basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

SENIOR CERTIFICATE EXAMINATIONS/ NATIONAL SENIOR CERTIFICATE EXAMINATIONS

ELECTRICAL TECHNOLOGY: DIGITAL ELECTRONICS

MAY/JUNE 2025

MARKING GUIDELINES

MARKS: 200

These marking guidelines consist of 14 pages.

INSTRUCTIONS TO THE MARKERS

1. All questions 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.

3. This memorandum is only a guide with model answers. 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 C ✓ (1)

1.2 C.✓ (1)

1.3 D.✓ (1)

1.4 C.✓ (1)

1.5 B ✓ (1)

1.6 C ✓ (1)

1.7 D ✓ (1)

1.8 C ✓ (1)

1.9 D ✓ (1)

1.10 A ✓ (1)

1.11 D ✓ (1)

1.12 C ✓ (1)

1.13 D ✓ (1)

1.14 D ✓ (1)

1.15 B ✓ (1)

[15]

QUESTION 2: OCCUPATIONAL HEALTH AND SAFETY

2.1 Health and safety equipment refer to any artefact which is manufactured, provided or installed ✓ in the interest of the health or safety of any person. ✓ (2)

2.2 Removing safety guards/covers from machinery before using it. ✓
Removing the earth pin from a 3-pin plug intended for use in a three-wire earth system. ✓
Removing an emergency stop button from a motor control circuit. (2)

2.3 The purpose of the act is to provide health and safety for people at work in general. ✓
To create a safe environment for those who work with machinery. ✓ (2)

2.4 Every employer is required by law ✓ to make employees conversant with the hazards to their health and the safety attached to any work that they perform. ✓ (2)

2.5 An employee/learner with good discipline stays focused and completes his/her tasks set out for the duration in time. ✓
An employee/learner with good discipline will not fool around with or disturb others in the workshop in such a way that it might cause an accident. ✓ (2)
[10]

QUESTION 3: SWITCHING CIRCUITS

3.1 Astable refers to a circuit that changes its output continuously between two states ✓ without the need of an external trigger input.✓ (2)

3.2 3.2.1 The input circuit has two trigger inputs.✓ (1)

3.2.2 R_1&R_2 divides the output voltage ✓ to a value which is fed back to the non-inverting input.✓ (2)

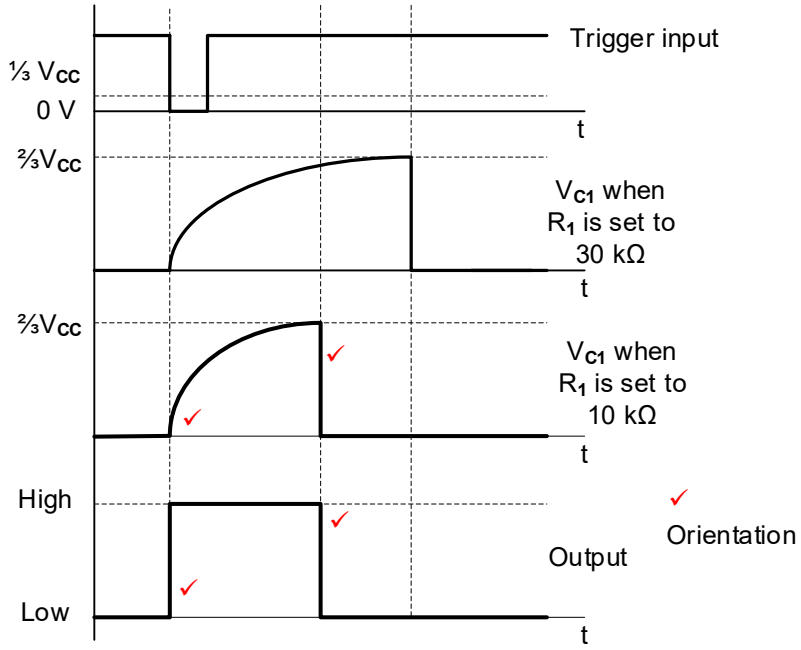
3.2.3
- When PB_1 is pressed it connects the inverting input of the op-amp through C_1 and R_3 to the positive supply connecting a positive voltage (signal) to the inverting input. ✓
- The moment this input signal is higher than the positive voltage present on the non-inverting terminal, ✓
- The output swings to negative saturation ✓ which changes the voltage on the non-inverting terminal to a negative value. ✓ (4)

3.2.4 The circuit has already been triggered at trigger pulse 1 ✓ and will remain in this state until a negative trigger pulse is applied. ✓ (2)

3.3 3.3.1 R_2 is a pull-up resistor ✓ keeping the voltage at pin 2 high and the 555 timer in a stable state. ✓ (2)

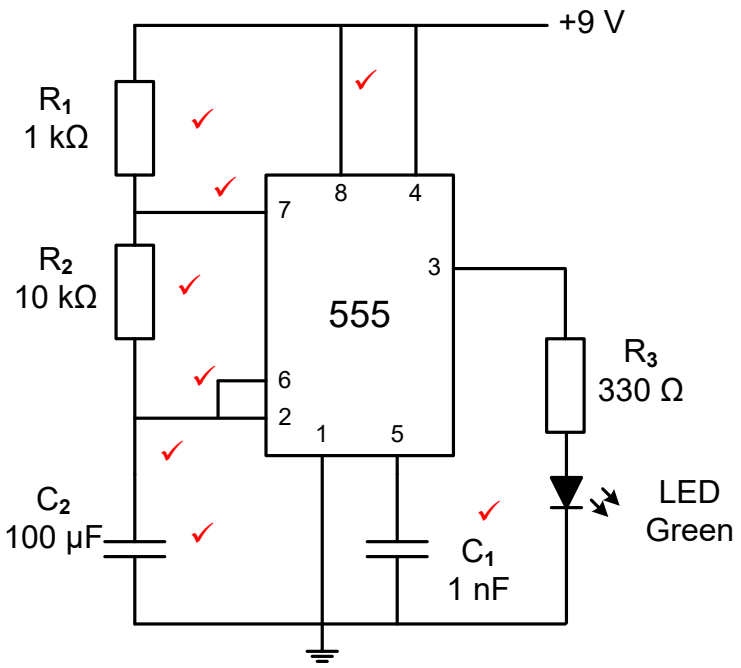
3.3.2 A 1 kΩ resistor must be inserted in series with VR_1 ✓ and the supply ✓ to protect pin 6 and pin 7 from being connected directly to the supply. (2)

3.3.3



(5)

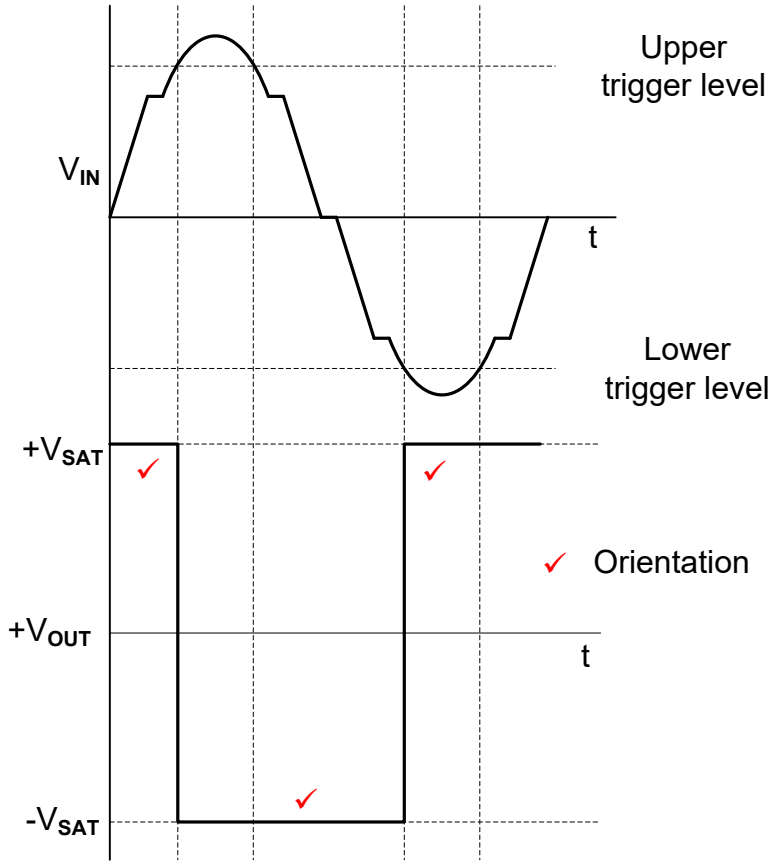
3.4



(8)

3.5 3.5.1 Signal recovery in communication systems. ✓
Converting analogue to digital signals. ✓ (2)

3.5.2



(4)

3.6 The comparator:

- The comparator compares an input voltage to a single reference voltage value ✓ and
- saturates at the slightest difference where it stays until the input rises above or falls below the reference again. ✓
- No feedback takes place and it operates in open loop mode. ✓

The Schmitt trigger:

- The Schmitt trigger compares the input voltage to two different voltage values ✓
- These values are determined by the feedback voltage from the voltage divider on the output. ✓
- As soon as the input rises above the upper trigger level, the output saturates where it remains until the input voltage falls below the lower trigger voltage level. ✓ (6)

3.7 3.7.1 10 kΩ ✓ (1)

3.7.2 -1 ✓ (1)

3.7.3
$$V_{OUT} = -\left(V_1\frac{R_F}{R_1} + V_2\frac{R_F}{R_2} + V_3\frac{R_F}{R_3}\right) \quad ✓$$
$$= -\left(0{,}2\frac{100\,000}{33\,000} + 0{,}9\frac{100\,000}{33\,000} + 0{,}7\frac{100\,000}{33\,000}\right) \quad ✓$$
$$= -5{,}45\ V \quad ✓$$
(3)

3.7.4
$$A_V = -\frac{R_F}{R_{IN}} \quad ✓$$
$$= -\frac{100\,000}{20\,000} \quad ✓$$
$$= -5 \quad ✓$$
(3)

3.8 When a constant current is fed to the capacitor, it charges at a constant rate. ✓
The op-amp's input draws zero current. ✓
The op-amp's two input terminals always possess the same voltage. (2)
[50]

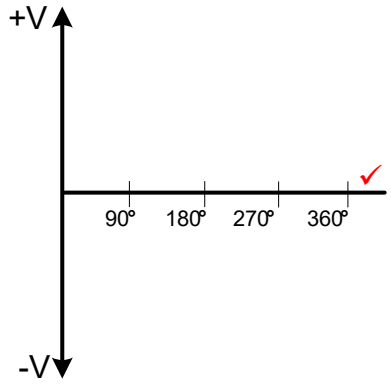
QUESTION 4: SEMICONDUCTOR DEVICES

4.1 4.1.1 The amplitude of the output waveform will be reduced. ✓ (1)

4.1.2
- The gain of the amplifier can be controlled ✓
- The amplifier will be stable ✓
- The output signal distortion is reduced
- The range of frequencies that can be amplified is increased (2)

4.2 4.2.1 An ideal op-amp is not dependant on frequency ✓ and would be able to amplify all frequencies from 0 Hz to infinite. (1)

4.2.2



(1)

4.2.3
- Operational amplifiers are high-gain amplifiers that has the ability of amplifying signals from 0 Hz (DC) to MHz range. ✓
- It can be used to perform many mathematical operations. ✓ (2)

4.3 4.3.1 The circuit will become an open loop whereby the output waveform will be saturated ✓ and the voltage gain will be infinite. (1)

4.3.2 Virtual earth ✓ (1)

4.3.3
$$V_{OUT} = V_{IN}\left(-\frac{R_F}{R_{IN}}\right) \quad ✓$$
$$R_F = R_{IN} \times \left(-\frac{V_{OUT}}{V_{IN}}\right) \quad ✓$$
$$= 15 \times 10^3 \times \left(-\frac{-12}{1}\right)$$
$$= 180\,000\ \Omega \quad ✓$$
(3)

4.4 4.4.1 The comparator's output controls the state of the flip-flop.✓ (1)

4.4.2 When the trigger voltage goes below ⅓V_{cc}, the flip-flop sets ✓ and the output Pin 3 goes to a high level.✓ (2)

4.4.3
- 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 discharged with the help of Pin 7. ✓ (3)

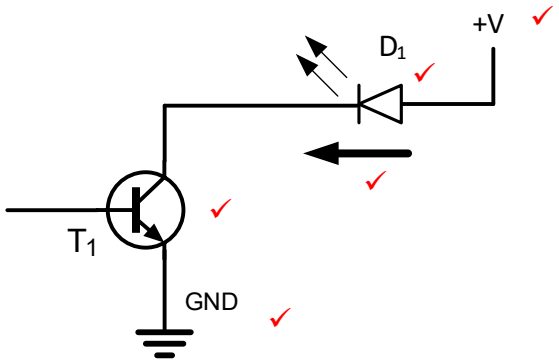
4.4.4 Temperature measurements. ✓
Controlling the positioning of a servo device. ✓ (2)

[20]

QUESTION 5: DIGITAL AND SEQUENTIAL DEVICES

5.1 Liquid Crystal display (LCD) ✓ (1)

5.2



(5)

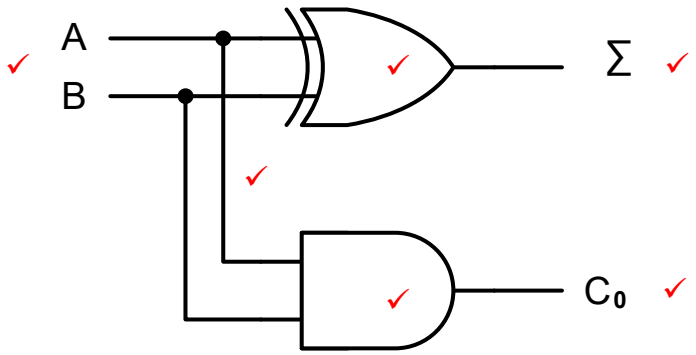
5.3 5.3.1 3- digit decimal input to 2-bit binary output encoder circuit.✓ (1)

5.3.2

INPUTS	OUTPUTS	
Push Button	A_1	A_0
X		1✓
Y	1✓	
Z	1✓	1✓

(4)

5.4 5.4.1



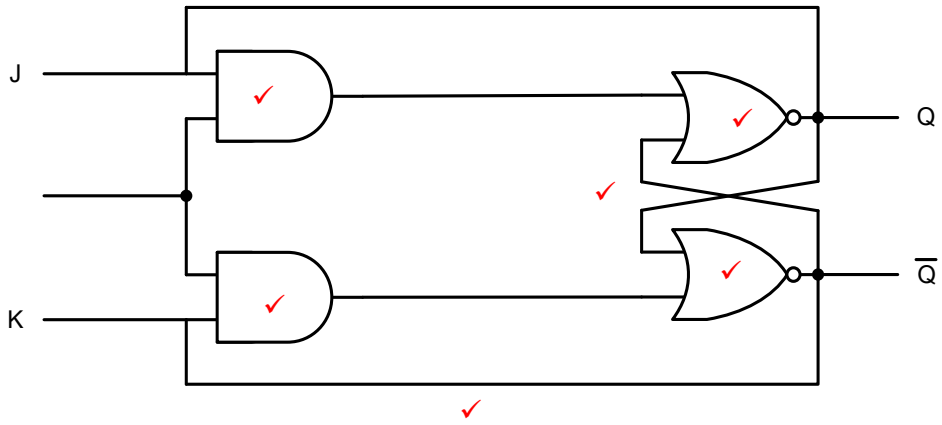
NOTE: 1 mark for each correctly placed symbol = 2
1 mark for correctly placed connection = 1
1 mark for correctly labelled inputs = 1
1 mark for each correctly labelled output = 2 (6)

5.4.2

INPUTS		OUTPUTS	
A	B	∑	C_0
0	0	0✓	0
0	1	1	0✓
1	0	1	0✓
1	1	0	1✓

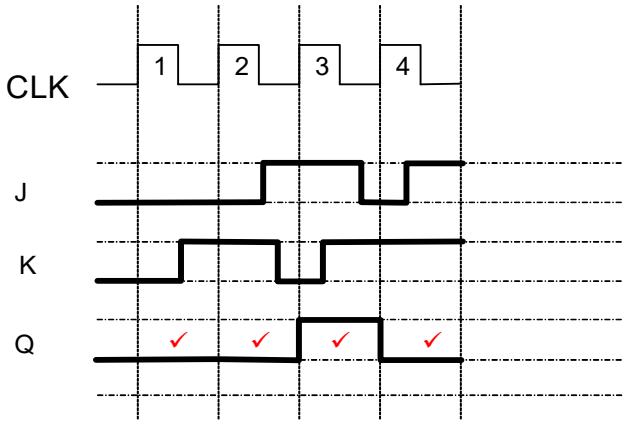
(4)

5.5 5.5.1



NOTE: 1 mark for each correctly placed symbol = 4
1 mark for the latch = 1
1 mark for correctly placed connection = 1 (6)

5.5.2



(4)

5.6 A = 8 Hz ✓
B = 4 Hz ✓
C = 2 Hz ✓ (3)

5.7 In a synchronous counter, all flip-flops are connected to the same clock ✓ that clocks all the JK flip-flops simultaneously. ✓
In an asynchronous counter all the flip-flops are not triggered at the same time✓ so their outputs do not change states at the same time because only the first flip-flop is connected to the external clock. ✓ (4)

5.8 5.8.1 Three stage binary✓counter. (1)

5.8.2 Up✓ (1)

5.8.3

CLOCK PULSES	BINARY COUNT SEQUENCE		
	C	B	A
0	0	0	0
1	0	0	1
2	0	1	0 ✓
3	0	1✓	1
4	1✓	0	0
5	1	0	1 ✓
6	1	1	0
7	1	1	1
8	0	0	0 ✓

(5)

5.9 5.9.1 SIPO ✓ (Serial - In: Parallel - Out) (1)

5.9.2 A = 4-bit Parallel Data Out ✓
B = Serial Data in ✓ (2)

5.9.3 As data is clocked into this device, one clock pulse at a time, ✓ each bit shifts one place to the right ✓ until the complete four-bit value is stored in the register. ✓ After four clock pulses, ✓ the full value appears on the output lines that can be read by the following stage, all at the same time. ✓ (5)

5.10
- PIPO (Parallel-In-Parallel-Out) ✓
- SISO (Series-In-Series-Out) ✓ (2)

[55]

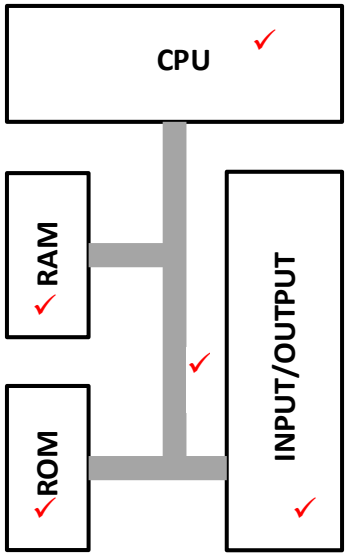
QUESTION 6: MICROCONTROLLERS

6.1 6.1.1

- Reduction in the size of circuits ✓because discrete components are replaced within a single IC package to perform the same function.
- Circuits are cheaper because discrete components are placed in an IC format and therefore manufacturers have to stock and use fewer components. ✓
- Circuits are more reliable because fewer components are used to manufacture the IC than when discrete components are used.
- Reduction in production cost because manufacturers have to place fewer components on factory lines and stock fewer components. (2)

6.1.2 The basic function of the microcontroller is to sense external information and data, ✓ and together with its internally programmed instruction set, it issues orderly, step by step commands ✓ to its connected devices, to execute a series of operations. ✓ (3)

6.1.3



(5)

6.1.4 The Memory Address Register (MAR) stores the address of the next instruction ✓ to be executed by the processor. (2)

6.2 6.2.1 A = Request ✓
B = Acknowledge ✓
C = Transmitter ✓ (3)

6.2.2
- Bits are grouped together consisting of both data and control bits.
- The signal is synchronised so that the receiver will be able to distinguish when the next group of bits will arrive. ✓
- The data is preceded by a 'start bit', usually binary 0, the byte is then sent and a 'stop bit' which is added to the end. ✓
- In addition to the control data small gaps are inserted between each 'chunk' to distinguish each group. ✓
- When the sender receives data, it sends a 'request' to the receiver stage and then waits for an 'acknowledge' signal. ✓
- Once this is received the sender then sends the data together with 'start' and 'stop' parity bits. ✓ (5)

6.3 6.3.1 A set of rules and regulations ✓ that allow two electronic devices to connect and to exchange data and information ✓ between each other. (2)

6.3.2 Simplex ✓
Duplex ✓ (2)

6.4 A shared boundary across which two separate components of a computer system exchange information. ✓ (1)

6.5 6.5.1 The Universal Asynchronous Receiver Transmitter logic chip that receives parallel data from the CPU ✓ and converts it into series data and then places the data on the output terminal. ✓ (2)

6.5.2
- Reliable for high speed serial communication ✓
- Uses less wires than parallel communication ✓
- Useful for communicating serial data, i.e. text, numbers to a PC from a mouse or keyboard. ✓
- Easy and low-cost serial interface connection between two computer systems. (3)

6.5.3 Serial Peripheral Interface (SPI) ✓
Inter-Integrated Circuit (I^2C) ✓ (2)

6.6 6.6.1 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 (3)

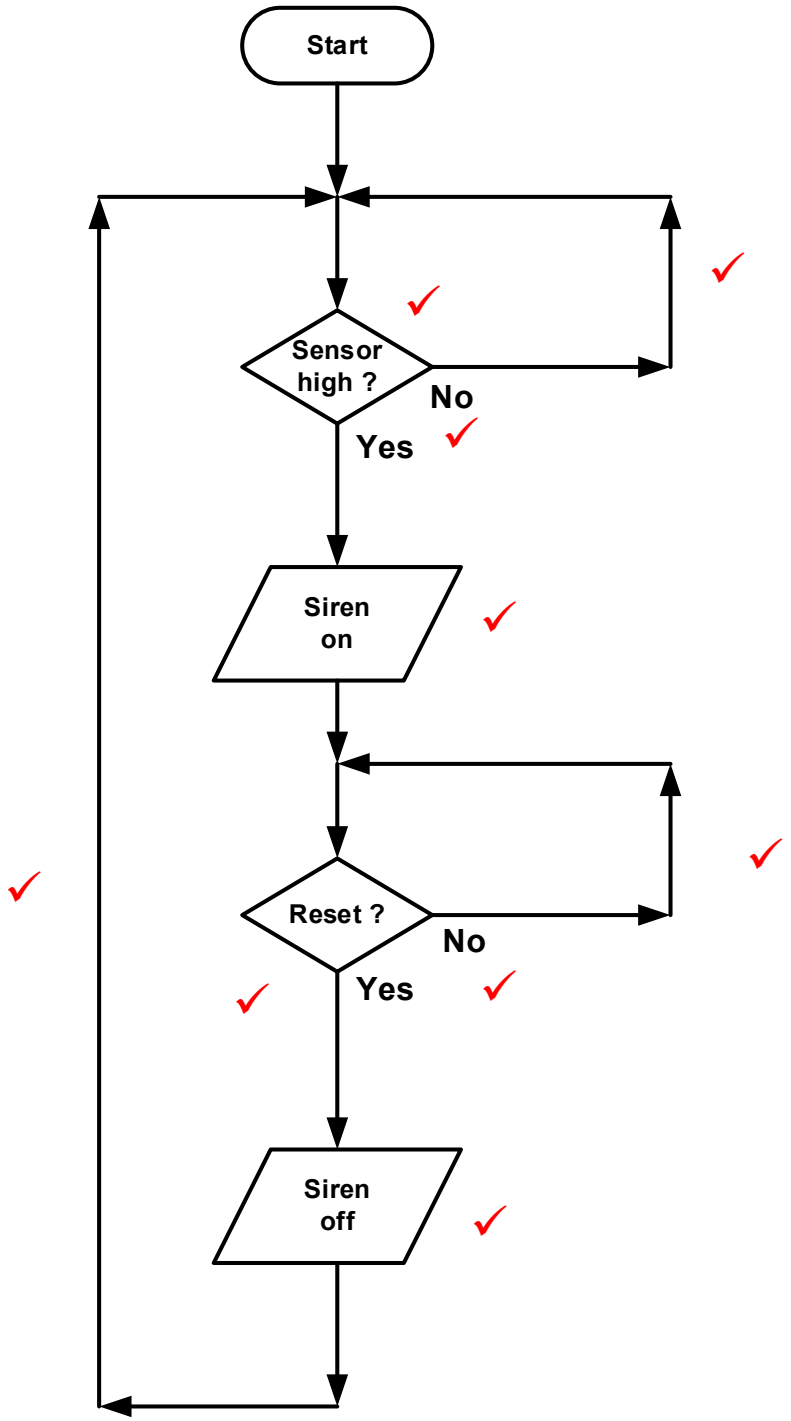
6.6.2

CHARACTERISTICS	RS-232	RS-485
Mode of operation	Simplex ✓ OR Half duplex	Simplex OR Half duplex OR Full duplex
Line configuration	Single-ended	Differential ✓

(2)

6.7 In legal data flow, the data lines will follow one 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)

6.8



NOTE: 1 mark for each correctly labelled symbol = 4
1 mark for each correctly placed flow line = 3
1 mark for each correctly placed YES/NO = 2 (9)

[50]

TOTAL: 200