

# Digital & Data Communication (4343201) - Winter 2024 Solution

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## Question 1(a) [3 marks]

Differentiate Basic modes of Communication: Broad casting communication and Point to Point Communication.

### Solution

**Table 1.** Broadcasting vs Point-to-Point

Parameter	Broadcasting Communication	Point to Point Communication
Definition	One transmitter sends signals to multiple receivers simultaneously	One transmitter communicates with one specific receiver
Direction	Unidirectional (one-way)	Bidirectional (two-way)
Examples	TV, Radio, FM	Telephone, Mobile calls, Private networks
Privacy	Low (signal available to everyone in range)	High (dedicated connection between endpoints)
Efficiency	High for mass communication	Better for personal/private communication

- **Broadcasting:** Targeted at mass audience (One-to-Many).
- **Point-to-Point:** Targeted at specific individual (One-to-One).

### Mnemonic

“BDPEC - Broadcasting Distributes to Public, Endpoints Connect in point-to-point”

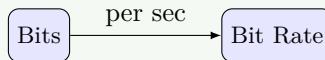
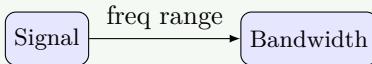
## Question 1(b) [4 marks]

Define: Bit Rate, Baud Rate, Bandwidth and Repeater Distance.

### Solution

**Table 2.** Definitions

Term	Definition
<b>Bit Rate</b>	Number of binary bits transmitted per second (bps). Measures actual data transfer speed.
<b>Baud Rate</b>	Number of signal units or symbols transmitted per second. One symbol may contain multiple bits.
<b>Bandwidth</b>	Range of frequencies used by a signal, measured in Hertz (Hz). Determines maximum data capacity of a channel.
<b>Repeater Distance</b>	Maximum distance between repeaters in a communication system before signal degradation requires regeneration.



**Figure 1.** Communication Rate Concepts

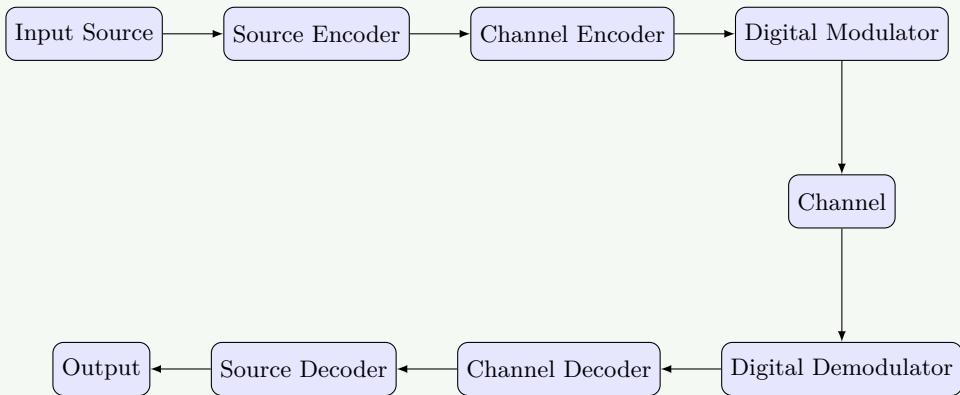
### Mnemonic

“BBRR - Better Bandwidth Requires Repeaters”

## Question 1(c) [7 marks]

Draw the block diagram of digital communication system. Explain the functions of each block in brief. State advantages and disadvantages of it.

### Solution



**Figure 2.** Digital Communication System

- **Source Encoder:** Converts analog signal to digital, removes redundancy, compresses data.
- **Channel Encoder:** Adds redundancy for error detection and correction.
- **Digital Modulator:** Converts digital data to suitable form for transmission (ASK, FSK, PSK).
- **Channel:** Medium through which signal travels (wired/wireless).
- **Digital Demodulator:** Extracts original digital data from received modulated signal.
- **Channel Decoder:** Detects and corrects errors using added redundancy.

- **Source Decoder:** Decompresses data and converts to original form.

**Table 3.** Advantages and Disadvantages

Advantages	Disadvantages
Better noise immunity	Requires more bandwidth
Easier signal regeneration	Complex implementation
Secure transmission possible	Synchronization required
Integration with computers	Quantization errors
Better quality for long distance	Higher cost for simple applications

**Mnemonic**

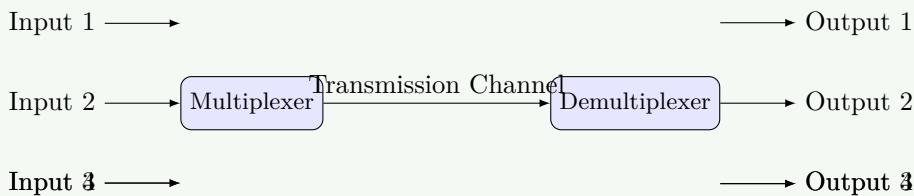
“SECDCSO - Secure Encoding Creates Digital Communication System Output”

**Question 1(c OR) [7 marks]**

Justify the needs of multiplexing techniques for digital communication. Draw and explain Time Division multiplexing technique in brief. Discuss its merits and demerits.

**Solution****Need for Multiplexing:****Table 4.** Need for Multiplexing

Need	Explanation
<b>Channel Efficiency</b>	Allows multiple signals on one channel, saving bandwidth
<b>Cost Reduction</b>	Reduces need for multiple transmission media
<b>Infrastructure Utilization</b>	Maximizes use of expensive infrastructure
<b>Spectrum Conservation</b>	Conserves limited frequency spectrum

**Time Division Multiplexing (TDM):****Figure 3.** Time Division Multiplexing (TDM)

- **Working:** In TDM, each input signal gets a specific time slot. The multiplexer samples each input sequentially, combining them into a single high-speed data stream. At the receiver, signals are separated based on timing.

**Table 5.** Merits and Demerits

Merits	Demerits
Efficient bandwidth usage	Requires synchronization
No guard bands needed	Complex buffering required
No cross-talk	Timing issues can cause errors
Flexible allocation	Unused slots waste capacity
Digital implementation	Higher data rate than individual channels

**Mnemonic**

“TIME - Transmission Interleaves Multiple Endpoints”

**Question 2(a) [3 marks]**

Differentiate: Coherent and Non-Coherent Detection Technique.

**Solution**

**Table 6.** Coherent vs Non-Coherent Detection

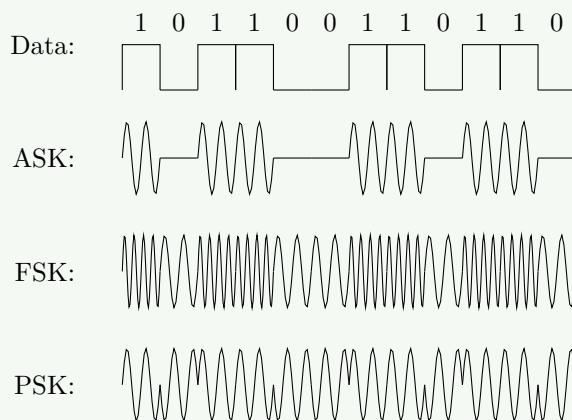
Parameter	Coherent Detection	Non-Coherent Detection
<b>Phase Information</b>	Uses phase information	Ignores phase information
<b>Local Oscillator</b>	Required	Not required
<b>Complexity</b>	More complex	Simpler
<b>Performance</b>	Better noise immunity	Less efficient in noise
<b>Implementation</b>	Difficult	Easier
<b>Applications</b>	High-quality systems	Low-cost systems

**Mnemonic**

“PLCPIA - Phase Local Complex Performance Implementation Applications”

**Question 2(b) [4 marks]**

Sketch the ASK, FSK, PSK and QPSK waveform for the data sequence 101100110110.

**Solution**

**Figure 4.** Modulation Waveforms

- **QPSK:** Represented by phase shifts of 0, 90, 180, 270 degrees for dibits (00, 01, 10, 11).

**Mnemonic**

“AFPQ - Amplitude Frequency Phase Quadrature”

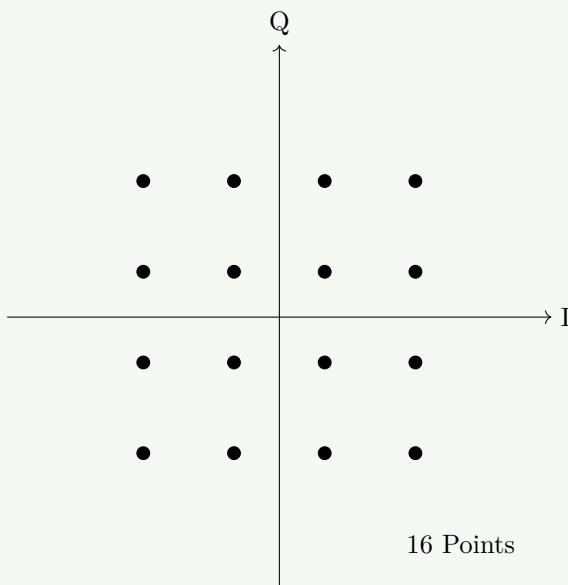
## Question 2(c) [7 marks]

Explain the principle of 16-QAM. Also explain constellation diagram and waveform for 16-QAM. Write its advantages and disadvantages.

### Solution

**Principle of 16-QAM:** 16-QAM (Quadrature Amplitude Modulation) combines amplitude and phase modulation to transmit 4 bits per symbol. It uses 16 different combinations of amplitude and phase, allowing higher data rates in the same bandwidth.

**Constellation Diagram:**



**Figure 5.** 16-QAM Constellation

**Waveform:** The 16-QAM waveform varies in both amplitude (4 levels) and phase (4 phases), creating 16 unique symbols. Each point represents 4 bits (0000 to 1111).

**Table 7.** Advantages and Disadvantages

Advantages	Disadvantages
High spectral efficiency	Sensitive to noise and interference
Higher data rate	Requires higher SNR
Bandwidth efficient	Complex implementation
Better use of channel capacity	Susceptible to amplitude distortion

### Mnemonic

“SCHAP - Sixteen Combinations Have Amplitude and Phase”

## Question 2(a OR) [3 marks]

**Compare:** ASK and PSK

**Solution****Table 8.** ASK vs PSK

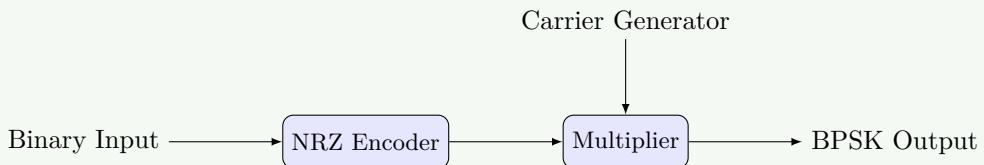
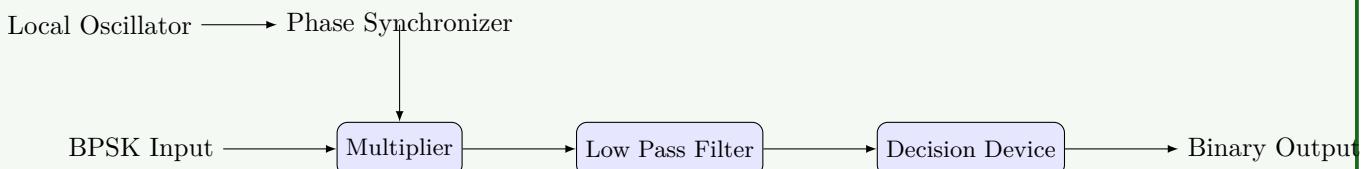
Parameter	<b>ASK (Amplitude Shift Keying)</b>	<b>PSK (Phase Shift Keying)</b>
<b>Modulation Parameter</b>	Amplitude	Phase
<b>Noise Immunity</b>	Poor	Good
<b>Power Efficiency</b>	Less efficient	More efficient
<b>Bandwidth Efficiency</b>	Lower	Higher
<b>Implementation</b>	Simple	More complex
<b>BER Performance</b>	Higher error rate	Lower error rate

**Mnemonic**

“ANPBIP - Amplitude Noise Power Bandwidth Implementation Performance”

**Question 2(b OR) [4 marks]**

Draw the block diagram of BPSK modulator and demodulator.

**Solution****BPSK Modulator:****Figure 6.** BPSK Modulator**BPSK Demodulator:****Figure 7.** BPSK Demodulator**Mnemonic**

“MNECO - Modulation Needs Encoding, Carriers, Oscillators”

**Question 2(c OR) [7 marks]**

Explain QPSK generation and detection with the help of block diagram and waveform. Discuss its advantages and disadvantages.

### Solution

#### QPSK Generation Block Diagram:

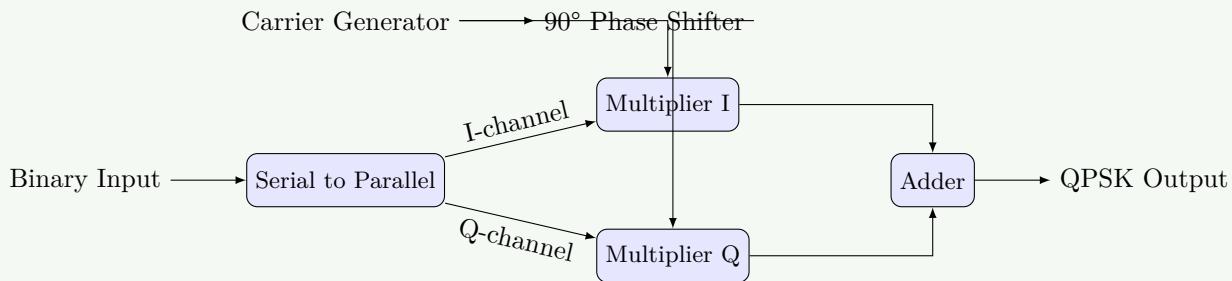


Figure 8. QPSK Generation

#### QPSK Detection Block Diagram:

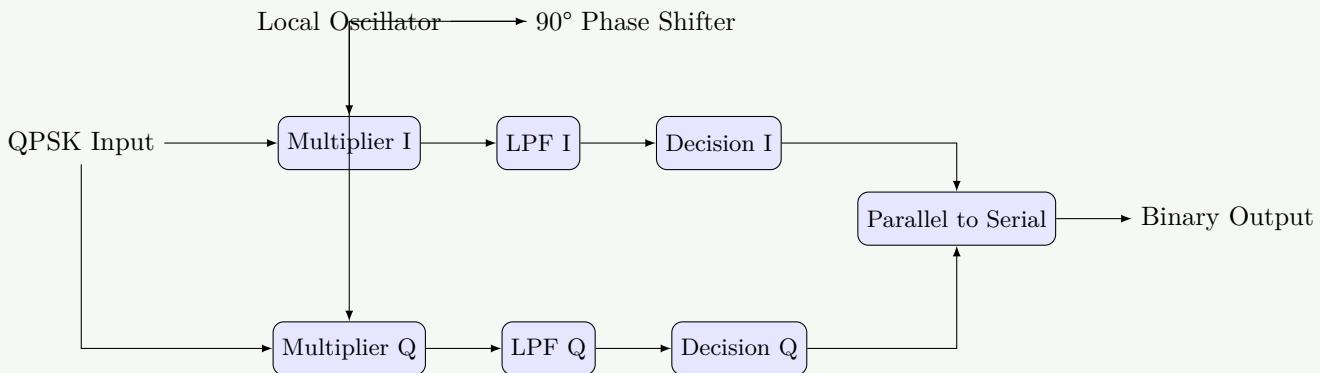


Figure 9. QPSK Detection

- QPSK Waveform:** Each symbol in QPSK represents 2 bits, with 4 possible phase states ( $0^\circ$ ,  $90^\circ$ ,  $180^\circ$ ,  $270^\circ$ ).

Table 9. Advantages and Disadvantages

Advantages	Disadvantages
Twice the data rate of BPSK	More complex implementation
Same bandwidth as BPSK	Sensitive to phase errors
Good noise immunity	Requires carrier recovery
Spectral efficiency	More complex synchronization

### Mnemonic

“PACE - Phase Alteration Carries Extra data”

## Question 3(a) [3 marks]

State the features of RS-422.

### Solution

Table 10. Features of RS-422

Features of RS-422
Differential signaling for noise immunity
Maximum data rate of 10 Mbps
Maximum cable length of 1200 meters
Multi-drop capability (1 driver, up to 10 receivers)
Balanced transmission line
Higher noise immunity than RS-232

**Mnemonic**

“DMMBHN - Differential Maximum Multi-drop Balanced Higher Noise-immunity”

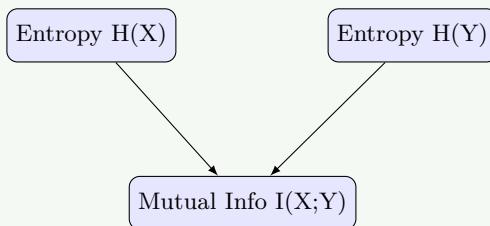
**Question 3(b) [4 marks]**

**Define:** Entropy, Information, Mutual Information and Probability.

**Solution**

**Table 11.** Definitions

Term	Definition
<b>Entropy</b>	Measure of uncertainty or randomness in a message source, calculated as $H(X) = -\sum p(x) \log_2 p(x)$
<b>Information</b>	Reduction in uncertainty when a message is received, measured in bits
<b>Mutual Information</b>	Measure of dependency between two random variables, indicating how much information one variable contains about the other
<b>Probability</b>	Mathematical measure of likelihood that an event will occur, ranging from 0 (impossible) to 1 (certain)



**Figure 10.** Information Theory Concepts

**Mnemonic**

“EIMP - Entropy Information Measures Probability”

**Question 3(c) [7 marks]**

**Explain Huffman Code and Shannon-Fano code with suitable example.**

## Solution

**Huffman Code:** Huffman coding assigns variable-length codes to symbols based on their frequencies, with shorter codes for more frequent symbols.

**Example:**

Table 12. Huffman Example

Symbol	Frequency	Huffman Code
A	45%	0
B	25%	10
C	15%	110
D	10%	1110
E	5%	1111

**Huffman Tree:**

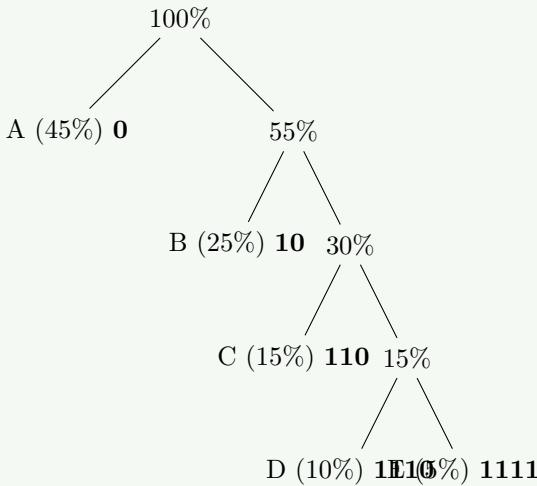


Figure 11. Huffman Tree

**Shannon-Fano Code:** Shannon-Fano algorithm recursively divides symbols into two groups of similar frequency, then assigns 0 to one group and 1 to the other.

**Shannon-Fano Tree:**

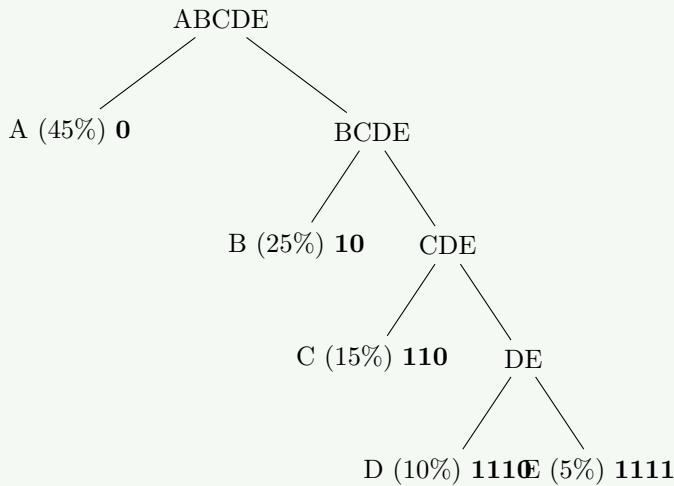


Figure 12. Shannon-Fano Tree

**Mnemonic**

“FREDS - Frequency Reduces Encoding Digit Size”

**Question 3(a OR) [3 marks]**

State the features of RS-232.

**Solution**

**Table 13.** Features of RS-232

Features of RS-232
Single-ended signaling
Maximum data rate of 20 kbps
Maximum cable length of 15 meters
Point-to-point communication (1 driver, 1 receiver)
Voltage levels: -15V to +15V
25-pin or 9-pin DB connector standard

**Mnemonic**

“SMPVD - Single Maximum Point-to-point Voltage DB-connector”

**Question 3(b OR) [4 marks]**

What is channel capacity in terms of SNR? Explain its importance.

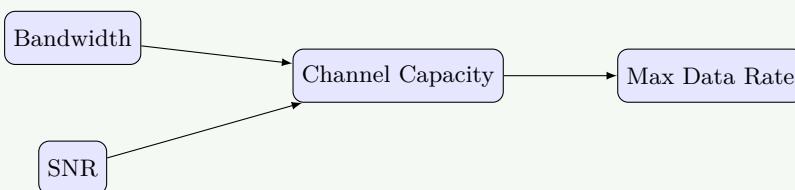
**Solution**

**Channel Capacity:** The maximum rate at which information can be transmitted over a communication channel with an arbitrarily small probability of error.

**Formula:**  $C = B \times \log_2(1 + SNR)$  Where: C = Channel capacity (bps), B = Bandwidth (Hz), SNR = Signal-to-Noise Ratio.

**Table 14.** Importance

Importance of Channel Capacity
Sets theoretical limits for data transmission
Guides system design and optimization
Helps evaluate performance of communication systems
Determines required bandwidth for a given data rate
Informs coding techniques to approach capacity



**Figure 13.** Channel Capacity Factors

**Mnemonic**

“BSNR - Bandwidth and SNR Need Relationship”

**Question 3(c OR) [7 marks]**

Explain in detail any one error detection and error correction technique in digital communication.

**Solution**

**Hamming Code Error Detection and Correction:** Hamming code is a linear error-correcting code that can detect and correct single-bit errors.

- Data bits are at powers of 2 positions not used by parity.
- Parity bits are at positions 1, 2, 4, 8...

**Example: 7-bit Hamming code (4 data, 3 parity)**

**Table 15.** Hamming Code Structure

Position	1	2	3	4	5	6	7
Bit Type	P1	P2	D1	P4	D2	D3	D4

**Parity Bit Calculation:**

- P1 checks 1, 3, 5, 7.
- P2 checks 2, 3, 6, 7.
- P4 checks 4, 5, 6, 7.

**Error Correction:** Parity checks indicate error position (binary value of P4 P2 P1 gives position).

**Table 16.** Error Location

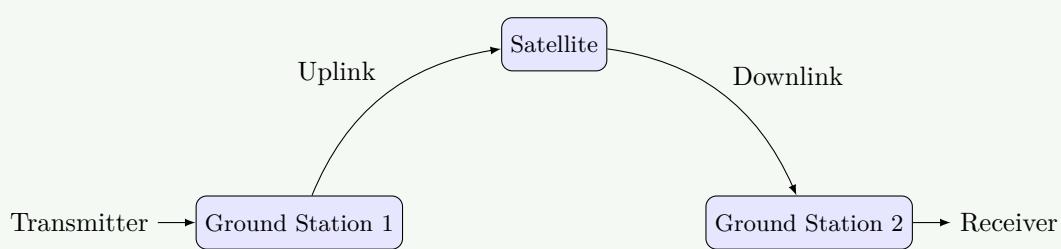
P4	P2	P1	Error Position
0	0	0	No error
0	0	1	Position 1
1	0	1	Position 5
1	1	1	Position 7

**Mnemonic**

“PECD - Parity Enables Correction of Data”

**Question 4(a) [3 marks]**

Draw the block diagram of satellite communication and explain in brief.

**Solution**

**Figure 14.** Satellite Communication

**Explanation:** Satellite communication involves transmitting signals from an Earth station to a satellite (uplink), which amplifies and retransmits them to Earth (downlink).

**Key Components:**

- **Earth Stations:** Transmit/Receive signals.
- **Transponders:** Satellite repeaters.

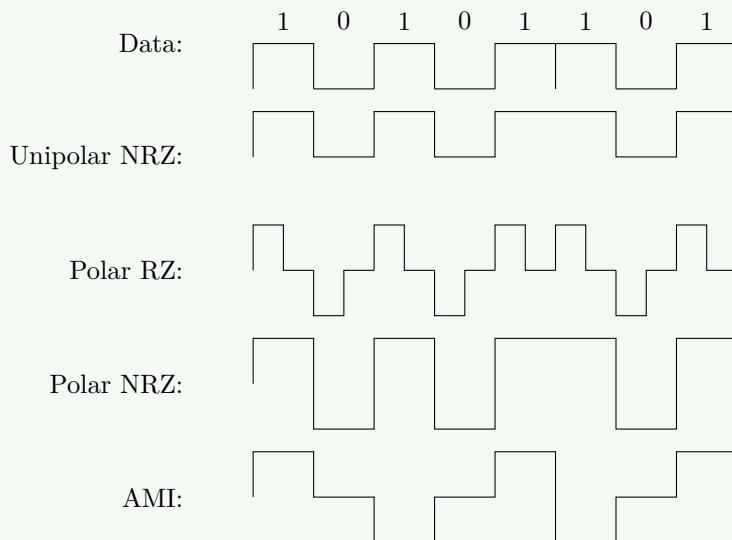
**Mnemonic**

“STAR - Satellite Transmits And Receives”

## Question 4(b) [4 marks]

Sketch the Unipolar NRZ, Polar RZ, Polar NRZ and AMI waveform for 10101101 data sequence.

**Solution**

**Figure 15.** Line Coding Waveforms

**Mnemonic**

“UPPA - Unipolar Polar Polar AMI”

## Question 4(c) [7 marks]

Explain data transmission techniques in details with suitable example for digital communication.

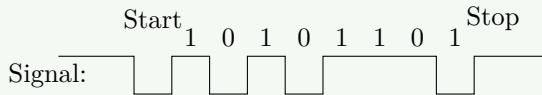
**Solution**

**Data Transmission Techniques:**

**Table 17.** Techniques

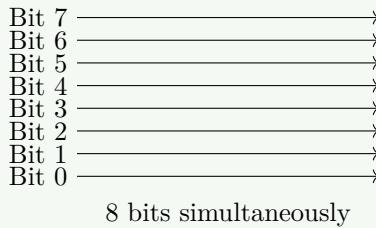
Technique	Description	Example
<b>Serial</b>	Data bits sent one after another over single channel	USB, UART
<b>Parallel</b>	Multiple bits sent simultaneously over multiple channels	Printer, SCSI
<b>Synchronous</b>	Continuous stream with timing signals	Ethernet
<b>Asynchronous</b>	Start/stop bits used	RS-232

**Serial Transmission (UART Example):**



**Figure 16.** Serial Transmission

**Parallel Transmission:**



**Figure 17.** Parallel Transmission

### Mnemonic

“SPASH - Serial Parallel Asynchronous Synchronous Half-duplex”

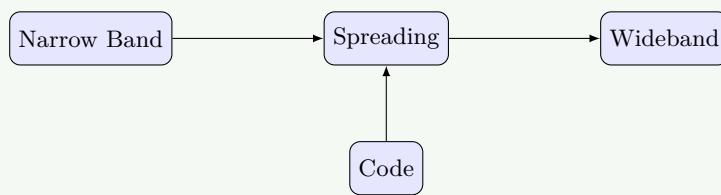
## Question 4(a OR) [3 marks]

Interpret the aspects of spread spectrum techniques.

### Solution

**Table 18.** Spread Spectrum Aspects

Aspect	Interpretation
<b>Bandwidth Spreading</b>	Signal spread over wider bandwidth
<b>Security</b>	Difficult to intercept/jam
<b>Noise Immunity</b>	Resistant to narrowband interference
<b>Multiple Access</b>	Allows sharing of frequency
<b>Low Power Density</b>	Signal appears as noise



**Figure 18.** Spread Spectrum Concept

**Mnemonic**

“BSNML - Bandwidth Security Noise Multiple Low-power”

**Question 4(b OR) [4 marks]**

Write a short note on probability and discuss its properties for digital communication.

**Solution**

**Probability:** Foundation for analyzing error rates and reliability.

**Table 19.** Properties

Property	Description	Relevance
<b>Range</b>	$0 \leq P(E) \leq 1$	Bounds for error prob
<b>Certainty</b>	$P(S) = 1$	Total prob
<b>Additivity</b>	$P(A \cup B) = P(A) + P(B)$	Total error rate
<b>Conditional</b>	$P(A B)$	Channel modeling
<b>Independence</b>	$P(A \cap B) = P(A)P(B)$	Uncorrelated noise

**Mnemonic**

“RACIC - Range Additivity Certainty Independence Conditional”

**Question 4(c OR) [7 marks]**

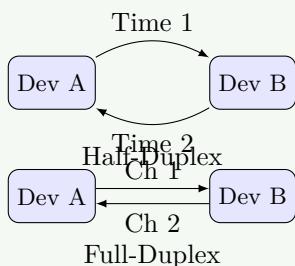
Explain Data transmission mode in details with example.

**Solution**

**Data Transmission Modes:**

**Table 20.** Modes

Mode	Description	Example
<b>Simplex</b>	One-way only	TV, Radio
<b>Half-Duplex</b>	Two-way, one at a time	Walkie-talkie
<b>Full-Duplex</b>	Two-way simultaneous	Telephone



**Figure 19.** Transmission Modes**Mnemonic**

“SHF - Simplex Half Full”

**Question 5(a) [3 marks]**

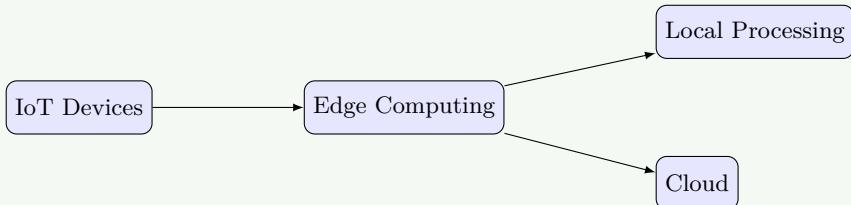
Explain Edge Computing in detail.

**Solution**

**Edge Computing:** Distributed computing bringing computation closer to data sources.

**Table 21.** Key Aspects

Aspect	Description
<b>Decentralization</b>	Processing at network edge
<b>Reduced Latency</b>	Faster response
<b>Bandwidth Efficiency</b>	Less data to cloud
<b>Security</b>	Sensitive data remains local

**Figure 20.** Edge Computing Architecture**Mnemonic**

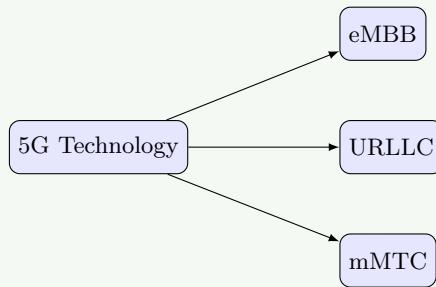
“DRBLES - Decentralized Reduces Bandwidth, Latency, Exposure, Strengthens reliability”

**Question 5(b) [4 marks]**

Enlist the features of 5G Technology in data communication.

**Solution****Table 22.** Features of 5G

Features of 5G Technology
<b>High Data Rates</b> (up to 20 Gbps peak)
<b>Ultra-Low Latency</b> (1 ms or less)
<b>Massive Device Connectivity</b> (1M devices per km <sup>2</sup> )
<b>Network Slicing</b> (customized virtual networks)
<b>Beamforming</b> (directed signal transmission)
<b>Millimeter Wave Spectrum</b> (24-100 GHz)

**Figure 21.** 5G Use Cases**Mnemonic**

“HUMBLE-MN - High-speed Ultra-low-latency Massive Beamforming Low-latency Enhanced Millimeter Network”

**Question 5(c) [7 marks]**

Write a details note on Data communication including its characteristics and components.

**Solution**

**Data Communication:** Process of transferring digital information.

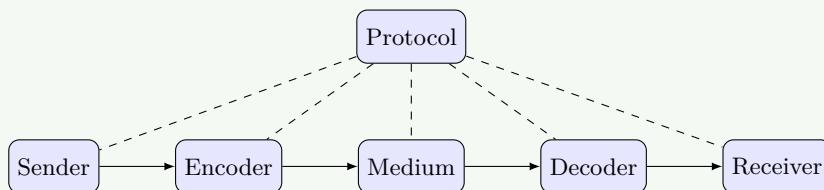
**Characteristics:**

- **Delivery:** Correct destination.
- **Accuracy:** No errors.
- **Timeliness:** On time.
- **Jitter:** Consistent timing.
- **Security:** Protected access.

**Components:**

**Table 23.** Components

Component	Description
Message	Information to be communicated
Sender	Device sending data
Receiver	Device receiving data
Medium	Physical path
Protocol	Rules governing communication

**Figure 22.** Data Communication Model**Mnemonic**

“DATJS-MSRTP - Delivery Accuracy Timeliness Jitter Security - Message Sender Receiver Transmission Protocol”

## Question 5(a OR) [3 marks]

Identify and write privacy consideration in Data communication.

### Solution

- Data Encryption:** Protecting data during transmission.
- Access Control:** Only authorized users.
- Authentication:** Verifying identity.
- Data Minimization:** Collecting only necessary data.
- End-to-End Security:** Protection throughout path.

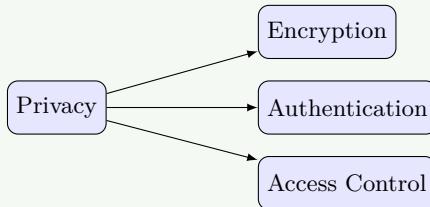


Figure 23. Privacy Considerations

### Mnemonic

“DAAESE - Data is Authenticated, Accessed, Encrypted Securely End-to-end”

## Question 5(b OR) [4 marks]

What is block chain in communication security? Enlist its features.

### Solution

**Blockchain:** Distributed ledger technology providing secure, tamper-proof records.

Table 24. Features

Feature	Description
<b>Decentralization</b>	No central authority
<b>Immutability</b>	Cannot be altered
<b>Transparency</b>	Visible to participants
<b>Cryptographic Security</b>	Secured using crypto
<b>Consensus</b>	Network agreement



Figure 24. Blockchain Structure

### Mnemonic

“DITCSD - Decentralized Immutable Transparent Cryptographic Secure Distributed”

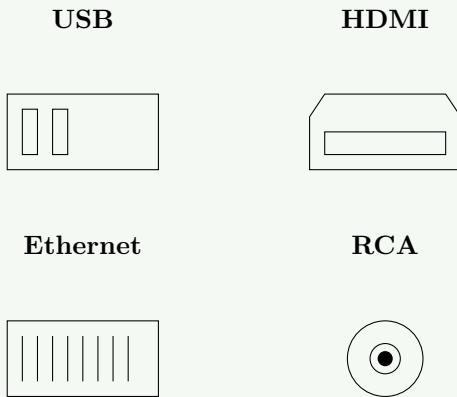
## Question 5(c OR) [7 marks]

Write and illustrate different communication ports: USB, HDMI, RCA and Ethernet.

## Solution

### Communication Ports:

1. **USB (Universal Serial Bus)**: Data/Power, 40 Gbps, Hot-swappable.
2. **HDMI**: Audio/Video, 48 Gbps, HDCP.
3. **RCA**: Analog Audio/Video, Colored (Red/White/Yellow).
4. **Ethernet (RJ-45)**: Network, 10 Gbps, Twisted pair.



**Figure 25.** Port Illustrations

**Table 25.** Comparison

Port	Type	Max Speed	Use
<b>USB</b>	Digital	40 Gbps	Data/Power
<b>HDMI</b>	Digital	48 Gbps	Audio/Video
<b>RCA</b>	Analog	Low	Audio/Video
<b>Ethernet</b>	Digital	10 Gbps	Network

## Mnemonic

“UHRE - USB Handles Rapid Ethernet, HDMI Delivers Rich Entertainment”