Province of the
EASTERN CAPE
EDUCATION

NATIONAL SENIOR CERTIFICATE

GRADE 12

SEPTEMBER 2015

ELECTRICAL TECHNOLOGY

MARKS: **200**

TIME: **3 hours**

ELCTDM

This question paper consists of 11 pages, including formula sheets.

INSTRUCTIONS AND INFORMATION

1. The question paper consists of SEVEN questions.

2. Answer ALL the questions.

3. Sketches and diagrams must be large, neat and fully labelled.

4. ALL calculations must be shown, and correct to TWO decimal places.

5. Number the answers correctly according to the numbering system used in this question paper.

6. A formula sheet is provided at the end of the paper.

7. You may use a non-programmable calculator.

8. Show the units for all answers of calculations.

9. Write neatly and legibly.

QUESTION 1: OCCUPATIONAL HEALTH AND SAFETY

1.1 Dangerous practices most commonly refer to processes that have some form of risk or hazard when performed. State TWO activities or tasks that can be referred to as dangerous practices performed in an electrical workshop. (2)

1.2 An employer has the right to monitor communication within the workplace as long as the employee is aware of the monitoring before it takes place. Name ONE such form of communication that an employer may monitor. (1)

1.3 Good work ethics require certain character traits or characteristics. Name THREE characteristics that contribute to good work ethics. (3)

1.4 It is important that employees work as a team. Describe TWO characteristics that contribute to effective teamwork. (2)

1.5 As a first-aider, you are the first on the scene of an accident. Before giving first aid, what is the first action that must be taken? (2)

[10]

QUESTION 2: THREE-PHASE AC GENERATION

2.1 Draw a phasor diagram showing the three voltages in a three-phase system. (3)

2.2 List THREE advantages that three-phase systems have over single phase systems. (3)

2.3 A delta-connected alternator generates 220 V per phase. Each phase in this balanced system has an impedance of 44 Ω. Calculate the line voltage, line current and phase current. (8)

2.4 Explain the difference between *active power* (also called real or true power) and *reactive power*. (2)

2.5 Although three-phase alternators can deliver power to balanced and unbalanced loads, why is it important that each phase of the alternators be balanced?
Justify your answer. (4)

[20]

QUESTION 3: THREE-PHASE TRANSFORMERS

3.1 State whether the following statements are TRUE or FALSE.

3.1.1 The generators in the power stations produce electricity at 22 kV. (1)

3.1.2 This 22 kV is increased by transformers before it is sent out at 275 kV, 400 kV or even 765 kV onto the transmission grid. (1)

3.1.3 11 kV is fed into our homes for domestic use. (1)

3.1.4 Eskom is the first utility in the world to successfully operate transmission lines at 765 kV at high altitudes above sea level. (1)

3.1.5 380 V and 240 V are available for domestic use. (1)

3.1.6 High voltage overhead conductors are nearly always made of aluminium alloy. (1)

3.2 A farmer uses a three-phase delta-star transformer with a transformation ratio of 150 : 3 to reduce a line voltage from 11 kV. He uses both single and three-phase motors on his farm.

3.2.1 Determine the voltage across each phase of the three-phase motor if it is star-connected. (4)

3.2.2 This three-phase motor has a rating of 12 kW at a power factor of 0,8 lagging. Calculate the line current supplied from the secondary of the transformer. (6)

3.3 3.3.1 Does the size of the transformer affect the methods of cooling? (1)

3.3.2 Name THREE methods or ways in which transformers are cooled. (3)

[20]

QUESTION 4: THREE-PHASE MOTORS AND STARTERS

4.1 State THREE advantages that three-phase induction motors have over single-phase motors. (3)

4.2 Name the THREE main parts of a three-phase induction motor. (3)

4.3 Draw TWO sketches of a three-phase terminal block showing how the terminals are connected for:

4.3.1 Star (3)

4.3.2 Delta (3)

Label the terminals

4.4 A 50 kW three-phase induction motor has 12 poles in total and a rated laggingpower factor of 0,9. It is connected to a 380 V / 50 Hz supply.

Calculate the:

4.4.1 Apparent power (s) (3)

4.4.2 Line current (3)

4.4.3 Synchronous speed of the motor (4)

4.4.4 Slip if the shaft speed is 1 400 rpm (3)

4.4.5 Efficiency of the motor if the power on the shaft is 45 kW (3)

4.5 Draw a fully labelled circuit diagram of the control circuit of an automatic star-delta motor starter. (12)

[40]

QUESTION 5: RLC CIRCUITS

5.1 In a series or parallel circuit, describe the effect that the frequency has on:

5.1.1 Resistance (1)

5.1.2 Inductive reactance (1)

5.1.3 Capacitive reactance (1)

5.2 Define the term *impedance*. (3)

5.3 A parallel RLC consists of a 47 Ω resistor, an inductor with an inductive reactance of 70 Ω, and a capacitor with a capacitive reactance of 80 Ω. The parallel circuit is connected to a 110 V / 60 Hz supply.

Calculate the :

5.3.1 Total current drawn from the supply (8)

5.3.2 Impedance of the circuit (2)

5.4 In a radio tuned circuit where it is desired to draw the least current, contrast series and parallel RLC circuits. Decide which would be the better one to use. Justify your choice. (4)

[20]

QUESTION 6: LOGIC

6.1 What does the abbreviation PLC stand for? (1)

6.2 Give TWO examples of the following with reference to PLC's:

6.2.1 Inputs (2)

6.2.2 Outputs (2)

6.3 Name ONE industry where PLC's are used. (1)

6.4 Draw the ladder diagram symbols for the following:

6.4.1 Normally open contact (input) (1)

6.4.2 Normally closed contact (input) (1)

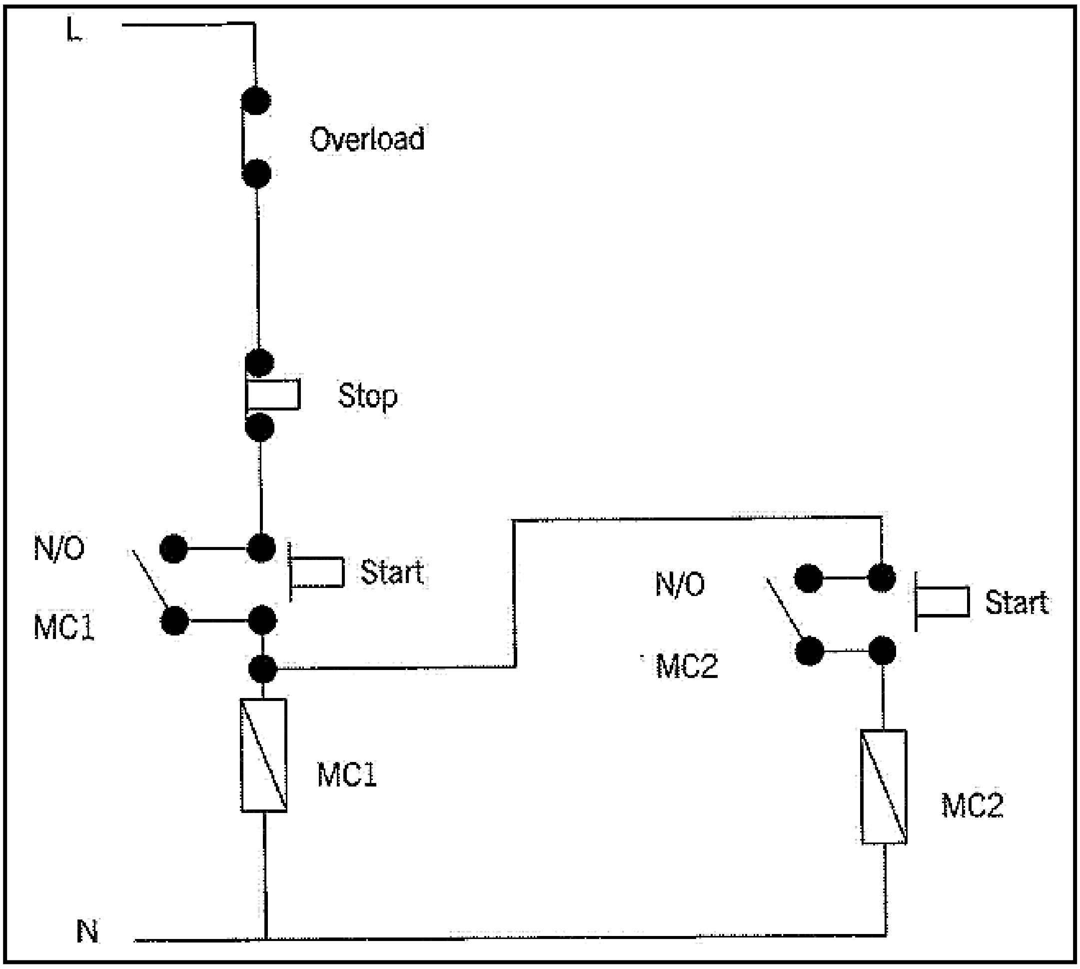
6.4.3 Output (coil) (1)

6.5 A PLC program is a set of instructions within a specific programming language for a PLC to perform a specific function. The execution of each instruction requires THREE basic steps. Describe these steps. (3)

6.6 Simplify the following Boolean expression using a Karnaugh map.

$ABC + A\bar{B}C + AB\bar{C} + A\bar{B}\bar{C}$ (8)

6.7 Draw the ladder diagram for a sequence starter without a timer. Refer to the following wiring diagram.



(8)

6.8 Refer to the following truth table.

A	B	SUM	CARRY
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

6.8.1 Write the Boolean expressions for the given truth table. (4)

6.8.2 Design and draw the gate network for the expressions in QUESTION 6.8.1. (8)

[40]

QUESTION 7: AMPLIFIERS

7.1 Draw a neat sketch showing the layout of the dual-in-line IC package of an LM 741 op-amp. Show especially the inputs, the output and the supply voltage. (5)

7.2 With reference to an ideal op-amp, what is meant by infinite bandwidth? (2)

7.3 State THREE advantages of negative feedback. (3)

7.4 Name TWO applications of the op-amp as a comparator. (2)

7.5 An inverting op-amp using open loop gain and a 5 V reference voltage on the non-inverting input is joined to a supply voltage of (+) and (–) 15 volts. What would the output voltage be if:

7.5.1 5 V were placed on the inverting input? (1)

7.5.2 3 V were placed on the inverting input? (1)

7.5.3 6 V were placed on the inverting input? (1)

7.6 Draw the circuit diagram of a non-inverting operational amplifier. Label the components and show input and output waveforms. (8)

7.7 The feedback resistor used in a non-inverting amplifier is 100 kΩ and the input resistor is 10 kΩ. Calculate the amplitude of the output signal if the amplitude of the input signal is 3 V. (3)

7.8 Draw a fully labelled circuit diagram of an op-amp integrator circuit. (5)

7.9 Draw the input and output waveforms of the op-amp integrator and explain the mathematical function that the circuit performs. (4)

7.10

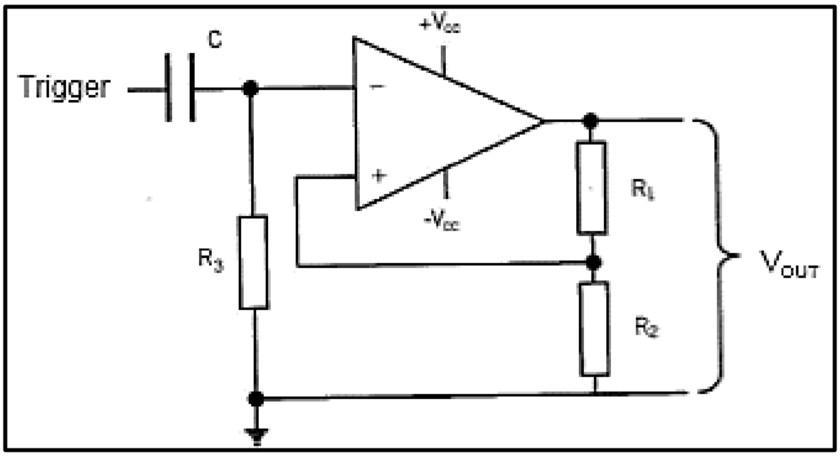


FIGURE 7.10

7.10.1 Identify the circuit in FIGURE 7.10. (1)

7.10.2 Name TWO applications for the circuit in QUESTION 7.10.1. (2)

7.11 7.11.1 What is a mono-stable multivibrator? (2)

7.11.2 Draw fully labelled waveforms of the input pulse and the output of a mono-stable multivibrator. Draw at least TWO cycles of these waveforms. (6)

7.12

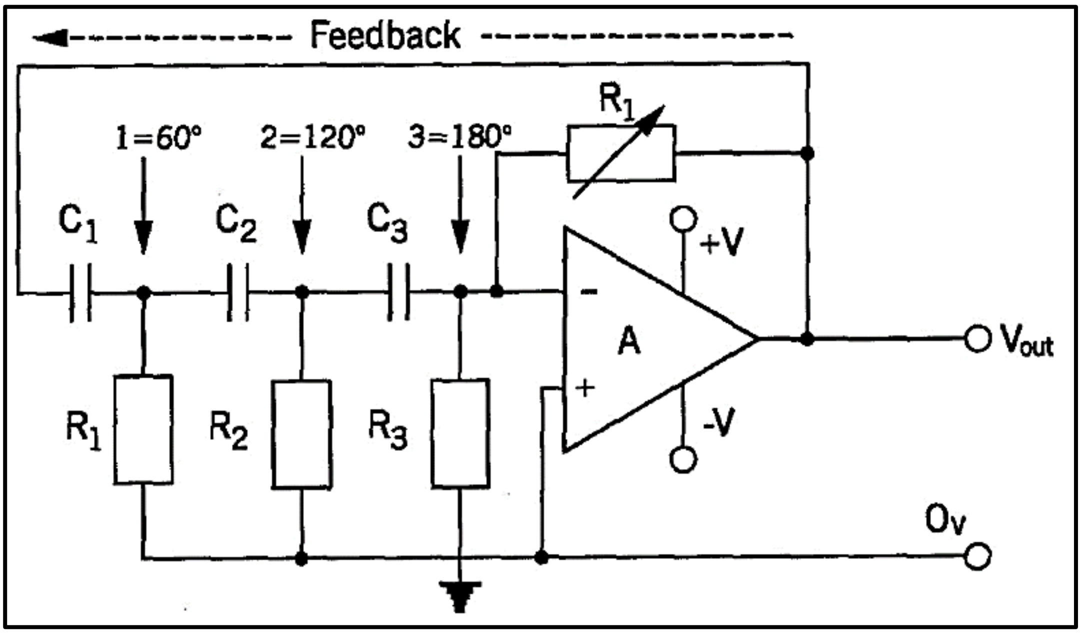


FIGURE 7.12

7.12.1 Identify the circuit in FIGURE 7.12. (1)

7.12.2 Calculate the oscillating frequency for an RC oscillator making use of three RC networks. Assume all resistor values are the same and all capacitor values are the same. The value of each resistor is 10 kΩ and that of each capacitor 250 pF. (3)

[50]

TOTAL: 200

FORMULA SHEET

THREE-PHASE AC GENERATION

Star

$V_L = \sqrt{3}\, v_{PH}$

$I_L = I_{PH}$

Delta

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

$V_L = V_{PH}$

$S = \sqrt{3}\, V_L I_L$

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

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

Two wattmeter method

$P_T = P_1 + P_2$

THREE-PHASE TRANSFORMERS

Star

$V_L = \sqrt{3}\, V_{PH}$

$I_L = I_{PH}$

Delta

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

$V_L = V_{PH}$

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

$S = \sqrt{3}\, V_L I_L$

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

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

$\frac{V_{PH(p)}}{V_{PH(S)}} = \frac{N_P}{N_S} = \frac{I_{PH(p)}}{I_{PH(S)}}$

RLC CIRCUITS

$X_L = 2\pi fL$

$X_c = \frac{1}{2\pi fc}$

Series

$I_T = I_R = I_C = I_L$

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

$V_L = I\, X_L$

$V_C = I\, X_C$

$V_T = I\, Z$

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

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

$\cos\theta = \frac{R}{Z}$

$\cos\theta = \frac{V_R}{V_T}$

Parallel

$V_T = V_R = V_C = V_L$

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

$I_C = \frac{V_c}{X_c}$

$I_L = \frac{V_L}{X_L}$

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

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

THREE-PHASE MOTORS AND STARTERS	AMPLIFIERS
Star $V_L = \sqrt{3}\, V_{PH}$ $I_L = I_{PH}$ **Delta** $I_L = \sqrt{3}\, I_{PH}$ $V_L = V_{PH}$ **Power** $P = \sqrt{3}\ V_L\, I_L \cos\theta$ $S = \sqrt{3}\ V_L\, I_L$ $Q = \sqrt{3}\ V_L\, I_L \sin\theta$ Efficiency $(\eta) = \frac{P_{in} - losses}{P_{in}}$ **Speed** $n_s = \frac{60 \times f}{p}$ Slip $= \frac{n_s - n_r}{n_s}$	Gain $A_V = \frac{V_{out}}{V_{in}} = -\left[\frac{R_f}{R_{in}}\right]$ Gain $A_V = \frac{V_{out}}{V_{in}} = 1 + \left[\frac{R_f}{R_{in}}\right]$ $f_r = \frac{1}{2\pi\sqrt{LC}}$ $f = \frac{1}{2\pi\sqrt{6RC}}$ **APPARENT POWER** $P_{APP} = \frac{P_{ACTIVE}}{\cos\theta}$