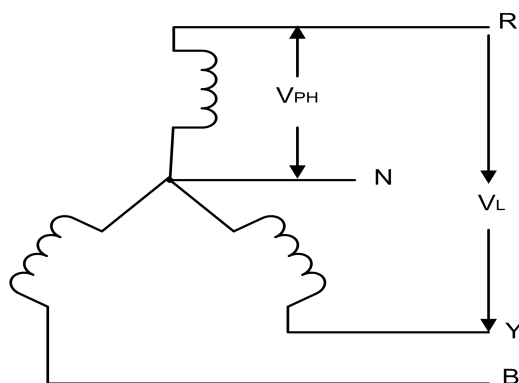


Diagram correctly drawn ✓

Phases labelled ✓

 V_{PH} correct ✓ V_L correct ✓

(4)

- 4.3 $\tan\theta = \sqrt{3} \left[\frac{W_B - W_R}{W_R + W_B} \right]$ ✓
 $= \sqrt{3} \left[\frac{17,25 \times 10^3 - 6,25 \times 10^3}{6,25 \times 10^3 + 17,25 \times 10^3} \right]$ ✓
 $= 0,81$ ✓
 $\theta = \tan^{-1} 0,81$
 $= 39^\circ$ ✓
 $\text{pf} = \cos 39$
 $= 0,78$ ✓ (5)

$$\begin{aligned}
 4.4 \quad 4.4.1 \quad V_{PH} &= \frac{V_L}{\sqrt{3}} = \frac{415}{\sqrt{3}} = 239,6 \text{ V} \checkmark \\
 I_{PH} &= \frac{V_{PH}}{Z_{PH}} \checkmark \\
 &= \frac{239,6}{45} \checkmark \\
 &= 5,32 \text{ A} \checkmark
 \end{aligned} \tag{4}$$

$$\begin{aligned}
 4.4.2 \quad I_L &= I_{PH} \checkmark \\
 &= 5,32 \text{ A} \checkmark
 \end{aligned} \tag{2}$$

$$\begin{aligned}
 4.4.3 \quad P &= \sqrt{3} V_L I_L \cos \theta \checkmark \\
 &= \sqrt{3} \times 239,6 \times 5,32 \times 0,85 \checkmark \\
 &= 1876,63 \text{ W} = 1,88 \text{ kW} \checkmark
 \end{aligned} \tag{3}$$

$$\begin{aligned}
 4.4.4 \quad S &= \sqrt{3} V_L I_L \checkmark \\
 &= \sqrt{3} \times 239,6 \times 5,32 \checkmark \\
 &= 2207,8 \text{ VA} = 2,21 \text{ kVA} \checkmark
 \end{aligned} \tag{3}$$

$$\begin{aligned}
 4.4.5 \quad \cos \theta &= 0,85 \checkmark \\
 \theta &= \cos^{-1} 0,85 \checkmark \\
 &= 31,79^\circ \checkmark
 \end{aligned} \tag{3}$$

$$\begin{aligned}
 4.5 \quad \eta &= \frac{P_{OUT}}{P_{IN}} \times 100\% \checkmark \\
 89,4 &= \frac{20 \times 10^3 \times 100}{P_{IN}} \checkmark \\
 P_{IN} &= \frac{20 \times 10^3 \times 100}{89,4} \\
 &= 22371,36 \text{ W} = 22,37 \text{ kW} \checkmark
 \end{aligned}$$

OR

$$\begin{aligned}
 P_{IN} &= \frac{100 P_{OUT}}{\eta} \\
 &= \frac{100 \times 20 \times 10^3}{89,4} \\
 &= 22371,36 \text{ W} = 22,37 \text{ kW}
 \end{aligned} \tag{3}$$

4.6 To reduce losses, ✓ as a smaller conductor is needed ✓ because the current is smaller. ✓ (3)

4.7 The power transferred back and forth between the supply and the inductor or capacitor ✓ and performs no real work. ✓ (2)

[35]

QUESTION 5: THREE-PHASE TRANSFORMERS

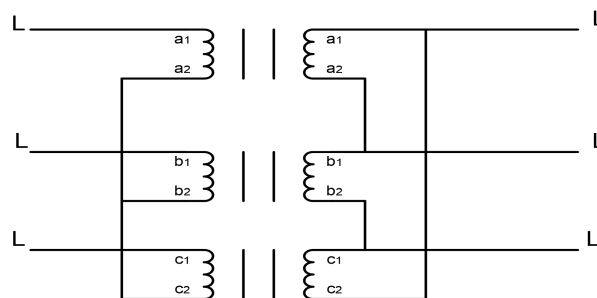
- 5.1 5.1.1 Transformer ratio ✓
 Voltage rating ✓
 Current rating ✓
 Power rating
 Efficiency
 Size
 Power factor
 frequency

(3)

- 5.1.2 Star ✓

(1)

- 5.1.3



- Primary phases correct ✓
 Star point correct ✓
 Secondary phase from a₁ to c₂ ✓
 Secondary phase from a₂ to b₁ ✓
 Secondary phase from b₂ to c₁ ✓

(5)

- 5.1.4 Star-star ✓
 Delta-delta
 Delta-star

(1)

- 5.2 Improves the insulation of the windings. ✓
 Provides cooling. ✓

(2)

- 5.3 5.3.1 Delta-star transformer ✓

(1)

$$\begin{aligned}
 5.3.2 \quad V_{PHS} &= \frac{V_{LS}}{\sqrt{3}} \checkmark \\
 &= \frac{7,7 \times 10^3}{\sqrt{3}} \checkmark \\
 &= 4445,60 \text{ V} = 4,45 \text{ kV} \checkmark
 \end{aligned}$$

(3)

$$\begin{aligned}
 5.3.3 \quad V_{LP} &= V_{PHP} \checkmark \\
 &= 22 \text{ kV} \checkmark
 \end{aligned}$$

(2)

$$\begin{aligned}
 5.3.4 \quad T.R. &= V_{PHP} : V_{PHS} \checkmark \\
 &= 22 \times 10^3 : 4445,6 \checkmark \\
 &= 4,95 : 1 \checkmark
 \end{aligned}$$

(3)

$$\begin{aligned}
 5.3.5 \quad S &= \sqrt{3}V_{LS}I_{LS} \checkmark \\
 &= \sqrt{3} \times 7,7 \times 10^3 \times 40 \checkmark \\
 &= 533471,65 \text{ VA} = 533,47 \text{ kVA} \checkmark
 \end{aligned}
 \tag{3}$$

$$\begin{aligned}
 5.3.6 \quad P &= \sqrt{3}V_{LS}I_{LS}\cos\theta \checkmark \\
 &= \sqrt{3} \times 7,7 \times 10^3 \times 40 \times 0,84 \checkmark \\
 &= 448116,18 \text{ W} = 448,12 \text{ kW} \checkmark
 \end{aligned}
 \tag{3}$$

$$\begin{aligned}
 5.3.7 \quad \frac{N_P}{N_S} &= \frac{V_{PHP}}{V_{PHS}} \checkmark \\
 N_S &= \frac{V_{PHS}N_P}{V_{PHP}} \\
 &= \frac{4445,6 \times 5000}{22 \times 10^3} \checkmark \\
 &= 1010,36 \text{ turns} \checkmark
 \end{aligned}
 \tag{3}$$

[30]

QUESTION 6: THREE-PHASE MOTORS AND STARTERS

6.1 6.1.1 Sequence motor starter without timer. (1)

6.1.2 (a) To de-energise the control circuit. (1)

(b) To keep the circuit energised $\checkmark$ after the start button has been released. (2)

6.1.3 Motor 1 must start before motor 2. $\checkmark$
 When motor 1 start button is pressed, MC₁ is energised closing the 2 normally open contacts and motor 1 is running. $\checkmark$
 Motor 2 can now be energised and both motors will run. $\checkmark$
 The stop button switches off both motors. $\checkmark$
 Each motor has its own independent overload relay. (4)

6.1.4 As soon as motor 1 start button is released, MC₁ will de-energise, $\checkmark$
 motor 1 will stop and the sequence cannot be completed. $\checkmark$ (2)

6.2 6.2.1 Cheaper cost $\checkmark$
 Rugged construction $\checkmark$
 Low maintenance (2)

6.2.2 Cranes $\checkmark$
 Conveyer belts $\checkmark$
 Lifting machines
 Fans
 Water pumps (2)

6.3 To prevent the reverse contactor from being energised $\checkmark$ while the motor is running in the forward direction. $\checkmark$ (2)

- 6.4 6.4.1 Iron losses ✓
Mechanical losses ✓ (2)

$$\begin{aligned}
 6.4.2 \quad \eta &= \frac{P_{\text{INPUT}} - \text{losses}}{P_{\text{INPUT}}} \times 100\% \checkmark \\
 &= \frac{5 \times 10^3 - 600}{5 \times 10^3} \times 100 \checkmark \\
 &= 88 \% \checkmark
 \end{aligned} \tag{3}$$

$$\begin{aligned}
 6.4.3 \quad \eta &= \frac{P_{\text{OUTPUT}}}{P_{\text{INPUT}}} \times 100 \% \checkmark \\
 P_{\text{OUTPUT}} &= \frac{\eta \cdot P_{\text{INPUT}}}{100} \\
 &= \frac{88 \times 5 \times 10^3}{100} \checkmark \\
 &= 4400 \text{ W} = 4,4 \text{ kW} \checkmark
 \end{aligned} \tag{3}$$

- 6.5 6.5.1 A – Terminal Box (Wiring Cover) ✓
B – Motor frame (Enclosure or Housing or Yolk) ✓
C – Rotor ✓ (3)

- 6.5.2 Each of the stator windings is connected to a line of the three-phase supply in the terminal box. ✓
Each coil creates a magnetic field at alternate intervals (120°). ✓
The coils are spaced around the stator in such a way that it creates the impression of a rotating magnetic field to the rotor. ✓

OR

When a three-phase supply is connected to a three-phase motor stator
✓ a rotary magnetic field is established. ✓

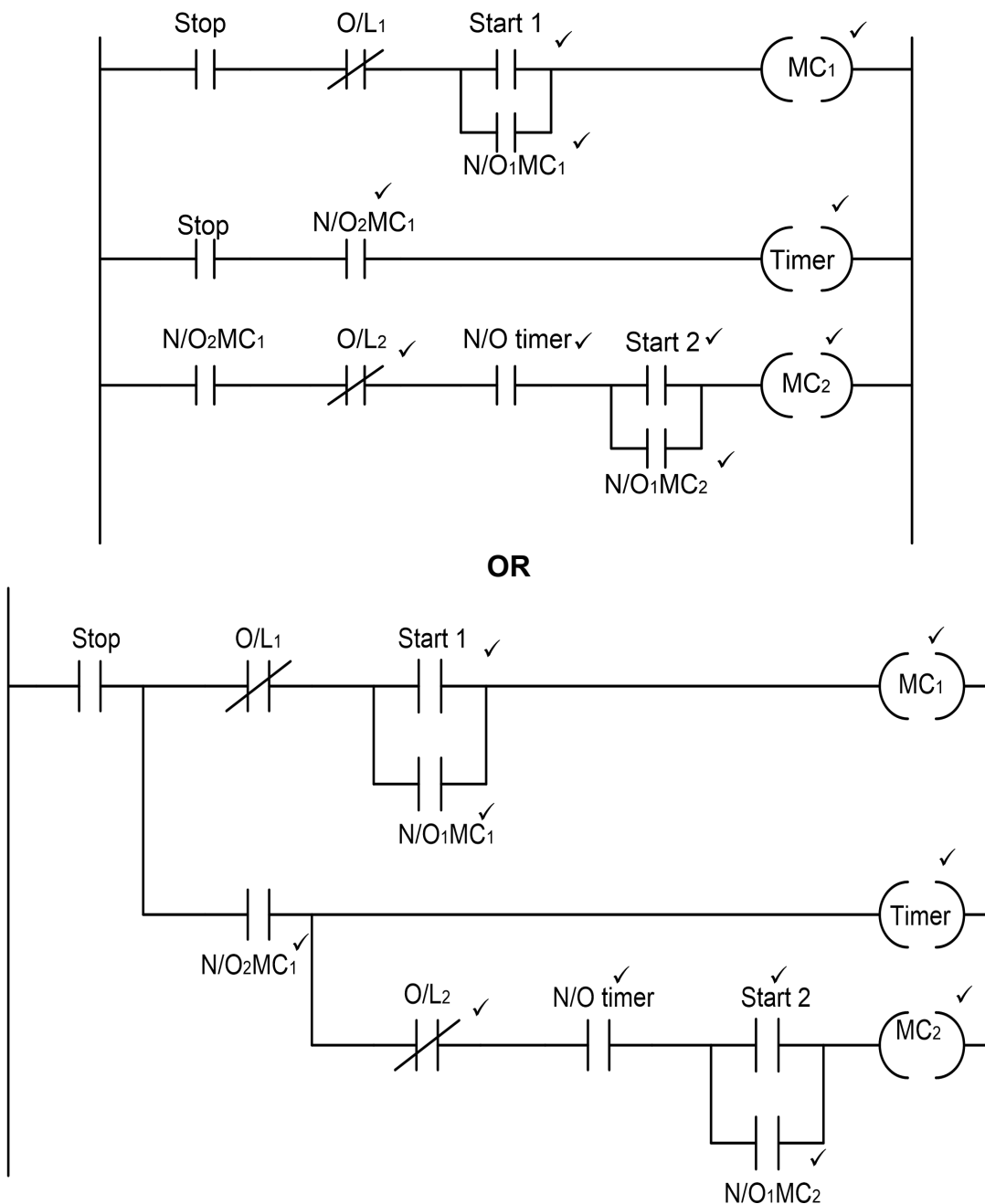
This is achieved by the three-phases reaching maximum strength 120° out of phase with each other. ✓ (3)

- 6.5.3 Number of pole pairs
Frequency of the supply (2)

$$\begin{aligned} 6.6 \quad P_{\text{OUTPUT}} &= \sqrt{3} V_L I_L \cos \theta \quad \checkmark \\ I_L &= \frac{P}{\sqrt{3} V_L \cos \theta} \\ &= \frac{8 \times 10^3}{\sqrt{3} \times 415 \times 0,85} \quad \checkmark \\ &= 13,09 \text{ A} \quad \checkmark \end{aligned} \quad \begin{matrix} (3) \\ \text{[35]} \end{matrix}$$

QUESTION 7: PROGRAMMABLE LOGIC CONTROLLERS (PLCs)

7.1

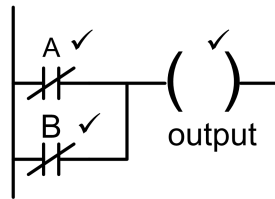


(10)

- 7.2 7.2.1 To execute the instructions as per the inputs ✓ and provide the necessary outputs. ✓ (2)
- 7.2.2 To isolate the processor against damage from random high current or voltage spikes ✓ and to pass information signals in and out of the processor. ✓ (2)
- 7.3 Analogue signals have a continuously changing signal ✓ and digital signals have a number of discrete steps. ✓ (2)

7.4 7.4.1 NAND gate ✓ (1)

7.4.2



(3)

7.4.3 A – 1 ✓
B – 1 ✓
C – 0 ✓

(3)

7.5 When the start button is pressed, contactor MC₁ will be energised. ✓
MCN/O₁ and MCN/O₂ contacts close. ✓
The lamp is on and will remain on. ✓
The lamp only switches off when the stop button is pressed. ✓ (4)

7.6 The converter changes the three-phase AC input ✓ to a DC voltage. ✓
The inverter changes the filtered DC voltage ✓ to an AC voltage at a different frequency. ✓ (4)

7.7 Filter capacitors smooth out the ripple ✓ to ensure a pure DC voltage on the DC rail. ✓ (2)

7.8 V/Hz drive ✓
Vector drives ✓
Direct Torque Control ✓
Pulse Width Modulation (3)

7.9 The output scan activates each of the outputs connected to the PLC according to its state in its memory. ✓ If the output is high it turns the particular load device on, and if it is low it turns it off. ✓ (2)

7.10 Connecting lines used by the PLC ✓ to allow new information to move in and around the processor. ✓ (2)
[40]

TOTAL: 200