Province of the
EASTERN CAPE
EDUCATION

NATIONAL SENIOR CERTIFICATE

GRADE 12

SEPTEMBER 2023

ELECTRICAL TECHNOLOGY: DIGITAL ELECTRONICS MARKING GUIDELINE

MARKS: 200

This marking guideline consists of 14 pages.

INSTRUCTIONS TO MARKERS

1. All calculations with multiple answers imply that any relevant, acceptable answer should be considered.

2. Calculations:

    2.1 All calculations must show the formulae.

    2.2 Substitution of values must be done correctly.

    2.3 All answers MUST contain the correct unit to be considered.

    2.4 Alternative methods must be considered, provided that the correct answer is obtained.

    2.5 Where an incorrect answer could be carried over to the next step, the first answer will be deemed incorrect. However, should the incorrect answer be carried over correctly, the marker has to re-calculate the values, using the incorrect answer from the first calculation. If correctly used, the candidate should receive the full marks for subsequent calculations.

    2.6 Markers should consider that learners answers may deviate slightly from the marking guideline depending on how and where in the calculation rounding off was used.

3. This marking guideline is only a guide with model answers.

4. Alternative interpretations must be considered and marked on merit. However, this principle should be applied consistently throughout the marking session at ALL marking centres.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

1.1	B ✓	(1)
1.2	A ✓	(1)
1.3	C ✓	(1)
1.4	D ✓	(1)
1.5	D ✓	(1)
1.6	B ✓	(1)
1.7	D ✓	(1)
1.8	B ✓	(1)
1.9	D ✓	(1)
1.10	D ✓	(1)
1.11	D ✓	(1)
1.12	B ✓	(1)
1.13	A ✓	(1)
1.14	D ✓	(1)
1.15	C ✓	(1)
		[15]

QUESTION 2: OCCUPATIONAL HEALTH AND SAFETY (GENERIC)

2.1
- Integrity ✓
- Sense of responsibility ✓
- Emphasis on quality
- Discipline
- Sense of teamwork (Any 2 x 1) (2)

2.2 An event that causes grave or severe physical injury to a person, ✓ threatening their health and safety. ✓ (2)

2.3
- Avoid direct contact with any chemical ✓
- Always wear personal protective clothing
- Always read and be aware of the warning symbols on containers

(Any 1 x 1) (1)

2.4 An unsafe act is the wilful performance of a task or activity in a manner that may threaten the health and safety of everyone. ✓
A calculated risk is the probability that injury or damage may occur while using dangerous equipment. ✓ (2)

2.5
- To prevent oneself from being electrocuted. ✓
- To prevent injury (Any 1 x 1) (1)

2.6 This could damage the equipment and render the equipment unsafe ✓ and compromise the safety of the user. ✓ (2)

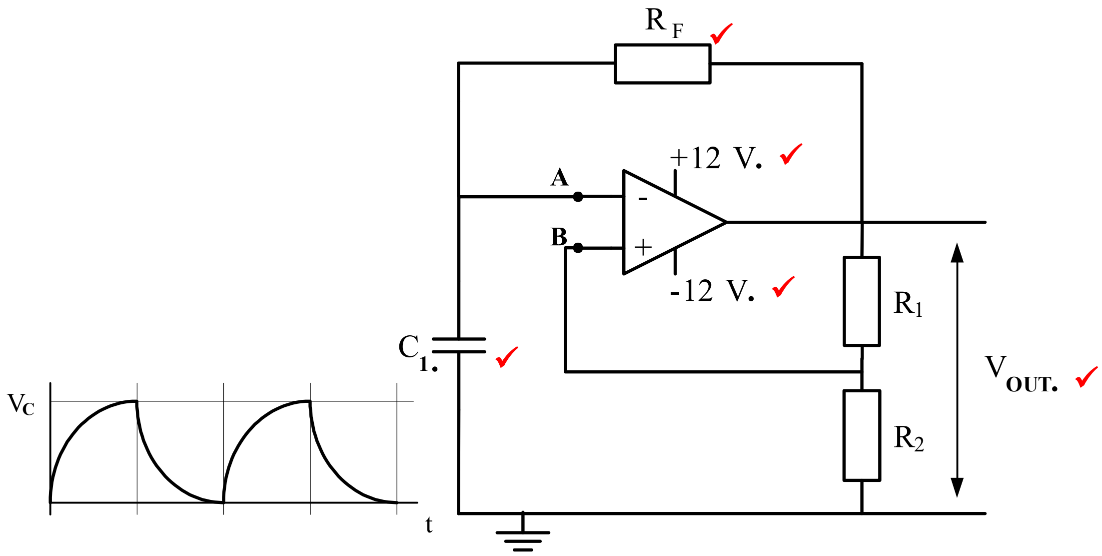
[10]

QUESTION 3: SWITCHING CIRCUITS

3.1 3.1.1 Monostable multivibrator ✓ (1)

3.1.2 Bistable multivibrator ✓ (1)

3.2



(5)

3.3 3.3.1 Bistable ✓multivibrator ✓ (2)

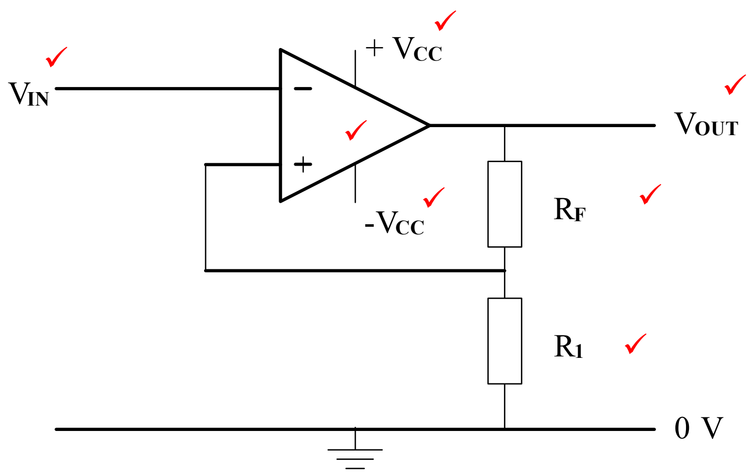
3.3.2 Resistors R_1 and R_2 are pull-up ✓ resistors. ✓ (2)

3.3.3 When set is pressed, it pulls pin 2 'low' ✓ (0 V) and cause the output to go 'high'. ✓ turning the LED on. ✓ (3)

3.3.4 Threshold pin 6 is purposefully held at 0 V ✓ causing the IC not to reset, ✓ keeping the output high ✓ when S_1 is pressed. (3)

3.4 3.4.1 The output signal represents an inverting Schmitt trigger ✓ because the output signal is inverted✓ with reference to the input signal. ✓ (3)

3.4.2



(7)

3.5 3.5.1 The gain of the amplifier is determined by the ratio ✓ of the feedback resistance ✓ to the input resistance of each. ✓ (3)

3.5.2 $V_{OUT} = -\left(V_1 \frac{Rf}{R1} + V_2 \frac{Rf}{R2} + V_3 \frac{Rf}{R3}\right)$ ✓

$= -\left(200\ \text{mV} \frac{100\ \text{k}\Omega}{20\ \text{k}\Omega} + 300\ \text{mV} \frac{100\ \text{k}\Omega}{10\ \text{k}\Omega} + 400\ \text{mV} \frac{100\ \text{k}\Omega}{25\ \text{k}\Omega}\right)$ ✓

$= -(200\ \text{mV} \times 5) + (300\ \text{mV} \times 10) + (400\ \text{mV} \times 4)$ ✓

$= -5{,}6\ \text{V}$ ✓ (4)

3.5.3 $V_{OUT} = V_{IN} \times \text{Gain}$

Gain $A_V = \frac{V_{OUT}}{V_{IN}}$ ✓

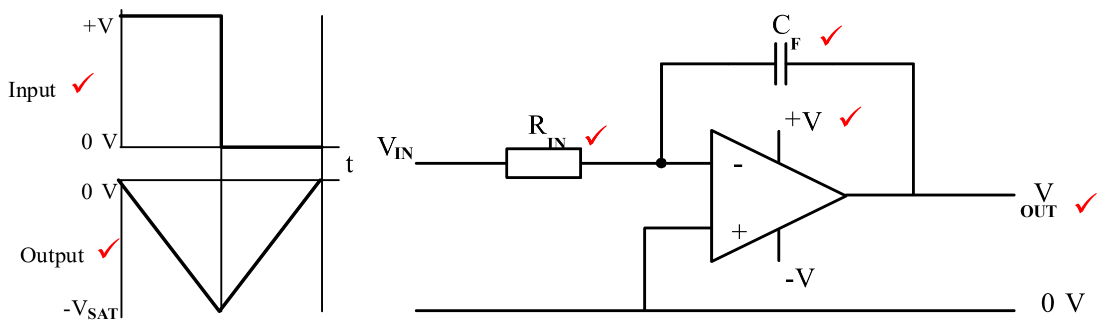
$= \frac{5{,}6}{0{,}2 + 0{,}3 + 0{,}4}$ ✓

$= 6{,}2\ \text{V}$ ✓ (3)

3.5.4 With a variable resistor in the feedback loop, the gain ✓ of the amplifier can be varied / controlled. ✓ (2)

3.5.5 If R_2 is changed to 5 kΩ, the gain for V_2 will increase, ✓ causing the total output voltage to increase. ✓ (2)

3.6



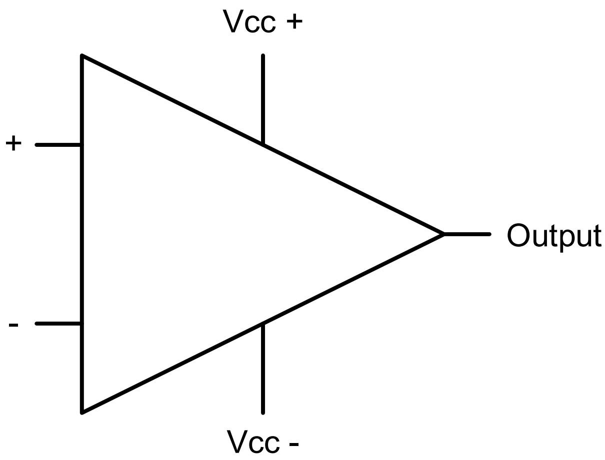
(6)

3.7
- The inputs draw zero current. ✓
- The two inputs will always have the same voltage. ✓
- The capacitor will charge at a constant rate, when a constant current is supplied. ✓ (3)

[50]

QUESTION 4: SEMICONDUCTORS

4.1



Drawing correct. ✓
Inputs and Output labelled correct. ✓
Positive and Negative supplies labelled correct. ✓ (3)

4.2.1 The signal will be 10 times greater than the input signal/the output will be 1 V. ✓ and the output signal will be 180° out of phase with the input signal.✓ (2)

4.2.2 The signal will be 11 times greater than the input signal/the output will be 1,1 V ✓ and the output signal will be in phase with the input signal. ✓ (2)

4.3.1 No, the output signal is incorrect. ✓ The output signal should be 180° out of phase with the input signal because the circuit is an inverting amplifier. ✓ (2)

4.3.2 $V_{OUT} = V_{IN}\left(\frac{R_f}{R_{IN}}\right)$ V ✓

$3\text{ V} = 20 \times 10^{-3}\left(\frac{150 \times 10^3}{R_{IN}}\right)$ V ✓

$R_{IN} = 1\,000\ \Omega$

$R_{IN} = 1\text{ k}\Omega$ ✓ (3)

4.4.1 Trigger ✓ (1)

4.4.2
- Pin 6 sets the voltage at which the 555 IC will trigger. ✓
- It is used to maintain the voltage across the timing capacitor ✓ which is then discharged through Pin 7. ✓ (3)

4.4.3 The 555 IC can only operate at power supply voltages between +5 V ✓ to +18 V. ✓ (2)

4.4.4 The RS flip-flop stores the incoming information temporarily, ✓ until new information is received. ✓ (2)

[20]

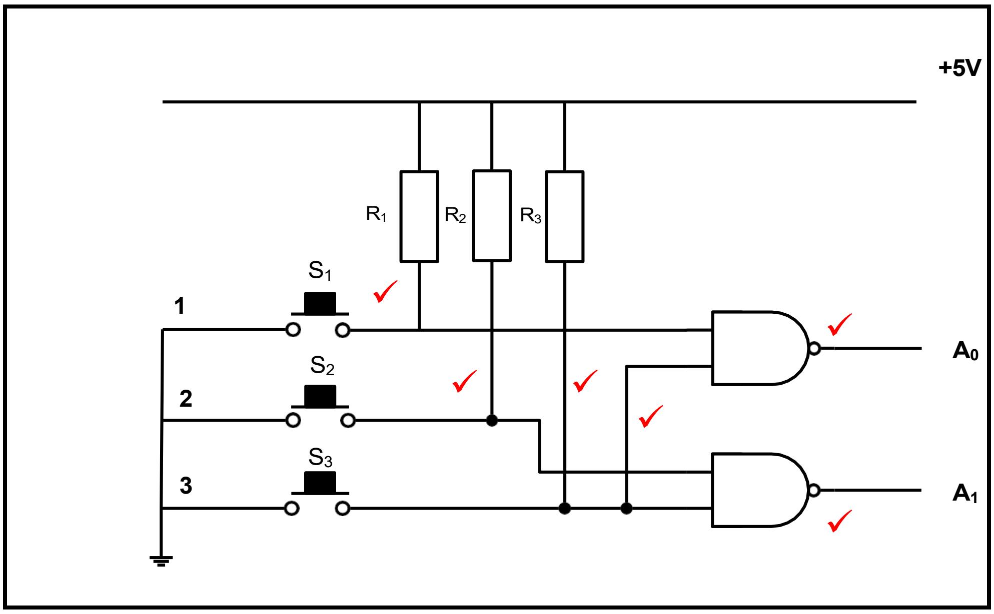
QUESTION 5: DIGITAL AND SEQUENTIAL DEVICES

5.1
- Liquid crystal is placed between two transparent plates. ✓
- The transparent plates are polarised. ✓
- A reflecting metal surface is mounted behind the lower plate. ✓
- A transparent plastic plate is placed on top of the upper polarised plate. ✓ (4)

5.2
- In common anode ✓ all eight LEDs are internally connected together to a common positive voltage rail. ✓
- In common cathode ✓ all eight LEDs are internally connected to a common 0 V ground. ✓ (4)

5.3
- Input voltage: 2 V (2,1 to 2,5 may also be taken as correct) ✓
- Current flow: 20 mA ✓
- Reverse voltage: 6 V
- Power: 600 mW
- Soldering time: 5 s (Any 2 x 1) (2)

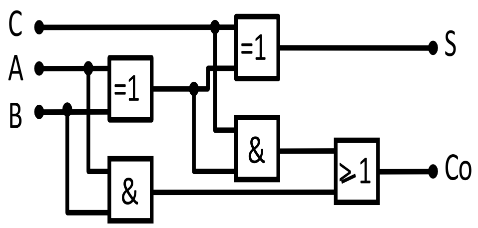
5.4 5.4.1



(6)

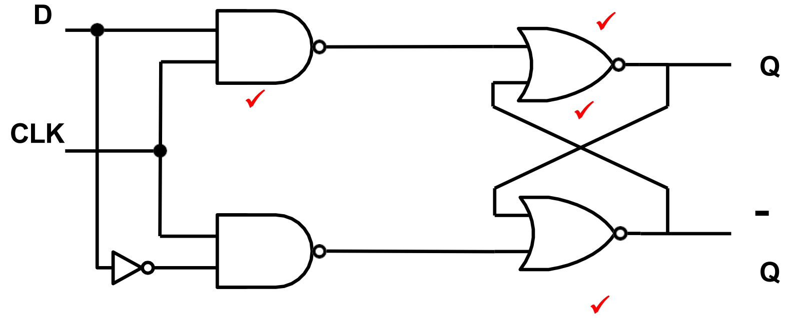
5.4.2 W = 0 ✓
X = 1 ✓
Y = 0 ✓
Z = 0 ✓ (4)

5.5

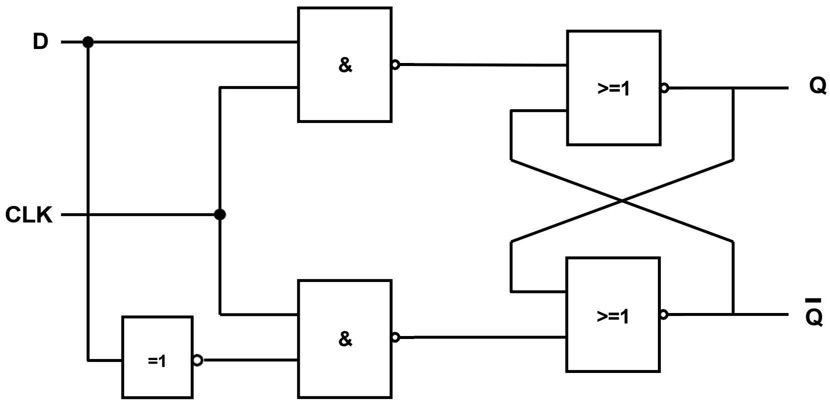


NOTE:
1 mark for each logic gate.
A mark is allocated to a logic function only if the relevant function's inputs and outputs are connected correctly and labelled correctly where applicable. (5)

5.6 5.6.1



OR



NOTE:
1 mark for each NAND gate = 2
1 mark for each NOR gate = 2
1 mark for the NOT gate
1 mark for the latch = 1 (6)

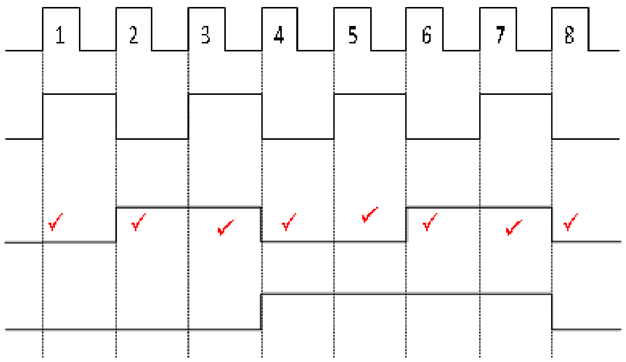
5.6.2

INPUTS		OUTPUTS	
CLK	D	Q	Q
0	0	LATCH	
0	1	LATCH (UNCHANGED)	
1	0	0	1
1	1	1	0

✓✓✓

1 mark for each correct row on the table (3)

5.7 5.7.1



NOTE: A mark is allocated for the correct count at each clock pulse e.g. the count at clock pulse 3 should be 011 and at clock pulse 8 the count should be 000. (8)

5.7.2 The circuit in FIGURE 5.6 is synchronous. ✓ (1)

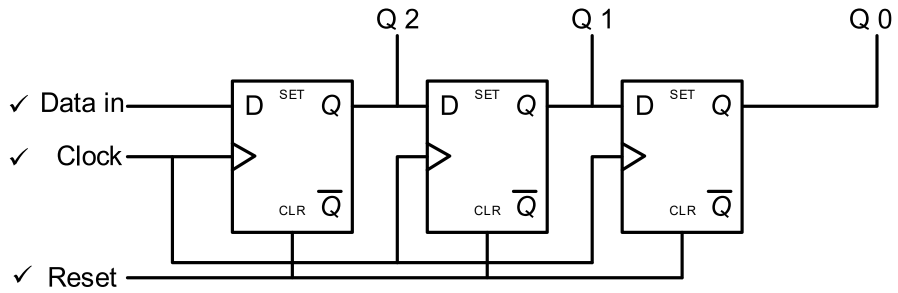
5.8 A synchronous counter uses a common clock pulse ✓ that tries to clock all the various JK flip-flops simultaneously. ✓

An asynchronous counter has a clock pulse only on the first JK latch ✓ that serves as the LSB. The output of each JK latch is set as the clock pulse for the next JK latch. ✓ (4)

5.9
- SIPO (Series-In-Parallel-Out) ✓
- PIPO (Parallel-In-Parallel-Out) ✓
- SISO (Series-In-Series-Out) ✓
- PISO (Parallel-In-Series-Out) (Any 3 x 1) (3)

5.10

✓Drawing correct
✓Q 0 to Q 2 = 1 Mark



MARKING NOTE:

- Each correct label receives 1 mark. NB: Q0 to Q2 together counts as one label.
- 1 mark is awarded for the sketch if it is correct. (5)

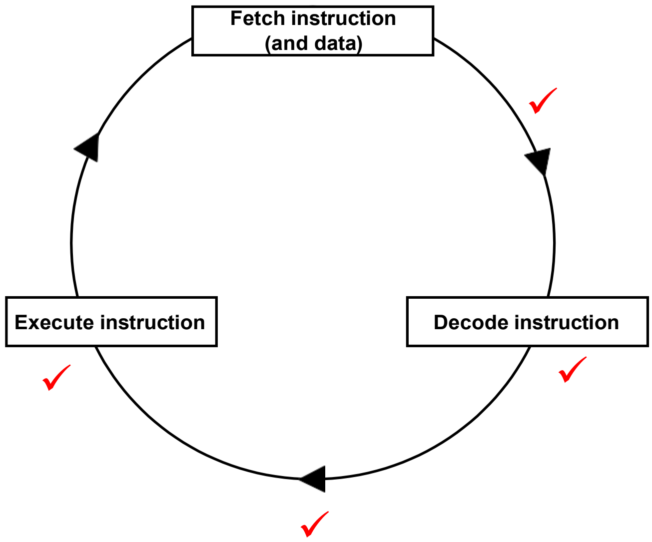
[55]

QUESTION 6: MICROCONTROLLERS

6.1 Microcontrollers are used in industrial control devices:

- Industrial instrumentation ✓
- Monitoring ✓
- Process control
- Cooling systems (Any 2 x 1) (2)

6.2 **NOTE:**



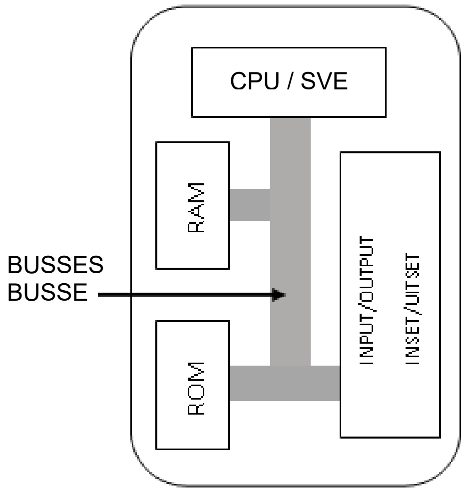
NOTE: 1 mark for each correct label = 3
1 mark for correct connection and direction = 1 (4)

6.3 A microprocessor is simply an IC which has only the Central Processing Unit (CPU) inside it. ✓
A microcontroller is essentially a complete, small-scale computer ✓ with all the necessary devices required to function, ✓ embedded together on a single IC chip. ✓

OR

A microprocessor is an Integrated Circuit (IC) with only a Central Processing Unit (CPU).
A microcontroller is a complete, small-scale computer with all the necessary devices required to function, embedded together on a single IC chip. (4)

6.4



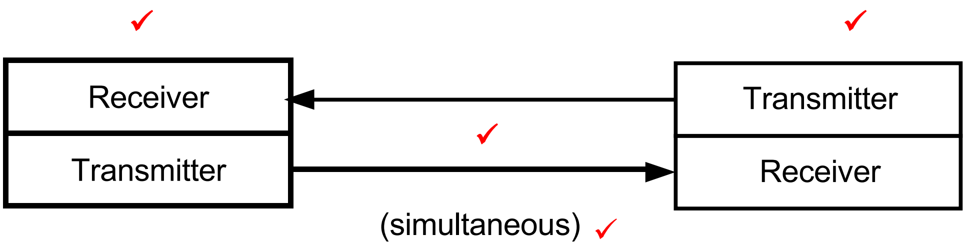
NOTE:

- 1 mark is awarded per label.
- The 6th mark is awarded if the learner has all labels correct and the sketch is also drawn correctly.
- The positioning of the components may differ from that of the marking guideline. (6)

6.5
- Memory data register ✓
- Memory address register ✓
- Counter register ✓
- Control register
- Current-instruction register (Any 3 x 1) (3)

6.6 It receives analogue data ✓ and converts the data into digital format which is then made available to the microcontroller to do further calculations. ✓ (2)

6.7



(4)

6.8
- Half-duplex ✓
- Full duplex/duplex ✓ (2)

6.9 6.9.1 The Memory Data Register (MDR) stores a copy ✓ of the current instruction to be executed. ✓ (2)

6.9.2 The Current Instruction Register (CIR) splits the instruction into two parts. ✓ One part is decoded by the control unit ready for execution, ✓ the other part is the address of the data stored that needs to be used together with that instruction. ✓ (3)

6.10 Takes up a lot of space on the logic chip for the parallel paths. ✓
Makes manufacturing the logic chip more complex. ✓ (2)

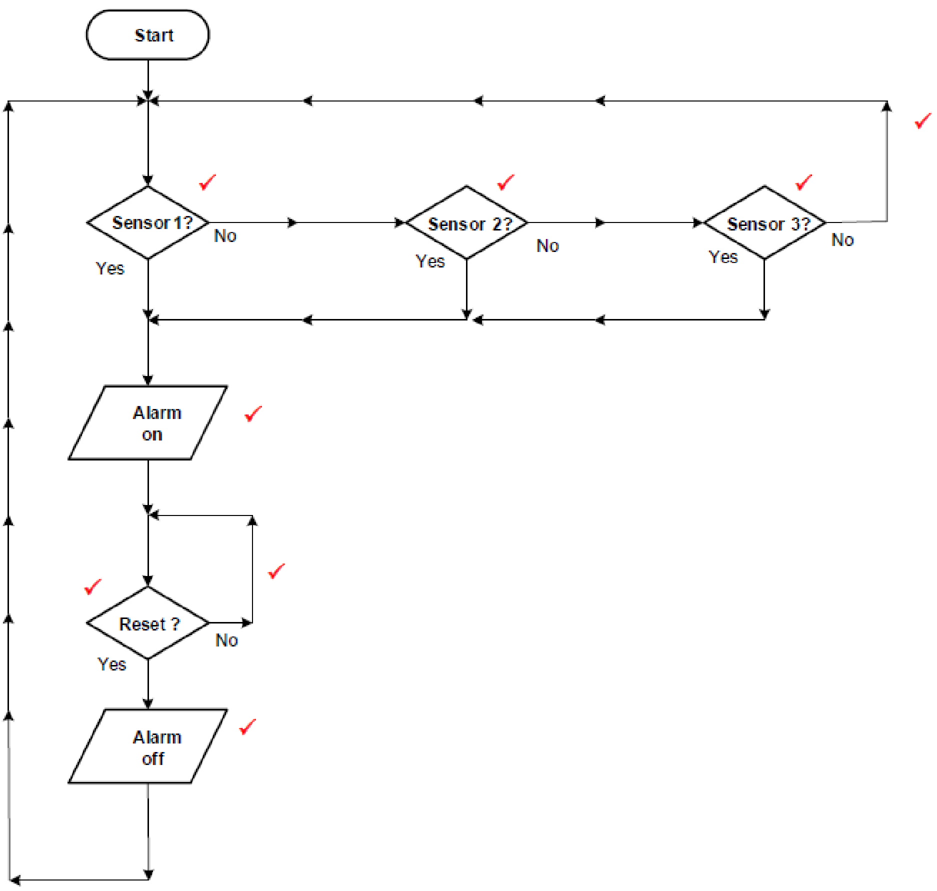
6.11 6.11.1
- Point of sale (POS) terminals ✓
- Metering instruments ✓
- Large special automated machines ✓
- Modems
- Computer Numerically Controlled machines (CNC) Robots
- Embedded control computers
- Medical instruments and equipment (Any 3 x 1) (3)

6.11.2 Differential ✓ (1)

6.12 In legal data flow the data lines will follow on another after a specific action ✓ and they will not cross one another or move against the other flow. ✓

In illegal data flow the data lines will just end without reaching a function. ✓ The data lines may also move against the flow of other lines or the data lines may cross other data lines. ✓ (4)

6.13



1 mark for each correctly placed label = 6
1 mark for each correctly placed flow line = 2 (8)

[50]

TOTAL: 200