basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

ELECTRICAL TECHNOLOGY

NOVEMBER 2011

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 unit for all answers of calculations.

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 List THREE disadvantages of a nuclear power station, based on the recent earthquake in Japan. Refer to the environment. (3)

1.2 The majority of power stations in South Africa are coal fired. Name TWO environmentally friendly alternatives. (2)

1.3 Explain why HIV/Aids can have a negative impact on the workforce of the country. (3)

1.4 State TWO skills that a successful entrepreneur should have. (2)
[10]

QUESTION 2: TECHNOLOGICAL PROCESS

2.1 The technological process has four steps. Describe the following TWO steps with regard to a step-up transformer:

2.1.1 Process (2)

2.1.2 Output (2)

2.2 Describe why it is important to evaluate a completed electrical product against the original design of the product. (3)

2.3 List THREE appropriate methods of marketing a product. (3)
[10]

QUESTION 3: OCCUPATIONAL HEALTH AND SAFETY

3.1 Name TWO electrical safety devices that protect equipment under fault conditions. (2)

3.2 Fault-finding is done on a motor control panel. Name and describe ONE safety precaution that must be taken before the test is started. (2)

3.3 Explain why no person under the influence of drugs may enter or remain in a workplace where machinery is used. (2)

3.4 Name and describe TWO safety precautions that must be taken when working with portable electrical equipment. (4)
[10]

QUESTION 4: THREE-PHASE AC GENERATION

4.1 Give ONE reason why electricity is generated in three phase and not in single phase. (1)

4.2 Determine the value of the line current if the phase current is 300 A in a delta-connected system.

Given:

$I_{ph} = 300\ A$ (3)

4.3 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°. The phase voltage is 220 V. The coils of the alternator are connected in star.

Given:

$I_{ph} = 20\ A$

$\theta = 30^\circ$

$V_{ph} = 220\ V$

Calculate:

4.3.1 The line voltage (3)

4.3.2 The power supplied by the alternator at full load (3)

[10]

QUESTION 5: RLC CIRCUITS

5.1 State how an increase in frequency will affect the capacitive reactance of a capacitor. (1)

5.2 State how a decrease in frequency will affect the inductive reactance of an inductor. (1)

5.3 Explain the term *impedance* with reference to an RLC circuit. (2)

5.4 Refer to FIGURE 5.1.

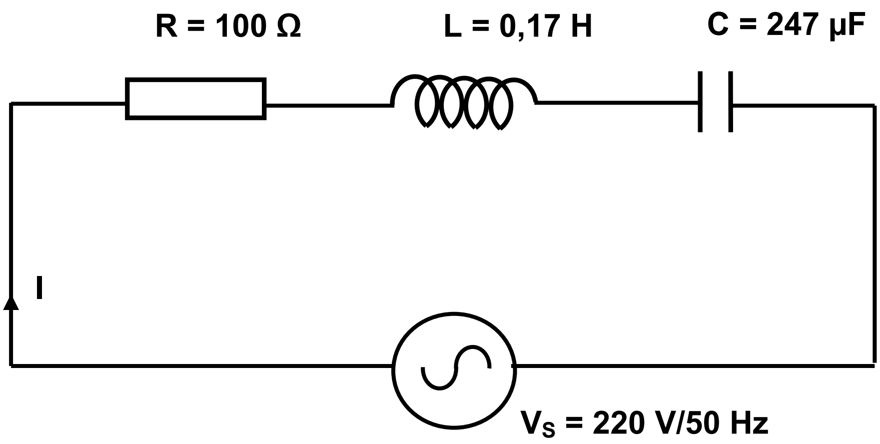

FIGURE 5.1: RLC SERIES CIRCUIT

Given:

C= 247 μF

L = 0,17 H

R = 100 Ω

V_s = 220 V

f = 50 Hz

Calculate:

5.4.1 The capacitive reactance of the capacitor (3)

5.4.2 The inductive reactance of the inductor (3)

5.4.3 The impedance of the circuit (3)

5.5 Refer to FIGURE 5.2.

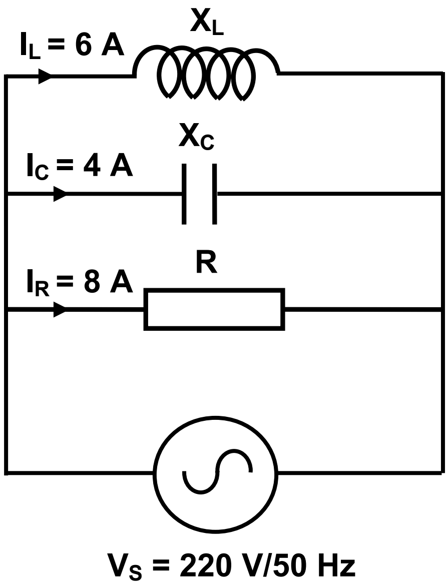

FIGURE 5.2: RLC PARALLEL CIRCUIT

Given:

I_L = 6 A

I_C = 4 A

I_R = 8 A

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 resistance of the resistor (3)

5.5.4 The supply current of the circuit (3)

5.6 Draw the phasor diagram of the above circuit. Indicate the direction of rotation. (5)

[30]

QUESTION 6: SWITCHING AND CONTROL CIRCUITS

6.1 The diagram in FIGURE 6.1 shows the characteristic curve of a DIAC.

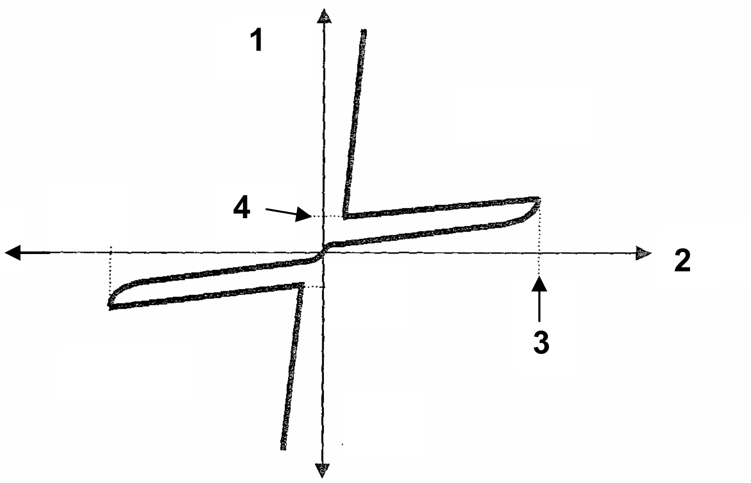

FIGURE 6.1: CHARACTERISTIC CURVE OF A DIAC

6.1.1 Name the unit of the axes numbered **1** and **2** and the labels numbered **3** and **4**. (4)

6.1.2 Draw a fully labelled symbol of a DIAC. (2)

6.1.3 With the aid of the characteristic curve shown in FIGURE 6.1, describe how a DIAC is switched on. (4)

6.2 Draw a fully labelled symbol of a TRIAC. (3)

6.3 Describe how a TRIAC is switched on. (3)

6.4 The circuit diagram in FIGURE 6.2 is connected to a 220 V/50 Hz supply. The circuit makes use of a SCR to control the temperature of the soldering iron indicated as resistor R_3.

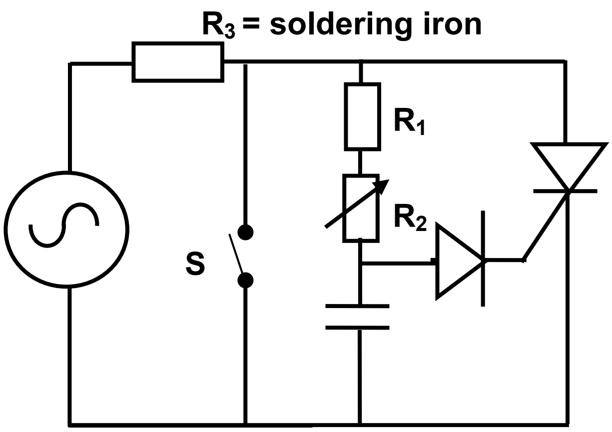

FIGURE 6.2: TEMPERATURE CONTROL

6.4.1 If S is closed, what will the voltage across the soldering iron be? (1)

6.4.2 When S is open, the temperature control part of the circuit becomes active. Explain what will happen to the temperature of the soldering iron if the value of R_2 is increased. (5)

6.4.3 What disadvantage does an SCR have in AC circuits? (1)

6.5 Explain why the current rating plays an important role in determining the physical size of an SCR. (2)
[25]

QUESTION 7: AMPLIFIERS

7.1 Name TWO applications of an operational amplifier (op amp). (2)

7.2 Name ONE disadvantage of an operational amplifier (op amp). (1)

7.3 List THREE characteristics of an ideal operational amplifier (op amp). (3)

7.4 Describe the term *open loop* with reference to an operational amplifier (op amp). (3)

7.5 Draw the diagram of an operational amplifier (op amp) as an inverting voltage comparator. (5)

7.6 Refer to FIGURE 7.1.

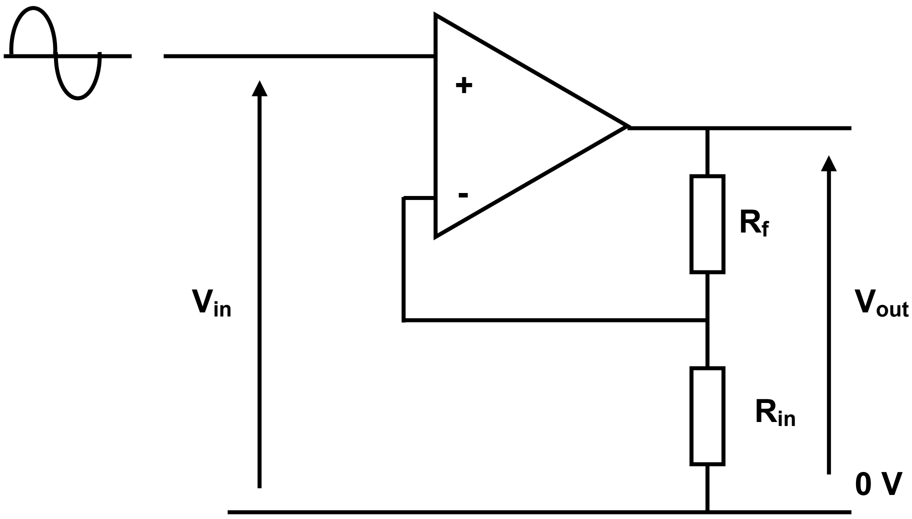

FIGURE 7.1: OPERATIONAL AMPLIFIER CIRCUIT

7.6.1 Name the operational amplifier circuit in FIGURE 7.1. (1)

7.6.2 With the given input signal at the non-inverting input, draw both the input and output signals on the same axis. (2)

7.6.3 Explain the function of R_f in the circuit. (3)

7.6.4 Explain what will occur to the gain of the operational amplifier (op amp) if the value of R_f is increased. (3)

7.6.5 What is the function of R_{in} in the circuit? (2)
[25]

QUESTION 8: THREE-PHASE TRANSFORMERS

8.1 Give ONE function of a transformer. (2)

8.2 Name ONE loss that occurs in three-phase transformers. (1)

8.3 A three-phase transformer with a turns ratio of 50 : 1 is connected in delta-star. The supply voltage is 11 kV and the secondary phase current is 450 A.

Given:

Ratio = 50 : 1

$V_{L(P)}$ = 11 kV

$I_{Ph(S)}$ = 450 A

Calculate:

8.3.1 The secondary phase voltage (3)

8.3.2 The secondary line voltage (3)

8.3.3 The primary phase current (3)

8.3.4 The primary line current (3)
[15]

QUESTION 9: LOGIC CONCEPTS AND PLCs

9.1 What do the letters *PLC* represent? (1)

9.2 Name the FOUR main parts of a PLC. (4)

9.3 Explain the term *program* when referring to a PLC. (3)

9.4 Draw the ladder logic symbol for each of the following:

9.4.1 Normally open switch (1)

9.4.2 Normally closed switch (1)

9.4.3 Relay (1)

9.5 Name THREE advantages of PLCs in comparison to relay control. (3)

9.6 Name THREE basic devices used in programming PLCs. (3)

9.7 Name the THREE programming languages used in programming PLCs. (3)

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

9.8.1 The logic symbol (2)

9.8.2 The circuit diagram, using two switches and a lamp to simulate the gate operation (4)

9.8.3 The ladder logic diagram (3)

9.9 Draw the ladder logic diagram of the circuit in FIGURE 9.1.

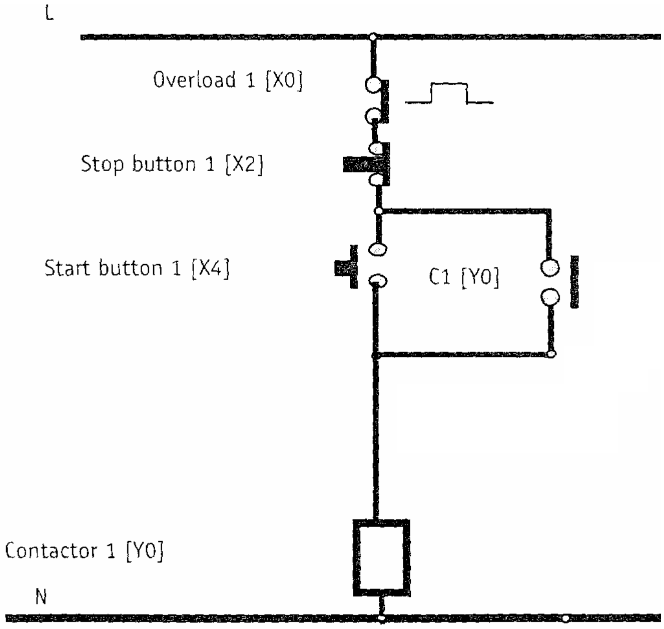

FIGURE 9.1: DIRECT-ON-LINE STARTER (6)

[35]

QUESTION 10: THREE-PHASE MOTORS AND CONTROL

10.1 With reference to insulation resistance tests on the stator of a three-phase induction motor:

10.1.1 Name the type of instrument you would use to do the test. (1)

10.1.2 Describe why it is important to test the insulation resistance between the windings and the frame of the motor. (3)

10.1.3 Describe the resistance reading you would expect when measuring between the windings of the motor. (3)

10.1.4 Use the exact lay-out in FIGURE 10.1, redraw the figure and draw in the windings, and then draw the windings connected in star.

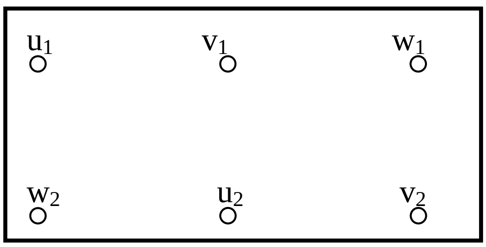

FIGURE 10.1: TERMINAL BOX OF A THREE-PHASE INDUCTION MOTOR (3)

10.2 A three-phase 15 kW induction motor is connected in delta to a 380 V/50 Hz supply. The motor is 100% efficient with a power factor of 0,9 at full load.

Given:

P = 15 kW

V_L = 380 V

f = 50 Hz

ŋ = 100%

Cos θ = 0,9

Calculate:

10.2.1 The current drawn from the supply (3)

10.2.2 The apparent power of the motor (3)

10.2.3 The phase current of the motor (3)

10.3 Explain why a star-delta starter is used to start three-phase induction motors. (3)

10.4 Name THREE parts of a three-phase induction motor. (3)

10.5 State TWO possible causes of overheating in a three-phase induction motor. (2)

10.6 How are the stator windings spaced in a three-phase induction motor? (1)

10.7 After a motor has been started and is running, what other function does the starter perform? (2)
[30]

TOTAL: 200

FORMULA SHEET

$$X_L = 2\pi FL$$

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

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

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

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

$$V_R = IR$$

$$V_L = IX_L$$

$$V_C = IX_C$$

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

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

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

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

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

Single phase:

$$P = VI\cos\theta$$

$$S = VI$$

$$Q = VI\sin\theta$$

Three phase:

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

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

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

Delta:

$$V_L = V_{Ph}$$

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

Star:

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

$$I_L = I_{Ph}$$

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

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