NATIONAL SENIOR CERTIFICATE EXAMINATION
NOVEMBER 2021

ELECTRICAL TECHNOLOGY: DIGITAL

Time: 3 hours 200 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of 13 pages, an Information Sheet of 2 pages (i–ii) and an Answer Sheet of 2 pages (i–ii). Please check that your question paper is complete.

2. Answer all the questions.

3. **NB: The following questions must be answered on the attached Answer Sheet:**

   (a) Question 4.2.2 on Answer Sheet 4.2.2
   (b) Question 4.6.2 on Answer Sheet 4.6.2
   (c) Question 5.5.1 and 5.5.2 on Answer Sheet 5.5.1

4. Read the questions carefully.

5. Please start each question on a new page in your Answer Book.

6. Do not write in the margin.

7. Number your answers exactly as the questions are numbered in the paper.

8. You may use a non-programmable calculator.

9. Use the attached Information Sheet.

10. ALL formulae and calculations must be shown.

11. Round off your final numerical answers to a MINIMUM of TWO decimal places.

12. It is in your best interests to write legibly and to present your work neatly.

QUESTION 1 GENERAL MULTIPLE-CHOICE QUESTIONS

For each question, choose the most correct answer by indicating your choice in the given **Answer Book**. **NB:** Only **one** choice per question is acceptable. If more than one choice is indicated, the relevant answers will be marked as incorrect.

1.1 The overloading of a computer mother board results in an electrical fire in the workplace. Which type of fire extinguisher or method of firefighting may be used on the fire?

A Wet chemical fire extinguisher
B Foam fire extinguisher
C CO_2 fire extinguisher
D Fire hose and water (1)

1.2 When the drill press is used, safety equipment must be used. Identify the safety equipment that is used with the drill press.

A Safety shoes, overall and hard hat.
B Safety shoes, overall, hearing protection and leather gloves.
C Safety glasses, drill vice and spark shield.
D Safety glasses and drill vice. (1)

1.3 The insulation of an electrical conductor is removed with a utility knife and the worker deeply cuts himself in the palm of his hand. What is the very first step that the first aider should follow?

A Obtain permission to help.
B Tell the injured person to put pressure on the wound himself.
C Put on first-aid gloves.
D Rinse the wound with water. (1)

1.4 Safety signs are very important and help inform people in the workplace about safety. Which safety sign is used to indicate the evacuation direction of the premises?

A 

C 

B 

D 

(1)

1.5 Identify the formula that would be used to determine the input voltage of a non-inverting amplifier.

A $V_O = V_I\left(1+\frac{R_f}{R_1}\right)$

B $V_I = \frac{V_I}{1+\frac{R_f}{R_1}}$

C $V_I = V_O\left(1-\frac{R_f}{R_1}\right)$

D $V_I = V_O - 1\left(\frac{R_f}{R_1}\right)$ (1)

1.6 To which input terminal of a 741-operational amplifier would a signal be connected if the output signal is in phase with the input signal?

A Terminal 2
B Terminal 3
C Terminal 1
D Terminal 4 (1)

1.7 Select the correct wave form in FIGURE 1 for a 555-timer astable multivibrator circuit, accept that the capacitor is already charged.

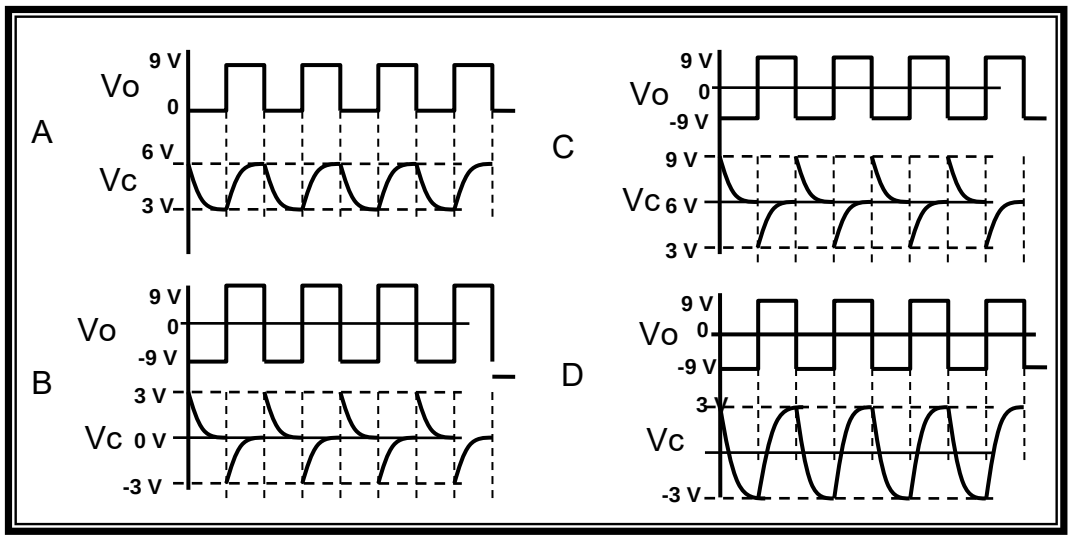


FIGURE 1

(1)

1.8 Which 741-operational amplifier circuit would amplify an input signal in phase without distorting the output signal?

A Inverting amplifier
B Non-inverting amplifier
C Voltage-following amplifier
D Schmitt trigger amplifier (1)

1.9 What is the function of a bistable multivibrator?

A To switch on a circuit.
B To generate a controlled clock pulse.
C To form a debounce circuit.
D To set and reset the output of a multivibrator circuit. (1)

1.10 Simple memory circuits are divided into three groups according to their common operation. These three groups are:

A Counter circuits, flip-flops and shift-register circuits.
B Pulse circuits, clocked circuits and peripheral trigger circuits.
C RS-latch circuits
D JK-latch circuits (1)

1.11 An active high RS flip-flop memory circuit reacts as follows:

A When a high is applied to the Set input, the output of the circuit will be a low.
B When a low is applied to the Set input, the output of the circuit will be a high.
C When a low is applied to the Set input, the output of the circuit will be a low.
D When a high is applied to the Set input, the output of the circuit will be a high. (1)

1.12 The function toggle is obtained in an active low JK flip-flop when the inputs are ...

A J = 0 and K = 0.
B J = 1 and K = 0.
C J = 0 and K = 1.
D J = 1 and K = 1. (1)

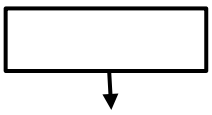
1.13 In which one of the following devices would a microcontroller be found?

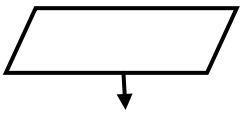
A Laptop
B Transistor radio
C Microwave oven
D Swimming-pool pump (1)

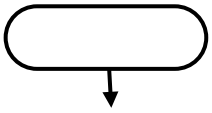
1.14 Microcontrollers can be programmed in various ways. One of the methods to program a microcontroller is to use a flow chart. A flow chart is defined as a ...

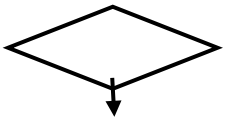
A block diagram with instructions in the order of execution.
B block diagram of the operation of the microcontroller.
C block diagram of the construction of the microcontroller.
D range of data that shows the flow of data to the microcontroller. (1)

1.15 Which one of the given symbols is used to indicate a process of a microcontroller?

A 

C 

B 

D 

(1)
[15]

QUESTION 2 SAFETY

2.1 Define the word *user* as contained in the Occupational Health and Safety Act (Act 85 of 1993). (2)

2.2 Explain the duty of the employer towards people who are not employed by him regarding occupational health and safety. (2)

2.3 Describe TWO responsibilities of a manufacturer in terms of operational equipment. (2)

2.4 Section 85.15 states that it is the employee's duty not to interfere with, damage or abuse objects. Explain this statement in terms of a drill press of which the wall plug is removed for safety reasons and which you have to use urgently to complete your PAT project. (2)

2.5 May the employer criminally charge an employee who refuses to use the necessary personal safety items at work? Substantiate your answer. (2)
[10]

QUESTION 3 SEMICONDUCTORS

3.1 Draw a neat IEC symbol of the 741-operational amplifier. (3)

3.2 Explain how a 100 mV sine wave signal would react if the gain of the circuit is 10 and the signal is connected to the ...

3.2.1 inverting input of the component. (2)

3.2.2 non-inverting input of the component. (2)

3.3 FIGURE 2 shows an inverting amplifier with an input and an output signal that are applied to the circuit. Study the circuit and then answer the questions that follow.

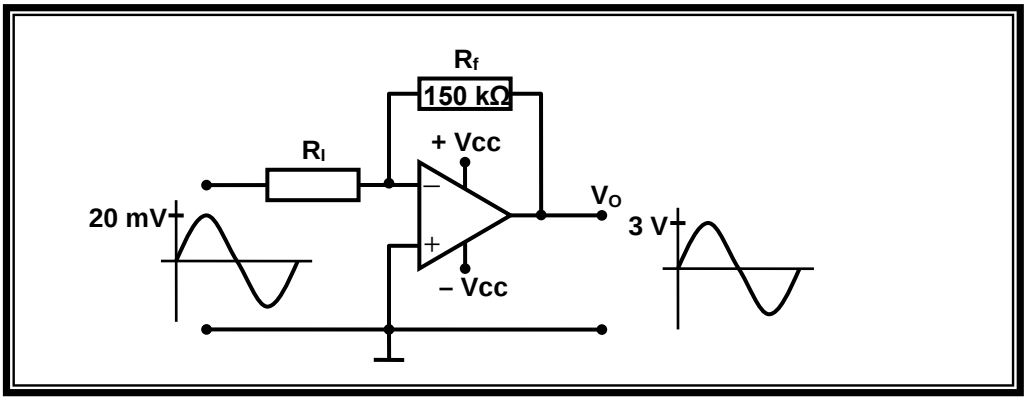


FIGURE 2

3.3.1 Is the output wave indicated correctly? Substantiate your answer. (2)

3.3.2 Calculate the value of the input resistor in the circuit. (3)

3.4 The IEC symbol of a 555-timer is shown in FIGURE 3. Study the figure and explain the function of the terminals indicated by writing down only your answer next to the relevant number in your Answer Book.

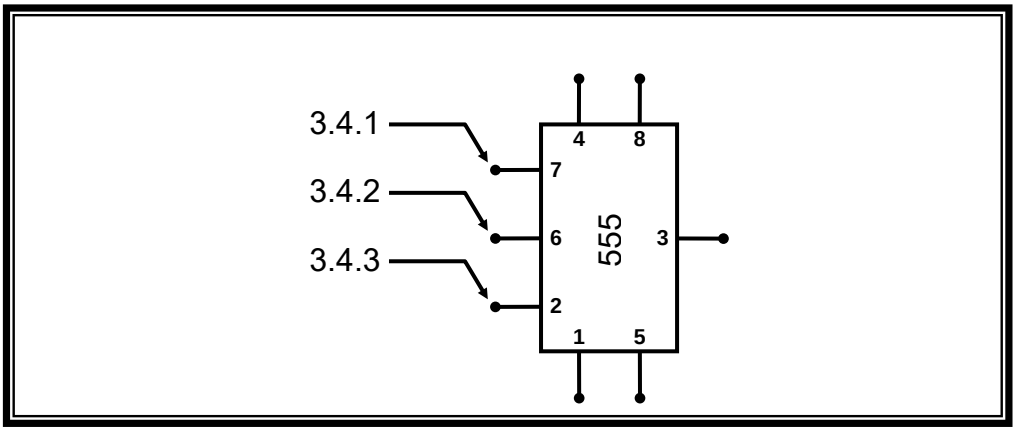


FIGURE 3

(6)

3.5 List the TWO working modes in which the 555-timer can be used, other than the astable multivibrator. (2)

[20]

QUESTION 4 SWITCH AND CONTROL CIRCUITS

4.1 Draw a neatly labelled circuit diagram to show the construction of a monostable multivibrator that uses a 741-operational amplifier. (5)

4.2 Study FIGURE 4 of the 741-operational amplifier that is used as an astable multivibrator and answer the questions that follow.

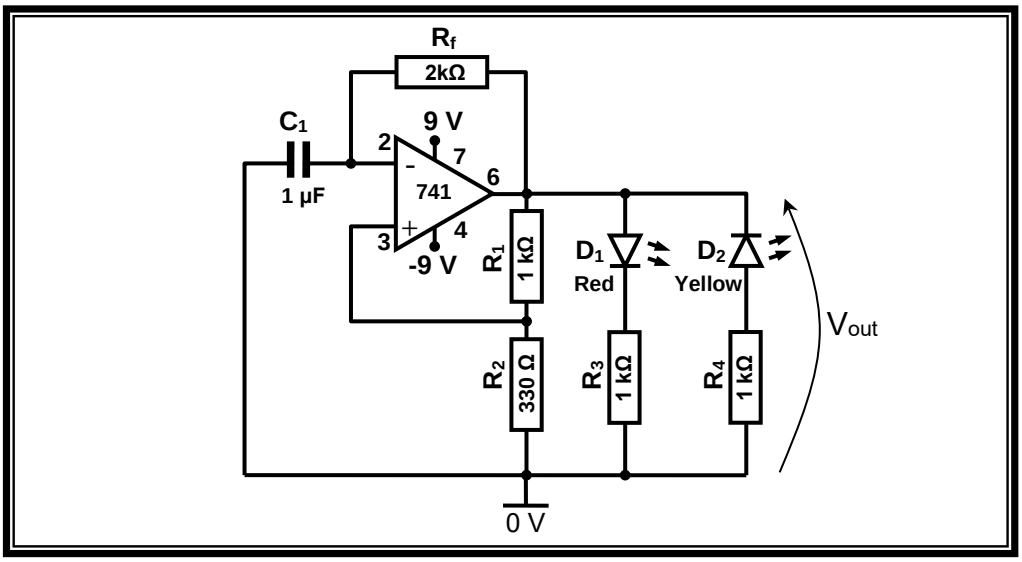


FIGURE 4

4.2.1 Calculate the clock pulse duration of the circuit. (3)

4.2.2 The relevant output wave for the circuit is shown on the **Answer Sheet 4.2.2**. Draw the wave forms that would be obtained over capacitor C_1 and resistor R_2 for the circuit on the Answer Sheet. (4)

4.3 A 741-operational amplifier is used as an adder in FIGURE 5. Study the circuit and then calculate the output voltage of the circuit.

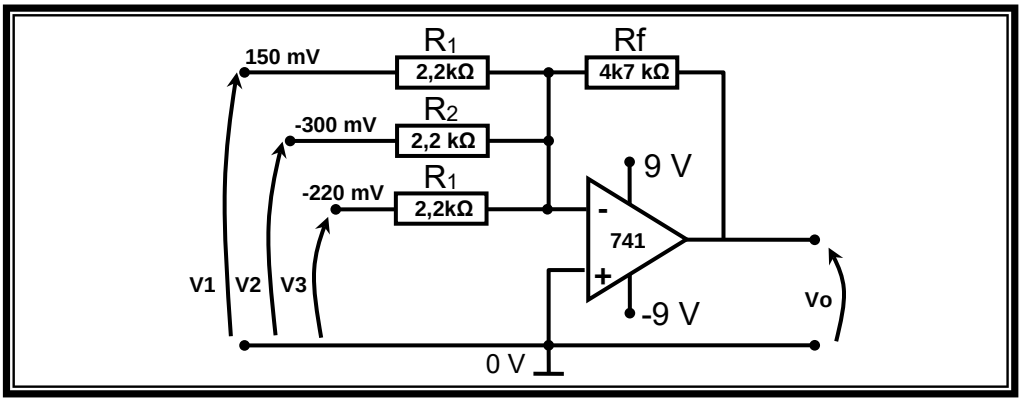


FIGURE 5

(3)

4.4 FIGURE 6 shows a Schmitt-trigger circuit that uses a 741-operational amplifier. Study the circuit and answer the questions that follow.

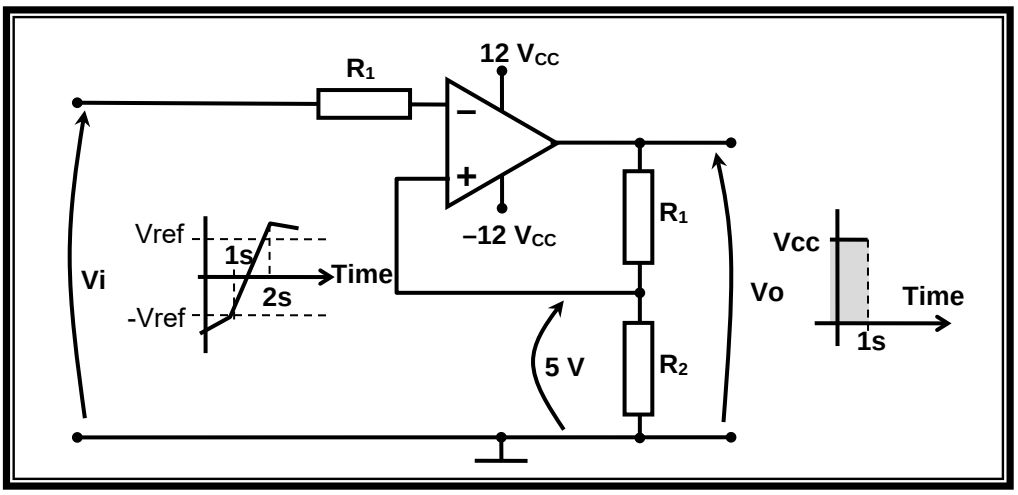


FIGURE 6

4.4.1 Explain point by point in chronological order the operation of the circuit from time interval 1 second. (6)

4.4.2 Name two possible uses for the Schmitt-trigger circuit. (2)

4.5 A 555-timer circuit is shown in FIGURE 7. Study the figure and then answer the questions that follow.

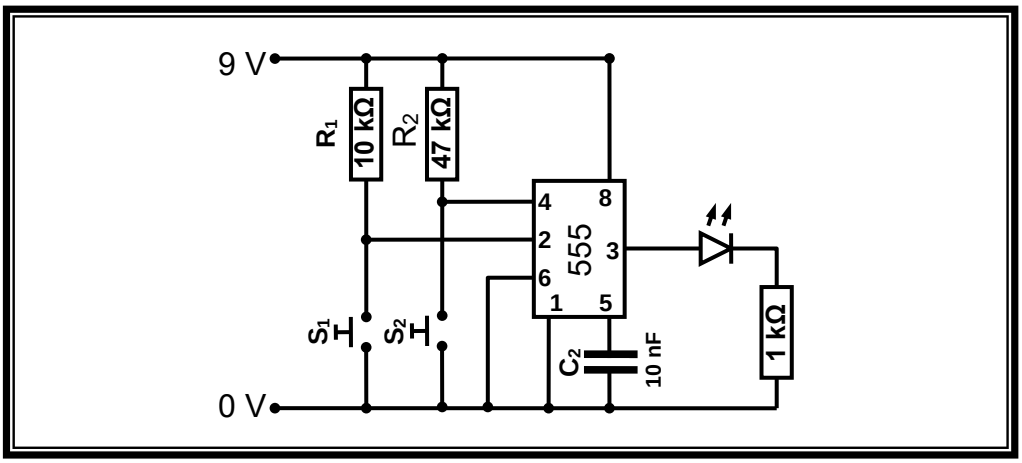


FIGURE 7

4.5.1 Identify the 555-circuit that is shown in FIGURE 7. (1)

4.5.2 Assume that the LED is switched off. Describe how the circuit would switch on the LED. (5)

4.5.3 Discuss the function of resistor R_2 in the circuit. (3)

4.6 A monostable circuit is constructed from a 555-timer and consists of a 220 ηF capacitor, a discharge resistance of 17 kΩ and a 3,3 kΩ resistor. The circuit is supplied with a direct-current 9 V input voltage.

FIGURE 8 shows the wave diagram of the circuit. Study the wave diagram and then answer the questions that follow.

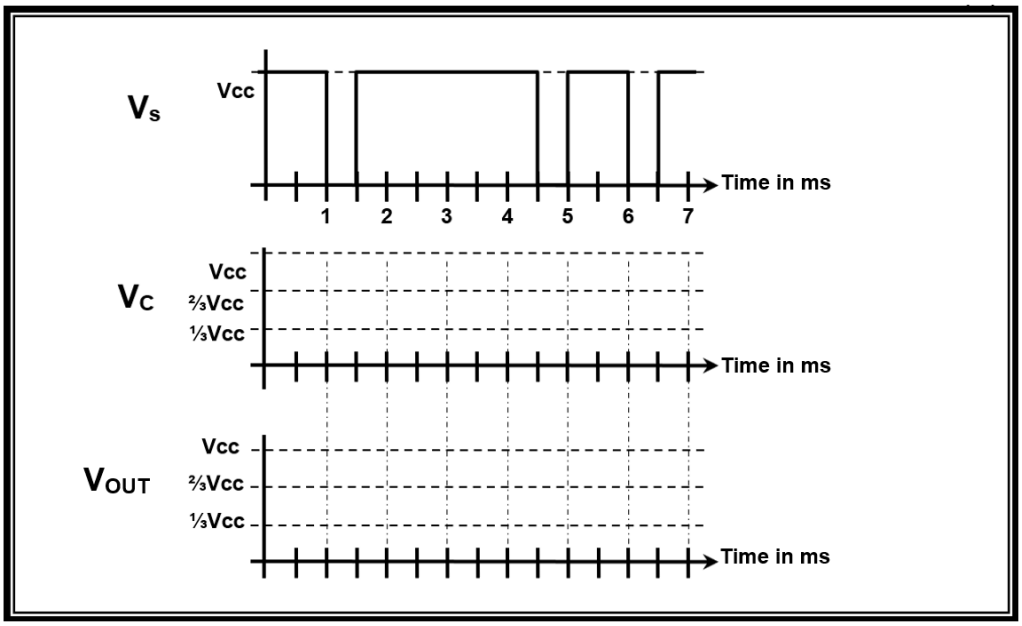


FIGURE 8

4.6.1 Draw a neatly labelled circuit diagram to show the construction of the circuit. (8)

4.6.2 Assume that the time constant of the circuit is 2,5 s. Draw the relevant capacitor and output wave forms of the circuit for the given input pulses on the **Answer Sheet 4.6.2** in the space that is provided. Make sure that your sketch is labelled properly. (4)

4.6.3 Explain the working principle of the monostable 555-timer circuit when the pulse switch is pressed. (6)

[50]

QUESTION 5 DIGITAL AND SEQUENTIAL DEVICES

5.1 Draw a neatly labelled IEC symbol of a common-anode seven-segment LED display unit. (2)

5.2 Explain the purpose of using a four-bit binary to seven-segment driver together with the seven-segment display unit. (5)

5.3 Draw a neatly labelled logic-gate diagram to show the construction of a half adder. (4)

5.4 Describe why a half adder is not used for the second and subsequent binary numbers. (2)

5.5 Study FIGURE 9 of a clocked RS-latch and answer the questions that follow.

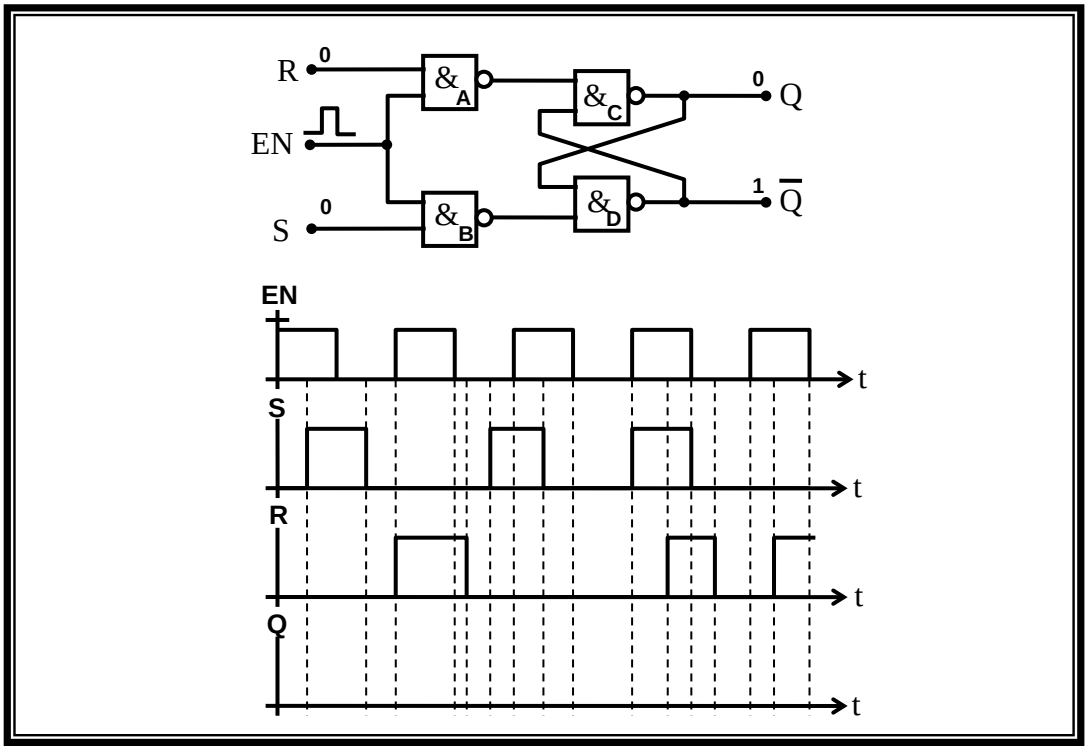


FIGURE 9

5.5.1 On the **Answer Sheet 5.5.1** an input-wave diagram for the circuit is shown. Draw the expected output waves of the circuit. (4)

5.5.2 On the same diagram of **Answer Sheet 5.5.1** also indicate the inadmissible inputs and outputs by shading them on the diagram. (3)

5.6 A JK-latch is shown in FIGURE 10. Study FIGURE 10 and explain step by step how the circuit would react if a logic level 1 is applied to both inputs J and K and the clock pulse changes from 0 to 1 to 0.

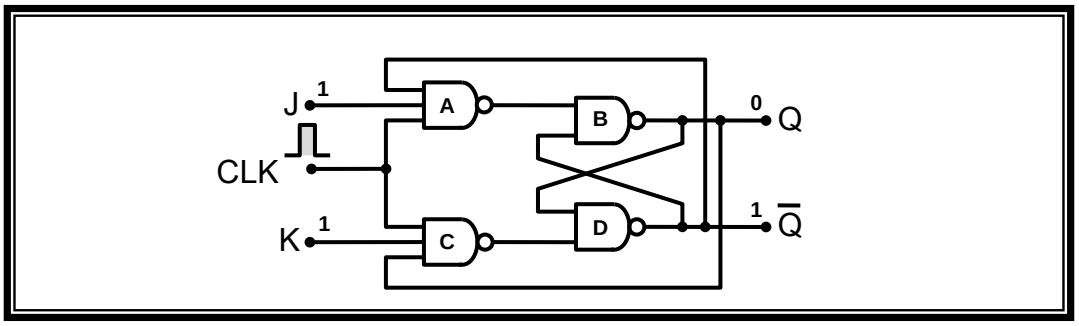


FIGURE 10

(10)

5.7 A truncated synchronous adder is shown in FIGURE 11. Study the figure and then answer the questions that follow.

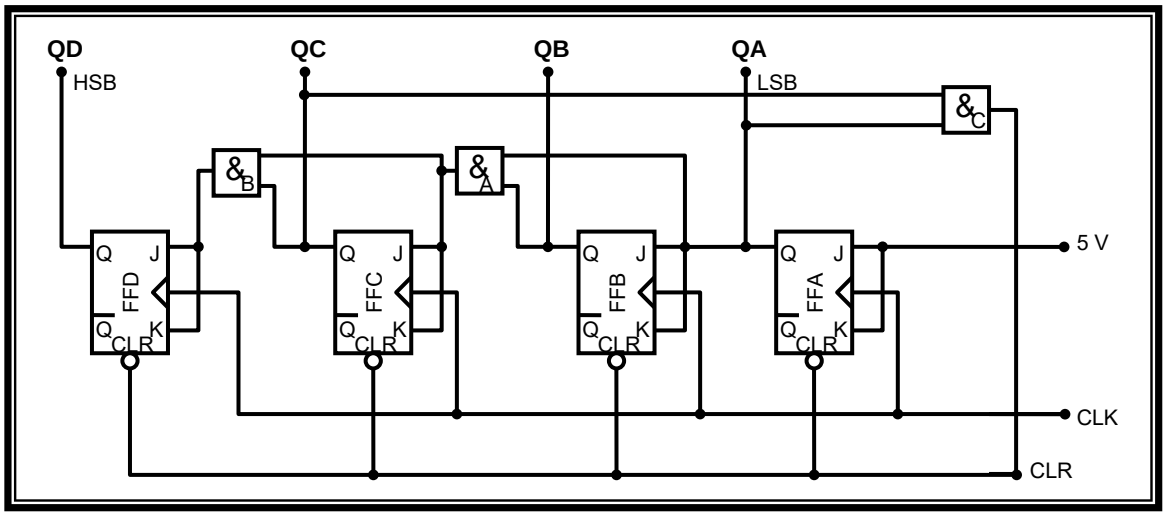


FIGURE 11

5.7.1 Explain the difference between a full-sequence counter and a truncated counter. (2)

5.7.2 Explain in chronological steps how the circuit would react for two clock pulses from binary count 0110_2. (12)

5.8 List three types of shift registers that are available. (3)

5.9 Draw a neatly labelled 3-BIT series-in-parallel-out shift register by using D-latches. (5)

5.10 Discuss the function of a 4-BIT parallel-in-series-out shift register. (3)

[55]

QUESTION 6 MICROCONTROLLERS

6.1 Draw a neatly labelled block diagram showing the basic construction of a microcontroller. (6)

6.2 Draw a neat cycle diagram to show the basic functioning of the microcontroller. (5)

6.3 Define a *microcontroller*. (3)

6.4 List THREE types of registers that are found in the central processing unit (CPU) of the microcontroller. (3)

6.5 Discuss the function of an analogue-to-digital converter in a microcontroller. (2)

6.6 Draw a labelled block diagram to show the basic layout of a simplex communication system. (3)

6.7 Name TWO other communication systems in addition to simplex that are used in microcontrollers. (2)

6.8 Give TWO disadvantages of a parallel communication system. (2)

6.9 There are two types of communication systems, namely synchronous and asynchronous communication. Describe the difference between the two. (4)

6.10 Various types of communication peripheral devices are used with micro-controllers. Give any two. (2)

6.11 Discuss the difference between legal and illegal data flow within a flow chart. (4)

6.12 Study FIGURE 12 and then explain how the flow chart works in terms of the use of a pulse switch to control a counter function of a microcontroller program.

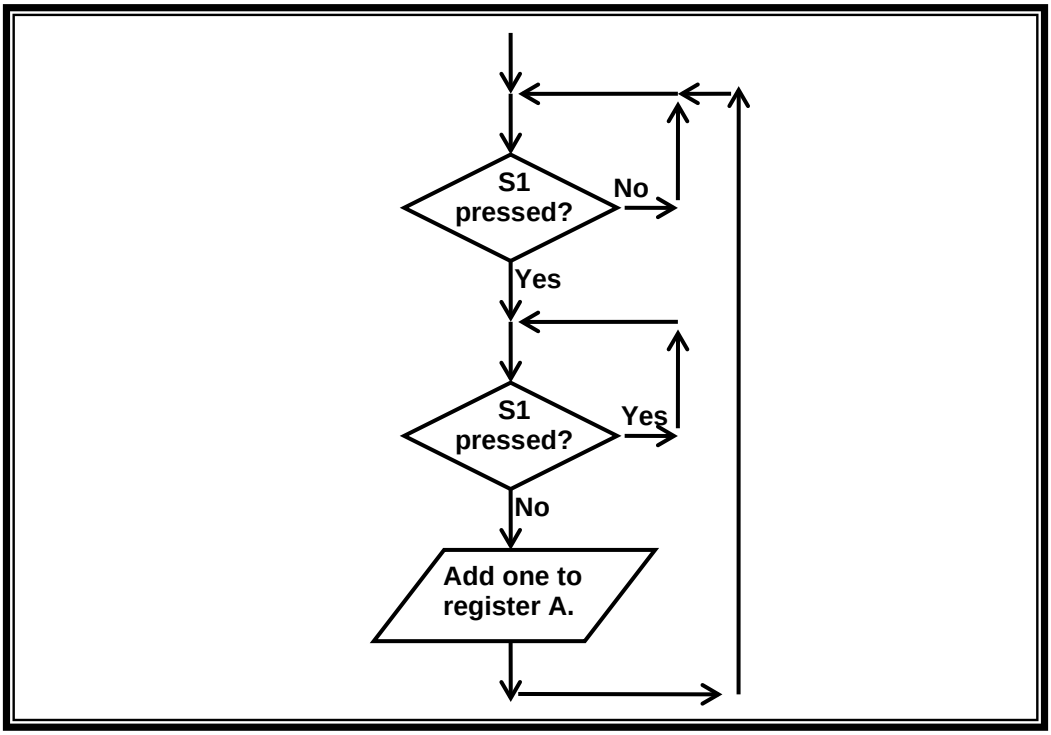


FIGURE 12

(4)

6.13 The electric motor of an air-cooling system is switched on by the following Boolean equation $X = (AB + C)$. If $\overline{X} = D$, the motor switches off. Using this information, develop a closed-loop flow chart for the cooling system so that the flow chart may be used to drive a PICAXE microcontroller. (10)

[50]

Total: 200 marks