

Student's Learning Outcomes (SLOs)

After studying this chapter, students will be able to:

- describe the working of a diode.
- describe the action of a light-emitting diode in passing current in one direction only and emitting light.
- compare analog and digital electronics.
- explain that electronic devices are built from digital logic circuits (that can act as switches that can convert incoming voltage into binary electrical pulses of high and low (1 or 0).
- explain that Boolean logic is the basis for converting analog data to digital data (this includes knowing that 'bit' is the smallest unit of data in computing; either 1 or 0. Eight bits make up a byte),
- state in words and in truth table form, the action of logic gates (specifically of AND, OR, NAND, NOR, and NOT).
- identify the use of logic gates for security purposes (e.g: burglar alarm, fire extinguisher etc.),
- use circuit symbols for the logic gates.
- identify in given problems how Boolean switches can be put into combinations that then allow them to achieve logical operations.

Subjective Type Questions

Long Questions prepared in the light of new Examination Techniques
(Knowledge, Understanding, Application, Analytical & Conceptual)

Introduction

Q1: What is electronics? Briefly explain.

Ans. Electronics is a branch of science that deals with the study and control of the flow of electrons in devices and circuits. It blends technical precision with innovative thinking, giving rise to advancements in areas such as artificial intelligence, renewable energy, and space exploration. From simple components like resistors to sophisticated microprocessors, each element contributes to the ever-evolving landscape of technology, providing many possibilities for innovation and shaping the future.

Q.2: What is semi-conductors? Discuss types of semi-conductors also tell about working of semiconductors and its applications.

Ans. Semi conductors:

Semiconductors are materials whose electrical conductivity lies between that of conductors and insulators.

Uses: They are widely used in electronic devices because their conductivity can be controlled. The most common semiconductors are silicon (Si) and germanium (Ge)

Dopping: Their conductivity can be increased by adding a small amount of impurity, a process known as doping.

Q.3: Explain the types of semiconductors.

Ans. Type of semi-conductors:

There are two main types of doped semiconductors (N-type and P-type).

N-type semiconductor: In an N-type semiconductor, a small amount of a pentavalent impurity such as phosphorus or arsenic is added to silicon (Fig.19.1-a). These elements have five valence electrons; four form covalent bonds with silicon, while the fifth remains free to move. These free electrons are the majority charge carriers, which increase the conductivity of the semiconductor.

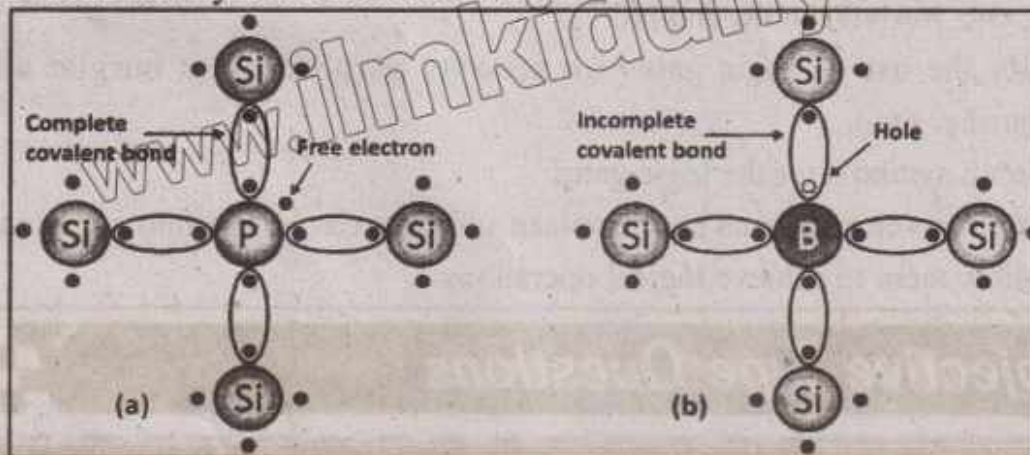


Fig. 19.1: (a) N-type semiconductors (b) P-type semiconductors

P-Type semiconductor: In a P-type semiconductor, a trivalent impurity such as boron or gallium is added to silicon (Fig. 19.1-b). These atoms have only three valence electrons, so one bond remains incomplete, creating a hole (a missing electron). Holes act as positive charge carriers, moving through the crystal and helping in current conduction.

Q.4: What is PN junction? Briefly explain.

Ans. PN Junction:

When an N-type and a P-type semiconductors are joined together, they form a PN junction semiconductor diode.

Operation: At the junction, electrons from the N-side and holes from the P-side

to flow, an external voltage is applied to overcome this barrier.

Examples: For silicon based diodes, the required voltage is about 0.7 V, and for germanium based diodes, it is about 0.3 V.

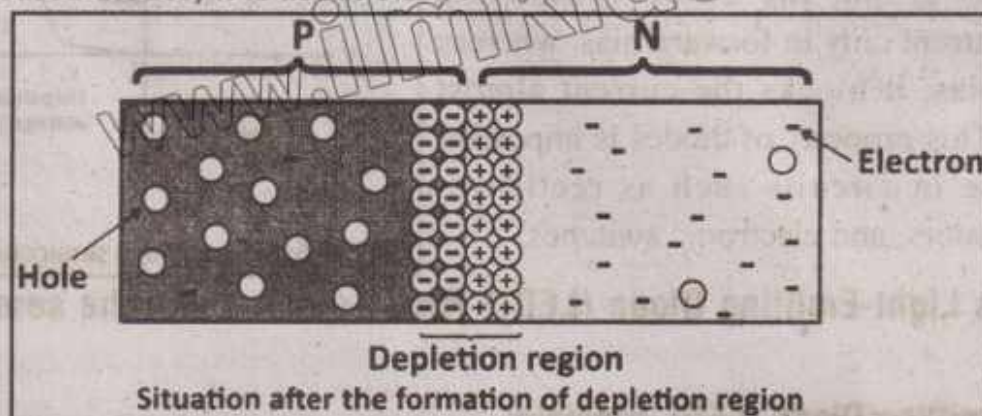


Fig.19.2: Schematic diagram of formation of PN junction

Q.5: Explain the working of Semiconductor Diode.

Ans. Principle:

A semiconductor diode (also known as a PN junction) allows current to flow in only one direction.

Symbolic representation: Its symbolic the presentation is shown in Fig. 19.3



Working:

Forward bias: The diode conducts current when the P-side is connected to the positive terminal and the N-side to the negative terminal of a battery (Fig. 19.4-a). This condition is known as forward bias. In forward bias, the applied voltage reduces the potential barrier at the junction and narrows the depletion region. This enables charge carriers (electrons and holes) to easily cross the junction, causing the flow of current through the diode.

Reverse bias: In contrast, when the P-side is connected to the negative terminal and the N-side to the positive terminal of a battery, the diode is said to be in reverse bias (Fig. 19.4-b). In this condition, the depletion region widens, increasing the potential barrier and preventing the flow of majority charge carriers. However, a very small current, known as leakage current, still flows due to the movement of minority carriers from both sides of the junction.

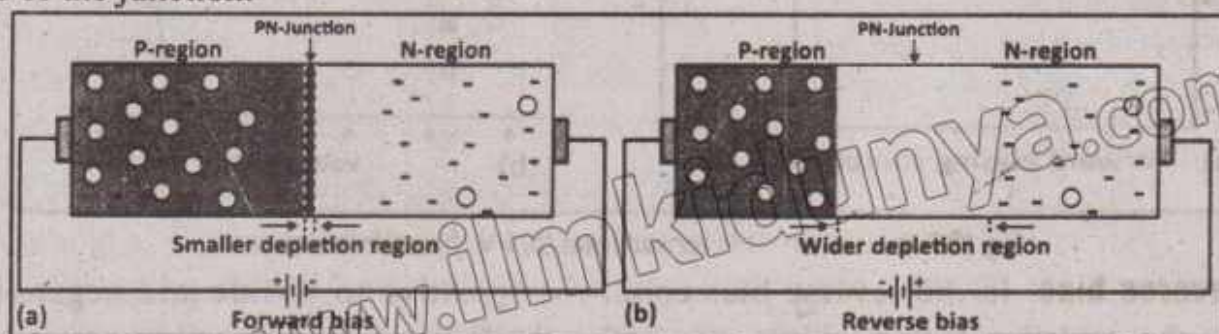


Fig. 19.4: Forward and reverse biasing of a PN junction showing changes in depletion region

The typical current-voltage (I-V) characteristic curve of a diode is shown in Fig. 19.5. In this graph, the diode conducts a significant current only in forward bias, whereas in reverse bias, it blocks the current almost completely. This property of diodes is important for their use in circuits such as rectifiers, voltage regulators, and electronic switches.

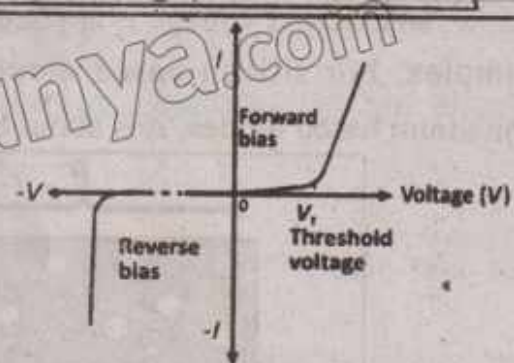


Fig. 19.5: I-V graph of a semiconductor diode

Q.6: What is Light-Emitting Diode (LED)? Also explain about the semiconductor device.

Ans. Light-Emitting Diode (LED) Principle:

A Light-Emitting Diode (LED) is a semiconductor device that allows electric current to flow in one direction, like a typical diode, and emits light when electrons recombine with holes.



Fig. 19.6: LED symbol

Symbol: The symbol of LED is shown in Fig. 19.6.

Construction: It consists of a PN-junction made from P-type and N-type materials. When the LED is connected in a forward bias, the applied voltage reduces the depletion region and allows the flow of charge carriers across the junction. As electrons from the N-type material move across and recombine with holes in the P-type material, energy is released in the form of photons, creating visible light.

Working For Forward bias: The working of an LED under forward bias condition is shown in Fig. 19.7(a). Here, a simple circuit diagram demonstrates the LED setup with a resistor R to limit the current, a voltmeter V for the measurement of voltage across the LED, and an ammeter (mA) in series to measure the current flowing through the circuit.

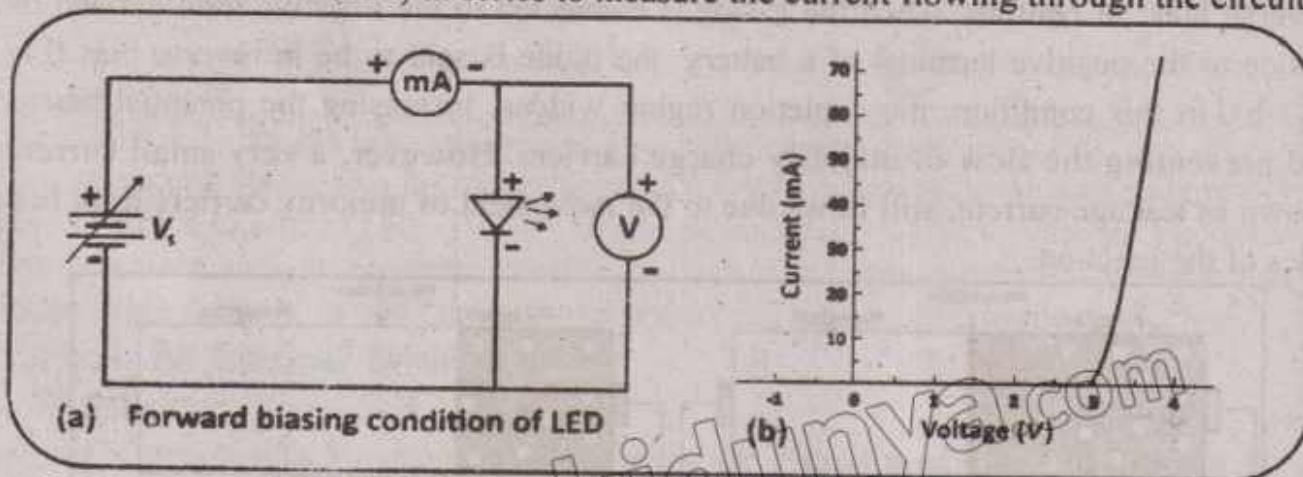


Fig. 19.7: (a) LED circuit in forward bias (b) I-V characteristic curve

For Reverse bias: In the reverse bias condition (positive to N-side and negative to P-side), the depletion region widens, preventing the flow of current, and as a result, no light is emitted. Therefore, LEDs are designed to function only under forward bias

condition.

The behaviour of the LED can also be understood using a current-voltage (I-V) characteristic graph as shown in Fig. 19.7-b. In this graph, it is observed that initially small current flows as voltage increases. However, after a certain threshold voltage, a sudden sharp increase in current occurs, resulting in light emission.

Colour dependency: The colour of the light produced by an LED depends on the materials used during its manufacture, affecting the wavelength (and thus the colour) of the emitted light.

User: LEDs are highly efficient, durable, energy-saving, and are extensively used in a variety of applications including radios, lamps, digital clocks, calculators, video displays, remote controls, and modern lighting systems.

Thus, LEDs play an important role in both everyday life and advanced technologies by efficiently converting electrical energy directly into light.

19.2

Analog and Digital Electronics

Q.7: What is Analog and Digital Electronics? How it works together?

OR Differentiate between analog and digital electronic.

Ans. Electronic circuits, devices, or systems are mainly divided into analog and digital types.

Analog Electronics: In analog circuits, voltages and currents can vary smoothly and continuously within a certain range (Fig. 19.8-a).

Example: For example, an analog meter uses a pointer moving over a continuous scale to display readings. These circuits are used in devices like amplifiers and variable resistors, which allow for a wide range of adjustments, such as dimming a lamp to various brightness levels.

Digital Electronics: In digital circuits, voltages have only two values: "high" (e.g., 5 V) or "low" (e.g., near 0 V) (Fig. 19.8-b). These circuits are used in switching systems, like a simple ON/OFF switch for a lamp. While digital electronics were once limited to computers, these are now widely

used in modern telephones, radar systems, industrial machines, medical equipments, and household appliances. However, the quantities we perceive in daily life, such as sound or light, are analog and cannot be directly processed by digital circuits.

Analog-to-digital Converter (ADC):

To bridge this gap, an analog-to-digital converter (ADC) is used.

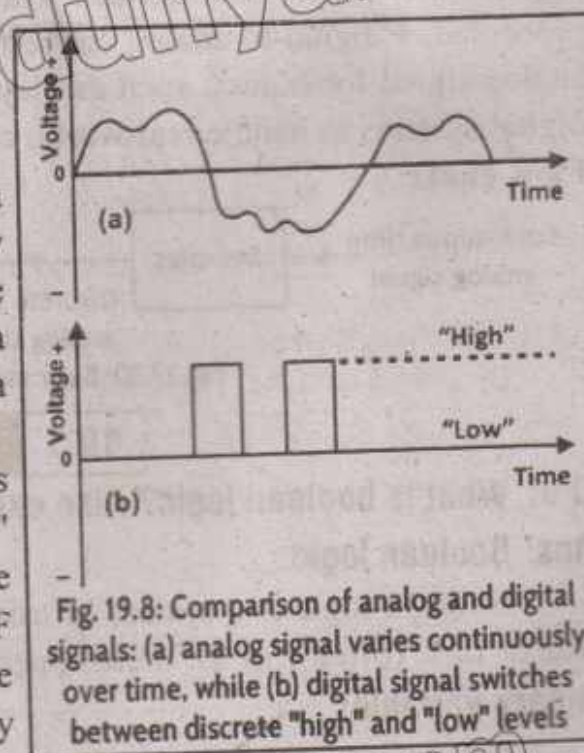
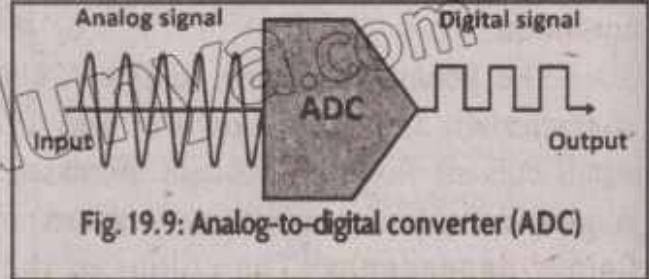


Fig. 19.8: Comparison of analog and digital signals: (a) analog signal varies continuously over time, while (b) digital signal switches between discrete "high" and "low" levels

It converts analog signals into digital binary form for processing by computers (Fig. 19.9). The ADC works by sampling the analog signal at regular intervals and converting each sample into a binary number that represents its voltage level.



Q.8: How Analog data convert to digital data? Explain.

Ans. Conversion from analog to digital data:

Analog data, such as sound or light, is continuous and can take any value within a range. In contrast, digital systems use binary data (0s and 1s), which is discrete. To convert analog data into a digital format, an analog-to-digital converter (ADC) is used. The process works as follows (Fig. 19.10).

Working:

- 1. Sampling:** The continuous analog signal is measured at regular intervals.
- 2. Quantization:** Each sampled value is rounded to the nearest predefined level.
- 3. Encoding:** The quantized values are then converted into binary numbers (0s and 1s).

For example, a sound wave (analog) is measured at regular intervals, each value is quantized to the nearest level, and then encoded into a series of binary numbers. This process makes the sound wave usable by digital devices, such as computers. Once processed, a digital-to-analog converter (DAC) can convert the binary data back into an analog signal for output, such as playing sound through a speaker. This process enables digital systems to handle real-world, continuous data efficiently.

Flow chart:

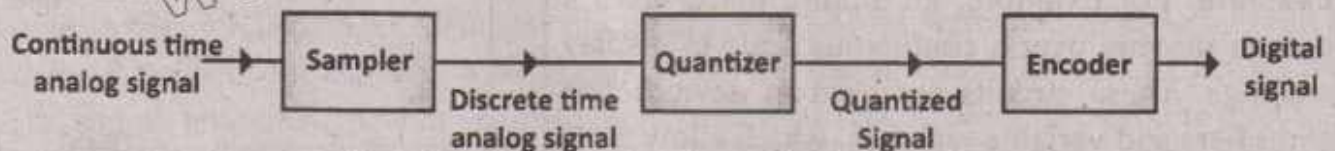


Fig. 19.10: Basic steps of analog-to-digital conversion

19.3 Boolean Logic

Q.9: What is boolean logic? Also explain about Boolean algebra and its uses.

Ans. Boolean logic:

Boolean logic is a system of true/false reasoning. It treats values as just two states true or false (often 1 or 0). It uses operations like AND, OR, NOT.

Binary variable:

A binary variable has only two possible states, like a switch that is either ON (closed) or OFF (open). These states are represented by 1 and 0 respectively. For example, in a circuit with a battery, lamp, and switch, the state of the switch (open or closed) is the input, and state of the lamp (OFF or ON) is the output. When the switch is open (input = 0), no current flows, and the lamp is OFF i.e; the output is zero. However, when the switch is closed (input = 1), the lamp turns ON and the output is 1 (Fig. 19.11).

Boolean algebra: To understand how inputs affect outputs, George Boole developed Boolean algebra, the foundation of digital electronics and computing, which uses binary values (bits), where each bit is either 0 or 1. A byte is formed using eight bits, which represents data in computers. Boolean algebra is used in ADC which converts analog data (continuous signals) into digital data (discrete binary values). It also forms the basis for designing digital systems.

Uses: Boolean algebra uses three basic logic operations: AND, OR, and NOT. These operations are implemented using logic gates, which are digital circuits with binary inputs and outputs.

Explain:

A logic gate's output can only be high (1) or low (0), depending on the conditions at its input.

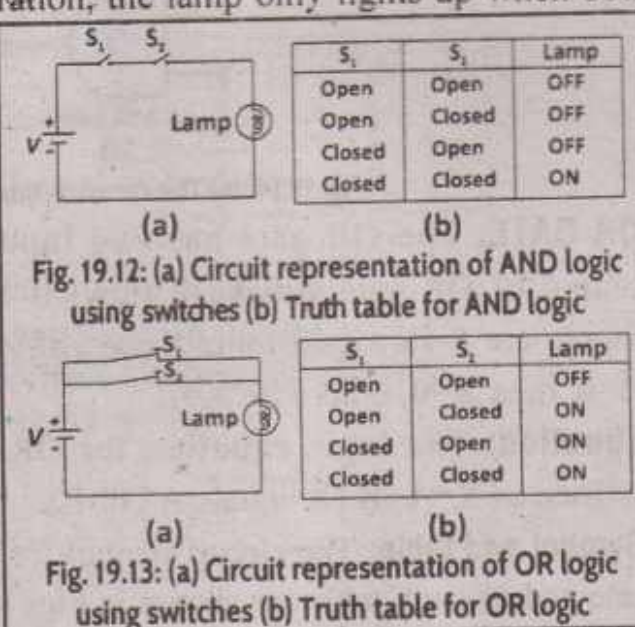
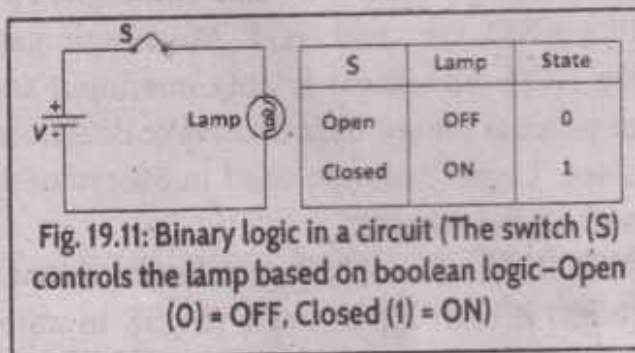
Examples:

- AND gate gives an output of 1 only if all its inputs are 1.
- An OR gate gives an output of 1 if at least one input is 1.
- A NOT gate inverts the input (1 becomes 0, and 0 becomes 1). AND and OR circuit symbols and truth tables are shown in Fig. 19.12 and Fig. 19.13, respectively.

AND gate: In the case of the AND gate, a lamp is connected in series with two switches, S_1 and S_2 , along with a battery. In this configuration, the lamp only lights up when both switches are closed, forming a complete path for current to flow. If either switch is open, the current is interrupted, and the lamp remains OFF. This setup models the logic AND operation, where the output is 1 only if both inputs are 1. The circuit, switching combinations (Fig. 19.12(a)), and truth table are illustrated in Fig. 19.12(b).

OR gate: For the OR gate, the lamp is connected in a circuit where switches S_1 and S_2 are placed in parallel (Fig. 19.13-a). In this arrangement, the lamp glows if either or both switches are closed, as current can flow through at least one path. The lamp remains OFF only when both switches are open. This models the logic OR operation, where the output is 1 if any one or both inputs are 1. The complete explanation and truth table for the OR operation are provided in Fig. 19.13(b).

Importance in solving complex digital operations: These simple logic gates can be combined to perform complex operations, forming the backbone of modern digital systems, from computers to smartphones. By using Boolean algebra and logic gates, we can systematically design circuits that process binary data efficiently and reliably.



Q.10: Explain about logic gates.**Ans: Logic gates:**

"Logic gates are the circuits that are designed to perform these basic logic functions."

Actually, the term logic is applied to digital circuits used to implement logic functions.

A logic gate is a basic component of digital circuits that performs logical operations like AND, OR, and NOT. Most logic gates have two inputs and one output. However, in the NOT gate, there is only one input and one output. These gates enable digital devices to process binary data and make decisions.

Uses: Logic gates are used in everyday devices like smartphones, computers, calculators, and digital watches.

AND GATE: The AND gate has two inputs. The output of the AND gate will only be 1 (high) if both inputs are 1 (high). In other words, if A and B are two inputs of the AND gate, then output X will be 1 if $A=1$ and $B=1$.

Equation: The logic equation for the AND gate is written as $X=AB$ (X equals A AND B).

Symbol and table: The circuit symbol for AND gate and its truth table are shown in Fig. 19.14 (a) and Fig. 19.14 (b), respectively.

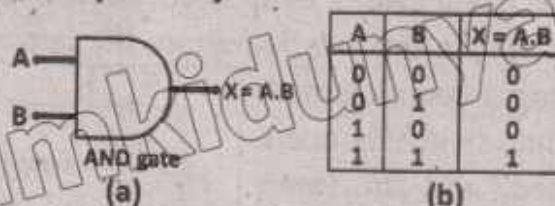


Fig. 19.14: (a) The circuit symbol and (b) Truth table for an AND gate

OR GATE: The OR gate has two inputs. The output of OR gate will be 0 (low) if both the inputs are 0 (low). In other words, if $A=0$ and $B=0$, then $X=0$, otherwise $X=1$.

Equation: The logic equation for OR gate is written as $X=A+B$ (X equals A OR B).

Symbol and table: The circuit symbol for OR gate and its truth table are shown in Fig. 19.15 (a) and Fig. 19.15 (b), respectively

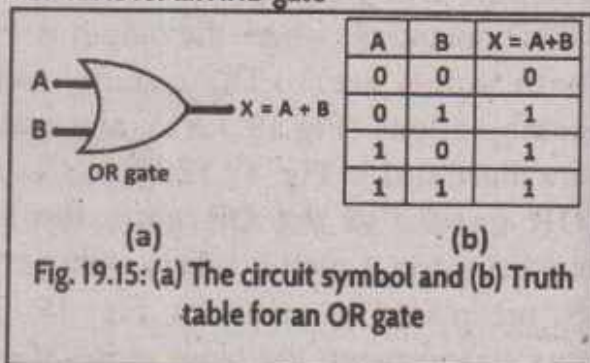


Fig. 19.15: (a) The circuit symbol and (b) Truth table for an OR gate

NOT GATE:

NOT gate has single input. It is also called an inverter as it inverts the input signal, i.e; if its input is 1, then the output will 0 and vice versa.

Equation: The Logic equation for the NOT gate is $X=\bar{A}$ (equals NOT A).

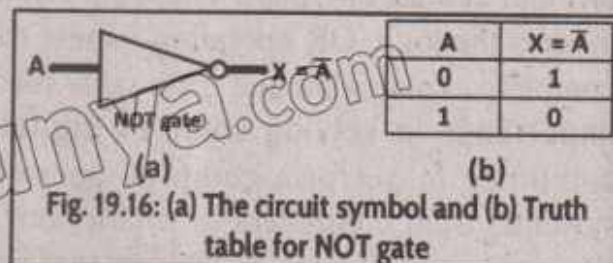


Fig. 19.16: (a) The circuit symbol and (b) Truth table for NOT gate

Symbol and table: The symbol of NOT gate (Fig 19.16-a) and the truth table is shown in Fig. 19.16 (b).

NAND GATE

A NAND gate is a combination of AND gate and NOT gate. The symbol for a NAND gate is made from an AND gate along with the bubble circle at its output as shown in Fig. 19.17 (b).

Equation: The logic equation for the NAND gate is written as $X = \overline{A \cdot B}$ (read as X equals NOT A AND B).

Table: From truth table (Fig.19.17-c), we can see that the output is 0 when both inputs A and B are 1, otherwise output is 1.

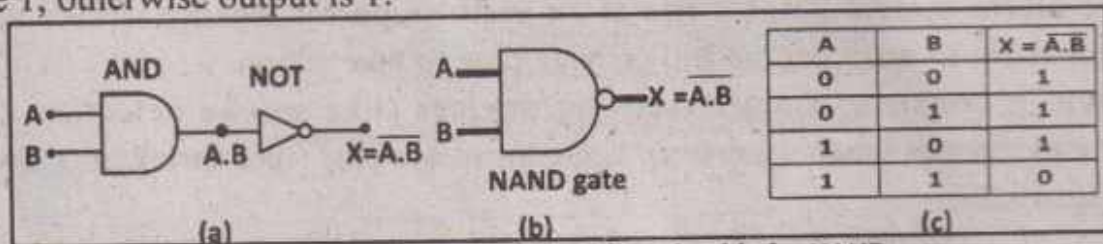


Fig. 19.17 (a,b): The circuit symbol (c) Truth table for NAND gate

NOR GATE

A NOR gate is an OR gate with a NOT gate at its output (Fig. 19.18-a). The symbol for a NOR gate is made from an OR gate with the inversion circle (bubble) at its output as shown in Fig. 19.18 (b).

Equation: The logic equation for the NOR gate is written as $X = \overline{A + B}$ (read as X equals not A OR B). From truth table (Fig. 19.18-c), we can see that the output is 1 when both inputs A and B are 0, otherwise output is 0.

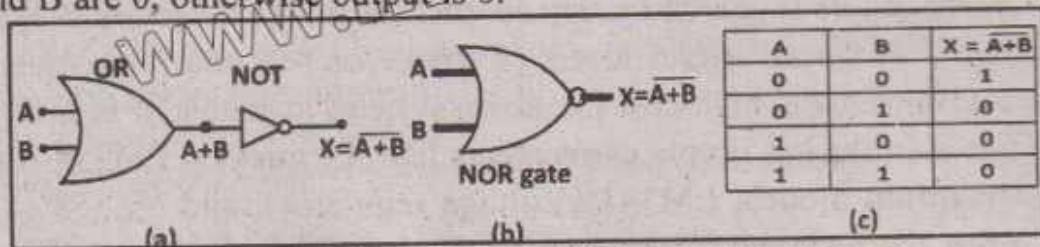


Fig. 19.18 (a,b): The circuit symbol (c) Truth table for NOR gate

19.5

Applications of Logic Gates

Q.11: Write about Application of Logic gates in daily life?

Ans. Burglar Alarm:

Construction: We can create a simple burglar alarm using a single NAND gate, an LDR (Light-Dependent Resistor), a push-button switch (S), and an alarm. The LDR is connected between one input (B) of the NAND gate and the positive terminal of the battery, while the push-button switch (S) is connected to the other input (A).

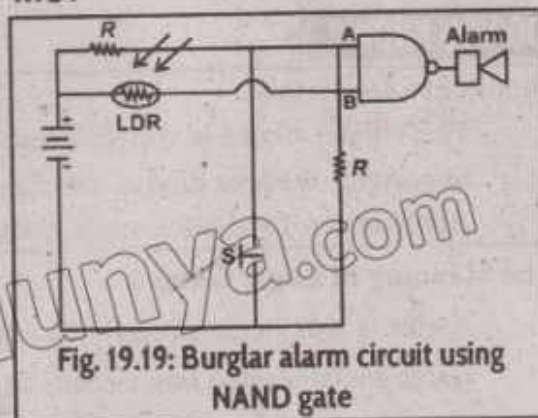


Fig. 19.19: Burglar alarm circuit using NAND gate

Working:

The alarm is connected to the output of the NAND gate (Fig. 19.19). When light

falls on the LDR, its resistance is low, causing input B to be high (1). However, if the burglar interrupts the light (e.g., by blocking it), the LDR's resistance becomes high, causing input B to be low (0). Similarly, if the burglar steps on the push-button switch (S), input A becomes low (0). The NAND gate outputs low (0) only when both inputs are high (1); otherwise, it outputs high (1). This means the alarm will sound if either the light is blocked ($B = 0$), the switch is pressed ($A = 0$), or both events occur simultaneously. This simple yet effective circuit ensures the alarm is triggered in response to unauthorized entry, making it a practical burglar alarm system.

Fire Alarm System

A fire alarm system detects fire at an early stage by sensing smoke and heat, triggering an alarm to warn people and provide time to take action.

Construction: It consists of alarm-starting devices (like smoke detectors and heat sensors), alarm devices (such as sirens), fire control systems (like sprinklers), and power supplies (Fig. 19.20).

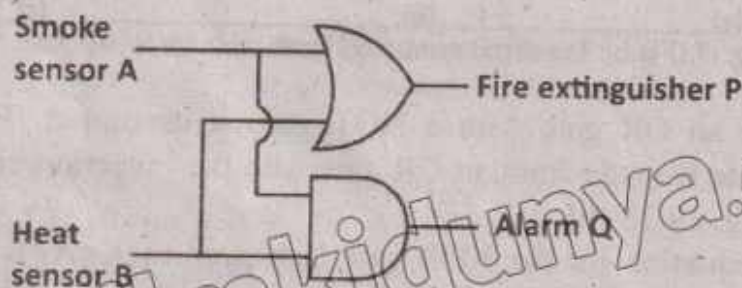


Fig. 19.20: Circuit diagram of fire alarm using basic logic gates

Working: The alarm can be triggered by sensors such as smoke detectors or heat sensors, which are designed to detect certain levels of smoke or heat that may indicate a fire. While there are advanced and high-cost fire alarm systems available, it is also possible to make a basic fire alarm using simple components like thermistors, LM358 (Operational amplifier), germanium diodes, LM341 (Voltage regulator), and NE555 (Timer IC). Furthermore, a fire alarm system can be constructed using basic logic gates. For instance, a circuit with logic gates can process inputs from smoke and heat sensors, triggering the alarm when either of the conditions is met, providing an affordable and efficient fire detection solution.

DO YOU KNOW?

Diodes are Important

- The silicon diode is the simplest of all the semiconductor devices. It is also one of the most important. Without diodes, one can not build electronic equipment.
- Applications for diodes range from power supplies to cell phones and everything in between.

The Meaning of Logic Gates

- A gate is a device that performs a basic operation on electrical signals.
- Gates are combined into circuits to perform more complicated tasks.
- Logic Gates are the circuits that are designed to perform these basic logic functions.
- Actually, the term logic is applied to digital circuits used to implement logic functions.

How Fire Alarms Can Save Lives?

Early detection saves lives

2

Fire alarms can detect fires before they become large

3

Fire alarms can alert the authorities

Fire alarms can be connected to a monitoring service

5

There are different types of fire alarms

6

Fire alarms should be tested regularly

Tidbits

A diode is like a one-way road for current allowing it to flow in only one direction and blocks in the opposite direction.

Unlike normal bulbs, LEDs do not waste much energy as heat. They instantly glow by simply letting current flow across a special junction.

Analogue signals are continuous like ocean waves. Digital signals are sharp like stair steps just highs and lows, (1's and 0's).

Tiny circuits called logic gates act like smart switches, making decisions inside our computers, watches, and phones.

Brain Teaser

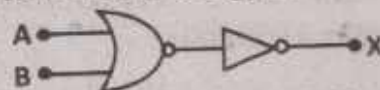
1. In an LED, electrons meet holes and produce something surprising. What is released during this encounter heat, light, or sound?

Ans. Light is released during this encounter.

2. In Boolean logic, what is the output of an AND gate if one input is 0 and the other is 1?

Ans. The output is 0.

3. Show that the circuit given below acts as OR gate.



Ans. The circuit acts as an OR gate because the NOR gate followed by an inverter results in the logic operations $A+B$.

Combine the NOR gate and inverter operations.

Substituting the NOR gate output into the inverter input:

$$X = \overline{\overline{A+B}}$$

Apply De Morgan's Law

The double negation cancels out:

$$X = A+B$$

Recognize the OR gate operation.

The final output $X = A+B$ represents the OR gate operations.

4. Show that the circuit given below acts as AND gate.



Ans. The circuit acts as an AND gate because the output X is equivalent to $A \text{ AND } B$, which is demonstrated through the application of De Morgan's Law and the properties of NOT and NOR gates.

The output X is the logical AND of inputs A and B. Therefore, the circuit acts as an AND gate.

5. A fire alarm must go OFF when either smoke is detected or heat is detected. Which logic gate fits this setup?

Ans. The fire alarm going OFF when either smoke or heat is detected indicates an OR relationship. An OR gate's output is HIGH (alarm OFF) if either or both of its inputs (smoke, heat) are HIGH.

Objective Type Questions

Additional MCQ's

Multiple Choice Questions prepared in the light of new Examination Techniques
(Knowledge, Understanding, Application, Analytical & Conceptual)

19.1 Semiconductors

- Electronic is a branch of physics that deal with the study of.
(a) flow of electrons (b) flow of neutron
(c) flow of proton (d) all of them
- Semi conductors have electrical conductivity that lies b/w
(a) conductors and super conductor (b) Insulator and vacuum
(c) conductor and insulator (d) Metals and alloys
- The process of adding impurities to a pure semi conductor is called:
(a) Annealing (b) Doping (c) Heating (d) Diffusion
- Which of the following pentavalent impurity?
(a) Boron (b) Gallium (c) Phosphorus (d) Indium
- Which impurity is added to form a P-type semi-conductors?
(a) Arsenic (b) Phosphorus (c) Boron (d) Antimony
- Silicon has how many valence electrons?
(a) 2 (b) 3 (c) 4 (d) 5
- The most common used semi-conductor material is:
(a) Silicon (b) Iron (c) Aluminium (d) Copper

19.2 Analog and Digital Electronics

- Electronic circuits are mainly divided into which two types?
(a) Mechanical and electrical (b) Analog and digital
(c) Input and output (d) AC and DC
- In analog circuits, voltage varies.
(a) In steps (b) In two values
(c) Smoothly and continuously (d) Randomly
- Digital signals have how many voltages level?
(a) one (b) two (c) three (d) four

11. Which of the following is an example of a digital signal?
(a) Sound wave (b) Light intensity (c) ON/OFF switch (d) Temperature
12. Digital Data is represented in the form of:
(a) Waves (b) Graph (c) Binary number (d) Voltmeter
13. Which device convert analog signals into digital form?
(a) Amplifier (b) Transformer
(c) Rectifier (d) Analog to Digital converter
14. In ADC, rounding each sampled value to the nearest predefined level is called.
(a) Quantization (b) Modulation (c) Encoding (d) Sampling

19.3 Boolean Logic

15. Converting quantized values into binary numbers (0s and 1s) is known as.
(a) Sampling (b) Encoding (c) Quantization (d) Filtering
16. Binary states represented by :
(a) A and B (b) ON and OFF (c) 0 and 1 (d) True and False
17. Which of the following is NOT a basic logic operation?
(a) AND (b) OR (c) NOT (d) XOR
18. What is the output of an AND gate if inputs are 0 and 1?
(a) 0 (b) 1 (c) 2 (d) undefined

19.4 Logic Gates

19. A logic gate is a basic component of:
(a) Analog (b) Digital (c) Electrical (d) Mechanical
20. The Boolean expression of AND gate is:
(a) $X=A+B$ (b) $X=A.B$ (c) $X=A$ (d) $X=A-B$
21. Logic gates are used in:
(a) Fans (b) Bulb (c) computers (d) motors

Answers

- | | | | | | | |
|---------|---------|---------|---------|---------|---------|---------|
| 1. (a) | 2. (c) | 3. (b) | 4. (c) | 5. (c) | 6. (c) | 7. (a) |
| 8. (b) | 9. (c) | 10. (b) | 11. (c) | 12. (c) | 13. (d) | 14. (a) |
| 15. (b) | 16. (c) | 17. (d) | 18. (a) | 19. (b) | 20. (b) | 21. (c) |

Additional Short Questions

Short Answer Questions prepared in the light of new Examination Techniques
(Knowledge, Understanding, Application, Analytical & Conceptual)

19.1 Semiconductors

1. What is electronics?

Ans. Electronics is the branch of physics that deals with the flow of electrons in devices

and circuits.

2. Where does electronic use?

Ans. It blend technical precision with innovative thinking, giving rise to advancement in areas such as artificial intelligence renewable energy, and space exploration.

3. What is semi-conductors?

Ans. Semi-conductors are material whose electrical conductivity lies between that of conductors and insulators. e.g. silicon and germanium.

4. What is doping?

Ans. Conductivity of semi-conductor can be increased by adding impurities this process is known as doping.

5. Name types of semi-conductors.

Ans. There are two types of semi-conductors.

(i) N-type semi-conductor. (ii) P-type semi-conductor.

6. What is p-type semi-conductor?

Ans. In p-type semi-conductors, a trivalent impurity such as boron or gallium is added to silicon. These atoms have only three valence electrons. So one bond remains incomplete creating a hole. Holes act as positive charge carrier moving through the crystal and helping in current conduction.

7. What is diode?

Ans. Diode is like one way road for current allowing it to flow in only one direction and blocks in opposite direction.

8. What voltages required in silicon based diode?

Ans. For silicon based diode voltages required 0.7 V.

9. What voltages required for germanium based diode?

Ans. 0.3 V voltages required for germanium based diode.

10. Draw schematic diagram of formation of PN Junction.

Ans.

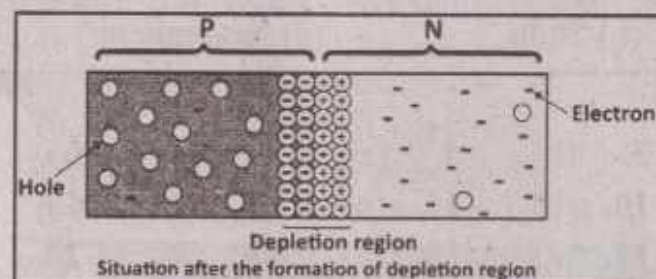


Fig.19.2: Schematic diagram of formation of PN junction

11. Define Forward bias conductor?

Ans. When P-side is connected to the positive terminal and N-side to negative terminal of battery. This condition is known as Forward bias.

12. Define Reverse bias conductor?

Ans. When P-side is connected to negative terminal and N-side to positive terminal of a battery, the diode is said to be reverse bias.

13. The colour of LED depend on which factor?

Ans. The colour of light produced by an LED depends on the materials used during its

manufacture, affecting wavelength of emitted light.

14. Used of LED's?

Ans. LED's are highly efficient durable, energy savings and are extensively used in a variety of applications including radios, lamps, digital clocks, calculators, video displays, remote controls and modern lighting system.

19.2

Analog and Digital Electronics

15. Differentiate between Analog data and Digital data.

Ans.	Analog Data	Digital Data
	In analog circuit voltages and currents can vary smoothly and continuously within a certain range.	In digital circuits voltages have only two values high or low only two values
	These circuits are used in amplifiers and variable resistors. e.g: dimming lamp.	These circuits used in switching system. e.g: It is used in household appliances.

16. How can analogue data convert to digital data.

Ans. Analog data convert digital data by ADC.

19.3

Boolean logic

17. Define binary variable?

Ans. A binary variable has only two possible states, like a switch that is either ON or OFF. These states represented by 0 and 1.

18. Explain AND gate truth table

Ans.	S₁	S₂	Lamp
	Open	Open	OFF
	Open	Closed	OFF
	Closed	Open	OFF
	Closed	Closed	ON

19. Explain truth table of OR gate.

Ans.	S₁	S₂	Lamp
	Open	Open	OFF
	Open	Closed	ON
	Closed	Open	ON
	Closed	Closed	ON

19.4

Logic Gates

20. Write uses of logic gate?

Ans. Logic gates are used in everyday devices like smart phone computers, calculators and digital watches.

21. Write truth table of NOR gate and symbolic representation.

Ans.

A	$X = \bar{A}$
0	1
1	0



22. Draw symbolic representation of AND gate.

Ans.



23. Draw symbolic representation of OR gate.

Ans.



Exercise Questions (Solved)

A. Multiple Choice Questions

★ Tick (✓) the correct answer.

19.1 A diode allows current to flow in:

- (a) both directions
- (b) neither direction
- (c) one direction only
- (d) random directions

19.2 What is the primary function of a light-emitting diode?

- (a) To block current in both directions
- (b) To emit light when current passes in one direction
- (c) To amplify electrical signals
- (d) To convert light into electrical energy

19.3 The output of a two inputs NOR gate is '1', when:

- (a) A is '1' and B is '0'
- (b) A is '0' and B is '1'
- (c) both A and B are '0'
- (d) both A and B are '1'

19.4 The output of a NAND gate is '0', when:

- (a) both of its inputs are '0'
- (b) both of its inputs are '1'
- (c) any of its inputs is '0'
- (d) any of its inputs is '1'

19.5 How many bits make up a byte in Boolean logic?

- (a) 2
- (b) 4
- (c) 6
- (d) 8

Answers

19.1 (c) 19.2 (b) 19.3 (c) 19.4 (b) 19.5 (d)

B. Short Answer Questions

19.1 What is the function of a semiconductor diode?

Ans. It allow electric current to flow in only one direction (low resistance) and blocks current in the opposite direction (high resistance). It is used for rectification (AC to DC).

19.2 What happens when a diode is forward biased?

Ans. When a diode is forward biased, it conducts current easily because the barrier potential decreases and charges carrier can cross the junction.

19.3 What is the function of an LED?

Ans. An LED (Light Emitting Diode) converts electrical energy into light energy and is used as an indicator or for illumination.

19.4 Why does an LED emit light when current passes through it?

Ans. When current passes, electrons combine with holes, releasing energy in the form of light (Photons).

19.5 What does an analog-to-digital converter (ADC) do?

Ans. An ADC converts analogue signals into digital signals. An analog to digital converter (ADC) converts a continuous analog signal (e.g. voltage, current) into a discrete digital representation.

19.6 What is the difference between analog and digital signals?

Ans.	Analog	Digital
	Analog signals are continuous and can take on any value within a range.	Digital signals are discrete and represent information as a sequence of binary values (0's and 1's).

19.7 What is Boolean logic in digital electronics?

Ans. Boolean logic is a system of logic using binary variables (0 and 1) and logical operations such as AND, OR and NOT.

19.8 What does a NOT gate do in a digital circuit?

Ans. A NOT gate inverts the input signals, if the input is 1 the output is 0 and if the input is 0 output is 1.

19.9 What is the role of an AND gate in digital circuits?

Ans. An AND gate gives output 1 only if all its inputs are 1. if any input 0 the output will be 0.

C. Constructed Response Questions

19.1 Why would a diode be damaged if it is connected in reverse bias with a very high voltage? What does this tell us about the diode's physical limits?

Ans. A diode is damaged under high reverse bias due to avalanche breakdown, leading to excessive heat and potential melting of the semiconductor material.

This demonstrates that diodes have a maximum reverse voltage limit determined by their physical properties and doping concentration.

19.2 What makes an LED glow brighter or dimmer depending on the voltage applied? How is this property used in adjustable display brightness?

Ans. The brightness of an LED is determined by the forward current, which is controlled by the applied voltage. Higher voltage leads to higher current and brighter light. This property is used in adjustable displays by varying the voltage or current supplied to the LEDs.

19.3 Why are digital systems more reliable than analog systems when transmitting signals over long distances?

Ans. Digital systems are more reliable than analog systems for long-distance transmission because they are more immune to noise, can be regenerated to remove noise accumulation, and can incorporate error detection and correction techniques.

19.4 Why is the NOT gate also called an inverter, and how can such a simple function have a major role in digital decision-making?

Ans. A NOT gate is called an inverter because it inverts the input signal.

It plays a major role in digital decision-making by providing the complement of a signal, enabling the implementation of complex logical functions and conditional operations.

19.5 Why would a security system use NAND gates instead of OR or AND gates for certain logical conditions?

Ans. Security systems might use NAND gates due to their universality, which simplifies design and manufacturing. They are also useful for implementing tamper detection and active low logic, where a '0' signal indicates an active or triggered state.

D. Comprehensive Questions

19.1 Explain how the depletion region of a diode changes in forward and reverse bias. What effect does this have on current flow?

Ans. For Answer See Q # 4, 5

19.2 Describe how an LED produces light. Also explain how the type of semiconductor material affects the colour of the light.

Ans. For Answer See Q # 6

19.3 What is Boolean logic? Discuss its importance in solving complex digital problems with examples.

Ans. For Answer See Q # 9

19.4 What are logic gates? Describe the working of NAND and OR gates with the help of truth tables and circuit symbols.

Ans. For Answer See Q # 10

19.5 How does a NOR gate work, and how can it be used to build other basic logic gates?

Ans. For Answer See Q # 10

19.6 How can a burglar alarm be designed using a NAND gate and an LDR? Explain.

Ans. For Answer See Q # 11

