

**Unit-I****Chapter 1 : Digital Communication System 1-1 to 1-12**

Syllabus : Elements of digital communication system with its block diagram : Source, Channel, Transmitter, Receiver, Advantages and disadvantages of digital communication, Communication channel characteristics : Bit rate, Baud rate, Bandwidth, Repeater distance, Applications.

1.1	Introduction.....	1-1
1.2	Historical Perspective of Digital Communication	1-1
1.3	Elements of an Analog Communication System ...	1-2
1.4	Primary Communication Resources	1-3
1.5	Introduction to Digital Communication	1-3
1.5.1	Analog to Digital Conversion	1-4
1.5.2	Graphical Representation of A/D Conversion Process	1-4
1.6	Elements of Digital Communication System	1-4
1.6.1	Why Digital Communication ?.....	1-6
1.6.2	Comparison of Analog and Digital Transmission (Effect of Noise)	1-6
1.6.3	Digital Communication is Suitable for Long Distances	1-6
1.6.4	Digital Networks can Handle Many Types of Services	1-7
1.7	Communication Channels	1-7
1.8	Characteristics of Communication Channels	1-7
1.8.1	Bit Rate	1-7
1.8.2	Bauds (or Baud Rate)	1-8
1.8.3	Signal Bandwidth	1-8
1.8.4	Channel Bandwidth	1-9
1.8.5	Digital Versus Analog Bandwidth	1-9
1.8.6	Repeater Distance	1-9
1.8.7	Characteristics of Communication Channel	1-10
1.9	Advantages and Disadvantages of Digital Communication	1-10
1.9.1	Advantages of Digital Communication ..	1-10
1.9.2	Disadvantages	1-11

1.10	Comparison of Analog and Digital Communications	1-11
1.11	MSBTE Questions and Answers	1-12
1.12	I-Scheme Questions and Answers	1-12
	• Review Questions	1-11

Unit-I**Chapter 2 : Coding Methods and Error****Control****2-1 to 2-41**

Syllabus : Concept of entropy and information rate, Channel capacity : Hartley's law, Shannon Hartley's theorem, Source coding : Huffman coding, Channel / line coding : Error, Causes of error and its effect, Error detection and correction using parity, Checksum, Vertical Redundancy Check (VRC), Longitudinal Redundancy Check (LRC), Cyclic Redundancy Check (CRC), Linear block code, Hamming code, Line coding formats : Classification of line codes, Unipolar-RZ, RZ, NRZ-I, NRZ-L, Polar, NRZ and RZ Bipolar NRZ/AMI, RZ, Manchester split phase and differential Manchester, Polar quaternary and their waveforms.

2.1	Introduction.....	2-1
2.2	Hartley's Law	2-1
2.2.1	Statement of Hartley's Law	2-1
2.2.2	Shannon's Theorem on the Channel Capacity	2-2
2.2.3	Shannon Hartley Theorem and Channel Capacity Equation	2-2
2.2.4	Trade-off between Bandwidth and SNR	2-2
2.2.5	What is Shannon's Information Rate ? Why is it Difficult to Achieve ?	2-3
2.2.6	Trade off between (S/N) and Bandwidth	2-3
2.3	Definition of Information (Measure of Information)	2-4
2.3.1	Unit of Information	2-4
2.3.2	Properties of Information	2-4
2.4	Discrete Information Sources	2-5



2.5	Average Information or Entropy	2-5	2.15.1	Error Correction Techniques	2-24
2.5.1	Expression for Entropy	2-6	2.15.2	FEC (Forward Error Correction)	2-24
2.5.2	Information Rate (R)	2-7	2.15.3	Error Correction Techniques	2-24
2.6	Source Coding	2-8	2.16	Linear Block Codes	2-24
2.7	Huffman Coding	2-9	2.16.1	Code Word Structure	2-25
2.8	Causes and Effects of Errors	2-14	2.17	Hamming Codes	2-25
2.8.1	Channel Coding	2-14	2.17.1	Features	2-25
2.8.2	Need of Error Control Coding	2-14	2.17.2	Error Detection and Correction Capabilities of Hamming Code	2-25
2.8.3	Types of Errors	2-14	2.17.3	Hamming Codeword Structure	2-25
2.8.4	Disadvantages of Coding	2-15	2.17.4	Deciding the Parity Bits for a 7 bit Code	2-26
2.9	Important Definitions Related to Codes	2-15	2.17.5	Detection and Correction of Errors	2-27
2.9.1	Code Word	2-15	2.18	Line Coding	2-31
2.9.2	Code Rate	2-15	2.19	Definition of Line Coding	2-31
2.9.3	Hamming Weight of a Code Word $w(x)$	2-15	2.19.1	Some Important Characteristics of Line Coding	2-31
2.9.4	Code Efficiency	2-15	2.20	Classification of Line Codes	2-31
2.9.5	Hamming Distance	2-16	2.20.1	Properties of Line Codes	2-32
2.9.6	Minimum Distance d_{min}	2-16	2.21	Unipolar Line Codes	2-33
2.9.7	Redundancy	2-17	2.21.1	Unipolar RZ Format	2-33
2.10	Error Detection	2-17	2.21.2	Unipolar NRZ Format	2-33
2.10.1	Error Detection Methods	2-17	2.21.3	NRZ-L (Non Return to Zero Level)	2-33
2.11	Parity	2-18	2.21.4	NRZ-I	2-33
2.11.1	Use of Parity Bit to Decide Parity	2-18	2.22	Polar Line Codes	2-34
2.12	Checksum for Error Detection	2-19	2.22.1	Polar RZ Format	2-34
2.13	Two Dimensional Parity Check	2-20	2.22.2	Polar NRZ Format	2-34
2.13.1	The Vertical Redundancy Check (VRC) Bits	2-20	2.22.3	Split Phase Manchester Format	2-34
2.13.2	The Longitudinal Redundancy Check (LRC) Bits	2-20	2.22.4	Differential Manchester Code	2-34
2.14	Cyclic Redundancy Check (CRC)	2-21	2.23	Bipolar Line Codes	2-35
2.14.1	Procedure to Obtain CRC	2-21	2.23.1	Bipolar NRZ Format (AMI)	2-35
2.14.2	Requirements of CRC	2-21	2.23.2	Polar Quaternary NRZ Format	2-35
2.14.3	CRC Generator	2-21	2.23.3	Comparison of Line Codes	2-36
2.14.4	CRC Checker	2-23	2.24	MSBTE Questions and Answers	2-39
2.15	Different Approaches for Error Control (Handshaking Techniques)	2-24	2.25	I-Scheme Solved Examples	2-40
			2.26	I-Scheme Questions and Answers	2-41
				• Review Questions	2-38

**Unit-II****Chapter 3 : Pulse Code Modulation
Techniques****3-1 to 3-28**

Syllabus : Sampling and quantization process : Types of sampling, Nyquist sampling theorem (only statement), Aliasing effect, Quantization process, Quantization error / noise, Companding, Pulse Code Modulation (PCM), Differential pulse code modulation (DPCM) : Transmitter and receiver block diagram and its working, Advantages and disadvantages, Delta modulation (D.M.), Block diagram of transmitter and receiver, Slope overload and granular noise, Advantages and disadvantages of DM. Adaptive delta modulation (ADM) : Transmitter and receiver block diagram, Advantages and disadvantages of ADM.

3.1	Introduction	3-1	3.5.3	Signal to Quantization Noise Ratio SNR_q	3-11
3.1.1	Pulse Modulation	3-1	3.6	Robust Quantization (Non-Uniform Quantization)	3-11
3.1.2	Advantages of Pulse Modulation	3-2	3.6.1	Nonuniform Quantization	3-11
3.2	Sampling Process	3-2	3.7	Companding	3-11
3.3	Sampling Theorem	3-3	3.7.1	Compressor Characteristics	3-12
3.3.1	Sampled Signal	3-3	3.7.2	Expander Characteristics	3-12
3.3.2	Spectrum of Sampled Signal	3-4	3.7.3	Compander Characteristics	3-13
3.3.3	Recovery of the Original Signal	3-5	3.8	Pulse Code Modulation (PCM)	3-13
3.3.4	Aliasing or Foldover Error	3-5	3.8.1	PCM Transmitter (Encoder)	3-13
3.3.5	Nyquist Rate and Nyquist Interval	3-6	3.8.2	Binary Representation of the PCM Signal	3-14
3.3.6	Importance of Sampling Theorem	3-6	3.8.3	PCM Receiver (Decoder)	3-15
3.4	Sampling Techniques	3-7	3.8.4	Quantization Noise in PCM	3-16
3.4.1	Ideal or Instantaneous or Impulse Sampling	3-7	3.8.5	Effect of Noise on the PCM System	3-16
3.4.2	Natural Sampling or Chopper Sampling	3-7	3.8.6	Applications of PCM	3-17
3.4.3	Flat Top Sampling or Rectangular Pulse Sampling	3-8	3.8.7	Advantages of PCM	3-17
3.4.4	Comparison of Sampling Techniques	3-9	3.8.8	Disadvantages of PCM	3-17
3.5	Quantization Process	3-9	3.9	Differential Pulse Code Modulation (DPCM)	3-18
3.5.1	Need of Quantization	3-10	3.9.1	DPCM Transmitter	3-18
3.5.2	Quantization Error or Quantization Noise ϵ	3-10	3.9.2	DPCM Receiver	3-19
			3.9.3	Advantage of DPCM	3-19
			3.9.4	Disadvantages	3-19
			3.10	Delta Modulation (D.M.)	3-19
			3.10.1	Delta Modulator Transmitter (Generation)	3-20
			3.10.2	D.M. Receiver	3-21
			3.10.3	Features of D.M.	3-21
			3.10.4	Applications of D.M.	3-21
			3.10.5	Distortions in the DM System	3-21
			3.10.6	Advantages of Delta Modulation	3-22
			3.10.7	Disadvantages of Delta Modulation	3-22
			3.11	Adaptive Delta Modulation (ADM)	3-23
			3.11.1	Adaptive Delta Modulation Transmitter	3-23
			3.11.2	ADM Receiver	3-24



3.11.3	Advantages of Adaptive Delta Modulation	3-24
3.11.4	Disadvantages of ADM	3-24
3.11.5	Comparison of Digital Pulse Modulation Systems	3-24
3.12	Comparison of Analog and Digital Pulse Modulation	3-25
3.13	MSBTE Questions and Answers	3-26
3.14	I-Scheme Questions and Answers.....	3-28
	• Review Questions	3-25

Unit-III

Chapter 4 : Digital Modulation Techniques 4-1 to 4-29

Syllabus : Types of digital modulation techniques and their advantages, Concept of coherent and non-coherent detection, Shift keying techniques : Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK), Phase Shift Keying (PSK), Differential Phase Shift Keying (DPSK), Quadrature Phase Shift Keying (QPSK), Constellation diagram, Transmitter and receiver block diagram and their working with waveforms, M-ary encoding : Need, M-ary FSK and M-ary PSK, Quadrature Amplitude Modulation (QAM) : Need, Transmitter and receiver block diagram and their working with waveforms, Constellation diagram.

4.1	Introduction	4-1
4.1.1	Concept of Coherent and Noncoherent Detection	4-1
4.1.2	Binary and M-ary Schemes	4-1
4.1.3	Probability of Error (P_e)	4-2
4.1.4	Power Spectra	4-2
4.1.5	Bandwidth Efficiency	4-2
4.2	Digital to Analog Conversion	4-2
4.3	Need of Digital Carrier Wave Modulation Techniques	4-2
4.3.1	Analogy with Analog Modulation Schemes	4-3
4.3.2	Concept of Binary and M-ary Transmission	4-3
4.4	Amplitude Shift Keying (ASK)	4-4
4.4.1	Baud Rate (N_b)	4-4
4.4.2	Transmission Bandwidth of the ASK Signal	4-4
4.4.3	ASK Receiver	4-5
4.4.4	Constellation Diagram	4-5
4.4.5	Constellation Diagram of ASK	4-6
4.4.6	Merits and Demerits of ASK	4-6
4.4.7	Application	4-6
4.5	Frequency Shift Keying (FSK)	4-6
4.5.1	FSK Generation	4-6
4.5.2	Frequency Spectrum of Binary FSK Signal	4-7
4.5.3	Bandwidth of FSK Signal	4-7
4.5.4	Noncoherent FSK Receiver	4-7
4.5.5	Coherent FSK Demodulator	4-8
4.5.6	Advantages of FSK	4-8
4.5.7	Disadvantages of FSK	4-8
4.5.8	Application	4-8
4.6	Phase Shift Keying (PSK)	4-8
4.6.1	BPSK Transmitter	4-9
4.6.2	Coherent BPSK Receiver	4-9
4.6.3	Frequency Spectrum of BPSK (Power Spectral Density)	4-10
4.6.4	Bandwidth of BPSK	4-10
4.6.5	Constellation Diagram of BPSK	4-10
4.6.6	Advantages of BPSK	4-11
4.6.7	Disadvantage of BPSK	4-11
4.6.8	Applications	4-11
4.6.9	Comparison of Binary Modulation Systems	4-11
4.7	Differential Phase Shift Keying (DPSK)	4-12
4.7.1	DPSK Transmitter	4-12
4.7.2	DPSK Receiver	4-13
4.7.3	Bandwidth of DPSK Signal	4-14
4.7.4	Advantages of DPSK	4-14
4.7.5	Disadvantages of DPSK	4-14
4.7.6	Comparison of BPSK and DPSK	4-14
4.7.7	Comparison of FSK and DPSK	4-14
4.8	Quadrature Phase Shift Keying (QPSK)	4-15



4.8.1	Constellation Diagram of QPSK	4-15	4.12.6	4 QAM and 8 QAM Systems	4-25
4.8.2	QPSK Transmitter	4-16	4.13	Comparison of Digital CW Systems	4-26
4.8.3	QPSK Receiver	4-16	4.14	MSBTE Questions and Answers	4-27
4.8.4	QPSK Waveforms	4-17	4.15	I-Scheme Questions and Answers	4-29
4.8.5	Spectrum of QPSK Signal	4-17		• Review Questions	4-27
4.8.6	Bandwidth of QPSK	4-17	Unit-IV		
4.8.7	Advantages of QPSK	4-17	Chapter 5 : Multiplexing and Multiple Access 5-1 to 5-22		
4.8.8	Disadvantage	4-17	Syllabus : Need and methods of multiplexing : Time division multiplexing (TDM), Frequency Division Multiplexing (FDM), Code division multiplexing (CDM), Definition, Block diagram and their comparison, E and T carrier multiplexing hierarchy, Access techniques : Need and methods, Time division multiple access (TDMA), Frequency division multiple access (FDMA), Code division multiple access (CDMA).		
4.8.9	QPSK is Better than PSK	4-17	5.1	Introduction to Multiplexing	5-1
4.8.10	Applications	4-18	5.2	Concept of Multiplexing and Demultiplexing	5-1
4.8.11	Comparison of BPSK and QPSK	4-18	5.2.1	Types of Multiplexing	5-2
4.9	M-ary Modulation Techniques	4-18	5.3	Frequency Division Multiplexing (FDM)	5-2
4.9.1	Advantage	4-18	5.3.1	FDM Transmitter	5-2
4.9.2	Disadvantages	4-19	5.3.2	Guard Band	5-3
4.9.3	Types of M-ary Systems	4-19	5.3.3	FDM Receiver	5-3
4.10	M-ary PSK	4-19	5.4	Multiplexing Hierarchy in FDM	5-4
4.10.1	Euclidian Distance between Signal Points (d)	4-19	5.5	Advantages, Disadvantages and Applications of FDM	5-4
4.10.2	8 PSK System	4-19	5.5.1	Advantages of FDM	5-4
4.10.3	Frequency Spectrum and Bandwidth of M-ary PSK	4-20	5.5.2	Disadvantages of FDM	5-4
4.10.4	M-ary PSK Transmitter	4-20	5.5.3	Applications of FDM	5-4
4.10.5	M-ary PSK Receiver	4-20	5.6	Synchronous Time Division Multiplexing	5-4
4.10.6	Advantages of M-ary PSK	4-21	5.6.1	Synchronous TDM System	5-5
4.10.7	Disadvantages of M-ary PSK	4-21	5.7	Synchronization in TDM System	5-6
4.11	M-ary FSK	4-21	5.7.1	Synchronization in Synchronous TDM System	5-6
4.11.1	Bandwidth of M-ary FSK	4-22	5.7.2	Synchronization in Digital TDM System	5-6
4.11.2	Advantage of M-ary FSK	4-22	5.7.3	Advantages of TDM	5-6
4.11.3	Disadvantages	4-22	5.7.4	Disadvantages of TDM	5-6
4.11.4	Comparison of M-ary PSK and M-ary FSK	4-22	5.7.5	Applications of TDM	5-6
4.12	Quadrature Amplitude Shift Keying (QASK) or QAM	4-22	5.8	Bit Padding	5-7
4.12.1	QASK Transmitter	4-23	5.9	Statistical TDM (Asynchronous TDM)	5-7
4.12.2	QASK Receiver	4-23	5.10	Comparison of FDM and TDM Systems	5-7
4.12.3	Bandwidth of QASK System	4-24			
4.12.4	Comparison of QASK and QPSK	4-24			
4.12.5	Types of QAM	4-25			



5.10.1	Comparison of FDM, Synchronous TDM and Statistical TDM	5-8
5.11	Synchronous and Asynchronous Multiplexing	5-8
5.11.1	Synchronous Multiplexing	5-8
5.11.2	Asynchronous Multiplexing	5-8
5.12	Code Division Multiplexing (CDM)	5-9
5.12.1	Advantages	5-10
5.12.2	Disadvantages	5-10
5.12.3	Comparison of FDM and CDM Techniques	5-10
5.12.4	Comparison between TDM, FDM and CDM	5-10
5.13	T-Carrier System	5-10
5.13.1	Frame Synchronization	5-11
5.14	North American (T-Carrier) Hierarchy	5-12
5.15	T-Carrier Hierarchy	5-12
5.15.1	T Lines	5-13
5.16	CCITT Multiplexing Hierarchy (E-carrier) for TDM	5-13
5.16.1	E Lines	5-14
5.17	Wavelength Division Multiplexing (WDM)	5-14
5.18	Multiple Access	5-15
5.18.1	Difference between Multiple Access and Multiplexing	5-16
5.19	Multiple Access Techniques	5-16
5.19.1	FDMA	5-16
5.19.2	Features of FDMA	5-16
5.19.3	Advantages of FDMA	5-17
5.19.4	Disadvantages of FDMA	5-17
5.19.5	TDMA	5-17
5.19.6	Features of TDMA	5-17
5.19.7	Advantages of TDMA	5-17
5.19.8	Disadvantages	5-18
5.19.9	Problems with FDMA and TDMA	5-18
5.19.10	Code Division Multiple Access (CDMA)	5-18
5.19.11	Advantages of CDMA	5-19
5.19.12	Disadvantages	5-19
5.19.13	CDMA Applications	5-19
5.20	Applications of Multiple Access Techniques	5-19
5.21	Comparison of FDMA, TDMA and CDMA	5-19

5.22	MSBTE Questions and Answers	5-21
5.23	I-Scheme Questions and Answers	5-22
	• Review Questions	5-20

Unit-V

Chapter 6 : Spread Spectrum Modulation 6-1 to 6-16

Syllabus : Introduction to Spread Spectrum (SS) modulation, Advantages over fixed frequency, Applications of SS modulation, Block diagram of spread spectrum modulation system. Pseudo Noise (PN) sequence : Definition, Generation and maximum length sequence, Types of SS modulation : Direct sequence spread spectrum signal (DSSS) and frequency hopped spread spectrum (FHSS).

6.1	Introduction	6-1
6.2	How is the SS Signal Different from the Normal Signal ?	6-1
6.3	Applications of Spread Spectrum Modulation	6-2
6.4	Classification of the Spread Spectrum Modulation Techniques	6-2
6.4.1	Definition of a PN Sequence	6-3
6.4.2	Use of a PN Sequence in S.S.	6-3
6.5	Pseudo-Noise (PN) Sequences Generation	6-3
6.5.1	The Maximum Length Sequence	6-4
6.5.2	Properties of Maximum-Length Sequences	6-4
6.6	Block Diagram of Spread Spectrum Modulation System	6-5
6.7	Direct Sequence Spread Spectrum (DSSS) System	6-7
6.7.1	DSSS Transmitter	6-7
6.7.2	DS-SS Receiver	6-7
6.7.3	Performance Parameters of a DS-SS System	6-8
6.7.3.1	Processing Gain	6-8
6.7.3.2	Jamming Margin	6-8
6.7.4	Advantages and Disadvantages of the DS-SS System	6-9



6.7.5 Applications of DS-SS System6-9	6.10.1 Receiver used for Fast Hopping 6-13
6.8 Frequency Hop Spread Spectrum (FH-SS) Signals6-9	6.11 Advantages and Disadvantages of FH-SS System 6-13
6.8.1 Types of Frequency Hopping6-9	6.12 Applications of FHSS 6-13
6.9 Slow Frequency Hopping 6-10	6.13 Comparison of Slow and Fast Frequency Hopping 6-13
6.9.1 Transmitter6-10	6.14 Comparison of DS-SS and FHSS 6-14
6.9.2 FH / MFSK Receiver6-11	6.15 MSBTE Questions and Answers 6-15
6.9.3 Chip Rate (R_C) of FH/MFSK System ..6-11	6.16 I-Scheme Questions and Answers 6-16
6.9.4 Processing Gain PG6-11	• Review Questions 6-14
6.10 Fast Frequency Hopping6-12	

□□□

Tech Knowledge
Publications