Course File

Digital Communication & Stochastic Process
(EC 503)

Department of Electronics and Communication Engineering
Asansol Engineering College
Vivekananda Sarani, Kanyapur
Asansol -05

ASANSOL ENGINEERING COLLEGE

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

ECE- 5TH SEMESTER

Subject Code: EC-503	**Category:** Engineering Courses
Subject Name: Digital Communication & Stochastic Process	**Semester:** Fifth
L-T-P : 3-1-0	**Credit**: 3.5
Pre-Requisites: Signals & Systems, Probability & Random Processes & Basic concepts of Communication Theory.	

Course Objective: To provide an overview of electronic device components to Mechanical Engineering students.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1.	***Introduction to Stochastic Processes (SPs):*** Definition and examples of SPs, classification of random processes according to state space and parameter space, elementary problems. Stationary and ergodic processes, correlation coefficient, covariance, auto correlation function and its properties, random binary wave, power spectral density. Definition and examples of Markov Chains, transition probability matrix, Chapman Kolmogorov equations; Calculation of n-step transition probabilities.	**8**
2.	***Signal Vector Representation:*** Analogy between signal and vector, distinguishibility of signal, orthogonality and orthonormality, basis function, orthogonal signal space, message point , signal constellation, geometric interpretation of signals, likelihood functions, Schwartz inequality, Gram-Schmidt orthogonalization procedure, response of the noisy signal at the receiver, maximum likelihood decision rule, decision boundary, optimum correlation receiver; probability of error , error function, complementary error function, Type-I and Type-II errors.	**6**
3.	***Digital Data Transmission*****:** Concept of sampling, Pulse Amplitude Modulation (PAM), interlacing and multiplexing of samples, Pulse Code Modulation (PCM), quantization, uniform and non-uniform quantization, quantization noise, binary encoding, A-Law and μ -law Companding, differential PCM, delta modulation and adaptive delta modulation. Digital transmission components, source, multiplexer, line coder, regenerative repeater, concept of line coding – polar/unipolar/bipolar NRZ and RZ, Manchester, differential encoding and their PSDs, pulse shaping, Inter Symbol Interference (ISI), Eye pattern, Nyquist criterion for zero ISI, equalizer, zero forcing equalizer, timing extraction	**10**

4.	**Digital Modulation Techniques:** Types of Digital Modulation, coherent and non-coherent Binary Modulation Techniques, basic digital carrier modulation techniques: ASK, FSK and PSK, Coherent Binary Phase Shift Keying (BPSK), geometrical representation of BPSK signal; error probability of BPSK, generation and detection of BPSK Signal, power spectrum of BPSK. Concept of M-ary Communication, M-ary phase shift keying, the average probability of symbol error for coherent M-ary PSK, power spectra of MPSK, Quadrature Phase Shift Keying (QPSK), error probability of QPSK signal, generation and detection of QPSK signals, power spectra of QPSK signals, Offset Quadrature Phase Shift Queuing (OQPSK), Coherent Frequency Shift Keying (FSK), Binary FSK, error probability of BFSK signals, generation and detection of Coherent Binary FSK signals, power spectra of BFSK signal, Minimum Shift Keying (MSK), signal constellation of MSK waveforms, error probability of MSK signal, Gaussian Minimum Shift Keying: GMSK, basic concept of OFDM, constellation diagram. Some performance issues for different digital modulation techniques - Error Vector Magnitude (EVM), Eye Pattern and Relative Constellation Error (RCE), Conceptual idea for Vector Signal Analyzer (VSA)	**10**

Text Books:

1) Digital Communications, S. Haykin, Wiley India.
2) Principles of Communication Systems, H. Taub and D.L.Schilling, TMH Publishing Co.
3) Wireless Communication and Networks : 3G and Beyond, I. SahaMisra, TMH Education.
4) Digital Communications, J.G.Proakis, TMH Publishing Co.
5) S.M. Ross,Stochastic Processes, 2nd Edition, Wiley, 1996 (WSE Edition).

References:

1) Digital Communications Fundamentals andApplications, B. Sklar and P.K.Ray, Pearson.
2) Modern Digital and Analog Communication Systems, B.P.Lathi and Z.Ding,Oxford University Press.
3) Digital Communication, A. Bhattacharya, TMH Publishing Co.
4) J. Medhi,Stochastic Processes, 3rd Edition, New Age International, 2009.

PRE-REQUISITES: Basic concepts of Analog Communication, Probability and Random Variables are required to go through this course. Basic knowledge of the terms involved in Electronics and communication would be an added advantage.

COURSE OUTCOMES:

After the completion of the course students will be able to:

CO EC503.1: Illustrate Random Process and its classification, Markov Chain, State transition ***Level II***

CO EC503.2: Identify the difference between signal and vector, orthogonality and orthonormality, orthogonal signal space, GSOP, likelihood function and error probability. ***Level III***

CO EC503.3: Analyze sampling theorem, PAM, PCM, Quantization, Companding, DPCM, DM and ADM. ***Level IV***

CO EC503.4: Explain line coding techniques and their PSDs, ISI, Nyquist criteria for zero ISI and equalization techniques. ***Level V***

CO EC503.5: Explain different coherent binary digital modulation schemes, their generation and detection, signal space diagram, error probability calculation. ***Level V***

CO EC503.6: Explain different coherent M-ARY digital modulation schemes, their generation and detection, signal space diagram, error probability calculation and PSDs. ***Level II***

GAP ANALYSIS:

Sl. No.	**Gap**	**Action Taken**	**Relevance to POs, PSOs**
1.	**Matched Filter Receiver:** Matched filter analysis is required to analyze non-coherent modulation schemes in presence of noise.	Topic is covered by taking extra classes.	PO1, PO2, PSO1
2.	**Non coherent Phase Shift Keying:** Differential phase shift keying is one of the most important non-coherent digital modulation techniques.	Topic is covered by taking extra classes.	PO1, PO2, PSO1

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COURSE OUTCOME	COURSE OUTCOME After completion of the course students will able to	Bloom's Taxonomy Level	PO-CO MAPPING												PO-PSO MAPPING		
			PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
EC-503.1	**Illustrate** Random Process and its classification, Markov Chain, State transition.	**III**		3								1		1	3	2	1
EC-503.2	**Identify the** difference between signal and vector, orthogonality and orthonormality, orthogonal signal space, GSOP, likelihood function and error probability.	**III**		3								1		1	3	2	1
EC-503.3	**Analyse** sampling theorem, PAM, PCM, Quantization, Companding, DPCM, DM and ADM.	**IV**			3							1		1	3	2	1
EC-503.4	**Explain** line coding techniques and their PSDs, ISI, Nyquist criteria for zero ISI and equalization techniques.	**V**			3							1		1	3	2	1
EC-503.5	**Explain** different coherent binary digital modulation schemes, their generation and detection, signal space diagram, error probability calculation	**V**		3								1		1	3	2	1
EC-503.6	**Explain** different coherent M-ARY digital modulation schemes, their generation and detection, signal space diagram, error probability calculation and PSDs.	**V**			3							1		1	3	2	1
EC-503 © (DIGITAL COMMUNICATION & STOCHASTIC PROCESS)				3	3							1		1	3	2	1

Lesson Plan of Digital Communication & Stochastic Process (EC-503)

Odd Sem 2021

Day	Module No.	Topics to be covered	Course Outcomes	Text Books/ References	Pedagogical Tools used
1	1	Introduction, Communication Example	CO-1	TB-2, R-2,	PPT Presentation
2	1	Introduction To Probability, Conditional Probability, Joint Probability ,Statistical Independence, Random Variable-Continuous And Discrete	CO-1	TB-2, R-2,	PPT Presentation
3	1	Cumulative Distribution Function, Correlation Coefficient, Covariance	CO-1	TB-2, R-2,	PPT Presentation
4	1	Probability Density Function – Gaussian, Rayleigh And Rician,Mean, Variance,	CO-1	TB-2, R-2,	PPT Presentation
5	1	Introduction To Random Process, Definition and examples of SPs, Stationary and Ergodic Processes,	CO-1	TB-2, R-2,	Chalk & Talk
6	1	Classification of random processes according to State Space and Parameter Space.	CO-1	TB-2, R-2,	Chalk & Talk
7	1	Definition and examples of Markov Chains	CO-1	TB-2, R-2,	Chalk & Talk
8	1	Transition probability matrix	CO-1	TB-2, R-2,	Chalk & Talk
9	1	Chapman Kolmogorov equations	CO-1	TB-2, R-2,	Chalk & Talk
10	1	Calculation of n-step transition probabilities.	CO-1	TB-2, R-2,	Chalk & Talk
11	1	Auto Correlation Function And Its Properties,	CO-1	TB-2, R-2,	Chalk & Talk
12	1	Random Binary Wave, Power Spectral Density.	CO-1	TB-2, R-2,	Chalk & Talk
13	2	Analogy Between Signal And Vector, Distinguishability Of Signal	CO-2	TB-1, R-1,	Chalk & Talk
14	2	Orthogonality And Orthonormality, Basis Function	CO-2	TB-1, R-1,	Chalk & Talk
15	2	Gram-Schmidt Orthogonalization Procedure,	CO-2	TB-1, R-1,	Chalk & Talk
16	2	Orthogonal Signal Space, Message Point , Signal Constellation,	CO-2	TB-1, R-1,	Chalk & Talk
17	2	Geometric Interpretation Of Signals,	CO-2	TB-1, R-1,	Chalk & Talk
18	2	Likelihood Functions, Schwartz Inequality,	CO-2	TB-1, R-1,	Chalk & Talk
19	2	Response Of The Noisy Signal At The Receiver	CO-2	TB-1, R-1,	Chalk & Talk
20	2	Calculation of Mean, Variance and Co-variance of noisy receiver	CO-2	TB-1, R-1,	Chalk & Talk
21	2	Maximum Likelihood Decision Rule, Decision Boundary	CO-2	TB-1, R-1,	Chalk & Talk
22	2	Optimum Correlation Receiver; Probability Of Error ,	CO-2	TB-1, R-1,	PPT Presentation
23	2	Error Function, Complementary Error Function, Type-I And Type-II Errors	CO-2	TB-1, R-1,	PPT Presentation
24	4	Types Of Digital Modulation, Coherent And Non-Coherent Binary Modulation Techniques	CO-5	TB-3, R-3	Chalk & Talk
25	4	Basic Digital Carrier Modulation Techniques: ASK, FSK And PSK	CO-5	TB-3, R-3	Chalk & Talk
26	4	Coherent Binary Phase Shift Keying (Bpsk)	CO-5	TB-3, R-3	Chalk & Talk
27	4	Geometrical Representation of BPSK Signal; Error Probability Of BPSK	CO-5	TB-3, R-3	Chalk & Talk
28	4	Generation And Detection of BPSK Signal, Power Spectrum Of BPSK.	CO-5	TB-3, R-3	Chalk & Talk
29	4	Coherent Frequency Shift Keying (FSK), Binary FSK,	CO-5	TB-3, R-3	Chalk & Talk
30	4	Error Probability of BFSK Signals	CO-5	TB-3, R-3	Chalk & Talk
31	4	Generation And Detection of Coherent Binary FSK Signals,	CO-5	TB-3, R-3	Chalk & Talk
32	4	Power Spectra of BFSK Signal,	CO-5	TB-3, R-3	Chalk & Talk
33	4	Concept Of M-Ary Communication,	CO-6	TB-3, R-3	Chalk & Talk
34	4	M-Ary Phase Shift Keying,	CO-6	TB-3, R-3	Chalk & Talk
35	4	The Average Probability Of Symbol Error For Coherent M-Ary PSK	CO-6	TB-3, R-3	PPT Presentation
36	4	Quadrature Phase Shift Keying (QPSK), Power Spectra Of MPSK,	CO-6	TB-3, R-3	PPT Presentation
37	4	Error Probability Of QPSK Signal	CO-6	TB-3, R-3	Chalk & Talk
38	4	Generation And Detection Of QPSK Signals	CO-6	TB-3, R-3	Chalk & Talk

39	**4**	Power Spectra Of QPSK Signals, Offset Quadrature Phase Shift Queuing (OQPSK),	CO-6	TB-3, R-3	Chalk & Talk
40	**4**	Minimum Shift Keying (MSK), Signal Constellation Of MSK Waveforms,	CO-6	TB-3, R-3	Chalk & Talk
41	**4**	Error Probability Of MSK Signal, Gaussian Minimum Shift Keying: GMSK,	CO-6	TB-1, R-2, R-3	Chalk & Talk
42	**4**	Basic Concept Of OFDM, Constellation Diagram,	CO-6	TB-1, R-2, R-3	Chalk & Talk
43	**4**	Performance Issues For Different Digital Modulation Techniques - Error Vector Magnitude (EVM),	CO-6	TB-1, R-2, R-3	Chalk & Talk
44	**4**	Eye Pattern And Relative Constellation Error (RCE),	CO-6	TB-1, R-2, R-3	Chalk & Talk
45	**4**	Conceptual Idea For Vector Signal Analyzer (VSA)	CO-6	TB-1, R-2, R-3	Chalk & Talk
46	**3**	Concept Of Sampling, Pulse Amplitude Modulation (PAM)	CO-3	TB-1, R-2, R-3	Chalk & Talk
47	**3**	Interlacing And Multiplexing Of Samples,	CO-3	TB-1, R-2, R-3	Chalk & Talk
48	**3**	Pulse Code Modulation (PCM), Quantization	CO-3	TB-1, R-2, R-3	Chalk & Talk
49	**3**	Uniform And Non-Uniform Quantization	CO-3	TB-1, R-2, R-3	Chalk & Talk
50	**3**	Quantization Noise, Binary Encoding, A-Law And μ -Law Companding,	CO-3	TB-1, R-2, R-3	Chalk & Talk
51	**3**	Differential PCM	CO-3	TB-1, R-2, R-3	PPT Presentation
52	**3**	Delta Modulation	CO-3	TB-1, R-2, R-3	PPT Presentation
53	**3**	Drawbacks of Delta Modulation, Adaptive Delta Modulation	CO-3	TB-1, R-2, R-3	PPT Presentation
54	**3**	Digital Transmission Components, Source, Multiplexer, Line Coder, Regenerative Repeater	CO-4	TB-1, R-2, R-3	PPT Presentation
55	**3**	Concept Of Line Coding – Polar/Unipolar/Bipolar Nrz And Rz	CO-4	TB-1, R-2, R-3	Chalk & Talk
56	**3**	Manchester, Differential Encoding And Their Psds, Pulse Shaping	CO-4	TB-1, R-2, R-3	Chalk & Talk
57	**3**	Inter Symbol Interference (ISI), Eye Pattern	CO-4	TB-1, R-2, R-3	Chalk & Talk
58	**3**	Nyquist Criterion For Zero ISI, Equalizer	CO-4	TB-1, R-2, R-3	Chalk & Talk
59	**3**	Zero Forcing Equalizer, Timing Extraction	CO-4	TB-1, R-2, R-3	Chalk & Talk

Text Books:

1. Taub and Schilling , “Principles of Communication Systems”, 2nd ed., Mc-Graw Hill

2. B.P.Lathi -Communication Systems- BS Publications

3. Simon Haykin- Communication System, Wiley Publications.

4. G. Kennedy, Electronic Communication System, Tata Mc Graw Hill

References:

1. Carlson—Communication System,4/e , Mc-Graw Hill

2. Proakis & Salehi Fundamentals of Communication Systems- Pearson

3. Singh & Sapre—Communication Systems: 2/e, TMH

4. P K Ghosh- Principles of Electrical Communications- University Press
5. L.W.Couch Ii, "Digital and Analog Communication Systems", 2/e, Macmillan Publishing
6. Blake, Electronic Communication Systems- Cengage Learning
7. S Sharma, Analog Communication Systems- Katson Books
8.V Chandra Sekar – Analog Communication- Oxford University Press

Prepared By:	**Approved By:**
Mr. Amit Kumar Rai	(Name of HOD/Program Coordinator)
Signature with Date	**Signature with Date**

Attendance of Digital Communication & Stochastic Process (EC 503)

Odd 2021

ROLL NO	STUDENT NAME	10-09-21	14-09-21	15-09-21	16-09-21	20-09-21	21-09-21	22-09-21	23-09-21	24-09-21	28-09-21	29-09-21	30-09-21	01-10-21	05-10-21	07-10-21	08-10-21	21-10-21	22-10-21	26-10-21	27-10-21	02-11-21	03-11-21	09-11-21	11-11-21	12-11-21	16-11-21	18-11-21	22-11-21	23-11-21	25-11-21	26-11-21	02-12-21	03-12-21	06-12-21	TOT PR %
10800319003	ANKITACHOUDHARY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	A	24	25	26	27	28	29	30	31	32	33	93
10800319005	HARSH KUMAR	1	2	3	4	A	5	6	7	8	A	9	10	11	12	13	A	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	A	A	29	84
10800319006	DIVYANSHUKUMAR	A	A	1	2	3	4	5	6	7	8	9	10	11	12	13	A	A	14	15	16	17	18	A	A	A	A	19	20	21	22	23	24	25	26	75
10800319007	SOURAVCHAND	A	A	1	2	A	A	3	A	4	5	6	7	8	9	10	11	A	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	77
10800319008	RITESH ANAND	1	2	3	4	5	A	6	7	8	9	A	10	11	12	13	A	14	15	A	16	17	18	19	A	20	21	A	22	23	A	24	25	26	A	77
10800319009	KAJAL KMCHAUDHURY	1	A	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	A	A	26	A	27	28	29	30	88
10800319010	IMRAN USMANI	1	2	A	3	A	4	5	6	A	7	8	A	9	10	11	12	13	14	15	16	A	A	A	A	A	A	A	17	18	A	19	20	21	22	51
10800319011	PRATIK SINGHBHARDWAJ	A	A	A	A	A	1	A	A	A	A	A	A	2	A	A	3	A	A	A	4	A	A	5	A	A	A	A	A	A	6	A	A	7	8	26
10800319012	DEEPAKKUMAR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	A	30	31	32	A	91
10800319013	HARE KRISHNA	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	A	16	17	18	19	20	A	21	A	22	23	24	25	26	A	27	28	29	A	80
10800319014	MD. WASIFRIZWAN	1	2	3	4	5	6	A	A	7	8	A	9	10	11	12	A	13	A	14	15	16	17	18	19	A	A	20	21	22	23	A	24	25	A	66
10800319015	BAISHAKHIMAHATA	1	2	3	4	5	6	7	8	9	A	10	11	12	13	14	A	15	A	16	17	18	19	A	20	A	21	22	23	24	A	25	A	26	27	73
10800319016	SAYANTANMUKHERJEE	1	2	3	A	4	5	6	7	8	9	10	11	A	12	13	A	A	A	14	15	16	A	17	18	A	19	20	21	22	23	24	25	26	27	70
10800319017	ANIKCHATTERJEE	1	2	3	4	5	6	7	8	9	A	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	95
10800319018	SUNANDAYADAV	1	2	3	4	A	5	6	7	8	9	10	11	12	A	13	A	14	15	16	17	18	19	20	A	A	A	21	22	23	A	A	24	A	A	66
10800319019	ANSHU PRIYA	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	97
10800319020	GAURAVKUMAR	1	2	3	4	5	6	7	8	9	A	10	11	12	13	14	15	16	17	18	19	20	21	22	A	23	24	A	25	26	27	28	29	30	31	90
10800319022	SAYANTANIMOZUMDAR	1	2	3	4	A	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	A	26	27	28	29	30	31	32	82
10800319023	SHEETALKUMARI	1	A	2	3	4	5	6	7	8	9	10	11	A	12	13	A	14	A	15	16	17	18	19	20	21	22	A	23	24	25	26	27	28	29	73
10800319024	SUBHADIPMAHATA	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	A	16	17	18	A	19	20	21	22	23	24	25	26	A	27	28	29	30	31	86
10800319025	TANNU PRIYA	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	A	29	30	31	32	33	90
10800319026	ANANYA	1	2	3	4	5	6	7	A	8	A	9	10	11	A	12	13	14	15	16	17	18	19	A	20	21	A	22	23	24	25	26	27	A	28	77
10800319027	SUSOVAN DAS	1	2	3	A	4	A	5	6	7	8	9	A	A	10	11	A	12	13	A	14	15	16	17	A	18	19	20	21	22	A	A	A	23	A	70
10800319029	SOURAVKUMAR	1	2	3	4	5	6	7	8	9	10	A	11	12	A	13	14	15	16	17	18	19	20	21	A	22	23	24	25	26	27	A	28	A	A	82
10800319030	ABHISHEKKUMARCHOUDHARY	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	1	2	3	4	5	6	7	8	9	10	11	12	A	A	40
10800319031	SHIBRAMPARAMANIK	A	A	1	2	3	4	A	5	6	7	8	A	9	A	A	A	A	A	A	A	A	A	A	A	10	A	A	A	A	A	A	A	A	A	20
10800319032	SUBHASUNDARCHAKRABORTY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	97
10800319033	SUDARSHANLAHIRI	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	95
10800319034	SWARAJKRISHNAMONDAL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	A	29	30	31	32	33	93
10800319035	TUSHAR PAL	1	2	3	4	5	6	A	7	A	A	A	A	A	A	A	A	8	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	30
10800319037	RISHABHSINHA	A	A	1	2	3	4	5	6	A	7	8	9	10	11	12	A	A	13	14	15	16	17	A	18	19	20	21	22	23	24	A	25	26	27	79
10800319038	TRINABHPRIYAM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	A	16	17	18	19	20	21	A	A	22	23	24	25	A	26	27	A	A	28	77
10800319039	GADDAMSHANKAR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	A	33	93
10800319040	SANDEEPCHOWDHURY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	95
10800319041	ADITI RAJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	A	A	93
10800319042	SHAMBHAVIRAJ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	A	21	22	23	24	A	25	26	27	28	29	30	31	32	91
10800319043	SUMANKUMARPRASAD	A	A	A	A	A	1	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	2	3	4	5	6	7	8	9	10	11	12	A	44

10800319044	MD. ASIFAKHTAR	A	A	1	2	A	3	4	A	A	5	6	7	A	8	A	9	A	A	10	11	12	13	14	A	A	A	A	15	16	17	18	19	A	20	48
10800319045	SOURABHKUMAR SINGH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	A	15	16	17	18	19	20	21	22	23	24	25	26	27	A	A	28	A	A	29	82
10800319046	SOUMYADEEPMAJI	1	2	3	4	A	5	6	A	7	A	8	9	A	10	11	A	A	A	A	A	A	A	12	13	14	A	A	15	16	A	17	18	A	A	59
10800319047	CHANDANKUMARMONDAL	A	A	A	A	A	1	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	2	A	A	3	4	A	5	6	7	8	9	10	11	48
10800319048	SAIKATMUKHERJEE	1	2	3	4	5	6	7	8	9	10	11	12	A	13	14	A	15	16	17	18	A	19	20	21	A	22	23	24	25	26	27	28	29	30	84
10800319049	SUBHADEEPBANERJEE	1	2	A	3	4	5	6	7	A	8	A	9	A	10	A	11	A	12	13	14	15	16	17	A	18	19	20	21	22	23	A	24	25	26	75
10800319050	SUPRIYOMITRA	1	2	3	A	4	A	A	A	A	A	A	A	A	A	5	6	7	8	9	10	11	12	13	14	A	15	16	17	18	A	A	19	20	21	68
10800319051	SUSMITAMUKHERJEE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	A	16	17	18	19	20	21	22	23	24	A	25	26	27	28	29	30	31	32	91
10800319052	JASPRIT KAUR	1	2	3	4	A	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	A	91
10800319053	SUDIPTA PAL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	A	18	19	20	21	22	23	24	25	26	27	28	A	29	30	31	32	90
10800319054	SREEPARNARAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	A	A	19	20	21	22	23	24	25	26	27	28	29	30	31	32	90
10800319055	SM GAZAMFARIMAM	A	A	A	A	A	1	A	A	A	2	3	A	4	5	6	7	8	9	10	11	12	13	14	15	A	16	17	18	19	20	21	22	23	A	68
10800319056	SAMPRITIMISRA	1	2	3	4	5	6	A	7	8	9	A	10	11	12	13	A	14	A	15	16	17	18	19	20	A	21	A	22	A	23	24	25	26	A	71
10800319057	PRABHATKUMAR	1	2	3	4	5	6	7	A	A	A	8	9	A	10	11	12	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	13	44
10800319058	REJAULMALLIK	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	A	25	A	26	27	A	28	29	30	31	84
10800319059	SANJU KUMARI	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	A	A	16	A	A	17	18	19	20	A	21	22	23	24	A	25	26	27	28	80
10800319060	RAMRATANKUMAR	1	A	2	3	4	5	6	7	8	9	A	10	11	12	13	14	15	16	17	18	19	20	A	21	22	23	24	25	26	27	28	29	30	31	79
10800319061	SHIVSHUBHAM	1	2	3	4	5	6	7	8	A	9	10	11	A	A	A	A	A	A	A	A	A	A	A	A	12	A	A	A	A	13	14	15	A	16	39
10800319062	SOUMILI ROY	1	2	3	4	5	6	7	8	9	A	A	A	A	10	11	12	A	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	82
10800319063	RITWIKSARKAR	1	2	3	A	4	5	6	7	A	A	A	8	9	A	A	A	A	10	11	12	A	A	A	13	A	14	15	16	17	18	19	20	21	A	51
10800319064	SAMBHAWSAMRAT	1	2	3	4	5	6	7	8	9	10	11	12	A	13	14	A	15	16	17	18	19	20	21	22	23	24	25	26	27	A	A	A	28	29	70
10800319065	PRIYANSHUVIKRAM	1	2	3	4	5	6	7	8	9	10	11	12	A	13	14	15	A	16	17	18	19	A	A	A	A	20	A	21	22	23	24	25	A	26	60
10800320074	MIR ANIKETALAM	1	A	2	3	4	5	6	7	A	8	9	10	A	11	12	A	13	14	A	A	A	A	A	A	15	A	16	17	18	19	20	21	22	23	73
10800320075	Subhom Mondal	A	A	A	A	A	1	A	2	A	3	4	A	5	6	7	A	8	9	10	11	A	12	A	13	A	A	A	14	15	16	17	18	19	20	57
10800320079	PALLABISADHU	1	2	3	4	A	5	6	7	8	9	10	A	11	12	13	14	15	A	16	17	18	19	20	21	22	23	24	A	25	26	27	28	29	30	82
10800320080	KUNAL RAJ	1	2	3	A	A	4	A	5	6	7	8	9	10	11	A	A	A	A	12	13	A	14	15	A	A	A	A	A	16	17	18	19	20	A	55
10800320082	Kasturi chatterjee	1	2	3	4	5	6	7	8	9	A	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	95
10800320085	Sayani Mitra	1	2	3	4	5	6	7	8	A	A	A	9	10	11	12	13	14	15	16	17	A	18	19	20	A	A	21	A	22	A	23	24	25	26	70
10801619054	PRANOY DHAR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	A	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	95
10801619062	AMAN SHREEPRASAD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	A	25	26	27	28	29	30	31	32	33	95

Individual Routine Odd 2021

Mr Amit Kr Rai

LAB	09:40 - 11:40		RECESS	12:40 - 02:40		02:40 - 04:40		
Theory	09:40-10:40	10:40-11:40	11:40-12:40	12:40-01:40	01:40-02:40	02:40-03:40	03:40-04:40	04:40-05:40
Mon					EC 503 AKR (A)			
Tue	BS-ECE 301 AKR (ME-A)		EC 503 AKR (A)					
Wed	EC 592 (A1) AKR & KN					EC 592 (A2) AKR & KN		
Thu		EC 503 AKR (A)				BS-ECE 301 AKR (ME-A)		
Fri	EC 503 AKR (A)				BS-ECE 301 AKR (ME-A)			

ASANSOL ENGINEERING COLLEGE
ECE DEPARTMENT
ROUTINE ODD SEM, 2021

ECE 5th - Semester , Sec - A

LAB	09:40 - 11:40		RECESS	12:40 - 02:40		02:40 - 04:40		
Theory	09:40-10:40	10:40-11:40	11:40-12:40	12:40-01:40	01:40-02:40	02:40-03:40	03:40-04:40	04:40-05:40
MON	PE EC 505A/C BR/AB	EC 501 CG	EC 502 SSM	RECESS	EC 503 AKR	Tutorial	Tutorial	Library
TUE	OE-EC 506 (PM)	EC 504 SG	EC 503 AKR	RECESS	PE EC 505A/C BR/AB	EC 501 CG	Tutorial	Library
WED	EC 591(A2) CG & MKD EC 592 (A1) AKR & KN		RECESS	EC 593(A2) SG & JB EC 591(A1) CG & MKD		EC 593(A1) SG & JB EC 592 (A2) AKR & KN		Tutorial
THU	EC 501 CG	EC 503 AKR	EC 504 SG	EC 502 SSM	RECESS	OE-EC 506 (PM)	Tutorial	Library
FRI	EC 503 AKR	EC 502 SSM	EC 504 SG	RECESS	PE EC 505A/C BR/AB	MC-HU581 (A) HG		OE-EC 506 (PM)

ECE 5th - Semester , Sec - B

LAB	09:40 - 11:40		RECESS	12:40 - 02:40		02:40 - 04:40		
Theory	09:40-10:40	10:40-11:40	11:40-12:40	12:40-01:40	01:40-02:40	02:40-03:40	03:40-04:40	04:40-05:40
MON	PE EC 505A/C BR/AB	EC 503 PP	EC 504 SMK	RECESS	EC 502 SS	EC 501 SCP	Tutorial	Library
TUE	EC 502 SS	EC 503 PP	RECESS	EC 504 SMK	PE EC 505A/C BR/AB	OE-EC 506 (PM)	Tutorial	Library
WED	OE-EC 506 (PM)	EC 501 SCP	EC 504 SMK	EC 503 PP	RECESS	MC-HU581 (B) HG		Library
THU	EC 591 (B1) SCP & MKD EC 592 (B2) PP & KN		RECESS	EC 592 (B1) PP & KN EC593 (B2) SMK & JB		EC 593 (B1) SMK & JB EC 591 (B2) SCP & MKD		Tutorial
FRI	EC 503 PP	EC 501 SCP	EC 502 SS	RECESS	PE EC 505A/C BR/AB	Tutorial	OE-EC 506 (PM)	Library

SSM - Sambit Sundar Mondal (ECE)		SG - Sujit Goswami (ECE)
SMK - Sumanta Karmakar (ECE)		SCP - Shiv Charan Puri (ECE)
AKR - Amit Kumar Rai (ECE)		PP - Prajit Paul (ECE)
SS - Soumen Sen (ECE)		HG - Hirak Gupta (BS-HU)
CG - Chiranjib Goswami (ECE)		BR - Bhaskar Roy (AEIE)
AB - Md Aref Billaha (ECE)		PM- Priya Mukherjee (BS-HU)
Routine Coordinator	HOD	Principal

ASANSOL ENGINEERING COLLEGE

MECHANICAL ENGINEERING DEPARTMENT

TIME TABLE OF 3RD SEMESTER (SECTION-A), 2021-22

Theory	9:40-10:40	10:40-11:40	11:40-12:40	12:40-1:40	1:40-2:40	2:40-3:40	3:40-4:40	4:40-5:40
Lab.	9:40-11:40		11:40-12:40	12:40-2:40		2:40-4:40		
Monday	**PC-ME391 (Workshop) (A) (NK)**		**GATE**	**GATE**	**RECESS**	**GATE**	**GATE**	**GATE**
Tuesday	**ES-ECE301 (AKR-ECE)**	**GATE**	**ES-ME301 (AD)**	**PC-ME302 (DD)**	**RECESS**	**PC-ME301 (NK)**	**BS-M301 (AB-MATH)**	**GATE**
Wednesday	**PC-ME302 (DD)**	**PC-ME301 (NK)**	**ES-ME301 (AD)**	**RECESS**	**GATE**	**BS-M301 (AB-MATH)**	**BS-BIO301 (SC-PHY)**	**GATE**
Thursday	**BS-M301 (AB-MATH)**	**PC-ME301 (NK)**	**PC-ME302 (DD)**	**RECESS**	**ES-ME301 (AD)**	**ES-ECE301 (AKR-ECE)**	**BS-BIO301 (SC-PHY)**	**GATE**
Friday	**ES-ME301 (AD)**	**PC-ME301 (NK)**	**RECESS**	**BS-M301 (AB-MATH)**	**ES-ECE301 (AKR-ECE)**	**PC-ME302 (DD)**	**BS-BIO301 (SC-PHY)**	**GATE**

TIME TABLE OF 3RD SEMESTER (SECTION-B), 2021-22

Theory	9:40-10:40	10:40-11:40	11:40-12:40	12:40-1:40	1:40-2:40	2:40-3:40	3:40-4:40	4:40-5:40
Lab.	9:40-11:40		11:40-12:40	12:40-2:40		2:40-4:40		
Monday	**GATE**	**GATE**	**GATE**	**PC-ME391 (Workshop) (B) (NK)**		**RECESS**	**GATE**	**GATE**
Tuesday	**PC-ME301 (SP)**	**ES-ECE301 (IR-ECE)**	**ES-ME301 (SY)**	**RECESS**	**PC-ME302 (SNP)**	**GATE**	**BS-M301 (AB-MATH)**	**GATE**
Wednesday	**ES-ME301 (SY)**	**PC-ME301 (SP)**	**BS-BIO301 (JM-PHY)**	**RECESS**	**PC-ME302 (SNP)**	**BS-M301 (AB-MATH)**	**ES-ECE301 (AKR-ECE)**	**GATE**
Thursday	**ES-ME301 (SY)**	**PC-ME302 (SNP)**	**BS-BIO301 (JM-PHY)**	**RECESS**	**ES-ECE301 (IR-ECE)**	**PC-ME301 (SP)**	**BS-M301 (AB-MATH)**	**GATE**
Friday	**BS-BIO301 (JM-PHY)**	**PC-ME301 (SP)**	**ES-ME301 (SY)**	**BS-M301 (AB-MATH)**	**RECESS**	**PC-ME302 (SNP)**	**GATE**	**GATE**

Faculty Abbreviation (Batch - A)

AD	ANISH DEB
DD	DEBERATA DAS
NK	NIKHIL KUMAR
AKR-ECE	AMIT KR RAI
SC-PHY	S. CHAKRABORTY
AB-MATH	ARNAB BANDYOPADHYAY (MATH)

Faculty Abbreviation (Batch - B)

SY	SURAJ YADAV
SNP	SARNENDU PAUL
SP	SRIJAN PAUL
IR-ECE	INTEKHAB HUSSAIN
JM-PHY	JOYSHREE MAJI
AB-MATH	ARNAB BANDYOPADHYAY (MATH)

Course Completion Odd 2021

Syllabus Coverage Details					
Program		B. Tech	*Department*		ECE
Course Name		Digital Communication & Stochastic Process	*Course Code*		EC-503
Session		2021 - 2022	*Batch*		1
SL. No.	**Module No.**	**Topics Covered**		**Hours Taken**	**Date of Completion**
1	1	Introduction to Digital Communication System		1	10.09.2021
2	1	Elements of Digital Communication System: Source Coding & Channel Coding		1	14.09.2021
3	1	Pulse Modulation and its Types		1	15.09.2021
4	1	Different Methods of Analog to Digital Converter		1	16.09.2021
5	1	ADVANTAGES & DISADVANTAGES OF DIGITAL COMMUNICATION		1	20.09.2021
6	1	Probability, Important Terms in probability, Random Variable		1	21.09.2021
7	1	Types of Random Variables: Discrete & Continuous Random Variable		1	22.09.2021
8	1	Joint Distribution, Marginal Probabilities,		1	23.09.2021
9	1	Joint Density & Marginal Densities		1	24.09.2021
10	1	Numerical on Cumulative Distribution function & Probability Density Function, Properties of Probability Density Function		1	28.09.2021
11	1	Ensemble Averagés: Mean of a Random Variable		1	29.09.21
12	1	Moment & Variance of Random Variable		1	30.09.21
13	1	Correlation : Positive Correlation, Negative Correlation, Covariance		1	01.10.21
14	1	Random Process: Definition, Sample Function, Ensemble, Types of Ensemble: Finite & Infinite Ensemble		1	05.10.21
15	1	Characterization & Specification of Random Process, Mean of a Random Process		1	07.10.21
16	1	Why do we need Ensemble statistics? Auto-correlation function in Random Process		1	08.10.21
17	1	Properties of Auto-correlation Function, Types of Random Process		1	21.10.21
18	1	Types of Random Process: Stationary Random Process, Non Stationary Random Process, Ergodic Random Process with Examples		1	22.10.21
20	1	Discrete Parameter & Discrete State Space, Discrete Parameter & Continuous State Space, Continuous Parameter & Discrete State Space, Continuous Parameter & Continuous State Space,		1	26.10.21
21	1	Markov Chain: Definition , State Transition Diagram, Examples of Markov Chain		1	27.10.21
22	1	Chapman Kolmogorov Equations, N-step transitions		1	02.11.21
23	1	Chapman Kolmogorov Equations & Problem Solving		1	03.11.21
24	2	Signal Vector Representation: Component of a Vector, Orthogonality of Vector		1	09.11.21
25	2	Orthogonal Vector Space		1	11.11.21
26	2	Orthogonal Signal Space		1	12.11.21
27	2	Conceptualized model of Digital Communication System		1	16.11.21
28	2	Geometric Representation of Signals, Gram Schmidt Orthogonalization Procedure		1	18.11.2021
29	2	Gram Schmidt Orthogonalization Procedure, Numerical on Finding Basis Function		1	22.11.2021
30	2	Synthesizer & Analyzer		1	22.11.21
31	2	Relationship Between Energy Content of a Signal and its Vector Representation		1	23.11.21
32	2	Response of Noisy Receiver, Likelihood functions		1	25.11.21
33	2	Maximum Likelihood Detector		1	26.11.21
34	2	Probability of Error, Error Functions, Q-Functions & Complementary Error Function.		1	02.12.21
35	4	Coherent Binary Phase Shift Keying		1	03.12.21

36	4	Coherent Binary Phase Shift Keying: Signal Space Diagram,	1	06.12.21
37	4	Generation & Detection, Error Probability of BPSK.	1	07.12.21
38	4	ERROR PROBABILITY OF QPSK, M-ARY TRANSMISSION	1	09.12.21
39	4	QUADRATURE PHASE SHIFT KEYING SIGNAL SPACE DIAGRAM	1	10.12.21
40	4	QPSK GENERATION & DETECTION, WAVEFORM REPRESENTATION	1	13.12.21
41	4	Error Probability of QPSK, OQPSK	1	14.12.21
42	4	M-ary Phase Shift Keying: Signal Space Diagram, Calculation of Error Probability	1	16.12.21
43	4	Differential Phase Shift Keying	1	17.12.21
44	4	Minimum Shift Keying: Trellis Diagram	1	20.12.21
45	4	Error Vector Magnitude, Receive Constellation Error	1	21.12.21
48	4	IIR filter design using butterworth and chebyshev method	1	23.12.21
49	3	Quantization, Quantization Noise, Quantization Noise Power	1	24.12.21
50	3	Quantization Error, Signal to Noise Ratio, Non-Uniform Quantization, A-Law & u-Law, Compressor, Expandor	1	03.01.22
51	3	Output SNR & Transmission Bandwidth, Exponential Increase in Transmission Bandwidth	1	04.01.22
52	3	Differential Pulse Code Modulation, SNR Improvement in DPCM	1	06.01.22
53	3	Delta Modulation, Block Diagram of Delta Transmitter & Receiver, Limitations of Delta Modualtion	1	07.01.22
54	3	Time Domain of Different Line Coding scheme, Power Spectral density of Various Line Codes	1	10.01.22
55	3	Pulse Shaping, Nyquist Criteria for Zero ISI, Eye Pattern	1	14.01.22

Akrar

Teacher Signature

[signature]

HOD Signature

INTRODUCTION TO DIGITAL COMMUNICATION SYSTEMS

Digital communication is a mode of communication where theinformation or the thought is encoded digitally as discrete signals and electronicallytransferred to the recipients .

A digital communication system is a communication system where the information signal sent from the transmitter to the receiver can be fully described as a digital signal.

5

THE NECESSITY OF DIGITIZATION

The conventional methods of communication used analog signals for long distance communications, which suffer from many losses such as distortion, interference, and other losses including security breach.

In order to overcome these problems, the signals are digitized using different techniques. The digitized signals allow the communication to be more clear and accurate without losses.

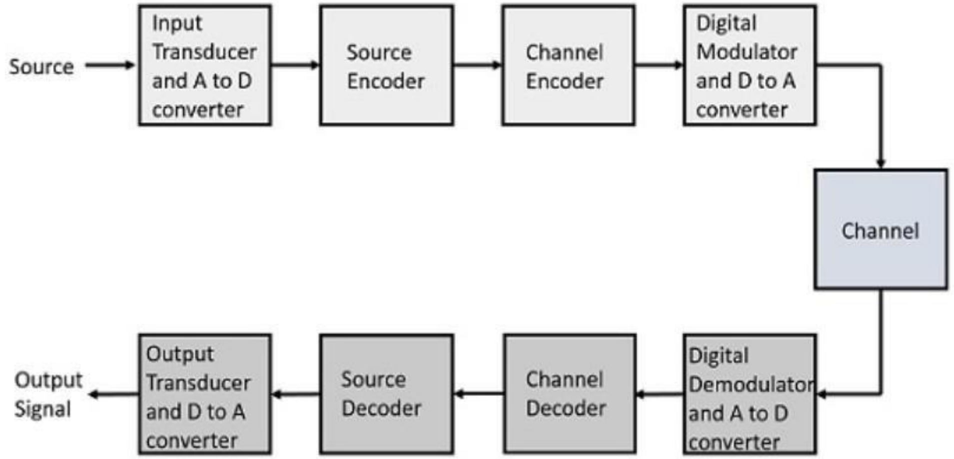
6

FEW EXAMPLES OF DIGITAL COMMUNICATION SYSTEM

- TELEVISION
- TELEPHONE
- COMPUTER PERIPHERALS
- REMOTE CONTROL HANDSET
- DOOR ENTRY SYSTEM
- VOICE ACTIVITY SYSTEM
- PRESSURE SWITCHES
- TOUCH PADS
- CONTROL PANEL
- DIGITAL WATCHES WITH INFRARED COMMUNICATION FACILITIES

7

Elements of Digital Communication

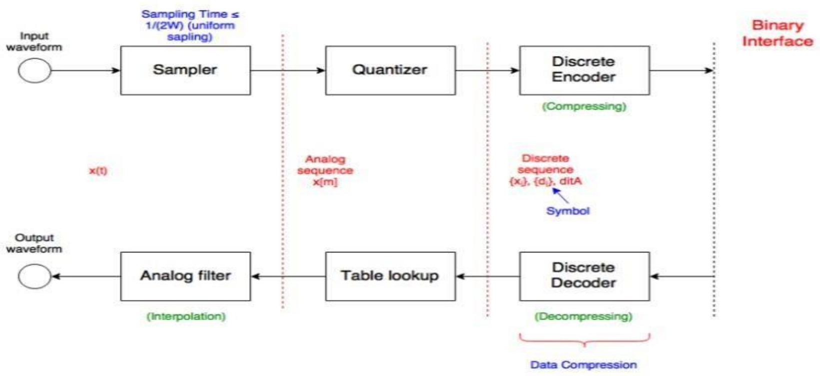


SOURCE CODING

Source encoding aims to convert information waveforms (text, audio, image, video, etc.) into bits, the universal currency of information in the digital world. The three major steps are:

- Sampling: convert the continuous-time analog waveform to discrete-time sequence (but still continuous-valued).
- Quantization: convert each continuous-valued symbol to discrete-valued representatives.
- Data compression: remove the redundancy in the data and generate roughly i.e.uniformly distributed bits. **Source decoding does the reverse of encoding**

Block Diagram of Source Coding



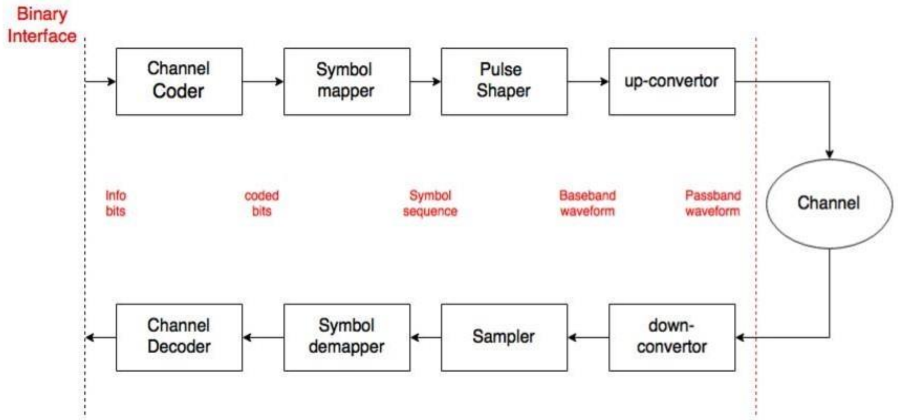
CHANNEL CODING

Channel encoding aims to convert information bits into passband waveforms bits, the universal currency of information in the digital world. The four major steps are:

- Error correcting codes: introduce redundancy into the information bits and produce longercoded bits.
- Symbol mapping: map the coded bits to constellation points, each of which is a complexsymbol.
- Pulse shaping: modulate the symbol to suitable baseband waveforms. There are somespecific conditions needed to be satisfied, which will be discussed in later lectures.
- Up conversion: convert the baseband waveform to passband waveform, so that theeffective frequency band follows the constraints from the physical world. Channel

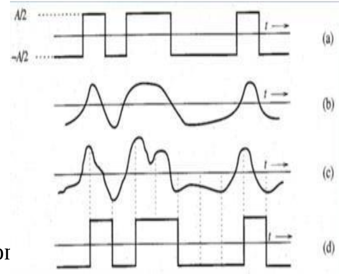
decoding does the reverse of encoding

Block Diagram of Channel Coding



Advantages of Digital Communication

- Digital communication is much more rugged than analog communication because it can with stand channel noise and distortion much better than analog communication as long as the noise and distortion are within limits.



- The greatest advantage of digital communicatior the viability of regenerative repeater in the former.

Advantages of Digital Communication

- The probability of error occurrence is reduced by employingand error correcting codes.
- Spread spectrum technique is used to avo
- Digital circuits are easy to desi
- The hardware imple
- The occu

Advantages of Digital Communication

- As the signals are digitized, there are many advantages of digital communication over analogcommunication .
- The effect of distortion, noise, and interference is much less in digital signals as they are lessaffected.
- Digital circuits are more reliable.
- The signal is un-altered as the pulse needs a high disturbance to alter its properties, which isvery difficult.
- Combining digital signals using Time Division Multiplexing is easier than combining analogsignals using Frequency Division Multiplexing
- Signal processing functions such as encryption and compression are employed in digitalcircuits to maintain the secrecy of the information.

COMPARISON BETWEEN ANALOG AND DIGITAL COMMUNICATION SYSTEM

Analog Communication	Digital Communication
Transmitted modulated signal is analog in nature.	Transmitted signal is digital i.e. train of digital pulses.
Amplitude, frequency or phase variations in the transmitted signal represent the information or message.	Amplitude, width or position of the transmitted pulses is constant. The message is transmitted in the form of code words.
Noise immunity is poor for AM, but improved for FM and PM.	Noise immunity is excellent.
It is not possible to separate out noise and signal. Therefore, repeaters cannot be used.	It is possible to separate signal from noise. Therefore, repeaters can be used.
Coding is not possible.	Coding techniques can be used to detect and correct the errors.
Bandwidth required is lower than that for the digital modulation method.	Due to higher bit rates, higher channel bandwidth is required.
Not Suitable for transmission secret information in military applications.	Due to coding techniques digital signals used for transmission of secret information
Analog systems are AM, FM, PM PAM, PWM and PDM,	Digital signals are PCM, DM, ADM and DPCM

MULTIPLE CHOICE QUESTIONS

1) In uniform quantization process
a. The step size remains same
b. Step size varies according to the values of the input signal
c. The quantizer has linear characteristics
d. Both a and c are correct
ANSWER: (d) Both a and c are correct

2) The process of converting the analog sample into discrete form is called
a. Modulation
b. Multiplexing
c. Quantization
d. Sampling
ANSWER:(c) Quantization

3) The characteristics of compressor in μ-law companding are
a. Continuous in nature
b. Logarithmic in nature
c. Linear in nature
d. Discrete in nature
ANSWER: (a) Continuous in nature

4) The modulation techniques used to convert analog signal into digital signal are
a. Pulse code modulation
b. Delta modulation
c. Adaptive delta modulation
d. All of the above
ANSWER: (d) All of the above

5) The sequence of operations in which PCM is done is
a. Sampling, quantizing, encoding
b. Quantizing, encoding, sampling
c. Quantizing, sampling, encoding
d. None of the above
ANSWER:(a) Sampling, quantizing, encoding

6) In PCM, the parameter varied in accordance with the amplitude of the modulating signal is
a. Amplitude
b. Frequency
c. Phase
d. None of the above
ANSWER: (d) None of the above

7) One of the disadvantages of PCM is
a. It requires large bandwidth
b. Very high noise
c. Cannot be decoded easily
d. All of the above
ANSWER: (a) It requires large bandwidth

8) The expression for bandwidth BW of a PCM system, where v is the number of bits per sample and f_m is the modulating frequency, is given by
a. $BW \geq vf_m$
b. $BW \leq vf_m$
c. $BW \geq 2\ vf_m$

d. BW ≥ 1/2 vf_m
ANSWER: (a) BW ≥ vf_m

9) The error probability of a PCM is
a. Calculated using noise and inter symbol interference
b. Gaussian noise + error component due to inter symbol interference
c. Calculated using power spectral density
d. All of the above
ANSWER: (d) All of the above

10) In Delta modulation,
a. One bit per sample is transmitted
b. All the coded bits used for sampling are transmitted
c. The step size is fixed
d. Both a and c are correct
ANSWER: (d) Both a and c are correct

11) In digital transmission, the modulation technique that requires minimum bandwidth is
a. Delta modulation
b. PCM
c. DPCM
d. PAM
ANSWER: (a) Delta modulation

12) In Delta Modulation, the bit rate is
a. N times the sampling frequency
b. N times the modulating frequency
c. N times the nyquist criteria
d. None of the above
ANSWER: (a) N times the sampling frequency

13) In Differential Pulse Code Modulation techniques, the decoding is performed by
a. Accumulator
b. Sampler
c. PLL
d. Quantizer
ANSWER: (a) Accumulator

14) DPCM is a technique
a. To convert analog signal into digital signal
b. Where difference between successive samples of the analog signals are encoded into n-bit data streams
c. Where digital codes are the quantized values of the predicted value
d. All of the above
ANSWER: (d) All of the above

15) DPCM suffers from
a. Slope over load distortion
b. Quantization noise
c. Both a & b
d. None of the above
ANSWER:(c) Both a & b

16) The noise that affects PCM
a. Transmission noise
b. Quantizing noise
c. Transit noise
d. Both a and b are correct
ANSWER: (d) Both a and b are correct

17) The factors that cause quantizing error in delta modulation are
a. Slope overload distortion
b. Granular noise
c. White noise
d. Both a and b are correct
ANSWER:(d) Both a and b are correct

18) Granular noise occurs when
a. Step size is too small
b. Step size is too large
c. There is interference from the adjacent channel
d. Bandwidth is too large
ANSWER: (b) Step size is too large

19) The crest factor of a waveform is given as –
a. 2Peak value/ rms value
b. rms value / Peak value
c. Peak value/ rms value
d. Peak value/ 2rms value
ANSWER: (c) Peak value/ rms value
20) The digital modulation technique in which the step size is varied according to the variation in the slope of the input is called
a. Delta modulation
b. PCM
c. Adaptive delta modulation
d. PAM
ANSWER: (c) Adaptive delta modulation

21) The digital modulation scheme in which the step size is not fixed is
a. Delta modulation
b. Adaptive delta modulation
c. DPCM
d. PCM
ANSWER:(b) Adaptive delta modulation

22) In Adaptive Delta Modulation, the slope error reduces and
a. Quantization error decreases
b. Quantization error increases
c. Quantization error remains same
d. None of the above
ANSWER: (b) Quantization error increases

23) The number of voice channels that can be accommodated for transmission in T1 carrier system is
a. 24
b. 32
c. 56
d. 64
ANSWER: (a) 24

24) The maximum data transmission rate in T1 carrier system is
a. 2.6 megabits per second
b. 1000 megabits per second
c. 1.544 megabits per second
d. 5.6 megabits per second
ANSWER: (c) 1.544 megabits per second

25) T1 carrier system is used

a. For PCM voice transmission
b. For delta modulation
c. For frequency modulated signals
d. None of the above
ANSWER: (a) For PCM voice transmission

26) Matched filter may be optimally used only for
a. Gaussian noise
b. Transit time noise
c. Flicker
d. All of the above
ANSWER:(a) Gaussian noise

27) Characteristics of Matched filter are
a. Matched filter is used to maximize Signal to noise ratio even for non Gaussian noise
b. It gives the output as signal energy in the absence of noise
c. They are used for signal detection
d. All of the above
ANSWER: (d) All of the above

28) Matched filters may be used
a. To estimate the frequency of the received signal
b. In parameter estimation problems
c. To estimate the distance of the object
d. All of the above
ANSWER: (d) All of the above

29) The process of coding multiplexer output into electrical pulses or waveforms for transmission is called
a. Line coding
b. Amplitude modulation
c. FSK
d. Filtering
ANSWER:(a) Line coding

30) For a line code, the transmission bandwidth must be
a. Maximum possible
b. As small as possible
c. Depends on the signal
d. None of the above
ANSWER: (b) As small as possible

31) Regenerative repeaters are used for
a. Eliminating noise
b. Reconstruction of signals
c. Transmission over long distances
d. All of the above
ANSWER:(d) All of the above

32) Scrambling of data is
a. Removing long strings of 1's and 0's
b. Exchanging of data
c. Transmission of digital data
d. All of the above
ANSWER: (a) Removing long strings of 1's and 0's

33) In polar RZ format for coding, symbol '0' is represented by
a. Zero voltage

b. Negative voltage
c. Pulse is transmitted for half the duration
d. Both b and c are correct
ANSWER: (d) Both b and c are correct

34) In a uni-polar RZ format,
a. The waveform has zero value for symbol ‘0’
b. The waveform has A volts for symbol ‘1’
c. The waveform has positive and negative values for ‘1’ and ‘0’ symbol respectively
d. Both a and b are correct
ANSWER: (d) Both a and b are correct

35) Polar coding is a technique in which
a. 1 is transmitted by a positive pulse and 0 is transmitted by negative pulse
b. 1 is transmitted by a positive pulse and 0 is transmitted by zero volts
c. Both a & b
d. None of the above
ANSWER: (a) 1 is transmitted by a positive pulse and 0 is transmitted by negative pulse

36) The polarities in NRZ format use
a. Complete pulse duration
b. Half duration
c. Both positive as well as negative value
d. Each pulse is used for twice the duration
ANSWER: (a) Complete pulse duration

37) The format in which the positive half interval pulse is followed by a negative half interval pulse for transmission of ‘1’ is
a. Polar NRZ format
b. Bipolar NRZ format
c. Manchester format
d. None of the above
ANSWER: (c) Manchester format

38) The maximum synchronizing capability in coding techniques is present in
a. Manchester format
b. Polar NRZ
c. Polar RZ
d. Polar quaternary NRZ
ANSWER: (a) Manchester format
39) The advantage of using Manchester format of coding is
a. Power saving
b. Polarity sense at the receiver
c. Noise immunity
d. None of the above
ANSWER: (a) Power saving

40) Alternate Mark Inversion (AMI) is also known as
a. Pseudo ternary coding
b. Manchester coding
c. Polar NRZ format
d. None of the above
ANSWER:(a) Pseudo ternary coding

41) In DPSK technique, the technique used to encode bits is
a. AMI
b. Differential code
c. Uni polar RZ format

d. Manchester format
ANSWER: (b)Differential code

42) The channel capacity according to Shannon's equation is
a. Maximum error free communication
b. Defined for optimum system
c. Information transmitted
d. All of the above
ANSWER: (d) All of the above

43) For a binary symmetric channel, the random bits are given as
a. Logic 1 given by probability P and logic 0 by (1-P)
b. Logic 1 given by probability 1-P and logic 0 by P
c. Logic 1 given by probability P^2 and logic 0 by 1-P
d. Logic 1 given by probability P and logic 0 by $(1-P)^2$
ANSWER: (a) Logic 1 given by probability P and logic 0 by (1-P)

44) The technique that may be used to increase average information per bit is
a. Shannon-Fano algorithm
b. ASK
c. FSK
d. Digital modulation techniques
ANSWER: (a) Shannon-Fano algorithm

45) Code rate r, k information bits and n as total bits, is defined as
a. r = k/n
b. k = n/r
c. r = k * n
d. n = r * k
ANSWER: (a) r = k/n

46) The information rate R for given average information H= 2.0 for analog signal band limited to B Hz is
a. 8 B bits/sec
b. 4 B bits/sec
c. 2 B bits/sec
d. 16 B bits/sec
ANSWER:(b) 4 B bits/sec

47) Information rate is defined as
a. Information per unit time
b. Average number of bits of information per second
c. rH
d. All of the above
ANSWER: (d) All of the above

48) The mutual information
a. Is symmetric
b. Always non negative
c. Both a and b are correct
d. None of the above
ANSWER: (c) Both a and b are correct

49) The relation between entropy and mutual information is
a. I(X;Y) = H(X) – H(X/Y)
b. I(X;Y) = H(X/Y) – H(Y/X)
c. I(X;Y) = H(X) – H(Y)
d. I(X;Y) = H(Y) – H(X)

ANSWER:(a) I(X;Y) = H(X) – H(X/Y)

50) Entropy is
a. Average information per message
b. Information in a signal
c. Amplitude of signal
d. All of the above
ANSWER: (a) Average information per message

51) The memory less source refers to
a. No previous information
b. No message storage
c. Emitted message is independent of previous message
d. None of the above
ANSWER: (c) Emitted message is independent of previous message

52) The information I contained in a message with probability of occurrence is given by (k is constant)
a. $I = k \log_2 1/P$
b. $I = k \log_2 P$
c. $I = k \log_2 1/2P$
d. $I = k \log_2 1/P^2$
ANSWER:(a) $I = k \log_2 1/P$

53) The expected information contained in a message is called
a. Entropy
b. Efficiency
c. Coded signal
d. None of the above
ANSWER: (a) Entropy

54) Overhead bits are
a. Framing and synchronizing bits
b. Data due to noise
c. Encoded bits
d. None of the above
ANSWER: (a) Framing and synchronizing bits

55) ISI may be removed by using
a. Differential coding
b. Manchester coding
c. Polar NRZ
d. None of the above
ANSWER: (a) Differential coding

56) Timing jitter is
a. Change in amplitude
b. Change in frequency
c. Deviation in location of the pulses
d. All of the above
ANSWER: (c) Deviation in location of the pulses

57) Probability density function defines
a. Amplitudes of random noise
b. Density of signal
c. Probability of error
d. All of the above
ANSWER: (a) Amplitudes of random noise

58) Impulse noise is caused due to
a. Switching transients
b. Lightening strikes
c. Power line load switching
d. All of the above
ANSWER: (d) All of the above

59) In coherent detection of signals,
a. Local carrier is generated
b. Carrier of frequency and phase as same as transmitted carrier is generated
c. The carrier is in synchronization with modulated carrier
d. All of the above
ANSWER: (d) All of the above

60) Synchronization of signals is done using
a. Pilot clock
b. Extracting timing information from the received signal
c. Transmitter and receiver connected to master timing source
d. All of the above
ANSWER:(d) All of the above

61) Graphical representation of linear block code is known as
a. Pi graph
b. Matrix
c. Tanner graph
d. None of the above
ANSWER: (c) Tanner graph

62) A linear code
a. Sum of code words is also a code word
b. All-zero code word is a code word
c. Minimum hamming distance between two code words is equal to weight of any non zero code word
d. All of the above
ANSWER: (d) All of the above

63) For decoding in convolution coding, in a code tree,
a. Diverge upward when a bit is 0 and diverge downward when the bit is 1
b. Diverge downward when a bit is 0 and diverge upward when the bit is 1
c. Diverge left when a bit is 0 and diverge right when the bit is 1
d. Diverge right when a bit is 0 and diverge left when the bit is 1
ANSWER: (a)Diverge upward when a bit is 0 and diverge downward when the bit is 1

64) The code in convolution coding is generated using
a. EX-OR logic
b. AND logic
c. OR logic
d. None of the above
ANSWER: (a) EX-OR logic
65) Interleaving process permits a burst of B bits, with l as consecutive code bits and t errors when
a. $B \le 2tl$
b. $B \ge tl$
c. $B \le tl/2$
d. $B \le tl$
ANSWER: (d) $B \le tl$

66) For a (7, 4) block code, 7 is the total number of bits and 4 is the number of
a. Information bits
b. Redundant bits

c. Total bits- information bits
d. None of the above
ANSWER: (a) Information bits

67) Parity bit coding may not be used for
a. Error in more than single bit
b. Which bit is in error
c. Both a & b
d. None of the above
ANSWER: (c) Both a & b

68) Parity check bit coding is used for
a. Error correction
b. Error detection
c. Error correction and detection
d. None of the above
ANSWER: (b) Error detection

69) For hamming distance d_{min} and t errors in the received word, the condition to be able to correct the errors is
a. $2t + 1 \leq d_{min}$
b. $2t + 2 \leq d_{min}$
c. $2t + 1 \leq 2d_{min}$
d. Both a and b
ANSWER: (d) Both a and b

70) For hamming distance d_{min} and number of errors D, the condition for receiving invalid codeword is
a. $D \leq d_{min} + 1$
b. $D \leq d_{min}{}^{-1}$
c. $D \leq 1 - d_{min}$
d. $D \leq d_{min}$
ANSWER:(b) $D \leq d_{min}{}^{-1}$

71) Run Length Encoding is used for
a. Reducing the repeated string of characters
b. Bit error correction
c. Correction of error in multiple bits
d. All of the above
ANSWER: (a) Reducing the repeated string of characters

72) The prefix code is also known as
a. Instantaneous code
b. Block code
c. Convolutional code
d. Parity bit
ANSWER: (a) Instantaneous code

73) The minimum distance for unextended Golay code is
a. 8
b. 9
c. 7
d. 6
ANSWER: (c) 7

74) The Golay code (23,12) is a codeword of length 23 which may correct
a. 2 errors
b. 3 errors
c. 5 errors

d. 8 errors
ANSWER: (b) 3 errors

75) Orthogonality of two codes means
a. The integrated product of two different code words is zero
b. The integrated product of two different code words is one
c. The integrated product of two same code words is zero
d. None of the above
ANSWER: (a) The integrated product of two different code words is zero

76) The probability density function of a Markov process is
a. p(x1,x2,x3…….xn) = p(x1)p(x2/x1)p(x3/x2)…….p(xn/xn-1)
b. p(x1,x2,x3…….xn) = p(x1)p(x1/x2)p(x2/x3)…….p(xn-1/xn)
c. p(x1,x2,x3……xn) = p(x1)p(x2)p(x3)…….p(xn)
d. p(x1,x2,x3……xn) = p(x1)p(x2 * x1)p(x3 * x2)……..p(xn * xn-1)
ANSWER:(a) p(x1,x2,x3…….xn) = p(x1)p(x2/x1)p(x3/x2)…….p(xn/xn-1)

77) The capacity of Gaussian channel is
a. C = 2B(1+S/N) bits/s
b. C = B^2(1+S/N) bits/s
c. C = B(1+S/N) bits/s
d. C = B(1+S/N)2 bits/s
ANSWER: (c) C = B(1+S/N) bits/s

78) For M equally likely messages, the average amount of information H is
a. H = $\log_{10}M$
b. H = $\log_2 M$
c. H = $\log_{10}M^2$
d. H = $2\log_{10}M$
ANSWER:(b) H = $\log_2 M$

79) The channel capacity is
a. The maximum information transmitted by one symbol over the channel
b. Information contained in a signal
c. The amplitude of the modulated signal
d. All of the above
ANSWER: (a) The maximum information transmitted by one symbol over the channel

80) The capacity of a binary symmetric channel, given H(P) is binary entropy function is
a. 1 – H(P)
b. H(P) – 1
c. $1 - H(P)^2$
d. $H(P)^2 - 1$
ANSWER:(a) 1 – H(P)

81) According to Shannon Hartley theorem,
a. The channel capacity becomes infinite with infinite bandwidth
b. The channel capacity does not become infinite with infinite bandwidth
c. Has a tradeoff between bandwidth and Signal to noise ratio
d. Both b and c are correct
ANSWER: (d) Both b and c are correct

82) The negative statement for Shannon's theorem states that
a. If R > C, the error probability increases towards Unity
b. If R < C, the error probability is very small
c. Both a & b
d. None of the above
ANSWER: (a) If R > C, the error probability increases towards Unity

83) For M equally likely messages, M>>1, if the rate of information R ≤ C, the probability of error is
a. Arbitrarily small
b. Close to unity
c. Not predictable
d. Unknown
ANSWER: (a) Arbitrarily small

84) For M equally likely messages, M>>1, if the rate of information R > C, the probability of error is
a. Arbitrarily small
b. Close to unity
c. Not predictable
d. Unknown
ANSWER: (b) Close to unity

85) In Alternate Mark Inversion (AMI) is
a. 0 is encoded as positive pulse and 1 is encoded as negative pulse
b. 0 is encoded as no pulse and 1 is encoded as negative pulse
c. 0 is encoded as negative pulse and 1 is encoded as positive pulse
d. 0 is encoded as no pulse and 1 is encoded as positive or negative pulse
ANSWER: (b) 0 is encoded as no pulse and 1 is encoded as positive or negative pulse

86) Advantages of using AMI
a. Needs least power as due to opposite polarity
b. Prevents build-up of DC
c. May be used for longer distance
d. All of the above
ANSWER: (d)All of the above

87) The interference caused by the adjacent pulses in digital transmission is called
a. Inter symbol interference
b. White noise
c. Image frequency interference
d. Transit time noise
ANSWER: (a) Inter symbol interference

88) Eye pattern is
a. Is used to study ISI
b. May be seen on CRO
c. Resembles the shape of human eye
d. All of the above
ANSWER: (d) All of the above

89) The time interval over which the received signal may be sampled without error may be explained by
a. Width of eye opening of eye pattern
b. Rate of closure of eye of eye pattern
c. Height of the eye opening of eye pattern
d. All of the above
ANSWER:(a) Width of eye opening of eye pattern

90) For a noise to be white Gaussian noise, the optimum filter is known as
a. Low pass filter
b. Base band filter
c. Matched filter
d. Bessel filter
ANSWER:(c) Matched filter

91) Matched filters are used
a. For maximizing signal to noise ratio
b. For signal detection
c. In radar
d. All of the above
ANSWER: (d) All of the above

92) The number of bits of data transmitted per second is called
a. Data signaling rate
b. Modulation rate
c. Coding
d. None of the above
ANSWER: (a) Data signaling rate

93) Pulse shaping is done
a. to control Inter Symbol Interference
b. by limiting the bandwidth of transmission
c. after line coding and modulation of signal
d. All of the above
ANSWER: (d) All of the above

94) The criterion used for pulse shaping to avoid ISI is
a. Nyquist criterion
b. Quantization
c. Sample and hold
d. PLL
ANSWER: (a) Nyquist criterion

95) The filter used for pulse shaping is
a. Raised – cosine filter
b. Sinc shaped filter
c. Gaussian filter
d. All of the above
ANSWER: (d) All of the above

96) Roll – off factor is defined as
a. The bandwidth occupied beyond the Nyquist Bandwidth of the filter
b. The performance of the filter or device
c. Aliasing effect
d. None of the above
ANSWER: (a) The bandwidth occupied beyond the Nyquist Bandwidth of the filter

97) Nyquist criterion helps in
a. Transmitting the signal without ISI
b. Reduction in transmission bandwidth
c. Increase in transmission bandwidth
d. Both a and b
ANSWER: (d) Both a and b

98) The Nyquist theorem is
a. Relates the conditions in time domain and frequency domain
b. Helps in quantization
c. Limits the bandwidth requirement
d. Both a and c
ANSWER: (d) Both a and c

99) The difficulty in achieving the Nyquist criterion for system design is
a. There are abrupt transitions obtained at edges of the bands

b. Bandwidth criterion is not easily achieved
c. Filters are not available
d. None of the above
ANSWER: (a) There are abrupt transitions obtained at edges of the bands

100) Equalization in digital communication
a. Reduces inter symbol interference
b. Removes distortion caused due to channel
c. Is done using linear filters
d. All of the above
ANSWER: (d) All of the above

101) Zero forced equalizers are used for
a. Reducing ISI to zero
b. Sampling
c. Quantization
d. None of the above
ANSWER: (a)Reducing ISI to zero

102) The transmission bandwidth of the raised cosine spectrum is given by
a. $B_t = 2w(1 + \alpha)$
b. $B_t = w(1 + \alpha)$
c. $B_t = 2w(1 + 2\alpha)$
d. $B_t = 2w(2 + \alpha)$
ANSWER: (a) $B_t = 2w(1 + \alpha)$

103) The preferred orthogonalization process for its numerical stability is
a. Gram- Schmidt process
b. House holder transformation
c. Optimization
d. All of the above
ANSWER: (b) House holder transformation

104) For two vectors to be orthonormal, the vectors are also said to be orthogonal. The reverse of the same
a. Is true
b. Is not true
c. Is not predictable
d. None of the above
ANSWER: (b) Is not true

105) Orthonormal set is a set of all vectors that are
a. Mutually orthonormal and are of unit length
b. Mutually orthonormal and of null length
c. Both a & b
d. None of the above
ANSWER: (a) Mutually orthonormal and are of unit length

106) In On-Off keying, the carrier signal is transmitted with signal value ‘1’ and ‘0’ indicates
a. No carrier
b. Half the carrier amplitude
c. Amplitude of modulating signal
d. None of the above
ANSWER: (a) No carrier

107) ASK modulated signal has the bandwidth
a. Same as the bandwidth of baseband signal
b. Half the bandwidth of baseband signal

c. Double the bandwidth of baseband signal
d. None of the above
ANSWER: (a) Same as the bandwidth of baseband signal

108) Coherent detection of binary ASK signal requires
a. Phase synchronization
b. Timing synchronization
c. Amplitude synchronization
d. Both a and b
ANSWER: (d) Both a and b

109) The probability of error of DPSK is _______________ than that of BPSK.
a. Higher
b. Lower
c. Same
d. Not predictable
ANSWER: (a) Higher

110) In Binary Phase Shift Keying system, the binary symbols 1 and 0 are represented by carrier with phase shift of
a. Π/2
b. Π
c. 2Π
d. 0
ANSWER: (b) Π

111) BPSK system modulates at the rate of
a. 1 bit/ symbol
b. 2 bit/ symbol
c. 4 bit/ symbol
d. None of the above
ANSWER: (a) 1 bit/ symbol

112) The BPSK signal has +V volts and -V volts respectively to represent
a. 1 and 0 logic levels
b. 11 and 00 logic levels
c. 10 and 01 logic levels
d. 00 and 11 logic levels
ANSWER: (a) 1 and 0 logic levels

113) The binary waveform used to generate BPSK signal is encoded in
a. Bipolar NRZ format
b. Manchester coding
c. Differential coding
d. None of the above
ANSWER: (a) Bipolar NRZ format

114) The bandwidth of BFSK is _______________ than BPSK.
a. Lower
b. Same
c. Higher
d. Not predictable
ANSWER: (c) Higher

115) In Binary FSK, mark and space respectively represent
a. 1 and 0
b. 0 and 1
c. 11 and 00

d. 00 and 11
ANSWER: (a) 1 and 0
116) The frequency shifts in the BFSK usually lies in the range
a. 50 to 1000 Hz
b. 100 to 2000 Hz
c. 200 to 500 Hz
d. 500 to 10 Hz
ANSWER: (a) 50 to 1000 Hz

117) The spectrum of BFSK may be viewed as the sum of
a. Two ASK spectra
b. Two PSK spectra
c. Two FSK spectra
d. None of the above
ANSWER: (a) Two ASK spectra

118) The maximum bandwidth is occupied by
a. ASK
b. BPSK
c. FSK
d. None of the above
ANSWER: (c) FSK

119) QPSK is a modulation scheme where each symbol consists of
a. 4 bits
b. 2 bits
c. 1 bits
d. M number of bits, depending upon the requireme
ANSWER: (b) 2 bits

120) The data rate of QPSK is ___________ of BPSK.
a. Thrice
b. Four times
c. Twice
d. Same
ANSWER: (c) Twice

121) QPSK system uses a phase shift of
a. Π
b. Π/2
c. Π/4
d. 2Π
ANSWER: (b) Π/2

122) Minimum shift keying is similar to
a. Continuous phase frequency shift keying
b. Binary phase shift keying
c. Binary frequency shift keying
d. QPSK
ANSWER: (a) Continuous phase frequency shift keying

123) In MSK, the difference between the higher and lower frequency is
a. Same as the bit rate
b. Half of the bit rate
c. Twice of the bit rate
d. Four time the bit rate
ANSWER: (b) Half of the bit rate

124) The technique that may be used to reduce the side band power is
a. MSK
b. BPSK
c. Gaussian minimum shift keying
d. BFSK
ANSWER: (c) Gaussian minimum shift keying

125) Which circuit is called as regenerative repeaters?
a) Analog circuits
b) Digital circuits
c) Amplifiers
d) A/D converters
ANSWER : c) Amplifiers
126. What are the advantages of digital circuits?
a) Less noise
b) Less interference
c) More flexible
d) All of the mentioned
ANSWER : d) All of the mentioned

127. How many different combinations can be made from a n bit value?
a) $2^{(n+1)}$
b) $2^{(n)}$
c) $2^{(n)}+1$
d) None of the mentioned
ANSWER : b) $2^{(n)}$

128. Data transmitted for a given amount of time is called ________
a) Noise
b) Power
c) Frequency
d) Bandwidth
ANSWER : d) Bandwidth

129. Which block or device does the data compression?
a) Channel encoder
b) Source encoder
c) Modulator
d) None of the mentioned
ANSWER : d) None of the mentioned

130. Pulse shaping is done by which block or system?
a) Encoder
b) Baseband modulator
c) Pulse code modulator
d) Demodulator
ANSWER : d) Demodulator

SAMPLE QUESTION PAPERS CO WISE

Sample Questions

CO I & CO II Level Low

1. Draw the block diagram of digital communication system.
2. Write down the advantages and disadvantages of digital communication system.
3. What is conditional probability?
4. What do you mean by statistical independence?
5. What do you mean by Random variable?
6. What are the types of Random variables? Explain with examples.
7. Define cumulative density function.
8. Write down the properties of CDF.
9. Define probability density function.
10. Define joint & conditional CDF.
11. Define joint & conditional PDF.
12. What are the statistical averages of Random Variable?
13. Define mean of a Random Variable with example.
14. Define standard deviation of Random Variable.
15. Define Correlation of Random Variable?
16. Define Gaussian, Rayleigh & Rician PDF.
17. Define co-variance of Random Variable.
18. Define Random Process.
19. Define ensemble mean.
20. Random process is a collection of infinite number of random variables. Justify.
21. How do you characterize a random process?
22. How do you specify a Random Process?
23. Define auto-correlation in random process.
24. What are the properties of an Auto correlation function?
25. What is the classification of random process? Explain them.
26. What do you mean by wide-sense stationary random process?
27. Explain stationary and non-stationary random process with examples.
28. Define power spectral density of a random process.
29. Define component of a signal.
30. What do you mean by orthogonal signal space?
31. Define basis function.
32. Prove Gram-Schmidt orthogonalization procedure.
33. Define geometric interpretation of signals.
34. Define likelihood functions.
35. Define Maximum Likelihood Functions.

36. What is observation space related to likelihood function?
37. Define Probability of Error.
38. Define Error Functions and its types.
39. Define properties of Error Function.
40. Explain correlation receiver?

CO I & CO II Level Medium

1. Define Gaussian, Rayleigh & Rician PDF.
2. Define co-variance of Random Variable.
3. Explain with examples positive & negative correlations.
4. Mathematically specify the definitions for RVs being uncorrelated, and RVs being independent.
5. Prove that RVs that are independent are by definition also uncorrelated.
6. Prove that RVs can be uncorrelated but not independent (by example).
7. Random process is a collection of infinite number of random variables. Justify.
8. How do you characterize a random process?
9. How do you specify a Random Process?
10. Define auto-correlation in random process.
11. What are the properties of an Auto correlation function?
12. Graphically show that how autocorrelation function depends on τ (separation time).
13. What do you mean by wide-sense stationary random process?
14. Explain stationary and non-stationary random process with examples.
15. Define power spectral density of a random process.
16. Prove that the power spectral density of a random process is the Fourier transform of an auto-correlation function of random process.
17. Draw the conceptualized model of digital passband transmission.
18. Prove Gram-Schmidt orthogonalization procedure.
19. Explain Schwartz inequality in geometric representation.
20. Explain the receiver response in presence of noise.

CO I & CO II Level Hard

1. Random variable is a misnomer. Justify?
2. Mathematically specify the definitions for RVs being uncorrelated, and RVs being independent.
3. Prove that RVs that are independent are by definition also uncorrelated.
4. Prove that RVs can be uncorrelated but not independent (by example).
5. Random process is a collection of infinite number of random variables. Justify.
6. Graphically show that how autocorrelation function depends on τ (separation time).
7. Prove that the power spectral density of a random process is the Fourier transform of an auto-correlation function of random process.

CO III & CO IV Level Low

1. State sampling theorem.

2. State and Prove sampling theorem.
3. Define Nyquist rate and interval.
4. What are the practical difficulties in signal reconstruction?
5. Draw the block diagram of PCM transmitter and receiver.
6. Define regenerative repeaters with proper block diagram
7. Define quantization.
8. Define quantization noise.
9. Define non-uniform quantization.
10. Draw the characteristics of non-uniform quantization.
11. What are the types of non-uniform quantization?
12. Define A-law and μ law.
13. Draw the characteristics of A-law and μ law.
14. Write down the expression of A-law and μ law.
15. Define Companding in pulse code modulation.
16. Draw the characteristics of companding in PCM.
17. Draw the block diagram of Differential Pulse Code modulation.
18. Prove that how SNR improves with bandwidth in DPCM.
19. Explain delta modulation for analog to digital conversion.
20. Draw the block diagram of Delta modulator and demodulator.
21. What are the limitations of delta modulation?
22. Define Slope overload distortion and granular noise in Delta modulation.
23. What is the solution of limitations present in Delta modulation?
24. Draw the block diagram of Adaptive Delta modulator and demodulator.
25. What do you mean by Line Coding?
26. What are the components of digital communication system?
27. Write down the properties of Line Coding.
28. What do you mean by transparency in line coding?
29. What do you mean by electrical representation of digital signal?
30. What are the different types of line coding scheme?
31. Define AMI line coding scheme.
32. Draw the power spectrum of different line coding schemes.
33. Explain the advantages and disadvaok3ntages of different line coding schemes.
34. Compare different line coding schemes in terms of bandwidth utilization.
35. Define differential encoding and draw the electrical representation for the binary sequence 1011100.
36. Which line coding scheme has error checking probability?
37. What is Pulse shaping in baseband transmission?
38. What is Inter symbol interference in pulse shaping?
39. What do you mean by zero forcing equalizer?
40. Draw and explain eye pattern.

CO III & CO IV Level Medium

1. Explain interpolation formulae of signal reconstruction.
2. Explain aliasing and its effect with proper diagram.
3. Define regenerative repeaters with proper block diagram
4. Explain early late gate synchronizer for synchronization in pulse shaping.
5. Prove that in uniform quantization, quantization noise is proportional to step size.
6. Write down the expression of A-law and μ law.
7. Find out the theoretical minimum bandwidth in PCM.
8. Explain Differential Pulse Code Modulation.
9. Explain Differential Pulse Code modulation.
10. Prove that how SNR improves with bandwidth in DPCM.
11. Explain delta modulation for analog to digital conversion.
12. Explain Adaptive Delta Modulation.
13. For a given sequence 1010101100 draw the electrical representation for following line codes (a) Polar NRZ & RZ (c) Unipolar RZ & NRZ (e) Bipolar RZ & NRZ

(d) Manchester Encoding

14. Draw the power spectrum of different line coding schemes.
15. Explain the advantages and disadvantages of different line coding schemes.
16. Compare different line coding schemes in terms of bandwidth utilization.
17. Define differential encoding and draw the electrical representation for the binary sequence 1011100.
18. What is Pulse shaping in baseband transmission?
19. What is Inter symbol interference in pulse shaping?
20. What are Nyquist criteria for zero ISI?
21. What do you mean by raised cosine pulse in pulse shaping?
22. Explain the working of tapped delay line equalizer with proper block diagram.

CO III & CO IV Level Hard

1. Prove that how SNR improves with bandwidth in DPCM.
2. The information in an analog waveform, with maximum frequency fm=3 KHz, is to be transmitted over M level PCM system, where number of pulse level M=16. The quantization distortion is specified not to exceed ±1% of the peak-to-peak analog signal.

(a)What is the minimum number of bits/sample, or bits/PCM word that should be used in this PCM system.

(b)What is the minimum required sampling rate, and what is the resulting bit transmission rate.

(c) What is the PCM pulse or symbol transmission rate.

3. A Delta modulator is used to encode speech signal band-limited to 3KHz with sampling frequency 100 KHz. For ±1 volt peak signal voltage, find

(a) Minimum step size to avoid slope overloading.

(b) Signal to quantization noise ratio if speech is assumed to have nonuniform probability density function (PDF).

4. Derive the power spectrum of Polar RZ line coding schemes.
5. Explain the advantages and disadvantages of different line coding schemes.
6. What do you mean by raised cosine pulse in pulse shaping?
7. Explain the working of tapped delay line equalizer with proper block diagram.
8. A signal m(t) band-limited to 3 kHz is sampled at a rate 33.33% higher than the Nyquist rate. The maximum acceptable error in the sample amplitude is 0.5% of the peak amplitude mp. The quantized samples are binary coded. Find the minimum bandwidth of a channel required to transmit the encoded binary signal. If 24 such signals are time-division multiplexed, determine the minimum transmission bandwidth required to transmit the multiplexed signal.

CO V & CO VI Level Low

1. What are the basic digital modulation techniques?
2. Draw the modulated waveforms of basic digital modulation techniques.
3. Draw the hierarchy of digital modulation techniques.
4. Draw the signal space diagram of coherent binary phase shift keying.
5. Draw the signal space characteristics of coherent binary phase shift keying.
6. Draw the signal space diagram of coherent binary frequency shift keying.
7. Draw the signal space characteristics of coherent binary frequency shift keying.
8. Draw the signal space diagram of coherent binary quadrature phase shift keying.
9. Draw the signal space characteristics of coherent quadrature phase shift keying.
10. Define M-ary modulation with examples.
11. Show how power and energy are related in M-ary modulation.
12. Draw the signal space diagram of coherent M-ary octaphase shift keying.
13. Draw the signal space characteristics of coherent M-ary octaphase shift keying.
14. Define Trellis diagram.
15. Define Gaussian Minimum Shift Keying.
16. Compare the bandwidth of MSK & GMSK.
17. Draw the signal space diagram of non-coherent differential binary phase shift keying.
18. Draw the signal space characteristics of non-coherent differential binary phase shift keying.
19. Explain the generation and detection of non-coherent differential binary phase shift keying.
20. Find out the error probability of non-coherent differential binary phase shift keying.
21. Define error vector magnitude.
22. What are the performance issues of digital communication system?

CO V & CO VI Level Medium

1. Find out the error probability of coherent binary phase shift keying.
2. Find out the error probability of coherent binary frequency shift keying.
3. Draw the signal space diagram of coherent binary quadrature phase shift keying.
4. Find out the error probability of coherent quadrature phase shift keying.
5. Explain differential phase shift keying for non-coherent digital modulation.
6. Show how power and energy are related in M-ary modulation.
7. Find out the error probability of coherent M-ary octa phase shift keying.
8. Draw the signal space diagram of coherent Minimum Shift Keying.
9. Draw the signal space characteristics of coherent Minimum Shift Keying.
10. Explain the generation and detection of coherent Minimum Shift Keying.
11. Find out the error probability of coherent binary Minimum Shift Keying.
12. Define Trellis diagram.
13. Define Gaussian Minimum Shift Keying.
14. Compare the bandwidth of MSK & GMSK.
15. Draw the signal space diagram of non-coherent differential binary phase shift keying.
16. Draw the signal space characteristics of non-coherent differential binary phase shift keying.
17. Explain the generation and detection of non-coherent differential binary phase shift keying.
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CO V & CO VI Level Hard

1. Find out the error probability of coherent binary frequency shift keying.
2. Find out the error probability of coherent quadrature phase shift keying.
3. Find out the error probability of coherent M-ary octa phase shift keying.
4. Draw the signal space diagram of coherent Minimum Shift Keying.
5. Draw the signal space characteristics of coherent Minimum Shift Keying.
6. Explain the generation and detection of coherent Minimum Shift Keying.
7. Find out the error probability of coherent binary Minimum Shift Keying.
8. Draw the signal space characteristics of non-coherent differential binary phase shift keying.
9. Explain the generation and detection of non-coherent differential binary phase shift keying.
10. Find out the error probability of non-coherent differential binary phase shift keying.
11. (a) A binary source generates digits 1 and 0 randomly with equal probability. Assign probabilities to the following events with respect to 10 digits generated by the source : (1) there are exactly two 1s and eight 0s. (2) there are at least four 0s. (b) Consider an AWGN channel with 4-kHz bandwidth and the noise power spectral density η / 2 = 10-12 W/Hz. The signal power required at the receiver is 0.1 mW. Calculate the capacity of this channel.

MAULANA ABUL KALAM AZAD UNIVERSITY OF TECHNOLOGY, WEST BENGAL

Paper Code : EC-601

DIGITAL COMMUNICATION

Time Allotted : 3 Hours *Full Marks* : 70

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

GROUP – A
(Multiple Choice Type Questions)

1. Choose the correct alternatives for and any *ten* of the following : 10 × 1 = 10

i) In the present day standard digital voice communication, the amplitude of the voice signal is sampled at a rate of around
- a) 2000 samples/sec
- b) 800 samples/sec
- c) 16000 samples/sec
- d) 8000 samples/sec.

ii) Which of the following modulation is digital in nature ?
- a) PAM b) PPM
- c) DM d) None of these.

iii) Quantization noise occurs in
- a) PAM b) PWM
- c) DM d) None of these.

iv) Pulse stuffing is used in
- a) Synchronous TDM
- b) Asynchronous TDM
- c) Any TDM
- d) None of these.

v) The main advantage of PCM is
- a) less bandwidth
- b) less power
- c) better performance in presence of noise
- d) possibility of multiplexing.

vi) The number of bits per sample in a PCM system is increased from 8 to 16. The bandwidth of the system will increase
- a) 8 times b) 2 times
- c) $\frac{1}{2}$ time d) 2^8 times.

vii) The line code that has zero d.c. component for pulse transmission of random Binary data is
- a) UP-NRZ b) UP-RZ
- c) BPRZ-AMI d) BPNRZ.

viii) Flat-top sampling leads to
- a) an aperture effect b) Aliasing
- c) loss of the signal d) none of these.

ix) The main advantage of TDM over FDM is that it
- a) needs less power
- b) needs less bandwidth
- c) needs simple circuitry
- d) gives better S/N ratio.

x) A PAM signal can be detected by using
- a) an ADC b) an integrator
- c) a bandpass filter d) a highpass filter.

xi) Which of the following gives the minimum probability of error ?
- a) ASK b) FSK
- c) PSK d) DPSK.

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   a) ASK b) FSK
   c) PSK d) DPSK.

Asansol Engineering College

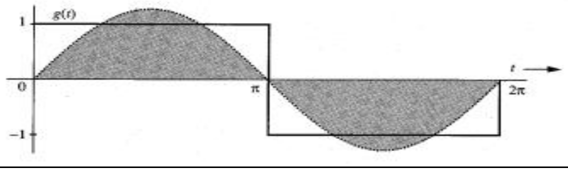
Department of Electronics & Communication Engineering

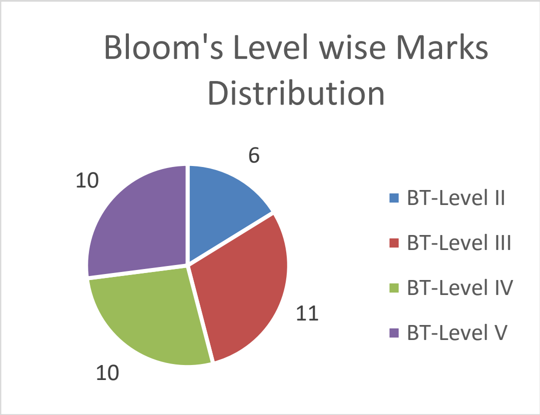
Course: Digital Communication & Stochastic Process (ECE)

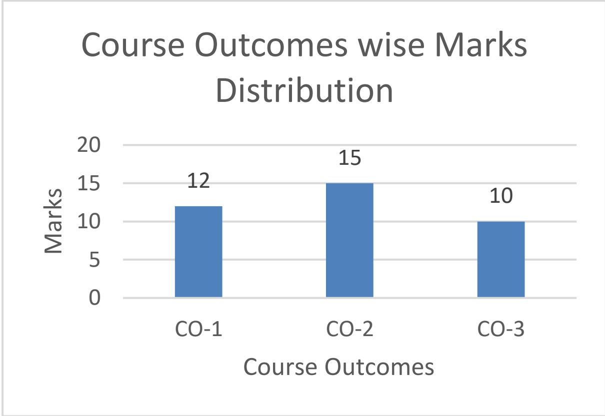
Semester: V Code: EC 503

Time: 1 Hour ***Full Marks: 25***

Class Test CA-3 Odd Semester-2022

Q. No	A) Multiple Choice Questions **(Answer any 5)**	Marks	Course Outcome	BT Level
1.	Binomial distribution deals with a) Continuous random variable b) Discrete random variable c) Continuous & Discrete random variable d) None of the mentioned	1	CO-1	II
2.	The type of distortion which occurs in delta modulation is a) Slope overload distortion b) Granular noise c) Slope overload distortion & Granular noise d) None of the mentioned	1	CO-3	II
3.	For a stationary process, the auto correlation function depends on a)Time b)Time difference c) Doesn't depend on time d)None of the above	1	CO-1	II
4.	The signals which are obtained by encoding each quantized signal into a digital word is called as a) PAM signal b) PCM signal c) FM signal d) Sampling and Quantization	1	CO-3	II
5.	Minimum bandwidth is required for a)PCM. b) DPCM. c) ADM. d)DM.	1	CO-3	II
6.	Quantization noise can be reduced by ________ the number of levels. a) decreasing b) increasing c) doubling d) squaring	1	CO-3	II
7.	In a M-ary transmission if four symbols are transmitted, then the baud rate of the system will …………………of the bit rate. A) half b) doubled c) one-fourth d) one-third	1	CO-3	III
Q. No.	B) Short Answer Type Questions **(Answer any 4)**	Marks	Course Outcome	BT Level
8.	Consider a Markov chain with two states 0 & 1. The transition matrix has the form $P = \begin{bmatrix} \frac{1}{3} & \frac{2}{3} \\ \frac{1}{2} & \frac{1}{2} \end{bmatrix}$. Calculate the following transition matrix. $P(X_2 = 0/X_0 = 1)$ & $P(X_1 = 1/X_0 = 0)$	5	CO-1	V
9.	Explain Chapman Kolmogorov Equation and how it is related to Markov Chain. **OR** How can you illustrate the phenomena of Companding?	5	CO-1	III
10.	For a square signal g(t) shown below, find the compeonent of g(t) of the form sin t. In other words , appoximate g(t) in terms of sin t. g(t) ≈ csin t $0 \le t \le 2\pi$ so that the energy of the error signal is maximum. 	5	CO-2	IV
11.	Prove Gram Schmidt Orthogonalization Procedure to find the orthonormal basis functions for a given set of signals. **OR** How can you quantize an analog signal-briefly illustrate the same?	5	CO-2	V
12.	Explain Delta & Adaptive Delta Modulation. Discuss the drawbacks of Delta modulation and how it can be solved in Adaptive Delta Modulation.	5	CO-3	III
13.	Explain Maximum Likelihood Decision Rule and draw an observation space for case M=3 & N=2 and label it. OR Draw the block diagram of a PCM transmitter & receiver?	5	CO-2	IV


Bloom's Level wise Marks Distribution
6
11
10
10
BT-Level II
BT-Level III
BT-Level IV
BT-Level V


Course Outcomes wise Marks Distribution
Marks
20
15
10
5
0
12
15
10
CO-1
CO-2
CO-3
Course Outcomes

Asansol Engineering College

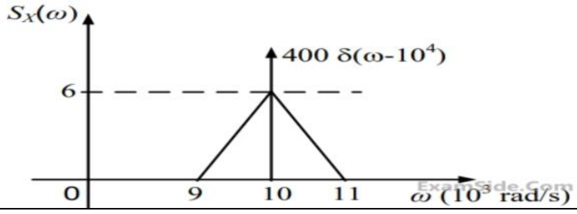
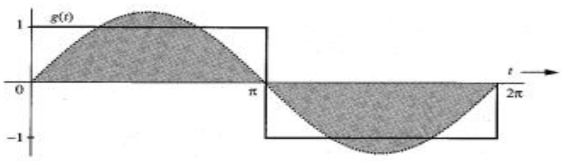
Department of ECE

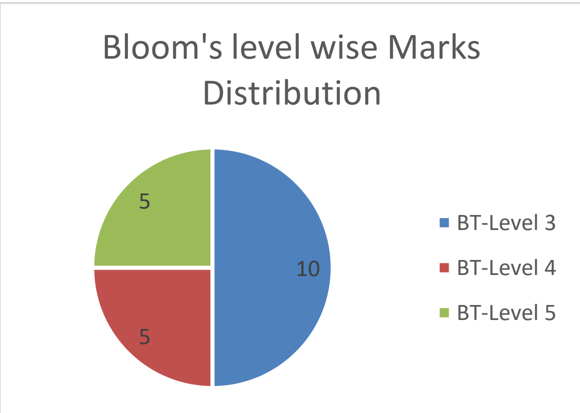
Course: Digital Communication & Stochastic Process (ECE)

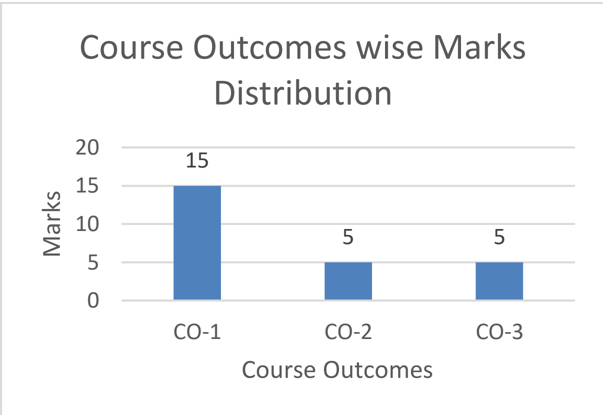
Semester: V Code: EC-503

***Full Marks*: 25**

Assignment CA-2 Odd-2022

ANSWER ALL QUESTIONS				
Q. No	Question	Marks	Course Outcome	BT Level
1.	Consider the random process x(t) = U + Vt. where U is a zero mean Gaussian random variable and V is a random variable uniformly distributed between 0 and 2. Assume that U and V are statistically independent. The mean value of the random process at t = 2 is	05	CO-1	BT-4
2.	The power spectral density of a real process X(t) for positive frequencies is shown below. The value of $E[X^2(t)]$ and E[X(t)], respectively, are 	05	CO-1	BT-5
3.	A speech signal is sampled at 8 kHz and encoded into PCM format using 8 bits/sample. The PCM data is transmitted through a baseband channel via 4-level PAM. The minimum bandwidth (in kHz) required for transmission is __________.	05	CO-3	BT-3
4.	Consider a Markov chain with two states $X \in \{0, 1\}$. The transition matrix has the form: $P = \begin{pmatrix} \frac{1}{3} & \frac{2}{3} \\ \frac{1}{2} & \frac{1}{2} \end{pmatrix}$. Calculate the following transition probabilities: $P(X_1 = 1 \mid X_0 = 0)$ $P(X_2 = 0 \mid X_0 = 1)$ $P(X_3 = 0 \mid X_0 = 0)$	05	CO-1	BT-4
5	For a square signal g(t) shown below, find the compeonent of g(t) of the form sin t. In other words , appoximate g(t) in terms of sin t. $g(t) \approx c \sin t \quad 0 \le t \le 2\pi$ so that the energy of the error signal is maximum. 	05	CO-2	BT-3





29/10/2021
9:40 AM

Name - Pranoy Dhar, Roll- 10801619054
Sec-A, Dept - ECE, Session-(2019-2023)
Subject Code : EC503, Subject - Digital Communication & Stochastic process

25

Group-B

2. In case of Random Variable, the variable itself is not random, the possible values of the Random Variable is already known to us, either in a discreate manner or continuous, but at what time of testing which value will be there for the variable is totally unknown, thus, the term 'Random Variable' is a misnomer.

2

$$f_{xy}(x,y) = e^{-(x+y)}, \quad x \geq 0,\ y \geq 0$$

$$\int_0^\infty \int_0^\infty e^{-(x+y)}\, dx\, dy =$$

$$= \int_0^\infty \int_0^\infty e^{-x} \cdot e^{-y}\, \partial x \cdot \partial y = \int_0^\infty e^{-x} \cdot \left.\frac{e^{-y}}{-1}\right|_0^\infty$$

$$= -\int_0^\infty e^{-x}(0-1)\,\partial x = \int_0^\infty e^{-x}\,\partial x$$

$$= -(0-1) = 1$$

2

$$\therefore\ P(X<1) = \int_{-\infty}^{0} e^{-x}\,\partial x = -\left(e^{0} - e^{\infty}\right) = \infty$$

Group-C

1. (a) $P_{\frac{y}{x}}\left(\frac{0}{1}\right) = 0.1$, $P_{\frac{y}{x}}\left(\frac{1}{0}\right) = 0.2$

$P_x(0) = 0.4$ | $P_y(0), P_y(1) = ?$

$P_y(0) = 0.6 \times (0.1) + 0.4 \times (0.8)$

$= 0.38$

$P_y(1) = 0.4 \times 0.2 + 0.6 \times 0.9$

$= 0.62$

$P_y(0) + P_y(1) = 1$

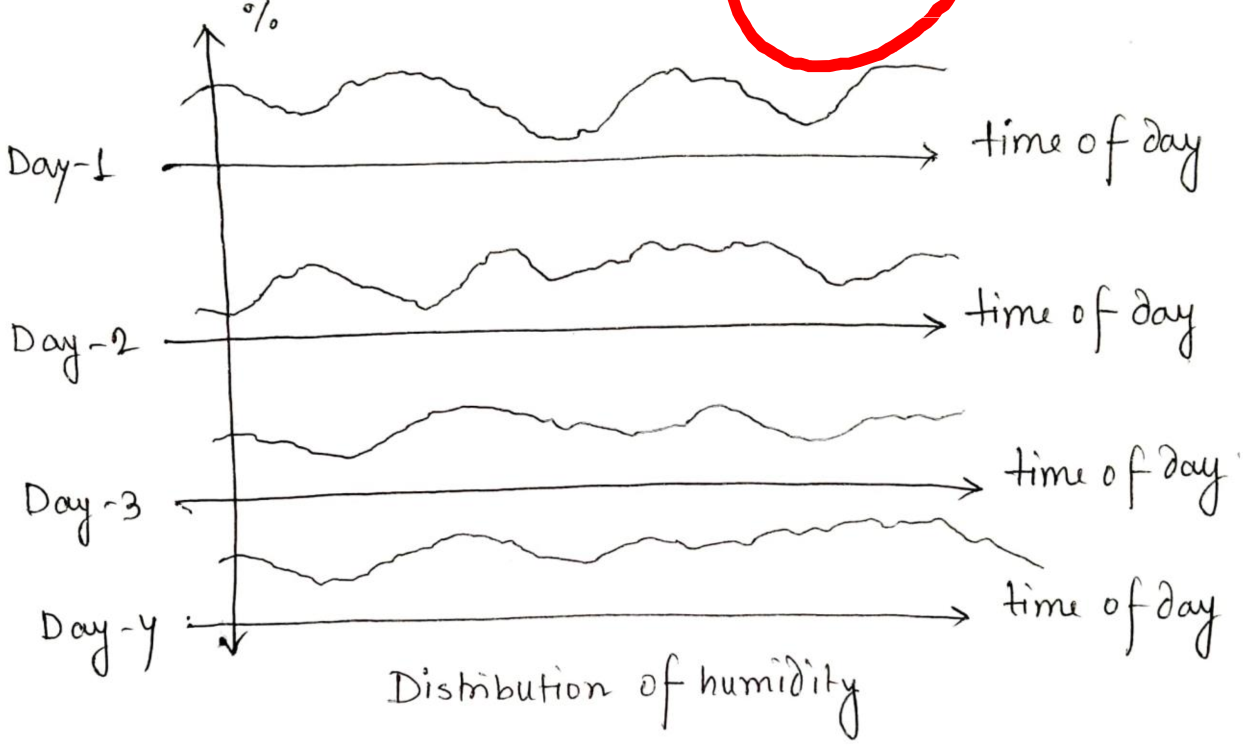
5

(b) A process is called Random process when there are more than one Random Variable or parameters are present, which will decide the final outcome of the specific process.

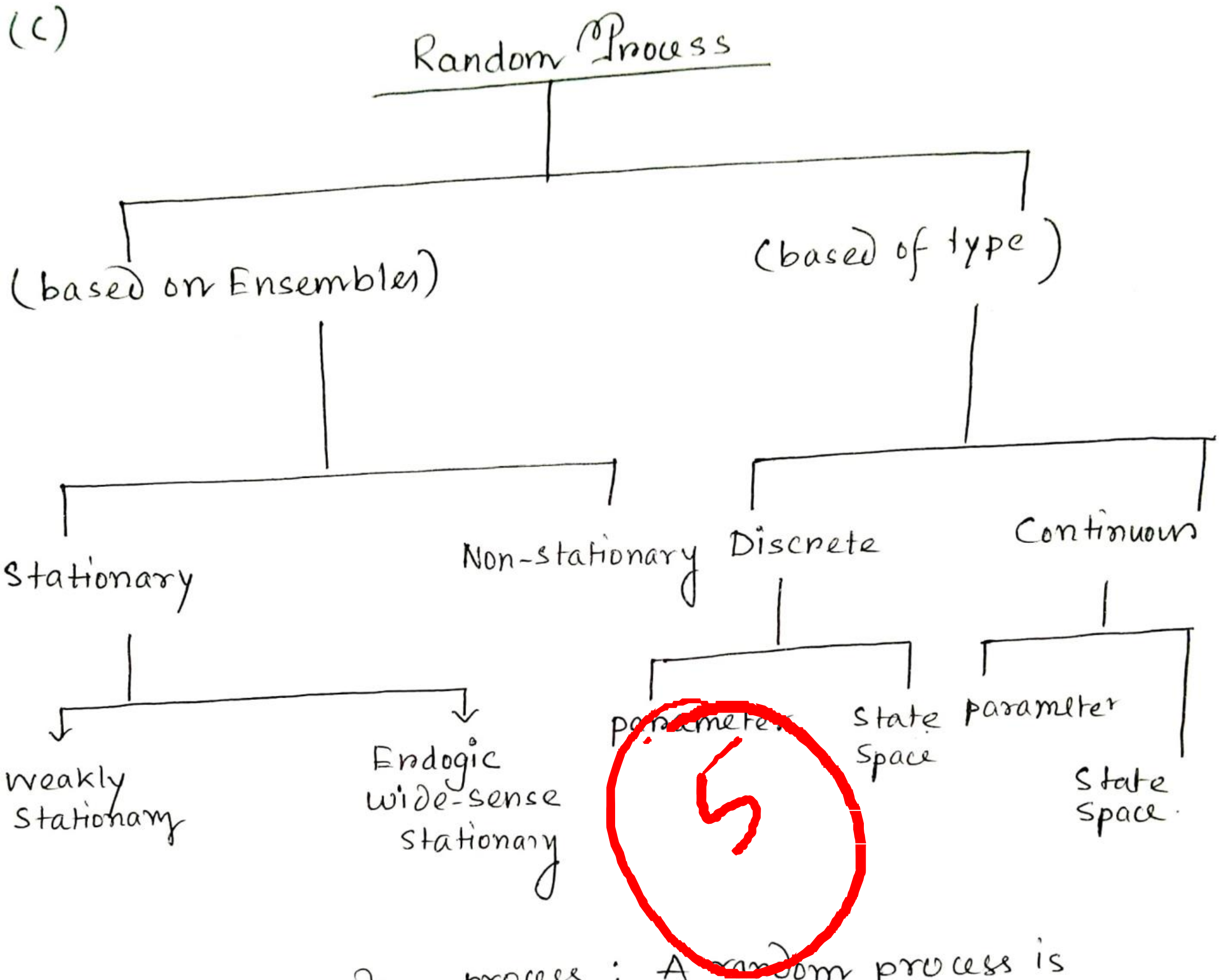
eg- Measuring humidity of the air, at a specific time of the day, for each day in a week. Here, humidity will depend upon time & day both, thus it is a random process of measuring humidity.

- The set of all possible sample functions is called ensembles of a random process.

5



(c)



staitionary random process : A random process is called stationary if it's statistical properties like variance, do not change over time.

eg: The temperature over the period of a year, the mean of temp. at different time will vary.

Ergodic / wide sense Stationary :-

Weakly stationary :-

Discrete parameter, Discrete State Space -

- Number of students left every time a school bus leaves, & the no. of school bus.

Discrete parameter, Continuous State Space

-

Continuous parameter, Continuous State Space

- Measuring ~~time~~ temp, at a time of Day, for all Days in a weak, Continuous parameter is temp, Continuous State Space = time

Continuous parameter, Distnete state space.

-

MCQ

6

1.) 1 and 4/3

2.)

3.) a) even symmetry

4.)

5.) all of the mentioned

6) Random-event & real number

7.) It's statistic Varry with shift in time.

8) Time diff.

9) 0.33

10) 1/3 & 1/2

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Roll No. - 10800319003
Dept. - ECE
Sem - 5th
Year - 3rd
Batch - A1

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Date : 29/10/21
Time : 9:40 am - 10:40 am

Digital Communication & Stochastic Processes

EC- 503

CLASS TEST

GROUP - A

Objective Type Questions :-

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① ⓑ 1 and 4/3 ✓
② ⓒ 1/2 √π ✓
③ ⓐ even symmetry ✓
④ ⓓ 1/21 ✓
⑤ ⓒ All of the mentioned ✗
⑥ ⓒ Random event and a real number ✓
⑦ ⓐ Its statistics vary with shift in time origin ✗
⑧ ⓑ Time difference ✗
⑨ ⓐ 0.33 ✓
⑩ ⓑ 1/3 & 1/2 ✓

GROUP - B

(1) $$\int_4^{\infty} \frac{1}{3\sqrt{2\pi}} \cdot e^{-(x-4)^2/18} \, dx$$

Let, $\left(\frac{x-4}{3}\right)^2 = y^2 \Rightarrow 2y \cdot dy = \frac{2}{3}\left(x - \frac{4}{3}\right) dx$

$\Rightarrow dx = \frac{ay}{x-y} dy$

$\Rightarrow dx = 3\, dy$

$\therefore \int_0^{\infty} \frac{1}{3/\sqrt{2\pi}} = e^{-y^2/2} (3 dy)$

$= \frac{1}{\sqrt{2\pi}} \times \sqrt{2\pi} = 1$

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(b) $$\int_0^{\infty} \frac{1}{3\sqrt{2\pi}} \cdot e^{-(x-4)^2/18} dx = 1$$

GROUP - C

① ⓐ given, $P_{\frac{y}{x}}\left(\frac{0}{1}\right) = 0.1$ and $P_{\frac{y}{x}}\left(\frac{1}{0}\right) = 0.2$

$P_x(0) = 0.4$

$\therefore P_{\frac{y}{x}}\left(\frac{0}{0}\right) = 1 - P_{\frac{y}{x}}\left(\frac{1}{0}\right) = 1 - 0.2 = 0.8$

5

$\therefore P_x(1) = 1 - P_x(0) = 0.6$

So, $P_y(0) = P_x(1)\ P_{y/x}(0/1) + P_x(0) \cdot P_{y/x}(0/0)$

$= 0.4 \times 0.8 + 0.6 \times 0.1$

$= 0.32 + 0.06$

$= 0.38$

ⓑ A random-process is a time-varying function that assigns the outcome of a random experiment to each time instant : X(t)
For a fixed (sample path): a random process is a time varying function, e.g. a signal.
For fixed t : a random process is a random variable.
Random Process can be continuous or discrete. Real random process is also called Stochastic Process. Example - Noise source.
The set of all possible sample functions {v,(t,E i)} is called the ensemble and defines the random process v(t) that describes the noise source.

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c) Random process may be classified in the following broad categories :-

① **Stationary Random Process**

→ A random process whose statistical characteristics does not change with time is called as Stationary Random Process. For a stationary process, we can say that a shift of time origin will be impossible to detect. There are 2 types of Stationary Random Process :- Strict Sense Stationary Random Process (SSS) and Wide Sense Stationary Random Process (WSS).

② **Non-Stationary Random Process**

→ A random process whose shift of time origin is possible to detect can be defined as Non-Stationary Random Process. For working purposes, they are categorized into two classes : Deterministic and Stochastic.

③ **Ergodic Random Process**

→ Mean and auto-correlation function are the ensemble averages or ensemble statistics of the random process. The time mean for each sample function of a random process X(t) is given as

$$\overline{X(t)} = \lim_{T \to \infty} \frac{1}{T} \int_{-T/2}^{T/2} x(t)\,dt$$

For an Ergodic Random Process, ensemble averages are equal to time averages of any sample function.

④ **Wide sense (or Weakly) Stationary Random Process**

→ A process that is not stationary in the strict sense, may yet have a mean value and the auto-correlation function that are independent of the shift of time origin.

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Paper Name : Digital Communication and Stochastic Process, Time = 9:40 - 10:40

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Group-A

1. b) 1/2 and 2/3

2. a) $1/\sqrt{2\pi}$

3. a) even symmetry

4. c) 1/21

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5. c) All of the mentioned

6. c) Random event and a real number.

7. a) Its statistics vary with shift in time origin

8. b) Time difference

9. a) 0.33

10. b) 1/3 & 1/2

Group-B

1.

$$f_n(x) = \int_4^{\infty} \frac{1}{3\sqrt{2\pi}} \exp\{-(x-4)^2/18\}$$

Let, $\left(\frac{x-4}{3}\right)^2 = y^2 \Rightarrow 2y \cdot dy = 2/3(x-4/3)\,dx$

$dx = \frac{ay}{x-y}\,dy$

$dx = 3\,dy$

$\therefore \int_0^{\infty} \frac{1}{3\sqrt{2\pi}} \cdot e^{-y^2/2}(3\,dy)$

3

$= 1/\sqrt{2\pi} \times \sqrt{2\pi} = 1$

$= \int^{\infty} \frac{1}{3\sqrt{2\pi}} \cdot e^{-(x-4)^2/18}\,dx = 1$

$= \int_0^{\infty} \frac{1}{3\sqrt{2\pi}} e^{-(x-4)^2/18}\,dx = 1$

Group-C

1\. a) given $P_{y|x}(0/1) = 0.1$ and $P_{y|x}(1/0) = 0.2$

$P_x(0) = 0.4$

$\therefore P_{y|x}(0/0) = 1 - P_{y|x}(1/0) = 1 - 0.2 = 0.8$

$\therefore P_x(1) = 1 - P_x(0) = 0.6$

5

So,

$P_y(0) = P_x(1) P_{y|x}(0/1) + P_x(0) \cdot P_{y|x}(0/0)$

$= 0.4 \times 0.8 + 0.6 \times 0.1$

$= 0.32 + 0.06$

$= 0.38$ Ans.

$P_y(1) = 1 - 0.38$

$= 0.62$ Ans.

b) Random Process is a time varying function that assigns the outcome of a random experiment to each time instant: [illegible] $x(t)$. for a fixed (sample path): a random process is a time varying function.

ex – a signal – For fixed t: a random process is a random variable.

2

- Sample functions of a binary random process.

The set of all possible sample functions $\{v(t, E, i)\}$ is called the ensemble and defines the random process $v(t)$ that describes the noise source.

(c)

Random process are classified according to the type of the index variable and classification of the random variable obtaind from Samples of the random process. The major classification are ——

① Continuous Random process – voltage in a circuit, temp at a given location over time, temp at different position in a room.

② Discrete Random process – Quantized voltage in a circuit over time.

③ Continuous Random Sequence – Sampled voltage in a circuit time.

④ Discrete Random Sequence – Sampled and quantized voltage from a circuit over time.

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Group-B

1.) $f_x(x) = \frac{1}{3\sqrt{2\pi}} \cdot e^{\{-(x-4)^2/18\}}$.

a.) $P(x \geq 4) = \int_4^\infty \frac{1}{3\sqrt{2\pi}} \cdot e^{\left[-\frac{(x-4)^2}{18}\right]} \cdot dx$

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Let $x-4 = y \Rightarrow dx = dy$

$\Rightarrow P(x \geq 4) = \int_4^\infty \frac{1}{3\sqrt{2\pi}} \cdot e^{-y^2/18} \cdot dy$.

$= \frac{1}{3\sqrt{2\pi}} \cdot \sqrt{18\pi}$

$= 1$

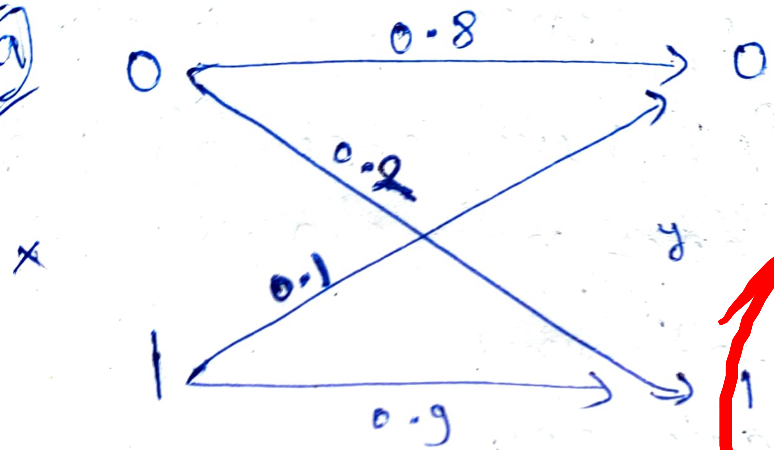
3

b.) $P(x \geq -2) = \int_{-2}^\infty \frac{1}{3\sqrt{2\pi}} \cdot e^{\left[-\frac{(x-4)^2}{18}\right]} \cdot dx$.

$= \frac{1}{3\sqrt{2\pi}} \cdot \sqrt{18\pi} = 1$

Group-C

1) (a)



$P_x(0) = (0.4)$

$P_y(0), P_y(1) = ?$

$\Rightarrow P_x(1) = 0.6$

5

$P_y(0) = P_x(0) \cdot P_{x/y}\left(\frac{0}{0}\right) + P_x(1) \cdot P_{x/y}\left(\frac{0}{1}\right)$

$= (0.4 \times 0.8) + (0.6) \times (0.1)$

$= 0.32 + 0.06$

$= 0.38.$

$P_y(1) = (1 - 0.38) = 0.62.$

(b) Random process is the collection of random variables. In random process, random variable is dependent on more than one parameter.

Eg: When we toss two coins, we know what is the range of outcomes but we do not know which will occour at a particular time. So, there is randomness.

Ensemble — It is the state space for random process.

(c) Classification of Random process:-

- On the basis of ensemble statistics

i) Stationary R.P. :- Here ensemble stats. does not change.

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- strict sense stationary:
- Wide sense stationary.

ii) Non- stationary RP :- Cond^ns for non sationary:, $f(x,t) \neq f_x(x)$.

$$R_x(t_1,t_2) \neq R_x(t_2-t_1)$$

iii) Ergodic RP :- In this ensemble stats. equals to time stats. accross any sample func^n.

- On the basis of parameter and state space:-

i) Discrete parameter discrete state space :-

Taking example of buses going to and fro and taking only 20 students at a time. In this no. of buses is parameter and No. of students waiting is state space.

ii) Continuous Parameter, discrete state space:

Avg. time of day is parameter and no of students waiting is a state space.

iii) Discrete parameter, continuous state space

No of students waiting is parameter and avg. ~~No of s~~ time students waiting is continuous.

iv) Coont. parameter Cont. state space

Avg. time of day is parameter and avg time students waiting is state space.

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Group-A

1) (b) 1 and 4/3

2) (a) $\frac{1}{\sqrt{2\pi}}$

3) (a) even sym.

4) (d) non

5) (c) All

6) (d)

7) (b)

8) (d)

9)

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Paper Name:- Digital communication and stochastic process

Paper code:- EC 503 Date & Time:- 29/10/11 9:39

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Group A

1) b) 1 and 4/3 ✓

2) b) odd symmetry ✗

3) a) even symmetry ✓

4) c) 1/21 ✗

5) e) all of the ...

6) c) Random event and real number ✓

7) a) In statistical vary with ships. ✗

8) b) Time difference ✓

9) a) 0.33 ✓

10) b) 1/3 & 1/2 ✓

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Group - C

1) a) Given $P_{y/x}(0/1) = 0.1$ and $P_{y/x}(1/0) = 0.2$

$P_x(0) = 0.4$

$\therefore P_{y/x}(0/0) = 1 - P_{y/x}(1/0) = 1 - 0.2 = 0.8$

$\therefore P_x(1) = 1 - P_x(0) = 0.6$

we know,

So,

$$P_y(0) = P_x(1)\, P_{y/x}(0/1) + P_x(0)\,.\,P_{y/x}(0/0)$$

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$$= 0.4 \times 0.8 + 0.6 \times 0.1$$

$$= 0.32 + 0.06 = 0.38 \quad \underline{\text{Ans}}$$

$$\therefore P_y(1) = 1 - P_y(0) = 1 - 0.38 = 0.62$$

b) Random process is an extension of random ~~process~~ variable. The collection of Random variables is known as random process. For example we can say the temperature of a city at any time of the day. The temperature x of the certain city is an random variable and it takes different values everyday. To get the complete statistics of x, we have to take ~~~~ the values of x at that time ~~of~~ for many days. But the temperature for any other time ~~is~~ also ~~~~ have entirely different distribution from the prev temperature. So, here ~~the~~ Random variable ~~that~~ is a function of time. So, it is an Random process.

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In Random procen, we repeat the same experiment a large number of times. ~~and we need~~ ~~to~~ So, we get many wave form. The collection of all possible waveform of an Random procen is known as ensemble.

c) The random procen may be classified in following broad categories.

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i) <u>Stationary Random procen</u>:- An random procen whose statistical characteristics does not change with time is known as Stationary Random process. The statistical characteristics are mean and auto correlation. ~~Exa~~

<u>Example</u>:- Rotating a ~~fan~~ ceiling fan at maximum speed.

There are two types of stationary procen:-

1) Strict sense stationary random procen
2) wide ~~Range~~ sense stationary random process

ii) <u>wide-sense stationary Random procen</u>:- ~~A procen that is not strictly stationary procen sense~~

A procen that is not stationary in the strict sense is known as wide-sense stationary procen.

Example:- The same example of Rotating ceiling fan in real life that will surely slow down a ~~distate~~ after a given time.

iii) Non stationary ~~pro~~ Random process :- A random process whose shift of time origin is possible to detect can be defined non-stationary process. That means its mean and auto correlation will change at different time origin

Example :- Spinning a ball. The ball will slow down after every minutes of time instance.

iv) Ergodic Random process :- If the mean and auto correlation remains constant in both cases i.e. across ~~bot~~ ensamble and across ensamble, then it is called ergodic random process.

Example :- call centre.