



Province of the
EASTERN CAPE
EDUCATION

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Porafensie Ya Kapa Botjhabela: Lefapha la Thuto

NATIONAL SENIOR CERTIFICATE

GRADE 12

SEPTEMBER 2026

ELECTRICAL TECHNOLOGY: POWER SYSTEMS

MARKS: 200

TIME: 3 hours

This question paper consists of 15 pages, including a 2-page formula sheet.

INSTRUCTIONS AND INFORMATION

1. This question paper consists of SEVEN questions.
2. Answer ALL the questions.
3. Sketches and diagrams must be large, neat and fully labelled.
4. Show ALL calculations and round off answer correctly to TWO decimal places.
5. Number the answers correctly according to the numbering system used in this question paper.
6. You may use a non-programmable calculator.
7. Calculations must include the following:
 - 7.1 Formulae and manipulations where needed.
 - 7.2 Correct replacements of values.
 - 7.3 Correct answer and relevant units where applicable.
8. A formula sheet is provided at the end of this question paper.
9. Write neatly and legible.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

Various options are given as possible answers to the following questions. Choose the answer and write only the letter (A–D) next to the question numbers (1.1 to 1.15) in the ANSWER BOOK, for example 1.16 D.

- 1.1. ... means anything that may cause injury to a person or property.
- A Major incident
 - B Risk
 - C Danger
 - D Accident
- (1)
- 1.2 The reference quantity in a series RLC circuit is ...
- A resistance.
 - B voltage.
 - C current.
 - D reactance.
- (1)
- 1.3 In a purely capacitive circuit, the relationship between the voltage and current is as follows:
- A The current leads the voltage
 - B The current lags the voltage
 - C The current and voltage are in phase
 - D The current is zero
- (1)
- 1.4 The power factor has a value of ... during resonance.
- A 0
 - B -1
 - C 0,866
 - D 1
- (1)
- 1.5 SI unit for reactive power is:
- A Watt
 - B Volt ampere
 - C Reactive volt ampere
 - D Volts
- (1)
- 1.6 The standard frequency used in South Africa is ...
- A 100 Hz.
 - B 60 Hz.
 - C 80 Hz.
 - D 50 Hz.
- (1)

- 1.7 A disadvantage of a three-phase system is the ...
A three-phase system is more economical.
B three-phase system can be connected in star or delta.
C supply of power is constant.
D system is not available everywhere. (1)
- 1.8 The type of transformer used immediately after generation in distribution networks is call a ... transformer.
A step-down
B step-up
C auto
D single-phase (1)
- 1.9 The ... monitors the flow of gas into the conservancy tank on top of transformers.
A Bucholtz relay
B inverse definite minimum time relay
C instantaneous overcurrent relay
D standby earth fault relay (1)
- 1.10 Which ONE of the following relates to a mechanical inspection of a three-phase motor?
A Insulation-resistance test between the windings and earth
B Insulation-resistance test between windings
C Continuity test of the stator windings
D Stator must be checked for cracks (1)
- 1.11 An advantage of a three-phase squirrel-cage rotor when compared to wound rotor types or synchronous motors ...
A has a lower starting torque.
B is less efficient
C requires less maintenance.
D has more moving parts. (1)
- 1.12 A three-phase motor with three pole pairs per phase has ... poles.
A 9
B 18
C 6
D 15 (1)
- 1.13 The chronological order of operation for the scan cycle of a PLC is ...
A input scan, output scan, process scan.
B input scan, process scan, output scan.
C process scan, input scan, output scan.
D output scan, process scan, input scan. (1)

1.14 ... is the machine language installed on a computer that instructs it to interact with its inputs and outputs.

- A Software
- B Hardware
- C Barcode
- D Panel wiring

(1)

1.15 The part of a VSD that converts DC back to AC is the ...

- A filter
- B converter
- C transformer
- D inverter

(1)

[15]

QUESTION 2: OCCUPATIONAL HEALTH AND SAFETY

2.1 Name TWO unsafe acts to avoid in a workshop.

(2)

2.2 Define the term *employer* with reference to the Occupational Health and Safety Act, 1993 (Act 85 of 1993).

(2)

2.3 Explain how faulty tools and equipment are considered an unsafe condition in a workshop.

(3)

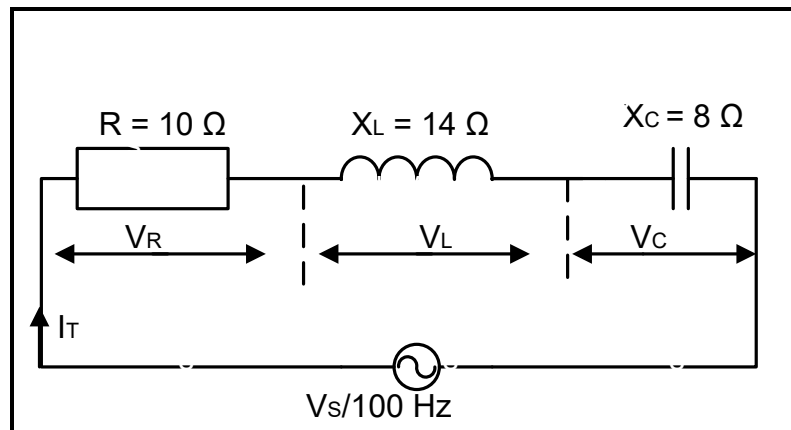
2.4 Describe what a *third-degree burn* is.

(3)

[10]

QUESTION 3: RLC CIRCUITS

- 3.1 Define *phasor diagram* with reference to RLC circuits connected across an alternating voltage supply. (2)
- 3.2 FIGURE 3.2 below represents a series RLC circuit which consists of a resistor with a value of $10\ \Omega$, an inductor with an inductive reactance of $14\ \Omega$ and a capacitor with a capacitive reactance of $8\ \Omega$, all connected across an alternating supply with a frequency of $100\ \text{Hz}$. The voltage across each component is as follows: $V_R = 150\ \text{V}$, $V_L = 180\ \text{V}$, and $V_C = 90\ \text{V}$.

**FIGURE 3.2: RLC SERIES CIRCUIT**

Given:

$$\begin{aligned} R &= 10\ \Omega \\ X_L &= 14\ \Omega \\ X_C &= 8\ \Omega \\ f &= 100\ \text{Hz} \\ V_R &= 150\ \text{V} \\ V_L &= 180\ \text{V} \\ V_C &= 90\ \text{V} \end{aligned}$$

- 3.2.1 State, giving a reason, whether the power factor will be leading or lagging. (2)

Calculate the:

- 3.2.2 Total supply voltage of the circuit (3)
- 3.2.3 Circuit impedance (3)
- 3.2.4 Total current flow (3)
- 3.3 State THREE conditions that will occur if the power factor is at unity in a series RLC circuit. (3)
- 3.4 Define the term *capacitive reactance*. (2)

3.5 Refer to FIGURE 3.5 below and answer the questions that follow.

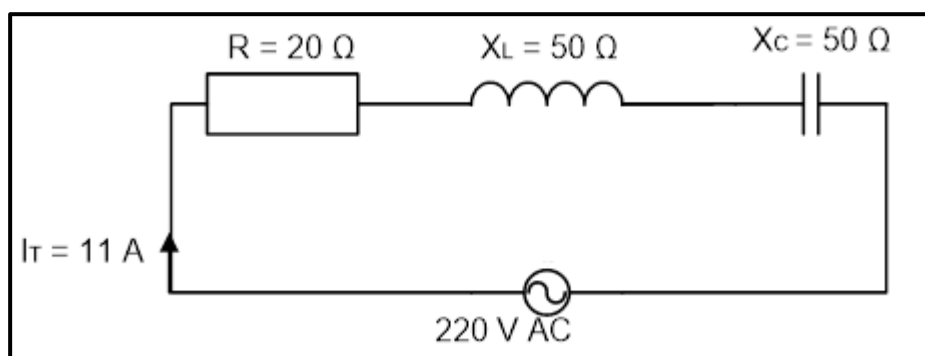


FIGURE 3.5

Calculate the:

- 3.5.1 Total current flow in the circuit (3)
- 3.5.2 Voltage drops across the inductor (3)
- 3.5.3 Q-factor of the circuit (3)
- 3.6 Explain why the phase angle of the circuit in FIGURE 3.5 would be zero. (2)
- 3.7 Refer to FIGURE 3.7 below and answer the questions that follow.

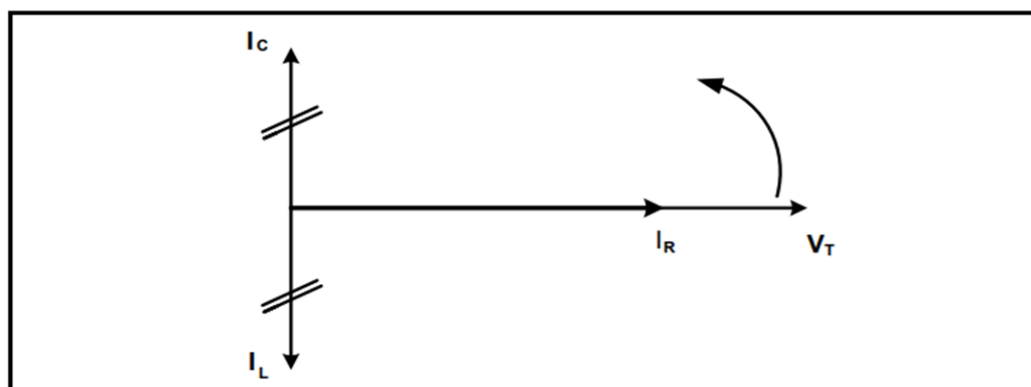


FIGURE 3.7

- 3.7.1 Identify the diagram in FIGURE 3.7. (1)
- 3.7.2 Give ONE reason why the supply voltage is used as the reference in FIGURE 3.7. (1)
- 3.7.3 Discuss the relationship between the current and the impedance in a parallel resonant circuit. (1)
- 3.8 Determine the resonant frequency if a RLC circuit has a capacitor with a value of 75 μF , and an inductor with a value of 50 mH. (3)

[35]

QUESTION 4: THREE-PHASE AC GENERATION

4.1 Write down ONE function of the following meters:

4.1.2 Power factor meter (1)

4.1.2 Kilowatt-hour meter (1)

4.1.3 Wattmeter (1)

4.2 Draw a labelled, diagrammatic representation of a four-wire star connection. (4)

4.3 When two meters are connected to a balanced three-phase system, they give the following readings. Wattmeter R gives a reading of 6,25 kW and Wattmeter B gives a reading of 17,25 kW. Calculate the power factor. (5)

4.4 Three loads with impedances of 45Ω each, are connected in a star to a 415 V three-phase line operating at a power factor of 0,85 lagging.

Given:

$$Z_{PH} = 45 \Omega$$

$$V_L = 415 V$$

$$\cos\theta = 0,85$$

Calculate the:

4.4.1 Current through each impedance (4)

4.4.2 Line current (2)

4.4.3 Real power (3)

4.4.4 Apparent power (3)

4.4.5 Phase angle (3)

4.5 A three-phase system delivers an output power of 20 kW at an efficiency of 89,4%. Determine the input power. (3)

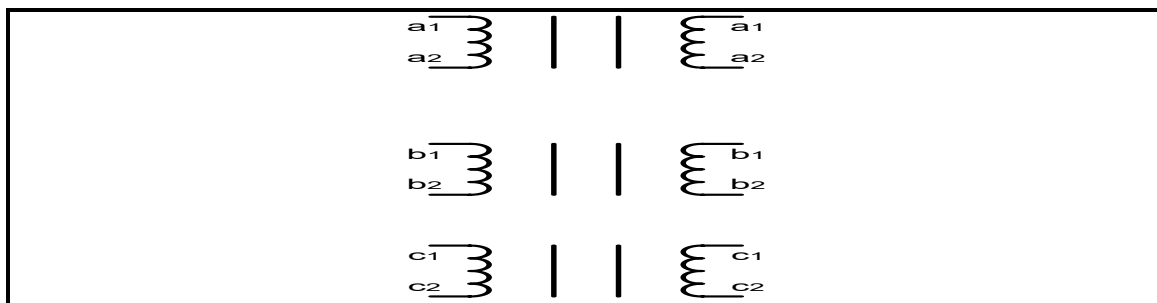
4.6 Explain why transmission lines are usually supplied by a star connection (3)

4.7 Explain the term *reactive power*. (2)

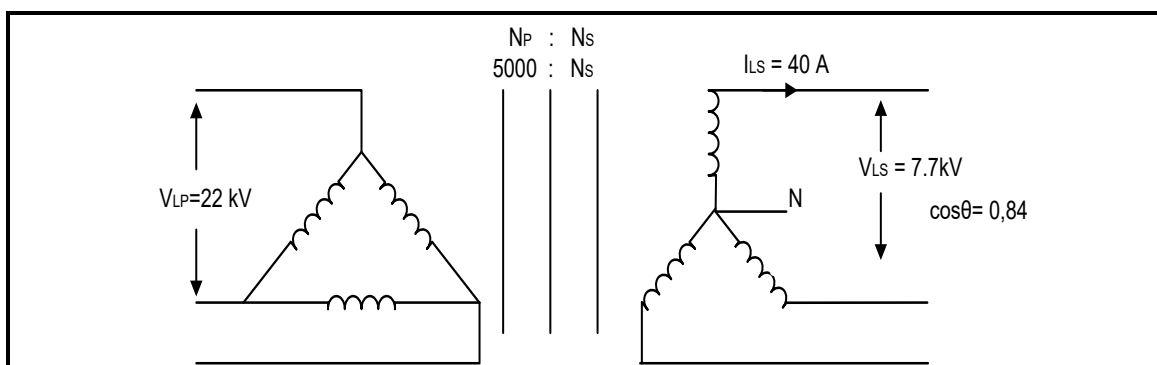
[35]

QUESTION 5: THREE-PHASE TRANSFORMERS

- 5.1 Three single-phase transformers can be used to create a three-phase transformer unit. Refer to FIGURE 5.1 below and answer the questions that follow.

**FIGURE 5.1: THREE SINGLE-PHASE TRANSFORMERS**

- 5.1.1 List THREE characteristics the single-phase transformers in FIGURE 5.2 must have to be connected as a three-phase transformer. (3)
- 5.1.2 Name the connection method used to create a neutral. (1)
- 5.1.3 Redraw FIGURE 5.2 in your ANSWER BOOK and connect the transformers as a three-phase star-delta transformer. (5)
- 5.1.4 Name ANY other method used to connect three single-phase transformers as a three-phase transformer. (1)
- 5.2 Explain the purpose of the dielectric oil used in oil immersed transformers. (2)
- 5.3 Refer to FIGURE 5.3 below and answer the questions that follow.

**FIGURE 5.3: THREE-PHASE TRANSFORMER**

Given:

$$V_{LP} = 22 \text{ kV}$$

$$V_{LS} = 7.7 \text{ kV}$$

$$N_P = 5\,000$$

$$I_{LS} = 40 \text{ A}$$

$$\cos\theta = 0.84$$

- 5.3.1 Identify the configuration of the transformer in FIGURE 5.3. (1)

Calculate the:

- 5.3.2 Secondary phase voltage (3)
- 5.3.3 Primary phase voltage (2)
- 5.3.4 Transformation ratio (3)
- 5.3.5 Apparent power (3)
- 5.3.6 Real power (3)
- 5.3.7 Number of turns on the secondary side (3)

[30]

QUESTION 6: THREE-PHASE MOTORS AND STARTERS

6.1 Refer to FIGURE 6.1 and answer the questions that follow.

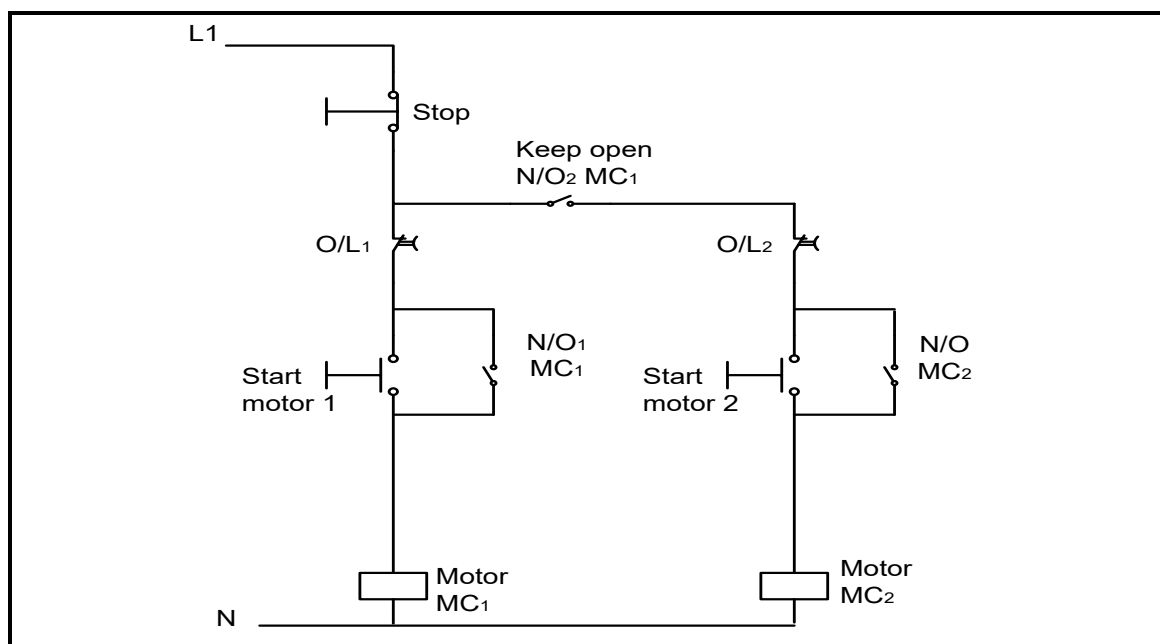


FIGURE 6.1: THREE-PHASE STARTER CONTROL CIRCUIT

- 6.1.1 Identify the control circuit in FIGURE 6.1. (1)
- 6.1.2 Explain the function of the following components. (1)
- (a) Stop button (1)
 - (b) N/O₁MC₁ (2)
- 6.1.3 Describe the sequence of the control circuit. (4)
- 6.1.4 Explain what would happen if N/O₁MC₁ was faulty and remained open. (2)

6.2 Answer the following questions with reference to the squirrel-cage induction motor.

6.2.1 Give TWO reasons why squirrel-cage induction motors are more widely used in industrial applications than slip ring motors. (2)

6.2.2 Name TWO types of equipment squirrel-cage induction motors are suitable for. (2)

6.3 Explain why a normally closed forward contact is connected in series with the reverse contactor in a forward reverse starter. (2)

6.4 The input power of a three-phase motor is 5 kW, and the total losses amount to 600 W.

Given:

$$P_{\text{INPUT}} = 5 \text{ kW}$$

$$\text{losses} = 600 \text{ W}$$

6.4.1 Name TWO losses other than copper losses that may occur. (2)

Calculate the:

6.4.2 Efficiency of the motor (3)

6.4.3 Output power of the motor (3)

6.5 Refer to FIGURE 6.5 and answer the questions that follow.

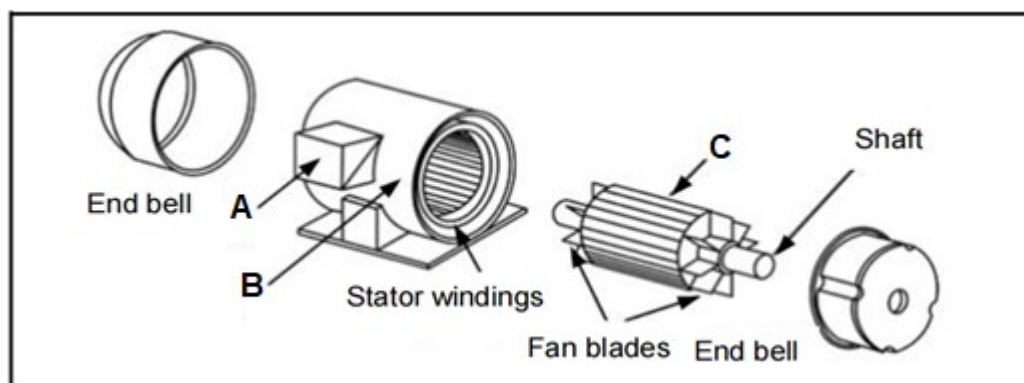


FIGURE 6.5: VIEW OF A THREE-PHASE MOTOR PARTS

6.5.1 Name parts **A**, **B** and **C**. (3)

6.5.2 Explain how a rotating magnetic field is created in the stator windings. (3)

6.5.3 Mention TWO factors that determine the speed of an induction motor. (2)

6.6 A star connected three-phase motor has a rated power of 8 kW at a power factor of 0,85 when connected to a 415 V supply. Calculate the line current.

Given:

$$P_{\text{OUTPUT}} = 8 \text{ kW}$$

$$V_L = 415 \text{ V}$$

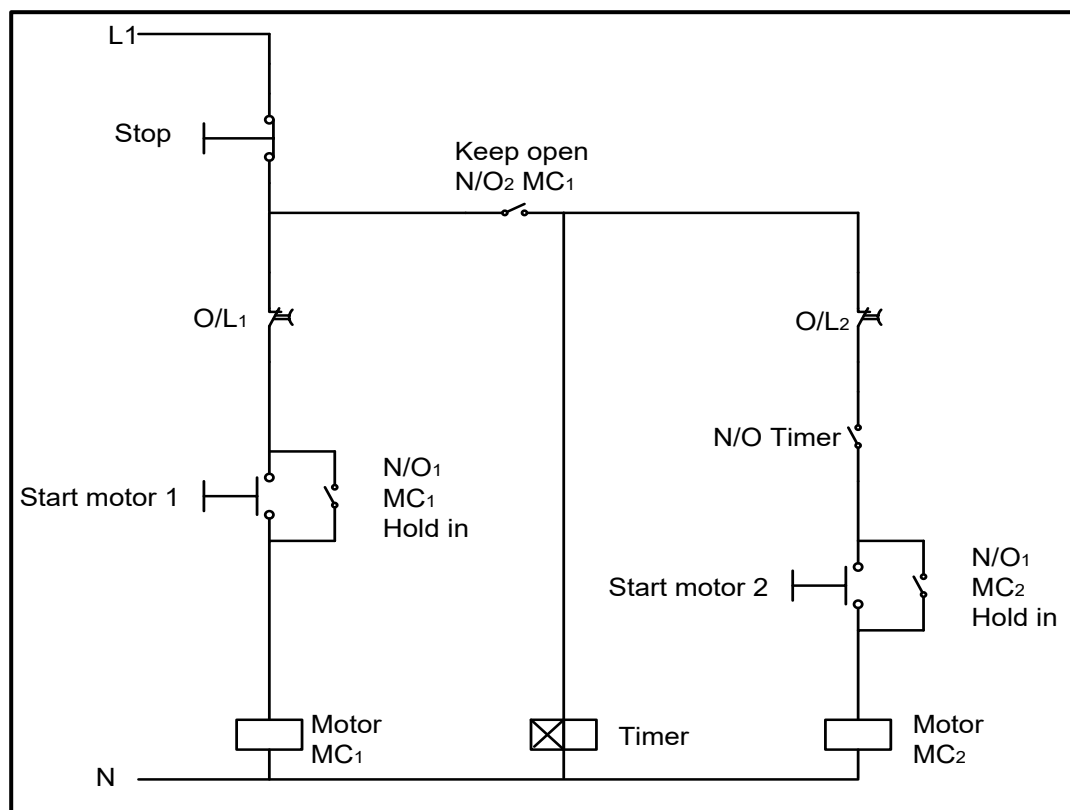
$$\cos\theta = 0,85$$

(3)

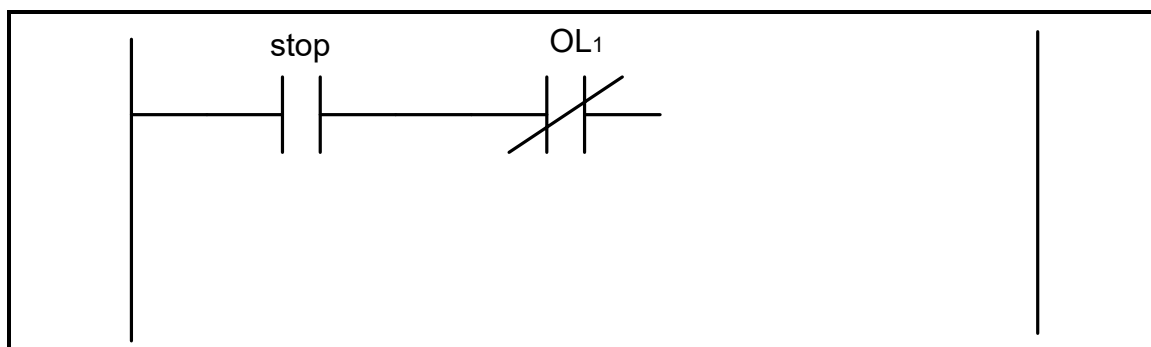
[35]

QUESTION 7: PROGRAMMABLE LOGIC CONTROLLERS (PLCs)

7.1

**FIGURE 7.1: SEQUENCE STARTER WITH A TIMER CONTROL CIRCUIT**

Refer to FIGURE 7.1 above and complete the ladder logic program in FIGURE 7.1.1 below, in your ANSWER BOOK, that will execute the same function in a PLC system.



(10)

FIGURE 7.1.1

7.2 Explain the function of the following PLC hardware components:

7.2.1 Central Processing Unit (CPU) (2)

7.2.2 Modulator-demodulator (modem) (2)

7.3 Differentiate between an *analogue signal* and a *digital signal*. (2)

- 7.4 Refer to the gate drawn in FIGURE 7.4 below and answer the questions that follow.

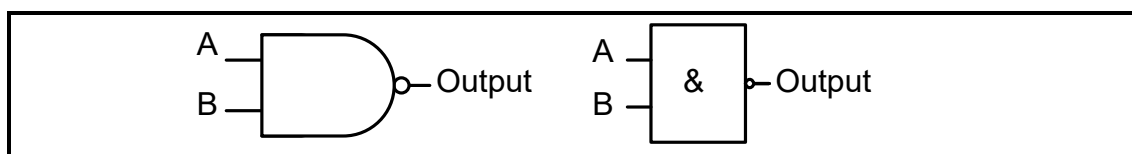


FIGURE 7.4: LOGIC GATE

- 7.4.1 Identify the gate shown in FIGURE 7.4. (1)
- 7.4.2 Draw the equivalent logic ladder diagram for this gate. (3)
- 7.4.3 Complete the truth table in FIGURE 7.4.3 below by writing down the output state next to the letter. (3)

A	B	OUTPUT
0	0	1
0	1	A
1	0	B
1	1	C

FIGURE 7.4.3: TRUTH TABLE

- 7.5 Explain the sequence of operation in FIGURE 7.5 below when the start button is pressed. (4)

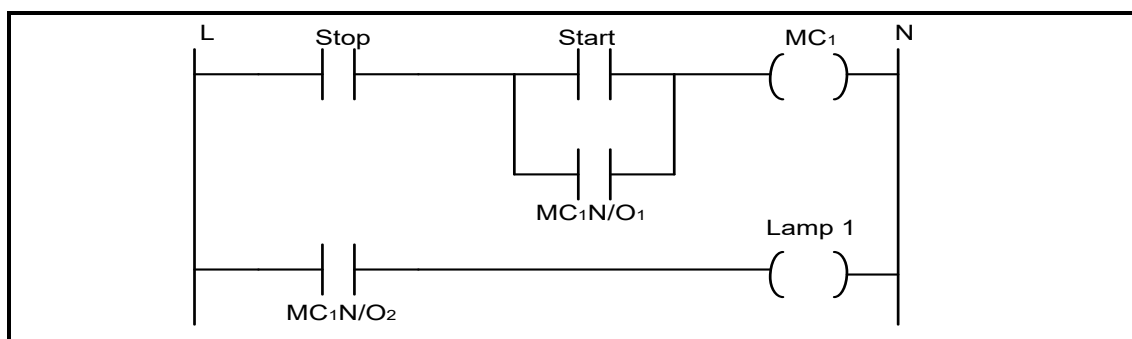


FIGURE 7.5: LADDER LOGIC CIRCUIT

- 7.6 Explain the difference between a *converter* and an *inverter* of a variable speed drive. (4)
- 7.7 State the purpose of the filter circuit of a variable speed drive. (2)
- 7.8 Name THREE methods of speed control used in three-phase motors. (3)
- 7.9 State how the output scan of a PLC achieves its function. (2)
- 7.10 Explain what *busses* in the central processing unit (CPU) are. (2)

[40]

TOTAL: 200

FORMULA SHEET	
RLC CIRCUITS	THREE-PHASE AC GENERATION
$X_L = 2\pi fL \quad \text{and} \quad X_C = \frac{1}{2\pi fC}$ $f_r = \frac{1}{2\pi\sqrt{LC}} \quad \text{and} \quad I = \frac{V}{R}$ $P = VI \cos \theta$ SERIES $I_T = I_R = I_L = I_C$ $I_T = \frac{V_T}{Z}$ $Z = \sqrt{R^2 + (X_L - X_C)^2}$ $V_L = I \times X_L \quad \text{and} \quad V_C = I \times X_C$ $V_T = IZ \quad \text{and} \quad V_T = \sqrt{V_R^2 + (V_L - V_C)^2}$ $\cos \theta = \frac{R}{Z} \quad \text{and} \quad \cos \theta = \frac{V_R}{V_T}$ $Q = \frac{X_L}{Z} = \frac{X_C}{Z} = \frac{V_L}{V_S} = \frac{V_C}{V_S} = \frac{1}{R} \sqrt{\frac{L}{C}}$ PARALLEL $V_S = V_R = V_L = V_C$ $I_R = \frac{V_R}{R}$ $I_L = \frac{V_L}{X_L} \quad \text{and} \quad I_C = \frac{V_C}{X_C}$ $I_T = \sqrt{I_R^2 + (I_L - I_C)^2}$ $Z = \frac{V}{I_T}$ $\cos \theta = \frac{I_R}{I_T}$ $Q = \frac{X_L}{Z} = \frac{X_C}{Z} = \frac{V_L}{V_S} = \frac{V_C}{V_S} = \frac{1}{R} \sqrt{\frac{L}{C}}$	STAR $V_L = \sqrt{3} \times V_{PH} \quad \text{and} \quad V_{PH} = I_{PH} \times Z_{PH}$ $I_L = I_{PH}$ DELTA $V_L = V_{PH} \quad \text{and} \quad V_{PH} = I_{PH} \times Z_{PH}$ $I_L = \sqrt{3} \times I_{PH}$ POWER $S = \sqrt{3} V_L I_L$ $Q = \sqrt{3} V_L I_L \sin \theta$ $P = \sqrt{3} V_L I_L \cos \theta$ $P = S \cos \theta$ $\cos \theta = \frac{P}{S}$ $\eta = \frac{\text{output}}{\text{input}} \times 100\%$ TWO-WATTMETER METHOD $P_T = W_1 + W_2$ $\tan \theta = \sqrt{3} \left(\frac{W_1 - W_2}{W_1 + W_2} \right)$ THREE-WATTMETER METHOD $P_T = W_1 + W_2 + W_3$

FORMULA SHEET	
THREE-PHASE TRANSFORMERS STAR $V_L = \sqrt{3} \times V_{PH} \quad \text{and} \quad I_L = I_{PH}$ DELTA $V_L = V_{PH} \quad \text{and} \quad I_L = \sqrt{3} \times I_{PH}$ POWER $S = \sqrt{3} V_L I_L$ $Q = \sqrt{3} V_L I_L \sin \theta$ $P = \sqrt{3} V_L I_L \cos \theta$ $P = S \cos \theta$ $\cos \theta = \frac{P}{S}$ $\eta = \frac{P_{output}}{P_{output} + losses} \times 100\%$ $T. Ratio = \frac{V_{PHP}}{V_{PHS}} = \frac{N_P}{N_S} = \frac{I_{PHS}}{I_{PHP}}$	THREE-PHASE MOTORS AND STARTERS STAR $V_L = \sqrt{3} \times V_{PH} \quad \text{and} \quad I_L = I_{PH}$ DELTA $V_L = V_{PH} \quad \text{and} \quad I_L = \sqrt{3} \times I_{PH}$ POWER $S = \sqrt{3} V_L I_L$ $Q = \sqrt{3} V_L I_L \sin \theta$ $P = \sqrt{3} V_L I_L \cos \theta$ $P = S \cos \theta$ $\cos \theta = \frac{P}{S}$ $\eta = \frac{P_{output}}{P_{input}} \times 100\%$ $\eta = \frac{P_{INPUT} - Losses}{P_{INPUT}} \times 100\%$ MOTOR SPEED $n_s = \frac{60 \times f}{p}$ $\% Slip = \frac{n_s - n_r}{n_s} \times 100\%$ $S = N_S - N_R$ <i>Overload setting = 125% × rated current</i>