K S School of Engineering and Management, Bengaluru-109

CALENDAR OF EVENTS: EVEN SEMESTER (2019-2020)

SESSION: FEB 2020 - JUN 2020

Week No.	Month	Day						Days	Institutional Activities / Holidays
		Mon	Tue	Wed	Thu	Fri	Sat		
1	Feb	10 *	11	12	13	14	15	6	10 - Commencement of Classes 15 - Monday Time Table
2	Feb	17	18	19	20	21 H	22	5	21 - Maha Shivarathri 22 - Friday Time Table 22 - Graduation Day
3	Feb	24	25	26	27	28	29 DH	5	
4	Mar	2	3	4	5	6 TA	7**	6	7 - Sports Day
5	Mar	9	10	11	12 T1	13 T1	14 T1	6	
6	Mar	16	17	18 BV	19 ASD	20	21 DH	5	
7	Mar	23	24	25 H	26	27	28	5	25 - Ugadhi 28 - Friday Time Table
8	Mar/Apr	30	31	1	2**	3**	4 DH	5	2 & 3 - Aarohana
9	Apr	6 H	7	8	9	10 H	11	4	6 - Mahaveera Jayanthi 10 - Good Friday 11 - Wednesday Time Table
10	Apr	13 TA	14 H	15	16	17	18 DH	4	14 - Ambedkar Jayanthi
11	Apr	20 T2	21 T2	22 T2	23	24 BV	25 ASD	6	25 - Tuesday Time Table
12	Apr/May	27	28	29	30	1 H	2 DH	4	1 - May Day
13	May	4	5	6	7	8	9	6	9 - Friday Time Table
14	May	11	12	13	14	15 TA	16 DH	5	
15	May	18 T3	19 T3	20 T3	21	22 LT	23 LT	6	23 - Project Exhibition
16	May	25 H	26 LT	27 LT	28	29	30 DH	4	25 - Ramzan
17	Jun	1 *						1	1 - Last Working Day

Total No of Working Days : 83

Total Number of Working Days (Excluding Holidays and Tests) = 70

H	Holiday
BV	Blue Book Verification
T1,T2, T3	Tests 1,2, 3
ASD	Attendance & Sessional Display
DH	Declared Holiday
LT	Lab Test
TA	Test attendance

Monday	14
Tuesday	13
Wednesday	13
Thursday	14
Friday	13
Total	67

K. Rama [signature]
24/1/2020

Dr. K. RAMA NARASIMHA
Principal/Director
K S School of Engineering and Management
Bengaluru - 560 109

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K S School of Engineering and Management, Bengaluru-109

Department of Electronics and Communication Engineering

CALENDAR OF EVENTS: EVEN SEMESTER (2019-2020)

SESSION: FEB 2020 - JUN 2020

Week No.	Month	Day						Days	Institutional Activities / Holidays	Departmental Activities
		Mon	Tue	Wed	Thu	Fri	Sat			
1	Feb	10 *	11	12	13	14	15	6	10 - Commencement of Classes 15 - Monday Time Table	
2	Feb	17	18	19	20	21 H	22	5	21 - Maha Shivarathri 22 - Friday Time Table 22 - Graduation Day	
3	Feb	24	25	26	27	28	29 DH	5		27,28,29-WorkShop on Lab-View
4	Mar	2	3	4	5	6 TA	7**	6	7 - Sports Day	
5	Mar	9	10	11	12 T1	13 T1	14 T1	6		9-IEEE Innaguration, Technical Talk on High Performance Computing, International Women's Day Celebration
6	Mar	16	17	18 BV	19 ASD	20	21 DH	5		
7	Mar	23	24	25 H	26	27	28	5	25 - Ugadhi 28 - Friday Time Table	
8	Mar/Apr	30	31	1	2**	3**	4 DH	5	2 & 3 - Aarohana	2,3,4-Workshop on AI/ML/IOT
9	Apr	6 H	7	8	9	10 H	11	4	6 - Mahaveera Jayanthi 10 - Good Friday 11 - Wednesday Time Table	
10	Apr	13 TA	14 H	15	16	17	18 DH	4	14 - Ambedkar Jayanthi	
11	Apr	20 T2	21 T2	22 T2	23	24 BV	25 ASD	6	25 - Tuesday Time Table	25-Miniproject Exhibution
12	Apr/May	27	28	29	30	1 H	2 DH	4	1 - May Day	
13	May	4	5	6	7	8	9	6	9 - Friday Time Table	6-Technical Seminar on VLSI(6th Sem) 9-Quiz Competition
14	May	11	12	13	14	15 TA	16 DH	5		
15	May	18 T3	19 T3	20 T3	21	22 LT	23 LT	6	23 - Project Exhibition	
16	May	25 H	26 LT	27 LT	28	29	30 DH	4	25 - Ramzan	
17	Jun	1 *						1	1 - Last Working Day	
									Total No of Working Days : 83	

Total Number of Working Days (Excluding Holidays and Tests)=70

H	Holiday
BV	Blue Book Verification
T1,T2, T3	Tests 1,2, 3
ASD	Attendance & Sessional Display
DH	Declared Holiday
LT	Lab Test
TA	Test attendance

Monday	14
Tuesday	13
Wednesday	13
Thursday	14
Friday	13
Total	67

Professor & Head
Dept. of Electronics & Communication Engineering
K. S. School of Engineering & Management
Bangalore-560 109

K.S. SCHOOL OF ENGINEERING AND MANAGEMENT, BENGALURU-560109
DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

ACADEMIC YEAR : 2019-20 (EVEN SEMESTER)

CLASS TIME TABLE

(w.e.f. 10th Feb 2020)

CLASS : VI ECE 'B' | LECTURE HALL: 209 | Class Teacher: Mrs. Deepa R Bhangi

DAY	8.40-9.35	9.35-10.30	10.30-10.45	10.45-11.40	11.40-12.35	12.35-1.20	1.20-2.10	2.10-3.00	3.00-3.50
MONDAY	CCN SB	ARM KM	TEA BREAK	VLSI SGM	Elec-2 SBN/RVT	LUNCH BREAK	Embedded Controller Lab (B1 Batch : KM/SBN/DRB) Computer Communication Networks Lab (B2 Batch : PS/RBA/SB)		
TUESDAY	DC PS	VLSI SGM		Elec-1 SS	Elec-2 SBN/RVT		VLSI SGM	DC PS	CCN SB
WEDNESDAY	CCN SB	DC PS		ARM KM	Elec-2 SBN/RVT		Embedded Controller Lab (B2 Batch :DRB/KM) Computer Communication Networks Lab (B3 Batch :RBA/KB/SB)		
THURSDAY	VLSI SGM	Elec-1 SS		ARM KM	Elec-2 SBN/RVT		DC PS	ARM KM	Library
FRIDAY	Elec-1 SS	VLSI SGM		CCN SB	Elec-1 SS		Embedded Controller Lab (B3 Batch :DND/AKM/KM) Computer Communication Networks Lab (B1 Batch :KB/SB)		
SATURDAY	AS PER CALENDAR OF EVENTS			AS PER CALENDAR OF EVENTS			AS PER CALENDAR OF EVENTS		

CODE	SUBJECT	HOURS /WEEK	STAFF
17EC61	Digital Communication	4	Mr. Puneeth S
17EC62	ARM Microcontroller and Embedded Systems	4	Dr. Kishore M
17EC63	VLSI Design	5	Mrs. Shanthala G M
17EC64	Computer Communicatioin Network	4	Mr. Senthil Babu K
17EC654	Digital Switching Systems (Elec-1)	3	Mrs.Shalini Shravan
17EC661/17EC663	Data Structures using C++/Digital System Design using Verilog (Elec-2)	3	Mr. Sanjay B Nayak/ Mrs. Renuka V T
17ECL67	Embedded Controller Lab	3	Dr. Dushyanth N D / Dr. Arun Kumar / Mr. Sanjay B Nayak / Dr. Kishore / Mrs. Deepa R Bangi
17ECL68	Computer Communication Networks Lab	3	Mr. Senthil Babu K / Mr. Ravikiran B A / Mr. Puneeth S/ Mrs. Kripa B

Time Table Co-ordinator

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K. Rama

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K.S. SCHOOL OF ENGINEERING AND MANAGEMENT, BENGALURU - 560109

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

SESSION: 2019-2020 (EVEN SEMESTER)

LESSON PLAN

NAME OF THE STAFF : PUNEETH S

COURSE CODE/TITLE : 17EC61/ DIGITAL COMMUNICATIONS

SEMESTER/YEAR : VI / III

Sl. No.	Topic to be covered	Mode of Delivery	Teaching Aid	No. of Periods	Cumulative No. of Periods	Proposed Date	Execution Date
	MODULE 1						
1	**Bandpass Signal to Equivalent Low pass Introduction:** Hilbert Transform, Application of Hilbert Transform	L	BB	1	1	11/2/2020	11/2/2020
2	Problems and Solution	PS(TX)	BB	1	2	11/2/2020	11/2/2020
3	Properties, Pre-envelopes, Complex envelope of Band Pass signals	L	BB	1	3	12/2/2020	12/2/2020
4	Canonical representation of bandpass signals, Polar representation	L	BB	1	4	13/2/2020	13/2/2020
5	Complex low pass representation of bandpass systems, Problems and Solution	L, PS(TX)	BB	1	5	18/2/2020	18/2/2020
6	Complex representation of bandpass signals and system	L	BB	1	6	18/2/2020	18/2/2020
7	Problems and Solution	PS(TX)	BB	1	7	19/2/2020	19/2/2020
8	Line code representation: Unipolar, Polar, Bipolar (AMI) and Manchester code	L, PS(TX)	BB, LCD	1	8	20/2/2020	20/2/2020
9	Overview of HDB3, B3ZS, B6ZS, Problems and Solution	L, PS(TX)	BB, LCD	1	9	25/2/2020	25/2/2020
10	Power Spectral Densities of Line Codes	L	BB	1	10	25/2/2020	25/2/2020
	MODULE 2						
11	**Signaling over AWGN Channels** Introduction, Geometric representation of signals	L	BB	1	11	26/2/2020	26/2/2020
12	Gram-Schmidt Orthogonalization procedure	L	BB	1	12	27/2/2020	26/2/2020

13	Problems and Solution	L, PS(TX)	BB	1	13	3/3/2020	03/03/2020 03/03/2020
14	Problems and Solution	L, PS(TX)	BB	1	14	3/3/2020	04/03/2020
15	Conversion of the continuous AWGN channel into a vector channel	L	BB	1	15	4/3/2020	10/3/2020
16	Optimum receivers using coherent detection: ML Decoding	L	BB, LCD	1	16	5/3/2020	10/3/2020
17	Correlation receiver	L	BB, LCD	1	17	10/3/2020	11/3/2020
18	Matched filter receiver	L	BB, LCD	1	18	10/3/2020	06/4/2020
19	Problems and Solution	L, PS(TX)	BB	1	19	11/3/2020	06/4/2020
	MODULE 3						
20	**Digital Modulation Techniques** Phase shift Keying techniques using coherent detection, Generation, Detection	L	BB, LCD	1	20	17/3/2020	9/4/2020
21	Error probabilities of BPSK, Problems and Solution	L, PS(TX)	BB	1	21	17/3/2020	13/4/2020
22	Generation, Detection of QPSK	L	BB, LCD	1	22	18/3/2020	13/4/2020
23	Error probabilities of QPSK, Problems and Solution	L, PS(TX)	BB	1	23	19/3/2020	14/4/2020
24	M–ary PSK	L	BB, LCD	1	24	24/3/2020	20/4/2020
25	M–ary QAM	L	BB, LCD	1	25	24/3/2020	20/4/2020
26	Frequency shift keying techniques using Coherent detection: BFSK generation and Detection	L	BB, LCD	1	26	26/3/2020	23/4/2020
27	Error probability	L		1	27	31/3/2020	27/4/2020
28	Non coherent orthogonal modulation techniques: BFSK	L	BB, LCD	1	28	31/3/2020	27/4/2020
29	DPSK Symbol representation	L, PS(TX)	BB, LCD	1	29	1/4/2020	30/4/2020
30	Block diagrams treatment of Transmitter and Receiver	L	BB, LCD	1	30	7/4/2020	07/5/2020
31	Probability of error (without derivation of probability of error equation)	L	BB	1	31	7/4/2020	07/5/2020
	MODULE 4						
32	**Communication through Band Limited Channels:** Digital Transmission through Band limited channels	L	BB	1	32	8/4/2020	11/5/2020
33	Digital PAM Transmission through Band limited Channels.	L	BB	1	33	9/4/2020	14/5/2020
34	Signal design for Band limited Channels, Design of band limited signals for zero ISI–The Nyquist	L	BB	1	34	11/4/2020	14/5/2020

	Criterion (statement only)						
35	Design of band limited signals with controlled ISI-Partial Response signals	L	BB	1	35	15/4/2020	15/5/2020
36	Probability of error for detection of Digital PAM	L	BB	1	36	16/4/2020	18/5/2020
37	Probability of error for detection of Digital PAM with Zero ISI	L	BB	1	37	23/4/2020	18/5/2020
38	Symbol–by–Symbol detection of data with controlled ISI	L	BB	1	38	25/4/2020	19/5/2020
39	Problems and Solution	L, PS(TX)	BB	1	39	25/4/2020	19/5/2020
40	Channel Equalization: Linear Equalizers, ZFE	L	BB, LCD	1	40	28/4/2020	20/5/2020
41	MMSE, Adaptive Equalizers	L	BB, LCD	1	41	28/4/2020	20/5/2020
	Module 5						
42	**Principles of Spread Spectrum Introduction:** Model of a Spread Spectrum Digital Communication System	L	BB	1	42	29/4/2020	21/5/2020
43	Direct Sequence Spread Spectrum Systems	L	BB	1	43	30/4/2020	21/5/2020
44	Effect of De-spreading on a narrowband Interference, Probability of error (statement only)	L	BB	1	44	5/5/2020	22/5/2020
45	Some applications of DS Spread Spectrum Signals	L	BB, LCD	1	45	5/5/2020	22/5/2020
46	Generation of PN Sequences, Properties of PN Sequences	L	BB, LCD	1	46	6/5/2020	23/5/2020
47	Problems and Solution	L, PS(TX)	BB	1	47	12/5/2020	26/5/2020
48	Frequency Hopped Spread Spectrum, Slow Frequency Hopped Spectrum System	L	BB, LCD	1	48	12/5/2020	26/5/2020
49	Slow Frequency Hopped Spectrum System	L	BB, LCD	1	49	13/5/2020	02/06/2020
50	CDMA based on IS-95	L	BB, LCD	1	50	14/5/2020	03/06/2020
	Revision						
51	*Revision*	L, PS(TX)	BB	1	0	21/5/2020	4/06/2020
52	*Revision*	L, PS(TX)	BB	1	0	28/5/2020	4/06/2020

Total Number of Lecture Hours = 50
Total Number of Tutorial Hours = 0
Total Number of Revision Hours = 2

Course In charge

Head of the Department

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

SESSION: 2019-2020 (EVEN SEMESTER)

CO-PO MAPPING

Course: DIGITAL COMMUNICATION			
Type: Core		**Course Code: 17EC61**	
No of Hours			
Theory (Lecture Class)	Practical/Field Work/Allied Activities	Total/Week	Total teaching hours
4	0	4	50
Marks			
Internal Assessment	Examination	Total	Credits
40	60	100	4

Aim/Objectives of the Course

1. To explain the use of Hilbert Transform and represent the binary data using Line Codes.
2. To explain and apply Gram-Schmidt Orthogonalization procedure, detection and estimation in optimum receivers.
3. To explain and estimate the probability of error of coherent and non-coherent digital modulation.
4. To Illustrate Correlative coding, precoding and concept of equalization
5. To describe the spread spectrum modulation technique.

Course Learning Outcomes

After completing the course, the students will be able to

CO1	**Explain** and **solve** Hilbert transform, pre envelopes, and complex envelopes, represent binary data using line codes and **estimate** power spectral densities.	Applying (K3)
CO2	**Explain** and **apply** Gram-Schmidt Orthogonalization procedure, detection and estimation concept in optimum receivers	Applying (K3)
CO3	**Explain** and **estimate** the probability of error of coherent and non-coherent digital modulation techniques.	Applying (K3)
CO4	**Explain** and **solve** estimation of probability of error through bandlimited channel, Correlative coding, DB and MDB, Pre-coding and equalization principle for non-ideal channels.	Applying (K3)
CO5	**Explain** Spread spectrum modulation techniques and **solve** the properties of spread spectrum modulation technique	Applying (K3)

Syllabus Content

MODULE 1:Bandpass signal to equivalent low pass: Hilbert Transform, Pre-envelopes, Complex envelopes, Canonical representation of bandpass signals, Complex low pass representation of band-pass systems, Complex representation of bandpass signals and systems. **Line codes:** Unipolar, Polar, Bipolar (AMI) and Manchester code and their power spectral densities. Overview of HDB3, B3ZS, B6ZS. (Text 1, Ref 1, 2) **LO:** At the end of this session the student will be able to 1. Explain and solve Hilbert transform, pre envelops and complex envelops. 2. Explain and apply the concepts of complex bandpass signals and systems. 3. Apply the concepts of different types of line codes.	CO1 10 hrs PO1-3 PO2-2 PO3-1 PO4-1 PO5-1 PO12 -2 PSO1- 3 PSO2-2

Module 2: Signaling over AWGN channels-Detection and Estimation: Introduction, Geometric representation of signals, Gram-Schmidt Orthogonalization procedure, Conversion of the continuous AWGN channel into a vector channel, Optimum receivers using coherent detection: ML Decoding, Correlation receiver, matched filter receiver. (Text 1) **LO:** At the end of this session the student will be able to 1. Explain Geometric representation of signals and solve Gram-Schmidt Orthogonalization procedure. 2. Derive expressions for Conversion of the continuous AWGN channel into a vector channel. 3. Explain and apply the concepts of Optimum receivers using coherent detection-ML Decoding, Correlation receiver and matched filter receiver.	CO2 10 hrs. PO1-3 PO2-2 PO3-1 PO4-1 PO5-2 PO12-2 PSO1-3 PSO2-2
Module 3: Digital Modulation Techniques: Digital modulation formats, Phase shift Keying techniques using coherent detection: BPSK, QPSK generation, and detection and error probabilities, M-ary PSK, M-ary QAM. Frequency shift keying techniques using Coherent detection: BFSK generation, detection and error probability. **Non coherent orthogonal modulation techniques:** BFSK, DPSK Symbol representation, Block diagrams treatment of Transmitter and Receiver, Probability of error (Without derivation) (Text 1). **LO:** At the end of this session the student will be able to 1. Explain different types of Digital modulation formats. 2. Explain the working of BPSK, QPSK generation techniques. 3. Derive the expressions for error probabilities for different detection techniques. 4. Explain the working of Frequency shift keying techniques using Coherent detection: BFSK generation, detection. 5. Derive the expressions for error probability for FSK modulation techniques.	CO3 10 hrs PO1-3 PO2-2 PO3-1 PO4-1 PO5-2 PO6-2 PO12-2 PSO1-3 PSO2-2
Module 4: Communication through Band Limited Channels: Digital Transmission through Band limited channels - Inter Symbol Interference, Eye diagrams, Signal design for Band limited ideal channel with zero ISI – Nyquist Criterion (statement only), Sinc and Raised pulse shaping. Signal design for Band limited channel with controlled ISI – Correlative coding, DB and MDB, Pre-coding. Basic Concepts of Equalization for non-ideal channels – ZFE, MMSE, (without derivations), Adaptive Equalizers (Block diagram only) (Text 2, Ref 2). **LO:** At the end of this session the student will be able to 1. Explain the concept of Inter Symbol Interference, Eye diagrams.	CO4 10 hrs PO1-3 PO2-2 PO3-1 PO4-1 PO5-2 PO12-2

2. Derive the expression for Sinc and Raised pulse shaping. 3. Apply the concepts of DB and MDB, Pre-coding. 4. Explain the Basic Concepts of Equalization for non-ideal channels – ZFE, MMSE. 5. Explain with a neat block diagram the working of Adaptive Equalizers.	PSO1-3 PSO2-2
Module 5: Two port network parameters **Principles of Spread Spectrum:** Concept of Spread Spectrum, Direct Sequence/SS, Frequency Hopped SS, Processing Gain, Interference, and probability of error statement only. PN sequences for Spread Spectrum – M- sequences with Properties; Gold, Kasami sequences with basic properties. Direct sequence spread spectrum system concepts, Frequency Hopped Spread spectrum system concepts, Spread Spectrum Synchronization (block diagram treatment) - Code Acquisition and Tracking. (Text 2) **LO:** At the end of this session the student will be able to 1. Explain the Concept of Spread Spectrum Modulation. 2. Explain the different types of Spread Spectrum Modulation. 3. Explain the properties and apply the concepts of PN – sequence generation. 4. Explain the Concept of Frequency Hopped Spread spectrum system. 5. Explain the working of Code Acquisition and Tracking with a neat block diagram.	**CO5** 10 hrs PO1-3 PO2-2 PO3-1 PO4-1 PO5-1 PO6-2 PO12-2 PSO1-3 PSO2-2

Text Books

1. Simon Haykin, "Digital Communication Systems", John Wiley & sons, First Edition, 2014, ISBN 978-0-471-64735-5.
2. John G Proakis and Masoud Salehi, "Fundamentals of Communication Systems", 2014 Edition, Pearson Education, ISBN 978-8-131-70573-5.

Reference Books

1. Ian A Glover and Peter M Grant, "Digital Communications", Pearson Education, Third Edition, 2010, ISBN 978-0-273-71830-7.
2. B.P.Lathi and Zhi Ding, "Modern Digital and Analog communication Systems", Oxford University Press, 4th Edition, 2010, ISBN: 978-0-198-07380-2.
3. Wayne Tomasi, Advanced Electronic Communication System, 6th Edition, Pearson education 2012.
4. Dr. Sanjay Sharma, Communication System Analog and Digital, Katria and Sons, 2012.

Useful Websites

- http://freevideolectures.com/Course/2311/Digital-Communication
- https://onlinecourses.nptel.ac.in/explorer
- http://nptel.iitg.ernet.in/

Useful Journals

- Communications Magazine, IEEE (http://ieeexplore.ieee.org/)
- Journal of the Institution of Electronic and Radio Engineers (http://digital-library.theiet.org/content/journals/ecej)
- International Journal of Communication Systems (http://onlinelibrary.wiley.com/)
- AEU - International Journal of Electronics and Communications (http://www.journals.elsevier.com/aeu-international-journal-of-electronics-and-communications/)
- Digital Communications and Networks (http://www.journals.elsevier.com/digital-communications-and-networks/))

Teaching and Learning Methods

1. Lecture class: 50 hrs

Assessment

Type of test/examination: Written examination

Continuous Internal Evaluation(CIE) : 40 marks (Average of three tests and assignments will be considered)

Semester End Exam(SEE) : 100 marks (students have to answer all main questions) which will be reduced to 60 Marks.

Test duration: 1 :30 hrs

Examination duration: 3 hrs

CO to PO Mapping

PO1: Science and engineering Knowledge	**PO7:**Environment and Society
PO2: Problem Analysis	**PO8:**Ethics
PO3: Design & Development	**PO9:**Individual & Team Work
PO4: Investigations of Complex Problems	**PO10:** Communication
PO5: Modern Tool Usage	**PO11:**Project Mngmt & Finance
PO6: Engineer & Society	**PO12:**Life long Learning

At the end of the Program, the students should:

PSO1: Be able to acquire knowledge and apply concepts in the field of engineering and interdisciplinary subjects.

PSO2: Be able to identify the existing problems, effectively utilize tools to provide solution, and disseminate the information.

CO	PO	PO1	PO2	PO3	PO 4	PO5	PO6	PO 7	PO8	PO9	PO10	PO1 1	PO12	PS O1	PS O 2
17 EC61	K-level														
CO1	K3	3	2	1	1	1	--	-	-	-	-	-	2	3	2
CO2	K3	3	2	1	1	2	-	-	-	-	-	-	2	3	2
CO3	K3	3	2	1	1	2	2	-	-	-	-	-	2	3	2
CO4	K3	3	2	1	1	2	-	-	-	-	-	-	2	3	2
CO5	K3	3	2	1	1	1	2	-	-	-	-	-	2	3	2

Course In charge

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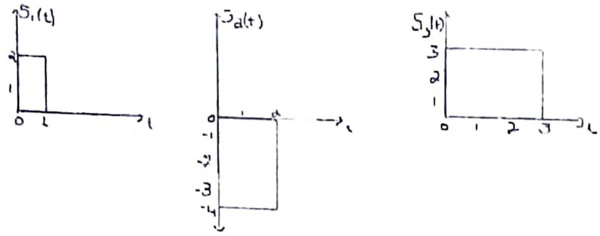
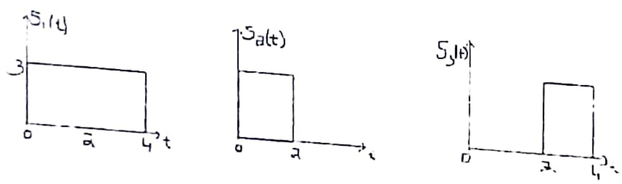
DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING
SESSION: 2019-2020 (EVEN SEMESTER)

ASSIGNMENT-1

Batch	2017
Year/Semester/Section	3rd/6th/A&B
Course Code/Title	17EC61/15EC61/Digital Communication
Name of the Course Incharge	Mr. Manu D K, Mr. Puneeth S

Assignment No: 1
Date of Issue: 17/2/2020
Total marks: 15
Date of Submission: 9/3/2020

Sl. No.	Assignment Questions	K Level	CO	Marks
1.	Define Hilbert Transform and explain the properties of it.	Understand (K2)	CO1	2
2.	Express bandpass signal s(t) in canonical form. Also illustrate the scheme for deriving the in phase and quadrature components of the bandpass signal s(t).	Understand (K2)	CO1	2
3.	Determine Hilbert transform, pre envelope, complex envelope and natural envelope of (i) x(t) = sinc(t) (ii) x(t)= e^{-it}	Apply (K3)	CO1	2
4.	With relevant expressions explain the procedure for computational analysis of a bandpass system driven by a bandpass signal.	Understand (K2)	CO1	2
5.	a) A binary data sequence is 011010. Sketch the following line codes: a) NRZ unipolar b) RZ polar c) NRZ bipolar d) Manchester b) Explain the advantage of HDBN code over conventional alternate mark inversion (AMI) code. Code the pattern "10100000110000011000000" using HDB3 encoding, B3ZS and AMI encoding.	Knowledge (K1) Understand (K2)	CO1	2
6.	Explain the geometric representation of signals. Show that energy of the signal is equal to squared length of vector representing it.	Apply (K3)	CO2	1
7.	Explain the Gram Schmidt orthogonalization procedure.	Understand (K2)	CO2	1
8.	Three Signals S1(t), S2(t) and S3(t) are shown in the figure. Apply Gram Schmidt orthogonalization procedure to determine orthonormal	Apply (K3)	CO2	1

	basis for the signals. Express the signals S1(t), S2(t) and S3(t) in terms of orthonormal basis function.  Figure 1			
9.	**Explain** the geometric representation of set of M energy signals as linear combination of N orthonormal basis functions. **Illustrate** for the case N=2 and M=3 with necessary diagrams and equations.	Understand (K2)	CO2	1
10.	Three Signals S1(t), S2(t) and S3(t) are shown in the figure-2. **Apply** Gram Schmidt orthogonalization procedure to obtain orthonormal basis for the signals. **Express** the signals S1(t), S2(t) and S3(t) in terms of orthonormal basis function. Also give signal constellation diagram.  Figure-2	Apply (K3)	CO2	1

Course In charge

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HOOL OF ENGINEERING AND MANAGEMENT, BENGALURU-560109

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

SESSION: 2019-2020 (EVEN SEMESTER)

KSSEM

ASSIGNMENT-II

Batch	2017
Year/Semester/Section	3rd/6th/A&B
Course Code/Title	17EC61/15EC61/Digital Communication
Name of the Course In charge	Mr. Puneeth S, Mr. Manu D K

Assignment No: II
Date of Issue: 30/3/2020

Total marks:15
Date of Submission:

Sl. No.	Assignment Questions	K Level	CO	Marks
1.	**Explain** how continuous AWGN channel converted into vector channel.	Understanding (K2)	CO2	2
2.	**Explain** the maximum likelihood decision rule for signal detection problem.	Understanding (K2)	CO2	2
3.	**Explain** the matched filter receiver and **derive** the expression for impulse response of matched filter.	Applying (K3)	CO2	2
4.	With a neat diagram **explain** correlator receiver.	Understanding (K2)	CO2	2
5.	**Derive** the expression for mean and variance of correlator outputs. Also **show** that correlator outputs are statistically independent.	Applying (K3)	CO2	2
6.	a) **Explain** the signal space representation, generation and coherent detection of binary phase keying modulation. Also **derive** the expression for probability of error for binary PSK using coherent detection. b) Binary data is transmitted over AWGN channel using BPSK at a rate of 1Mbps. It is desired to have average probability of error $P_e \leq 10^{-4}$. Noise PSD is $(N_0/2)=10^{-12}$ Watts/Hz. **Determine** the average carrier power required at receiver input if the detector is of coherent type[Assume erfc(3.5)=0.00025]	Applying (K3)	CO3	1
7.	a) With neat diagram and expressions, **explain** Signal Space diagram, generation and coherent detection scheme of BFSK.	Applying (K2)	CO3	1

	Also **derive** the probability of error for BFSK. b) In a FSK system, following data are observed. **Determine** the average probability of symbol error assuming coherent detection. Transmitted binary data rate=2.5×10^{6} bits/second PSD of zero mean AWGN=10^{-20} Watts/Hz Amplitude of received signal in the absence of noise= 1 uV			
8.	With a neat block diagram, **explain** the Signal constellation diagram, generation and coherent detection of QPSK signals also **derive** the probability of error for QPSK.	Applying (K3)	CO3	1
9.	a) **Explain** the generation and optimum detection of differential phase shift keying (DPSK) with neat block diagram. b) For a binary sequence given by 10010011, **illustrate** the operation of DPSK.	Understanding (K2) Applying (K3)	CO3	1
10.	a) **Define** bandwidth efficiency. **Tabulate and comment** on the bandwidth efficiency of M-ary PSK signals for different values of M. b) **What** is the advantage of M-ary QAM over M-ary PSK system? **Obtain** the constellation of QAM for M=4 and draw signal space diagram.	Understanding (K2)	CO3	1

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

SESSION: 2019-2020 (EVEN SEMESTER)

ASSIGNMENT-III

Batch	2017
Year/Semester/Section	$3^{rd}/6^{th}$/A&B
Course Code/Title	17EC61/15EC61/Digital Communication
Name of the Course In charge	Mr. Manu D K, Mr. Puneeth S

Assignment No: III | **Total marks:20**
Date of Issue: 07/05/2020 | **Date of Submission:**

Sl. No.	Assignment Questions	K Level	CO	Marks
1.	With neat block diagram **explain** the digital PAM transmission through bandlimited baseband channels. Also obtain the expression for inter symbol interference.	Understanding (K2)	CO4	2
2.	a. State and **prove** Nyquist condition for Zero ISI with all cases with necessary equation.	Understanding (K2)	CO4	1
	b. **Explain** the design of bandlimited signals with controlled ISI. Also explain Duo binary signals and partial response signals.	Understanding (K2)	CO4	1
3.	a. **Explain** the Duo binary encoder and pre coder.	Understanding (K2)	CO4	1
	b. **Illustrate** the encoding for a binary sequence 011100101. Assume previous pre coder outputs has one.	Applying (K3)	CO4	1
4.	**Show that** the probability of error of digital PAM with zero ISI equal to probability of error or M-ary PAM.	Understanding (K2)	CO4	2
5.	With neat diagram and relevant expression **explain** the concept of Adaptive equalization.	Understanding (K2)	CO4	2
6.	a. **Explain** the model of a spread spectrum digital communication system.	Understanding (K2)	CO5	1
	b. **Explain** the generation and demodulation of direct sequence spread spectrum signals with necessary equation and block diagram.	Understanding (K2)	CO5	1
7.	a. List and briefly **explain** any 3 application of direct sequence spread spectrum.	Understanding (K2)	CO5	1
	b. With a neat block diagram, **explain** the frequency hopped spread spectrum technique. Explain the terms chip rate, jamming Margin and processing gain.	Understanding (K2)	CO5	1

8.	A direct sequence spread spectrum signal is designed so that the Power ratio $\frac{P_R}{P_N}$ at the intended receiver is 10^{-2}. If the desired $\frac{E_b}{N_o}$=10 for acceptable performance, **determine** the minimum value of processing gain.	Applying (K3)	CO5	2
9.	A slow frequency hopped/MFSK system has the following parameters, i. The number of bits/ MFSK symbol=4 ii. The number of MFSK symbols per hop=5 iii. **Calculate** the Processing gain of the system in decibels.	Applying (K3)	CO5	2
10.	**Explain** the generation of Maximum Length Sequence. Also **explain** the properties of ML sequence?	Understanding (K2)	CO5	2

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

SESSION: 2019-2020 (EVEN SEMESTER)

I SESSIONAL TEST QUESTION PAPER

SET-B

USN										

Degree : B.E
Branch : Electronics & Communication Engineering
Course Title : Digital Communication
Duration : 90 Minutes

Semester : VI
Date : 03-06-2020
Course Code : 17EC61/15EC61
Max Marks : 30

Note: Answer ONE full question from each part

Q. No.	Question	Marks	K Level	CO mapping
	PART-A			
1(a)	Define Hilbert Transform and Prove that signal s(t) and its Hilbert transform $\widehat{s(t)}$ are orthogonal over the interval $(-\infty,\infty)$.	5	Understanding (K2)	CO1
(b)	Determine Hilbert transform of signal x(t)= $Sin(2\pi f_c t)$	5	Applying (K3)	CO1
(c)	Show that energy of the signal is equal to squared length of signal vector.	5	Applying (K3)	CO2
	OR			
2(a)	Explain pre envelope and complex envelope of a signal s(t) with an example.	5	Understanding (K2)	CO1
(b)	Determine Hilbert transform, pre envelope x(t) = sinc(t)	5	Applying (K3)	CO1
(c)	Using Gram Schmidt orthogonalization procedure obtain the expression for basis function in terms energy signals.	5	Applying (K3)	CO2
	PART-B			
3(a)	Express bandpass signal s(t) in canonical form. Also illustrate the scheme for deriving the in phase and quadrature components of the bandpass signal s(t).	5	Understanding (K2)	CO1
(b)	A binary data sequence is 011010. Sketch the following line codes: a) NRZ unipolar b) RZ polar c) NRZ bipolar d) Manchester e) RZ Unipolar	5	Remembering (K1)	CO1

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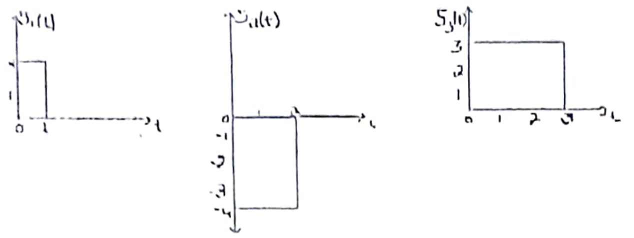
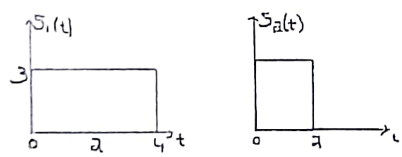
(c)	Three Signals S1(t), S2(t) and S3(t) are shown in the figure-1. Apply Gram Schmidt orthogonalization procedure to determine orthonormal basis for the signals.  Figure 1	5	Applying (K3)	CO2
OR				
4(a)	Compare the power spectra of various line codes in terms of bandwidth, DC component with neat sketch.	5	Understanding (K2)	CO1
(b)	Code the pattern "101000001100001100000" using HDB3 encoding, B3ZS and AMI encoding.	5	Remembering (K1)	CO1
(c)	Three Signals S1 (t), S2 (t) are shown in the figure-2. Apply Gram Schmidt orthogonalization procedure to obtain orthonormal basis for the signals. Express the signals S1 (t) and S2 (t) in terms of orthonormal basis function.  Figure 2	5	Applying (K3)	CO2

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K.S. SCHOOL OF ENGINEERING AND MANAGEMENT, BANGALORE - 560109
DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING
SESSION: 2019-2020 (EVEN SEMESTER)
II SESSIONAL TEST QUESTION PAPER

USN | | | | | | | | | |

Degree	: B.E	Semester	: VI A & B
Branch	: Electronics & Communication Engineering	Date	: 04-05-2020
Course Title	: Digital Communication	Course Code	: 17EC61/15EC61
Duration	: 90 Minutes	Max Marks	: 30

Note: Answer ONE full question from each part
After completion of test, scanned copy of answer sheet to be mailed to respective faculty. Details are
A sec Manu D K 9845223111 manu.d.k@kssem.edu.in
B Sec Puneeth S 9164812059 puneeth.s@kssem.edu.in

Q. No.	Question	Marks
	Part A	
1 (a)	**Explain** the maximum likelihood decision rule for signal detection problem.	5
(b)	**Explain** the signal space representation, generation and coherent detection of binary phase shift keying modulation.	5
(c)	Binary data is transmitted over AWGN channel using BPSK at a rate of 1Mbps. It is desired to have average probability of error $P_e \leq 10^{-4}$. Noise PSD is $(N_o/2)=10^{-12}$ Watts/Hz. **Determine** the average carrier power required at receiver input if the detector is of coherent type [Assume erfc (3.5)=0.00025].	5
	OR	
2 (a)	With a neat diagram **explain** correlator receiver.	5
(b)	With neat diagram and expressions, **explain** Signal Space diagram, generation and coherent detection scheme of BFSK.	5
(c)	**Derive** an expression for probability of error of Binary Frequency Shift Keying.	5
	Part B	
3 (a)	**Explain** the matched filter receiver and derive the expression for impulse response of matched filter.	5
(b)	**Derive** an expression for probability of error of QPSK.	5
(c)	For a binary sequence given by 10010011, **illustrate** the operation of DPSK.	5
	OR	
4 (a)	**Derive** the expression for mean and variance of correlator outputs. Also **show** that correlator outputs are statistically independent.	5
(b)	**Explain** the advantage of M-ary QAM over M-ary PSK system? **Obtain** the constellation of QAM for M=4 and draw signal space diagram.	5
(c)	**Define** bandwidth efficiency. **Tabulate and comment** on the bandwidth efficiency of M-ary PSK signals for different values of M.	5

Course In charge

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING
SESSION: 2019-2020 (EVEN SEMESTER)
III SESSIONAL TEST QUESTION PAPER

USN | | | | | | | | | |

Degree	: B.E		Semester	:	VI A & B
Branch	: Electronics & Communication Engineering		Date	:	27-05-2020
Course Title	: Digital Communication		Course Code	:	17EC61/15EC61
Duration	: 90 Minutes		Max Marks	:	30

Note: Answer ONE full question from each part
After completion of test, scanned copy of answer sheet to be mailed to respective faculty. Details are
A sec Manu D K 9845223111 manu.d.k@kssem.edu.in
B Sec Puneeth S 9164812059 puneeth.s@kssem.edu.in

Q. No.	Question	Marks
	Part A	
1 (a)	With neat block diagram **explain** the digital PAM transmission through bandlimited baseband channels and obtain an expression for inter symbol interference.	5
(b)	State and **prove** Nyquist condition for Zero ISI.	5
(c)	**Explain** the generation and demodulation of direct sequence spread spectrum signals with necessary equation and block diagram.	5
	OR	
2 (a)	**Explain** the design of bandlimited signals with controlled ISI.	5
(b)	For a binary sequence 011100101, **determine** pre coded sequence, transmitted sequence, received sequence and decoded sequence. Assume previous pre coder output is one.	5
(c)	**Explain** any 2 application of direct sequence spread spectrum.	5
	Part B	
3 (a)	With neat diagram **explain** Duo binary encoder and Precoder.	5
(b)	**Explain** the necessity of equalization.	5
(c)	A direct sequence spread spectrum signal is designed so that the Power ratio $\frac{P_R}{P_N}$ at the intended receiver is 10^{-2}. If the desired $\frac{E_b}{N_0}=10$ for acceptable performance, determine the minimum value of processing gain.	5
	OR	
4 (a)	**Explain** the probability of error of digital PAM with zero ISI.	5
(b)	With neat diagram and relevant expression **explain** the concept of Adaptive equalization.	5
(c)	A slow frequency hopped/MFSK system has the following parameters, i. The number of bits/ MFSK symbol=4 ii. The number of MFSK symbols per hop=5 **Calculate** the Processing gain of the system in decibels.	5

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

SESSION: 2019-2020 (EVEN SEMESTER)

I SESSIONAL TEST SCHEME & SOLUTION

SET-A

Degree	:	B.E	Semester	:	VI
Branch	:	Electronics and Communication Engineering	Date	:	12-03-2020
Course Title	:	Digital Communication	Course Code	:	17EC61/15EC61
Duration	:	90 Minutes	Max Marks	:	30

Note: Answer ONE full question from each part

Q. No.	Scheme & Solution	Marks
	PART-A	

Hilbert Transform of signal $x(t)$ is

$$\hat{x}(t) = \frac{1}{\pi}\int_{-\infty}^{\infty}\frac{x(\tau)}{t-\tau}\,d\tau \qquad \text{Defination} - 1M -$$

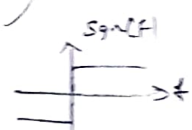
$$\hat{x}(t) = \int_{-\infty}^{\infty} x(\tau)\,\frac{1}{\pi(t-\tau)}\,d\tau$$

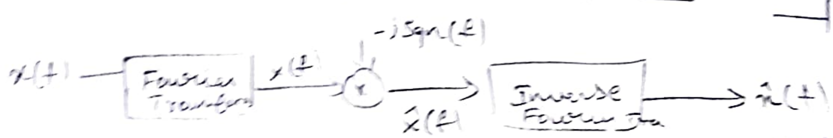
$$\hat{x}(t) = x(t) * \frac{1}{\pi t}$$

Apply FT on both side $\quad - 2M -$

1(a) $\quad \hat{X}(f) = X(f)\, FT\left[\frac{1}{\pi t}\right]$ $\quad$ 5

$$\boxed{\hat{X}(f) = -j\,\mathrm{sgn}(f)\, X(f)}$$





Hilbert Transformer

Block Diagram - 1M -

Explanation - 1M -

Given $x(t) = e^{-jt}$

$x(t) = \cos t - j\sin t$

$\cos t = \cos\omega_1 t$

$\omega_1 = 1$

$2\pi f_1 = 1$

$f_1 = \frac{1}{2\pi}$

(b) $\quad$ we know $\hat{X}(f) = -j\,\mathrm{sgn}(f)\, X(f)$ — ① $\quad$ Eqn 1M $\quad$ 5

Apply FT to $x(t)$

$\sin t = \sin\omega_2 t$

$\omega_2 = 1$

$f_2 = \frac{1}{2\pi}$

$$X(f) = \frac{1}{2}\left[\delta\left(f-\frac{1}{2\pi}\right)+\delta\left(f+\frac{1}{2\pi}\right)\right] - j\frac{1}{2j}\left[\delta\left(f-\frac{1}{2\pi}\right)-\delta\left(f+\frac{1}{2\pi}\right)\right]$$

F.T. 1M

$\therefore \hat{X}(f) = -j\,\mathrm{sgn}(f)\left\{\frac{1}{2}\left[\delta\left(f-\frac{1}{2\pi}\right)+\delta\left(f+\frac{1}{2\pi}\right)\right]-\frac{1}{2}\left[\delta\left(f-\frac{1}{2\pi}\right)-\delta\left(f+\frac{1}{2\pi}\right)\right]\right\}$

$= \frac{-j}{2}\left[\delta\left(f-\frac{1}{2\pi}\right)-\delta\left(f+\frac{1}{2\pi}\right)\right]+\frac{j}{2}\left[\delta\left(f-\frac{1}{2\pi}\right)+\delta\left(f+\frac{1}{2\pi}\right)\right]$ (2M) Simplification

$\hat{x}(t) = \sin t + j\cos t$

$\hat{x}(t) = (\cos t - j\sin t)\,j = j e^{-it}$ // (1M) Answer

(c) Consider M energy signals

$S_i(t) = \{S_1(t), S_2(t) \ldots S_M(t)\}$ where $i = 1, 2 \ldots M$ (1M)

These signals are mapped to N orthonormal basis function $\phi_j(t) = \{\phi_1(t), \phi_2(t) \ldots \phi_N(t)\}$ where $j = 1, 2 \ldots N$ & $N \le M$ (1M)

The linear relationship b/n $S_i(t)$ & $\phi_j(t)$ is $\boxed{S_i(t) = \sum_{j=1}^{N} S_{ij}\,\phi_j(t)}$ (1M)

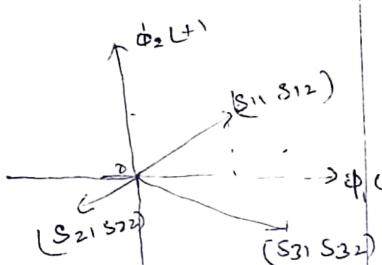
At $M = 3$, $i = 1, 2, 3$ & $N = 2$

$\therefore S_i(t) = \sum_{j=1}^{2} S_{ij}\,\phi_j(t) = S_{i1}\phi_1(t) + S_{i2}\phi_2(t)$

(1M) $\therefore S_1(t) = S_{11}\phi_1(t) + S_{12}\phi_2(t)$

$S_2(t) = S_{21}\phi_1(t) + S_{22}\phi_2(t)$

$S_3(t) = S_{31}\phi_1(t) + S_{32}\phi_2(t)$



(1M) 5

OR

2(a) Pre envelope $S_+(t) = S(t) + j\hat{S}(t)$

where $S(t) \rightarrow$ Signal (Band pass Signal)

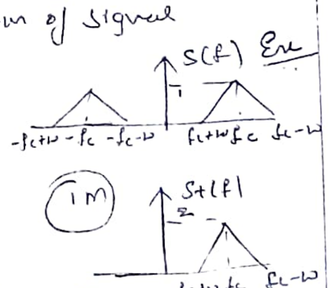
$S_+(t) \rightarrow$ pre envelope of Signal

$\hat{S}(t) \rightarrow$ Hilbert Transform of Signal

$S_+(f) = S(f) + j\hat{S}(f)$

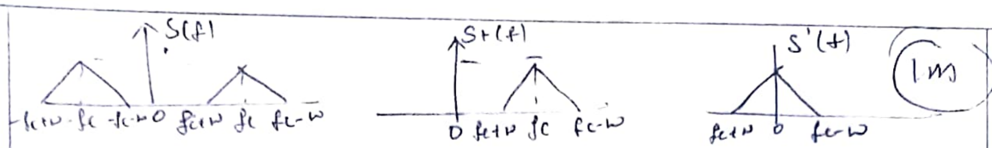
$S_+(f) = \begin{cases} 2S(f) & f \ge 0 \\ 0 & f < 0 \end{cases}$ (2M)

$|||^{ly}$ $S_-(f) = \begin{cases} 0 & f > 0 \\ 2S(f) & f < 0 \end{cases}$



(1M) 5

Complex envelope $\tilde{S}(t) = S_+(t)\,e^{-j2\pi f_c t}$ (1M)

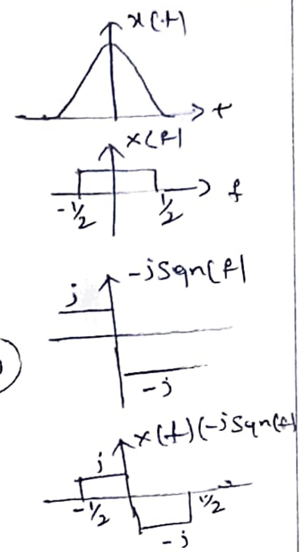


Band pass Signal — Pre-envelope — Complex Envelope

(b) 5

Given $x(t) = \text{Sinc}(t)$

$X(f) = \text{rect}(f)$ (1M)



$\therefore$ Hilbert Transform

$$\hat{X}(f) = -j\,\text{sgn}(f)\,X(f)$$

$$\hat{X}(f) = -j\,\text{sgn}(f)\,\text{rect}(f)$$

$$\hat{X}(f) = \begin{cases} j & -\tfrac{1}{2} \le f \le 0 \\ -j & 0 \le f \le \tfrac{1}{2} \end{cases}$$ (2M)

$$\therefore \hat{x}(t) = \int_{-\infty}^{\infty} \hat{X}(f)\, e^{j2\pi f t}\, df$$

$$= \int_{-1/2}^{0} j\, e^{j2\pi f t}\, df + \int_{0}^{1/2} (-j)\, e^{j2\pi f t}\, df$$

$$\hat{x}(t) = \frac{1}{\pi t}\left(1 - \cos \pi t\right)$$ (1M)

Pre-envelope $x_+(t) = x(t) + j\,\hat{x}(t) = \text{sinc}(t) + \frac{j}{\pi t}(1 - \cos \pi t)$ (1M)

(c) 5

Gram Schmidt orthogonalization procedure is used to find N orthogonal / orthonormal basis function

we have $S_i(t) = \sum_{j=1}^{N} S_{ij}\, \phi_j(t)$ — ① $\quad i = 1, 2 \dots M$, $j = 1, 2 \dots N$, where $N \le M$

At $N = 1$ & $i = 1$ Eq ① becomes

$$S_1(t) = S_{11}\, \phi_1(t)$$

$$\therefore \phi_1(t) = \frac{S_1(t)}{S_{11}} \quad \text{— ②}$$

Squaring & Integrating on both side for interval $0 \le t \le T$

$$\int_0^T \phi_1^2(t)\, dt = \int_0^T \frac{S_1^2(t)}{S_{11}^2}\, dt$$

$$1 = \frac{1}{S_{11}^2} \int_0^T S_1^2(t)\, dt$$

finding ϕ_1 (2M)

$$S_{11} = \sqrt{\int_0^T S_1^2(t)\, dt} = \sqrt{E_1}$$

$\therefore$ Eq ② becomes $\boxed{\phi_1(t) = \frac{S_1(t)}{\sqrt{E_1}}}$

At $n=2$ & $i=2$ Eq ① become

$$S_2(t) = S_{21}\phi_1(t) + S_{22}\phi_2(t)$$

$$\phi_2(t) = \frac{S_2(t) - S_{21}\phi_1(t)}{S_{22}} \quad \text{--- ③}$$

Squaring & Integrating on both side for interval $0 \le t \le T$

$$S_{22} = \sqrt{\int_0^T (S_2(t) - S_{21}\phi_1(t))^2\, dt}$$

finding ϕ_2 (2M)

let $g_2(t) = S_2(t) - S_{21}\phi_1(t)$: $S_{22} = \sqrt{\int_0^T g_2^2(t)\, dt}$

$$\boxed{\phi_2(t) = g_2(t) \Big/ \sqrt{\int_0^T g_2^2(t)\, dt}}$$

In general $\phi_i(t) = \dfrac{g_i(t)}{\sqrt{\int_0^T g_i^2(t)\, dt}}$ & $g_i(t) = S_i(t) - \sum_{j=1}^{i-1} S_{ij}\phi_j(t)$

$S_{ij} = \int_0^T S_i(t)\phi_j(t)\, dt$

General Eq (1M)

PART-B

3(a)

Real part of pre envelope of signal gives original Bandpass signal i.e $s(t) = Re[s_+(t)]$ — ①

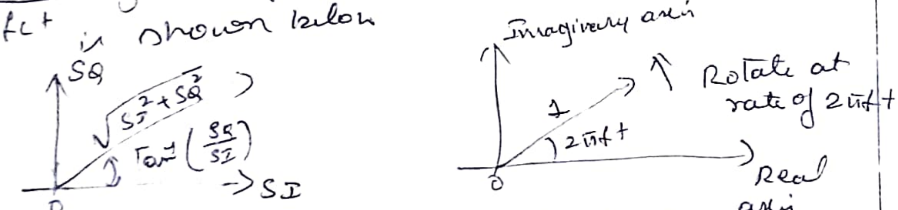
In terms of complex envelope $s(t) = Re[\tilde{s}(t)\, e^{j2\pi f t}]$ — ② (1M)

where $\tilde{s}(t) = s_I(t) + j s_Q(t)$ — ③

Substituting ③ in ② (1M)

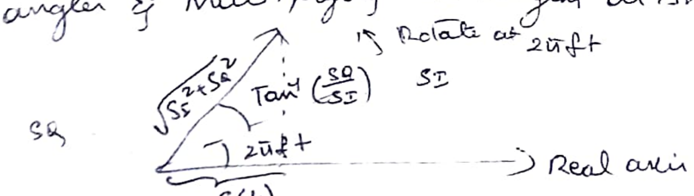
$$s(t) = s_I(t)\cos(2\pi f t) - s_Q(t)\sin(2\pi f t) \quad \text{— ④}$$

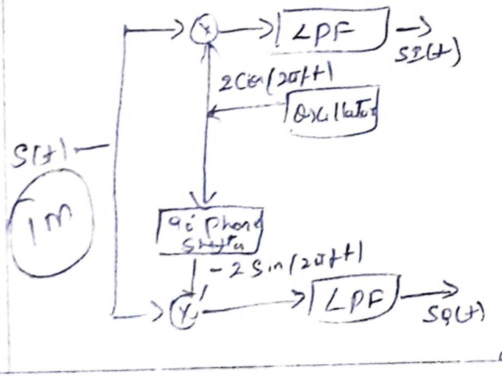
(1M) Phasor Diagram of Eq ③ & complex exponential $e^{j2\pi f_c t}$ is shown below



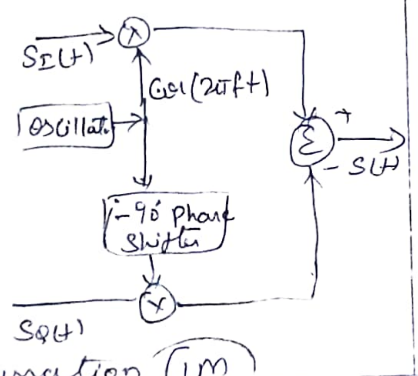
5

Adding the angles & multiplying the lengths as shown below



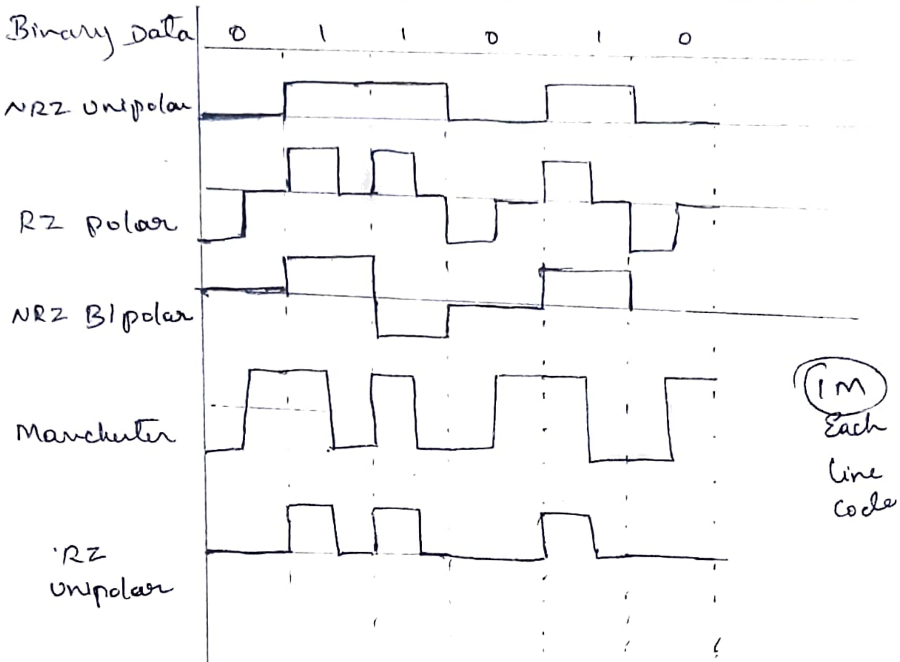


(1M)



Explanation (1M)

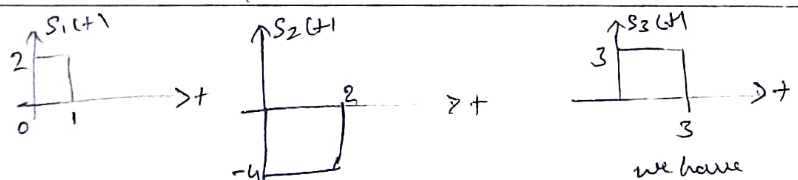
(b)



(1M Each line code)

5

(c)



we have

$$\phi_i(t) = \frac{g_i(t)}{\sqrt{\int_0^T g_i^2(t)dt}} \quad -(1)$$

(1M)

$$g_i(t) = s_i(t) - \sum_{j=1}^{i-1} s_{ij}\,\phi_j(t) \quad -(2)$$

$$s_{ij} = \int_0^T s_i(t)\,\phi_j(t) \quad -(3)$$

At $i=1$ Eq (1) becomes

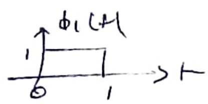
$$\phi_1(t) = \frac{g_1(t)}{\sqrt{\int_0^T g_1^2(t)dt}} = \frac{1}{\sqrt{4}}\, s_1(t)$$

Eq (2) $g_1(t) = s_1(t)$

$$\int_0^T g_1^2(t)\,dt = \int_0^1 2^2 dt = 4$$

finding ϕ_1 (2M)

$$\therefore \phi_1(t) = \frac{1}{2}\begin{cases} 2 & 0 \le t \le 1 \\ 0 & \text{other} \end{cases} = \begin{cases} 1 & 0 \le t \le 1 \\ 0 & \text{otherwise} \end{cases}$$



5

At $i=2$ Eq (1) becomes

finding ϕ_2 (2M)

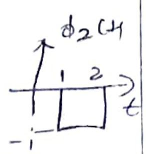
$$\phi_2(t) = \frac{g_2(t)}{\sqrt{\int_0^T g_2^2(t)dt}} = \frac{1}{\sqrt{16}}\, g_2(t)$$

$$g_2(t) = s_2(t) - s_{21}\phi_1(t) = s_2(t) + 4\phi_1(t) = \begin{cases} -4 & 1 \le t \le 2 \\ 0 & \text{otherwise} \end{cases}$$

$$s_{21} = \int_0^T s_2(t)\,\phi_1(t)\,dt = \int_0^1 (-4)\,dt = -4$$

$$\int_0^T g_2^2(t)\,dt = 16.$$

$$\therefore \phi_2(t) = \frac{1}{4}\begin{cases} -4 & 1 \le t \le 2 \\ 0 & \text{otherwise} \end{cases} = \begin{cases} -1 & 1 \le t \le 2 \\ 0 & \text{otherwise} \end{cases}$$



At $i=3$ Eq ① ② below

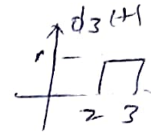
$$\phi_3(t) = \frac{g_3(t)}{\sqrt{\int_0^T g_3^2(t)\,dt}}$$

$$g_3(t) = s_3(t) - (s_{31}\phi_1(t) + s_{32}\phi_2(t)) = s_3(t) - 3\phi_1(t) + 3\phi_2(t) = \begin{cases} 3 & 2 \le t \le 3 \\ 0 & \text{otherwise} \end{cases}$$

$$s_{31} = \int_0^T s_3(t)\phi_1(t)\,dt = 3 \qquad \therefore \int_0^T g_3^2(t)\,dt = 9$$

$$s_{32} = \int_0^T s_3(t)\phi_2(t)\,dt = -3$$

$$\phi_3(t) = \frac{1}{\sqrt{9}}\begin{cases} 3 & 2 \le t \le 3 \\ 0 & \text{otherwise} \end{cases} = \begin{cases} 1 & 2 \le t \le 3 \\ 0 & \text{otherwise} \end{cases}$$



OR

4(a)

Consider a bandpass signal $x(t)$ & Bandpass S/m $h(t)$: O/P $y(t) = x(t) * h(t) = h(t) * x(t)$ (1M)

$$y(t) = \int_{-\infty}^{\infty} h(\tau)\, x(t-\tau)\, d\tau$$

we have $x(t) = Re[x'(t)\, e^{j2\pi f t}]$ where $x'(t)$ & $h'(t)$ are Complex valued Signal

(1M) $h(t) = Re[h'(t)\, e^{j2\pi f t}]$

$$y(t) = \int_{-\infty}^{\infty} Re[h'(\tau) e^{j2\pi f \tau}]\, Re[x'(t-\tau)\, e^{j2\pi f (t-\tau)}]\, d\tau$$

$$y(t) = \frac{Re}{2}\int_{-\infty}^{\infty} h'(\tau)\, x'(t-\tau)\, e^{j2\pi f t}\, d\tau$$ Simplification (1M) — 5

$$y(t) = \frac{1}{2} e^{j2\pi f t}\, Re\int_{-\infty}^{\infty} h'(\tau)\, x'(t-\tau)\, d\tau$$

$$\boxed{y(t) = \frac{1}{2} e^{j2\pi f t}\, y'(t)}$$ (1M)

where $\boxed{y'(t) = Re\int_{-\infty}^{\infty} h'(\tau)\, x'(t-\tau)\, d\tau}$

Bandpass Signal $x(t)$ → | Band pass S/m $h(t)$ | → O/P $y(t)$ (1M)

↓ Matter

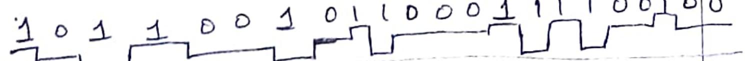
Complex Signal $x'(t)$ → | Complex S/m $h'(t)$ | → O/P $y'(t) = 2y(t)$

(b)

Given Binary Data: 1 0 1 0 0 0 0 0 1 1 0 0 0 0 1 1 0 0 0 0 0 0

(B 0 0 V ... 0 0 0 V ... B 0 0 V)

(2M) HDB3 Encoding: 1 0 1 1 0 0 1 0 1 1 0 0 0 1 1 1 1 1 0 0 1 0 0 — AMI Coding — 5



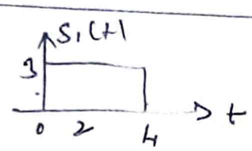
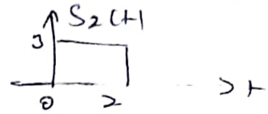
Binary Data: 1 0 1 0 0 0 0 0 1 1 0 0 0 0 1 1 0 0 0 0 0 0

(B 0 V ... B 0 V ... B 0 V, B 0 V)

B3ZS

(2M) Encoding: 1 0 1 1 0 1 0 0 1 1 1 0 1 0 1 1 1 0 1 1 0 1

AMI Encoding (1M) = ½ + ½

AMI Encoding		
(c)	 	5

At $i=1$ Eq ① becomes

$$\phi_1(t) = \frac{g_1(t)}{\sqrt{\int_0^T g_1^2(t)\,dt}} = \frac{s_1(t)}{\sqrt{36}}$$

we have

$$\phi_i(t) = \frac{g_i(t)}{\sqrt{\int_0^T g_i^2(t)\,dt}} \quad -①$$

(1M)

Eq ② becomes

$$g_1(t) = s_1(t)$$

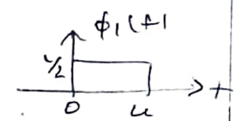
$$g_i(t) = s_i(t) - \sum_{j=1}^{i-1} s_{ij}\phi_j(t) \quad -②$$

$$\int_0^T g_1^2(t)\,dt = \int_0^4 3^2\,dt = 36$$

finding ϕ_1 (1½M)

$$s_{ij} = \int_0^T s_i(t)\phi_j(t)\,dt \quad -③$$

$$\phi_1(t) = \frac{1}{6}\begin{cases} 3 & 0 \le t \le 4 \\ 0 & \text{otherwise} \end{cases} = \begin{cases} \frac{1}{2} & 0 \le t \le 4 \\ 0 & \text{otherwise} \end{cases}$$



At $i=2$ Eq ① becomes

$$\phi_2(t) = \frac{g_2(t)}{\sqrt{\int_0^T g_2^2(t)\,dt}} = \frac{1}{\sqrt{9}}\,g_2(t)$$

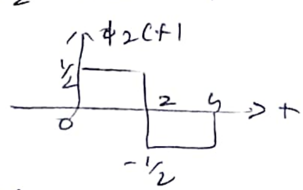
$$g_2(t) = s_2(t) - s_{21}\phi_1(t) = s_2(t) - 3\phi_1(t) = \begin{cases} \frac{3}{2} & 0 \le t \le 2 \\ -\frac{3}{2} & 2 \le t \le 4 \end{cases}$$

$$s_{21} = \int_0^T s_2(t)\phi_1(t)\,dt = \int_0^2 \frac{3}{2}\,dt = 3$$

$$\therefore \int_0^T g_2^2(t)\,dt = \int_0^2 \left(\frac{3}{2}\right)^2 dt + \int_2^4 \left(-\frac{3}{2}\right)^2 dt = \frac{9}{4}[2+2] = 9$$

$$\phi_2(t) = \frac{1}{3}\begin{cases} \frac{3}{2} & 0 \le t \le 2 \\ -\frac{3}{2} & 2 \le t \le 4 \end{cases} = \begin{cases} \frac{1}{2} & 0 \le t \le 2 \\ -\frac{1}{2} & 2 \le t \le 4 \end{cases}$$

finding ϕ_2 (1½M)



$$\therefore s_1(t) = s_{11}\phi_1(t) = 6\phi_1(t)$$

(1M)

$$s_2(t) = s_{21}\phi_1(t) + s_{22}\phi_2(t) = 3\phi_1(t) + 3\phi_2(t)$$

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

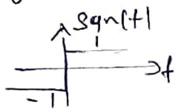
SESSION: 2019-2020 (EVEN SEMESTER)

I SESSIONAL TEST SCHEME & SOLUTION

SET-B

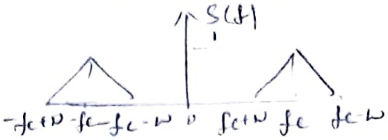
Degree	:	B.E	Semester	:	VI
Branch	:	Electronics and Communication Engineering	Date	:	12-03-2020
Course Title	:	Digital Communication	Course Code	:	17EC61/15EC61
Duration	:	90 Minutes	Max Marks	:	30

Note: Answer ONE full question from each part

Q. No.	Scheme & Solution	Marks
	PART-A	
1(a)	Hilbert transform of a signal $x(t)$ is $\hat{x}(t) = \frac{1}{\pi}\int_{-\infty}^{\infty}\frac{x(\tau)}{t-\tau}d\tau$ 1M Proof Consider $\int_{-\infty}^{\infty} x(t)\hat{x}(t)\,dt = \int_{-\infty}^{\infty} X(f)\hat{X}(-f)\,df$ 1M $= \int_{-\infty}^{\infty} X(f)\{j\,sgn(f)X(-f)\}\,df$ Simplification 1M $= j\int_{-\infty}^{\infty} sgn(f)X(f)X^{*}(f)\,df$ $= j\int_{-\infty}^{\infty} sgn(f)\lvert X(f)\rvert^{2}\,df$ $sgn(f) \rightarrow$ odd function  1M $\lvert X(f)\rvert^{2} \rightarrow$ Even function Product of odd & Even function results in zero $\therefore \int_{-\infty}^{\infty} x(t)\hat{x}(t)\,dt = 0$ 1M	5
(b)	$x(t) = \sin(2\pi f_c t)$ $X(f) = \frac{1}{2j}[\delta(f-f_c) - \delta(f+f_c)]$ 1M we know $\hat{X}(f) = -j\,sgn(f)\,X(f)$ 1M $\hat{X}(f) = -j\,sgn(f)\left[\frac{1}{2j}[\delta(f-f_c) - \delta(f+f_c)]\right]$ $= -\frac{1}{2}[\delta(f-f_c) + \delta(f+f_c)]$ 2M	5

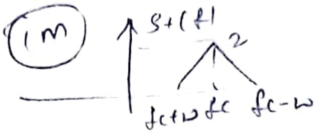
	Apply Inverse Fourier Transform $\hat{x}(t) = -\cos(2\pi f_c t)$ 1M	
(c)	Consider Energy Signal $s_i(t)$ then $\text{Energy} = \int_{-\infty}^{\infty} s_i^2(t)\,dt$ 1M $= \int_{-\infty}^{\infty} s_i(t)\, s_i(t)\,dt$ $= \int_{-\infty}^{\infty} \sum_{j=1}^{N} s_{ij}\phi_j(t) \sum_{k=1}^{N} s_{ik}\phi_k(t)\,dt$ 1M $= \sum_{j=1}^{N} s_{ij} \sum_{k=1}^{\infty} s_{ik} \int_{-\infty}^{\infty} \phi_j(t)\phi_k(t)\,dt$ We know basis functions are orthogonal i.e. $\int_{-\infty}^{\infty} \phi_j(t)\,\phi_k(t)\,dt = 1$ for $j = k$ 1M $= \sum_{j=1}^{N} s_{ij}\, s_{ij}$ $= \sum_{j=1}^{N} s_{ij}^2$ 1M $= \lVert s_i \rVert^2$ 1M	5
	OR	
2(a)	Preenvelope: Preenvelope of a Signal $x(t)$ is $x_+(t) = x(t) + j\hat{x}(t)$ In frequency domain	5

(2M) $S_{+}(f) = \begin{cases} 2S(f) & f \geq 0 \\ 0 & f < 0 \end{cases}$



III^{ly} $S_{-}(f) = \begin{cases} 0 & f > 0 \\ 2S(f) & f < 0 \end{cases}$

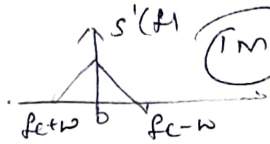
(1M)



Complex Envelope

(1M) $s'(t) = s_{+}(t) e^{-j2\pi f_c t}$

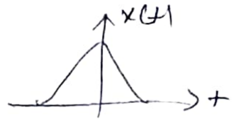
$s'(f) = S_{+}(f + f_c)$



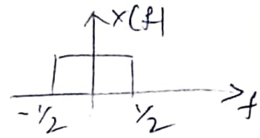
(1M)

(b) Given $x(t) = \operatorname{Sinc}(t)$

$X(f) = \operatorname{rect}(f)$ (1M)

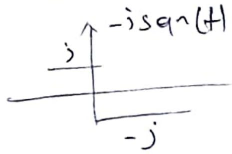


$\therefore \hat{X}(f) = -j \operatorname{sgn}(f) X(f)$



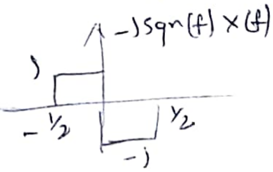
$\hat{X}(f) = -j \operatorname{sgn}(f) \operatorname{rect}(f)$

Apply Inverse FT



$\hat{x}(t) = \int_{-\infty}^{\infty} \hat{X}(f) e^{j2\pi f t} df$ (2M)

$= \int_{-1/2}^{0} \hat{X}(f) e^{j2\pi f t} df + \int_{0}^{1/2} \hat{X}(f) e^{j2\pi f t} df$ 5



$= \int_{-1/2}^{0} j\, e^{j2\pi f t} df + \int_{0}^{1/2} (-j)\, e^{j2\pi f t} df$

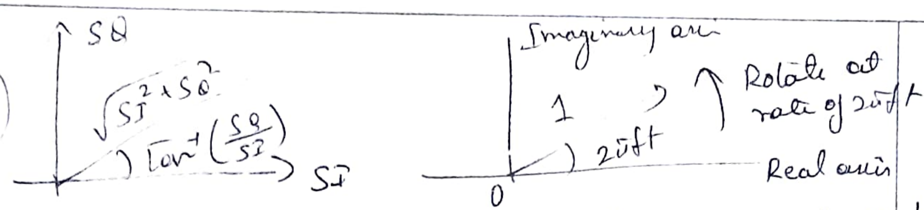
$\boxed{\hat{x}(t) = \frac{1}{\pi t}(1 - \cos \pi t)}$ (1M)

Pre Envelope

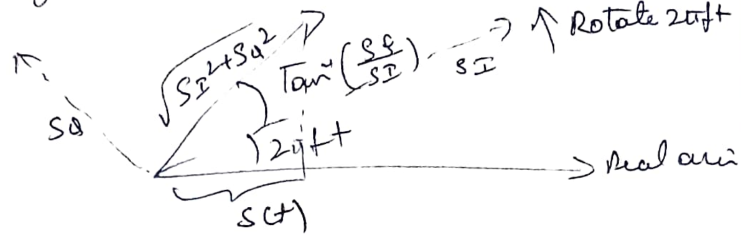
(1M) $x_{+}(t) = x(t) + j\hat{x}(t) = \operatorname{Sinc}(t) + j\frac{1}{\pi t}(1 - \cos \pi t)$

(c)	Gram Schmidtt orthogonalization Procedure is used to find orthogonal basis function we know $s_i(t) = \sum_{j=1}^{N} s_{ij} \phi_j(t)$ -① At $i=1$ $N=1$ Eq ① becomes $s_1(t) = s_{11}\phi_1(t)$ $\phi_1(t) = \frac{s_1(t)}{s_{11}}$ -② Squaring & Integrating on both side $\int_0^T \phi_1^2(t)dt = \int_0^T \frac{s_1^2(t)}{s_{11}^2} dt$ $1 = \frac{1}{s_{11}^2}\int_0^T s_1^2(t)dt$ finding ϕ_1 (2M) $s_{11} = \sqrt{\int_0^T s_1^2(t)dt}$ Eq ② becomes $\boxed{\phi_1(t) = \frac{s_1(t)}{\sqrt{\int_0^T s_1^2(t)dt}}}$ At $i=2$ $N=2$ Eq ① becomes $s_2(t) = \sum_{j=1}^{2} s_{2j}\phi_j(t) = s_{21}\phi_1(t) + s_{22}\phi_2(t)$ $\phi_2(t) = \frac{s_2(t) - s_{21}\phi_1(t)}{s_{22}} = \frac{g_2(t)}{s_{22}}$ finding ϕ_2 (2M) Squaring & Integrating $s_{22} = \sqrt{\int_0^T g_2^2(t)dt}$ $\boxed{\phi_2(t) = g_2(t)/\sqrt{\int_0^T g_2^2(t)dt}}$ In general $\phi_i(t) = \frac{g_i(t)}{\sqrt{\int_0^T g_i^2(t)dt}}$ general Eq (1M) $g_i(t) = s_i(t) - \sum_{j=1}^{i-1} s_{ij}\phi_j(t)$ $s_{ij} = \int_0^T s_i(t)\phi_j(t)dt$	5
	PART-B	
3(a)	Real part of Pre envelope of signal given original Bandpass signal $s(t) = Re[s_+(t)] = Re[s'(t)e^{j2\pi f t}]$ -① (1M) where $s'(t) = s_I(t) + js_Q(t)$ -② Substituting ② in ① $s(t) = s_I(t)\cos(2\pi f t) - s_Q(t)\sin(2\pi f t)$ (1M) Phasor diagram of Eq ② & complex exponential $e^{j2\pi f t}$ is shown below	5

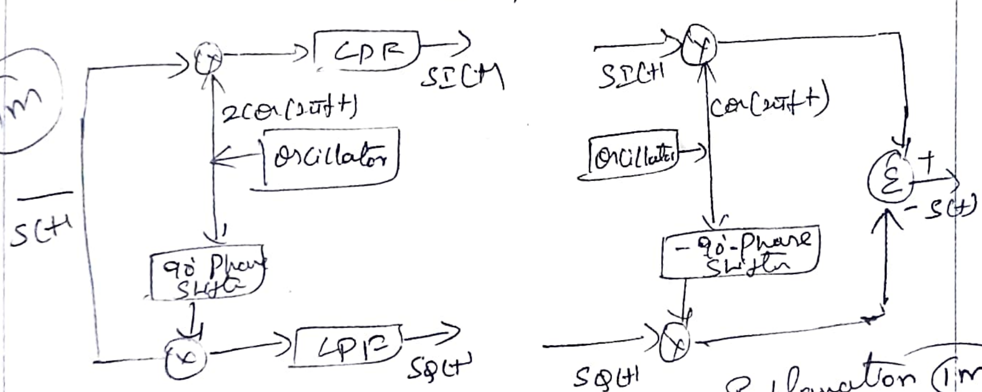
1m



adding angle & multiplying length as shown below

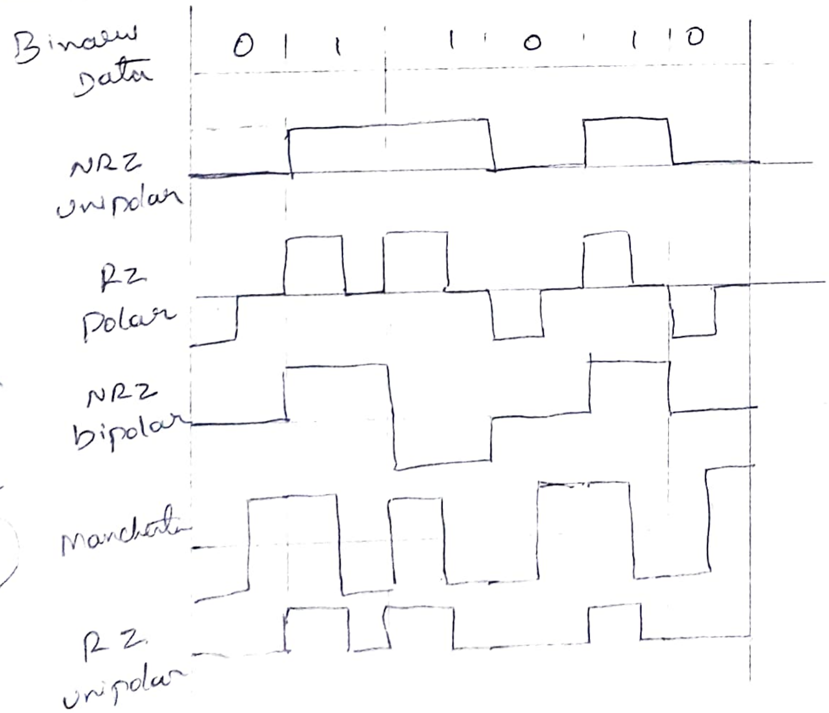


1m



Explanation 1m

(b) Each line code 1m



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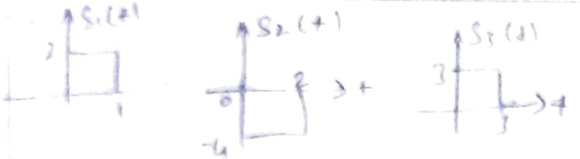


we have

$$\phi_i(t) = \frac{g_i(t)}{\sqrt{\int_0^T g_i^2(t)\,dt}} \quad -(1)$$

$$g_i(t) = s_i(t) - \sum_{j=1}^{i-1} s_{ij}\,\phi_j(t) \quad -(2)$$

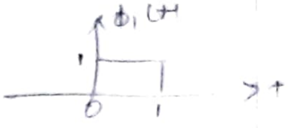
$$s_{ij} = \int_0^T s_i(t)\,\phi_j(t)\,dt \quad -(3)$$

At $i=1$ Eq (1) becom

$$\phi_1(t) = \frac{g_1(t)}{\sqrt{\int_0^T g_1^2(t)\,dt}} = \frac{1}{\sqrt{4}}\,s_1(t)$$

Eq (2) becom- $g_1(t) = s_1(t)$

$$\int_0^T g_1^2(t)\,dt = \int_0^1 2^2\,dt = 4 \qquad \phi_1(t) = \frac{1}{2}\begin{cases} 2, & 0 \le t \le 1 \\ 0 & \text{otherwise} \end{cases} = \begin{cases} 1 & 0 \le t \le 1 \\ 0 & \text{otherwise} \end{cases}$$



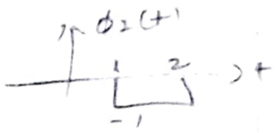
At $i=2$ Eq (1) becom

$$\phi_2(t) = \frac{g_2(t)}{\sqrt{\int_0^T g_2^2(t)\,dt}} = \frac{1}{\sqrt{16}}\,g_2(t)$$

(c) $g_2(t) = s_2(t) - s_{21}\phi_1(t) = s_2(t) + 4\phi_1(t) = \begin{cases} -4 & 1 \le t \le 2 \\ 0 & \text{otherwise} \end{cases}$ 5

$$s_{21} = \int_0^T s_2(t)\,\phi_1(t)\,dt = \int_0^1 (-4)\,dt = -4$$

$$\int_0^T g_2^2(t)\,dt = 16 \qquad \phi_2(t) = \frac{1}{4}\begin{cases} -4 & 1 \le t \le 2 \\ 0 & \text{otherwise} \end{cases} = \begin{cases} -1 & 1 \le t \le 2 \\ 0 & \text{otherwise} \end{cases}$$



At $i=3$ Eq (3) becom

$$\phi_3(t) = \frac{g_3(t)}{\sqrt{\int_0^T g_3^2(t)\,dt}}$$

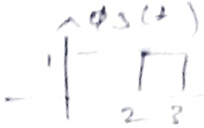
$$g_3(t) = s_3(t) - [s_{31}\phi_1(t) + s_{32}\phi_2(t)] = s_3(t) - 3\phi_1(t) + 3\phi_2(t)$$

$$= \begin{cases} 3 & 2 \le t \le 3 \\ 0 & \text{otherwise} \end{cases}$$

$$s_{31} = \int_0^T s_3(t)\,\phi_1(t)\,dt = 3$$

$$s_{32} = \int_0^T s_3(t)\,\phi_2(t)\,dt = -3$$

$$\phi_3(t) = \begin{cases} 1 & 2 \le t \le 3 \\ 0 & \text{otherwise} \end{cases}$$



OR

4(a) Unipolar NRZ: Most of the power centred around origin, waste of power due to DC component. PSD of signal doesnot attenuate zero at zero frequency 5

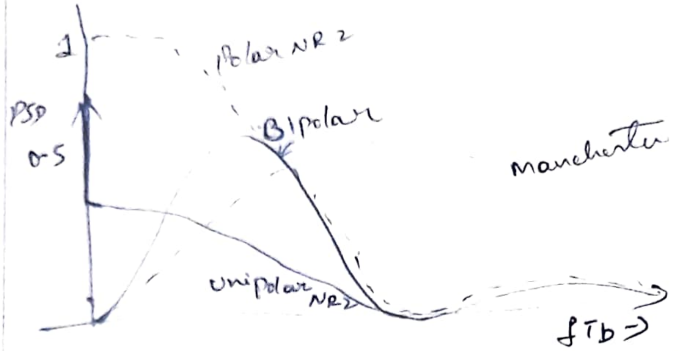


fig (1M)

Explanation of each line code PSD (1M)

Polar NRZ: Most of power centered at origin, simple to implement but PSD is large at zero frequency

Bipolar NRZ: Doesnot have DC component, insignificant at low frequency, doesnot demand more BW, but requires double power than other formant

Manchester:- Doesnot have DC component, insignificant at low frequency, But provides proper clocking

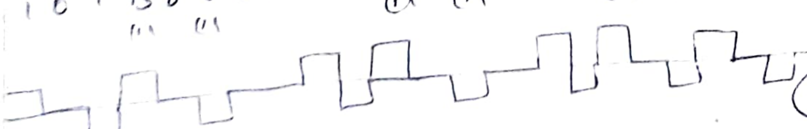
(b)

Binary Data: 1 0 1 0 0 0 0 0 1 1 0 0 0 0 1 1 0 0 0 0 0 0

HDB3: 1 0 1 B 0 0 V 0 1 1 0 0 0 V 1 1 B 0 0 V 0 0

AMI (2½M)

B3ZS: 1 0 1 B 0 V 0 0 1 1 B 0 V 0 1 1 B 0 V B 0 V



AMI (2½M)

5

(c)

5

we have $\phi_i(t) = \dfrac{g_i(t)}{\sqrt{\int_0^T g_i^2(t)\,dt}}$ — (1)

$g_i(t) = s_i(t) - \sum_{j=1}^{i-1} s_{ij}\,\phi_j(t)$ — (2)

$s_{ij} = \int_0^T s_i(t)\,\phi_j(t)\,dt$ — (3)

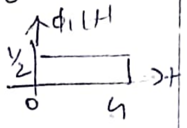
Eq (1M)

At $i = 1$ Eq ① become

$$\phi_1(t) = \frac{g_1(t)}{\sqrt{\int_0^T g_1^2(t)\,dt}} = \frac{s_1(t)}{\sqrt{36}}$$

Eq ② become

$g_1(t) = s_1(t)$ $\quad \therefore \int_0^T g_1^2(t)\,dt = \int_0^4 3^2\,dt = 36$



$$\phi_1(t) = \frac{1}{6}\begin{cases} 3 & 0 \le t \le 4 \\ 0 & \text{otherwise} \end{cases} = \begin{cases} 1/2 & 0 \le t \le 4 \\ 0 & \text{otherwise} \end{cases}$$

$\phi_1(t) = 1\tfrac{1}{2}$ M

At $i = 2$ Eq ① become

$$\phi_2(t) = \frac{g_2(t)}{\sqrt{\int_0^T g_2^2(t)\,dt}} = \frac{1}{\sqrt{9}}\, g_2(t)$$

$$g_2(t) = s_2(t) - s_{21}\phi_1(t) = s_2(t) - 3\phi_1(t) = \begin{cases} 3/2 & 0 \le t \le 2 \\ -3/2 & 2 \le t \le 4 \end{cases}$$

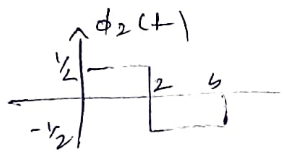
$$s_{21} = \int_0^T s_2(t)\,\phi_1(t)\,dt = \int_0^2 3/2\,dt = 3$$

$$\therefore \int_0^T g_2^2(t)\,dt = \int_0^2 \left(\tfrac{3}{2}\right)^2 dt + \int_2^4 \left(\tfrac{-3}{2}\right)^2 dt = \tfrac{9}{4}\,[2+2] = 9$$

$$\phi_2(t) = \frac{1}{3}\begin{cases} 3/2 & 0 \le t \le 2 \\ -3/2 & 2 \le t \le 4 \end{cases}$$

$\phi_2(t) = 1\tfrac{1}{2}$ M

$$= \begin{cases} 1/2 & 0 \le t \le 2 \\ -1/2 & 2 \le t \le 4 \end{cases}$$



$s_1(t) = s_{11}\phi_1(t) = 6\phi_1(t)$

$s_2(t) = s_{21}\phi_1(t) + s_{22}\phi_2(t) = 3\phi_1(t) + 3\phi_2(t)$

1M

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DEPARTMENT OF ELECTRONICS AND COMUNICATION ENGINEERING

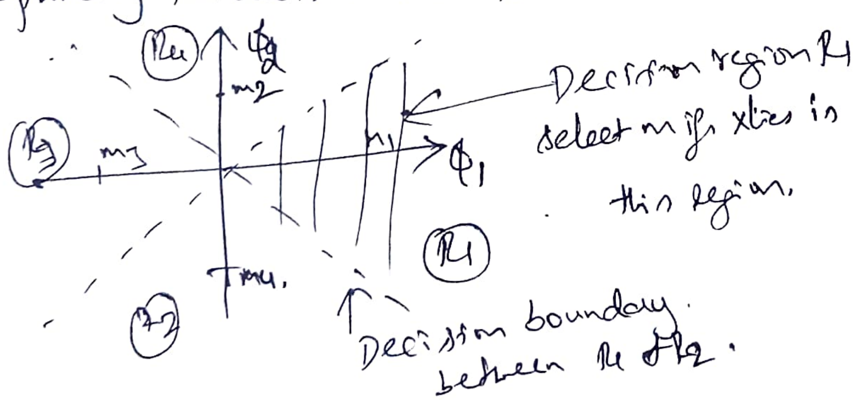
SESSION: 2019-2020 (EVEN SEMESTER)

II SESSIONAL TEST SCHEME & SOLUTION

SET-A

Degree	:	B.E	Semester	:	VI A&B
Branch	:	Electronics and Communication Engineering	Date	:	04-05-2020
Course Title	:	Digital Communication	Course Code	:	17EC61/15EC61
Duration	:	90 Minutes	Max Marks	:	30

Note: Answer ONE full question from each part

Q. No.	Questions with Scheme & Solution	Marks
	PART-A	
1(a)	Average probability of symbol error in this decision $P_e(m_i, x) = P(m_i \text{ not sent}/x) = (1-P)(m_i \text{ sent}/x)$ Optimum decision rule is set $\hat{m} = m_i$ if $(p(m_i \text{ sent}/x) \geq p(m_k \text{ sent}/x)$ for all $k \neq i$. Graphically the decision rule is  Let R denote the N-dimensional space of all possible vectors 'x'. And this region be partitioned into M decision regions $R_1\ R_2 - R_4$. vector x lies in region R_i if $l_n(f_x(x/m_k))$ is maximum for $k=i$	5

(b)

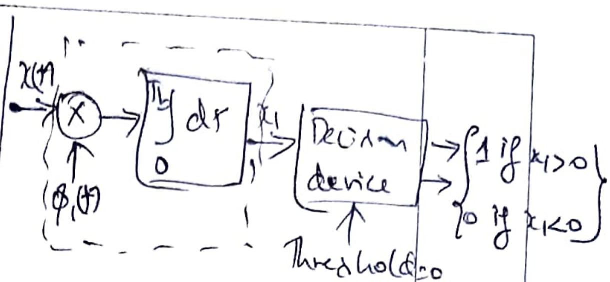
$$s_1(t) = \sqrt{\frac{2E_b}{T_b}} \cos 2\pi f_c t$$

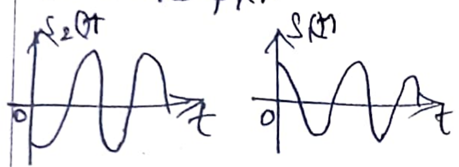
$$s_2(t) = \sqrt{\frac{2E_b}{T_b}} \cos(2\pi f_c t + \pi)$$

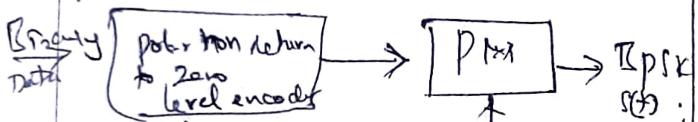
$$\phi_1(t) = \sqrt{\frac{2}{T_b}} \cos(2\pi f_c t) \quad (0 \le t \le T_b)$$

$$s_1(t) = \sqrt{E_b}\, \phi_1(t)$$

$$s_2(t) = -\sqrt{E_b}\, \phi_1(t).$$







Generation of BPSK $\quad \phi_1(t) = \sqrt{\frac{2}{T_b}} \cos(2\pi f_c t).$

5

(c)

$$P_e = \frac{1}{2} \operatorname{erfc} \sqrt{\frac{E_b}{N_0}} \text{ for BPSK}$$

$$E_b = PT_b$$

$$P_e = \frac{1}{2} \operatorname{erfc} \sqrt{\frac{PT_b}{N_0}}$$

$$10^{-4} = \frac{1}{2} \operatorname{erfc} \sqrt{\frac{P \cdot 1}{2\times10^{-12} \times 1\times10^{6}}}$$

$$2\times10^{-4} = \operatorname{erfc} \sqrt{\frac{P}{2\times10^{-6}}}$$

$$\operatorname{erfc}(3.5) = \operatorname{erfc} \sqrt{\frac{P}{2\times10^{-6}}}$$

$$\boxed{P = 2.45\times10^{-5}\,\text{W}}$$

5

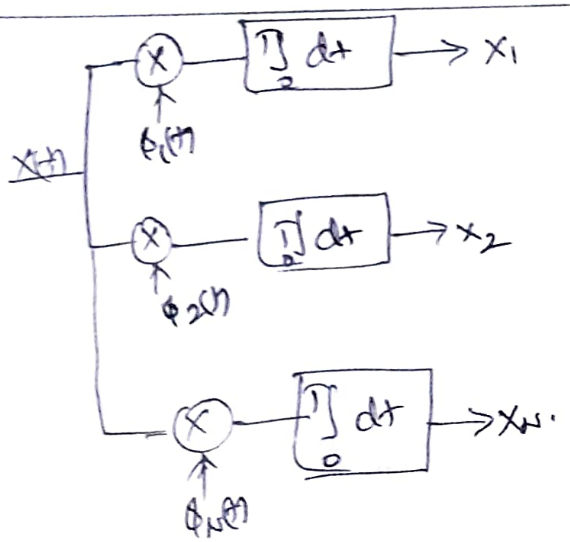
OR

2(a) Let $s_1(t), s_2(t) \ldots s_M(t)$ which are equally likely to occur and with AWGN channel called correlation receiver is used two subsystems

→ Detector

→ Maximum likelihood decoder.

5

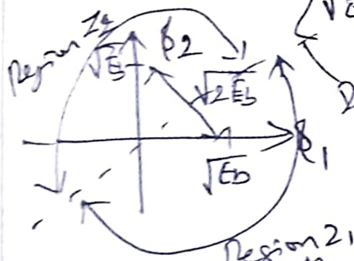


Explanation

BFSK. $s_i(t) = \begin{cases} \sqrt{\dfrac{2E_b}{T_b}}\cos(2\pi f_1 t), & 0 \le t \le T_b \text{ Sym '1'} \\ \sqrt{\dfrac{2E_b}{T_b}}\cos(2\pi f_2 t) & 0 \le t \le T_b \text{ Sym '0'}. \end{cases}$

using basis function.

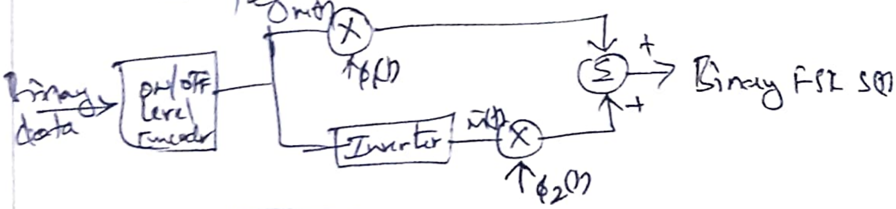
$s_i(t) = s_1(t) = \begin{cases} \sqrt{E_b}\,\phi_1(t) & 0 \le t \le T_b \quad \text{logic '1'} \\ \sqrt{E_b}\,\phi_2(t) & 0 \le t \le T_b \quad \text{logic '0'}. \end{cases}$

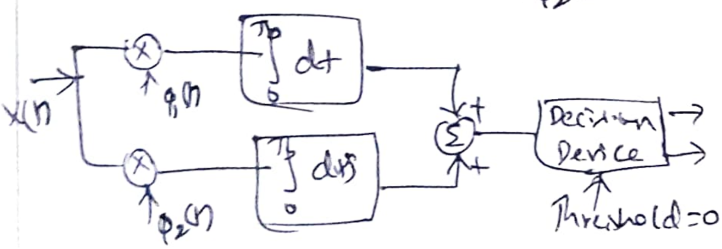


Decision Boundary.

Signal space Diagram.

(b) 5





If $y > 0$ choose 1

choose 0 If $y < 0$.

Explanation.

(c)	Assuming $s_1(t)$ is transmitted $Pe(1) = \int_{-\infty}^{0} f_{x_1}(x_1\|1)\, dx_1$ $f_{x_1}(x_1\|1) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{(x-u)^2}{2\sigma^2}}$ $u = E(\text{signal}) + E(\text{noise})$ $u_1 = \sqrt{E_b} = u_2$ $\sigma^2 = N_0$ $f_{x_1}(x_1\|1) = \frac{1}{\sqrt{2\pi N_0}} e^{-\left[\frac{x_1 - \sqrt{E_b}}{\sqrt{2N_0}}\right]^2}$ $Pe(1) = \int_{-\infty}^{0} \frac{1}{\sqrt{2\pi N_0}} e^{-\left[\frac{x_1-\sqrt{E_b}}{\sqrt{2N_0}}\right]^2} dx_1$ Let $\frac{x_1 - \sqrt{E_b}}{\sqrt{2N_0}} = y$ $x_1 \to 0$, $y = -\sqrt{\frac{E_b}{2N_0}}$ $dx_1 = \sqrt{2N_0}\, dy$ $x_1 \to \infty$, $y = -\infty$ $\boxed{P_e(1) = \frac{1}{2} \operatorname{erfc}\sqrt{\frac{E_b}{2N_0}}}$ IIIly $\boxed{Pe(0) = \frac{1}{2} \operatorname{erfc}\sqrt{\frac{E_b}{2N_0}}}$ $Pe = Pe(1)\,p(1) + Pe(0)\,p(0)$ $p(1) = p(0) = \frac{1}{2}$ $\boxed{Pe = \frac{1}{2} \operatorname{erfc}\sqrt{\frac{E_b}{2N_0}}}$	5
	PART-B	
3(a)	Matched filter Receiver: $y_j(t) = \int_{-\infty}^{t} x(\tau)\, h_j(t-\tau)\, d\tau$. (1) $y_j(T) = \int_{0}^{T} x(t)\, h_j(T-t)\, dt$ $(0 \le t < T)$ (2) o/p of jth correlator $x_j = \int_{0}^{T} x(t)\, \phi_j(t)\, dt$. (3) Compare (2) & (3)	5

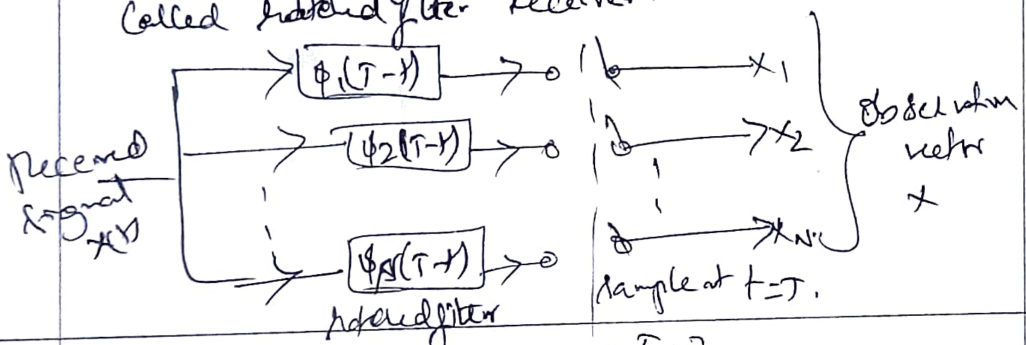
$h_j(T-t) = \phi_j(t) \qquad 0 < t \le T$

$t = T - t$

$h_j(t) = \phi_j(T-t)$

$\therefore \boxed{h(t) = \phi(T-t)}, \quad 0 \le t \le T$

A time invariant filter defined in this way is called matched filter & receiver used is called matched filter receiver.



(a) Mean is given by $m_{x_j} = E[x_j]$

$= E[s_{ij} + N_j]$

$\boxed{m_{x_j} = s_{ij} + E[N_j]}$

$\boxed{m_{x_j} = s_{ij}}$

(b) Variance of x_j $(\sigma^2_{x_j})$

4a $\sigma^2_{x_j} = \mathrm{var}(x_j)$

$= E[(x_j - m_{x_j})^2]$

$= E[(x_j - s_{ij})^2]$ 5

$= E[s_{ij} + N_j - s_{ij}]^2$

$\boxed{\sigma^2_{x_j} = E[N_j^2]}$ — (1)

Let $N_j = \int_0^T N(t)\,\phi_j(t)\,dt$ — (2)

$\sigma^2_{x_j} = E\left[\int_0^T N(t)\,\phi_j(t)\,dt \int_0^T N(p)\,\phi_j(p)\,dp\right]$

$$\sigma_{x_j}^2 = E\left[\int_0^T\int_0^T \phi_j(t)\,\phi_j(p)\,N(t)\,N(p)\,dt\,dp\right]$$

$$= \int_0^T\int_0^T \phi_j(t)\,\phi_j(p)\,E\left[N(t)\,N(p)\,dt\,dp\right]$$

$$= \int_0^T\int_0^T \phi_j(t)\,\phi_j(p)\,R_N(t,p)$$

$$= \int_0^T\int_0^T \phi_j(t)\,\phi_j(p)\,\frac{N_0}{2}\,\delta(t-p)\,dt\,du.$$

$$\sigma_{x_j}^2 = \frac{N_0}{2}\int_0^T \phi_j^2(t)\,dt.$$

$$\boxed{\sigma_{x_j}^2 = \frac{N_0}{2}} \quad \text{for all } j.$$

(c) Consider a binary sequence $b_k = 10010011$ 5

b_k		1	0	0	1	0	0	1	1
d_{k-1}		1	1	0	1	1	0	1	1
Differential encoded sequence	1	1	0	1	1	0	1	1	1
Transmitted phase	0	0	π	0	0	π	0	0	0.

OR

4(b)

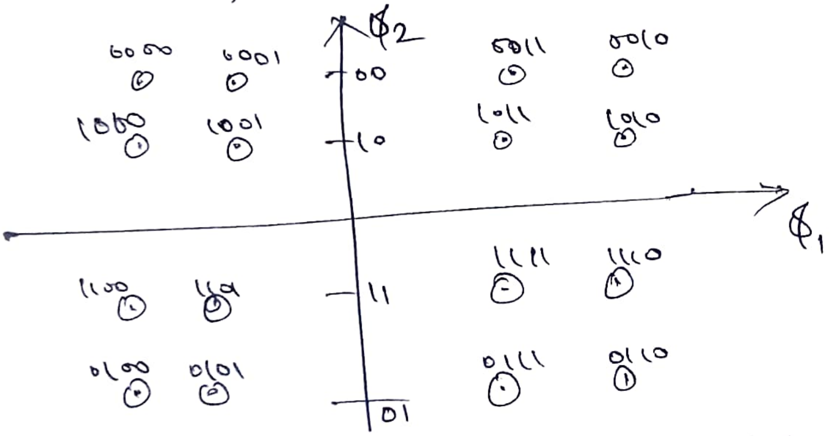
In M-ary PSK system in phase and Quadrature Components of a modulated signal are interrelated such that envelope remains to be constant resulting in circular constellation for message point.

Defined as

$$S_i(t) = \sqrt{\frac{2E_0}{T}}\, a_i \cos(2\pi f_c t) + \sqrt{\frac{2E_0}{T}}\, b_i \sin(2\pi f_c t) \quad 0 \le t < T$$

The signal $S_i(t)$ can be expressed as

$$\left.\begin{aligned} \phi_1(t) &= \sqrt{\frac{2}{T}} \cos(2\pi f_c t) \\ \phi_2(t) &= \sqrt{\frac{2}{T}} \sin(2\pi f_c t) \end{aligned}\right\} \quad 0 \le t < T.$$



Constellation Diagram of M-ary PSK.

5

4(b)

Let $x(t) = S_4(t) + w(t) \quad 0 \le t < T$

$$x_1 = \int_0^T x(t)\, \phi_1(t)\, dt = \int_0^T [S_4(t) + w(t)]\, \phi_1(t)\, dt.$$

$$\boxed{x_1 = \sqrt{\frac{E}{2}} + w_1}$$

$||^{ly}$ $$\boxed{x_2 = \sqrt{\frac{E}{2}} + w_2}$$

The Conditional pdf

$$f_{x_1}(x_1 | S_4(t)) = \frac{1}{\sqrt{2\pi\sigma^2}}\, e^{-\left[\frac{(x_1 - x)^2}{2\sigma^2}\right]}$$

5

	$f_{x_2}(x_2 \mid s_u(t)) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\left[\frac{(x_2-\mu)^2}{2\sigma^2}\right]}$ $P_{C} = \int_0^{\infty} f_{x_1}(x_1 \mid s_u(t))\, dx_1 \times \int_0^{\infty} f_{x_2}(x_2 \mid s_u(t))\, dx_2$ $\boxed{P_C = \frac{1}{2}\, erfc\left(\sqrt{\frac{E_b}{2N_0}}\right)}$ $P_C = 1 - P_e$ $\boxed{P_e \simeq erfc\sqrt{E_b/N_0}}$	
(c)	Bandwidth Efficency is defined as the Ratio of data rate to Channel Bandwidth measured in bits per second Hertz. ie $\boxed{\rho = \frac{R_b}{B}}$ bits/Hz. $B = \frac{2}{T}$ $T = T_b \log_2 M$. & $T_b = \frac{1}{R_b}$. $B = \frac{2R_b}{\log_2 M}$, $\rho = \frac{R_b}{B} = \frac{R_b}{\frac{2R_b}{\log_2 M}}$ $\boxed{\rho = \frac{\log_2 M}{2}}$	5

M	2	4	8	16	32	64
ρ	0.5	1	1.5	2	2.5	3

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DEPARTMENT OF ELECTRONICS AND COMUNICATION ENGINEERING

SESSION: 2019-2020 (EVEN SEMESTER)

III SESSIONAL TEST SCHEME & SOLUTION

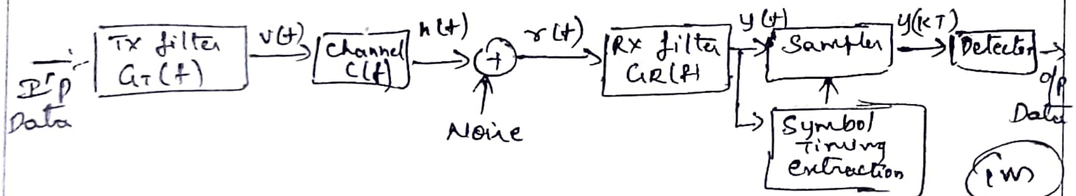
SET-A

Degree	:	B.E	**Semester**	:	VI A&B
Branch	:	Electronics and Communication Engineering	**Date**	:	26-05-2020
Course Title	:	Digital Communication	**Course Code**	:	17EC61/15EC61
Duration	:	90 Minutes	**Max Marks**	:	30

Note: Answer ONE full question from each part

Q. No. | **Questions with Scheme & Solution** | **Marks**

PART-A



(1M)

Digital commⁿ of M-ary PAM is shown where i/p is binary (or) M-ary data mapped to corresponding Amplitude levels

Baseband signal at o/p of Tx filter $\boxed{v(t) = \sum_{n=-\infty}^{\infty} a_n g_T(t-nT)}$ (1M)

channel o/p is $h(t)$ & hence i/p to demodulator

(1M) $\boxed{r(t) = \sum_{n=-\infty}^{\infty} a_n h(t-nT) + n(t)}$ where

$h(t) = c(t) * g_T(t)$

$n(t) =$ noise

o/p of Rx filter is $y(t)$

$\boxed{y(t) = \sum_{n=-\infty}^{\infty} a_n x(t-nT) + w(t)}$ where

$x(t) = h(t) * g_R(t)$

$w(t) = n(t) * g_R(t)$

Sampling the receiver o/p at every T seconds

$$y(mT) = \sum_{n=-\infty}^{\infty} a_n x(mT - nT) + w(mT)$$

$$y(m) = \sum_{m=-\infty}^{\infty} a_n x_{m-n} + w_n$$

1(a) (1M) $\boxed{y(m) = x_0 a_m + \sum_{n \neq m} x_{m-n} a_n + w_m}$ — 5

$x_0 a_m \rightarrow$ Desired symbol a_m scaled by gain factor x_0

(1M) Second term $\sum_{m \neq n} a_n x_{m-n}$ is the Intersymbol Interference

$$x_0 = \int_{-\infty}^{\infty} |h^2(t)|\, dt = \int_{-\infty}^{\infty} |H(f)|^2 df = E_h$$

Condition for Zero ISI $x(nT) = \begin{cases} 1 & n = 0 \\ 0 & n \neq 0 \end{cases}$

has Fourier Transform $X\left(f + \frac{m}{T}\right) = T.$ (1M)

Proof Consider Inverse F T of $X(f)$

$$x(t) = \int_{-\infty}^{\infty} X(f)\, e^{j2\pi f t}\, df$$

Sampling at $t = nT$

$$x(nT) = \int_{-\infty}^{\infty} X(f)\, e^{j2\pi f nT}\, df$$ (1M)

Breaking the integral

$$x(nT) \sum_{m=-\infty}^{\infty} \int_{\frac{2m-1}{2T}}^{\frac{2m+1}{2T}} X(f)\, e^{j2\pi f nT}\, df$$

(b) Let $f = p + \frac{m}{T}$ $p \to$ dummy variable 5

$df = dp$

$$x(nT) = \sum_{m=-\infty}^{\infty} \int_{-1/2T}^{1/2T} X\left(p + \frac{m}{T}\right) e^{j2\pi f pT}\, dp$$ (1M)

$$x(nT) = \int_{-1/2T}^{1/2T} \left[\sum_{m=-\infty}^{\infty} X\left(p + \frac{m}{T}\right)\right] e^{j2\pi f pT}\, dp \quad -(1)$$

Above Eq looks like Inverse Fourier Eq with Fourier co-efficient is $Z(f) = \sum_{m=-\infty}^{\infty} X\left(p + \frac{m}{T}\right)$ -(2)

Apply Fourier Series to $Z(f)$ at period $T = \frac{1}{T}$. ∴ Fourier

Co-effic, $Z_n = T \int_{-1/2T}^{1/2T} Z(f)\, e^{-j2\pi f nT}\, df$ (3)

Comparing (1) & (3) $Z_n = T\,x(-nT)$

under Zero ISI ∴ $Z_n = \begin{cases} T & n = 0 \\ 0 & n \neq 0 \end{cases}$ (1M)

Fourier Series of Z_n Inverse

$Z(f) = \sum_{n=-\infty}^{\infty} Z_n\, e^{j2\pi f nT}\, df$

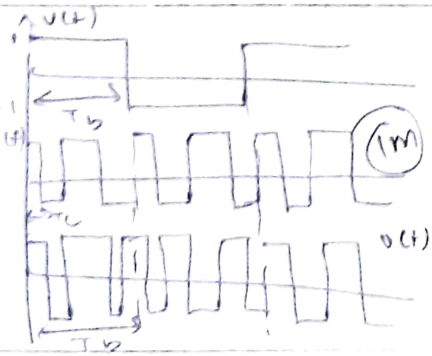
at $n = 0$

$Z(f) = T$ -(4) (1M)

Compare (3) & (4)

$$\sum_{m=-\infty}^{\infty} X\left(f + \frac{m}{T}\right) = T$$

(c)



Data Signal

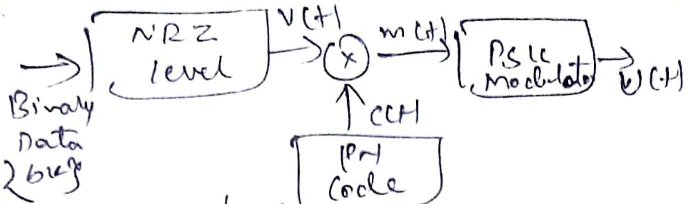
(1M) PN Signal

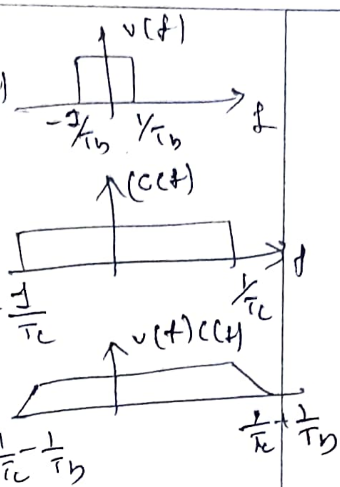
product Signal

$$v(t) = \sum_{n=-\infty}^{\infty} a_n g_T(t - nT_b)$$ 5

$a_n = \pm 1$

$$c(t) = \sum_{n=-\infty}^{\infty} c_n\, p(t - nT_c)$$





(2M) with explanation

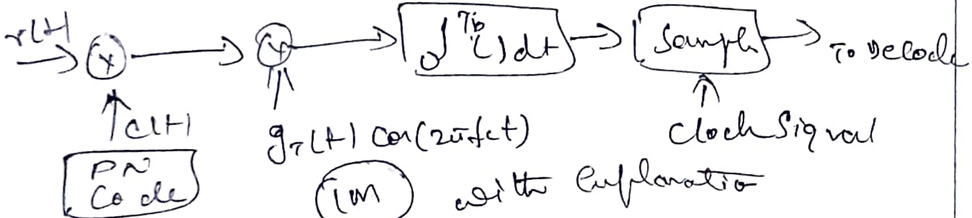
$O(t) = A_c\, v(t)\, c(t) \cos(2\pi f_c t)$

$v(t)\, c(t) = \pm 1$

(1M) $v(t) = A_c \cos(2\pi f_c t + \theta(t))$

$\theta(t) = 0$; $v(t)\, c(t) = 1$

$\theta(t) = \pi$; $v(t)\, c(t) = -1$



$g_T(t) \cos(2\pi f_c t)$ (1M) with explanation

Demodulator

OR

Under zero ISI we know that $\frac{1}{T} << 2W$. To realize the Tx & Rx filter.

To achieve the symbol Trn at $\frac{1}{T} = 2W$ symbols/sec we use controlled amount of ISI

i.e $x(nT) = \begin{cases} 1 & n = 0, 1 \\ 0 & \text{others} \end{cases}$ (1M)

2(a) Since $Z_n = T x(-nT)$ 5

$Z_n = \begin{cases} T & n = 0, -1 \\ 0 & \text{other} \end{cases}$

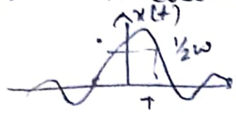
$\therefore Z(f) = \sum_{n=-\infty}^{\infty} Z_n e^{j2\pi f n T}$

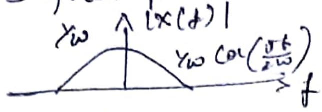
$Z(f) = T + T e^{-j2\pi f T} = X(f)$ (2M)

at $T = \frac{1}{2W}$ $X(f) = \begin{cases} \frac{1}{W} e^{-j\pi f/2W} \cos\left(\frac{\pi f}{2W}\right) & |f| < W \\ 0 & \text{other} \end{cases}$

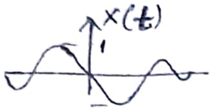
$x(t) = \text{Sinc}(2wt) + \text{Sinc}(2wt - 1)$

pulse is called Duobinary Signal pulse (1M)

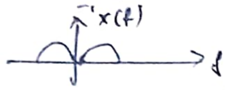




Special case $x(nT) = \begin{cases} 1 & n = -1 \\ -1 & n = 1 \\ 0 & \text{otherwise} \end{cases}$



$X(f) = \begin{cases} \frac{1}{2w}\left[e^{j\pi f/w} - e^{-j\pi f/w}\right] = \frac{j}{w} \sin\frac{\pi f}{w}; & |f| \le w \\ 0 & |f| > w \end{cases}$



$x(t) = \text{Sinc}\left(\frac{t+T}{T}\right) - \text{Sinc}\left(\frac{t-T}{T}\right)$ (1M)

This signal is called Modified Duobinary Signal

(b)

Given Binary Data $\{d_n\}$	0 1 1 1 0 0 1 0 1	
$\{p_n\}$ Precoded Sequence	1 1 0 1 0 0 0 0 1 1 0	
$\{a_n\}$ Transmitted Sequence	1 1 -1 1 -1 -1 -1 -1 1 1 -1	Each has
$\{b_n\}$ Received Sequence	2 0 0 0 -2 -2 0 2 0	(1M)
$\{d_n\}$ Decoded Sequence	0 1 1 1 0 0 1 0 1	

5

where $p_n = d_n \ominus p_{n-1}$ $b_n = a_n \oplus a_{n-1}$ (1M)

$a_n = \begin{cases} 1 & \text{if } p_n = 1 \\ -1 & \text{if } p_n = 0 \end{cases}$ $d_n = \begin{cases} 0 & \text{if } b_n = \pm 2 \\ 1 & \text{if } b_n = 0 \end{cases}$

(c)

① Low Detectability of Signal Trn

→ Avg S/g rx power << Noise

($2\frac{1}{2}$M) → S/g is recovered using processing Gain & Coding Gain

Any two with explanation

5

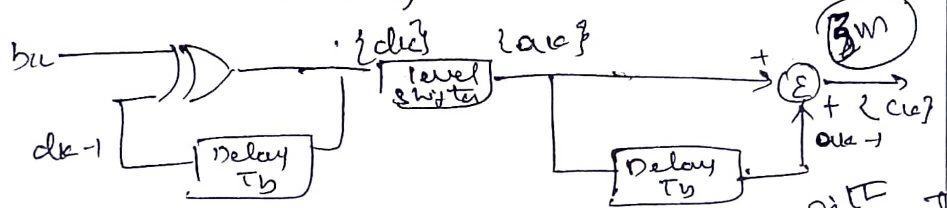
② Code Division Multiple Access

→ Several users transmit message in same channel

($2\frac{1}{2}$M) → Identical power for all users

	③ Communication over channels with multipath Fadding LOS (2½ M) ④ Wireless LAN's → 802.11 Standard (2½ M) → " Chip Barker sequence {1, -1, 1, 1 -1, 1, 1, 1, -1, -1, -1}	

PART-B

3(a)	Precoder is used in Duobinary encoder to avoid error propagation  (3M) with explanation $d_k = b_k \oplus d_{k-1}$ $d_k = 1$ if b_k or b_{k-1} is 1 $d_k = 0$. otherwise (1M) if $d_k = 1$ $a_k = 1$ $d_k = 0$ $a_k = -1$ Sequence a_k is applied to duobinary encoder $\therefore c_k = a_k + a_{k-1}$ (1M) $c_k = 0$ if b_k is 1 $c_k = \pm 2$ if b_k is 0.	5

(b)

when Signal passed through channel distortion is introduced in terms of amplitude & Delay.

This Distortion problem creates problem of ISI & also detection of signal also difficult.

This difficulty can be compensated with the help of equalizer. (1M)

Equalizer are basically filter

(2M)

Explanation (3M)

5

(c)

we know $\frac{E_b}{N_0} = \frac{P_R T_b}{N_0}$. (2M)

$$\frac{E_b}{N_0} = \frac{P_R}{B_N} \frac{T_b}{T_B}$$

Processing Gain $= \frac{E_b}{N_0} \times \frac{P_N}{P_R}$

(3M)

$$= 10 \frac{1}{10^{-2}}$$

$$= 1000$$

5

OR

4(a)

The Rx Signal sample under zero ISI

$y_m = x_0 a_m + w_m$

where $x_0 = \int_{-\infty}^{\infty} |G_T(f)|^2 df$

$w_m \Rightarrow$ Additive white Gaussian Noise with $\mu = 0$ & $\sigma_w^2 = \frac{E_g N_0}{2}$

$a_m \rightarrow$ one of M possible equally spaced amplitude levels with equal probability

(2M)

under zero ISI, Probability of error for digital PAM is

$$P_M = \frac{2(M-1)}{M} Q\left(\sqrt{\frac{2E_g}{N_0}}\right)$$

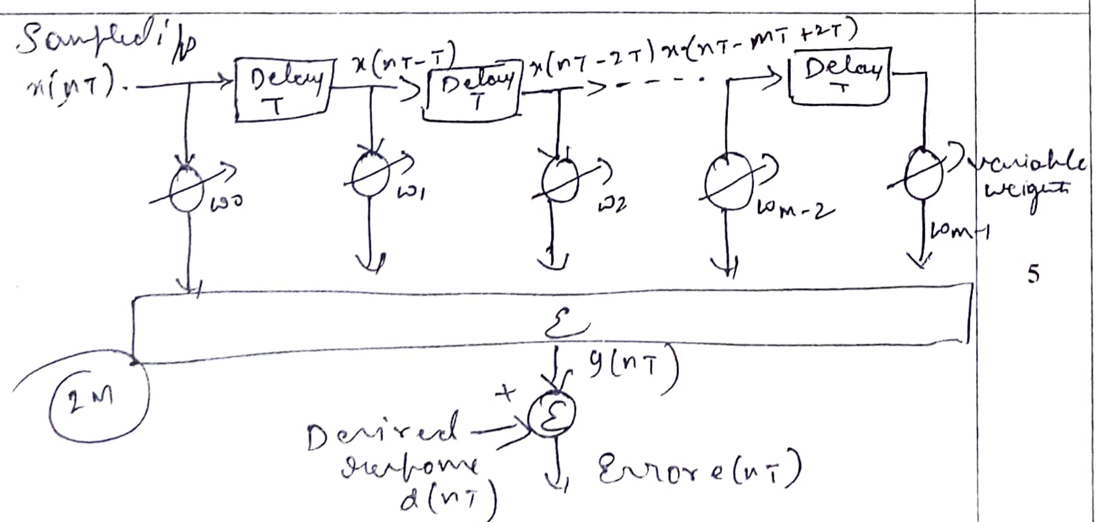
(3M)

$$E_g = \frac{3E_{av}}{(M^2-1)} = \frac{3kE_{bav}}{M^2-1}$$

$$P_M = \frac{2(M-1)}{M} Q\sqrt{\frac{6(\log_2 M)E_{bav}}{(M^2-1)N_0}}$$

5

(b)



(2M)

5

	o/p of adaptive filter $y(nT) = \sum_{i=0}^{M} \omega_i \, x(nT - iT)$ (1M) $e(nT) = d(nT) - y(nT)$ Explanation (2M)	
(c)	Processing Gain = $\dfrac{\text{Bandwidth of Spreaded Signal}}{\text{Bandwidth of unspreaded Signal}}$ (2M) $= \dfrac{5f_s}{f_s/4}$ $= 20$ (2M) [Processing Gain in dB] $= 10 \log 20$ $= \underline{\underline{13\ dB}}$ (1M)	5

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