basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

ELECTRICAL TECHNOLOGY

NOVEMBER 2012

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 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 Coal is the primary source of energy used by South African power stations.

1.1.1 Name and describe ONE negative impact the use of coal may have on the environment. (2)

1.1.2 Give TWO reasons why coal is still used as an energy source even though it has a negative impact on the environment. (2)

1.2 Name TWO skills that a successful entrepreneur should have. (2)

1.3 The cellular phone is a technological development. Name and describe ONE benefit to society. (2)

1.4 Describe how the term *equal access to employment* relates to electrical technology school leavers. (2)

[10]

QUESTION 2: TECHNOLOGICAL PROCESS

2.1 Name the FOUR steps that are used in the technological process after a product has been identified. (4)

2.2 Describe why it is necessary to use these steps in relation to the product. (2)

2.3 Give FOUR reasons why it is necessary to make a prototype of a product before production of that product. (4)

[10]

QUESTION 3: OCCUPATIONAL HEALTH AND SAFETY

3.1 State TWO unsafe acts that must not take place in an electrical technology workshop. (2)

3.2 Explain why water may not be used to extinguish a fire caused by an electrical fault. (2)

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

3.4 Give TWO reasons why good ventilation in an electrical technology workshop is important. (2)

3.5 Describe why it is important to use tools with insulated handles when working on electrical circuits. (2)

[10]

QUESTION 4: THREE-PHASE AC GENERATION

4.1 Indicate whether the reading on a voltmeter when measuring an AC voltage is a maximum value, average value or effective/rms value. (1)

4.2 Define the term *apparent power*. (3)

4.3 Explain what is meant by the term *active current*. (3)

4.4 A three-phase balanced load is connected in delta. The phase voltage is 240 V/50 Hz and the phase current is 10 A. If the power factor is 0,8, calculate the line current drawn at full load.

Given:

V_p = 240 V
f = 50 Hz
I_{Ph} = 10 A
Cos θ = 0,8 (3)

[10]

QUESTION 5: RLC CIRCUITS

5.1 Define the term *capacitive reactance*. (3)

5.2 Explain why the brightness of a lamp when connected in series with an inductor will decrease when the frequency of the supply is increased. (3)

5.3 The phasor diagram in FIGURE 5.1 indicates the current values flowing through the components of a parallel circuit connected across a 240 V/50 Hz supply.

Given:

I_C = 10 A
I_R = 15 A
I_L = 15 A
V = 240 V
f = 50 Hz

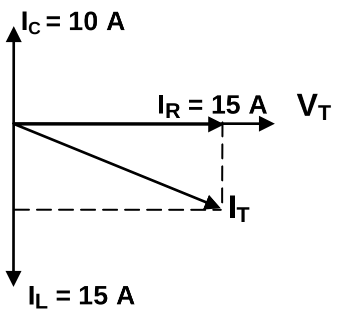

FIGURE 5.1: PHASOR DIAGRAM OF AN RLC PARALLEL CIRCUIT

Calculate:

5.3.1 The total current flow through the circuit (3)

5.3.2 The inductive reactance (3)

5.3.3 The inductance of the coil (3)

5.4 The RC circuit in FIGURE 5.2 consists of a 30 ohm resistor and a 147 microfarad capacitor connected across a 240 V/50 Hz supply.

Given:

R = 30 Ω
C = 147 µF
V = 240 V
f = 50 Hz

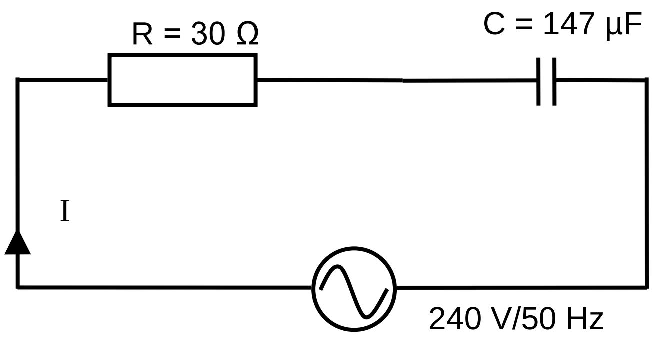

FIGURE 5.2: RC CIRCUIT

Calculate:

5.4.1 The capacitive reactance (3)

5.4.2 The impedance of the circuit (3)

5.4.3 The current flow in the circuit (3)

5.4.4 The phase angle (3)

5.5 With reference to FIGURE 5.2, describe what would happen to the voltage across the resistor if the capacitance of the capacitor was increased. (3)

[30]

QUESTION 6: SWITCHING AND CONTROL CIRCUITS

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

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

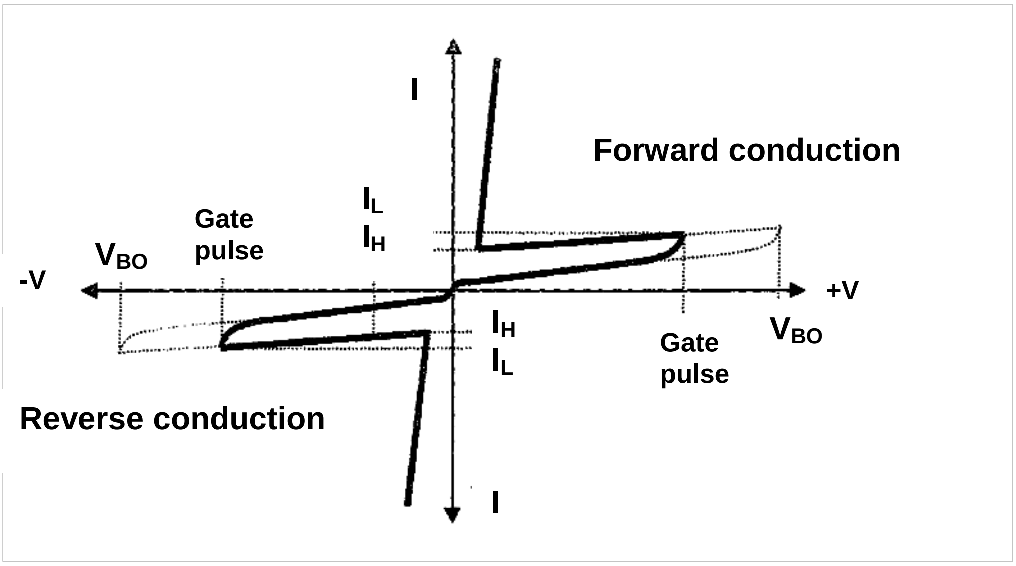

FIGURE 6.1: CHARACTERISTIC CURVE OF A TRIAC

6.2.1 Give ONE application of a TRIAC. (1)

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

6.2.3 Describe what happens to the TRIAC at the points labelled 'gate pulse'. (2)

6.2.4 Describe what happens to the TRIAC if the voltage across it reaches V_{BO}. (2)

6.2.5 Explain what the value I_H represents on the characteristic curve. (2)

6.2.6 Explain what happens to the voltage across the TRIAC when it begins to conduct. (2)

6.2.7 Name ONE advantage a TRIAC has over an SCR. (1)

6.3 The diagram in FIGURE 6.2 shows a lamp-dimming circuit using an SCR.

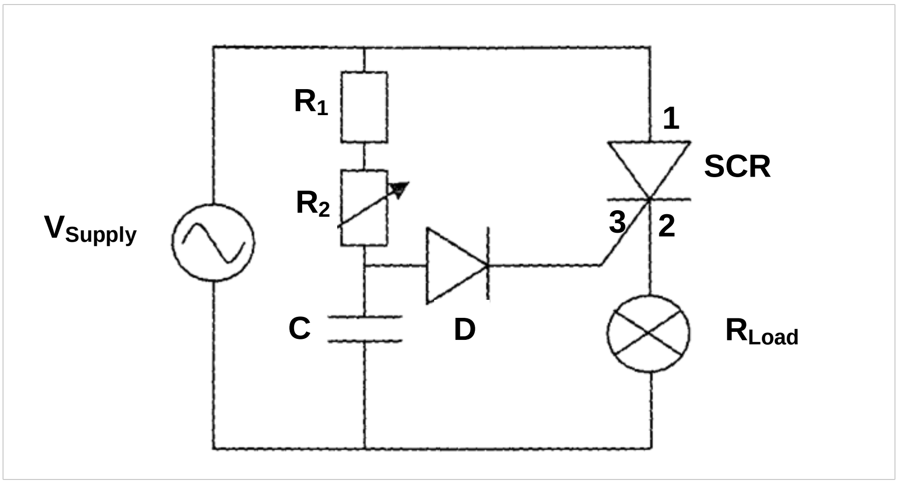

FIGURE 6.2: LAMP-DIMMING CIRCUIT

6.3.1 Label the SCR terminals numbered **1**, **2** and **3**. (3)

6.3.2 Describe the function of R_1 in the circuit. (3)

6.3.3 If the value of R_2 is increased, describe how this will affect the brightness of the lamp. (4)

[25]

QUESTION 7: AMPLIFIERS

7.1 7.1.1 The standard circuit symbol for an op amp is shown in FIGURE 7.1. Label the numbers **1**, **2** and **3**. (3)

7.1.2 Label **4** and **5** AND state their function.

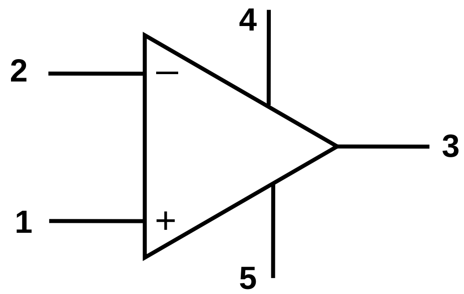

FIGURE 7.1: SYMBOL OF AN OP AMP (2)

7.2 With reference to an op amp, explain the term *feedback*. (2)

7.3 Draw the output wave forms of the op amp circuits below.

7.3.1

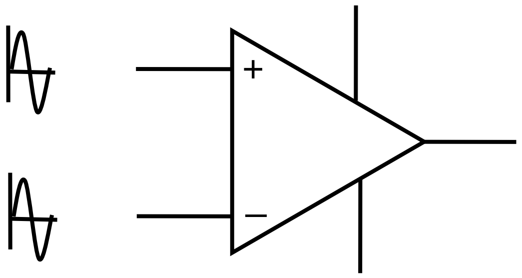

FIGURE 7.2: OP AMP (2)

7.3.2

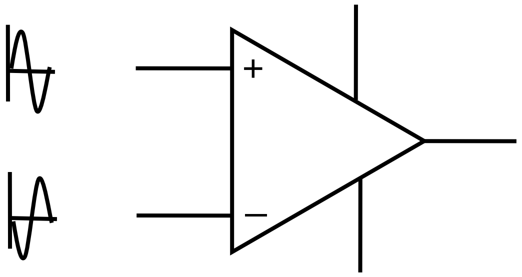

FIGURE 7.3: OP AMP (2)

7.4 Refer to FIGURE 7.4.

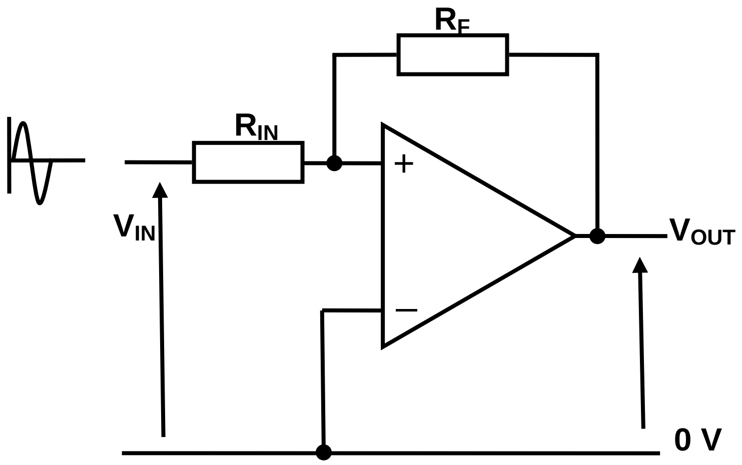

FIGURE 7.4: OP AMP CIRCUIT

7.4.1 Name the circuit. (1)

7.4.2 Draw input and output waveforms on the same axis. (2)

7.4.3 Describe what will happen to the voltage gain of the circuit if R_{IN} is increased. (3)

7.4.4 If the resistive value of R_{IN} and R_F are the same, state what would happen to the phase and amplitude of the output. (2)

7.5 In the amplification process the amplitude of the wave form changes. What happens to the frequency of the wave form? (1)

7.6 Explain what effect the very high input impedance (close to infinity) of an op amp will have on the preceding circuit (circuit connected to the input of the op amp). (5)
[25]

QUESTION 8: THREE-PHASE TRANSFORMERS

8.1 State ONE cause of overheating in a transformer. (1)

8.2 Name the TWO types of circuits in a transformer. (2)

8.3 Describe why the secondary winding of a transformer must be connected in star if the transformer is to supply both a domestic and an industrial load. (3)

8.4 A 240 kVA three-phase transformer supplies power to a soccer stadium. The transformer is connected in delta-star. The input line voltage is 11 kV and the output line voltage is 415 V at a lagging power factor of 0,85.

Given:

$S = 240$ kVA
$V_{L(p)} = 11\,000$ V
$V_{L(s)} = 415$ V
$\cos\theta = 0{,}85$

Calculate:

8.4.1 The secondary phase voltage (3)

8.4.2 The current drawn from the supply by the transformer at full load (3)

8.4.3 The power delivered at full load to the stadium (3)
[15]

QUESTION 9: LOGIC CONCEPTS AND PLCs

9.1 Describe the function of the following components of a PLC:

9.1.1 Power supply (2)

9.1.2 Control Processing Unit (CPU) (2)

9.1.3 Output module (2)

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

9.2.1 A circuit diagram using two switches and a lamp to simulate the gate operation (4)

9.2.2 The ladder logic diagram (3)

9.3 Refer to FIGURE 9.1.

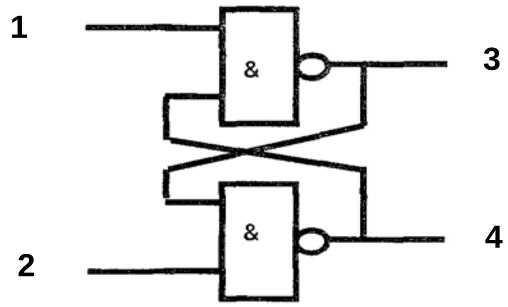

FIGURE 9.1: CIRCUIT OF A LATCH

9.3.1 Name the latch circuit. (1)

9.3.2 Label the numbers **1**, **2**, **3** and **4**. (4)

9.3.3 State ONE application of this latch. (1)

9.3.4 Give the outputs on **3** and **4** if the input at **1** is logic position 0 and the input at **2** is logic position 1. (2)

9.4 State THREE advantages of PLCs in comparison to relay control. (3)

9.5 Draw the circuit diagram that represents the ladder logic program in FIGURE 9.2.

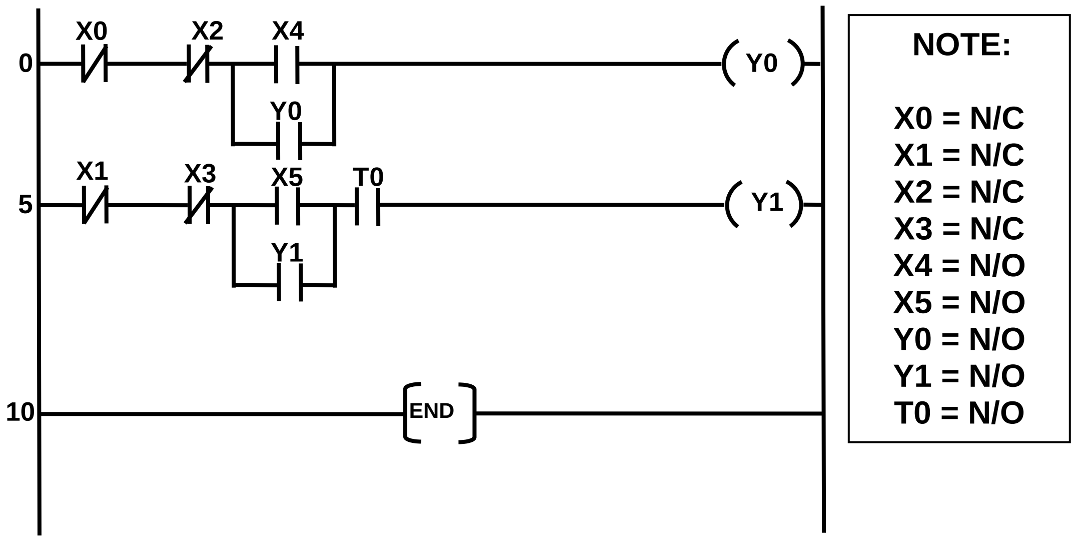

FIGURE 9.2: LADDER LOGIC PROGRAM FOR SEQUENCE CONTROL (11)

[35]

QUESTION 10: THREE-PHASE MOTORS AND CONTROL

10.1 State how the direction of rotation of a three-phase motor may be changed. (1)

10.2 Name TWO electrical inspections that need to be done on a new three-phase motor before it is connected to the power supply. (2)

10.3 State the minimum value of resistance when measuring the insulation resistance between the windings of a motor. (1)

10.4 Describe the function of a star-delta starter. (2)

10.5 Describe why it is necessary to have protective devices as part of motor control. (2)

10.6 The input power of a 415 V/50 Hz, three-phase star-connected induction motor is 9 kW. The motor is 100% efficient with a power factor of 0,9.

$P = 9$ kW
$V_L = 415$ V
$\cos\theta = 0{,}9$
$f = 50$ Hz

Calculate:

10.6.1 The phase voltage (3)

10.6.2 The line current (3)

10.6.3 The apparent power (3)

10.7 List THREE motor properties that will be displayed on its name plate. (3)

10.8 State THREE advantages that a three-phase induction motor has over a single-phase motor. (3)

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

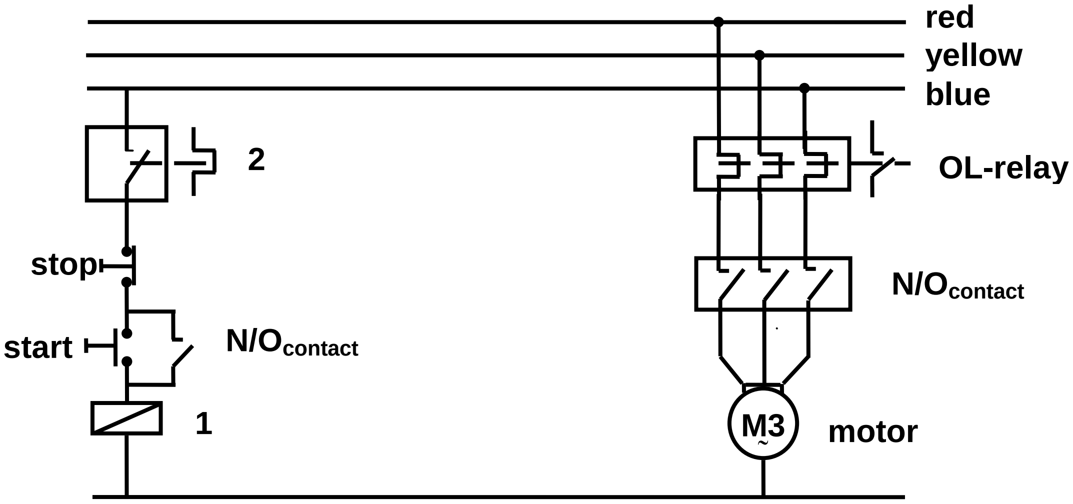

FIGURE 10.1: DIRECT-ON-LINE-STARTER

10.9.1 Identify the components labelled **1** and **2**. (1)

10.9.2 Explain what occurs to the three-phase induction motor if one phase fails. (3)

10.9.3 Describe the protection that the component labelled **2** offers to the motor. (3)
[30]

TOTAL: 200

FORMULA SHEET

$$X_L = 2\pi FL$$

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

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

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

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

$$V_R = IR$$

$$V_L = IX_L$$

$$V_C = IX_C$$

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

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

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

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

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

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

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

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

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

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

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

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

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