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# basic education

Department:  
Basic Education  
**REPUBLIC OF SOUTH AFRICA**

## **NATIONAL SENIOR CERTIFICATE**

**GRADE 12**

**ELECTRICAL TECHNOLOGY**

**FEBRUARY/MARCH 2013**

**MARKS: 200**

**TIME: 3 hours**

**This question paper consists of 10 pages and 1 formula sheet.**

**INSTRUCTIONS AND INFORMATION**

1. Answer ALL the questions.
2. Sketches and diagrams must be large, neat and fully labelled.
3. ALL calculations must be shown and must be correctly rounded off to TWO decimal places.
4. Number the answers correctly according to the numbering system used in this question paper.
5. Non-programmable calculators may be used.
6. The correct formula, substitution of values, answer and the unit must be shown in all calculations, where applicable.
7. A formula sheet is provided at the end of this question paper.
8. Write neatly and legibly.

**QUESTION 1: TECHNOLOGY, SOCIETY AND THE ENVIRONMENT**

- 1.1 Wind energy is used as a source to generate electrical power. State TWO advantages of wind energy over coal energy, with reference to the environment. (2)
- 1.2 Describe ONE positive impact of the development of solar energy on society. (2)
- 1.3 Inclusivity recognises equal rights for all people. Describe TWO measures that must be taken to allow wheelchair-bound learners to attend Electrical Technology classes. (2)
- 1.4 Discuss TWO skills that a successful entrepreneur should have. (4)  
**[10]**

**QUESTION 2: THE TECHNOLOGICAL PROCESS**

- 2.1 Describe the following terms with reference to the technological process:
- 2.1.1 Making (2)
- 2.1.2 Evaluating (2)
- 2.2 Name THREE methods of collecting data needed to evaluate a product. (3)
- 2.3 Name THREE key elements to be considered in the marketing of a product. (3)  
**[10]**

**QUESTION 3: OCCUPATIONAL HEALTH AND SAFETY**

- 3.1 Name ONE personal safety precaution that must be taken when using a grinding machine. (1)
- 3.2 Name TWO unsafe acts in a workshop. (2)
- 3.3 Name ONE unsafe condition in a workshop. (1)
- 3.4 Describe why it is important to wear surgical gloves when treating an open wound. (2)
- 3.5 State FOUR steps that must be followed when a person is electrically shocked (electrocuted). (4)  
**[10]**

**QUESTION 4: THREE-PHASE AC GENERATION**

- 4.1 State TWO advantages of three-phase generation over single-phase generation. (2)
- 4.2 State the value of the phase current in a star-connected system if the line current is 30 A. (1)
- 4.3 Draw a voltage phasor diagram of a three-phase delta-connected system. (4)
- 4.4 A small alternator supplies power to a balanced inductive load. The current in each phase of the alternator is 20 A and it lags the voltage by  $30^\circ$ . The phase voltage is 240 V. If the coils of the alternator are connected in star, calculate the total power generated by the alternator. (3)

Given:

$$I_{PH} = 20 \text{ A}$$

$$\theta = 30^\circ$$

$$V_{PH} = 240 \text{ V}$$

(3)  
[10]

**QUESTION 5: RLC CIRCUITS**

- 5.1 State how an increase in frequency will affect the following:
- 5.1.1 Inductive reactance (1)
- 5.1.2 Capacitive reactance (1)
- 5.2 State whether an increase in frequency affects the capacitance of a capacitor. (1)
- 5.3 Study FIGURE 5.1 below and answer the questions that follow.

Given:

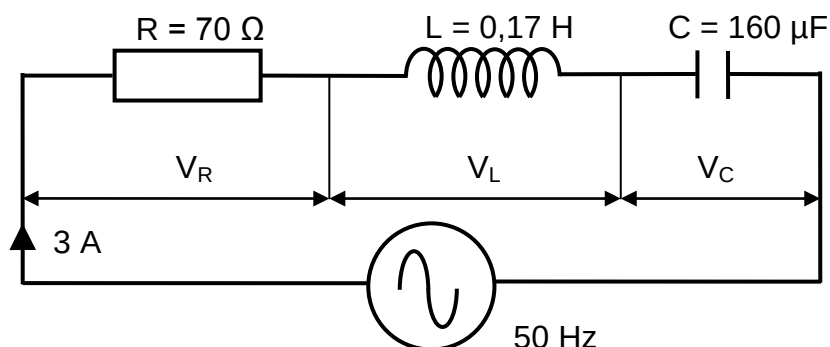
$$I_T = 3 \text{ A}$$

$$R = 70 \text{ } \Omega$$

$$L = 0,17 \text{ H}$$

$$C = 160 \text{ } \mu\text{F}$$

$$f = 50 \text{ Hz}$$



**FIGURE 5.1: RLC CIRCUIT**

Calculate the:

- 5.3.1 Voltage drop across the resistor (3)
- 5.3.2 Inductive reactance (3)

5.3.3 Voltage drop across the inductor (3)

5.3.4 Capacitive reactance (3)

5.3.5 Voltage drop across the capacitor (3)

5.4 Study FIGURE 5.2 below and answer the questions that follow.

Given:

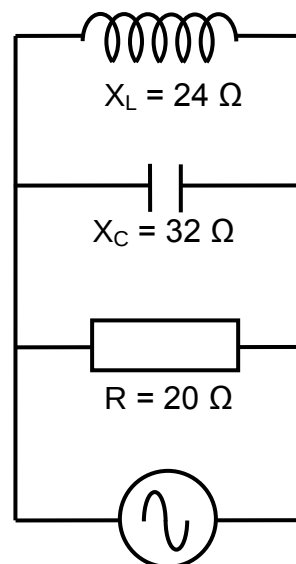
$$R = 20 \, \Omega$$

$$X_C = 32 \, \Omega$$

$$X_L = 24 \, \Omega$$

$$V = 240 \, \text{V}$$

$$f = 50 \, \text{Hz}$$



$$V = 240 \, \text{V}/50 \, \text{Hz}$$

**FIGURE 5.2: RLC CIRCUIT**

5.4.1 Calculate the current flowing through the resistor. (3)

5.4.2 Calculate the current flowing through the capacitor. (3)

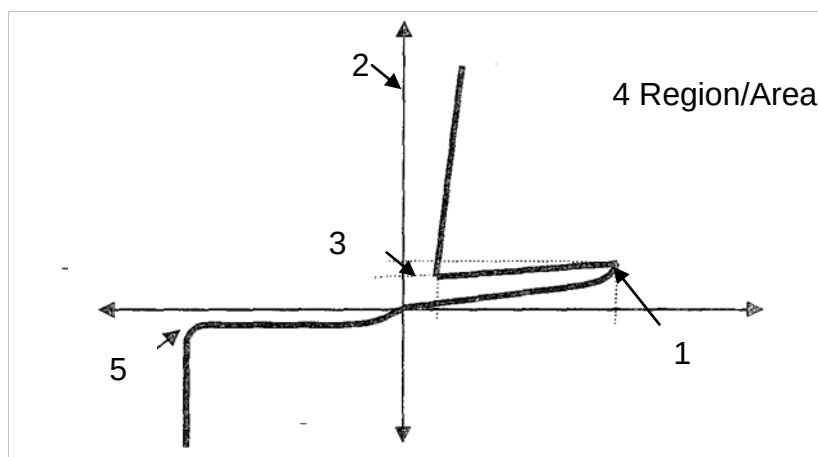
5.4.3 Calculate the current flowing through the inductor. (3)

5.4.4 State THREE conditions that would exist if the circuit is at resonant frequency. (3)

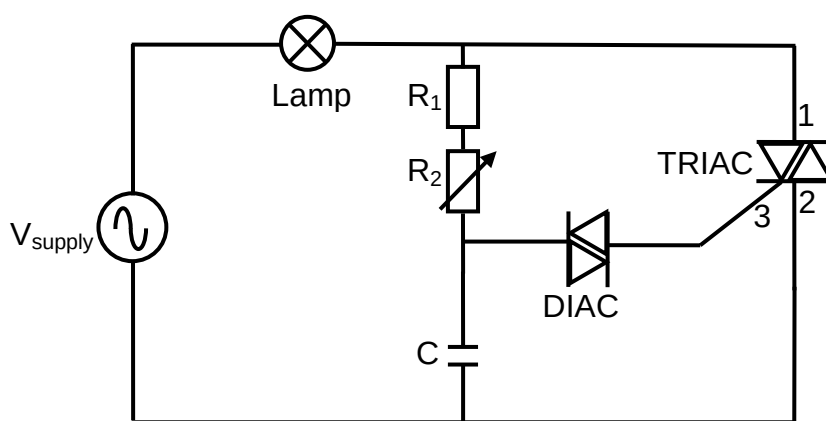
**[30]**

**QUESTION 6: SWITCHING AND CONTROL CIRCUITS**

- 6.1 Draw a fully labelled symbol of a silicon controlled rectifier (SCR). (3)
- 6.2 Describe how an SCR is switched on. (3)
- 6.3 State TWO applications of an SCR. (2)
- 6.4 FIGURE 6.1 below is the characteristic curve of an SCR. State what the labels **1** to **5** represent. (5)

**FIGURE 6.1: CHARACTERISTIC CURVE OF AN SCR**

- 6.5 Describe how a DIAC is switched on. (3)
- 6.6 The lamp-dimming circuit in FIGURE 6.2 below is connected to a 240 V/50 Hz supply. (5)

**FIGURE 6.2: LAMP-DIMMING CIRCUIT**

- 6.6.1 Label terminals **1** to **3** on the TRIAC. (3)
- 6.6.2 State the function of **R<sub>1</sub>**. (1)
- 6.6.3 Describe the disadvantage for the circuit if the DIAC is replaced by a diode. (4)
- 6.6.4 Name component **R<sub>2</sub>**. (1)
- [25]**

**QUESTION 7: AMPLIFIERS**

- 7.1 List FOUR characteristics of an ideal operational amplifier (op amp). (4)
- 7.2 State TWO advantages of op amp amplification over transistor amplification. (2)
- 7.3 Draw a circuit of a non-inverting op amp. (5)
- 7.4 Draw the input and output wave forms of the op amp in QUESTION 7.3, using a sinusoidal waveform as an input. Draw the wave forms on the same axis. (4)
- 7.5 Describe the working principle of an op amp. (2)
- 7.6 State TWO factors that influence the voltage gain of an op amp circuit. (2)
- 7.7 If one of the two input terminals of an op amp is grounded, explain what would happen to the output if the:
- 7.7.1 Input is connected to the inverting terminal (3)
- 7.7.2 Input is connected to the non-inverting terminal (3)
- [25]**

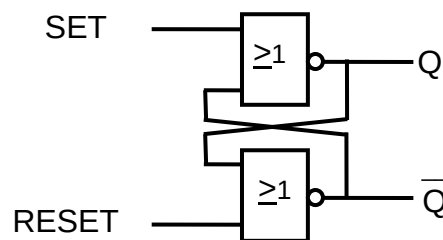
**QUESTION 8: THREE-PHASE TRANSFORMERS**

- 8.1 List FOUR types of losses that occur in transformers. (4)
- 8.2 In a step-down transformer, state whether the PRIMARY or SECONDARY winding will have a heavier gauge (thicker) conductor. (1)
- 8.3 State ONE application of a transformer. (1)
- 8.4 A three-phase 300 kVA transformer has a star-connected secondary winding with a phase voltage of 240 V at a lagging power factor of 0,8.
- Given:
- $S = 300 \text{ kVA}$   
 $V_{PH(S)} = 240 \text{ V}$   
 $Pf = 0,8$
- Calculate the:
- 8.4.1 Secondary line voltage (3)
- 8.4.2 Secondary phase current (3)
- 8.4.3 Output power at full load (3)
- [15]**



**QUESTION 9: LOGIC CONCEPTS AND PLCs**

- 9.1 Draw a block diagram of a programmable logic controller (PLC). (4)
- 9.2 State THREE advantages of PLC control over relay control. (3)
- 9.3 With reference to a NOT-gate, draw the following:
- 9.3.1 The logic symbol (2)
- 9.3.2 The circuit diagram, using a switch, a relay and a lamp to simulate the operation of the gate (5)
- 9.3.3 The ladder logic diagram (4)
- 9.4 FIGURE 9.1 below represents a bistable latch (RS latch) with the different inputs in the truth table. Redraw and complete the truth table for this latch in your ANSWER BOOK.

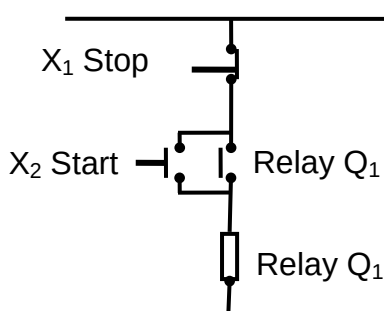


| SET | RESET | Q | $\bar{Q}$ |
|-----|-------|---|-----------|
| 0   | 0     |   |           |
| 0   | 1     |   |           |
| 1   | 0     |   |           |
| 0   | 1     |   |           |
| 1   | 0     |   |           |
| 1   | 1     |   |           |

**FIGURE 9.1: BISTABLE RS LATCH WITH TRUTH TABLE** (6)

- 9.5 The following operands are used in the programming of PLCs. Name TWO devices that can be used as:
- 9.5.1 Inputs (2)
- 9.5.2 Outputs (2)
- 9.6 With reference to PLCs, describe the term *program*. (2)

- 9.7 FIGURE 9.2 below represents the control circuit of a direct-on-line starter without an overload. Draw the ladder logic diagram of this starter.



**FIGURE 9.2: DIRECT-ON-LINE STARTER**

(5)  
[35]

### QUESTION 10: THREE-PHASE MOTORS AND CONTROL

- 10.1 Name ONE protective device used in three-phase motor control. (1)
- 10.2 Name TWO mechanical tests that must be carried out on a new three-phase motor. (2)
- 10.3 List THREE types of three-phase motor starters. (3)
- 10.4 Identify the nature of the power factor of a three-phase induction motor. (1)
- 10.5 Describe the purpose of no-volt protection with reference to motor control circuits. (3)
- 10.6 A three-phase delta-connected induction motor draws 14 A from a 415 V/50 Hz supply at a power factor of 0,8.

Given:

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

$$\cos \theta = 0,8$$

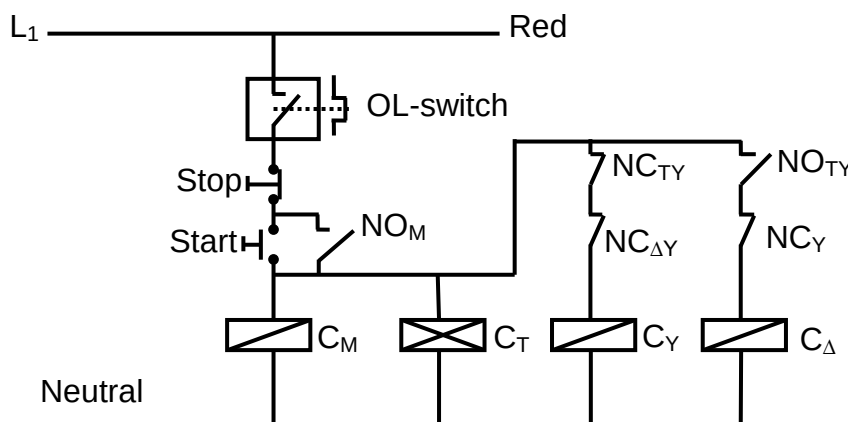
$$I_L = 14 \text{ A}$$

$$f = 50 \text{ Hz}$$

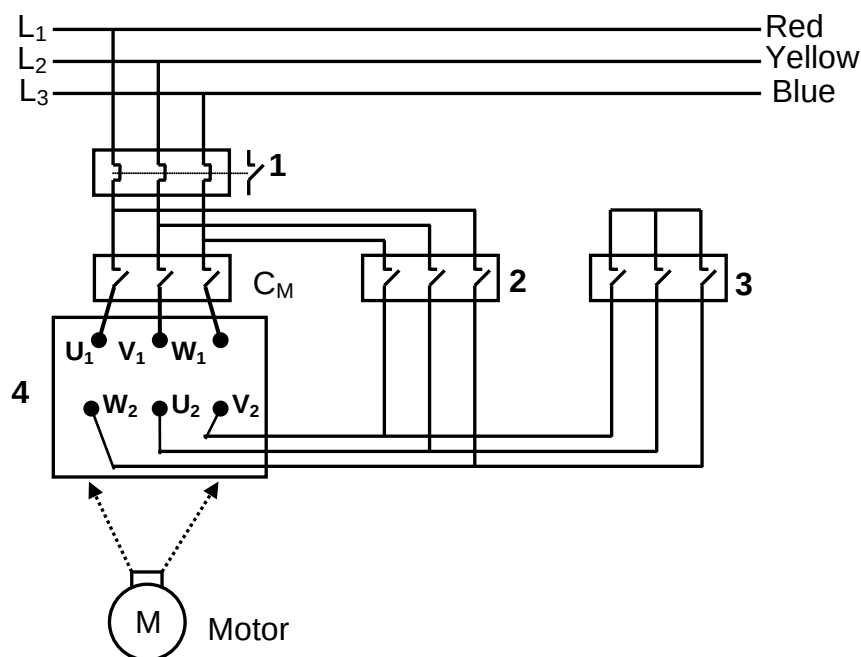
Calculate the:

- 10.6.1 Power of the motor at full load (3)
- 10.6.2 Phase current of the motor (3)

- 10.7 The diagrams in FIGURE 10.1 and FIGURE 10.2 below show a star-delta control and power circuit. With reference to these diagrams, answer the questions that follow.



**FIGURE 10.1: CONTROL CIRCUIT**



**FIGURE 10.2: POWER CIRCUIT**

- 10.7.1 With reference to the power circuit of the star-delta starter, label parts **1** to **4**. (4)
- 10.7.2 Explain the term *normally open* with reference to the control circuit. (3)
- 10.7.3 Describe the starting sequence of the control circuit. Refer to interlocking. (7)

[30]

**TOTAL: 200**

**FORMULA SHEET**

$$X_L = 2\pi fL$$

$$X_C = \frac{1}{2\pi fC}$$

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

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

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

$$V_R = IR$$

$$V_L = IX_L$$

$$V_C = IX_C$$

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

$$Q = \frac{X_L}{R} = \frac{V_L}{V_R}$$

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

$$\theta = \cos^{-1} \frac{I_R}{I_T}$$

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

$$\tan \theta = \frac{X_C}{R}$$

$$\theta = \tan^{-1} \frac{X_C}{R}$$

$$\left. \begin{aligned} P &= VI \cos \theta \\ S &= VI \\ Q &= VI \sin \theta \end{aligned} \right\} \text{Single-phase}$$

$$\left. \begin{aligned} P &= \sqrt{3} V_L I_L \cos \theta \\ P &= 3V_{ph} I_{ph} \cos \theta \\ S &= \sqrt{3} V_L I_L \\ Q &= \sqrt{3} V_L I_L \sin \theta \end{aligned} \right\} \text{Three-phase}$$

$$\left. \begin{aligned} V_L &= V_{ph} \\ I_L &= \sqrt{3} I_{ph} \end{aligned} \right\} \text{Delta}$$

$$\left. \begin{aligned} V_L &= \sqrt{3} V_{ph} \\ V_{ph} &= \frac{V_L}{\sqrt{3}} \end{aligned} \right\} \text{Star}$$

$$f = \frac{1}{T}$$

$$\frac{V_{ph(P)}}{V_{ph(S)}} = \frac{N_P}{N_S} = \frac{I_{ph(S)}}{I_{ph(P)}}$$