Province of the EASTERN CAPE EDUCATION

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NATIONAL SENIOR CERTIFICATE

GRADE 12

SEPTEMBER 2025

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 replacement of values.

    7.3 Correct answer and relevant units where applicable.

8. A formula sheet is attached at the end of this question paper.

9. Write neatly and legibly.

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 A burn must be treated by …

A covering the burnt area with butter.
B putting ice on the burn wound.
C puncturing the blisters.
D running cold water over the burnt area until the pain reduces. (1)

1.2 When the current lags the voltage in a RLC circuit:

A $V_C > V_L$
B $V_L < V_C$
C $V_L > V_C$
D R = Z (1)

1.3 The circuit will be more … in nature and the resulting impedance will have a lagging phase angle.

A resistive
B inductive
C capacitive
D resonance (1)

1.4 At what frequency will a coil of inductance 80 mH have a reactance of 302 Ω?

A 50 Hz
B 150 Hz
C 60 Hz
D 600 Hz (1)

1.5 Apparent power is expressed in the SI units of …

A watts.
B volt-amperes.
C reactive volt-amperes.
D amperes. (1)

1.6 The purpose of oil in a transformer is for …

A insulating and cooling.
B heating and insulating.
C lubricating and insulating.
D preventing rust and insulating. (1)

1.7 The … method(s) can determine the total power and the power factor of a circuit.

A two-wattmeter
B three-wattmeter
C one-wattmeter
D All of the above-mentioned (1)

1.8 The main function of a transformer is to:

A Change alternating current to direct current
B Decrease the power
C Step up and step down an AC voltage
D Step and step down a DC voltage (1)

1.9 Main source of heat generation in transformers is … losses.

A eddy current
B friction
C copper or I^2R
D hysteresis (1)

1.10 Electromagnetically operated switches used in starters are called …

A overloads.
B no-volt coils.
C isolators.
D contactors. (1)

1.11 Rated speed of an induction motor is the …

A speed of rotation of the magnetic field.
B speed when maximum load is connected.
C difference between synchronous speed and rotor speed.
D maximum speed that the motor is allowed to work properly. (1)

1.12 The simplest and cheapest of all starting methods and is usually used for squirrel-cage induction motors is the … starter.

A direct-on-line
B forward and reverse
C sequence control with a timer
D automatic star delta (1)

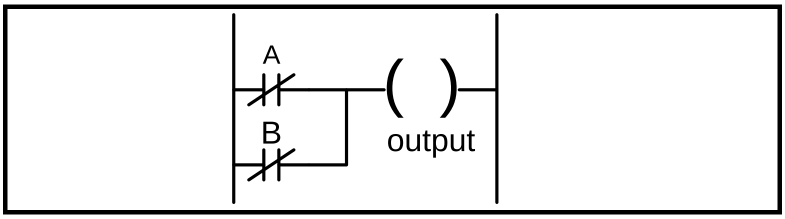
1.13 A sensor is …

A a discrete switch or push button that can produce an electrical ON or OFF.
B an electronic device used to detect light.
C a device which converts a physical condition into an electrical signal that can be used by PLC.
D an electro-mechanical device that translates a mechanical force into an electrical signal. (1)

1.14 An electro-mechanical device that translates a mechanical force into an electrical signal:

A Level sensor
B Proximity sensor
C Strain gauge
D Opto-coupler (1)

1.15 The ladder diagram below represents the …



A AND-gate
B NAND gate
C OR-gate
D NOR gate (1)

[15]

QUESTION 2: OCCUPATIONAL HEALTH AND SAFETY

2.1 State ONE chemical safety precaution observed during the manufacture of printed circuit boards. (1)

2.2 Explain the word *danger* with reference to the Occupational Health and Safety Act, 1993 (Act 85 of 1993). (1)

2.3 List TWO recommended ways to stop bleeding. (2)

2.4 Name TWO duties that every employer has to inform all employees and health and safety representatives of. (2)

2.5 Briefly explain the "let go" current during an electric shock. (2)

2.6 Explain how discipline is vital for a strong work ethic. (2)

[10]

QUESTION 3: RLC CIRCUITS

3.1 Draw a detailed phasor diagram of a pure inductive circuit. (3)

3.2 State the reference quantity in a series connected circuit. (1)

3.3 Refer to FIGURE 3.3 below and answer the questions that follows.

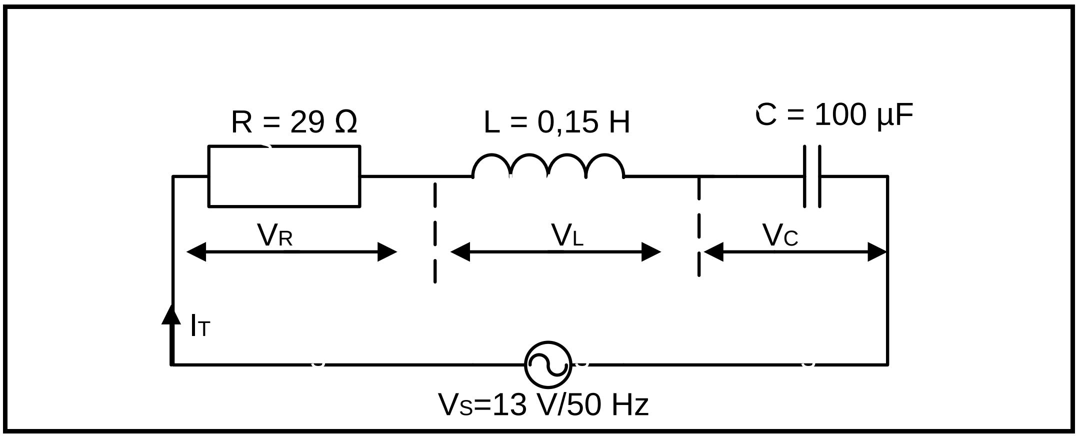


FIGURE 3.3: SERIES RLC CIRCUIT

Given: $R = 29\ \Omega$
$L = 0{,}15\ H$
$C = 100\ \mu F$
$f = 50\ Hz$
$V_T = 13\ V$

Calculate the:

3.3.1 Reactance of the inductor (3)

3.3.2 Reactance of the capacitance (3)

3.3.3 Circuit impedance (3)

3.3.4 Total circuit current (3)

3.4 Distinguish between the concepts *reactance* and *impedance*. (4)

3.5 Determine the resonant frequency of a series circuit consisting of an inductor of 0,5 H, a capacitor of 75 ɥF and a 100 Ω resistor.

Given: $L = 0{,}5\ H$
$C = 100\ ɥF$
$R = 100\ \Omega$ (3)

3.6 A three-branch parallel RLC circuit has the following in each branch; a resistor with a value of 10 Ω, an inductor with a reactance of 28,23 Ω and a capacitor with a reactance of 42,44 Ω. The circuit is connected to a 100 V/25 Hz supply.

Given: $\mathrm{R} = 10\ \Omega$
$X_L = 28{,}23\ \Omega$
$X_C = 42{,}44\ \Omega$
$\mathrm{V} = 100\ \mathrm{V}$
$\mathrm{f} = 25\ \mathrm{Hz}$

Calculate the:

3.6.1 Current through each branch (9)

3.6.2 Total current drawn from the supply (3)
[35]

QUESTION 4: THREE-PHASE AC GENERATION

4.1 List THREE advantages of three-phase systems. (3)

4.2 Draw a fully labelled phasor diagram of the voltages generated by a star connection, showing the direction of rotation, the phase angles and relative magnitudes of the phasors. (5)

4.3 Define the following terms:

4.3.1 *Transmission* (1)

4.3.2 *Substation equipment* (1)

4.3.3 *National grid* (1)

4.4 Name the type of induction that occurs in transformers. (1)

4.5 List TWO advantages of power factor correction for the supplier. (2)

4.6 A three-phase delta connected load is supplied by a 250 kVA generator with a phase voltage of 240 volts. The power factor of the load is 0,8 lagging.

Given: $S = 250\ \text{kVA}$
$\text{V} = 240\ \text{V}$
$\text{Cos}\theta = 0{,}8\ \text{lagging}$

Calculate the:

4.6.1 Line voltage (2)

4.6.2 Line current (3)

4.6.3 Phase current (3)

4.6.4 Active power (3)

4.6.5 Phase angle (3)

4.7 Two wattmeters are connected to a balanced three-phase system. Wattmeter R gives a reading of 3 kW and wattmeter B gives a reading of 8,5 kW.

Calculate the power factor.

Given: $\text{W}_{\text{RED}} = 3\ \text{kW}$
$\text{W}_{\text{BLUE}} = 8{,}5\ \text{kW}$ (5)

4.8 Name the meter used to measure power. (1)

4.9 State ONE advantage of the three wattmeter method. (1)
[35]

QUESTION 5: THREE-PHASE TRANSFORMERS

5.1 State ONE application of each of the following transformers:

5.1.1 Delta-delta transformer (1)

5.1.2 Star-delta transformer (1)

5.2 Name THREE factors that contribute to excessive heating in three-phase transformers. (3)

5.3 A delta-star connected transformer shown in FIGURE 5.3 below supplies a factory with 85 kW of electrical power. The current is lagging the voltage with a phase angle of 36,87°. The total loss in the transformer is 12,5 kW. The primary line voltage is13,8 kilo-volts and the secondary line voltage is 450 V.

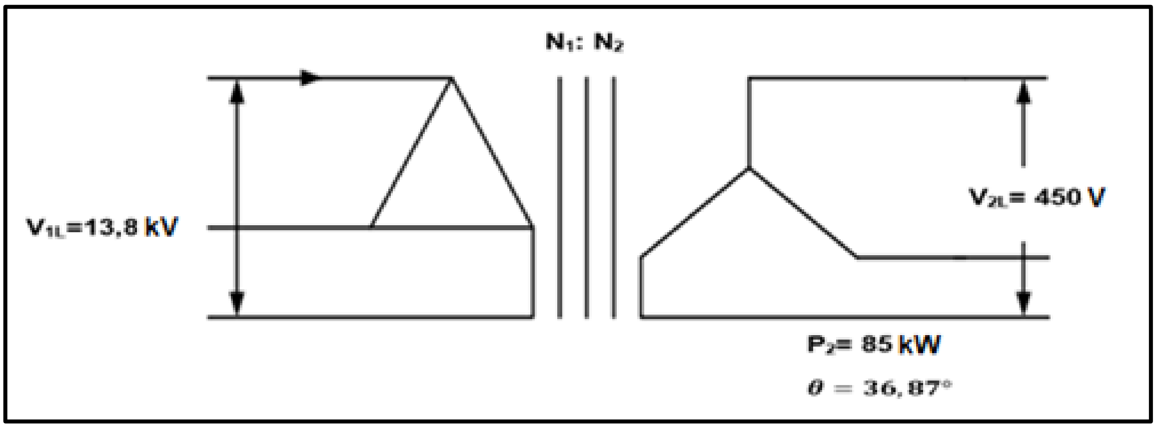


FIGURE 5.3

Calculate the:

5.3.1 Secondary line current (3)

5.3.2 Apparent power (3)

5.3.3 Reactive power (3)

5.3.4 Efficiency of the system (3)

5.4 Write down THREE methods employed when cooling oil immersed transformers. (3)

5.5 Name TWO types of transformer constructions available. (2)

5.6 List TWO requirements that must be satisfied for three single-phase transformers to operate as a three-phase transformer. (2)

5.7 State TWO safety aspects that should be adhered to when doing simulations with transformers. (2)

5.8 State TWO external conditions which could cause faults to develop in a transformer. (2)

5.9 Explain what effect an increase in the load will have on the primary current of a transformer. (2)

[30]

QUESTION 6: THREE-PHASE MOTORS AND STARTERS

6.1 Name any THREE parts of a three-phase squirrel-cage induction motor. (3)

6.2 State the main function of a starter in a three-phase motor. (1)

6.3 The stator of a three-phase induction motor driving a conveyor belt has 8 polepairs and the supply frequency is 50Hz.

Given: p = 8
f = 50 Hz

Calculate the synchronous speed of the motor. (3)

6.4 The rotor speed of a squirrel-cage induction motor is 3 420 rpm while the synchronous speed is 3 600 rpm. Determine the slip in rpm.

Given: n_r = 3 420
n_s = 3 600 (3)

6.5 Briefly describe the principle of operation of a squirrel-cage induction motor. (6)

6.6 Mention TWO mechanical inspections that should be performed on a motor after installation and before commissioning. (2)

6.7 Describe the term *full load speed* of an induction motor. (1)

6.8 List TWO examples of the information shown on the nameplate of a motor. (2)

6.9 Name TWO reasons for having a skewed rotor. (2)

6.10 Refer to FIGURE 6.10 below and answer the questions that follow.

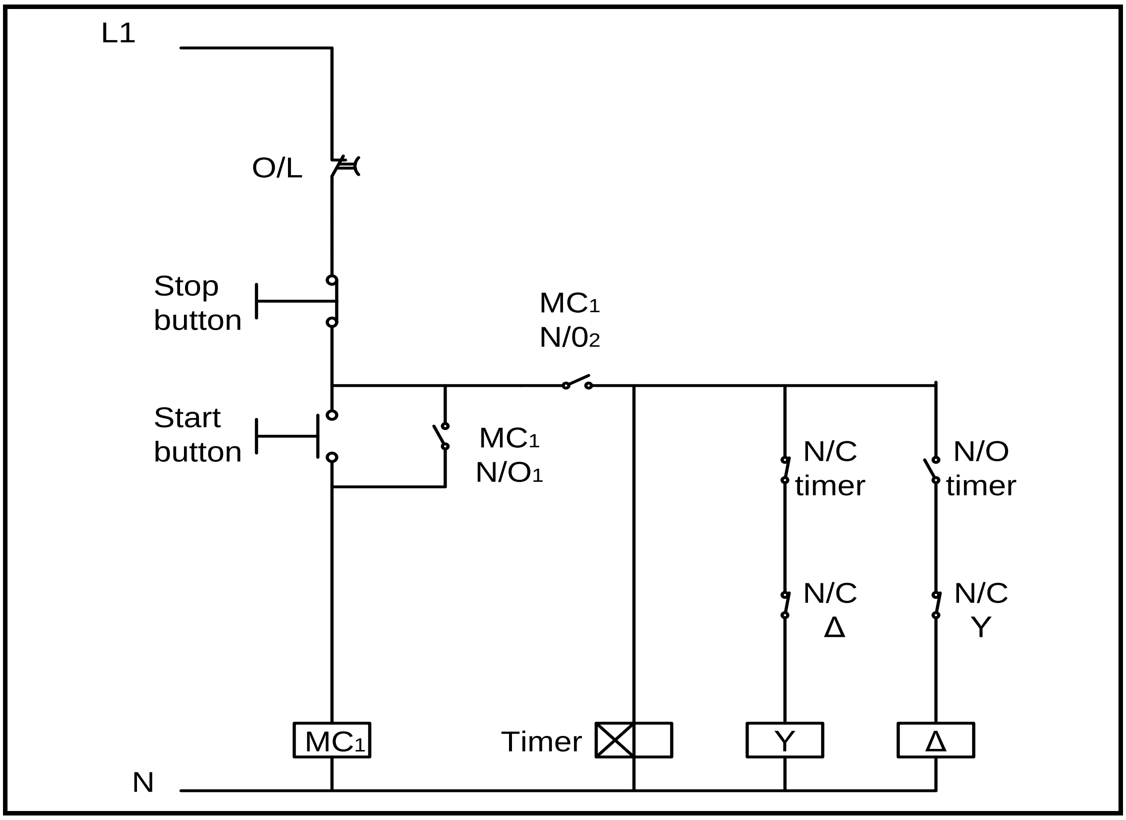


FIGURE 6.10: AUTOMATIC STAR DELTA CONTROL CIRCUIT

6.10.1 Identify the interlocking contacts in the circuit. (2)

6.10.2 Explain the purpose of the following contacts:

(a) MC_1N/O_1 (2)

(b) MC_1N/O_2 (2)

6.10.3 Describe the operation of the star-delta control circuit. (6)

[35]

QUESTION 7: PROGRAMMABLE LOGIC CONTROLLERS (PLCs)

7.1 Define an *opto-isolator*. (3)

7.2 When referring to a PLC explain what is meant by the following input categories:

7.2.1 Discrete (2)

7.2.2 Analogue (2)

7.3 Explain the term *sensor* as a device connected to the input of a PLC. (2)

7.4 Draw the block diagram of a typical PWM VFD speed control system. (7)

7.5 Refer to FIGURE 7.5 below and answer the question that follows.

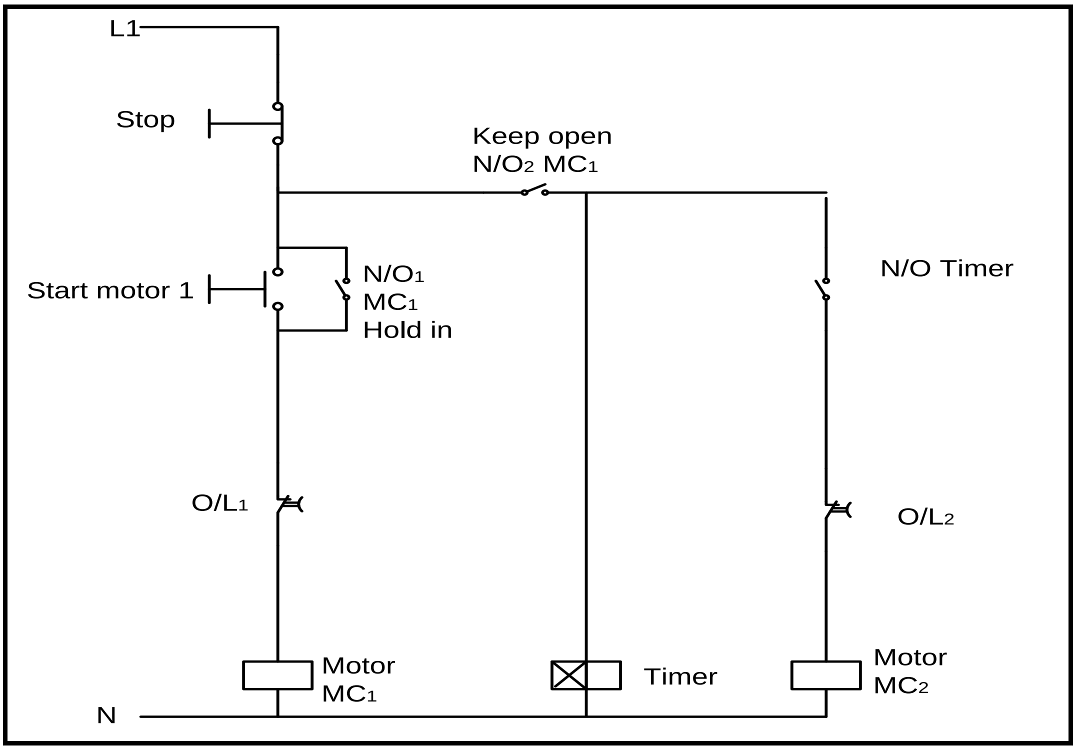


FIGURE 7.5

7.5.1 Identify the circuit shown in FIGURE 7.5. (1)

7.5.2 Draw the ladder logic diagram that will execute the same function in a PLC system. (10)

7.5.3 State the function of the timer in the circuit. (2)

7.6 State THREE points that should be considered in the application of VSDs. (3)

7.7 Discuss the start-up and run profiles of adjustable speed drives. (4)

7.8 State TWO applications of regenerative braking. (2)

7.9 Name TWO types of synchronous AC motors used with VSDs. (2)
[40]

TOTAL: 200

FORMULA SHEET

RLC-CIRCUITS

$X_L = 2\pi fL$ and $X_C = \frac{1}{2\pi fC}$

$f_r = \frac{1}{2\pi\sqrt{LC}}$ and $I = \frac{V}{R}$

$P = VI\cos\theta$

SERIES

$I_T = I_R = I_L = I_C$

$Z = \sqrt{R^2 + (X_L - X_C)^2}$

$V_L = I \times X_L$ and $V_C = I \times X_C$

$V_T = IZ$ and $V_T = \sqrt{{V_R}^2 + (V_L - V_C)^2}$

$\cos\theta = \frac{R}{Z}$ and $\cos\theta = \frac{V_R}{V_T}$

$Q = \frac{X_L}{Z} = \frac{X_C}{Z} = \frac{V_L}{V_S} = \frac{V_C}{V_S} = \frac{1}{R}\sqrt{\frac{L}{C}}$

PARALLEL

$V_S = V_R = V_L = V_C$

$I_R = \frac{V_R}{R}$

$I_L = \frac{V_L}{X_L}$ and $I_C = \frac{V_C}{X_C}$

$I_T = \sqrt{{I_R}^2 + (I_L - I_C)^2}$

$Z = \frac{V}{I_T}$

$\cos\theta = \frac{I_R}{I_T}$

$Q = \frac{X_L}{Z} = \frac{X_C}{Z} = \frac{V_L}{V_S} = \frac{V_C}{V_S} = \frac{1}{R}\sqrt{\frac{L}{C}}$

THREE-PHASE AC GENERATION

STAR

$V_L = \sqrt{3} \times V_{PH}$ and $V_{PH} = I_{PH} \times Z_{PH}$

$I_L = I_{PH}$

DELTA

$V_L = V_{PH}$ and $V_{PH} = I_{PH} \times Z_{PH}$

$I_L = \sqrt{3} \times I_{PH}$

POWER

$S = \sqrt{3}V_L I_L$

$Q = \sqrt{3}V_L I_L \sin\theta$

$P = \sqrt{3}V_L I_L \cos\theta$

$P = S\cos\theta$

$\cos\theta = \frac{P}{S}$

$\eta = \frac{output}{input} \times 100\%$

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