basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

ELECTRICAL TECHNOLOGY

NOVEMBER 2010

MARKS: 200

TIME: 3 hours

This question paper consists of 11 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 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.

QUESTION 1: TECHNOLOGY, SOCIETY AND THE ENVIRONMENT

1.1 Coal is the primary source of energy in South Africa. State FOUR examples of renewable energy sources. (4)

1.2 List FOUR competencies that are required of a successful entrepreneur. (4)

1.3 Why is it important to wear surgical gloves when treating an open wound? Give TWO reasons. (2)
[10]

QUESTION 2: TECHNOLOGICAL PROCESS

Mr Gumede and Mr Vermeulen are neighbours in adjacent flats. Each flat has a gate entrance. The two individual gates lead to the main gate outside. These two gates are currently non-self-locking. Recently they have been experiencing burglaries and criminals have gained access to their flats.

2.1 Identify the problem of the two neighbours in the above scenario in an electrical context. (2)

2.2 Write down the solution to the problem in QUESTION 2.1 in an electrical context. Name at least TWO additional devices that can be linked to the solution above. (5)

2.3 Draw a block diagram of the solution indicating the action that relates to the following:

- Input
- Process
- Output (3)

[10]

QUESTION 3: OCCUPATIONAL HEALTH AND SAFETY

3.1 Explain the negative impact HIV/Aids has on productivity in the electrical workshop. (3)

3.2 Name ONE safety precaution that must be taken when using a portable drilling machine. (1)

3.3 Explain why the precaution in QUESTION 3.2 must be taken. (2)

3.4 State ONE unsafe condition that may lead to an accident in an electrical technology workshop. (1)

3.5 Whose responsibility is it to maintain safety in an electrical technology workshop? Motivate the answer. (3)
[10]

QUESTION 4: THREE-PHASE AC GENERATION

4.1 State the function of a kilowatt-hour meter. (1)

4.2 State ONE advantage that a three-phase system has over that of a single-phase system. (1)

4.3 How many degrees apart are the three coils placed in three-phase generation? (1)

4.4 Draw a voltage phasor diagram that represents a three-phase supply. (4)

4.5 A three-phase balanced load is connected in star across a 415 V/ 50 Hz supply. At full load the load consumes 6 kW when the power factor of the load is 0,85 lagging. Calculate the line current drawn by the load.

Given: V_L = 415 V
f = 50 Hz
P = 6 kW
Cos θ = 0,85 (3)
[10]

QUESTION 5: RLC CIRCUITS

5.1 Complete the following sentences by writing down the missing word:

5.1.1 The current in a capacitor ... the voltage across a capacitor by 90°. (1)

5.1.2 An inductor is made up of insulated copper wire which is wound around a core to form a ... (1)

5.2 If the frequency of the supply voltage connected across an RLC circuit is increased, state how it will affect the following:

5.2.1 The capacitive reactance of the capacitor (1)

5.2.2 The inductive reactance of the coil (1)

5.3 An AC circuit comprises a 12 Ω resistor, a 150 mH inductor and a 47 µF capacitor all connected in series across a 240 V/50 Hz AC supply. Answer the following questions:

Given: R = 12 Ω
L = 150 mH
C = 47 µF
F = 50 Hz

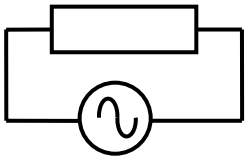
5.3.1 Draw a fully labelled circuit diagram. (4)

5.3.2 Calculate the frequency at which the circuit will resonate. (3)

5.3.3 Determine, by calculation, the inductive reactance of the circuit. (3)

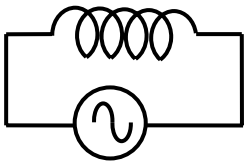
5.4 Study the electrical circuits in FIGURE 5.1 below. Draw, on the same set of axes, for each circuit, the graphical representation of the current and the voltage for that component.

5.4.1



(2)

5.4.2

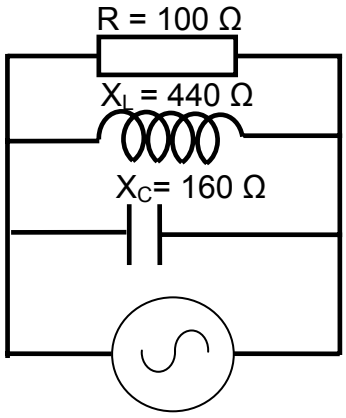


(2)

FIGURE 5.1: AC CIRCUITS

5.5 A 100 Ω resistor, an inductor with an inductive reactance of 440 Ω and a capacitor with a capacitive reactance of 160 Ω are all connected in parallel across a 240 V/50 Hz supply.

Given: $R = 100\ \Omega$
$X_L = 440\ \Omega$
$X_C = 160\ \Omega$
$V = 240\ V$
$F = 50\ Hz$



Calculate the following:

5.5.1 The current through the resistor (3)

5.5.2 The current flowing through the inductor (3)

5.5.3 The current change in the capacitor (3)

5.5.4 The total current flowing through the circuit (3)
[30]

QUESTION 6: SWITCHING AND CONTROL CIRCUITS

6.1 The diagram in FIGURE 6.1 below shows the characteristic curve of an SCR.

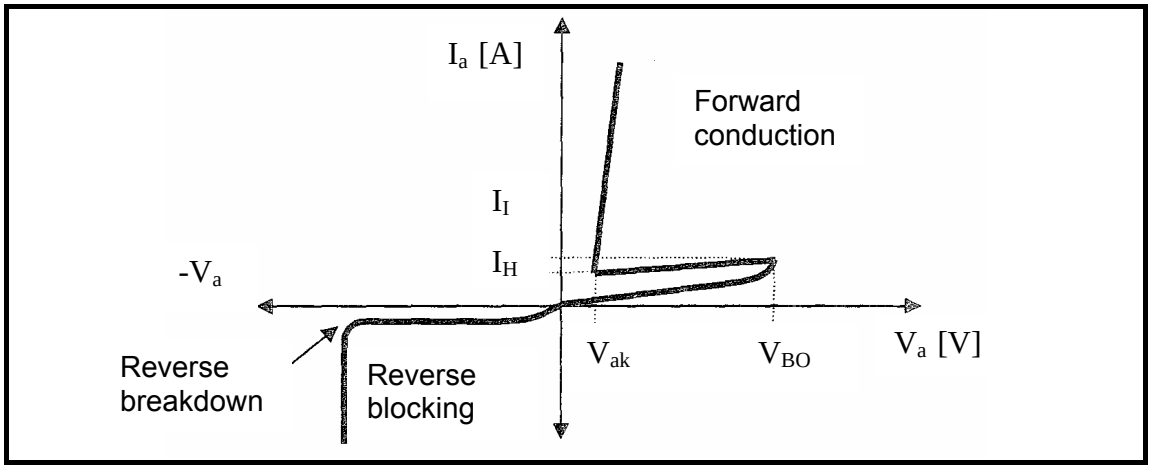


FIGURE 6.1: CHARACTERISTIC CURVE OF AN SCR

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

6.1.2 State how an SCR is switched on. (2)

6.1.3 State how an SCR is switched off. (2)

6.1.4 What happens to the SCR at the reverse breakdown voltage? (2)

6.1.5 State what occurs at $V_{BO.}$ (2)

6.2 Describe ONE disadvantage of an SCR in AC applications. (2)

6.3 The lamp dimming circuit in FIGURE 6.2 below is connected to a 240 V/50 Hz supply.

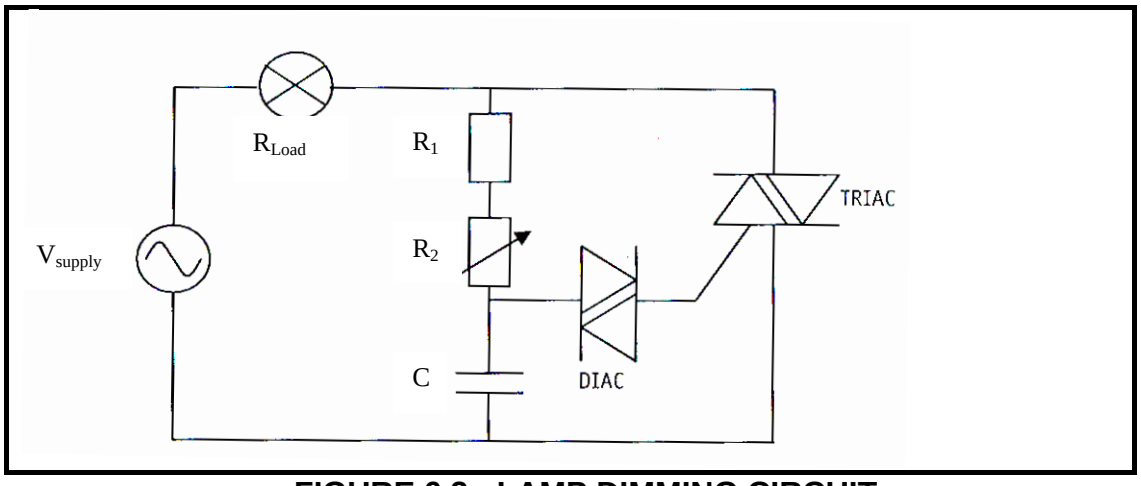


FIGURE 6.2: LAMP DIMMING CIRCUIT

6.3.1 What is the function of R_1? (2)

6.3.2 What is the function of R_2? (2)

6.3.3 Describe what would happen to the brightness of the lamp if the value of R_2 is increased. (4)

6.3.4 What is the function of the DIAC? (2)

6.4 Describe the factors that determine the physical size of a TRIAC. (2)
[25]

QUESTION 7: AMPLIFIERS

7.1 State the function of an amplifier. (1)

7.2 With reference to the operational amplifier in FIGURE 7.1 below, answer the following questions.

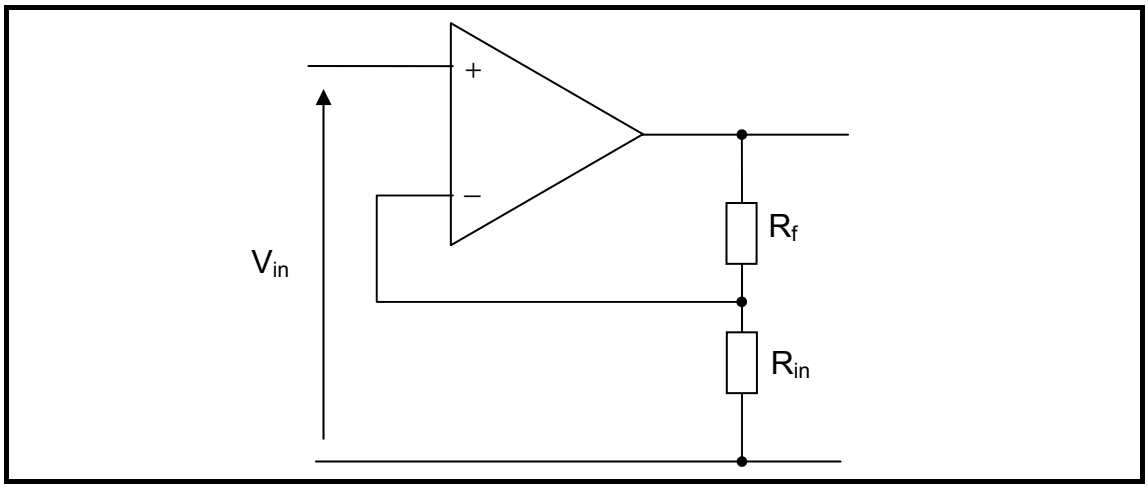


FIGURE 7.1

7.2.1 Name the circuit in FIGURE 7.1. (1)

7.2.2 Draw the output wave form if the input wave form is a sine wave. (2)

7.2.3 What will happen to the circuit if R_f is very low (short circuit) and R_{in} is made very high (infinite)? (4)

7.3 With reference to an operational amplifier, answer the following questions:

7.3.1 Name the ideal characteristics of an operational amplifier. (3)

7.3.2 What is meant by *open loop* gain? (3)

7.3.3 State TWO advantages of negative feedback. (2)

7.4 Operational amplifiers are commonly used in complex circuits (between stages) to link the stages. State, with a reason, the application (function) of the operational amplifier when utilised between stages. (2)

7.5 A comparator circuit compares two electrical signals. State, with a reason, the nature of the output if both signals have exactly the same value. (2)

7.6 Where would you use a non-inverting amplifier? Give ONE example to illustrate your answer. (2)

7.7 FIGURE 7.2 below is a circuit diagram of an operational amplifier.

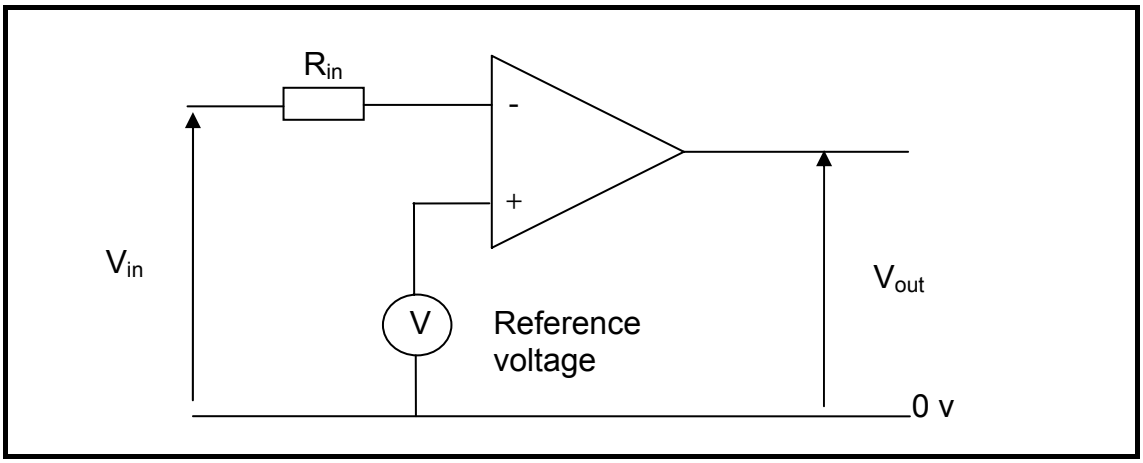


FIGURE 7.2: OPERATIONAL AMPLIFIER CIRCUIT

7.7.1 State in which mode the operational amplifier is connected. (1)

7.7.2 Draw the output wave for the circuit in FIGURE 7.2 if the input is a triangular wave. (2)

[25]

QUESTION 8: THREE-PHASE TRANSFORMERS

8.1 Explain what will happen to the primary current of an ideal transformer if the load is doubled. (2)

8.2 Three-phase transformers may be connected in different transformer configurations. Draw a star-delta transformer configuration. The coil of each phase must be shown on your drawings. (2)

8.3 State why the core of a transformer is laminated using silicon steel which has a high internal resistance. (1)

8.4 What causes heat build-up in transformers? (1)

8.5 A 250 kVA, three-phase transformer with 400 turns on the primary is connected in delta-star. The supply voltage is 6 600 V. The full-load line current on the primary is 20 A, the secondary line voltage is 415 V and the power factor is 0,9.

Given: $S = 250$ kVA
$N_p = 400$
$V_{L(p)} = 6\,600$ V
$I_{L(s)} = 415$ V
$\cos \theta = 0,9$

Calculate:

8.5.1 The secondary phase voltage (3)

8.5.2 The turns ratio (3)

8.5.3 The secondary current of the transformer at full load (3)
[15]

QUESTION 9: LOGIC CONCEPTS AND PLCs

9.1 List THREE advantages of programmable logic over relay logic. (3)

9.2 With reference to an OR-gate, draw the following:

9.2.1 A circuit diagram made up of switches and a lamp (4)

9.2.2 The ladder diagram (3)

9.3 With reference to the ladder diagram in FIGURE 9.1 below, answer the following questions.

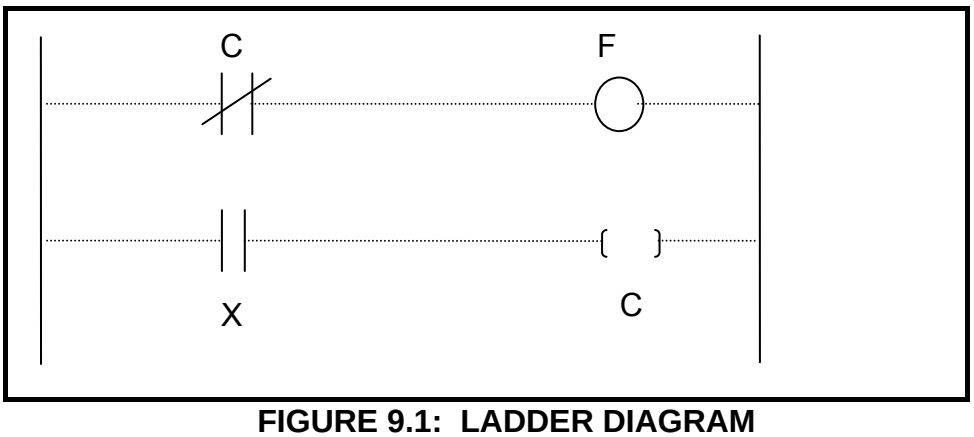


FIGURE 9.1: LADDER DIAGRAM

9.3.1 Draw the relay circuit of the ladder diagram in FIGURE 9.1. (5)

9.3.2 Name the logic function the circuit will perform. (1)

9.3.3 Write down the truth table for the circuit in FIGURE 9.1. (3)

9.4 The following operands are used in the programming of programmable logic controllers. Write down TWO examples of each.

9.4.1 Inputs (2)

9.4.2 Outputs (2)

9.4.3 Internal relays/flags or markers (2)

9.5 Explain the following terms with reference to programmable logic controllers:

9.5.1 Economical (1)

9.5.2 Reduced maintenance (2)

9.5.3 Ladder logic (1)

9.6 Draw the logic gate diagram that would represent the following Boolean expression:

$$(A.B+\overline{C})+(A.D)+C=F$$

(6)
[35]

QUESTION 10: THREE-PHASE MOTORS AND CONTROL

10.1 With reference to a star-delta starter, answer the following questions:

10.1.1 State the function of the starter. (1)

10.1.2 Describe how it achieves this function. (3)

10.2 State how the direction of rotation of a three-phase motor may be changed. (2)

10.3 A three-phase delta connected motor develops 8 kW at full load when the motor is connected across a 415 V/50 Hz supply. If the motor has a power factor of 0,85 and an efficiency of 100%, calculate:

Given: $P = 8$ kW
$V_L = 415$ V
$\cos\theta = 0{,}85$
$f = 50$ Hz

10.3.1 The current drawn by the motor at full load (3)

10.3.2 The apparent power of the motor (3)

10.4 Basic mechanical and electrical inspections should be carried out on three-phase motors before they are put into use.

10.4.1 State TWO electrical inspections. (2)

10.4.2 State TWO mechanical inspections. (2)

10.5 The circuit diagram shown in FIGURE 10.1 below represents the control circuit and power circuit of a direct-on-line starter.

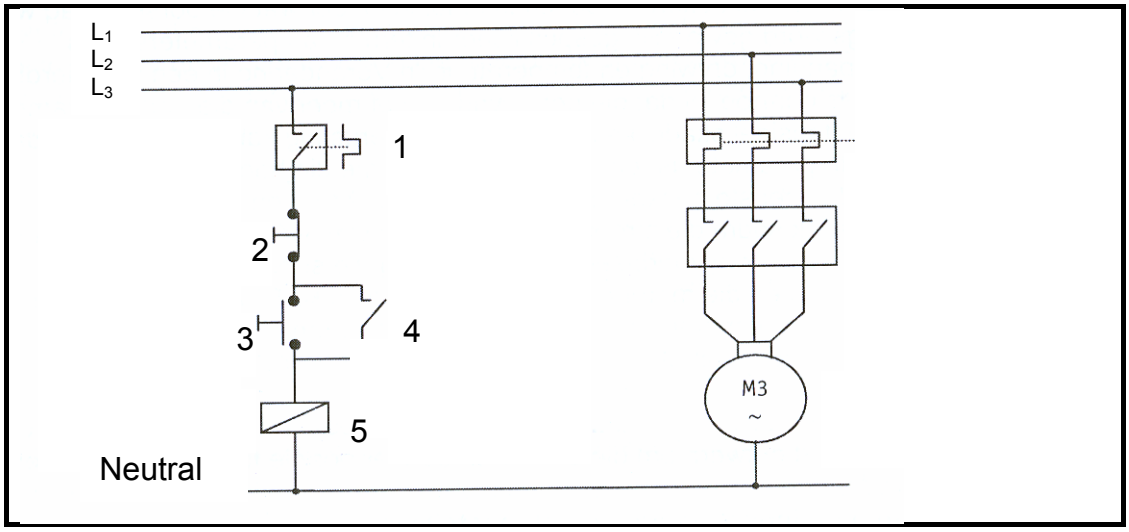


FIGURE 10.1

10.5.1 Name the parts marked 1 to 5. (5)

10.5.2 Describe the protection that the component labelled 4 offers to the motor. (3)

10.5.3 Describe the principle of operation of an overload unit in a direct-on-line starter. (4)

10.6 Name TWO losses that occur in three-phase electrical motors. (2)
[30]

TOTAL: 200

FORMULA SHEET

$$X_L = 2\pi FL$$

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

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

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

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

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

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

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

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

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

$$P = VI\cos\theta$$
$$S = VI$$
$$Q = VI\sin\theta$$

} Single phase/ Enkelfase

$$V_R = IR$$
$$V_L = IX_L$$
$$V_C = IX_C$$

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

} Three phase/ Driefase

$$V_L = V_{Ph}$$
$$I_L = \sqrt{3} I_{Ph}$$

} Delta

$$V_L = \sqrt{3}\, V_{Ph}$$
$$I_L = I_{Ph}$$

} Star/Ster

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

$$\frac{V_1}{V_2} = \frac{N_1}{N_2} = \frac{I_2}{I_1}$$

$$\beta = \frac{I_c}{I_b}$$

$$I_b = I_e - I_c$$