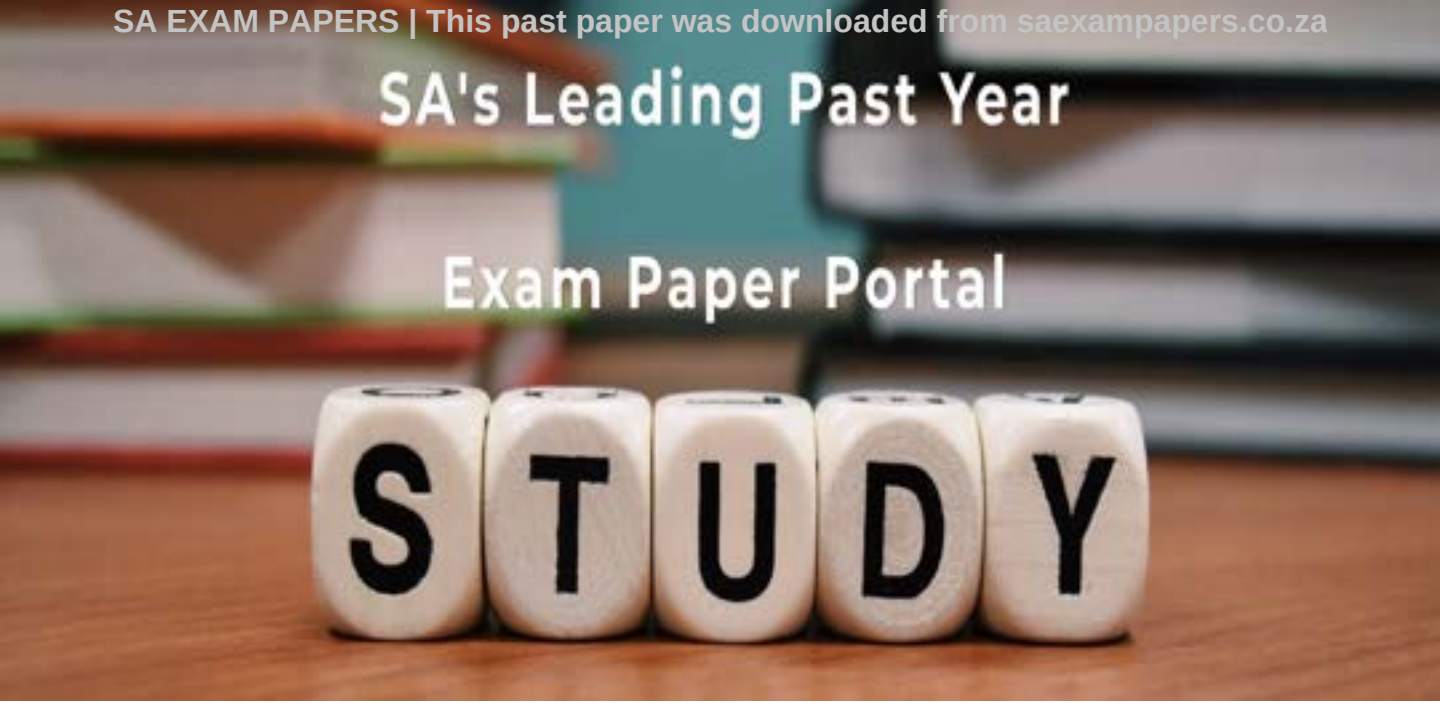

Province of the
EASTERN CAPE
EDUCATION

Iphondo leMpuma Kapa: Isebe leMfundo
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NATIONAL SENIOR CERTIFICATE

GRADE 12

SEPTEMBER 2024

ELECTRICAL TECHNOLOGY: DIGITAL ELECTRONICS MARKING GUIDELINE

MARKS: 200

This marking guideline consists of 15 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. These marking guidelines 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 A ✓

1.2 D ✓

1.3 C ✓

1.4 D ✓

1.5 C ✓

1.6 D ✓

1.7 B ✓

1.8 D ✓

1.9 A ✓

1.10 D ✓

1.11 A ✓

1.12 B ✓

1.13 D ✓

1.14 A ✓

1.15 C ✓ (15 x 1) **[15]**

QUESTION 2: OCCUPATIONAL HEALTH AND SAFETY

2.1 2.1.1 The probability that injury or damage will occur. ✓ (1)

2.1.2 Free from any hazard. ✓ (1)

2.2 The purpose of the Occupational Health and Safety Act is to provide for the health and safety of:

- Persons at work ✓
- Persons in connection with the use of plant and machinery ✓
- The protection of persons against hazards arising out of the activities of other persons at a work
- To establish an advisory council for occupational health and safety and related matters (Any 2 x 1) (2)

2.3
- Faulty tools or equipment ✓
- Poor ventilation ✓
- Poor quality or missing guards on machines ✓
- Excessive noise
- Lack of knowledge of emergency procedures (Any 3 x 1) (3)

2.4
- Keep person lying down ✓
- Cover the person to maintain body heat ✓
- Do not move the person in case of neck or spine injuries ✓
- If the person unconscious, put them on their side (recovery position)

(Any 3 x 1) (3)

[10]

QUESTION 3: SWITCHING CIRCUITS

3.1 It is used to eliminate switch bounce. ✓ (1)

3.2 3.2.1 Monostable multivibrator ✓ (1)

3.2.2 Bistable multivibrator ✓ (1)

3.3 3.3.1 A summing amplifier is used to add two or more different input Signals, ✓ to create one amplified output signal. ✓ (2)

3.3.2 $V_{OUT} = -(V_1 + V_2 + V_3)$ ✓

$= -(0,5 + 1,2 + 0,9)$ ✓

$= -2,6$ V ✓

OR

$$V_{OUT} = -(V_1\frac{Rf}{R1} + V_2\frac{Rf}{R2} + V_3\frac{Rf}{R3})\ V \checkmark$$

$$V_{OUT} = -(0,5\ \frac{20\,000}{20\,000} + 1,2\frac{20\,000}{20\,000} + 0,9\frac{20\,000}{20\,000})V \checkmark$$

$$V_{OUT} = -2,6\ V \checkmark$$

(3)

3.3.3

$$V_{OUT} = -(V_1\frac{Rf}{R1} + V_2\frac{Rf}{R2} + V_3\frac{Rf}{R3})\ V \checkmark$$

$$V_{OUT} = -(0,5\frac{40\,000}{5\,000} + 1,2\frac{40\,000}{10\,000} + 0,9\frac{40\,000}{20\,000})\ V \checkmark$$

$$V_{OUT} = -10,6\ V \checkmark$$

(3)

3.3.4 $V_{OUT} = -\left(V_1\frac{R_f}{R_1} + V_2\frac{R_f}{R_2} + V_3\frac{R_f}{R_3}\right)V$ ✓

$$R_f = -\left(\frac{V_{OUT}}{\frac{V_1}{R_1}+\frac{V_2}{R_2}+\frac{V_3}{R_3}}\right)\Omega$$

$$R_f = -\left(\frac{10{,}4}{\frac{0{,}5}{20\,000}+\frac{1{,}2}{20\,000}+\frac{0{,}9}{20\,000}}\right)\Omega$$ ✓

$R_f = 80\ k\Omega$ ✓

OR

$A_v = -\frac{R_f}{R_{in}}$ ✓

$R_f = A_V \times R_{in}\ \Omega$

$R_f = 4 \times 20\,000\ \Omega$ ✓

$R_f = 80\ k\Omega$ ✓ (3)

3.3.5 $Av = -\left(\frac{Vout}{Vin}\right)V$ ✓

$Av = -\left(\frac{Vout}{V1+V2+V3}\right)V$

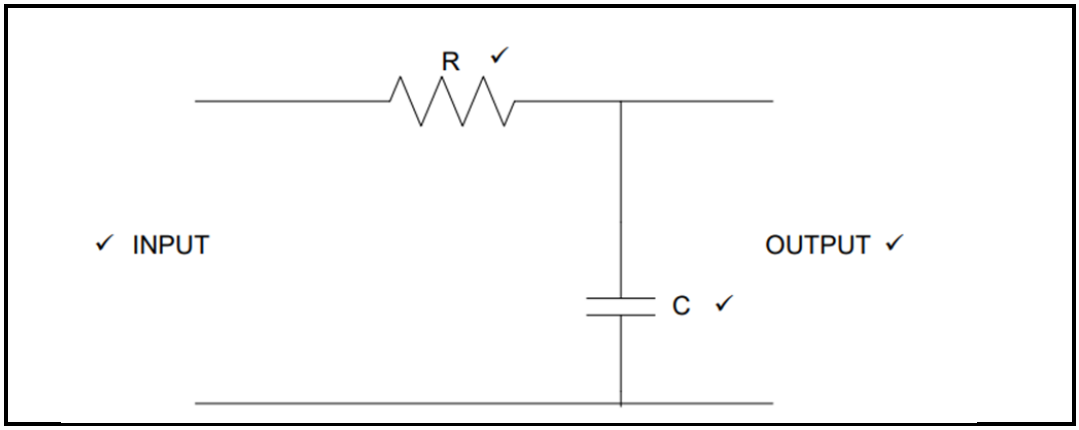
$Av = -\left(\frac{5{,}2}{0{,}5+1{,}2+0{,}9}\right)V$ ✓

$Av = -2\ V$ ✓ (3)

3.4 3.4.1 Open loop gain refers to a circuit with no feedback ✓ from the output back to the input. ✓ (2)

3.4.2
- Voltage divider resistors R_1 and R_2 set up the reference voltage VREF. ✓
- The reference voltage is fed back to the non-inverting input of the op-amp. ✓
- The comparator compares the input voltage VIN to the reference voltage VREF. ✓
- The gain of the op-amp is ±100 000 because of the open loop connection. ✓
- Whenever there is a fraction of a millivolt difference between VIN and VREF, this difference will be amplified. ✓
- The op-amp will be driven into either one of the saturation states ✓ (6)

3.5



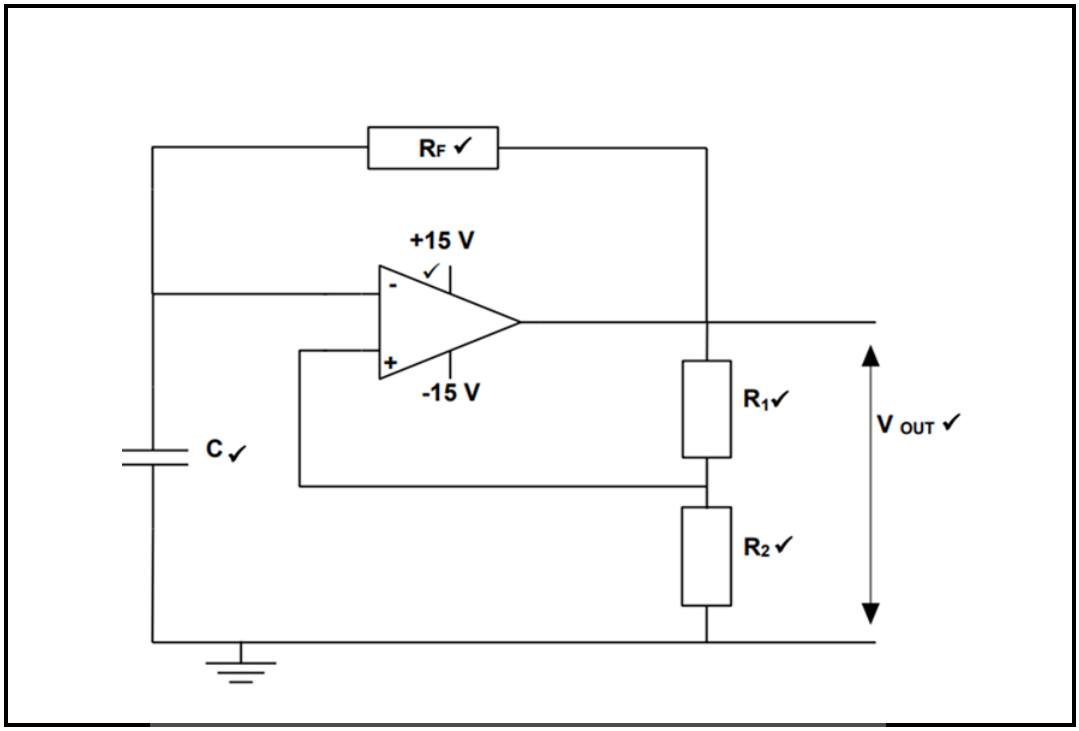
(4)

3.6
- 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 x 1) (3)

3.7
- Change the value of the timing capacitor. ✓
- Change the value of the timing resistor. ✓
- Change the values of both the timing capacitor and the timing resistor. ✓ (3 x 1) (3)

3.8 The feedback resistor is connected from the output ✓ of the op-amp to the inverting input. ✓
This allows a part of the output to flow back to the inverting input. ✓ (3)

3.9



*__Marker's note:__ One mark for the correct op-amp symbol. (6)

3.10
- A light dependent resistor (LDR) and a 100 kΩ resistor is connected in series. This forms a voltage divider. ✓
- The voltage divider feeds the non-inverting input of the op-amp. ✓
- The inverting input is fed by a 100 kΩ variable resistor. ✓
- Less light on the LDR the resistance rises and in turn the voltage on the non-inverting input also rises. ✓
- When the voltage level increases to a level higher than the level set by the variable resistor, the op-amp output will go high immediately. ✓
- This will switch the transistor on, and the alarm will be energised. ✓ (6)

[50]

QUESTION 4: SEMICONDUCTOR DEVICES

4.1 Positive Supply (+V) ✓ (1)

4.2 Two comparators ✓
S/R flip-flop ✓ (2)

4.3
- Monostable ✓
- Astable ✓
- Bistable (2)

4.4 4.4.1 Non-inverting op-amp ✓ (Any 2 x 1) (1)

4.4.2 $AV = 1 + \frac{Rf}{Rin}$ ✓

$= 1 + \frac{1000}{1900}$ ✓

$= 1 + 0,526$

$= 1,526$ ✓ (3)

4.5 4.5.1 The 555 IC can operate from power supply voltages of between +5 V ✓ and +18 V. ✓ (2)

4.5.2 In this mode the 555 timer is astable (free running), therefore its output will continuously toggle between HIGH and LOW ✓ thus generating a continuous train of square-wave pulses. ✓ (2)

4.5.3 This pin sets the voltage at which the 555 IC will trigger. It is used to maintain ✓ the voltage across the timing capacitor ✓ which is discharged through pin 7. ✓ (3)

4.6 The op-amp should be able to amplify any input of any frequency, ✓ from 0 Hz through to radio frequency and higher. ✓ This is not practical and the gain drops at higher frequencies. ✓ This is due to internal capacitances in the op-amp's chip. ✓ (4)

[20]

QUESTION 5: DIGITAL AND SEQUENTIAL DEVICES

5.1
- Robotics ✓
- Computer Numeric Control (CNC) machines. (Any 1 x 1) (1)

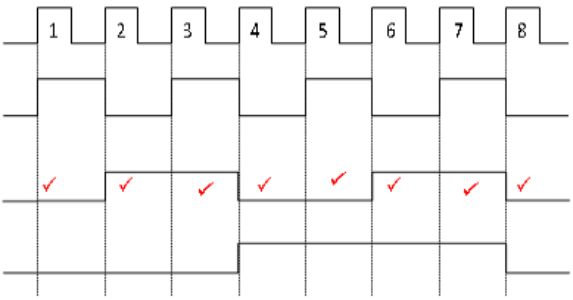
5.2 5.2.1 D-type latch ✓ D flip-flop (1)

5.2.2 In this circuit the R input has been replaced by the compliment (inversion) of the S input. ✓ The S input has been renamed to D input. ✓ If the clock input is low, the D-latch will not respond to an input signal. ✓ Once the clock input goes high the output will follow the D input. As the second input is always the inverse of the D input there will thus never be an illegal state. ✓ (4)

5.2.3
- Shift registers ✓
- Storage registers ✓ (2 x 1) (2)

5.3 Common anode – The anodes of the LED's are all connected ✓ to the positive supply. ✓
Common cathode – The cathodes of the LED's are connected ✓ to ground. ✓ (4)

5.4 5.4.1



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)

5.4.2 The circuit in FIGURE 5.4 is synchronous. ✓ (1)

5.5 SIPO (Series-in-Parallel-Out) ✓
PIPO (Parallel-in-Parallel-Out) ✓
SISO (Series-In-Series-Out) ✓
PISO (Parallel-In-Series-Out) ✓ (4)

5.6
- Liquid crystal display (LCD) ✓
- Light emitting diode (LED) ✓ (2 x 1) (2)

5.7
- It slows the counter down. ✓
- It introduces errors into the system. ✓ (2 x 1) (2)

5.8 They are slower ✓ due to the propagation delay through the additional gates in the system. ✓ (2)

5.9 Full sequence counter – This counter will count ✓ until its maximum count. ✓
Truncated counter – This counter will stop ✓ before reaching its maximum count. ✓ (4)

5.10
- Frequency divider ✓
- Decade counter ✓
- Binary coded decimal counter (Any 2 x 1) (2)

5.11 5.11.1 Encoder ✓ (1)

5.11.2

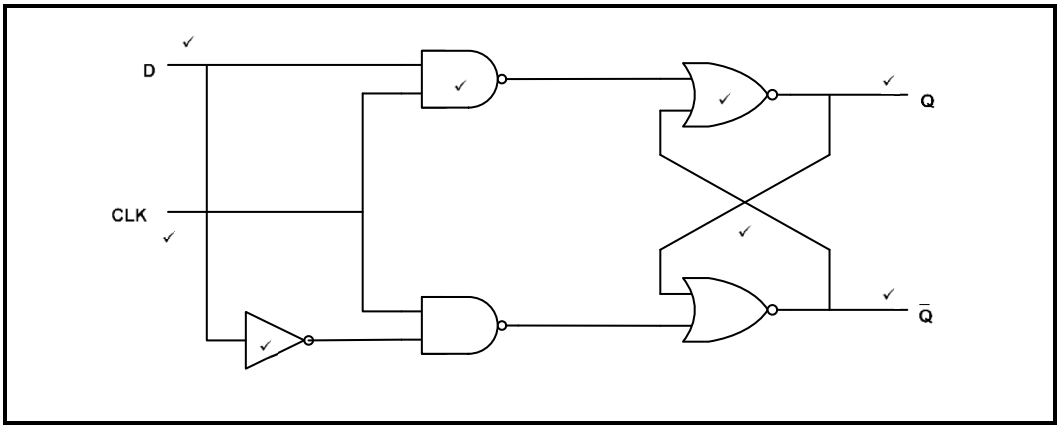
INPUTS	OUTPUTS ✓	
	A_1	A_0
0	0	0 ✓
1	0	1 ✓
2	1	0 ✓
3	1	1 ✓

(5)

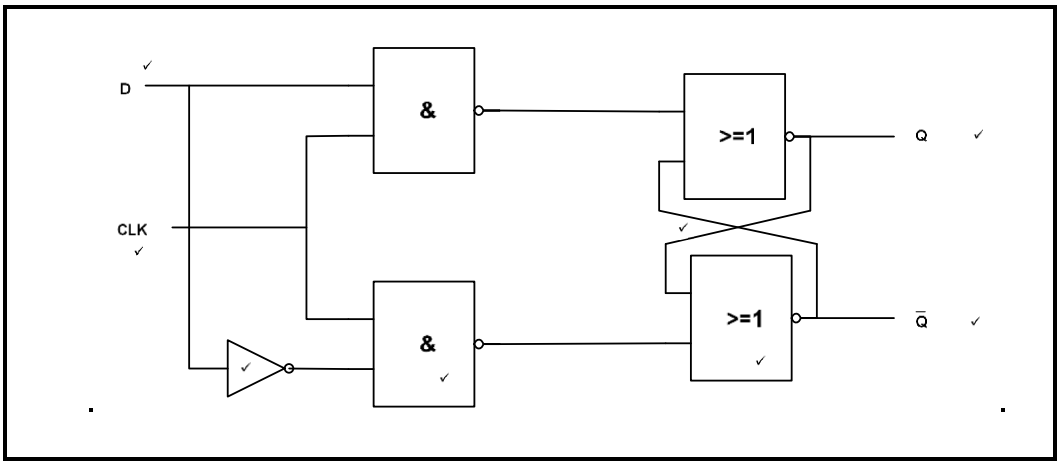
5.11.3 An encoder accepts the input data in a decimal format ✓and converts it to binary format ✓ (2)

5.12
- 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)

5.13



OR



(8)
[55]

QUESTION 6: MICROCONTROLLERS

6.1 RS 232 ✓
OR RS 485 (1)

6.2 Communication protocol is a set of rules ✓ that allow two electronic devices to connect and exchange data. ✓ (2)

6.3 6.3.1
- 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)

6.3.2 Differential ✓ (1)

6.4 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)

6.5 6.5.1 UART is a Universal ✓ Asynchronous ✓ Receiver ✓ Transmitter ✓ (4)

6.5.2 This communication peripheral sends and receives ✓ data serially. ✓
It converts parallel data ✓ to a serial data string, ✓ and vice versa through the RX/TX line. ✓ (5)

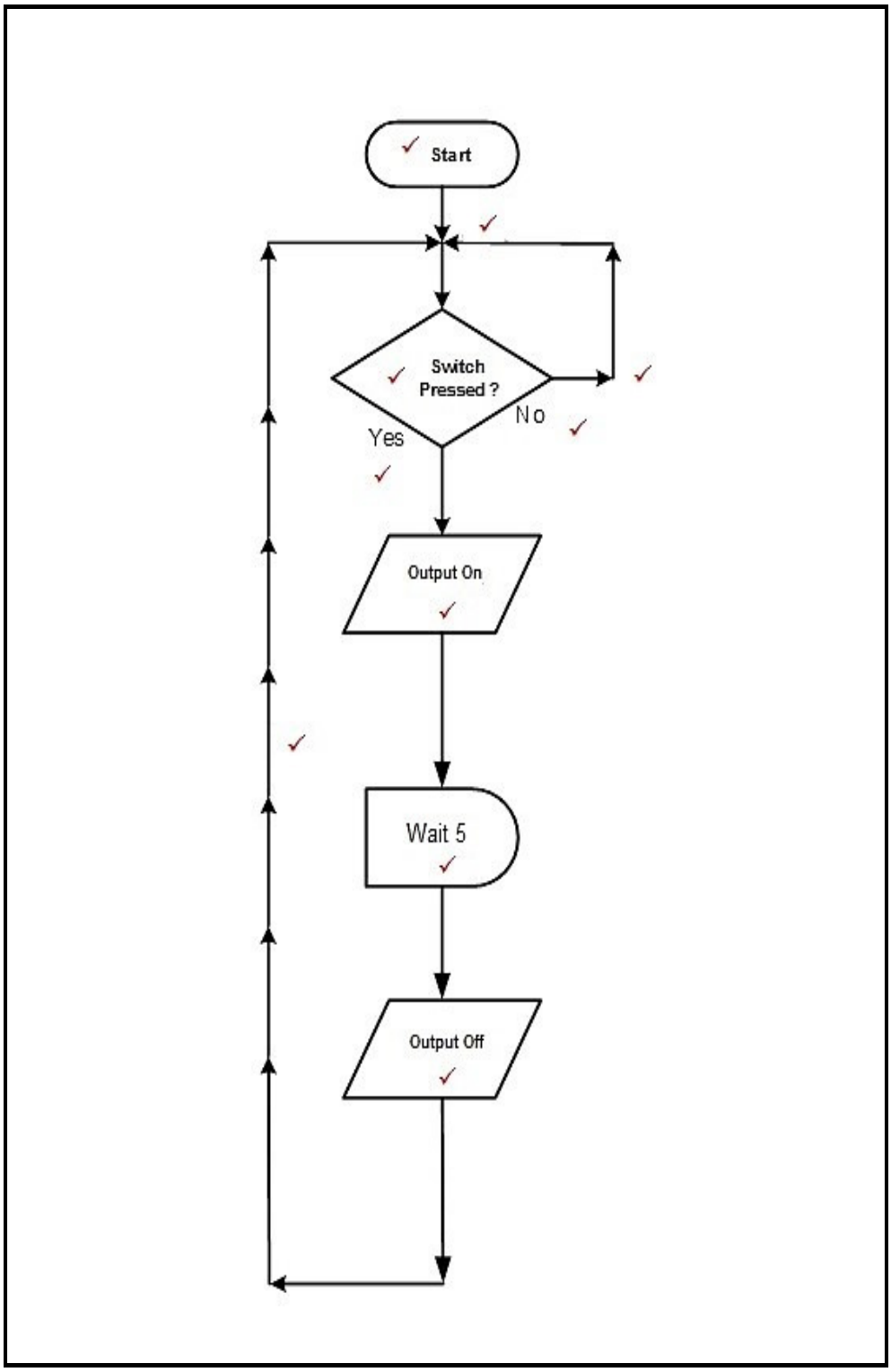
6.6 6.6.1 It is used to pass information, data and instructions ✓ between the respective parts of the microcontroller ✓ as well as to communicate with the outside world through input and output ports. ✓ (3)

6.6.2
- Control bus ✓
- Data bus ✓
- Address bus ✓ (3)

6.6.3
- Supports a higher data transfer rate. ✓
- The sender and the receiver use the same clock pulse. ✓ (2)

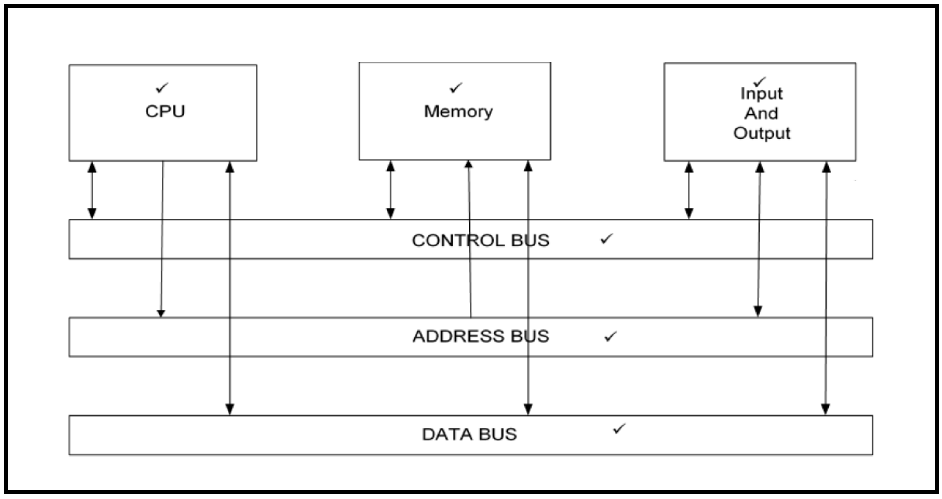
6.6.4
- Requires more communication lines. ✓
- Requires more space. ✓
- Requires larger connections. (2)

6.7



(10)

6.8 6.8.1



(6)

6.8.2 Shared boundary across which two separate components of a computer system exchange information. ✓ (1)

6.9
- Memory data register ✓
- Memory address register ✓
- Counter register ✓
- Control register
- Current-instruction register

(Any 3 x 1) (3)

[50]

TOTAL: 200