Subject Name Solutions

4343201 – Winter 2024

Semester 1 Study Material

Detailed Solutions and Explanations

Question 1(a) [3 marks]

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

Solution

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

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

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

Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Signal] {-{-}{} B[Bandwidth = Max Frequency {-} Min Frequency]}
    C[Bits] {-{-}{} D[Bit Rate = Bits/Second]}
    E[Symbols] {-{-}{} F[Baud Rate = Symbols/Second]}
    G[Distance] {-{-}{} H[Repeater Distance = Max Distance Before Signal Regeneration]}
{Highlighting}
{Shaded}
```

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

Block Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Input Source] {-{-}{} B[Source Encoder]}
    B {-{-}{} C[Channel Encoder]}
    C {-{-}{} D[Digital Modulator]}
    D {-{-}{} E[Channel]}
    E {-{-}{} F[Digital Demodulator]}
    F {-{-}{} G[Channel Decoder]}
    G {-{-}{} H[Source Decoder]}
    H {-{-}{} I[Output]}
{Highlighting}
{Shaded}
```

Functions:

Block	Function
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, etc.)
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

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:

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

Time Division Multiplexing (TDM):

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A1[Input 1] {-{-}{} M[Multiplexer]}
    A2[Input 2] {-{-}{} M}
    A3[Input 3] {-{-}{} M}
    A4[Input 4] {-{-}{} M}
    M {-{-}{} T[Transmission Channel]}
    T {-{-}{} D[Demultiplexer]}
    D {-{-}{} B1[Output 1]}
    D {-{-}{} B2[Output 2]}
    D {-{-}{} B3[Output 3]}
    D {-{-}{} B4[Output 4]}
{Highlighting}
{Shaded}
```

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, the demultiplexer separates the stream back into original signals based on timing.

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

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

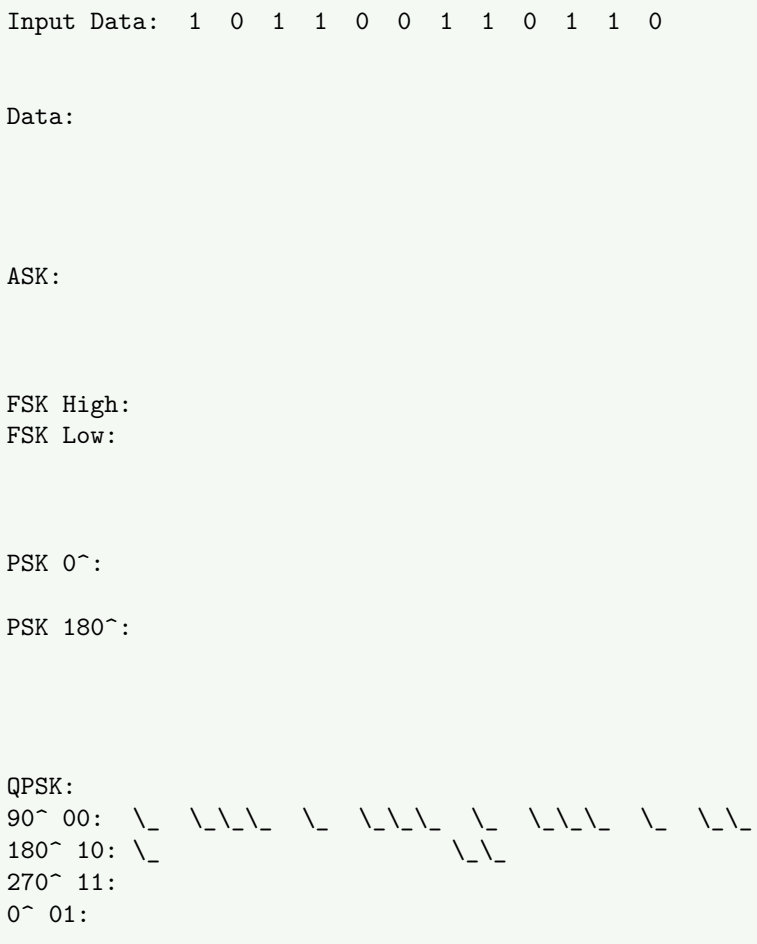
Mnemonic

"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



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:

```
{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-} I}
```

```
Each point represents 4 bits (0000 to 1111)
```

Waveform: The 16-QAM waveform varies in both amplitude (4 levels) and phase (4 phases), creating 16 unique symbols.

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

Parameter	ASK (Amplitude Shift Keying)	PSK (Phase Shift Keying)
Modulation Parameter	Amplitude	Phase
Noise Immunity	Poor	Good
Power Efficiency	Less efficient	More efficient
Bandwidth Efficiency	Lower	Higher
Implementation	Simple	More complex
BER Performance	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:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Binary Input] {-{-}{} B[NRZ Encoder]}
    B {-{-}{} C[Multiplier]}
    D[Carrier Generator] {-{-}{} C}
    C {-{-}{} E[BPSK Output]}
{Highlighting}
{Shaded}
```

BPSK Demodulator:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[BPSK Input] {-{-}{} B[Multiplier]}
    C[Local Oscillator] {-{-}{} D[Phase Synchronizer]}
    D {-{-}{} B}
    B {-{-}{} E[Low Pass Filter]}
    E {-{-}{} F[Decision Device]}
    F {-{-}{} G[Binary Output]}
{Highlighting}
{Shaded}
```

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:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Binary Input] {-{-}{} B[Serial to Parallel]}
    B {-{-}{}|I{-}channel| C[Multiplier I]}
    B {-{-}{}|Q{-}channel| D[Multiplier Q]}
    E[Carrier Generator] {-{-}{} C}
    E {-{-}{} F[90^ Phase Shifter]}
    F {-{-}{} D}
    C {-{-}{} G[Adder]}
    D {-{-}{} G}
    G {-{-}{} H[QPSK Output]}
{Highlighting}
{Shaded}
```

QPSK Detection Block Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[QPSK Input] {-{-}{} B[Multiplier I]}
    A {-{-}{} C[Multiplier Q]}
    D[Local Oscillator] {-{-}{} B}
    D {-{-}{} E[90^ Phase Shifter]}
    E {-{-}{} C}
    B {-{-}{} F[LPF I]}
    C {-{-}{} G[LPF Q]}
    F {-{-}{} H[Decision Device I]}
    G {-{-}{} I[Decision Device Q]}
    H {-{-}{} J[Parallel to Serial]}
```

```
    I {-{-}{} J}
    J {-{-}{} K[Binary Output]}
{Highlighting}
{Shaded}
```

QPSK Waveform: Each symbol in QPSK represents 2 bits, with 4 possible phase states ($0°, 90°, 180°, 270°$).
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

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

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

Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A["Entropy of X: H(X)"] {-{-}{-} C["Mutual Information: I(X;Y)"]}
    B["Entropy of Y: H(Y)"] {-{-}{-} C}
    C {-{-}{-} D[Measures shared information between X and Y]}
{Highlighting}
{Shaded}
```

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:

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

Huffman Tree:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[100\%] {-{-}{} B[60\%]}
    A {-{-}{} C[A: 40\%/0]}
    B {-{-}{} D[30\%]}
    B {-{-}{} E[B: 30\%/10]}
    D {-{-}{} F[15\%]}
    D {-{-}{} G[C: 15\%/110]}
    F {-{-}{} H[D: 10\%/1110]}
    F {-{-}{} I[E: 5\%/1111]}
{Highlighting}
{Shaded}
```

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.
Example:

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

Shannon-Fano Tree:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[A,B,C,D,E] {-{-}{} B[A/0]}
    A {-{-}{} C[B,C,D,E]}
    C {-{-}{} D[B/10]}
    C {-{-}{} E[C,D,E]}
    E {-{-}{} F[C/110]}
    E {-{-}{} G[D,E]}
    G {-{-}{} H[D/1110]}
    G {-{-}{} I[E/1111]}
{Highlighting}
{Shaded}
```

Mnemonic

"FREDS" - "Frequency Reduces Encoding Digit Size"

Question 3(a) OR [3 marks]

State the features of RS-232.

Solution

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 in bits per second
- B = Bandwidth in Hertz
- SNR = Signal-to-Noise Ratio

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

Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Bandwidth] {-{-}{} C[Channel Capacity]}
    B[SNR] {-{-}{} C}
    C {-{-}{} D[Maximum Achievable Data Rate]}
{Highlighting}
{Shaded}
```

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 in data transmission.
Working Principle:

1. Data bits are positioned at locations that are powers of 2 (1, 2, 4, 8, etc.)
2. Parity bits are added at positions 1, 2, 4, 8, etc.

3. Each parity bit checks specific data bits according to its position
4. On receiving, parity checks identify error position

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

Position	1	2	3	4	5	6	7
Bit type	P_1	P_2	D_1	P_4	D_2	D_3	D_4

Parity Bit Calculation:

- $P_1 checksbits 1, 3, 5, 7 (positions 1, 3, 5, 7)$
- $P_2 checksbits 2, 3, 6, 7 (positions 2, 3, 6, 7)$
- $P_4 checksbits 4, 5, 6, 7 (positions 4, 5, 6, 7)$

Error Correction: If an error occurs, the parity checks will indicate the error position, which can then be flipped to correct the error.

Table 1: Error Position from Parity Check Results

P_4	P_2	P_1	Error Position
0	0	0	No error
0	0	1	Position 1
0	1	0	Position 2
0	1	1	Position 3
1	0	0	Position 4
1	0	1	Position 5
1	1	0	Position 6
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

Satellite Communication Block Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Ground Station 1] {-{-}{}|Uplink| B[Satellite]}
    B {-{-}{}|Downlink| C[Ground Station 2]}
    D[Transmitter] {-{-}{} A}
    C {-{-}{} E[Receiver]}
{Highlighting}
{Shaded}
```

Brief Explanation: Satellite communication involves transmitting signals from an Earth station to a satellite (uplink), which then amplifies and retransmits the signals back to Earth (downlink). The satellite acts as a repeater in space, enabling long-distance communication.

Key Components:

- **Earth Stations**: Transmit and receive signals
- **Transponders**: Receive, amplify, and retransmit signals
- **Antennas**: Transmit and receive electromagnetic waves
- **Modems**: Convert digital data to analog signals and vice versa

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

```
Input Data:  1  0  1  0  1  1  0  1


Data:




Unipolar
NRZ:


Polar
RZ:



Polar
NRZ:




AMI:
```

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:

Technique	Description	Example
Serial Transmission	Data bits sent one after another over a single channel	USB, UART communication
Parallel Transmission	Multiple bits sent simultaneously over multiple channels	Printer ports, SCSI
Synchronous Transmission	Data sent in continuous stream with timing signals	Ethernet, HDLC

Asynchronous Transmission	Data sent with start/stop bits as timing references	RS-232, UART
Simplex	One-way communication	TV broadcasting
Half-Duplex	Two-way communication, one direction at a time	Walkie-talkie
Full-Duplex	Two-way simultaneous communication	Telephone calls

Serial Transmission Example:

```
            Start   1  0  1  0  1  1  0  1  Stop
             bit                            bit


UART:
```

Parallel Transmission Example:

```
Data: 10101101

      Bit 7:

      Bit 6:

      Bit 5:

      Bit 4:

      Bit 3:

      Bit 2:

      Bit 1:

      Bit 0:



Clock:
```

Mnemonic

"SPASH" - "Serial Parallel Asynchronous Synchronous Half-duplex"

Question 4(a) OR [3 marks]

Interpret the aspects of spread spectrum techniques.

Solution

Spread Spectrum Techniques:

Aspect	Interpretation
Bandwidth Spreading	Signal spread over a wider bandwidth than required
Security	Difficult to intercept or jam due to spreading
Noise Immunity	Resistant to narrowband interference
Multiple Access	Allows multiple users to share same frequency band
Low Power Density	Signal power spread across wide band, appearing as noise

Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Narrow Band Signal] {-{-}{} B[Spreading]}
    B {-{-}{} C[Wideband Spread Signal]}
    D[Spreading Code] {-{-}{} B}
{Highlighting}
{Shaded}
```

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 in Digital Communication: Probability theory provides the mathematical foundation for analyzing performance, error rates, and reliability of digital communication systems.
Properties of Probability:

Property	Description	Relevance in Digital Communication
Range	$0 \leq P(E) \leq 1$	Sets bounds for error probability
Certainty	P(S) = 1 for sample space S	Total probability of all possible outcomes
Additivity	P(A) = P(A) + P(B) for disjoint events	Calculating overall system error rates
Conditional Probability	P(A|B) = P(A)/P(B)	Useful for channel modeling
Independence	P(A) = P(A)(B)	Analyzing uncorrelated noise sources

Applications in Digital Communication:

- Bit Error Rate calculation
- Signal detection theory
- Channel capacity estimation
- Coding efficiency analysis

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:

Mode	Description	Diagram	Example
Simplex	One-way communication only. Transmitter can only send, receiver can only receive.	`mermaid graph LR; A[Transmitter] -->|One-way| B[Receiver]`	TV broadcasting, Radio

Half-Duplex	Two-way communication, but only one direction at a time.	`mermaid graph LR; A[Device A] -->|Time 1| B[Device B]; B -->|Time 2| A`	Walkie-talkie, CB radio
Full-Duplex	Two-way simultaneous communication.	`mermaid graph LR; A[Device A] -->|Channel 1| B[Device B]; B -->|Channel 2| A`	Telephone, Mobile calls

Example of Half-Duplex Communication:

```
Device A                    Device B
   |                           |
   |        REQUEST DATA       |
   |-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-|}
   |                           |
   |                           |
   |        SENDING DATA       |
   |{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-|}
   |                           |
   |    ACKNOWLEDGMENT (ACK)   |
   |-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-|}
   |                           |
```

Example of Full-Duplex Communication:

```
Device A                    Device B
   |                           |
   |        SENDING DATA       |
   |-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-|}
   |                           |
   |        SENDING DATA       |
   |{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-|}
   |                           |
   |      CONTINUOUS DATA      |
   |{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-{-}-|}
   |                           |
```

Mnemonic

"SHF" - "Simplex Half Full" or "Stop, Halt, Flow"

Question 5(a) [3 marks]

Explain Edge Computing in detail.

Solution

Edge Computing: Edge computing is a distributed computing paradigm that brings computation and data storage closer to the location where it is needed to improve response times and save bandwidth.
Key Aspects:

Aspect	Description
Decentralization	Processing at network edge instead of central cloud
Reduced Latency	Faster response due to proximity to data source
Bandwidth Efficiency	Less data sent to cloud, reducing network congestion
Local Data Processing	Data processed near collection point
Improved Security	Sensitive data remains local, reducing exposure
Reliability	Continues to function during cloud connectivity issues

Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[IoT Devices] {-{-}{} B[Edge Computing]}
    B {-{-}{} C[Local Processing]}
    B {-{-}{} D[Local Storage]}
    B {-{-}{} E[Cloud]}
    E {-{-}{} F[Central Storage \& Processing]}
{Highlighting}
{Shaded}
```

Mnemonic

"DRBLES" - "Decentralized Reduces Bandwidth, Latency, Exposure, Strengthens reliability"

Question 5(b) [4 marks]

Enlist the features of 5G Technology in data communication.

Solution

Features of 5G Technology
High Data Rates (up to 20 Gbps peak)
Ultra-Low Latency (1 ms or less)
Massive Device Connectivity (1 million devices per km^2)
Network Slicing (customized virtual networks)
Beamforming (directed signal transmission)
Millimeter Wave Spectrum (24-100 GHz)
Enhanced Mobile Broadband (eMBB)
Ultra-Reliable Low-Latency Communication (URLLC)

Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph TD
    A[5G Technology] {-{-}{} B[High Data Rates]}
    A {-{-}{} C[Ultra{-}Low Latency]}
    A {-{-}{} D[Massive Connectivity]}
    A {-{-}{} E[Network Slicing]}
    A {-{-}{} F[Three Main Use Cases]}
    F {-{-}{} G[eMBB]}
    F {-{-}{} H[URLLC]}
    F {-{-}{} I[mMTC]}
{Highlighting}
{Shaded}
```

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: Data communication is the process of transferring digital information between two or more points.
Characteristics of Data Communication:

Characteristic	Description
Delivery	System must deliver data to correct destination
Accuracy	System must deliver data accurately, without errors
Timeliness	System must deliver data in a timely manner
Jitter	System must maintain consistent timing between data arrivals
Security	System must protect data from unauthorized access

Components of Data Communication:

Component	Description
Message	The information (data) to be communicated
Sender	Device that sends the data message
Receiver	Device that receives the message
Transmission Medium	Physical path by which message travels
Protocol	Set of rules governing data communication

Data Communication Model:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Sender] {-{-}{} B[Encoder]}
    B {-{-}{} C[Transmission Medium]}
    C {-{-}{} D[Decoder]}
    D {-{-}{} E[Receiver]}
    F[Protocol] {-{-}{} A}
    F {-{-}{} B}
    F {-{-}{} C}
    F {-{-}{} D}
    F {-{-}{} E}
{Highlighting}
{Shaded}
```

Data Communication Types:

Type	Description
Analog	Continuous signal that varies in amplitude or frequency
Digital	Discrete signal represented by binary digits (0s and 1s)
Parallel	Multiple bits transmitted simultaneously on separate channels
Serial	Bits transmitted sequentially on a single channel

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

Privacy Considerations in Data Communication:

Privacy Consideration	Description
Data Encryption	Protecting data during transmission using encryption algorithms
Access Control	Ensuring only authorized users can access communication systems
Authentication	Verifying the identity of users and devices
Data Minimization	Collecting only necessary data to minimize privacy risks
Secure Protocols	Using communication protocols with built-in security features
End-to-End Security	Ensuring data is protected throughout the entire communication path

Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph TD
    A[Privacy in Data Communication] {-{-}{} B[Data Encryption]}
    A {-{-}{} C[Access Control]}
    A {-{-}{} D[Authentication]}
    A {-{-}{} E[Data Minimization]}
    A {-{-}{} F[Secure Protocols]}
    A {-{-}{} G[End{-}to{-}End Security]}
{Highlighting}
{Shaded}
```

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 in Communication Security: Blockchain is a distributed ledger technology that provides secure, tamper-proof record-keeping for data communication through cryptographic linking of data blocks.
Features of Blockchain:

Feature	Description
Decentralization	No central authority; distributed across network nodes
Immutability	Once recorded, data cannot be altered without consensus
Transparency	All transactions visible to authorized participants
Cryptographic Security	Data secured using advanced cryptographic techniques
Consensus Mechanism	Network agrees on validity of transactions
Smart Contracts	Self-executing contracts with terms directly written in code
Distributed Storage	Data stored across multiple nodes, preventing single point of failure

Diagram:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Block 1] {-{-}{}|Hash Link| B[Block 2]}
    B {-{-}{}|Hash Link| C[Block 3]}
    C {-{-}{}|Hash Link| D[Block 4]}

    A {-{-}{} A1[Transactions]}
    A {-{-}{} A2[Hash]}
    A {-{-}{} A3[Previous Hash]}

    B {-{-}{} B1[Transactions]}
    B {-{-}{} B2[Hash]}
    B {-{-}{} B3[Previous Hash]}
{Highlighting}
{Shaded}
```

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):**

```
USB{-A    }
```

```
USB{-C    }
```

Features:

- Data transfer, power delivery, and device connection
- Versions: USB 1.0 to USB 4.0
- Speed: Up to 40 Gbps (USB4)
- Hot-swappable
- Supports up to 127 devices in cascade

1. **HDMI (High-Definition Multimedia Interface):**

```
HDMI
```

Features:

- Digital audio/video transmission
- Versions: HDMI 1.0 to HDMI 2.1
- Resolution support: Up to 10K
- Bandwidth: Up to 48 Gbps (HDMI 2.1)
- HDCP (High-bandwidth Digital Content Protection)
- CEC (Consumer Electronics Control) for device control

1. **RCA (Radio Corporation of America):**

```
  R     G     B

Red    Green  Blue


  W     R


White  Red
Video  Audio
```

Features:

- Analog audio/video transmission
- Color-coded connectors (Red, White, Yellow)
- Used for composite video and stereo audio
- Simple connection but limited quality
- No digital content protection
- Being phased out by digital standards

1. **Ethernet (RJ-45):**

```
    RJ{-45       }

   |||||||||
```

Features:

- Network connectivity
- Standards: 10BASE-T to 10GBASE-T
- Speed: 10 Mbps to 10 Gbps
- Uses twisted-pair cabling (Cat5e, Cat6, Cat6a)
- Supports Power over Ethernet (PoE)
- Base communication for TCP/IP networks
- Maximum cable length: 100 meters

Comparison Table:

Port	Type	Data Type	Max Speed	Power Delivery	Max Length
USB	Digital	Data/Power	40 Gbps	Yes (100W)	5m
HDMI	Digital	Audio/Video	48 Gbps	Limited	15m
RCA	Analog	Audio/Video	Low	No	10m
Ethernet	Digital	Network Data	10 Gbps	Yes (PoE)	100m

Mnemonic

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