education

Department:
Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

ELECTRICAL TECHNOLOGY

FEBRUARY/MARCH 2010

MARKS: 200

TIME: 3 hours

This question paper consists of 13 pages and 1 formula sheet.

INSTRUCTIONS AND INFORMATION

1. This question paper consists of TEN questions. Answer ALL the questions.

2. Sketches and diagrams must be large, neat and fully labelled.

3. All calculations must be shown and correctly rounded off to TWO decimal places.

4. Number the answers correctly according to the numbering system used in this question paper.

5. A formula sheet is provided at the end of the question paper.

6. Non-programmable calculators may be used.

QUESTION 1: TECHNOLOGY, SOCIETY AND THE ENVIRONMENT

1.1 Sewage treatment facilities rely on different stages during the filtering and cleansing process. Huge volumes of water are pumped from stage to stage and oxygen is added to the water to kill pathogens.

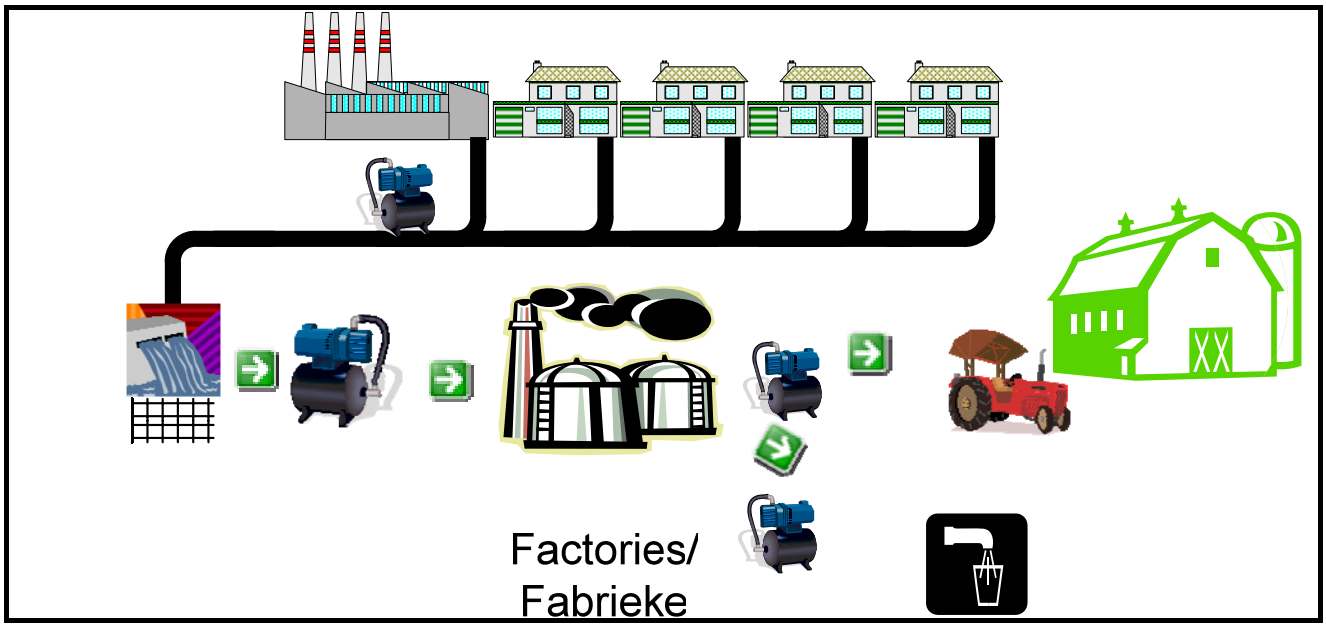

FIGURE 1.1: SEWAGE TREATMENT PROCESS

Sewage treatment plants in various areas of South Africa are failing, and as a result our rivers are being polluted with raw sewage. This has caused cholera outbreaks in some parts of South Africa and in Zimbabwe cholera has already claimed thousands of lives.

Pump system to sewerage plant/
Pompsisteem na rioolplaas

In what way, do you think, has electrical technology, or the misappropriation thereof, contributed to the non-treatment of sewage in South Africa? Name and discuss TWO issues. (4)

Pompstasie/
Pump station

1.2 HIV/Aids is an incurable disease. In the medical industry, electrical technology is used in various diagnostic medical instruments. How, do you think, can electrical technology contribute positively towards the treatment of HIV and Aids? (2)

1.3 Name TWO recent advancements in electrical technology and state how they have had an effect on society. (4)

[10]

Screening and grit for disposal/
Afskerming en grint vir opruiming

Processing
Proses-a

QUESTION 2: TECHNOLOGICAL PROCESS

Read the scenario below and answer the questions that follow.

Sibusiso decided to improve the security of his room at home, since someone could enter the room without his permission. He went out to the spaza shop and bought mousetraps to place at his door when he was away. His uncle told him the best way to catch a rat is with a mousetrap. This way the intruder would get a painful sting when the mousetrap is triggered and the problem would be solved.

Sibusiso was sure that his invention would work well and did not mind paying R400,00 for the mousetraps.

2.1 Do you think Sibusiso's invention can work? Motivate your answer. (2)

2.2 Do you think Sibusiso's uncle gave him good advice? Motivate your answer. (2)

2.3 What process would you suggest should Sibusiso follow to arrive at a solution that relies on electrical technology? List FOUR steps. (4)

2.4 State any TWO criteria that you think Sibusiso might be able to use to choose the best solution for his problem. (2)

[10]

QUESTION 3: OCCUPATIONAL HEALTH AND SAFETY

3.1 State TWO precautions that must be taken when measuring the current flow in a circuit with a digital multimeter. (2)

3.2 State TWO precautions that must be taken when using a grinding machine. (2)

3.3 Describe why it is important to have good ventilation in an electrical technology workshop. (2)

3.4 State TWO unsafe actions that can occur in an electrical technology workshop. (2)

3.5 Describe ONE precaution to be taken when stripping off the insulation of a conductor. (2)
[10]

QUESTION 4: THREE-PHASE AC GENERATION

4.1 State how the power factor of a resistive inductive load may be improved. (1)

4.2 Name TWO advantages of a three-phase system over a single-phase system. (2)

4.3 Define the term *balanced load*. (2)

4.4 Describe ONE disadvantage of a three-phase motor that has a poor lagging power factor. (2)

4.5 A 2,5 kW balanced load is connected in delta to a 380 V supply. The load has a power factor of 0,85 and a rendement of 100%. Calculate the kVA rating of the load at full load. (3)
[10]

QUESTION 5: RLC CIRCUITS

5.1 Describe ONE practical method used to determine whether an RLC series circuit is at resonant frequency. (3)

5.2 An incandescent lamp is connected in series with an inductor and a capacitor. Describe what will happen to the brightness of the lamp if the frequency is changed to resonant frequency. (3)

5.3 The diagram in FIGURE 5.1 below represents a phasor diagram of an RLC circuit. Analyse the diagram and answer the questions that follow.

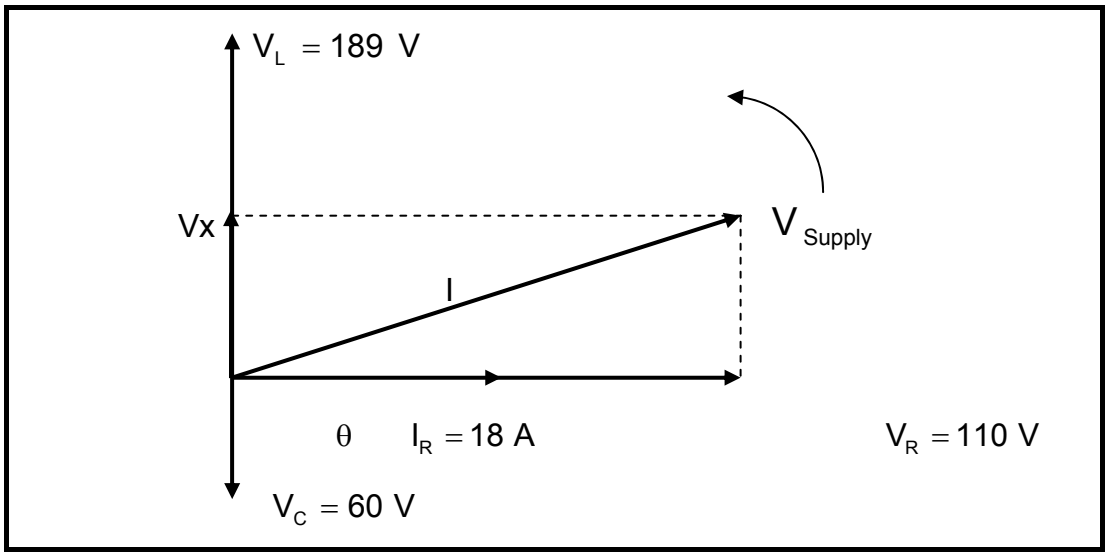

FIGURE 5.1: PHASOR DIAGRAM OF AN RLC CIRCUIT

5.3.1 State whether the phasor diagram represents a series circuit or a parallel circuit. Explain your answer. (3)

5.3.2 Calculate the supply voltage. (3)

5.3.3 Calculate the impedance of the circuit. (3)

5.3.4 Calculate the inductive reactance of the circuit if the frequency of the supply is 50 Hz. (3)

5.4 A resistor with a resistance of 39 Ω, a capacitor with a capacitive reactance of 50 Ω and an inductor with an inductive reactance of 75 Ω are all connected in parallel across a 240 V/50 Hz supply.

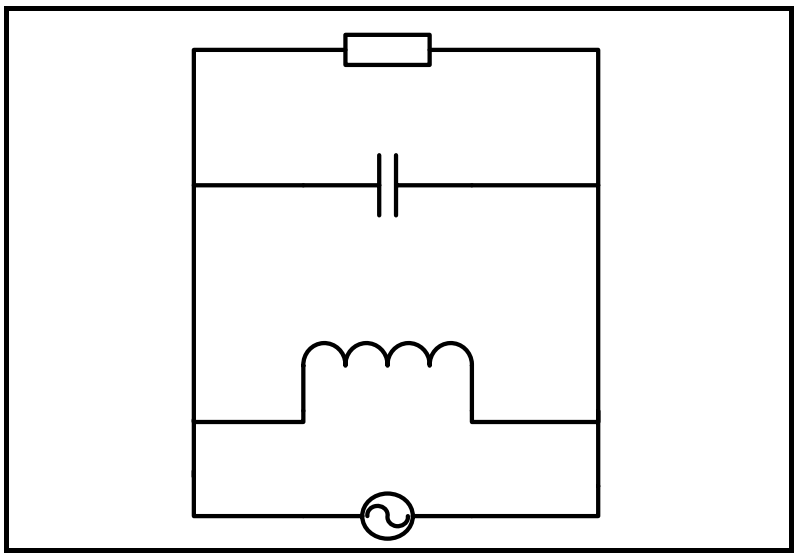

FIGURE 5.2: RLC CIRCUIT

Calculate the following:

5.4.1 The current through the resistor (3)

5.4.2 The current through the inductor (3)

5.4.3 The current through the capacitor (3)

5.4.4 The supply current (3)

[30]

QUESTION 6: SWITCHING AND CONTROL CIRCUITS

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

6.2 Explain how an SCR can be switched on and also how it can be switched off. (4)

6.3 The circuit shown in FIGURE 6.1 below uses a DIAC and a TRIAC to control the brightness of a lamp. The circuit is connected to a 220 V/50 Hz supply. Explain the operation of the circuit.

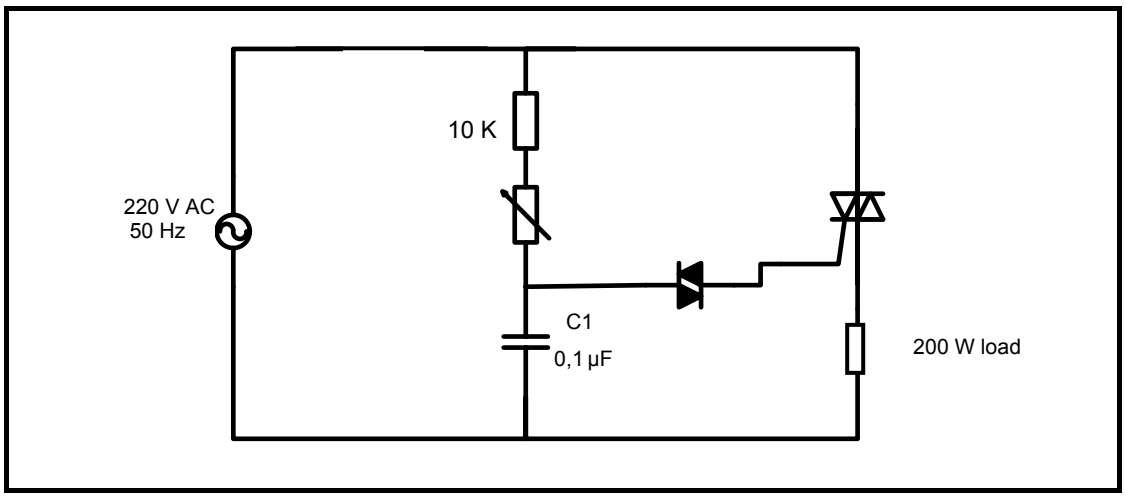

FIGURE 6.1: LAMP-DIMMING CIRCUIT (9)

200 Watt Load

6.4 State whether the voltage developed across the TRIAC in FIGURE 6.1 is high or low when current is flowing in the circuit. (1)

R 1
10K

6.5 The DIAC in FIGURE 6.1 triggers the TRIAC at 90° in the first half-cycle and again at 270° in the second half-cycle.

6.5.1 Draw the input voltage wave form and the voltage wave form across the lamp on the same set of axes. (5)

220 V AC
50 Hz

6.5.2 Compared to the full brightness of the lamp, state the expected brightness of the lamp. Give a reason for your answer. (3)

[25]

QUESTION 7: AMPLIFIERS

7.1 Name the THREE major classes of power audio amplifiers. (3)

7.2 Draw a block diagram of a basic amplifier showing the input and output signals. (4)

7.3 With reference to feedback in amplifiers, answer the following questions:

7.3.1 Name TWO advantages of using negative feedback in amplifier circuits. (2)

7.3.2 Draw an operational amplifier in the configuration of an inverting voltage comparator. (5)

7.4 Describe the TWO requirements for oscillation to occur in all oscillators. (4)

7.5 With reference to the amplifier in FIGURE 7.1 below, answer the questions that follow.

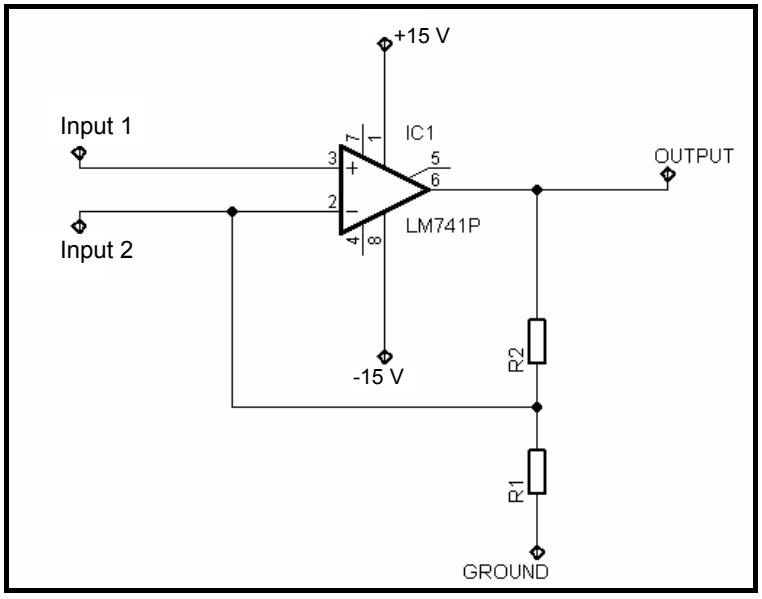

FIGURE 7.1: AMPLIFIER

7.5.1 Name the mode of operation of this circuit. (1)

7.5.2 Draw the input and output signals of this circuit. (3)

7.6 Calculate the oscillation frequency of an LC oscillator when the tank circuit has an inductance L = 10 mH and a capacitance C = 220 µF. (3)
[25]

QUESTION 8: THREE-PHASE TRANSFORMERS

8.1 Name the most common application of a transformer with the following configurations in the mains power distribution grid:

8.1.1 Star-star (1)

8.1.2 Delta-star (1)

8.1.3 Star-delta (1)

8.2 The transformer supplying Mamellong Comprehensive School with power is connected in delta to an 11 kV supply. The secondary side supplies the school with a three-phase four-wire system. The school receives a single-phase voltage of 220 V and three-phase line voltage of 380 V from the transformer.

8.2.1 Show, by means of a simple diagram, how the secondary side of the transformer is connected to the school. (5)

8.2.2 Calculate the value of the line current in the primary side at full load if the school consumes 500 kW at a power factor of 0,85. (4)

8.2.3 Calculate the transformation ratio. (3)
[15]

QUESTION 9: LOGIC CONCEPTS AND PROGRAMMABLE LOGIC CONTROLLERS (PLCs)

9.1 Answer the following questions with reference to PLCs:

9.1.1 The block diagram below shows the basic processes followed in a PLC. List and explain the purpose of each of the stages, (a) to (e).

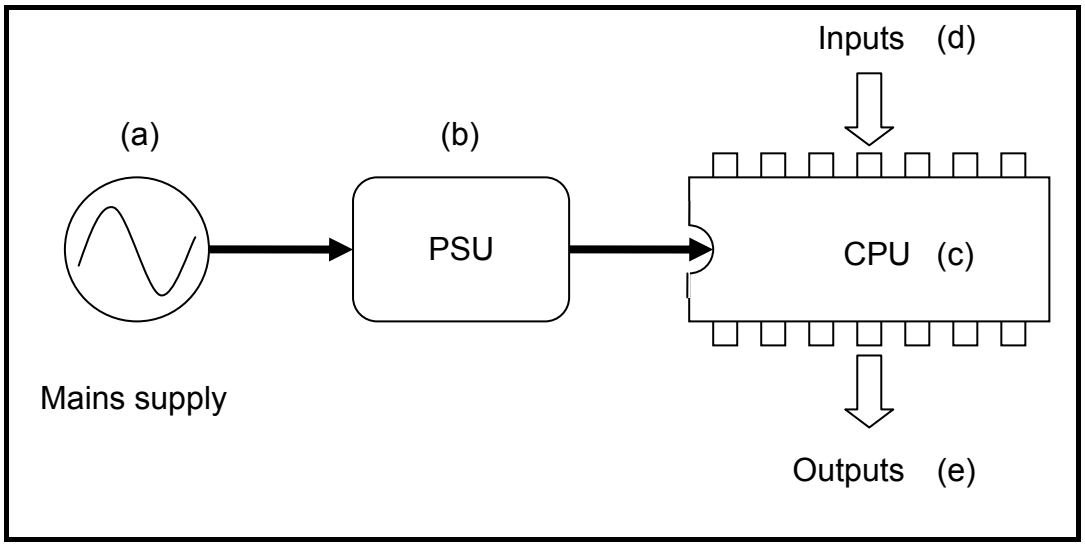

FIGURE 9.1: THE PLC PROCESS (5)

9.1.2 Name at least TWO input and TWO output devices used with PLCs. (4)

9.2 Referring to FIGURE 9.2 below, answer the following questions:

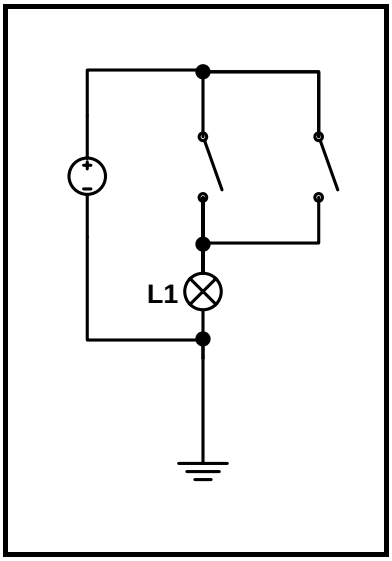

FIGURE 9.2: ELECTRICAL CIRCUIT

9.2.1 Draw the symbol of the logic gate represented by the circuit in FIGURE 9.2. (2)

9.2.2 Draw the truth table of the gate. (4)

9.2.3 Draw the ladder diagram of the gate. (3)

9.3 Determine the Boolean equation of the logic circuit in FIGURE 9.3 below. Ignore the zero indicators at the gates, as this indicates an idle state.

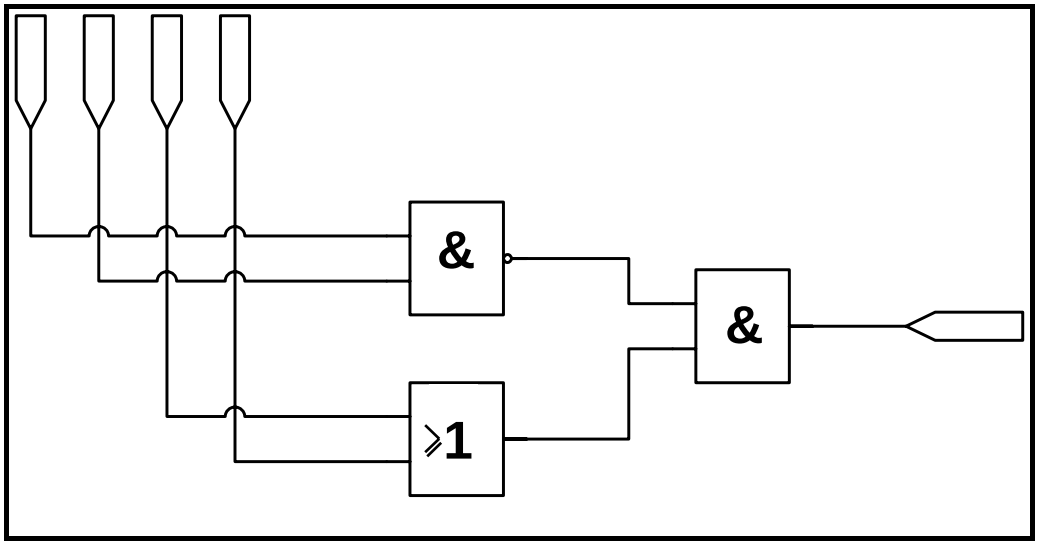

FIGURE 9.3: LOGIC CIRCUIT (3)

9.4 In the following Boolean equation, prove that the left-hand side is equal to the right-hand side:

(A + B) **.** (A + C) = A + BC (4)

9.5 Determine the equation that is represented by the plotted Karnaugh map shown in FIGURE 9.4 below.

			A'B' $\overline{A}\,\overline{B}$ 00	A'B $\overline{A}B$ 01	AB AB 11	AB' $A\overline{B}$ 10
C	C	0	**1**	**1**	**1**	
C'	$\overline{C}$	1		**1**	**1**	**1**

FIGURE 9.4: KARNAUGH MAP (6)

9.6 Explain the difference between *synchronous* and *asynchronous* counters by referring to clock pulses. (4)
[35]

QUESTION 10: THREE-PHASE MOTORS AND CONTROL

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

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

10.3 The circuit in FIGURE 10.1 below is the control circuit of a star-delta starter.

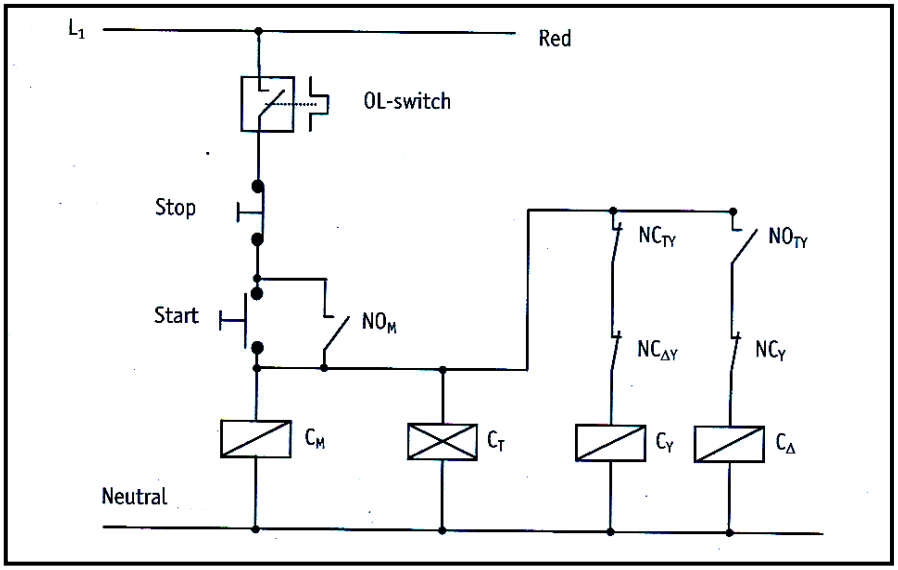

FIGURE 10.1: STAR-DELTA CONTROL CIRCUIT

10.3.1 Explain the starting sequence of this starter. (5)

10.3.2 Give the reasons why a star-delta starter is used to start a three-phase induction motor. (5)

10.3.3 Describe ONE function of the overload switch. (2)

10.4 Describe the term *N/O* with reference to electromagnetic relays. (2)

10.5 Describe the principle of operation of a three-phase induction motor. (6)

10.6 A 5 kW motor is connected in delta to a 380 V/50 Hz supply. If the motor has a power factor of 0,8, calculate at full load:

10.6.1 The current drawn from the supply (3)

10.6.2 The current flow in each phase (3)
[30]

TOTAL: 200

FORMULA SHEET

RLC

$$X_L = 2\pi\pi F$$

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

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

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

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

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

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

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

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

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

Amplifiers

$$Av = \frac{R_f}{R_{in}} + 1$$

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

$$I_b = I_e - I_c$$

$$P_G = 10log\frac{P_0}{P_i}$$

Alternating Current, Transformers and Motors

Single Φ

$$P = VIcos\theta$$

$$S = VI$$

$$Q = VIsin\theta$$

Three Φ

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

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

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

$$I_L = \sqrt{3} I_{PH}\ for\ \Delta$$

$$V_L = V_{Ph}\ for\ \Delta$$

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

$$I_L = I_{Ph}\ for\ Y$$

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

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

$$\eta = \frac{P_O}{P_I}$$

$$f_r = \frac{1}{2\pi\sqrt{(6RC)}}$$

END