Digital & Data Communication (4343201) - Summer 2025 Solution

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Question 1(a) [3 marks]

Define bit rate, baud rate and bandwidth

Solution

Table 1. Definition of Communication Parameters

Parameter	Definition	Unit
Bit Rate	Number of bits transmitted per second	bps (bits per second)
Baud Rate	Number of signal changes per second	Baud
Bandwidth	Range of frequencies in communication channel	Hz (Hertz)

- **Bit rate**: Actual data transmission speed
- **Baud rate**: Modulation rate or symbol rate
- **Bandwidth**: Channel capacity for frequency range

Mnemonic

"Bits Baud Bandwidth - BBB for communication"

Question 1(b) [4 marks]

Explain TDM with block diagram

Solution

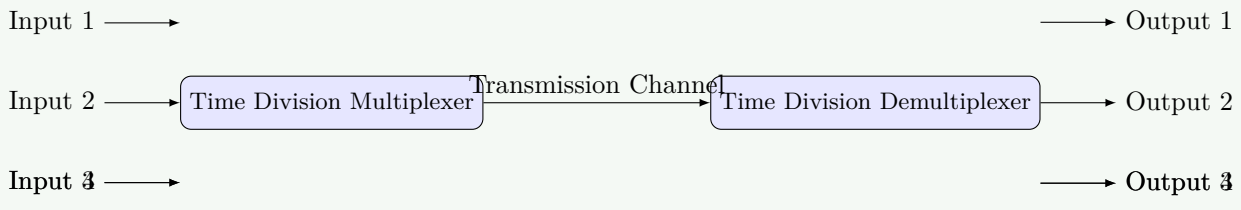

Figure 1. Time Division Multiplexing (TDM)

- **TDM principle**: Multiple signals share single channel by time slots
- **Time slots**: Each input gets dedicated time period
- **Synchronization**: Transmitter and receiver must be synchronized
- **Applications**: Digital telephone systems, computer networks

Mnemonic

"Time Divided Multiple - TDM shares time"

Question 1(c) [7 marks]

Explain block diagram of digital communication system

Solution

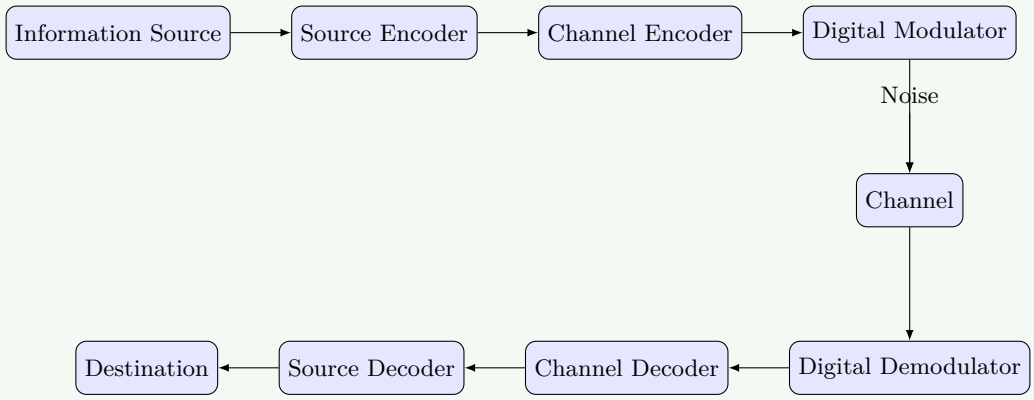

Figure 2. Digital Communication System

Table 2. System Components

Component	Function
Source Encoder	Converts analog to digital
Channel Encoder	Adds error correction codes
Digital Modulator	Converts digital to analog signal
Channel	Transmission medium
Digital Demodulator	Recovers digital signal
Channel Decoder	Detects and corrects errors
Source Decoder	Reconstructs original signal

- **Advantages**: Noise immunity, error correction capability
- **Processing**: Digital signal processing techniques
- **Reliability**: Better performance over long distances

Mnemonic

"Source Channel Modulate Transmit Demodulate Decode - SCMTDD"

Question 1(c OR) [7 marks]

Explain different types of Communication channel

Solution

Table 3. Channel Types

Channel Type	Characteristics	Applications
Telephone Channel	300-3400 Hz bandwidth	Voice communication
Coaxial Cable	High bandwidth, shielded	Cable TV, Internet
Optical Fiber	Very high bandwidth, light signals	Long distance, high speed
Wireless Channel	Radio frequency transmission	Mobile, satellite
Satellite Channel	Long distance, space communication	Global communication

- **Bandwidth**: Different channels offer varying frequency ranges
- **Noise characteristics**: Each channel has specific noise properties
- **Distance capability**: Varies from local to global coverage
- **Cost factors**: Installation and maintenance costs differ

Mnemonic

"Telephone Coax Optical Wireless Satellite - TCOWS channels"

Question 2(a) [3 marks]

Draw the modulation waveform for ASK, FSK and BPSK for the digital sequence 11100110

Solution

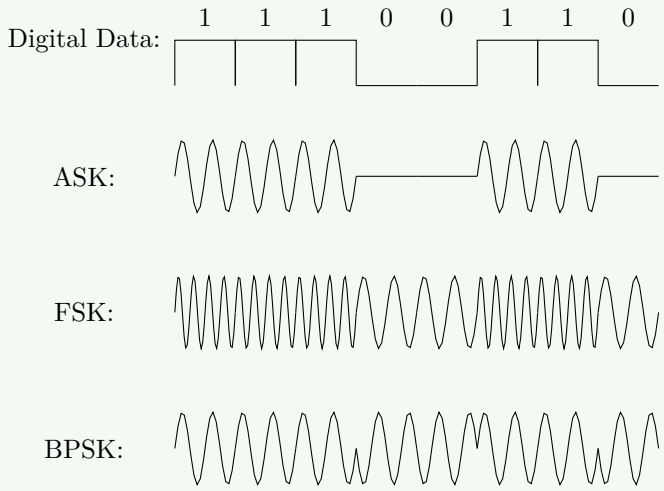

Figure 3. Modulation Waveforms

- **ASK**: Amplitude Shift Keying
- **FSK**: Frequency Shift Keying
- **BPSK**: Binary Phase Shift Keying

Mnemonic

"ASK Amplitude, FSK Frequency, BPSK Phase - AFP modulation"

Question 2(b) [4 marks]

Explain the basic principle and generation of frequency shift keying (FSK) signal

Solution

Table 4. FSK Generation

Binary Data	Frequency	Output
Logic '1'	f_1 (High frequency)	High freq carrier
Logic '0'	f_0 (Low frequency)	Low freq carrier

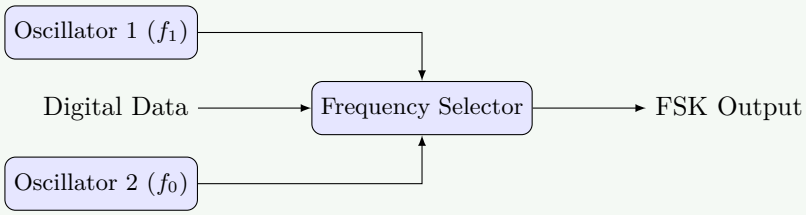

Figure 4. FSK Generation

- **Principle**: Binary data controls carrier frequency
- **Two frequencies**: f_1 for '1' and f_0 for '0'
- **Constant amplitude**: Only frequency changes
- **Detection**: Frequency discrimination at receiver

Mnemonic

"Frequency Shifts Key - FSK frequency control"

Question 2(c) [7 marks]

Explain the working of QPSK modulator and Demodulator with block diagram and constellation diagram

Solution

QPSK Modulator:

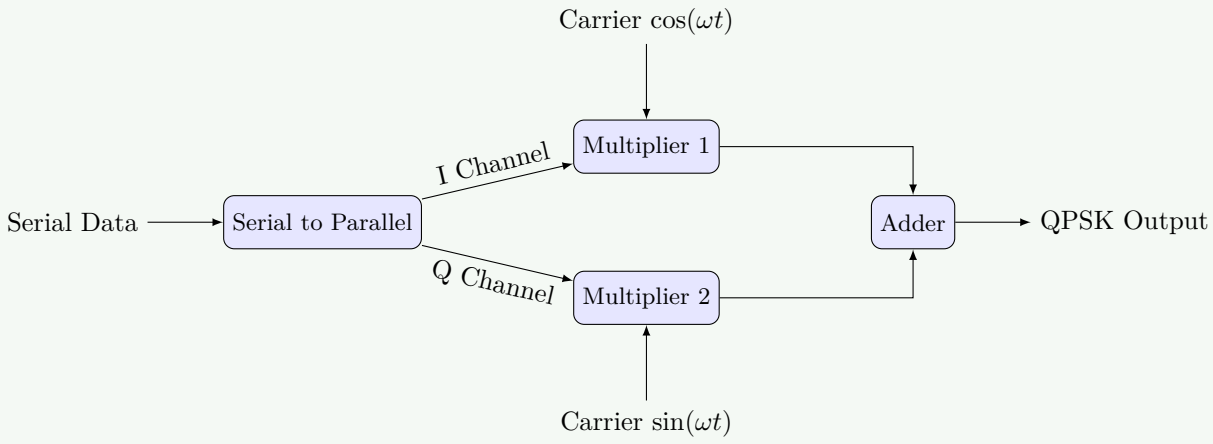

Figure 5. QPSK Modulator Block Diagram

Constellation Diagram:

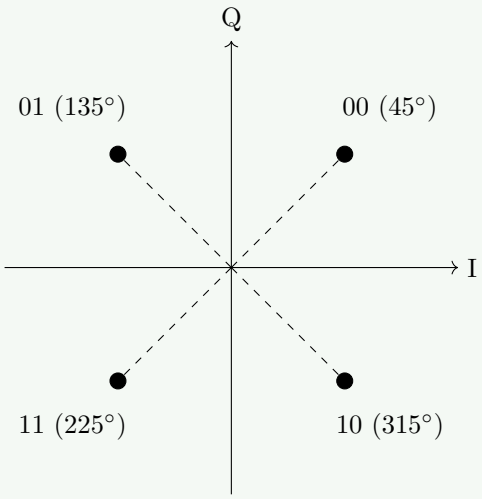

Figure 6. QPSK Constellation Diagram

Table 5. QPSK Truth Table

I	Q	Phase	Symbol
0	0	45°	00
0	1	135°	01
1	1	225°	11
1	0	315°	10

- **Four phases**: 45°, 135°, 225°, 315°
- **Two bits per symbol**: Higher data rate
- **Constant envelope**: Amplitude remains constant
- **Demodulation**: Phase detection and parallel to serial conversion

Mnemonic

"Quadrature Phase Shift Key - QPSK four phases"

Question 2(a OR) [3 marks]

Draw the block diagram of ASK modulator and describe working of it

Solution

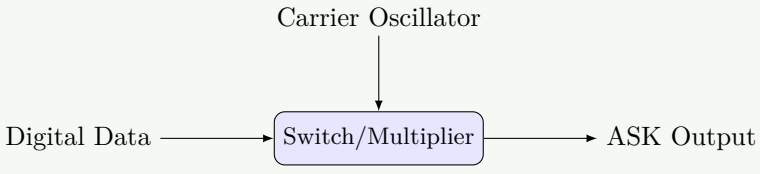

Figure 7. ASK Modulator

- **Working principle**: Digital data controls carrier amplitude
- **Logic '1'**: Carrier transmitted with full amplitude
- **Logic '0'**: No carrier transmitted (zero amplitude)
- **Simple implementation**: Uses analog switch or multiplier

Mnemonic

"Amplitude Shift Key - ASK amplitude control"

Question 2(b OR) [4 marks]

Explain the principal of 16-QAM and draw the constellation diagram

Solution

16-QAM Constellation:

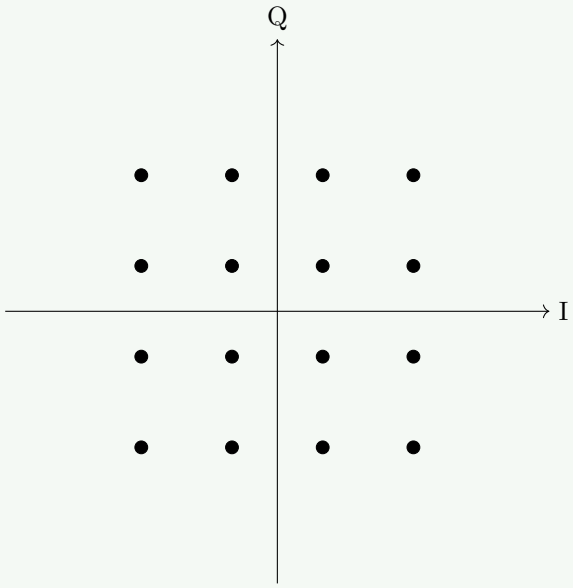

Figure 8. 16-QAM Constellation

Table 6. 16-QAM Characteristics

Parameter	Value
Bits per symbol	4 bits
Number of states	16
Amplitude levels	4 levels
Phase levels	4 phases

- **Principle**: Combines amplitude and phase modulation
- **Higher data rate**: 4 bits per symbol
- **Complex modulation**: Requires precise amplitude and phase control
- **Applications**: High-speed digital communication

Mnemonic

"16 Quadrature Amplitude Modulation - 16QAM complex signals"

Question 2(c OR) [7 marks]

Explain working of BPSK modulator and demodulator with block diagram and waveform

Solution

BPSK Modulator:

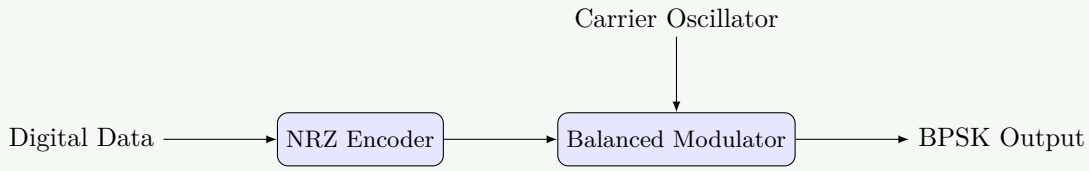

Figure 9. BPSK Modulator

BPSK Demodulator:

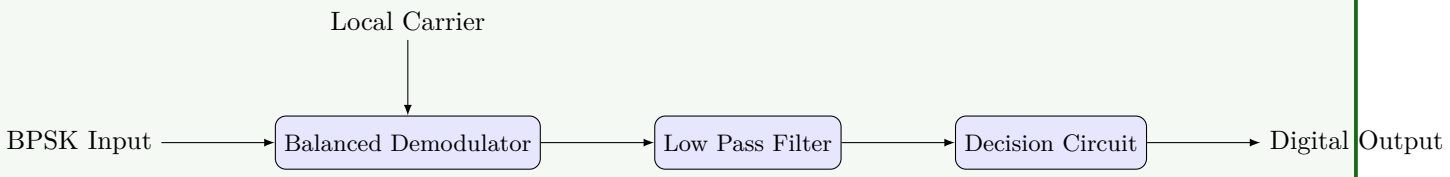

Figure 10. BPSK Demodulator

Waveforms:

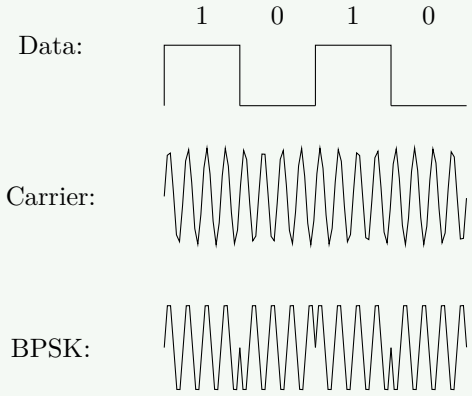

Figure 11. BPSK Waveforms

- **Phase shift**: 180° between '1' and '0'
- **Coherent detection**: Requires synchronized carrier
- **Best performance**: Lowest bit error rate
- **Constant envelope**: Amplitude remains constant

Mnemonic

"Binary Phase Shift Key - BPSK two phases"

Question 3(a) [3 marks]

Define Channel Capacity in terms of SNR and explain importance of it

Solution

Shannon's Channel Capacity Formula:

Table 7. Channel Capacity Formula

Formula	$C = B \log_2(1 + S/N)$
C	Channel capacity (bps)
B	Bandwidth (Hz)
S/N	Signal-to-Noise ratio

- **Importance**: Maximum theoretical data rate
- **SNR effect**: Higher SNR allows higher capacity
- **Bandwidth trade-off**: Can exchange bandwidth for SNR
- **Design limit**: Sets upper bound for system design

Mnemonic

"Channel Capacity Shannon's Limit - CCSL"

Question 3(b) [4 marks]

Describe Asynchronous and synchronous serial data communication techniques

Solution

Table 8. Synchronous vs Asynchronous

Parameter	Synchronous	Asynchronous
Clock	Separate clock signal	No separate clock
Start/Stop bits	Not required	Start and stop bits
Speed	Higher	Lower
Cost	Higher	Lower

- **Synchronous**: Clock synchronization required
- **Asynchronous**: Self-synchronizing with start/stop bits
- **Applications**: Synchronous for high-speed, Asynchronous for simple systems
- **Efficiency**: Synchronous more efficient, Asynchronous more flexible

Mnemonic

"Sync Clock, Async Start-Stop - SCSS"

Question 3(c) [7 marks]

Explain Huffman coding with help of suitable example

Solution

Example: Characters A, B, C, D with probabilities 0.4, 0.3, 0.2, 0.1
Huffman Tree Construction:

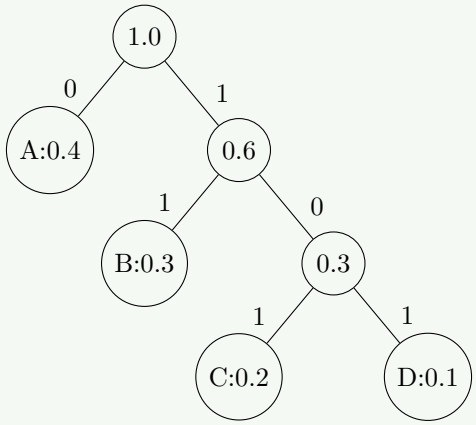

Figure 12. Huffman Tree

Table 9. Huffman Codes

Character	Probability	Code
A	0.4	0
B	0.3	10
C	0.2	110
D	0.1	111

- **Average code length**: $0.4 \times 1 + 0.3 \times 2 + 0.2 \times 3 + 0.1 \times 3 = 1.9$ bits
- **Compression achieved**: Reduces average bits per character
- **Prefix property**: No code is prefix of another

Mnemonic

"Huffman Minimum Average Length - HMAL"

Question 3(a OR) [3 marks]

State the significance of probability and entropy in communication

Solution

Table 10. Significance of Concepts

Concept	Significance
Probability	Measures likelihood of information occurrence
Entropy	Measures average information content
Maximum Entropy	Occurs with equal probability events

- **Information content**: $I = \log_2(1/P)$ bits
- **Entropy formula**: $H = -\sum P(x) \log_2 P(x)$
- **Channel design**: Helps optimize communication systems
- **Coding efficiency**: Guides source coding design

Mnemonic

"Probability Entropy Information - PEI communication"

Question 3(b OR) [4 marks]

Explain simplex, half duplex and full duplex data transmission mode

Solution

Table 11. Transmission Modes

Mode	Direction	Example	Flow
Simplex	One-way only	Radio broadcast	A → B
Half Duplex	Both ways, not simultaneous	Walkie-talkie	A ↔ B
Full Duplex	Both ways, simultaneous	Telephone	A ⇄ B

- **Simplex**: Unidirectional communication
- **Half duplex**: Bidirectional but alternate
- **Full duplex**: Simultaneous bidirectional
- **Bandwidth requirement**: Full duplex needs twice the bandwidth

Mnemonic

"Simple Half Full - SHF transmission modes"

Question 3(c OR) [7 marks]

Explain Shannon Fano coding with help of suitable example

Solution

Example: Characters A, B, C, D with probabilities 0.4, 0.3, 0.2, 0.1
Shannon-Fano Algorithm Steps:

1. **Step 1**: Arrange in descending order (A: 0.4, B: 0.3, C: 0.2, D: 0.1)
2. **Step 2**: Divide into two groups
   - Group 1: A(0.4) → Code starts with 0
   - Group 2: B(0.3), C(0.2), D(0.1) → Code starts with 1
3. **Step 3**: Subdivide Group 2
   - B(0.3) → Code: 10
   - C(0.2), D(0.1) → Code starts with 11
4. **Step 4**: Final subdivision
   - C(0.2) → Code: 110
   - D(0.1) → Code: 111

Table 12. Shannon-Fano Codes

Character	Probability	Code
A	0.4	0
B	0.3	10
C	0.2	110
D	0.1	111

- **Average length**: Same as Huffman (1.9 bits)
- **Top-down approach**: Divides from root to leaves
- **Not always optimal**: Huffman is generally better

Mnemonic

"Shannon Fano Top-Down - SFTD coding"

Question 4(a) [3 marks]

Describe Ethical and Privacy Considerations in Data Communication

Solution

Table 13. Ethics and Privacy

Aspect	Consideration
Data Privacy	User consent, data protection
Security	Encryption, access control
Transparency	Clear data usage policies

- **Privacy rights**: Users control over personal data
- **Ethical use**: Responsible data handling practices
- **Legal compliance**: Following data protection laws
- **Security measures**: Protecting against unauthorized access

Mnemonic

"Privacy Security Transparency - PST ethics"

Question 4(b) [4 marks]

Explain RS 232 standard with pin diagram

Solution

Table 14. RS-232 Pin Configuration (DB-9)

Pin	Signal	Function
1	DCD	Data Carrier Detect
2	RXD	Receive Data
3	TXD	Transmit Data
4	DTR	Data Terminal Ready
5	GND	Ground
6	DSR	Data Set Ready
7	RTS	Request To Send
8	CTS	Clear To Send
9	RI	Ring Indicator

- **Voltage levels**: +3V to +25V for '0', -3V to -25V for '1'
- **Maximum distance**: 50 feet at 19.2 kbps
- **Applications**: Serial communication between computers and modems

Mnemonic

"RS-232 Nine pins Serial - RNS communication"

Question 4(c) [7 marks]

Explain Hamming code with help of suitable example

Solution

Example: 4-bit data 1011
Hamming Code Construction:

Table 15. Hamming Code Bits

Position	1	2	3	4	5	6	7
Type	P1	P2	D1	P4	D2	D3	D4
Value	0	1	1	0	0	1	1

- **P1** (positions 1,3,5,7): P1 $\oplus$ 1 $\oplus$ 0 $\oplus$ 1 = 0, so P1 = 0
- **P2** (positions 2,3,6,7): P2 $\oplus$ 1 $\oplus$ 1 $\oplus$ 1 = 1, so P2 = 1
- **P4** (positions 4,5,6,7): P4 $\oplus$ 0 $\oplus$ 1 $\oplus$ 1 = 0, so P4 = 0

Final Hamming Code: 0110111
Error Detection:

- Calculate syndrome $S = S_4S_2S_1$
- If $S = 000$, no error
- If $S \neq 000$, error at position indicated by S
- **Single error correction**: Can correct one-bit errors
- **Double error detection**: Can detect two-bit errors
- **Systematic approach**: Organized parity bit placement

Mnemonic

"Hamming Single Error Correction - HSEC"

Question 4(a OR) [3 marks]

Define Edge Computing and explain feature of it

Solution

Table 16. Edge Computing Features

Feature	**Description**
Low Latency	Processing near data source
Bandwidth Saving	Reduces network traffic
Real-time Processing	Immediate data analysis

- **Definition**: Computing at network edge, close to data sources
- **Reduced latency**: Faster response times
- **Distributed processing**: Reduces central server load
- **Applications**: IoT, autonomous vehicles, smart cities

Mnemonic

"Edge Low-latency Real-time - ELR computing"

Question 4(b OR) [4 marks]

Explain needs of multimedia processing for communication and various file formats of different data

Solution

Table 17. Multimedia File Formats

Data Type	Formats	Characteristics
Audio	MP3, WAV, AAC	Compressed/Uncompressed
Video	MP4, AVI, MOV	Different codecs
Image	JPEG, PNG, GIF	Lossy/Lossless compression
Text	TXT, PDF, DOC	Various encodings

- **Processing needs**: Compression, format conversion, quality optimization
- **Bandwidth optimization**: Reducing file sizes for transmission
- **Quality preservation**: Maintaining acceptable quality levels
- **Compatibility**: Supporting multiple devices and platforms

Mnemonic

"Audio Video Image Text - AVIT multimedia"

Question 4(c OR) [7 marks]

Explain different Line coding with help of waveform

Solution

Line Coding Waveforms for data 1011:

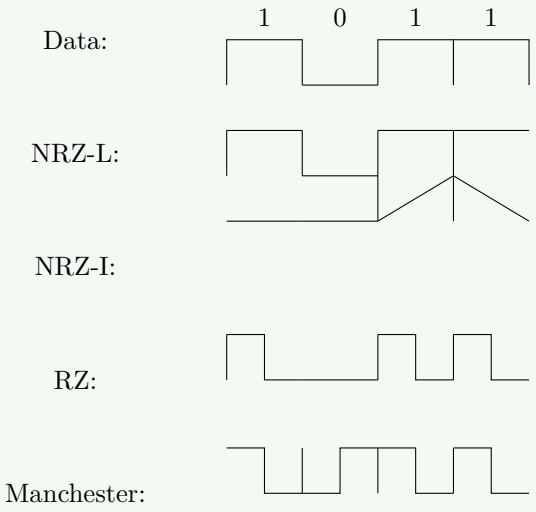

Figure 13. Line Coding Waveforms

Table 18. Line Coding Comparison

Code Type	Bandwidth	DC Component	Synchronization
NRZ-L	Low	Present	Poor
NRZ-I	Low	Present	Poor
RZ	High	Present	Good
Manchester	High	Absent	Excellent

- **NRZ**: Non-Return-to-Zero, simple but has DC component
- **RZ**: Return-to-Zero, better synchronization
- **Manchester**: Self-synchronizing, no DC component
- **Selection criteria**: Bandwidth, synchronization, complexity

Mnemonic

"NRZ RZ Manchester - NRM line codes"

Question 5(a) [3 marks]

Explain concept of spread spectrum technology

Solution

Table 19. Spread Spectrum Characteristics

Parameter	Description
Bandwidth Spreading	Signal spread over wide frequency
Low Power Density	Power distributed across spectrum
Interference Resistance	Resistant to jamming

- **Principle**: Spreads signal over much wider bandwidth than required
- **Techniques**: Direct Sequence (DS-SS), Frequency Hopping (FH-SS)
- **Advantages**: Security, interference resistance, multiple access
- **Applications**: GPS, CDMA, WiFi, Bluetooth

Mnemonic

"Spread Spectrum Security - SSS technology"

Question 5(b) [4 marks]

Explain block diagram of satellite communication

Solution

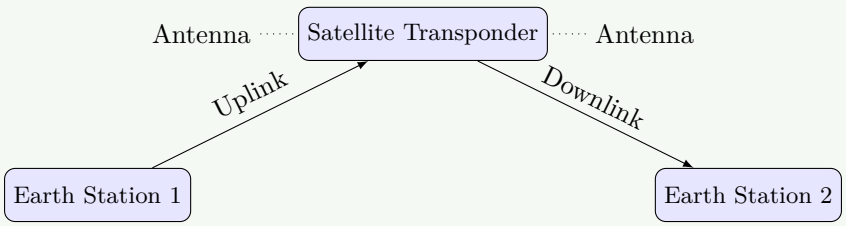

Figure 14. Satellite Communication

Table 20. Satellite Communication Components

Component	Function
Earth Station	Ground-based transmit/receive
Uplink	Earth to satellite transmission
Transponder	Satellite receiver-transmitter
Downlink	Satellite to earth transmission

- **Frequency bands**: C-band, Ku-band, Ka-band
- **Coverage area**: Large geographical coverage
- **Applications**: Broadcasting, telephony, internet
- **Advantages**: Wide coverage, long-distance communication

Mnemonic

"Earth Uplink Transponder Downlink - EUTD satellite"

Question 5(c) [7 marks]

Demonstrate model of Multimedia Communications and elements of Multimedia system

Solution

Multimedia Communication Model:

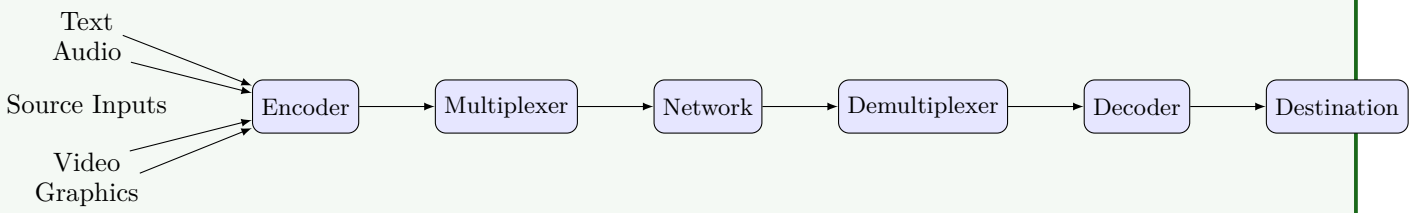

Figure 15. Multimedia Communication Model

Table 21. Multimedia System Elements

Element	Function	Examples
Capture	Input multimedia data	Camera, microphone
Storage	Store multimedia files	Hard disk, memory
Processing	Edit and manipulate	Video editing software
Communication	Transmit multimedia	Networks, internet
Presentation	Display multimedia	Monitor, speakers

- **Synchronization**: Audio-video synchronization critical
- **Compression**: Reduces bandwidth requirements
- **Quality of Service**: Maintains acceptable quality
- **Real-time constraints**: Time-sensitive data delivery

Mnemonic

"Capture Store Process Communicate Present - CSPCP multimedia"

Question 5(a OR) [3 marks]

Explain importance of Block chain in Communication Security

Solution

Table 22. Blockchain Security Features

Feature	Benefit
Decentralization	No single point of failure
Immutability	Cannot alter past records
Transparency	All transactions visible

- **Cryptographic security**: Hash functions and digital signatures
- **Distributed ledger**: Multiple copies prevent tampering
- **Smart contracts**: Automated security protocols
- **Applications**: Secure messaging, identity verification

Mnemonic

"Blockchain Distributed Immutable - BDI security"

Question 5(b OR) [4 marks]

Explain important elements, features and advantages of 5G technology

Solution

Table 23. 5G Specifications

Element	Specification
Speed	Up to 10 Gbps
Latency	Less than 1 ms
Connections	1 million devices per km^2
Reliability	99.999% availability

Key Features:
- **Enhanced Mobile Broadband**: Ultra-high-speed internet
- **Ultra-Reliable Low Latency**: Critical applications
- **Massive Machine Communication**: IoT connectivity
- **Network Slicing**: Customized network services

Advantages:
- **Higher capacity**: More simultaneous users
- **Energy efficiency**: Better battery life for devices
- **New applications**: AR/VR, autonomous vehicles

Mnemonic

"5G Speed Latency Connections - SLC features"

Question 5(c OR) [7 marks]

Compare RS 232, RS 422 and RS 485 standard

Solution

Table 24. RS Standards Comparison

Parameter	RS-232	RS-422	RS-485
Mode	Single-ended	Differential	Differential
Max Distance	50 feet	4000 feet	4000 feet
Max Speed	20 kbps	10 Mbps	10 Mbps
Drivers	1	1	32
Receivers	1	10	32
Topology	Pt-to-Pt	Pt-to-Multi	Multipoint

Table 25. Voltage Levels

Standard	Logic 1	Logic 0
RS-232	-3V to -25V	+3V to +25V
RS-422	Diff < -200mV	Diff $> +200$mV
RS-485	Diff < -200mV	Diff $> +200$mV

- **Applications**: RS-232 (PC serial), RS-422 (Industrial), RS-485 (Building automation)
- **Noise immunity**: Differential signaling in RS-422/485 better than RS-232
- **Distance capability**: RS-422/485 much longer than RS-232
- **Cost**: RS-232 cheapest, RS-485 most complex

Mnemonic

"RS-232 Simple, RS-422 Long, RS-485 Multi - SLM standards"