Subject Name Solutions

4343201 – Summer 2024

Semester 1 Study Material

Detailed Solutions and Explanations

Question 1(a) [3 marks]

Define: (1) Bit rate, (2) Baud rate, and (3) Bandwidth

Solution

Term	Definition
Bit Rate	Number of bits transmitted per second (bps)
Baud Rate	Number of signal elements or symbols transmitted per second
Bandwidth	Range of frequencies required to transmit a signal, measured in Hertz (Hz)

Mnemonic

"BBB - Bits move By Bands"

Question 1(b) [4 marks]

A signal has a bit rate of 8000bps and baud rate of 1000 baud. How many data element is carry by each signal? How many signals element do we need?

Solution

Table 1: Signal Calculation

Parameter	Value	Calculation
Bit rate	8000 bps	Given
Baud rate	1000 baud	Given
Data elements per signal	8 bits	Bit rate $\div Baudrate = 8000 \div 1000 = 8$
Signal elements needed	2^8 = 256	2^(bits per signal)

Diagram: Signal Element Representation

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[1000 Signals per second] {-{-}{}|Each signal carries| B[8 bits of data]}
    B {-{-}{}|Requires| C[256 different signal elements]}
{Highlighting}
{Shaded}
```

Mnemonic

"Divide to Decide" - Divide bit rate by baud rate to decide how many bits per signal.

Question 1(c) [7 marks]

Describe Elements of digital communication system with its block diagram

Solution

Diagram: Digital Communication System

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[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[Destination]}
{Highlighting}
{Shaded}
```

Key Elements:

Element	Function
Source	Generates message to be transmitted
Source Encoder	Converts message to digital format, removes redundancy
Channel Encoder	Adds redundancy for error detection/correction
Digital Modulator	Converts digital data to signals suitable for channel
Channel	Physical medium that carries the signal
Digital Demodulator	Extracts digital information from received signals
Channel Decoder	Detects/corrects errors using added redundancy
Source Decoder	Reconstructs original message from digital data
Destination	Receives the final message

Mnemonic

"Send Messages Carefully; Destination Must Comprehend Signals Deeply"

Question 1(c OR) [7 marks]

What is fundamental limitation of digital communication system? What are the advantages and disadvantages of digital communication system?

Solution

Fundamental Limitations:

Limitation	Description
Bandwidth	Digital signals require more bandwidth than analog
Noise	Limits maximum achievable data rate
Equipment	Digital systems need complex hardware and processing

Advantages vs Disadvantages:

Advantages	Disadvantages
Noise Immunity	Higher bandwidth requirements
Easy Multiplexing	Complex equipment
Error Detection & Correction	Quantization errors
Enhanced Security	Synchronization problems
Signal Regeneration	Higher initial cost
Integration with Computers	Sampling rate limitations

Mnemonic

"NEEDS" - Noise, Equipment, and Environment Determine Success

Question 2(a) [3 marks]

Describe QPSK Modulator with block diagram

Solution

Diagram: QPSK Modulator

```
              +{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
              |  2{-bit     |          +{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
input         | Serial{-to{-} |{-}{-}bit 1{-}{-}| Cos       |}
data {-{-}{-}{-}{-}{-}{-}{-}{-}| Parallel   |          | Carrier   |{-}{-}{-}{-}+}
              | Converter  |          +{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+    |   QPSK}
              |            |                          +{-{-}Signal}
              |            |          +{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+    |   Output}
              |            |{-{-}bit 2{-}{-}| Sin       |{-}{-}{-}{-}+}
              +{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+         | Carrier   |}
                                      +{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
```

Key Components:

- **Serial-to-Parallel Converter**: Splits data into 2-bit groups
- **Cosine Carrier**: Modulates first bit (I-channel)
- **Sine Carrier**: Modulates second bit (Q-channel)

Mnemonic

"Split Pair, Carrier Square" - data split into pairs, carried by squared signals

Question 2(b) [4 marks]

Describe ASK Modulator with block diagram

Solution

Diagram: ASK Modulator

```
              +{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+     +{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
Digital       | Product    |     |          |
Input {-{-}{-}{-}{-}{-}{-}| Modulator  |{-}{-}{-}{-}| Filter  |{-}{-}{-} ASK Signal}
              | (Mixer)    |     |          |
              +{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+     +{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
                     \^{}
                     |
              +{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
              | Carrier    |
              | Oscillator |
              +{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
```

ASK Modulation Process:

Component	Function
Digital Input	Binary data (0s and 1s) to be transmitted
Carrier Oscillator	Generates high-frequency sine wave
Product Modulator	Multiplies input with carrier (ON/OFF)
Filter	Removes unwanted frequency components

Mnemonic

"Amplify Signal when Keen" - carrier amplitude changes when signal is high

Question 2(c) [7 marks]

Compare ASK, FSK and PSK and Draw the wave form of ASK, FSK and PSK for the input digital signal 100101000101

Solution

Comparison Table:

Parameter	ASK	FSK	PSK
Modulation Parameter	Amplitude	Frequency	Phase
Noise Immunity	Poor	Moderate	Good
Bandwidth	Narrow	Wide	Moderate
Power Efficiency	Poor	Moderate	Good
Implementation	Simple	Moderate	Complex
BER Performance	Poor	Moderate	Good

Waveforms for input 100101000101:

```
Digital:  \_ \_ \_\_\_ \_   (1 0 0 1 0 1 0 0 0 1 0 1)

ASK:      \_\_\_ \_\_\_  \_\_\_ \_\_\_
        high low low high low high low low low high low high

FSK:      {      }
        f1  f2  f2  f1  f2  f1  f2  f2  f2  f1  f2  f1

PSK:      ~~~  ~~~  ~~~  ~~~
        0^  180^ 180^ 0^  180^ 0^  180^ 180^ 180^ 0^  180^ 0^
```

Mnemonic

"AFP - Alter Frequencies or Phases" to remember modulation types

Question 2(a OR) [3 marks]

Describe QPSK Demodulator with block diagram

Solution

Diagram: QPSK Demodulator

```
                +{-{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
                | Cos       |
                | Carrier   |{-{-}+}
                +{-{-}{-}{-}{-}{-}{-}{-}{-}{-}+  |}
                               v
QPSK      +{-{-}{-}{-}+      +{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+     +{-}{-}{-}{-}{-}{-}{-}{-}{-}
Signal{-{-}{-}| BPF |{-}{-}{-}{-}{-}| Product    |{-}{-}{-}{-}| LPF     |{-}{-}{-}{-} Bit 1}
          +{-{-}{-}{-}{-}+      | Detect     |     +{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
                       +{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
                              \^{}
                              |      +{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+    +{-}{-}{-}{-}{-}{-}{-}{
                              +{-{-}{-}{-}{-}| Product    |{-}{-}{-}| LPF     |{-}{-}{-}{-} Bit 2}
                                    | Detect     |    +{-{-}{-}{-}{-}{-}{-}{-}+}
                              +      +{-{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
                              |
```

```
+{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
| Sin       |
| Carrier   |
+{-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
```

Key Components:

- **BPF (Bandpass Filter)**: Removes noise outside signal bandwidth
- **Product Detectors**: Multiply with carrier signals (cos & sin)
- **LPF (Lowpass Filters)**: Extract original data bits

Mnemonic

"Filtered Pairs Deliver Data" - filters and paired carriers recover data

Question 2(b OR) [4 marks]

Draw the Constellation diagram of ASK, BPSK and QPSK

Solution

Constellation Diagrams:

```
ASK Constellation:      BPSK Constellation:     QPSK Constellation:

       |                       |                       |
       |                       |                       |      * 01
       |                       |                       |
       |                       |                       |
{-{-}{-}{-}{-}{-}{-}+{-}{-}{-}{-}{-}{-}{-}      {-}{-}{-}{-}{-}{-}{-}+{-}{-}{-}{-}{-}{-}{-}      {-}{
       |                       |                       |
       |                       |                       |
   *   |                *      |     *         *       |     *
 (0)   |  * (1)          (1)   |   (0)       10      |    00
       |                       |                       |
Q axis |               Q axis|                Q axis|
      I axis                 I axis                 I axis
```

Table 2: Constellation Characteristics

Modulation	Points	Phase States	Amplitude States
ASK	2	1 ($0°$)	2 (0, A)
BPSK	2	2 ($0°, 180°$)	1 (A)
QPSK	4	4 ($45°, 135°, 225°, 315°$)	1 (A)

Mnemonic

"Points Double When Phases Double" - BPSK has 2 points, QPSK has 4 points

Question 2(c OR) [7 marks]

Describe FSK Modulator and demodulator with block diagram and output wave form

Solution

FSK Modulator Diagram:

```
                         +{-{-}{-}{-}{-}{-}{-}{-}{-}+}
            +{-{-}{-}{-}{-}{-}{-}{-}+  |          |}
    {1 {-}{-}{-}| Switch |{-}| Osc f1  |{-}{-}+}
            |        |  |         |  |
Digital     +{-{-}{-}{-}{-}{-}{-}{-}+  +{-}{-}{-}{-}{-}{-}{-}{-}{-}+  |     +{-}{-}{-}{-}{-}{-}{-}{
```

```
Input {-{-}{-}+                            +{-}{-}{-}{-}|         |}
          |                                 | Adder   |{-{-}{-} FSK Signal}
          |   +{-{-}{-}{-}{-}{-}{-}{-}{-}+  +{-}{-}{-}{-}{-}{-}{-}{-}{-}+  +{-}{-}{-}|         |}
     {0 {-}+{-}{-}| Switch |{-}| Osc f2  |{-}{-}+    +{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
              |        |  |         |
              +{-{-}{-}{-}{-}{-}{-}{-}{-}+  +{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
```

FSK Demodulator Diagram:

```
                +{-{-}{-}{-}{-}{-}{-}{-}{-}{-}+  +{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+  +{-}{-}{-}{-}{-}{-}{-}{-}{
                |         |  |         |  |         |
                | BPF f1  |{-| Env     |{-}| Thresh  |{-}{-}+}
                |         |  | Detect  |  | Detect  |  |
                +{-{-}{-}{-}{-}{-}{-}{-}{-}{-}+  +{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+  +{-}{-}{-}{-}{-}{-}{-}{-}{
                                                       |  +{-{-}{-}{-}{-}{-}{-}{-}{-}+}
FSK Signal {-{-}+                                         +{-}|         |}
             |                                            | Logic   |{-{-}{-} Digital}
             |  +{-{-}{-}{-}{-}{-}{-}{-}{-}{-}+  +{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+  +{-}{-}{-}{-}{-}{-}{-}{-}{
             |  |         |  |         |  |         |  |  |         |
             +{-| BPF f2  |{-}| Env     |{-}| Thresh  |{-}{-}+  +{-}{-}{-}{-}{-}{-}{-}{-}{-}+}
                |         |  | Detect  |  | Detect  |
                +{-{-}{-}{-}{-}{-}{-}{-}{-}{-}+  +{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}+  +{-}{-}{-}{-}{-}{-}{-}{-}{
```

FSK Waveform:

```
Digital:  \_\_\_  \_\_\_
          0  1  0

FSK:      {}
          f2 f1 f2
          Low freq when 0
          High freq when 1
```

Key Components:

Component	Function
Oscillators	Generate different frequencies for 0 and 1
Bandpass Filters	Separate the two frequencies
Envelope Detectors	Extract amplitude variations
Threshold Detectors	Convert analog to digital

Mnemonic

"Frequency Shift Key - Two Tones Tell Truth"

Question 3(a) [3 marks]

State the significance of probability in communication

Solution

Significance	Description
Information Measurement	Quantifies uncertainty/surprise in messages
Channel Capacity	Determines maximum possible data rate
Error Analysis	Predicts and minimizes communication errors

Mnemonic

"ICE - Information, Capacity, Errors" need probability

Question 3(b) [4 marks]

State channel capacity in terms of SNR and explain its importance

Solution

Shannon's Channel Capacity Formula:

```
C = B \times log_{2}(1 + SNR)
```

Where:

- C = Channel capacity (bits/second)
- B = Bandwidth (Hz)
- SNR = Signal-to-Noise Ratio

Importance:

Aspect	Importance
Theoretical Limit	Defines maximum possible error-free data rate
System Design	Guides bandwidth and power requirements
Performance Evaluation	Benchmark for actual system performance
Coding Efficiency	Indicates how close a system is to optimal performance

Mnemonic

"BEST" - Bandwidth and Error-free Signal Transmission

Question 3(c) [7 marks]

Discuss classification of line codes with suitable example

Solution

Diagram: Line Code Classification

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph TD
    A[Line Codes] {-{-}{} B[Unipolar]}
    A {-{-}{} C[Polar]}
    A {-{-}{} D[Bipolar]}
    B {-{-}{} B1[NRZ]}
    B {-{-}{} B2[RZ]}
    C {-{-}{} C1[NRZ]}
    C {-{-}{} C2[RZ]}
    D {-{-}{} D1[AMI]}
    D {-{-}{} D2[Pseudoternary]}
{Highlighting}
{Shaded}
```

Line Code Examples:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph TD
    subgraph "Digital Data"
    D["1  0  1  1  0  1  0  0"]
    end

    subgraph "Unipolar NRZ"
    U["High  Low  High  High  Low  High  Low  Low"]
```

```
    end

    subgraph "Polar NRZ"
    P["+V   {-V   +V   +V   {-}V   +V   {-}V   {-}V"]}
    end

    subgraph "Bipolar AMI"
    B["+V   0   {-V   +V   0   {-}V   0    0"]}
    end
{Highlighting}
{Shaded}
```

Waveform Visualization:

```
Data:        1    0    1    1    0    1    0    0
           \_|\_   |   \_|\_  \_|\_   |   \_|\_   |    |

Unipolar
NRZ:       \_\_\_\_\_  \_\_\_\_\_    \_\_\_\_\_

Polar        \_\_\_\_\_    \_\_\_\_\_  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
NRZ:

Bipolar          \_\_\_\_\_
AMI:       \_\_\_\_\_       \_\_\_\_\_
           (+ for first 1, {- for second 1, etc.)}
```

Comparison Table:

Line Code Type	Signal Levels	DC Component	Clock Recovery	Bandwidth
Unipolar NRZ	0, +A	Yes	Poor	Narrow
Polar NRZ	-A, +A	Maybe	Poor	Moderate
Bipolar AMI	-A, 0, +A	No	Good	Wide

Mnemonic

"UPB - Use Proper Bits" for Unipolar, Polar, Bipolar

Question 3(a OR) [3 marks]

Discuss conditional probability

Solution

Conditional Probability Definition:

```
P(A|B) = P(A\capB) / P(B)
```

Table 3: Conditional Probability in Communication

Application	Description
Channel Modeling	Probability of receiving Y given X was sent
Error Detection	Probability of error given specific patterns
Decision Making	Optimizing receiver decisions based on observations

Mnemonic

"CEaD" - Calculate Events after Data

Question 3(b OR) [4 marks]

Define Entropy and Information. Discuss its physical significance

Solution

Definitions:

Term	Definition	Formula
Entropy	Average information content of a source	H(X) = -(x)$\log_2 P(x)$
Information	Measure of uncertainty reduction	I(x) = $\log_2(1/P(x))$

Physical Significance:

Aspect	Significance
Unpredictability	Higher entropy means less predictable source
Compression Limit	Minimum bits needed to represent a source
Optimal Coding	Guides efficient source coding design
Resource Allocation	Determines bandwidth/power requirements

Mnemonic

"UCOR" - Uncertainty Correlates with Optimal Resources

Question 3(c OR) [7 marks]

Describe Huffman code with suitable example

Solution

Huffman Coding: Variable-length prefix code for lossless data compression
Example: Encoding symbols {A, B, C, D, E}
Step 1: Calculate probabilities

Symbol	Probability
A	0.4
B	0.2
C	0.2
D	0.1
E	0.1

Step 2: Build Huffman Tree

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A["1.0"] {-{-}{} B["0.6"]}
    A {-{-}{} C["0.4 (A)"]}
    C {-{-}{} C1["0"]}
    B {-{-}{} D["0.3"]}
    B {-{-}{} E["0.3"]}
    D {-{-}{} F["0.2 (B)"]}
    D {-{-}{} G["0.1 (E)"]}
    F {-{-}{} F1["0"]}
    G {-{-}{} G1["1"]}
    E {-{-}{} H["0.1 (D)"]}
    E {-{-}{} I["0.2 (C)"]}
    H {-{-}{} H1["1"]}
    I {-{-}{} I1["0"]}
{Highlighting}
{Shaded}
```

Step 3: Assign codes

Symbol	Probability	Huffman Code
A	0.4	0
B	0.2	10
C	0.2	11
D	0.1	100
E	0.1	101

Average code length: $(0.4 \times 1) + (0.2 \times 2) + (0.2 \times 2) + (0.1 \times 3) + (0.1 \times 3) = 1.8 bits/symbol$

Mnemonic

"HIGH PROB, LOW BITS" - Higher probability symbols get shorter codes

Question 4(a) [3 marks]

List Data transmission techniques

Solution

Table 4: Data Transmission Techniques

Technique	Description
Serial Transmission	Bits sent one after another over single channel
Parallel Transmission	Multiple bits sent simultaneously over multiple channels
Synchronous Transmission	Data sent in blocks with timing controlled by clock
Asynchronous Transmission	Data sent with start/stop bits, no common clock
Half-Duplex	Data flows in both directions but not simultaneously
Full-Duplex	Data flows in both directions simultaneously

Mnemonic

"SPASH-F" - Serial, Parallel, Asynchronous, Synchronous, Half/Full

Question 4(b) [4 marks]

Explain needs of multimedia processing for communication

Solution

Multimedia Processing Needs:

Need	Description
Compression	Reduces bandwidth requirements for large media files
Format Standardization	Ensures compatibility across different systems
Quality Control	Maintains acceptable audio/video quality levels
Synchronization	Coordinates different media types (audio, video, text)
Error Resilience	Protects against data loss during transmission

Diagram: Multimedia Processing Flow

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Raw Media] {-{-}{} B[Compression]}
    B {-{-}{} C[Format Conversion]}
    C {-{-}{} D[Error Protection]}
    D {-{-}{} E[Transmission]}
    E {-{-}{} F[Error Correction]}
    F {-{-}{} G[Decompression]}
    G {-{-}{} H[Playback]}
{Highlighting}
{Shaded}
```

Mnemonic

"CQSEF" - Compress Quality, Standardize and Ensure Fidelity

Question 4(c) [7 marks]

Explain data transmission mode

Solution

Table 5: Data Transmission Modes

Mode	Direction	Operation	Example
Simplex	One-way only	Sender can't receive	Radio broadcast
Half-Duplex	Two-way, alternating	Only one device transmits at a time	Walkie-talkie
Full-Duplex	Two-way, simultaneous	Both devices transmit at same time	Telephone call

Diagram: Data Transmission Modes

```
Simplex:
  A {-{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-} B}
     Data flows one way

Half{-Duplex:}
  A {{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-}{-} B}
     Data flows in both directions,
     but only one direction at a time

Full{-Duplex:}
  A {================ B}
     Data flows in both directions
     simultaneously
```

Comparison:

Parameter	Simplex	Half-Duplex	Full-Duplex
Channel Usage	100% one way	100% alternating	100% both ways
Efficiency	Low	Medium	High
Implementation	Simple	Moderate	Complex
Cost	Low	Medium	High

Mnemonic

"SHF - Speed and Handling Factors" for Simplex, Half-duplex, Full-duplex

Question 4(a OR) [3 marks]

List Important characteristics of data communication

Solution

Key Data Communication Characteristics:

Characteristic	Description
Delivery	System must deliver data to correct destination
Accuracy	Data must arrive without alteration
Timeliness	Data must arrive within useful timeframe
Jitter	Variation in packet arrival times
Security	Protection from unauthorized access
Reliability	System resilience against failures

Mnemonic

"DATJSR" - Delivery, Accuracy, Timeliness, Jitter, Security, Reliability

Question 4(b OR) [4 marks]

Discuss the standards for data communication

Solution

Table 6: Key Data Communication Standards

Standard	Organization	Purpose
IEEE 802.x	IEEE	LAN/MAN networking protocols
X.25, X.400	ITU-T	Packet switching, messaging

TCP/IP	IETF	Internet protocols
RS-232/422/485	EIA/TIA	Physical interfaces
USB, HDMI	USB-IF, HDMI Forum	Device connections

Standards Organizations:

Organization	Role
IEEE	Technical standards for networks
ITU-T	Telecommunications standards
IETF	Internet protocols
ISO	Overall standardization

Mnemonic

"PITS" - Protocols, Interfaces, Transmission and Standards

Question 4(c OR) [7 marks]

Explain model of Multimedia communications and elements of Multimedia system

Solution

Multimedia Communication Model:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Content Creation] {-{-}{} B[Compression]}
    B {-{-}{} C[Storage]}
    C {-{-}{} D[Distribution]}
    D {-{-}{} E[Decompression]}
    E {-{-}{} F[Presentation]}
{Highlighting}
{Shaded}
```

Multimedia System Elements:

Element	Function
Input Devices	Capture multimedia content (camera, microphone)
Processing Hardware	CPU, GPU for handling multimedia data
Storage	Hard drives, SSDs, cloud storage
Communication Network	Transmits multimedia data between systems
Output Devices	Display, speakers for content presentation
Software	Codecs, players, editors for content manipulation

Media Types:

Media Type	Characteristics	Common Formats
Audio	Temporal, streaming	MP3, WAV, AAC
Video	Temporal, spatial, high bandwidth	MP4, AVI, HEVC
Image	Spatial, static	JPEG, PNG, GIF
Text	Structured, low bandwidth	TXT, HTML, XML

Mnemonic

"CNIS-OS" - Capture, Network, Input-output, Storage, Output, Software

Question 5(a) [3 marks]

Explain important elements of 5G technology

Solution

Key 5G Elements:

Element	Description
Millimeter Waves	Higher frequency (24-100 GHz) for more bandwidth
Massive MIMO	Multiple-input multiple-output antennas for improved capacity
Beamforming	Focused signal transmission for better efficiency
Network Slicing	Virtual networks on shared infrastructure
Edge Computing	Processing closer to data source for lower latency

Mnemonic

"MMBN-E" - Millimeter, MIMO, Beamforming, Network, Edge

Question 5(b) [4 marks]

Describe Spread spectrum communication

Solution

Spread Spectrum Definition: Technique where signal is spread over a wide frequency band, much wider than the minimum bandwidth required.

Types of Spread Spectrum:

Type	Method	Advantages
DSSS (Direct Sequence)	XOR data with higher-rate pseudorandom code	Good noise immunity
FHSS (Frequency Hopping)	Rapidly switches carrier among many frequencies	Resists jamming
THSS (Time Hopping)	Transmits in short bursts at different time slots	Low probability of intercept

Diagram: DSSS Process

```
Data:       |\_\_\_|  |\_\_\_|

PN Code:    |\_| |\_| |\_| |\_| |

Spread
Signal:     |\_| | |\_| |\_|\_| |
```

Mnemonic

"DFT - Difficult For Trackers" - Direct, Frequency, Time Hopping

Question 5(c) [7 marks]

Explain block diagram of satellite communication

Solution

Satellite Communication Block Diagram:

Mermaid Diagram (Code)

```
{Shaded}
```

```
{Highlighting}[]
graph LR
    A["Satellite Transponder"] {-{-}{-} B["Uplink"]}
    A {-{-}{-} C["Downlink"]}
    B {-{-}{-} D["Earth Station Tx"]}
    C {-{-}{-} E["Earth Station Rx"]}

    classDef satellite fill:\#f9f,stroke:\#333,stroke{-width:2px;}
    classDef earth fill:\#9cf,stroke:\#333,stroke{-width:2px;}
    classDef link stroke{-dasharray: 5 5;}

    class A satellite;
    class D,E earth;
    class B,C link;
{Highlighting}
{Shaded}
```

Key Components:

Component	Function
Earth Station (Tx)	Source of signals, performs uplink functions
Uplink	Transmission from earth to satellite (higher frequency)
Satellite Transponder	Receives, amplifies, and retransmits signals
Downlink	Transmission from satellite to earth (lower frequency)
Earth Station (Rx)	Receives and processes downlink signals

Frequency Bands:

Band	Frequency Range	Applications
C-band	4-8 GHz	Television, voice, data
Ku-band	12-18 GHz	Direct broadcast, VSAT
Ka-band	26-40 GHz	High-speed data, internet

Mnemonic

"STUDER" - Station Transmits Uplink, Downlink to Earth Receiver

Question 5(a OR) [3 marks]

Explain features and advantages of 5G technology

Solution

5G Features and Advantages:

Feature	Advantage
High Speed	Up to 10 Gbps data rates for faster downloads
Ultra-Low Latency	<1ms response time for real-time applications
Massive Connectivity	Up to 1 million devices per sq. km
Network Slicing	Customized virtual networks for specific applications
Improved Reliability	99.999% availability for critical services
Energy Efficiency	Lower power consumption per bit of data

Mnemonic

"HUMNER" - High-speed, Ultra-low latency, Massive connectivity, Network slicing, Enhanced reliability

Question 5(b OR) [4 marks]

Describe Edge Computing

Solution

Edge Computing Definition: Computing paradigm that brings data processing closer to the source of data generation.
Diagram: Edge Computing Architecture

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[IoT Devices] {-{-}{} B[Edge Devices]}
    B {-{-}{} C[Edge Servers]}
    C {-{-}{} D[Cloud Data Centers]}
{Highlighting}
{Shaded}
```

Key Characteristics:

Characteristic	Description
Proximity	Processing near data source reduces latency
Distributed	Computing resources spread across network edge
Real-time Processing	Fast response for time-critical applications
Bandwidth Optimization	Reduces data sent to central cloud
Data Privacy	Sensitive data processed locally

Mnemonic

"PDRBD" - Process Data Rapidly By Distributing

Question 5(c OR) [7 marks]

Explain importance of block chain in Communication Security

Solution

Blockchain in Communication Security:

Mermaid Diagram (Code)

```
{Shaded}
{Highlighting}[]
graph LR
    A[Transaction Request] {-{-}{} B[Block Creation]}
    B {-{-}{} C[Block Verification]}
    C {-{-}{} D[Block Addition to Chain]}
    D {-{-}{} E[Chain Distribution]}
{Highlighting}
{Shaded}
```

Security Benefits:

Benefit	Description
Immutability	Once recorded, data cannot be altered
Decentralization	No single point of failure or control
Transparency	All transactions visible to network participants
Cryptographic Security	Strong encryption protects data integrity
Smart Contracts	Self-executing agreements with built-in security
Consensus Mechanisms	Multiple validators ensure transaction legitimacy

Communication Applications:

Application	Security Benefit
Secure Messaging	End-to-end encryption with tamper-proof records
Identity Management	Self-sovereign identity verification
IoT Security	Secure device authentication and data integrity
Network Infrastructure	Secure routing and DNS systems

Mnemonic

"DTCSCI" - Decentralized Transparent Cryptographic System Creates Immutability