basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

# NATIONAL SENIOR CERTIFICATE

## GRADE 12

## ELECTRICAL TECHNOLOGY

## NOVEMBER 2013

**MARKS: 200**

**TIME: 3 hours**

**This question paper consists of 12 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. Show the units of answers for all calculations.
7. A formula sheet is attached at the end of this question paper.
8. Write neatly and legibly.

## QUESTION 1: TECHNOLOGY, SOCIETY AND THE ENVIRONMENT

1.1 The majority of electricity generated in South Africa uses coal as its primary source of energy.

1.1.1 State TWO environmentally friendly alternatives. (2)

1.1.2 Describe why it is important to look for alternatives to coal to generate electricity. (2)

1.2 The provision of electrical energy to all South Africans should be a basic human right.

1.2.1 Describe why access to electricity may have educational benefits. (2)

1.2.2 Describe ONE factor that may increase the cost of generating electricity. (2)

1.2.3 Explain why the provision of electricity to people's homes may reduce air pollution. (2)

**[10]**

## QUESTION 2: TECHNOLOGICAL PROCESS

2.1 Describe the function of the following FOUR subsystems in the design of an electrical system:

2.1.1 Input (2)

2.1.2 Process (2)

2.1.3 Output (2)

2.1.4 Power supply (2)

2.2 Describe why it is important to evaluate a PAT project on completion. (2)

**[10]**

## QUESTION 3: OCCUPATIONAL HEALTH AND SAFETY

3.1 Name TWO unsafe acts that can cause injuries in an electrical technology workshop. (2)

3.2 List THREE electrical safety devices that will cut off the power supply in an emergency. (3)

3.3 Name the type of fire extinguisher that must be used to combat electrical fires. (1)

3.4 State TWO safety precautions that must be taken when connecting a multimeter in a circuit to measure current. (2)

3.5 Describe why it is important to have good ventilation in a workshop. (2)

**[10]**

## QUESTION 4: THREE-PHASE AC GENERATION

4.1 State ONE advantage of a three-phase system over a single-phase system. (1)

4.2 Draw a delta-connected system showing the line and phase values of current and voltage. (4)

4.3 A three-phase balanced load is connected in star across a 380 V supply. At full load 60 kW, at a power factor of 0,85, is consumed.

Given:
$V_L$ = 380 V
$P_{out}$ = 60 kW
Cos θ = 0,85

4.3.1 Calculate the current drawn at full load. (3)

4.3.2 If the power factor of the load was improved to 0,98, describe what would happen to the current drawn at full load. (2)

**[10]**

## QUESTION 5: RLC CIRCUITS

5.1 Name TWO factors that influence the value of the capacitive reactance of a capacitor. (2)

5.2 Explain the term *inductive reactance* with reference to a coil. (2)

5.3 Describe how an increase in the number of turns on a coil will affect the inductive reactance of the coil. (2)

5.4 Draw the voltage and current waveforms on the same axis of the following when connected in an AC circuit:

5.4.1 A pure resistor (2)

5.4.2 A pure coil (2)

5.5 A series circuit with a 200 µF capacitor, a 180 mH inductor and a resistor of 10 Ω is connected to a 220 V/50 Hz supply.

Given:

$C = 200\ \mu F$
$L = 180\ mH$
$R = 10\ \Omega$
$V_S = 220\ V$
$f = 50\ Hz$

Calculate:

5.5.1 The inductive reactance of the inductor (3)

5.5.2 The capacitive reactance of the capacitor (3)

5.5.3 The impedance of the circuit (3)

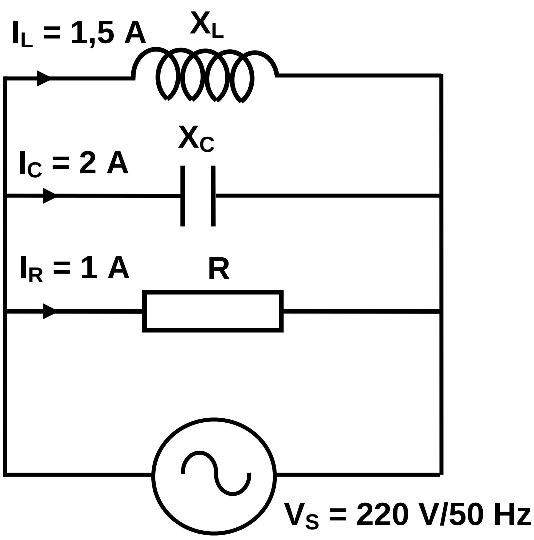
5.5.4 The current through the circuit (3)

5.5.5 Draw the phasor diagram showing the current and voltages in the circuit. (5)

5.6 FIGURE 5.1 represents a parallel RLC circuit. Calculate the supply current of the circuit.

Given:

$I_L = 1,5\ A$
$I_C = 2\ A$
$I_R = 1\ A$
$V_S = 220\ V$
$f = 50\ Hz$




(3)

**FIGURE 5.1: PARALLEL RLC CIRCUIT** **[30]**

## QUESTION 6: SWITCHING AND CONTROL CIRCUITS

6.1 Draw a fully labelled symbol of an SCR. (3)

6.2 State TWO applications of an SCR. (2)

6.3 Describe how an SCR is switched on using a controlled gate pulse. (3)

6.4 Explain what determines the physical size of an SCR. (2)

6.5 Describe how a DIAC is switched on. (3)

6.6 The lamp dimming circuit in FIGURE 6.1 below is connected to a 220 V/50 Hz supply.

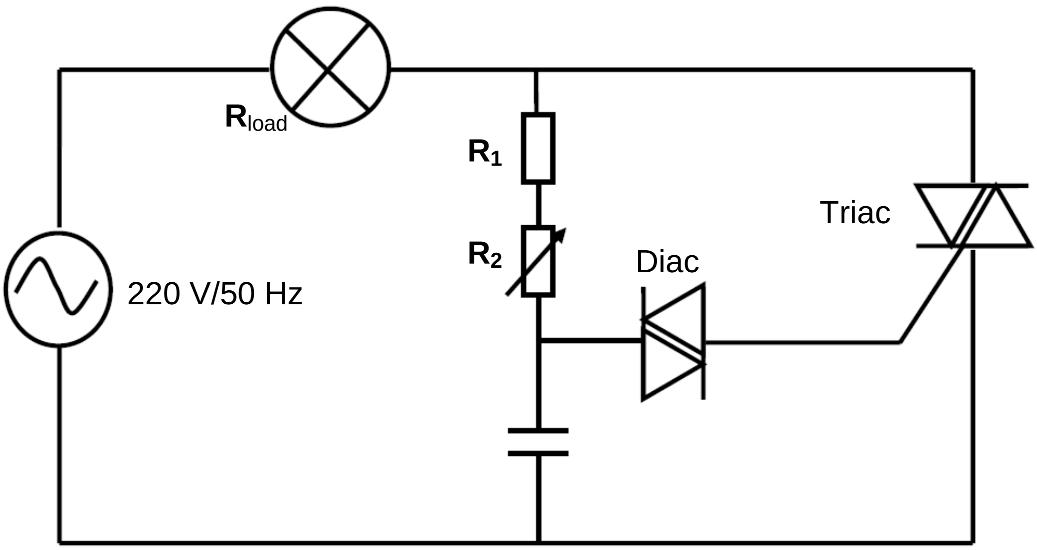



**FIGURE 6.1: LAMP DIMMING CIRCUIT**

6.6.1 Describe the function of the DIAC. (2)

6.6.2 If the value of $R_2$ is increased the brightness of the lamp will decrease. Explain how this occurs. (5)

6.7 The characteristic curve of a TRIAC is shown in FIGURE 6.2 below.

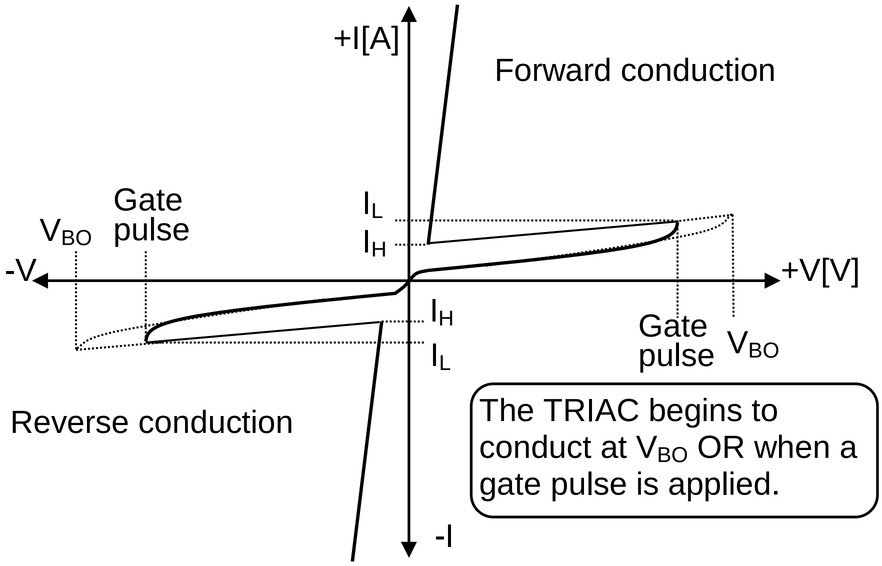



**FIGURE 6.2: CHARACTERISTIC CURVE OF A TRIAC**

6.7.1 Describe how the voltage will be affected when the TRIAC begins to conduct. (3)

6.7.2 Explain the term *holding current* marked $I_H$ on the characteristic curve. (2)
**[25]**

**QUESTION 7: AMPLIFIERS**

7.1 With reference to positive feedback:

7.1.1 Describe the term *positive feedback*. (3)

7.1.2 Name the main disadvantage of positive feedback. (1)

7.1.3 State ONE application of positive feedback in amplifiers. (1)

7.2 FIGURE 7.1 below is the symbol of an op-amp. Identify the labels marked **1**, **2** and **3**.

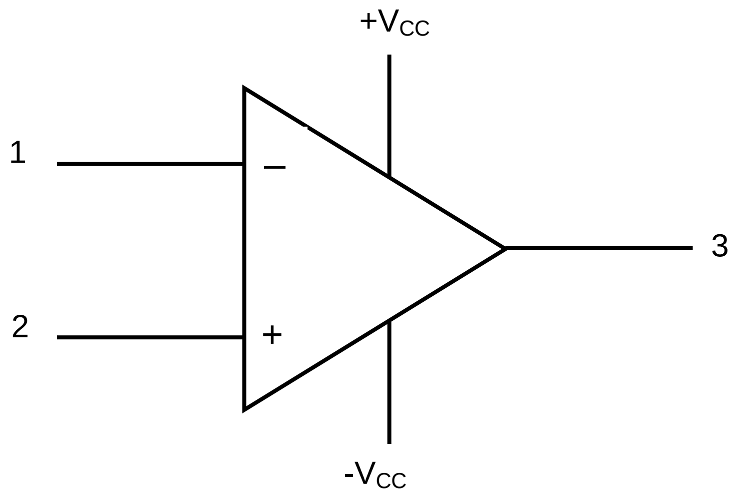



**FIGURE 7.1: OP-AMP SYMBOL** (3)

7.3 FIGURE 7.2 below is an op-amp circuit.

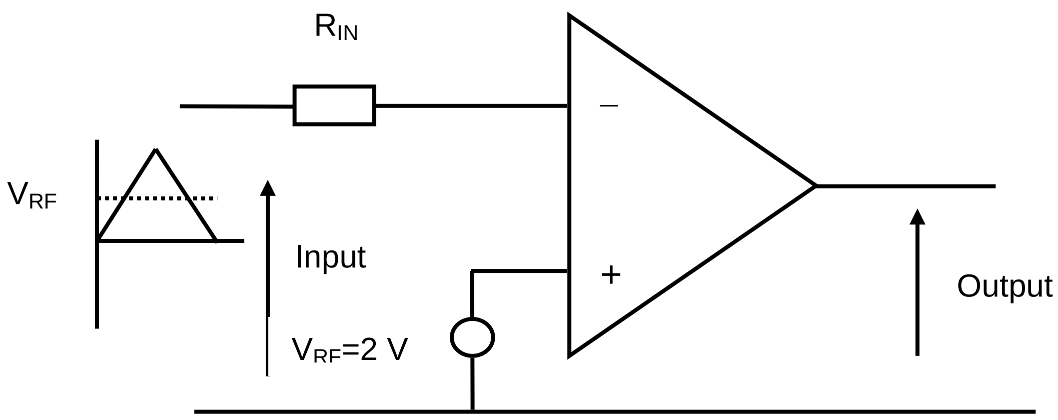



**FIGURE 7.2: OP-AMP CIRCUIT**

7.3.1 Name the op-amp circuit. (1)

7.3.2 Draw the input and output waveforms on the same axis. (5)

7.3.3 Describe the function of the reference voltage. (3)

7.4 Draw a non-inverting amplifier circuit using an op-amp. (5)

7.5 Explain how a non-inverting op-amp may be converted into a voltage follower. (3)

**[25]**

## QUESTION 8: THREE-PHASE TRANSFORMERS

8.1 Name ONE practical application of a transformer. (1)

8.2 Describe the basic operation of a transformer. (5)

8.3 If the load of an ideal transformer was doubled, what effect would it have on the following:

8.3.1 Input power (1)

8.3.2 Current (1)

8.3.3 Voltage (1)

8.4 A delta-star connected transformer supplies a factory with 66 kW at a power factor of 0,85. The primary line voltage is 11 kV, the secondary line voltage is 380 V. The transformer is 100% efficient.

Given:
$P_{out}$ = 66 kW
$V_{L(p)}$ = 11 kV
$V_{L(s)}$ = 380 V
$\cos\theta$ = 0,85

Calculate:

8.4.1 The secondary line current (3)

8.4.2 The primary line current (3)
**[15]**

## QUESTION 9: LOGIC CONCEPTS AND PLCs

9.1 Name TWO practical applications of a PLC. (2)

9.2 Describe the function of the following PLC components:

9.2.1 Memory (2)

9.2.2 CPU (2)

9.2.3 Input interfaces (2)

9.3 Name THREE types of programming languages used in PLC programming. (3)

9.4 The circuit in FIGURE 9.1 below represents a relay logic function.

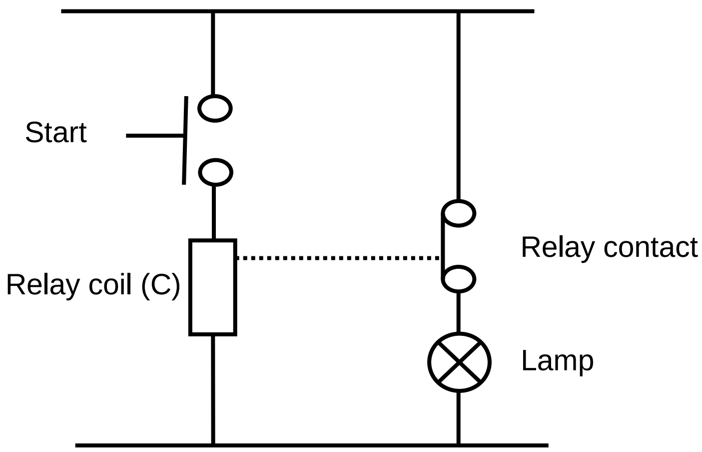



**FIGURE 9.1: RELAY CIRCUIT**

9.4.1 Name the logic function this circuit represents. (1)

9.4.2 Draw the equivalent logic symbol for this circuit. (2)

9.4.3 Draw the truth table of the logic function. (2)

9.4.4 Draw the ladder diagram of this circuit. (5)

9.5 FIGURE 9.2 below represents a ladder logic diagram.

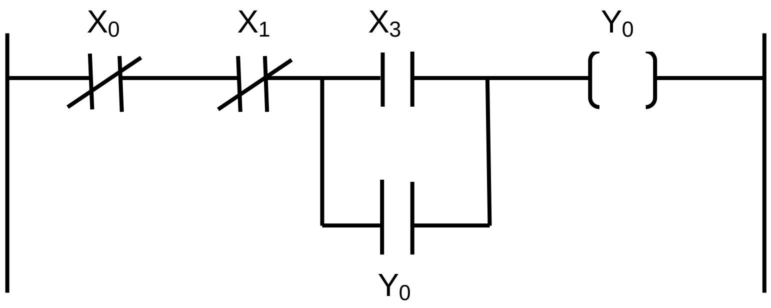



**FIGURE 9.2: LADDER LOGIC DIAGRAM**

9.5.1 Identify the control circuit represented in the ladder logic diagram. (1)

9.5.2 Draw the relay control circuit that represents the ladder diagram in FIGURE 9.2. (6)

9.6 Describe the following advantages of PLC control over relay control:

9.6.1 Simplified design (2)

9.6.2 Improved reliability (2)

9.6.3 Compactness and standardisation (2)

9.7 Name a digital device that may be used to count bottles in a cold drink factory. (1)
**[35]**

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

10.1 State the TWO modes in which a three-phase stator winding may be connected. (2)

10.2 Name THREE electrical tests that must be carried out on the stator winding of a motor before installation. (3)

10.3 Name TWO mechanical inspections that must be carried out on a motor during maintenance. (2)

10.4 State how the direction of rotation of a three-phase induction motor may be reversed. (1)

10.5 State TWO advantages of three-phase motors over single-phase motors. (2)

10.6 A three-phase 17 kW induction motor is connected in delta to a 380 V/50 Hz supply. The motor is 100% efficient with a power factor of 0,8 at full load.

Given:
P = 17 kW
$V_L$ = 380 V
f = 50 Hz
η = 100%
Cos θ = 0,8

Calculate:

10.6.1 The current drawn from the supply (3)

10.6.2 The apparent power of the motor (3)

10.7 Explain why the casing of a three-phase motor must be earthed. (2)

10.8 List THREE safety devices that must be included in a motor starter circuit. (3)

10.9 Describe ONE possible cause of overheating of a three-phase induction motor. (2)

10.10 Describe the term *normally open* with reference to electromagnetic relays. (2)

10.11 Explain the function of the end shield of the motor. (2)

10.12 Describe the purpose of using electrical switchgear in three-phase motor-control circuits. (3)
**[30]**

**TOTAL: 200**

## FORMULA SHEET

$$X_L = 2\pi FL$$

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

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

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

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

$$V_R = IR$$

$$V_L = IX_L$$

$$V_C = IX_C$$

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

$$Q = \frac{1}{R}\sqrt{\frac{L}{C}}$$

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

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

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

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

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

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

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

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

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