KSIT BANGALORE

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

COURSE FILE

NAME OF THE STAFF	:	Mrs. SANGEETHA. V
SUBJECT CODE/NAME	:	18EC61/DIGITAL COMMUNICATION
SEMESTER/YEAR	:	VI/III
ACADEMIC YEAR	:	2020 – 2021
BRANCH	:	ECE

V. S

COURSE IN-CHARGE

HOD

K. S. INSTITUTE OF TECHNOLOGY

VISION

"To impart quality technical education with ethical values, employable skills and research to achieve excellence".

MISSION

- To attract and retain highly qualified, experienced & committed faculty.
- To create relevant infrastructure.
- Network with industry & premier institutions to encourage emergence of new ideas by providing research & development facilities to strive for academic excellence.
- To inculcate the professional & ethical values among young students with employable skills & knowledge acquired to transform the society.

DEPARTMENT OF
ELECTRONICS & COMMUNICATION ENGINEERING

VISION

"To achieve excellence in academics and research in Electronics & Communication Engineering to meet societal need".

MISSION

- To impart quality technical education with the relevant technologies to produce industry ready engineers with ethical values.
- To enrich experiential learning through active involvement in professional clubs & societies.
- To promote industry-institute collaborations for research & development.

K.S. INSTITUTE OF TECHNOLOGY
DEPARTMENT: ELECTRONICS AND COMMUNICATION ENGG.

KSIT

PROGRAM EDUCATIONAL OBJECTIVES (PEO'S)

PEO1 : Excel in professional career by acquiring domain knowledge.

PEO2 : Motivation to pursue higher Education & research by adopting technological innovations by continuous learning through professional bodies and clubs.

PEO3 : To inculcate effective communication skills, team work, ethics and leadership qualities.

PROGRAM SPECIFIC OUTCOMES (PSO'S)

PSO1: Graduate should be able to understand the fundamentals in the field of Electronics & Communication and apply the same to various areas like Signal processing, embedded systems, Communication & Semiconductor technology.

PSO2: Graduate will demonstrate the ability to design, develop solutions for Problems in Electronics & Communication Engineering using hardware and software tools with social concerns.

K S INSTITUTE OF TECHNOLOGY

PROGRAM OUTCOMES (PO'S)

Engineering Graduates will be able to:

PO1 :Engineering knowledge: Apply the knowledge of mathematics, science, engineeringfundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2 : Problem analysis: Identify, formulate, review research literature, and analyze complexengineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3 : Design/development of solutions: Design solutions for complex engineering problems anddesign system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4 : Conduct investigations of complex problems: Use research-based knowledge and researchmethods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5 : Modern tool usage: Create, select, and apply appropriate techniques, resources, and modernengineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6 : The engineer and society: Apply reasoning informed by the contextual knowledge to assesssocietal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7 : Environment and sustainability: Understand the impact of the professional engineering solutionsin societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8 : Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms ofthe engineering practice.

PO9 :Individual and team work: Function effectively as an individual, and as a member or leader indiverse teams, and in multidisciplinary settings.

PO10 :Communication: Communicate effectively on complex engineering activities with the engineeringcommunity and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11 ;Project management and finance: Demonstrate knowledge and understanding of theengineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12: Life-long learning: Recognize the need for, and have the preparation and ability to engage inindependent and life-long learning in the broadest context of technological change.

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#14, Raghuvanahalli, Kanakapura Main Road, Bengaluru-5600109

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

CO-PO mapping : DIGITAL COMMUNICATION

Course: Digital Communication						
Course In-Charge: Mrs. V. Sangeetha						
Type: Core				**Course Code:18EC61**		
No of Hours per week						
Theory (Lecture Class)		Practical/Field Work/Allied Activities		Total/Week		Total teaching hours
4		0		3+2		65
Marks						
Internal Assessment		Examination		Total		Credits
40		60		100		4

Aim/Objective of the Course:

1. Understand the mathematical representation of signal, symbol, noise and channels.
2. Apply the concept of signal conversion to symbols and signal processing to symbols in transmitter and receiver functional blocks.
3. Compute performance issues and parameters for symbol processing and recovery in ideal and corrupted channel conditions.
4. Compute performance parameters and mitigate for these parameters in corrupted and distorted channel conditions.

Course Learning Outcomes:

After completing the course, the students will be able to,

CO1	**Develop** the concepts of Band pass sampling to well specified signals and channels.	Applying (K3)
CO2	**Utilize** performance parameters and transfer rates for low pass and bandpass symbol under ideal and corrupted non band limited channels.	Applying (K3)
CO3	**Identify** valid symbol processing and performance parameters at the receiver under ideal and corrupted bandlimited channels.	Applying (K3)
CO4	**Identify** the bandpass signals when subjected to corruption and distortion during transmission over a bandlimited channel.	Applying (K3)
CO5	**Identify** the need for data security using spread spectrum technique and error rate calculation.	Applying (K3)

Syllabus Content:	
Module 1: Bandpass Signal to Equivalent Lowpass: Hilbert Transform, Pre envelopes, Complex envelopes, Canonical representation of bandpass signals, Complex low pass representation of bandpass systems, Complex representation of band pass signals and systems. Line codes: Unipolar, Polar, Bipolar (AMI) and Manchester code and their power spectral densities. Overview of HDB3, B3ZS, B6ZS. LO: At the end of this session the student will be able to, 1. Find Hilbert transform for the given function. 2. Plot the different line code formatting. 3. Explain the pre envelope and complex envelope representation of signals. **Module 2:** Signaling over AWGN Channels- 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. LO: At the end of this session the student will be able to, 1. Apply the procedure for Gram Schmidt Orthogonalization. 2. Classify different types of receivers.	CO1 CO4 10hrs PO1-3 PO2-2 PO3-1 CO2 10hrs PO1-3 PO2-2 PO3-1
Module 3 Digital Modulation Techniques: Phase shift Keying techniques using coherent detection: generation, detection and error probabilities of BPSK and QPSK, 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 of probability of error equation). LO: At the end of this session the student will be able to, 1. Establish the relation between different modulation techniques. 2. Derive the probability of error for different modulation techniques..	CO3 CO5 10hrs PO1-3 PO2-2

Module 4: Communication through Band Limited Channels: Digital Transmission through Band limited channels: Digital PAM Transmission through Band limited Channels, Signal design for Band limited Channels: Design of band limited signals for zero ISI–The Nyquist Criterion (statement only), Design of band limited signals with controlled ISI-Partial Response signals, Probability of error for detection of Digital PAM: Probability of error for detection of Digital PAM with Zero ISI, Symbol–by–Symbol detection of data with controlled ISI Channel Equalization: Linear Equalizers (ZFE, MMSE), Adaptive Equalizers LO: At the end of this session the student will be able to, 1. Understand digital PAM transmission through bandlimited channels. 2. Derive Nyquist criterion for zero ISI and controlled ISI. 3. Classify different types of channel Equalizers.	CO4 10hrs PO1-3 PO2-2 PO3-1
Module 5: Principles of Spread Spectrum: Spread Spectrum Communication Systems: Model of a Spread Spectrum Digital Communication System, Direct Sequence Spread Spectrum Systems, Effect of De-spreading on a narrowband Interference, Probability of error (statement only), Some applications of DS Spread Spectrum Signals, Generation of PN Sequences, Frequency Hopped Spread Spectrum, CDMA based on IS-95. LO: At the end of this session the student will be able to, 1. Understand different spread spectrum techniques. 2. Analyze the importance of spread spectrum technique on CDMA technology.	CO5 10hrs PO1-3 PO2-2 PO3-1

Text Books: - (specify minimum two foreign authors 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. B.P.Lathi and Zhi Ding, "Modern Digital and Analog communication Systems", Oxford University Press, 4th Edition, 2010, ISBN: 978-0-198-07380-2.

2. Ian A Glover and Peter M Grant, "Digital Communications", Pearson Education, Third Edition, 2010, ISBN 978-0-273-71830-7.

3. John G Proakis and Masoud Salehi, "Communication Systems Engineering", 2nd Edition, Pearson Education, ISBN 978-93-325-5513-6.

Useful Websites

- nptel.ac.in/courses/117105077/pdf-m-7/m7l38.pdf
- nptel.ac.in/courses/117105077/20
- https://www.tutorialspoint.com/digital_communication/index.html

Useful Journals

- Journal of Electronics and Communication system.
- Journal of Analog and Digital Communication system.

Teaching and Learning Methods:

1. Lecture class: 54 Hrs.
2. Self-study: 2 Hrs
3. Field visits/Group Discussions/Seminars: 2Hrs

Assessment:

Type of test/examination: Written examination

Continuous Internal Evaluation(CIE) : 20 marks (Average of best two of total three tests will be considered)

Semester End Exam(SEE) : 80 marks (students have to answer all main questions)

Test duration: 1 :30 hr

Examination duration: 3 hrs

CO to PO Mapping

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

PSO1: Graduate should be able to understand the fundamentals in the field of Electronics and Communication and apply the same to various like signal processing, embedded systems, communication and semi-conductor technology.

PSO2: Graduate will demonstrate the ability to design, develop solutions for problems in electronics and Communication engineering using hardware and software tools with social concerns.

CO	PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	K3	3	2	1	-	-	-	-	-	-	-	-	-	3	2
CO2	K3	3	2	1	-	-	-	-	-	-	-	-	-	3	2
CO3	K3	3	2	-	-	-	-	-	-	-	-	-	-	3	2
CO4	K3	3	2	1	-	-	-	-	-	-	-	-	-	3	2
CO5	K3	3	2	1	-	-	-	-	-	-	-	-	-	3	2
18EC61		3	2	1	-	-	-	-	-	-	-	-	-	3	2

Justification for CO-PO,PSO mapping

CO -Subject Code	**Justification for PO mapping**
CO1	**PO1-** Strongly maps as the concepts of Band pass sampling to well specified signals and channels requires knowledge of science and engineering. **PO2-** Moderately maps as the concepts of Band pass sampling to well specified signals and channels requires knowledge of problem Analysis. **PO3-** Poorly maps as the concepts of Band pass sampling to well specified signals and channels requires knowledge of design & development in satellite communication. **PSO1-** Strongly maps as the concepts of Band pass sampling to well specified signals and channels and also apply those concepts in signal processing, communication. **PSO2-** Moderately maps as the concepts of Band pass sampling to well specified signals and channels requires ability to design, develop solutions for problems in electronics and Communication engineering using hardware and software tools.
CO2	**PO1-** Strongly maps as the performance parameters and transfer rates for low pass and bandpass symbol under ideal and corrupted non band limited channels requires knowledge of science and engineering. **PO2-** Moderately maps as the performance parameters and transfer rates for low pass and bandpass symbol under ideal and corrupted non band limited channels requires knowledge of problem Analysis. **PO3-** Poorly maps as the performance parameters and transfer rates for low pass and bandpass symbol under ideal and corrupted non band limited channels requires knowledge of design & development in satellite communication. **PSO1-** Strongly maps as the performance parameters and transfer rates for low pass and bandpass symbol under ideal and corrupted non band limited channels requires to apply those concepts in signal processing, communication. **PSO2-** Moderately maps as the performance parameters and transfer rates for low pass and bandpass symbol under ideal and corrupted non band limited channels requires ability to design, develop solutions for problems in electronics and Communication engineering using hardware and software tools.

<u>CO3</u>	**PO1-** Strongly maps as valid symbol processing and performance parameters at the receiver under ideal and corrupted bandlimited channels requires knowledge of science and engineering. **PO2-** Moderately maps as valid symbol processing and performance parameters at the receiver under ideal and corrupted bandlimited channels requires knowledge of problem Analysis. **PSO1-** Strongly maps as valid symbol processing and performance parameters at the receiver under ideal and corrupted bandlimited channels requires to apply those concepts in signal processing, communication. **PSO2-** Moderately maps as valid symbol processing and performance parameters at the receiver under ideal and corrupted bandlimited channels requires ability to design, develop solutions for problems in electronics and Communication engineering using hardware and software tools.
<u>CO4</u>	**PO1-** Strongly maps as the bandpass signals when subjected to corruption and distortion during transmission over a bandlimited channel requires knowledge of science and engineering. **PO2-** Moderately maps as the bandpass signals when subjected to corruption and distortion during transmission over a bandlimited channel requires knowledge of problem Analysis. **PO3-** Poorly maps as the bandpass signals when subjected to corruption and distortion during transmission over a bandlimited channel requires knowledge of design & development in satellite communication. **PSO1-** Strongly maps as the bandpass signals when subjected to corruption and distortion during transmission over a bandlimited channel requires knowledge of science and engineering. **PSO2-** Moderately maps as the bandpass signals when subjected to corruption and distortion during transmission over a bandlimited channel requires ability to design, develop solutions for problems in electronics and Communication engineering using hardware and software tools.
<u>CO5</u>	**PO1-** Strongly maps as the need for data security using spread spectrum technique and error rate calculation requires knowledge of science and engineering. **PO2-** Moderately maps as the need for data security using spread spectrum technique and error rate calculation requires knowledge of problem Analysis. **PO3-** Poorly maps as the need for data security using spread spectrum technique and error rate calculation requires knowledge of design & development in satellite communication. **PSO1-** Strongly maps as the need for data security using spread spectrum technique and error rate calculation requires knowledge of science and engineering. **PSO2-** Moderately maps as the need for data security using spread spectrum technique and error rate calculation requires ability to design, develop solutions for problems in electronics and Communication engineering using hardware and software tools.

Course In-charge **Module Co-ordinator** **HOD-ECE**

K. S INSTITUTE OF TECHNOLOGY, BENGALURU-560109

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

TENTATIVE CALENDAR OF EVENTS: EVEN SEMESTER (2020-2021)

SESSION: APR 2021 - AUG2021

Week No.	Month	Day						Days	Activities	Department Activities Tentative Dates
		Mon	Tue	Wed	Thu	Fri	Sat			
1	APR	19 *	20	21	22	23	24	6	19*-Commencement of Higher Semester 24 Wednersday Time Table	
2	APR/MAY	26	27	28	29	30	1H	5	1 May Day	
3	MAY	3	4	5	6	7	8	6	8 Monday Time Table	3rd - 8th May AICTE - ISTE Induction / Refresher programme (FDP)
4	MAY	10	11	12	13H	14H	15DH	3	13 Idul Fitr 14 Basava Jayanti	
5	MAY	17	18	19	20	21	22TA	6	22 Tuesday Time Table	
6	MAY	24 T1	25T1	26T1	27	28	29DH	5		24th - 29th May AICTE - ISTE Induction / Refresher programme (FDP)
7	MAY/JUN	31	1	2	3	4	5ASD	6	5 Wednersday Tme Table	5th June IEEE KSIT SB Digital Siganal Processing Applications using MATLAB
8	JUN	7	8	9	10	11	12DH	5		11th June IETE Webinar, 11th June IEEE Power of Positive Thoughts Webinar
9	JUN	14	15	16	17	18	19	6	19 Monday Time Table	14th June Internet Communication and Networking Webinar 15th June IEEE KSIT SB CREAT WIE TI Inter college Art Competation
10	JUN	21	22	23	24	25TA	26DH	5		
11	JUN/JUL	28T2	29T2	30T2	1	2	3	6	3 Thursday time Table	2nd July IETE Webinar
12	JUL	5	6	7	8	9ASD	10DH	5		
13	JUL	12	13	14	15	16	17	6	17 Tuesday Time Table	14th July ASH in association with IEEE-WIE Webinar
14	JUL	19 T3(VIII)	20 * T3(VIII)	21H	22	23	24DH	4	20 *VIII Sem Last working day 21 Bakrid / Eid al Adha	19th July IEEE KSIT SB FOUS FLOW Webinar
15	JUL	26	27	28TA	29	30	31	6		29,30,31 Practice Lab
16	AUG	2	3	4	5 T3	6 T3	7*T3	6	7 Wednersday Tme Table	2,3,4 Practice Lab
17	AUG	9	10LT	11LT	12LT	13LT	14LT	6	14* IV &VI Last working day	10,11,12,13,14, 1st &2nd Lab Internals

Total No of Working Days : 92

Total Number of working days (Excluding holidays and Tests)=79

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

Monday	16
Tuesday	16
Wednesday	16
Thursday	16
Friday	15
Total	79

Kumar

7/8/2021

K. S INSTITUTE OF TECHNOLOGY, BENGALURU-560109

TENTATIVE CALENDAR OF EVENTS: II SEMESTER (2020-2021)

SESSION: MAY 2021 - SEP 2021

Week No.	Month	Mon	Tue	Wed	Thu	Fri	Sat	Days	Activities
1	MAY			19*	20	21	22	4	19*-Commencement of Semester 22 Monday Time Table
2	MAY	24	25	26	27	28	29H	5	1 May Day
3	MAY/JUNE	31	1	2	3	4	5	6	5 Monday Time Table
4	JUNE	7	8	9	10	11	12H	5	
5	JUNE	14	15	16	17	18	19TA	6	19 Tuesday Time Table
6	JUNE	21	22	23	24	25TA	26H	5	
7	JUNE/JULY	28 T1	29 T2	30 T3	1	2	3	6	3 Wednesday Tme Table
8	JULY	5ASD	6	7	8	9	10H	5	
9	JULY	12	13	14	15	16	17	6	17 Monday Time Table
10	JULY	19	20	21DH	22	23TA	24H	4	
11	JULY/AUG	26	27	28	29	30	31	6	31 Wednesday time Table
12	AUG	2	3	4	5	6	7H	5	
13	AUG	9	10	11	12	13	14	6	14 Friday Time Table
14	AUG	16	17	18	19	20DH	21H	4	20 Muharram
15	AUG	23	24	25TA	26T2	27T2	28T2	6	
16	AUG/SEP	30	31	1	2 ASD	3	4H	5	
17	SEP	6	7	8	9	10DH	11	5	10 Varasiddhi Vinayaka Vrata 11 Friday Tme Table
18	SEP	13	14	15	16	17	18 H	5	
19	SEP	20	21	22	23T3	24T3	25T3	6	
20	SEP	27LT	28LT	29LT	30 LT*			4	30 * Last working day
Total No of Working Days : 106									

Total Number of working days (Excluding holidays and Tests)=90

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

Monday	20
Tuesday	17
Wednesday	19
Thursday	17
Friday	17
Total	**90**

PRINCIPAL
K.S. INSTITUTE OF TECHNOLOGY
BENGALURU - 560 109.

K.S.INSTITUTE OF TECHNOLOGY
DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGG.
LIST OF STUDENTS STUDYING IN VI SEMESTER (A& B SECTIONS)
FOR THE ACADEMIC YEAR 2021 (EVEN SEMESTER) BEFORE RV

SL. NO	USN	NAME OF THE STUDENT	Gender	Date of Birth	EMAIL_ID	Student Phone No	NAME OF THE FATHER	Father Phone No	Mother	Mother Phone No	Address	SEC
1	1KS17EC034	DHEERAJ RAJ P	Male	22/10/1999	dheerajraj.p@gmail.com	8197346614	N Prabhu	6362056626	B N Kavitha	8197346614	# 14, Modaliar lane ,mahadeshwara nilaya basavanagudi, Bangalore. -560004	A
2	1KS18EC001	A N BHOOMIKA CHOWDARY	Female	22-06-2000	bhoomikachowdhry@gmail.com	9538093744	A.narayana	9036159159	A.lavanya	9448632176	Siruguppa road ,havambavi ,ashoka nagar ,ballari ,Karnataka 583101	A
3	1KS18EC002	ABHISHEK.V	Male	27-12-1999	vabhishek9876@gmail.com	9071536853	Viswanath.T	9071536853	Prabha Viswanath		#218, 37th A cross, 26th Main, Jayanagar 9th Block, Bangaluru, 560069	A
4	1KS18EC003	ADITHI.S	Female	26-05-2000	adithisrinath7@gmail.com	8105340906	Srinath n r	9886767468	Lakshmi s v	9686340805	#688 9th a main 4th block koramangala bangalore 560034	A
5	1KS18EC004	AISHWARYA BANDIGANI	Female	02-08-2000	aishwaryabandigani4@gmail.com	8296340724	BASAVARAJ BANDIGANI	9148015451	RUKMINI	9164369063	At post Malapur taluk mudhol DIST Bagalkot Pin No. 587313	A
6	1KS18EC005	AISHWARYA R	Female	20-09-2000	raishwaryahyr@gmail.com	9972991389	Rangaswamy p c	9886502342	Lakshmi k t	9743944374	Rotary park road near negative field opposite rainbow international school hiriyur Chitradurga district Karnataka	A
7	1KS18EC006	AKASH R	Male	17-05-2000	rameshakash34@gmail.com	6362323466	Hanumesh R	9448653383	Girija	9036697250	Near ksit college Lakshmi balaji pg	A
8	1KS18EC007	AKHILA V	Female	04-05-2001	akhilavmane@gmail.com	8660614604	Vasanth rao s	9945282564	Roopa v	8660614604	Vidya nagar Chanel area near water tank shikaripura	A
9	1KS18EC008	ANAGHA S	Female	30-07-2000	anagha.satish30@gmail.com	7899524285	Satheesha M	9845097919	Latha M	9901839132	No.24,4th Main, M.S.R. City, J.P.Nagar, 8th Phase bangalore	A
10	1KS18EC009	ANANYA ANANTH	Female	12/6/2000	ananyaananth006@gmail.com	9449720138	Ananthramu C N	9448813108	Anjana Ananthram	9449628017	#567, Vrukshani Apprtment, Flat No. 201, 11th main,32nd cross,4th block, jaynagar , bengaluru -11	A
11	1KS18EC010	ASHRITHA S C	Female	03-05-2001	ashrithasc35@gmail.com	9480154616	Chandrashekar		Uma	9632196512	No. 303,Ever joy Surekha apartment, 8th cros S, near masjid, Uttarahalli, Bangalore -560061	A
12	1KS18EC011	AYEESHA RUMAN	Female	19-10-2000	ayesharumana18@gmail.com	8197866568	Shaik Abdul Rasheed	9880958256	Shaheen Fathima	7411735502	#220, DS MAX Stonehills Gollahalli Village, Anjanapura township, Bangalore- 560 062	A
13	1KS18EC012	C A SUSHMA	Female	30/06/2000	hemachoudari@gmail.com	9741791927	C Aniruddha	9880893452	J. Hema	9980477019	# 68, 5th Cross, K.R. layout, J.P. Nagar 6th Phase, Bangalore	A

SL. NO	USN	NAME OF THE STUDENT	Gender	Date of Birth	EMAIL_ID	Student Phone No	NAME OF THE FATHER	Father Phone No	Mother	Mother Phone No	Address	SEC
14	1KS18EC013	C M CHAITHANYA VARDHAN	Male	24/7/2000	chaithanyavardhan007@gmail.com	9148747674	C V Madhu Sudhan	9448516508	Shanthi P	9480172012	# 4, Bhairava Nilaya, 19th Cross, Ittumadu Main Road, Bangalore - 61	A
15	1KS18EC014	CHANDAN Y C	Male	18/12/2000	ycchandan211@gmail.com	8884356412	Chunchaiah Gowda	9986721448	Jayalakshmi	9972196802	# 84/4, Kannan Building, Opp. Fab Icecree Factory, Billekalli, Bangaore 76.	A
16	1KS18EC015	CHARAN G	Male	15-07-2000	charangkm2000@gmail.com	7019164764	Gopala Krishna Murthy C	9480182929	Tulasi	9986710288	No.43, 2nd Ramachandra agrahara, 4th main, 9th cross, chamarajpet, Bengaluru 560018	A
17	1KS18EC016	CHINNAPU CHARAN TEJA REDDY	Male	08-03-2001	ccharantejareddy@gmail.com	7337405950	Chinnappu Narayana Reddy	8660180765	Chinnappu Lakshmi devi	9491515334	5/6 vaddamanu(village) S.A kasinayana(mandal) kadapa(district) 516193 andhrapradesh.	A
18	1KS18EC017	CHITHRITHA G R	Female	3/1/2001	chithrithagr@gmail.com	9980113354	Raja Reddy G R	8453551197	Savithramma B V	9986475445	# Booragamakalahalli, Near Gangamma Temple, Chinthamani .	A
19	1KS18EC018	DARSHAN V	Male	28-05-2000	darshanvhero4831@gmail.com	7348979657	B.venkataramana	9916550572	Prema latha	9036086965	Near Hanuman temple apmc yard bye pass besides sitarama samudhaya bhavana kondarajanahalli kolar	A
20	1KS18EC019	DARSHAN S	Male	13-05-2001	darshansrinivasa034@gmail.com	6362427923	Srinivasa.g	9880649720	Radha	8861687721	no 38 2nd main 2nd cross manjunathanagar bsk 3rd stage ittmadu hoskerehalli Bangalore 560085	A
21	1KS18EC020	DEEKSHA S N	Female	9/7/2001	deekshs459@gmail.com	9632637851	Narayanaswamy S H	9663103051	Bharathi G V	9880569483	# Seethareddy Halli, Yeldur Hobli, Srinivasapura TQ, Kolar DT.	A
22	1KS18EC021	DEEPTHI ANDANI	Female	03-04-2000	deepsandani@gmail.com	8762483517	Andanaiah M P	9845127931	Sudha H K	8762413652	#1, behind siddaganga rural high school, raghuvanahalli, Kanakpura main road, bangalore -560062	A
23	1KS18EC022	DHANUSHREE C	Female	26-12-2000	dhanushree.c2000@gmail.com	9739839494	Chandrappa.A.V	9844553546	Geetha.B.P	9449870589	#30,4th cross,Naidu layout, Jaraganahalli,j.p.nagar post,Bangalore-560078	A
24	1KS18EC023	DHEERAJ M S	Male	27-12-2000	dheerajgowda361@gmail.com	9108915485	Shivaram	9663067808	Gurushanthamma	9663067267	Bank colony Uttarahalli	A
25	1KS18EC024	DHRITHIRHUTH RAJANNA	Male	16-12-1999	dhruthirhuth16@gmail.com	6363201205	Rajanna	9902085955	Rajeshwari	8861688346	No 20/A near flora convent, post office road, yelachenhalli jpnagar Bengaluru 560078	A
26	1KS18EC025	DINESH KUMAR NAYAK	Male	13/12/1999	dineshknayak99@gmail.com	8971765754	Sunil kumar nayak	9019197687	Archana	7978657514	# 313, Mahaveer Jewel, J.P. Nagar 5th Phase, 17th Cross, 15th Main, Bangalore	A
27	1KS18EC026	DIVAKARBABU Y	Male	12-01-2000	divakarb03@gmail.com	8050736978	Y sureshbabu	8152035035	Tulasi	7338387894	BSCT HOSTEL NEAR KATRIGUPPE WATER TANK BANASHANKARI	A

SL. NO	USN	NAME OF THE STUDENT	Gender	Date of Birth	EMAIL_ID	Student Phone No	NAME OF THE FATHER	Father Phone No	Mother	Mother Phone No	Address	SEC
28	1KS18EC027	G.J.NITHIN	Male	06-10-1999	nithingj.8@gmail.com	6362723785	G N JAYAPRAKASH	9449810008	G J SUMA	9880404739	#52 , H.B SAMAJA ROAD BASAVANAGUDI BENGALURU	A
29	1KS18EC028	GANESH P	Male	14-06-2000	naveenganesh146@gmail.com	9632073401	Purushothama S	9845496656	Bharathi	9632785163	# 12, 11A Cross, 4th main, Opp. BEML, S.R. Nagar, Bangalore -27.	A
30	1KS18EC029	GOKUL G	Male	30-12-2000	gokulgtron18@gmail.com	8073571857	Gajendra Naidu	9980394035	Kalpana	7019201891	chikkalasandra,hanumagiri nagar,7th main,7th cross,near ganesh temple road,bangalore61	A
31	1KS18EC030	HARSH SHARMA	Male	31-07-2000	harshblue9204@gmail.com	8660625658	Rajesh Sharma	9342866664	Radhika Sharma	8904393824	#89, 10th cross, 20th main, BTM 1st stage, gangotri circle; Maruti nagar main road, Bangalore-560068	A
32	1KS18EC031	HARSHITHA S	Female	12-04-2000	harshithanaik2000@gmail.com	9538240141	Sundar Naik	9916840165	Ramani	8884318698	#15 c,17 c cross,behind jss school,ganapathipura,konankunte, bangalore-62	A
33	1KS18EC032	JAHNAVI A P	Female	7/10/2000	jahnaviap@gmail.com	8971644789	Parthasarathy A S	8553638738	Radhika A	9035639755	#15,4th cross , new bank colony, konanakunte, Bengaluru- 560062	A
34	1KS18EC033	JANHAVI K P	Female	05-06-2000	janhavipgowda@gmail.com	9611821690	Putte Gowda KL	8861007491	Vishalakshi P gowda	8861007492	#673,snehas,5th main,ISRO layout, Bangalore 560078	A
35	1KS18EC034	JHANAVI V	Female	22-07-2000	jhananvidrithi22@gmail.com	9164103859	Venkatesh	9449242977	Sudhamani	7019376834	# 8, Flot No. 202, 3rd Main Road, Opp. 45 D Last Busstop, AGS Layout, Arehalli, Bangalore -61	A
36	1KS18EC035	JISHNU S	Male	25-01-2000	jishnusb125@gmail.com	9916728915	C K Sreesan	9731400625	V Bindusreesan	9535002630	No.3B, AISH JISH, 2nd Cross End, Old Bank Colony, Chunchunghatta Circle, Konankunte, Bangalore-560062	A
37	1KS18EC036	JYOTSNA B UPADHYE	Female	05-10-2000	jyotsnaupadhye@gmail.com	9845773182	B A Upadhye	9448831991	Roopa Upadhye	9449022410	102,ground floor, Siri Sivaganga Orchids, 5th main, 5th cross, Vallabhanagar, Uttarahalli, Bangalore-61	A
38	1KS18EC037	K RISHIKA RAVI	Female	12-06-2000	kukutlarishi126@gmail.com	8105840259	S Ravi	9743826259	P Harini	9945258399	#19 1st floor 5th A cross 2nd Block BSK 1st Stage	A
39	1KS18EC038	KARISHMA M	Female	13-03-2000	karishmamanjunath1303@gmail.com	9986077780	V.A.Manjunath	9900377780	Vasudha.N.M	9886970246	#898, 3rd cross, BSK 1st Stage, 2nd Block, Bengaluru-560 050	A
40	1KS18EC039	KOMALA K V	Female	11-04-2000	komalakv11@gmail.com	8722200570	Venkateshwarulu K L	9741400985	Nagrani K	9148825768	#204 4th main 5th cross srinivasnagar bangalore 560050	A
41	1KS18EC040	LAVANYA M	Female	20-05-2000	lavanyam041@gmail.com	8095616344	Muniraju N	9845654603	Lakshmi M	9845300679	#501 Bhumika paradise brindavana layout revenue layout padmanabhanagar bangalore-560061	A

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42	1KS18EC041	M.NIHITHA YADAV	Female	20/11/2000	nihi.yadav25@gmail.com	9381016510	M Chandraiah	9989989463	N Bhagavathi	9490972745	# 50, SriBhairava, 11th Corss, 3rd main, J.P. Nagar, Bangalore	A
43	1KS18EC042	MAHANTH SAI M	Male	2/8/2000	mahanthsai2@gmail.com	9663675393	M Venkatadri Naidu	8892093218	M.Kavitha	9901032448	#132 sf2 4rh main 4th cross srinivasnagar Bangalore 560050	A
44	1KS18EC043	MANOJ G S	Male	06-07-2000	manoj.gs9945@gmail.com	9945673159	Somashekar G M	9844107749	Shakunthala M	7892729749	#13 suki nilaya,4th cross,munireddy layout,kothnur dinne,j p nagar-8th phase,bangalore-560078	A
45	1KS18EC044	MEGHA R	Female	22-01-2001	rammeshmegha@gmail.com	7348954732	Ramesh G	9972954732	Nandini R	9148453031	163/28,6th cross,7th main, 2nd block, Jayanagar, Bangalore-11.	A
46	1KS18EC045	MEGHANA B S	Female	01-03-2001	bsm6420@gmail.com	9606199781	B.Shivanna	9731814423	Jayalakshmi	9019648168	Meghana.B.S.D/o B.Shivanna. KSIT Girls hostel Padmanab Nagar.	A
47	1KS18EC046	MEGHANA GOWDA V	Female	05-07-2000	meghanagowda2000@gmail.com	9108114342	vishakante gowda	9449010254	mala .g	9945608014	#65 krishnappa layout keb quarters backside subramanyapura main road bangalore-61	A
48	1KS18EC047	MOHAMMED FAIZAN SHAFI	Male	15/4/2001	mdfaizan5262426@gmail.com	7204798807	Mohammed Shafiuddin	8792191290	Sabiha Naz	9036569265	# 15/-1, 4th Cross, New Guddadahalli, Manjunath Nagar, Mysore road, Bangalore -26	A
49	1KS18EC048	MONISHA B R	Female	07-05-2000	monishagangatkar879@gmail.com	8296604592	Ravindra B G	9980858856	Sundaramma	9341390065	No 3, 2nd main astalakshmi layout Puttenahally main road JP nagar 6th phase Bangalore 78	A
50	1KS18EC049	N S V JASHWANTH	Male	17-07-2000	nsvjash@gmail.com	8884540752	n satya prasad	9341254795	n padma prasad	9945122966	#1 1st-A cross 24th main jp nagar 2nd phase	A
51	1KS18EC050	NAGA OMKAR N	Male	04-02-2001	nagaomkar23@gmail.com	8951146460	N Veerendra Babu	9739600806	N Nagalakshmi Sireesha	9019281421	No 7 Raj building 1st main uttarahalli main road Chikkalsandra sarvaboumanagar Bangalore 560061	A
52	1KS18EC051	NAGASHREE A	Female	5/10/2000	nagashreea55@gmail.com	9916466878	Arasaiah	9844854781	Renuka	9916466878	# 1709, Damodar Reddy Nilaya, Shastrinagar, Bangalore -26	A
53	1KS18EC052	NAMITH R	Male	24-03-2000	namith24300@gmail.com	7975534682	P. Ravindranath	9482417173	D. Navarathna Kumari	9449052487	#265, 1st stage, 6th phase, WRC, Industrial town, Rajajinagar, Bangalore-560044	A
54	1KS18EC053	NAVYA M S	Female	12-07-2000	navyams30@gmail.com	9480247725	Siddaramaiah	9480640873	Manjula PG	7760750236	Gubbi thotadappa girls hostel No. 55 ,Chamarajpet , Sirsi road Bangalore-560018	A
55	1KS18EC054	NIHARIKA S A	Female	19-01-2001	niharikancj@gmail.com	9743418658	Suresh A	73383604[illegible]	Kamakshi. R	9538318264	#206,7th main 4th block jayanagar Bangalore-11	A

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56	1KS18EC055	NIROSHA G J	Female	29-10-2000	niroshaniru750@gmail.com	7090984688	Jaychandra naidu	9845440892	Reeta	9945481077	#336/1,7th cross,7th main bhuvaneshwari nagar bangalore-85	A
57	1KS18EC056	NISHANTH J RAO	Male	25-01-2001	nishanthjrao123@gmail.com	7411112066	Janardhan Rao	9900402660	UMA J Rao	9980550368	#62, 7th Mian, nagendra Block, behind Ganesh Temple, Girinagar, Bangalore	A
58	1KS18EC057	P SAI GOVARDHAN	Male	18-06-2001	saigovardhan.p@gmail.com	9916520175	P Venugopal	9902237235	P Sreekala	9742446627	Vasavi hostel , vasavi temple road , opp vijaya bank , sajjan rao circle , vv puram , Bangalore	A
59	1KS18EC058	PARIKSHITH S	Male	31-08-2000	parikshith200@gmail.com	9449098805	Shivakumar L	9480607980	Saraswathi G C	9480585756	#24,A-5, Krishna block National Games Village, Koramangala, Bangalore-560047	A
60	1KS18EC059	PAVAN KUMAR P	Male	5/9/2001	pavanskyrock@gmail.com	9845439614	Prakash M S	9844040714	Pushpalatha A	9591545463	# 56, krishnappa layout, Behind KEB qrts. Subramanyapura, Bangalore -61.	A
61	1KS16EC005	AKASH CHANDRAPPA GURUVANNAVAR	Male	14/7/1998	akashguravannavar@gmail.com	8722196730	Chandrappa Guruvannavar	9902712559	Kavitha	7026535630	# C K Guruvannavar, Basava Nagar, Hirebagewadi, Belgaum - 591109	B
62	1KS18EC060	POOJA S	Female	27-11-1999	shivraj.pooja61@gmail.com	8884959532	Shivraj	9036655520	Jagadevi	8105455921	#1722 41st A cross 18th main 4th T block Jayanagar 9th Block, Bangalore	B
63	1KS18EC061	PRAKRUTHI S H	Female	29-11-2000	prakruthi078@gmail.com	9148272577	SHIVANAND HIREMATH	7975444829	PARVATHI SHIVANAND	9148272577	#19,flat no.1, ground floor, Ganesha mension, 1st cross, kothanur dinne main road, natarja layout, J.P nagar 8th phase,Bangalore south - 560078	B
64	1KS18EC063	PUNEETH M	Male	21-07-1999	mpuneethy@gmail.com	6361207052	Mahesh M	7619644661	Yashoda	9740382803	No155,6th cross, valentain school ,ittamadu main road,B.S.K 3rd stage ,Bengalore 560085	B
65	1KS18EC064	PURUSHOTHAM V R	Male	01-11-2000	purushotham1837@gmail.com	7349720698	Ramanna. V. R	9448149728	Leelavathi. P. C	08026725168	No. 21,'SRI RAMA NILAYA', muneshwara nagar, hoskerehalli, kerekodi, bsk 3rd stage, banglore - 560085	B
66	1KS18EC066	RAGHAVENDRA.K.P	Male	02-04-2000	kpraghavendra24@gmail.com	6361424323	K N Puttappa	9845068297	K.P.Manjula	7795898771	48 Akshya nidi ,1 St cross ,5th main thyagrajnagar Bangalore 560028	B
67	1KS18EC067	RAGHU B T	Male	17-10-2000	raghubt17@gmail.com	8197594262	B S Thagade gowda	9342567801	B. K. Mallamma	8971618981	#277 /B, water tank road, ranganatha extension, harohalli-562112	B
68	1KS18EC068	RAJ KRISHNA	Male	2/1/2000	raj.krishna211998@gmail.com	8709004878	Ramesh Prasad Saha	9931060615	Radha Devi	8095402341	# Post Office Road, Ganesh Medical Hall, naugachia, Bhagalpur, Bihar -853204	B

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69	1KS18EC069	RAJATH S BHUSHAN	Male	15-05-2000	sbhushan749@gmail.com	8104558162	S SHASHI BHUSHAN	9757352324	SMT. JAYASHREE S BHUSHAN	7676919645	S/o S. SHASHI BHUSHAN, No. 305, 3rd FLOOR, SHABARI ELITE # , 6th MAIN ROAD, DWARAKANAGAR 2nd STAGE, SHASHIDHARA LAYOUT, CHANNASANDRA, BANGALORE - 560 098	B
70	1KS18EC070	RAM BAHADUR MAHARA	Male	10-12-1998	ramd9231@gmail.com	9164005450	Dilip bahadur mahara	9886814075	Kunti devi mahara	8892361813	#13/2 Raghuvanahalli 3rd cross near ksit hostel kanakpura main road Bangalore 560062	B
71	1KS18EC071	RASETTY SANDEEP	Male	15/3/2001	sanjusandeep137@gmail.com	9618603196	R Krishna	9632349692	Amala R	6361997847	# 17, 4th Main, Kuvempu Raste, Vasanthapura main Road, chikkalasandra	B
72	1KS18EC073	RITHVIK P	Male	16-09-2000	rithvikprabhakar@gmail.com	9448891609	Prabhakar TK	9880854545	Roopa Prabhakar	9880634365	D-604 , Mantri Alpyne, Dr.Vishnuvardhan Rd Bharthi housing society, BSK 5TH stage	B
73	1KS18EC074	S MANOJ	Male	26-09-2000	manojsreeram2000@gmail.com	9380827052	VENKATA RAMANA	9182978236	Ammulu	9959762214	#298/12 ,7thcross 5th main bsk 3rd stage Bhuvaneshwari nagar Bangalore 85	B
74	1KS18EC075	S RAHUL	Male	28-07-2001	rahul.charan2008@gmail.com	8310483432	S suresh babu	9880137331	S rajeshwari	7406680290	# GF013, Near Global Villege, Back Gate, R.V. College Post, Mylasandra, Rangaswamappa Road, Neeladri princess Apartment,	B
75	1KS18EC076	S TUSHAR HARINATH	Male	25-02-2000	tusharharinath@gmail.com	7338359499	Srinivasa babu N	9731555529	S Naga jyothi	9986087845	# 68 1st main road 6th cross sakamma garden basavanagudi bangalore 560004	B
76	1KS18EC077	SAGAR T C	Male	14-01-2001	sagartc2001@gmail.com	7899371810	Chidanandappa K T	9980360305	Thippamma C	9164479748	#8, syndicate bank calony,2 nd cross, Kathriguppe,bsk 3 Rd stage, Bangalore 560085	B
77	1KS18EC078	SANJANA B	Female	18-11-2000	sanjanabadarinath2000@gmail.com	9380751330	Badarinath.B.S.	9740260055	L.Usha	7899006180	#16, 2ND cross , nagappa block, Srirampuram , Banglore-560021	B
78	1KS18EC079	SANKET B PASCHAPURI	Male	6/1/2000	sanketb5555@gmail.com	8951999357	Basavaraj T Paschapur	8904573983	Shilpa B Paschapuri	9538280987	# 28, 9th Cross, Shivanaga Nilaya, near Patidar Bhavan, Shastri Nagar, Belgaum.	B
79	1KS18EC080	SHASHANK H K	Male	28/5/2000	shashankhk28@gmail.com	7899201161	Kubendrappa H M	9632306726	Rekha M B	9611039902	# Davanagere, Chennagiri TQ, Hodigere Post.	B
80	1KS18EC081	SHEETAL N GOWDA	Female	30-03-2000	sheetalgowda91@gmail.com	8296326787	G C Nagaraju	9448516421	Sarojamma	7022303944	#81 bhyravi layout hosahalli bsk 6th stage 4th H block Banglore 62	B
81	1KS18EC082	SHIVA SHANKAR B	Male	14-02-2001	shivashankarb45678@gmail.com	7975761606 8904433830	Ramana Reddy B	9844431177	Savitri B	8971336044	Balaji layout, vajarahalli, Bangalore 62	B

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82	1KS18EC083	SHREYA V DEV	Female	30-01-2000	shreyavasudev999@gmail.com	8861835770	Vasudevachar C.	9482548727	Shobha B R	8123503455	#261/4,2nd main, byrappa block, t.r.nagar, Bangalore-28	B
83	1KS18EC084	SHREYAS C	Male	04-03-2000	shreyaschida2k@gmail.com	9035927929	Chidambarachari k	9901694421	Umavathi v	9741215686	#433/127, Shirke apartments,k.s town Bangalore-560060	B
84	1KS18EC085	SHREYAS D R	Male	09-05-2000	shreyasravi7879@gmail.com	9611172262	D.R.Ravindra	9448553166	V.Bharathi	8951720969	#32, 12th Main, 7th Cross, Raghavendra Block, Srinagar, Bangalore.	B
85	1KS18EC086	SHRIKANTH C K	Male	2/10/2000	shrikanthck007@gmail.com	6363246033	Kempaiah C K	9740161414	Shanthamma P	7019890784	# Ramanagara DT, Kanakapura TQ, Cheelur Post.	B
86	1KS18EC087	SIRI RAVINATH	Female	24-03-2000	siriravinath24@gmail.com	8660207997	ravinath		nagarathna	9035953725	No 651,1st floor,banagiri,4th main,vasanthapura,banglore,560061	B
87	1KS18EC088	SIRISHA.M	Female	10-05-2000	sirisha1052000@gmail.com	9611933643	Manjunath K	9880670506	Anuradha H	9900447759	#961,12th cross, 35th main, 1st phase, Jp Nagar, Bangalore -78	B
88	1KS18EC090	SOMASHEKAR M	Male	30-04-2000	shekarmeda342@gmail.com	7204682603	M.Ramanadham	9845381279	M.R.Reddemma	9902782775	# 36/110, 3rd Main, 5th Cross, L V Temple Road, P P Layout, BSK III Stage, Bangalore - 560085.	B
89	1KS18EC091	SUDHEER B	Male	20/7/2000	sudheerbkumar123@gmail.com	9036916419	Dhamu B	9880661455	Bhanu B	9036560062	# 14, 5th A Cross, Hanumagiri Layout, Chikkalasandra, Bangalore -61	B
90	1KS18EC092	SUJAY R	Male	10-01-2000	sujayrudresh1234@gmail.com	9731823479	Rudresh B N	8971430295	Hema G	7899619623	#2273,9th main, D block,Rajajinagar,Bengaluru 560010	B
91	1KS18EC093	SUPRIYA S	Female	28-02-2000	supriyababu321@gmail.com	9741900962	Shobanbabu s	9449619627	Sampoorna s	9483135162	# Vinayaka Nagar, Besid GMHS School, Gauribidanur. Chikkaballapur Dt.	B
92	1KS18EC094	SURAJ V GHORPADE	Male	22/8/2000	surajghorpade748@gmail.com	6361380629	Venkatesh M	8618014056	P T Meena	9448415010	# 106, SS Vrudhi Appartment , VISL Layout, Thalagattapura, Bangalore -61.	B
93	1KS18EC095	SUSHMA.A.V	Female	6/10/2000	sushmaav610@gmail.com	9071216551	Vidyashankara A S	8073928501	Sujatha	9449889650	# 1484/A, 24th main, 27th Cross, bSK 2nd stage, Bangalore -70	B
94	1KS18EC096	SUSHMITHA R	Female	25-05-2000	sush2552000@gmail.com	9353463294	R.Ashok Kumar	9845530281	R.Bujji	9845405649	No9,19th cross,krishnaiah layout,ittamadu main road,bsk 3rd stage,bengaluru 560085.	B
95	1KS18EC097	THANUSH R S	Male	13/6/2000	thanus008@gmail.com	9945116393	R.S. Suresha	9844388980	Rekha K G	9630989163	# 1729, FF102, SS Elizza Appartment, 2nd Stage, Kumaraswamy Layout, Bangalore	B
96	1KS18EC098	THANUSHREE D	Female	20-04-2000	thanushreed04@gmail.com	9980703548	DODDAGUDDAIAH	9663585907	Nagarathna.T.G.	9620003984	#26/1, 4th Main, magadi Main Road, Agrahara Dasarahalli, Bangalore79.	B

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97	1KS18EC099	VAISHNAVI G	Female	8/1/2001	vaishnavigurunaths@gmail.com	9743932931	Gurunath S	8762695744	Priyadarshini G	8277201905	# 994, 9th Main, 2nd Cross, Srinivas Nagar, BSK 1st Stage, Bangalore -50	B
98	1KS18EC100	VAKKALAGADDA ANIL	Male	05-10-2000	anilvakkalagadda820@gmail.com	9390146352	Anjaneyulu	9986212159 9502351357	Sulochana	9986356000 9390146352	# 6-25, Sho.Somavaram, Sambepalli mandal, Kadapa Dt. AP -516215	B
99	1KS18EC101	VANDANA K	Female	23/8/2000	vandana.k54320@gmail.com	7337620333	P. Krishnamurthy	9844050763	Vani P D	9448029075	# 77, 4th Main road, 1st Cross, Kattiraguppe Main Road, Vivekandha nagar, B.S. K. 3rd Stage, Bangalore -85.	B
100	1KS18EC102	VARSHINI.B.M	Female	14/2/2000	varshinibm14@gmail.com	9108157134	Muralimohan M S	7760976723	Shubha T V	9980204469	# 10, Sri Nilayam, 2nd Main, 2nd Cross, Jyothi Layout, Kanakapura MainRoad, Yelachenahalli, Bangalore .	B
101	1KS18EC103	VASANTH PAI.M	Male	28/8/2000	mvasanthpai@gmail.com	7996690249	Manjunath Pai K	9880312995	Savithri Bai	9620368169	# 7, Mahalasa Nilaya, Someswara Block, Hulimavu, B G Road, Bangalore -76	B
102	1KS18EC104	VIJAY BABU K	Male	30-06-2000	vijayvishwa34@gmail.com	9148597499	Kannan	9945301096	Lakshmi	8296123374	#40 2nd Cross 9th main ittamadu Bangalore 560085	B
103	1KS18EC105	VINAY K	Male	27/7/2000	krishnappa4545@gmail.com	9449054545	Krishnaiah N	9845003399	Sujatha K	9845113399	# 24, 11th Cross, bendre Nagar, Subramanayapura Main Road, BSK 2nd Stage, Bangalore -70	B
104	1KS18EC106	VINAY S	Male	2/3/2001	vinays020301@gmail.com	9632249629	M. Shivakuamraswamy	8711990145	Anitha B S	9535074243	# Thyagaraja Colony, Pandavapura Town, Mandya Dt. -571434	B
105	1KS18EC107	VIRAJA BELLARY	Female	24/12/2000	viruu2000@gmail.com	8310906021	Sudarshan B	8867606994	Anupama	8792880864	# 488, 5th Cross, RBI Layout, J.P. Nagar 7th Phase, Bangalore -78.	B
106	1KS18EC108	VISHAL MADHUSUDAN	Male	26/1/2000	vishalmadhusudan123@gmail.com	9108422145	C K Madhusudan	9008598208	Suma Madhusudan	8861943140	# Hed Post Mainalli,TQ Mundgol, Dit. UttaraKannada.	B
107	1KS18EC109	VISHWAS P	Male	5/6/2000	vishwasprakash56@gmail.com	9741678046	Prakash P	9945780598	Asha R	9986987662	# 490, Jigini, Near Pattalamma Temple, Anekal TQ, Bangalore	B
108	1KS18EC110	VIVEKGOWDA J	Male	26-12-2000	vivekverrarasa@gmail.com	6361797147	Jayaramaiah. mv	9590163864	Nagamma		Minasandra,mavatur(post),koratagere(taluk),tumkur(district)	B
109	1KS18EC111	VRINDHA SHAM BHATT (1YD18EC001)	Female	30/12/1999	vrindha99@gmail.com	9108605859	Gurunath sham bhatt	8971650429	Uma	9535420877	# 103, Sriven Rag Serenity , Kankapura Main Road, Vajarahalli, Bangalore	B
110	1KS19EC400	HEMANTHA V	Male	7/9/1999	hemanthavishnu33@gmial.com	7353326240	R VIJAYA KUMAR	9008179776	NAGAVENI V	6361843751	#215, GROUND FLOOR, VINAYAKA NAGAR, JP NAGAR 5TH PHASE, BANGALORE -78	B
111	1KS19EC401	KARTHIK B P	Male	24/11/1997	karthikbp123@gmial.com	7892638314	B.N. Parameshwara Rao	9741339260	G Uma	9686139493	# 139, 1st main, 1st Cross, K.S. Colony, Thyagaraj Nagar, Bangalore	B

SL. NO	USN	NAME OF THE STUDENT	Gender	Date of Birth	EMAIL_ID	Student Phone No	NAME OF THE FATHER	Father Phone No	Mother	Mother Phone No	Address	SEC
112	1KS19EC402	KRISHNA PRASAD B	Male	4/12/1998	krishnaprasadb13@gmail.com	7019295628	Babu B	9900380711	Sujatha D	8970090111	# 1/1, Vishnu Road, BSK 2nd Stage, Kadirenahalli, Bangalore - 70	B
113	1KS19EC403	NAVEEN G	Male	28/11/1999	navinaveen569@gmail.com	9972798543	Govindaraju	7829673552	Nirmala	7019879901	# 416, Manjunatha Colony, Chennamanakere Achukattu, Near CT Bed, T. R Nagar, Bangalore -85	B
114	1KS19EC404	PAVAN C N	Male	21/9/1998	pavanpavu93459@gmail.com	8971183375	Narayana Murthy C K	9591954741	Padma C N	9916816009	# 21, 1st Main, Bank Colony, Nagendra Block, BSK Ist stage, Bangalore -50	B
115	1KS19EC405	PRUTHVI DINESH	MALE	14/3/2000	pruthvi.sunitha@gmail.com	7338505236	Dinesh K	9880393464	Sunitha	9972022262	# 54, shivaprasad, 4th cross, Gavipura Ext. Post office, Hanumanth Nagar, Bangalore -19.	B
116	1KS19EC406	RAGHOTHAM C G	Male	18/5/1995	raghotham056@gmail.com	9972113894	Gopala Krishna C S	9448479279	Nagalakshmi S	9901304582	# 136, Sunkalpalya, Uttarahalli Main Road, Kengeri, Bangalore -60	B
117	1KS19EC407	SADHANA M	Female	7/2/2000	sadhanagowda0702@gmail.com	8884416696	Mallikarjunaiah	9448414343	Sunitha C L	9480091519	# 3418/92, 2nd Main Shastri Nagar, Bangalore -28	B
118	1KS19EC408	SINDHU G	Female	23/6/2000	23sindhug@gmail.com		Gangadharaiah B	9538365113	Umadevi S	8553054564	# 8, Sarakki, KEB Colony, J.P. Nagar 1st Phase, Bangalore -78	B
119	1KS19EC409	VARSHA M S	Female	17/12/1999	lokeshgowda2014@gmail.com	9740418647	HIVARAJAIAH	9900832383	Manjula DS	9482011159	# 28, 5th Main, 10th Cross, J.P. Nagar 7th Phase, Srinidhi Layout, Chunchunagatta Main Road, Bangalore.	B

K.S. INSTITUTE OF TECHNOLOGY, BANGALORE -109

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

INDIVIDUAL TIME TABLE FOR THE YEAR - 2020 (EVEN SEMESTER)

W.E.F. : 10/02/2020

NAME OF THE FACULTY : SANGEETHA .V **DESIGNATION: ASSISTANT PROFESSOR**

PERIOD / TIME / DAY	1 8.30 AM 9.25 AM	2 9.25 AM 10.20 AM	10.20 AM 10.35 AM	3 10.35 AM 11.30 AM	4 11.30 AM 12.25 PM	12.25 PM 1.15 PM	5 1.15 PM 2.10 PM	6 2.10 PM 3.05 PM	7 3.05 PM 4.00 PM
MON		DC (17EC61) -B	TEA BREAK		DC (17EC61) -B	LUNCH BREAK	← CN LAB (17ECL68) - A2 →		
TUE								DC (17EC61) -A	
WED	← CN LAB (17ECL68) - A3 →						DC (17EC61) -A		DC (17EC61) -A
THU	← CN LAB (17ECL68) - B3 →						DC (17EC61) -B		
FRI	DC (17EC61) -B						DC (17EC61) -A		

	Subject Code	Subject Name	Sem	Section	Work Load
Subject 1	17EC61	Digital Communication	VI	A&B	8
Lab -1	17ECL68	Computer Networks Lab	VI	A-2, B-1	4.5
Internship	15EC84	Internship/Professional Practice	VIII		2
Project	15ECP85	Project Work	VIII		2
ADDITIONAL WORK: MENTORING AND OTHERS					
TOTAL LOAD=16.5 Hrs/Week					

Time Table Co-ordinator

6/2/2020

HOD

HEAD OF THE DEPARTMENT
Dept. of Electronics & Communication Engg
K.S. Institute of Technology
Bengaluru - 560 109

6-2-2020

Principal

PRINCIPAL
K.S. INSTITUTE OF TECHNOLOGY
BENGALURU - 560 109.

K.S. INSTITUTE OF TECHNOLOGY, BANGALORE -109

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

VI SEMESTER TIME TABLE FOR THE YEAR 2020 (EVEN SEMESTER)

W.E.F. : 10/02/2020

SEC : 'A'

CLASS TEACHER : Mrs. JAYASUDHA B S K

CLASS ROOM : OB LH 204

PERIOD / TIME / DAY	1 8.30 AM 9.25 AM	2 9.25 AM 10.20 AM	10.20 AM 10.35 AM	3 10.35 AM 11.30 AM	4 11.30 AM 12.25 PM	12.25 PM 1.15 PM	5 1.15 PM 2.10 PM	6 2.10 PM 3.05 PM	7 3.05 PM 4.00 PM
MON	CMC(17EC651)/ DSS(17EC654)	VLSI (17EC63)	TEA	ARM (17EC62)	CCN (17EC64)	LUNCH	← EC LAB (17ECL67) - A1 / CN LAB (17ECL68) - A2 →		
TUE	CMC(17EC651)/ DSS(17EC654)	ARM (17EC62)		DSDV(17EC663)/ C++ (17EC661)	ARM (17EC62)		VLSI (17EC63)	DC (17EC61)	T
WED	← EC LAB (17ECL67) - A2 / CN LAB (17ECL68) - A3 →				DSDV(17EC663)/ C++ (17EC661)	BREAK	DC (17EC61)	CMC(17EC651)/ DSS(17EC654)	DC (17EC61)
THU	CCN (17EC64)	VLSI (17EC63)	BREAK	CCN (17EC64)	DSDV(17EC663)/ C++ (17EC661)		← EC LAB (17ECL67) - A3 / CN LAB (17ECL68) - A1 →		
FRI	CCN (17EC64)	ARM (17EC62)		CMC(17EC651)/ DSS(17EC654)	DSDV(17EC663)/ C++ (17EC661)		DC (17EC61)	VLSI (17EC63)	T

Sub-Code	Subject Name	Faculty Name
17EC61	Digital Communication	Mrs.Sangeetha.V
17EC62	ARM Microcontroller & Embedded Systems	Mrs. Jayasudha B.S.K
17EC63	VLSI Design	Mrs. Aruna Rao B P
17EC64	Computer Communication Networks	Dr. B Surekha
17EC651	Cellular Mobile Communication **(Professional Elective-2**	Dr. P.N Sudha
17EC654	Digital Switching Systems **(Professional Elective-2**	Dr. B.Sudharshan
17EC661	Data Structures Using C++ **(Open Elective-2)**	Dr. P Joy Prabhakaran
17EC663	Digital System Design using Verilog **(Open Elective-2)**	Mr. Sunil Kumar.G.R
17ECL67	Embedded Controller Lab	Dr. B.Sudharshan, Mrs. Aruna Rao B.P
17ECL68	Computer Networks Lab	Mr. Praveen.A, Mrs.Sangeetha.V, Mr. Saleem S Tevaramani

Time Table Co-ordinator

HEAD OF THE DEPARTMENT
Dept. of Electronics & Communication Engg
K.S. Institute of Technology
Bengaluru - 560 109

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K.S. INSTITUTE OF TECHNOLOGY, BANGALORE -109

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

VI SEMESTER TIME TABLE FOR THE YEAR 2020 (EVEN SEMESTER)

W.E.F. : 10/02/2020

SEC : 'B'

CLASS TEACHER : Mrs. ARUNA RAO B P

CLASS ROOM : OB LH 205

PERIOD	1	2		3	4		5	6	7
TIME / DAY	8.30 AM 9.25 AM	9.25 AM 10.20 AM	10.20 AM 10.35 AM	10.35 AM 11.30 AM	11.30 AM 12.25 PM	12.25 PM 1.15 PM	1.15 PM 2.10 PM	2.10 PM 3.05 PM	3.05 PM 4.00 PM
MON	CMC(17EC651)/ DSS(17EC654)	DC (17EC61)	TEA BREAK	VLSI (17EC63)	DC (17EC61)	LUNCH BREAK	CCN (17EC64)	ARM (17EC62)	T
TUE	CMC(17EC651)/ DSS(17EC654)	VLSI (17EC63)		DSDV(17EC663)/ C++ (17EC661)	CCN (17EC64)		EC LAB (17ECL67) - B1 CN LAB (17ECL68) - B2		
WED	CCN (17EC64)	ARM (17EC62)		CCN (17EC64)	DSDV(17EC663)/ C++ (17EC661)		VLSI (17EC63)	CMC(17EC651)/ DSS(17EC654)	ARM (17EC62)
THU	EC LAB (17ECL67) - B2 CN LAB (17ECL68) - B3				DSDV(17EC663)/ C++ (17EC661)		DC (17EC61)	ARM (17EC62)	T
FRI	DC (17EC61)	VLSI (17EC63)		CMC(17EC651)/ DSS(17EC654)	DSDV(17EC663)/ C++ (17EC661)		EC LAB (17ECL67) - B3 CN LAB (17ECL68) - B1		

Sub-Code	Subject Name	Faculty Name
7EC61	Digital Communication	Mrs.Sangeetha.V
7EC62	ARM Microcontroller & Embedded Systems	Mrs. Jayasudha B.S.K
7EC63	VLSI Design	Mr. Praveen.A
7EC64	Computer Communication Networks	Dr. B Surekha
7EC651	Cellular Mobile Communication **(Professional Elective-2**	Dr. P.N Sudha
7EC654	Digital Switching Systems **(Professional Elective-2**	Dr. B.Sudharshan
7EC661	Data Structures Using C++ **(Open Elective-2)**	Dr. P Joy Prabhakaran
7EC663	Digital System Design using Verilog **(Open Elective-2)**	Mrs. Aruna Rao B P
ECL67	Embedded Controller Lab	Mrs. Jayasudha BSK, Mrs.Shilpa
ECL68	Computer Networks Lab	Mr. Praveen.A,Mrs.Sangeetha.V, Mr. Saleem S Tevaramani,

Time Table Co-ordinator

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Bengaluru - 560 109

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BENGALURU - 560 109

BE 2018 Scheme Sixth Semester EC Syllabus

B. E. (EC / TC)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER – VI

DIGITAL COMMUNICATION

Course Code	**18EC61**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**03 + 02 (Tutorial)**	**SEE Marks**	**60**
		Exam Hours	**03**

CREDITS – 04

Course Learning Objectives: This course will enable students to:

- Understand the mathematical representation of signal, symbol, and noise.
- Understand the concept of signal processing of digital data and signal conversion to symbols at the transmitter and receiver.
- Compute performance metrics and parameters for symbol processing and recovery in ideal and corrupted channel conditions.
- Compute performance parameters and mitigate channel induced impediments in corrupted channel conditions.

Module-1	RBT Level
Bandpass Signal to Equivalent Low pass: Hilbert Transform, Pre-envelopes, Complex envelopes, Canonical representation of bandpass signals, Complex low pass representation of bandpass systems, Complex representation of band pass signals and systems **(Text 1: 2.8, 2.9, 2.10, 2.11, 2.12, 2.13).** **Line codes:** Unipolar, Polar, Bipolar (AMI) and Manchester code and their power spectral densities **(Text 1: Ch 6.10).** Overview of HDB3, B3ZS, B6ZS **(Ref. 1: 7.2)**	L1,L2,L3
Module-2	
Signaling over AWGN Channels- 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: 7.1, 7.2, 7.3, 7.4).**	L1,L2,L3
Module – 3	
Digital Modulation Techniques: Phase shift Keying techniques using coherent detection: generation, detection and error probabilities of BPSK and QPSK, M–ary PSK, M–ary QAM **(Relevant topics in Text 1 of 7.6, 7.7).** Frequency shift keying techniques using Coherent detection: BFSK generation, detection and error probability **(Relevant topics in Text 1 of 7.8).** Non coherent orthogonal modulation techniques: BFSK, DPSK Symbol representation, Block diagrams treatment of Transmitter and Receiver, Probability of error (without derivationof probability of error equation) **(Text 1: 7.11, 7.12. 7.13).**	L1,L2,L3
Module-4	
Communication through Band Limited Channels: Digital Transmission through Band limited channels: Digital PAM Transmission through Band limited Channels, Signal design for Band limited Channels: Design of band limited signals for zero ISI–The Nyquist Criterion (statement only), Design of band limited signals with controlled ISI-Partial Response signals, Probability of error for detection of Digital PAM: Probability of error for detection of Digital PAM with Zero ISI, Symbol–by–Symbol detection of data with controlled ISI **(Text 2: 9.1, 9.2, 9.3.1, 9.3.2).** Channel Equalization: Linear Equalizers (ZFE, MMSE), **(Text 2: 9.4.2).**	L1,L2,L3
Module-5	
Principles of Spread Spectrum: Spread Spectrum Communication Systems: Model of a Spread Spectrum Digital Communication System, Direct Sequence Spread Spectrum Systems, Effect of De-spreading on a narrowband Interference, Probability of error (statement only), Some applications of DS Spread Spectrum Signals, Generation of PN Sequences, Frequency Hopped Spread Spectrum, CDMA based on IS-95 **(Text 2: 11.3.1, 11.3.2, 11.3.3, 11.3.4, 11.3.5, 11.4.2).**	L1,L2,L3
Course Outcomes: At the end of the course, the students will be able to: • Associate and apply the concepts of Bandpass sampling to well specified signals and channels. • Analyze and compute performance parameters and transfer rates for low pass and bandpass symbol under ideal and corrupted non band limited channels.	

- Test and validate symbol processing and performance parameters at the receiver under ideal and corrupted bandlimited channels.
- Demonstrate that bandpass signals subjected to corruption and distortion in a bandlimited channel can be processed at the receiver to meet specified performance criteria.

Question paper pattern:

- Examination will be conducted for 100 marks with question paper containing 10 full questions, each of 20 marks.
- Each full question can have a maximum of 4 sub questions.
- There will be 2 full questions from each module covering all the topics of the module.
- Students will have to answer 5 full questions, selecting one full question from each module.
- The total marks will be proportionally reduced to 60 marks as SEE marks is 60.

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 MasoudSalehi, "Fundamentals of Communication Systems", 2014 Edition, Pearson Education, ISBN 978-8-131-70573-5.

Reference Books:

1. B.P.Lathi and Zhi Ding, "Modern Digital and Analog communication Systems", Oxford University Press, 4th Edition, 2010, ISBN: 978-0-198-07380-2.
2. Ian A Glover and Peter M Grant, "Digital Communications", Pearson Education, Third Edition, 2010, ISBN 978-0-273-71830-7.
3. Bernard Sklar and Ray, "Digital Communications - Fundamentals and Applications", Pearson Education, Third Edition, 2014, ISBN: 978-81-317-2092-9.

KS INSTITUTE OF TECHNOLOGY, BANGALORE

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

NAME OF THE STAFF : Mrs.V SANGEETHA

SUBJECT CODE/NAME : 18EC61/DIGITAL COMMUNICATION

SEMESTER/YEAR : VI / III-A

ACADEMIC YEAR : 2020-2021

Sl. No.	Topic to be covered	Mode of Delivery	Teaching Aid	No. of Periods	Cumulative No. of Periods	Proposed Date
	MODULE 1: Bandpass Signal to Equivalent Low pass					
1	Bandpass Signal to Equivalent Lowpass: Introduction	L+D	Microsoft teams	1	1	19.04.2021
2	Hilbert Transform and problems	L+D+PS	Microsoft teams	1	2	20.04. 2021
3	Pre-envelopes, Complex envelopes	L+D	Microsoft teams	1	3	21.04. 2021
4	Canonical representation of bandpass signals	L+D	Microsoft teams	1	4	22.04. 2021
5	Complex low pass representation of bandpass systems and systems	L+D	Microsoft teams	1	5	26.04. 2021
6	Line codes: Unipolar,Polar,Bipolar,Manchester code	L+D	Microsoft teams	2	7	27.04. 2021, 27.04. 2021
7	Unipolar & their spectral densities	L+D	Microsoft teams	1	8	28.04. 2021
8	Polar, Bipolar (AMI) & their spectral densities	L+D	Microsoft teams	1	9	29.04. 2021
9	Manchester code & their spectral densities	L+D	Microsoft teams	1	10	03.05. 2021
10	Overview of HDB3, B3ZS, B6ZS	L+D+PS	Microsoft teams	1	11	04.05. 2021
11	Kahoot Quiz	L+D	Microsoft teams	1	12	04.05.2021
	MODULE 2: Signaling over AWGN Channels					
12	Signaling over AWGN Channels- Introduction	L+ D	Microsoft teams	1	13	05.05.2021
13	Geometric representation of signals	L+D	Microsoft teams	1	14	06.05.2021
14	Gram-Schmidt Orthogonalization procedure	L+D	Microsoft teams	1	15	08.05.2021
15	Conversion of the continuous AWGN channel into a	L+D	Microsoft teams	1	16	10.05.2021

	vector channel					
16	Optimum receivers using coherent detection: ML Decoding	L+D	Microsoft teams	1	17	11.05.2021
17	Class Test	L+D	Microsoft teams	1	18	11.05.2021
18	Correlation receiver	L+D	Microsoft teams	1	19	12.05.2021
19	matched filter receiver	L+D	Microsoft teams	1	20	17.05.2021
20	matched filter receiver properties	L+D	Microsoft teams	1	21	18.05.2021
21	Numerical Problems	L+D+PS	Microsoft teams	1	22	18.05.2021
MODULE 3: Digital Modulation Techniques						
22	Digital Modulation Techniques: Phase shift Keying techniques using coherent detection:	L+D	Microsoft teams	1	23	19.05.2021
23	generation, detection and error probabilities of BPSK	L+D	Microsoft teams	1	24	20.05.2021
24	generation, detection and error probabilities of QPSK	L+D	Microsoft teams	1	25	22.05.2021
25	Internal assessment-I		Microsoft teams	1	26	24.05.2021
26	generation, detection and error probabilities of M–ary PSK	L+D	Microsoft teams	1	27	27.05.2021
27	generation, detection and error probabilities of M–ary QAM	L+D	Microsoft teams	1	28	31.05.2021
28	Frequency shift keying techniques using Coherent detection: BFSK generation, detection and error probability	L+D	Microsoft teams	1	29	01.06.2021
29	M-ary PSK,M-ary QAM	L+D	Microsoft teams	1	30	01.6.2021
30	QPSK probability Error	L+D	Microsoft teams	1	31	02.06.2021
31	Non coherent orthogonal modulation techniques: BFSK & probability of error,	L+D	Microsoft teams	1	32	03.06.2021
32	DPSK Symbol representation, Block diagrams treatment of Transmitter and Receiver, Probability of error (without derivation of probability of error equation)	L+D	Microsoft teams	1	33	05.06.2021
33	Numerical Problems on Coherent Detection techniques	L+D+PS	Microsoft teams	1	34	07.06.2021
34	Numerical Problems on BPSK,FSK	L+D+PS	Microsoft teams	1	35	08.06.2021
35	Numerical Problems on QPSK,DPSK	L+D+PS	Microsoft teams	1	36	08.06.2021
MODULE 4: Communication through Band Limited Channels						
36	Communication through Band Limited Channels: Digital Transmission through Band limited channels:	L+D	Microsoft teams	1	37	09.06.2021

37	Digital PAM Transmission through Band limited Channels	L+D	Microsoft teams	1	38	10.06.2021
38	Signal design for Band limited Channels: Design of band limited signals for zero ISI–The Nyquist Criterion (statement only)	L+D	Microsoft teams	1	39	14.06.2021
39	The Nyquist Criterion (statement only)	L+D	Microsoft teams	1	40	15.06.2021
40	Design of band limited signals with controlled ISI-Partial Response signals	L+D	Microsoft teams	1	41	15.06.2021
41	Internal Assessment-II		Microsoft teams	1	42	16.06.2021
42	Probability of error for detection of Digital PAM: Probability of error for detection of Digital PAM with Zero ISI	L+D	Microsoft teams	1	43	17.06.2021
43	Symbol–by–Symbol detection of data with controlled ISI	L+D	Microsoft teams	1	44	19.06.2021
44	Channel Equalization: Linear Equalizers (ZFE, MMSE)	L+D	Microsoft teams	1	45	21.06.2021
45	Adaptive Equalizers	L+D	Microsoft teams	1	46	22.06.2021, 22.06.2021
46	Numerical Problems	L+D+PS	Microsoft teams	1	47	23.06.2021
	MODULE 5: Principles of Spread Spectrum					
47	Principles of Spread Spectrum: Spread Spectrum Communication Systems: Model of a Spread Spectrum Digital Communication System,	L+D	Microsoft teams	1	48	24.06.2021
48	Internal assessment-2	L+D	Microsoft teams	1	49	28.06.2021
49	Direct Sequence Spread Spectrum Systems	L+D	Microsoft teams	1	50	01.07.2021
50	Effect of De-spreading on a narrowband Interference	L+D	Microsoft teams	1	51	03.07.2021
51	Probability of error (statement only),	L+D	Microsoft teams	1	52	05.07.2021
52	Some applications of DS Spread Spectrum Signals	L+D	Microsoft teams	1	53	06.07.2021
53	Generation of PN Sequences	L+D	Microsoft teams	1	54	06.07.2021
54	Frequency Hopped Spread Spectrum	L+D	Microsoft teams	1	55	07.07.2021
55	CDMA based on IS-95	L+D	Microsoft teams	1	56	08.07.2021
56	Numerical Problems on PN sequence	L+D+PS	Microsoft teams	1	57	12.07.2021
57	Numerical Problems on PN sequence	L+D+PS	Microsoft teams	1	58	13.07.2021
58	Revision Module-1	L+D	Microsoft teams	1	59	13.07.2021
59	Revision Module-2	L+D	Microsoft teams	1	60	14.07.2021
60	Revision Module-3	L+D	Microsoft teams	1	61	15.07.2021
61	Revision Module-4	L+D	Microsoft teams	1	62	17.07.2021

62	Revision Module-5	L+D	Microsoft teams		63	27.07.2021
63	Internal assessment-3	L+D	Microsoft teams		64	29.07.2021
64	University QP Revision	L+D	Microsoft teams		65	07.08.2021

Text Books:

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

Reference Books:

1. B.P.Lathi and Zhi Ding, "Modern Digital and Analog communication Systems", Oxford University Press, 4th Edition, 2010, ISBN: 978-0-198-07380-2.
2. Ian A Glover and Peter M Grant, "Digital Communications", Pearson Education, Third Edition, 2010, ISBN 978-0-273-71830-7.
3. John G Proakis and MasoudSalehi, "Communication Systems Engineering", 2nd Edition, Pearson Education, ISBN 978-93-325-5513-6.

WEB Materials:

- nptel.ac.in/courses/117105077/pdf-m-7/m7l38.pdf
- nptel.ac.in/courses/117105077/20
- https://www.tutorialspoint.com/digital_communication/index.htm

Details for Teaching Aids:

1. Microsoft teams for online class
2. Laptop for PPT

Signature of Course In-charge **Signature of Module Coordinator** **Signature of HOD-ECE**

KS INSTITUTE OF TECHNOLOGY, BANGALORE
DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

NAME OF THE STAFF : Mrs.V SANGEETHA

SUBJECT CODE/NAME : 18EC61/DIGITAL COMMUNICATION

SEMESTER/YEAR : VI / III-B

ACADEMIC YEAR : 2020-2021

Sl. No.	Topic to be covered	Mode of Delivery	Teaching Aid	No. of Periods	Cumulative No. of Periods	Proposed Date
MODULE 1: Bandpass Signal to Equivalent Low pass						
1	Bandpass Signal to Equivalent Lowpass: Introduction	L+D	Microsoft teams	1	1	19.04.2021
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3	Pre-envelopes, Complex envelopes	L+D	Microsoft teams	1	3	22.04. 2021
4	Canonical representation of bandpass signals	L+D	Microsoft teams	1	4	23.04. 2021
5	Complex low pass representation of bandpass systems and systems	L+D	Microsoft teams	1	5	23.04. 2021
6	Line codes: Unipolar,Polar,Bipolar,Manchester code	L+D	Microsoft teams	1	6	24.04. 2021
7	Unipolar & their spectral densities	L+D	Microsoft teams	1	7	26.04. 2021
8	Polar, Bipolar (AMI) & their spectral densities	L+D	Microsoft teams	1	8	28.04. 2021
9	Manchester code & their spectral densities	L+D	Microsoft teams	1	9	29.04. 2021
10	Overview of HDB3, B3ZS, B6ZS	L+PS	Microsoft teams	1	10	30.04. 2021
11	Kahoot Quiz	L+D	Microsoft teams	1	11	03.05.2021
MODULE 2: Signaling over AWGN Channels						
12	Signaling over AWGN Channels- Introduction	L+ D	Microsoft teams	1	12	05.05.2021
13	Geometric representation of signals	L+D	Microsoft teams	1	13	06.05.2021
14	Gram-Schmidt Orthogonalization procedure	L+D	Microsoft teams	1	14	07.05.2021
15	Conversion of the continuous AWGN channel into a	L+D	Microsoft teams	1	15	07.05.2021

16	vector channel Optimum receivers using coherent detection: ML Decoding	L+D	Microsoft teams	1	16	08.05.2021
17	Class Test	L+D	Microsoft teams	1	17	10.05.2021
18	Correlation receiver	L+D	Microsoft teams	1	18	12.05.2021
19	matched filter receiver	L+D	Microsoft teams	1	19	17.05.2021
20	matched filter receiver properties	L+D	Microsoft teams	1	20	19.05.2021
21	Numerical Problems	L+D+PS	Microsoft teams	1	21	20.05.2021
MODULE 3: Digital Modulation Techniques						
22	Digital Modulation Techniques: Phase shift Keying techniques using coherent detection:	L+D	Microsoft teams	1	22	21.05.2021
23	generation, detection and error probabilities of BPSK	L+D	Microsoft teams	1	23	21.05.2021
24	generation, detection and error probabilities of QPSK	L+D	Microsoft teams	1	24	
25	Internal assessment-I		Microsoft teams		25	24.05.2021
26	generation, detection and error probabilities of M–ary PSK	L+D	Microsoft teams	1	26	27.05.2021
27	generation, detection and error probabilities of M–ary QAM	L+D	Microsoft teams	1	27	28.05.2021
28	True or False	L+D	Microsoft teams	1	28	28.05.2021
29	Frequency shift keying techniques using Coherent detection: BFSK generation, detection and error probability	L+D	Microsoft teams	1	29	31.05.2021
30	Non coherent orthogonal modulation techniques: BFSK & probability of error,	L+D	Microsoft teams	1	30	02.06.2021
31	DPSK Symbol representation, Block diagrams treatment of Transmitter and Receiver, Probability of error (without derivation of probability of error equation)	L+D	Microsoft teams	1	31	03.06.2021
32	Minimum Shift keying, M-ary PSK	L+D	Microsoft teams	1	32	04.06.2021
33	Numerical Problems on Coherent Detection techniques	L+D+PS	Microsoft teams	1	33	05.06.2021
34	Numerical Problems	L+D+PS	Microsoft teams	1	34	07.06.2021
MODULE 4: Communication through Band Limited Channels						
35	Communication through Band Limited Channels: Digital Transmission through Band limited channels:	L+D	Microsoft teams	1	35	09.06.2021

36	Digital PAM Transmission through Band limited Channels	L+D	Microsoft teams	1	36	10.06.2021
37	Signal design for Band limited Channels: Design of band limited signals for zero ISI–The Nyquist Criterion (statement only)	L+D	Microsoft teams	1	37	11.06.2021
38	The Nyquist Criterion (statement only)	L+D	Microsoft teams	1	38	11.06.2021
39	Design of band limited signals with controlled ISI-Partial Response signals	L+D	Microsoft teams	1	39	14.06.2021
40	ISI		Microsoft teams	1	40	16.06.2021
41	Probability of error for detection of Digital PAM: Probability of error for detection of Digital PAM with Zero ISI	L+D	Microsoft teams	1	41	17.06.2021
42	Symbol–by–Symbol detection of data with controlled ISI	L+D	Microsoft teams	1	42	18.06.2021
43	Channel Equalization: Linear Equalizers (ZFE, MMSE)	L+D	Microsoft teams	1	43	18.06.2021
44	Adaptive Equalizers	L+D	Microsoft teams	1	44	19.06.2021
45	Numerical Problems	L+D+PS	Microsoft teams	1	45	21.06.2021
MODULE 5: Principles of Spread Spectrum						
46	Principles of Spread Spectrum: Spread Spectrum Communication Systems: Model of a Spread Spectrum Digital Communication System,	L+D	Microsoft teams	1	46	23.06.2021
47	Internal assessment-2	L+D	Microsoft teams	1	47	28.06.2021
48	Direct Sequence Spread Spectrum Systems	L+D	Microsoft teams	1	48	01.07.2021
49	Problem on Direct sequence spread Spectrum	L+D	Microsoft teams	1	49	02.07.2021
50	Effect of De-spreading on a narrowband Interference	L+D+PS	Microsoft teams	1	50	02.07.2021
51	Probability of error (statement only),	L+D	Microsoft teams	1	51	03.07.2021
52	Some applications of DS Spread Spectrum Signals	L+D	Microsoft teams	1	52	05.07.2021
53	Generation of PN Sequences	L+D	Microsoft teams	1	53	07.07.2021
54	Frequency Hopped Spread Spectrum	L+D	Microsoft teams	1	54	08.07.2021
55	Problem on FHSS	L+D+PS	Microsoft teams	1	55	09.07.2021
56	CDMA based on IS-95	L+D	Microsoft teams	1	56	12.07.2021
57	Numerical Problems on PN sequence	L+D+PS	Microsoft teams	1	57	14.07.2021
58	Numerical Problems on PN sequence	L+D+PS	Microsoft teams	1	58	15.07.2021
59	Revision Module-1	L+D	Microsoft teams	1	59	16.07.2021
60	Revision Module-2	L+D	Microsoft teams	1	60	17.07.2021
61	Revision Module-3	L+D	Microsoft teams	1	61	19.07.2021

62	Revision Module-4	L+D	Microsoft teams	1	62	21.07.2021
63	Revision Module-5	L+D	Microsoft teams	1	63	22.07.2021
64	Internal assessment-3	L+D	Microsoft teams	1	64	29.07.2021
65	University QP Revision	L+D	Microsoft teams	1	65	07.08.2021

Text Books:

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

Reference Books:

1. B.P.Lathi and Zhi Ding, “Modern Digital and Analog communication Systems”, Oxford University Press, 4th Edition, 2010, ISBN: 978-0-198-07380-2.
2. Ian A Glover and Peter M Grant, “Digital Communications”, Pearson Education, Third Edition, 2010, ISBN 978-0-273-71830-7.
3. John G Proakis and MasoudSalehi, “Communication Systems Engineering”, 2nd Edition, Pearson Education, ISBN 978-93-325-5513-6.

WEB Materials:

- nptel.ac.in/courses/117105077/pdf-m-7/m7l38.pdf
- nptel.ac.in/courses/117105077/20
- https://www.tutorialspoint.com/digital_communication/index.htm

Details for Teaching Aids:

1. Microsoft teams for online class
2. Laptop for PPT

V. S

Signature of Course In-charge

Signature of Module Coordinator

Signature of HOD-ECE

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

ASSIGNMENT –I QUESTIONS

Academic Year	2020-2021		
Batch	2018-2022		
Year/Semester/section	III/VI/ A&B		
Subject Code-Title	18EC61-Digital Communication		
Name of the Instructor	Mrs. SANGEETHA.V	Dept	ECE

Assignment No: 1 **Total marks:10**
Date of Issue:03.05.2021 **Date of Submission:15.05.2021**

Sl.No	Assignment Questions	K Level	CO	Marks
1.	**Construct** the Hilbert Transform for the following signal (i) $\delta(t)$ (ii) $\cos 2\pi ft + \sin 2\pi ft$	Applying K3	CO1	1
2.	**Identify** all the properties of Hilbert transform and also prove any two properties.	Applying K3	CO1	1
3.	**Make use of** concept of Pre envelope and Complex Envelope and write in detail.	Applying K3	CO1	1
4.	**Construct** the following Line codes for the given binary data 10110010 (i)Unipolar NRZ (ii) Split phase Manchester	Applying K3	CO1	1
5.	**Develop** the power spectral density of Manchester code with related equations and wave form.	Applying K3	CO1	1
6.	**Construct** the HDB3 and B6ZS signalling for the given binary data 10000001101	Applying K3	CO1	1
7.	**Develop** an expression for power spectral density of NRZ polar format.	Applying K3	CO2	1
8.	**Identify** the procedure for Gram Schmidt Orthogonalization.	Applying K3	CO2	1
9.	**Make use of** the concept of vector space representation write the following(i) Absolute Vector (or) Norm vector (ii) relationship between signal energy and its vector.	Applying K3	CO2	1
10.	With necessary representation when N=2,M=3 **construct** the geometric representation of signal.	Applying K3	CO2	1

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ASSIGNMENT-1 ANSWER KEY

Academic Year	**2020-2021**		
Batch	**2018-2022**		
Year/Semester/section	**III/VI/ A&B**		
Subject Code-Title	**18EC61-Digital Communication**		
Name of the Instructor	**Mrs. Sangeetha. V**	**Dept**	**ECE**

i) $\delta(t)$

$x(t) = \delta(t)$

Fourier transform of,

$\delta(t) = -j\,\mathrm{sgn}(f) = G(f)$

$\hat{G}(f) = (-j\,\mathrm{sgn}(f))(-j\,\mathrm{sgn}(f))$ (OR) $\hat{x}(t) = x(t) * \frac{1}{\pi t}$

$= j^2\,\mathrm{sgn}^2(f)$ $\hat{x}(t) = \delta(t) * \frac{1}{\pi t}$ $(\because \delta(t) = 1)$

$= 1$ (for any value of 'f') $\boxed{\hat{x}(t) = \frac{1}{\pi t}}$

$\Rightarrow \hat{G}(f) = 1$

Taking Inverse fourier transform.

$\hat{g}(t) = \mathrm{I.F.T}[1]$

$\boxed{\hat{g}(t) = \frac{1}{\pi t}}$

ii) $\cos 2\pi f t + \sin 2\pi f t$.

Hilbert transform is,

$\hat{x}(t) = \cos 2\pi f t + \sin 2\pi f t$.

$\hat{x}(t) = \cos\left(2\pi f t - \pi/2\right) + \sin\left(2\pi f t - \pi/2\right)$

$\boxed{\hat{x}(t) = \sin 2\pi f t - \cos 2\pi f t}$

(when $f > 0$)

Q.1)

Properties of Hilbert Transform.

(i) $|G(f)| = |\hat{G}(f)|$ Proof.

(ii) $\mathrm{H.T}[\hat{g}(t)] = -g(t)$. Proof.

(iii) $g(t)$ & $\hat{g}(t)$ are orthogonal to each other.

Q.2)

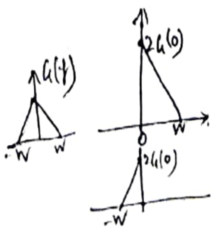
Pre-envelope.

$g_+(t) = g(t) + j\hat{g}(t)$

$G_+(f) = G(f)\left[1 + \mathrm{sgn}(f)\right]$

$G_-(f) = G(f)\left[1 - \mathrm{sgn}(f)\right]$.

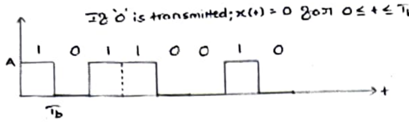
$\tilde{g}(t) = g_+(t) \cdot e^{-j2\pi f_c t}$



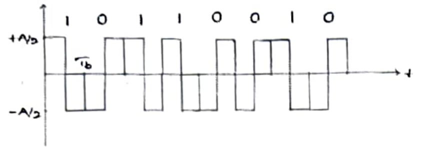
i) Unipolar NRZ:-

If '1' is transmitted; $x(t) = A$ for $0 \le t \le T_b$

If '0' is transmitted; $x(t) = 0$ for $0 \le t \le T_b$



ii) Split phase Manchester:-



Q.4) (1M)

Manchester format

$$A_k = \begin{cases} \pm a, & \text{symbol } 1 \\ \mp a, & \text{symbol } 0. \end{cases}$$

$$V(f) = T_b \sin\left(\frac{\pi f T_b}{2}\right) \operatorname{sinc}\left(\frac{\pi f T_b}{2}\right).$$

$$R_A(n) = \begin{cases} a^2, & n = 0 \\ 0, & n \neq 0. \end{cases}$$

PSD

$$S_X(f) = a^2 T_b \operatorname{sinc}^2\left(\frac{f T_b}{2}\right) \left(\sin^2\left(\frac{\pi f T_b}{2}\right)\right).$$

Q.5) (1M)

Q.6)

* HDB3

1 0 0 0 0 0 0 1 1 0 1

$\underline{0\ 0\ 0\ V}$

\+ 0 0 0 + 0 0 − + 0 +

* B6ZS

1 0 0 0 0 0 0 1 1 0 1

0 V B 0 V B

\+ 0 + − 0 − + − + 0 −

(1M)

Q.7)

PSD of Polar format

$$A_k = \begin{cases} +a, & \text{symbol } 1 \\ -a, & \text{symbol } 0. \end{cases}$$

$$V(f) = T_b \operatorname{sinc}(fT_b)$$

$$R_A(n) = \begin{cases} a^2, & n = 0 \\ 0, & n \neq 0. \end{cases}$$

PSD of $S_X(f) = a^2 T_b \operatorname{sinc}^2(fT_b$.

(1M)

Q.8)

Gram schmidt orthogonalization Procedure.

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

$$\phi_2(t) = \frac{s_2(t) - s_{21}\phi_1(t)}{s_{22}}$$

$$\phi_3(t) = \frac{s_3(t) - s_{31}\phi_1(t) - s_{32}\phi_2(t) - s_{33}\phi_3(t)}{s_{33}}$$

in general

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

where,

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

(1M)

Q.9)

(i) Absolute Vector (or) Norm Vector

$$\|s_i^2\| = s_i^T s_i = \sum_{j=1}^{N} s_{ij}^2 = E_i$$

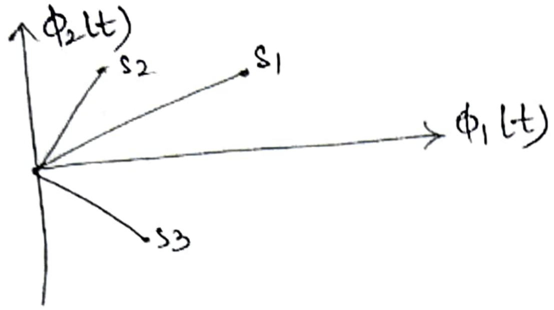
(ii) signal Energy and its Vector

$$E_i = \int_0^T \left[\sum_{j=1}^{N} s_{ij}\,\phi_j(t)\right]\left[\sum_{k=1}^{N} s_{ik}\,\phi_k(t)\right] dt$$

$$E_i = \sum_{j=1}^{N} s_{ij}^2 \Rightarrow E_i = \|s_i\|^2$$

(1M)

$$s_1(t) = s_{11}\phi_1(t) + s_{12}\phi_2(t)$$
$$s_2(t) = s_{21}\phi_1(t) + s_{22}\phi_2(t)$$
$$s_3(t) = s_{31}\phi_1(t) + s_{32}\phi_2(t)$$



Q.10) (1M)

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ASSIGNMENT-2 QUESTIONS

Academic Year	2020-2021		
Batch	2018-2022		
Year/Semester/section	III/VI/ A&B		
Subject Code-Title	18EC61-Digital Communication		
Name of the Instructor	Mrs. SANGEETHA.V	Dept	ECE

Assignment No: 2 | Total marks:10

Date of Issue:10.06.2021 | Date of Submission:21.06.2021

Sl.No	Assignment Questions	K Level	CO	Marks
1.	**Make use of**the maximum likelihood detection process and obtain the decision rule.	Applying K3	CO2	1
2.	The Random process $x(t)=S_i(t)+w(t)$ is received by a bank of correlators. The o/p of the correlators is $X_j=S_{ij}+w_j$,j=1,2,..N ,the noise w(t) is white Gaussian noise of zero mean &PSD of $N_0/2$. (i) Develop mean value of X_j (ii) Develop variance of X_j Develop X_j are mutually uncorrelated.	Applying K3	CO2	1
3.	**Construct** the generation of differentially encoded sequence for the binary sequence 110101.	Applying K3	CO3	1
4.	**Make use of** block diagram of DPSK transmitter and receiver write in detail.	Applying K3	CO3	1
5.	**Develop** the expression for probability of error of a coherent BPSK technique.	Applying K3	CO3	1
6.	**Make use of** block diagram of QPSK transmitter and receiver write in detail with waveform.	Applying K3	CO3	1
7.	**Make use of** block diagram of BFSK transmitter and receiver write in detail.	Applying K3	CO3	1
8.	A binary data is transmitted over an AWGN channel using BPSK at arate of 1 Mbps. It is desired to have average probability of error $Pe<10^{-4}$. Noise PSD is $No/2=10^{-12}$ W/Hz. Determine the average carrier power required at the receiver input, if the detector is of coherent type. Take erfc(3.5)=0.00025.	Applying K3	CO3	1
9.	**Develop** Nyquist criterion for zero ISI and Give an example of the pulse with zero ISI.	Applying K3	CO4	1
10.	**Make use of** eye pattern and write in detail with diagram.	Applying K3	CO4	1

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ASSIGNMENT-2 ANSWER KEY

Academic Year	**2020-2021**		
Batch	**2018-2022**		
Year/Semester/section	**III/VI/ A&B**		
Subject Code-Title	**18EC61-Digital Communication**		
Name of the Instructor	**Mrs. Sangeetha. V**	**Dept**	**ECE**

Q.1)

$\boxed{P_e(m_i/x) = 1 - P(m_i \text{ sent}/x)}$ —— ①

1 − Probability of estimating or Identifying the actual Sent message

To minimize the avg P_e, we use optimum decision rule (i.e) $\hat{m} = m_i$ if

$P(m_i \text{ sent}/x) \geq P(m_k \text{ sent}/x)$ $\forall k \neq i$, $k = 1, 2 \ldots M$ —— ②

$L(m_k) = -2 \sum_{j=1}^{N} x_j s_{kj} + E_k$.

The observation vector x lies in region Z_i if $\left(\sum_{j=1}^{N} x_j s_{kj} - \frac{1}{2}E_k\right)$ is maximum for $k = i$.

$\therefore$ $L(m_k)$ is maximum.

Q.2)

$$\mu_{X_j} = E[X_j] = E[s_{ij} + W_j] = s_{ij} + E[W_j] = s_{ij}$$

$$\sigma^2_{X_j} = \text{var}[X_j] = E[(X_j - s_{ij})^2] = E[W_j^2]$$

$$\sigma^2_{X_j} = E\left[\int_0^T W(t)\phi_j(t)\,dt \int_0^T W(u)\phi_j(u)\,du\right] = E\left[\int_0^T\int_0^T \phi_j(t)\phi_j(u)W(t)W(u)\,dt\,du\right]$$

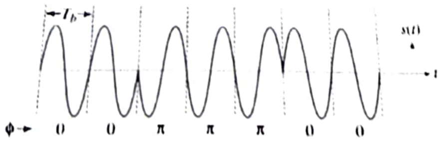
$$\sigma^2_{X_j} = \int_0^T\int_0^T \phi_j(t)\phi_j(u)E[W(t)W(u)]\,dt\,du = \int_0^T\int_0^T \phi_j(t)\phi_j(u)R_W(t,u)\,dt\,du$$

$$R_W(t,u) = \left(\frac{N_0}{2}\right)\delta(t-u)$$

$$\sigma^2_{X_j} = \frac{N_0}{2}\int_0^T\int_0^T \phi_j(t)\phi_j(u)\delta(t-u)\,dt\,du = \frac{N_0}{2}\int_0^T \phi_j^2(t)\,dt$$

$$\sigma^2_{X_j} = \frac{N_0}{2}, \quad \text{for all } j$$

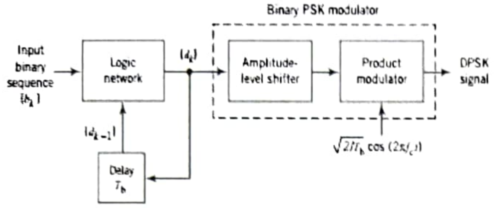
$k \rightarrow$	−1	0	1	2	3	4	5
Binary data $\{b_k\}$		1	0	1	1	0	1
Differentially encoded data $\{d_k\}$	1	1	0	0	0	1	1
Phase of the DPSK wave (rad)	0	0	π	π	π	0	0

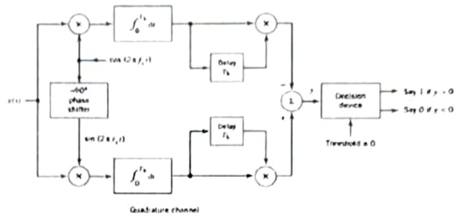


Q.3)

Q.4) Differential encoding starts with an arbitrary first bit, serving as the reference bit; to this end, symbol 1 is used as the reference bit. Generation of the differentially encoded sequence then proceeds in accordance with a two-part encoding rule as follows:

1. If the new bit at the transmitter input is 1, leave the differentially encoded symbol unchanged with respect to the current bit.
2. If, on the other hand, the input bit is 0, change the differentially encoded symbol with respect to the current bit.
The differentially encoded sequence, denoted by {dk}, is used to shift the sinusoidal carrier phase by zero and 180o, representing symbols 1 and 0, respectively. Thus, in terms of phase-shifts, the resulting DPSK signal follows the two-part rule: 1. To send symbol 1, the phase of the DPSK signal remains unchanged. 2. To send symbol 0, the phase of the DPSK signal is shifted by 180°.





Q.5)Probability of error calculation for BPSK

The received signal x(t) is given as
x(t)=s(t)+w(t)
let us assume that symbol 0 or $s_2(t)$ is transmitted then

$$E[x1] = -\sqrt{E_b}$$

$$Var[x1]=No/2$$

$$P_e(0) = \frac{1}{\sqrt{\pi N_0}} \int_0^{\infty} \exp\left[-\frac{(x_1+\sqrt{E_b})^2}{N_0}\right] dx_1$$

$$u = \frac{x_1+\sqrt{E_b}}{\sqrt{N_0}}$$

$$dx_1 = \sqrt{N_0}\, du$$

$$P_e(0) = \frac{1}{\sqrt{\pi}} \int_{\sqrt{E_b/N_0}}^{\infty} \exp(-u^2)\, du \qquad P_e(0) = \frac{1}{2}\text{erfc}\left(\sqrt{\frac{E_b}{N_0}}\right)$$

$$P_e(1) = \frac{1}{\sqrt{\pi N_0}} \int_{-\infty}^{0} \exp\left[-\frac{(x_1-\sqrt{E_b})^2}{N_0}\right] dx_1 \qquad P_e = P_e(0) = P_e(1) = \frac{1}{2}\text{erfc}\sqrt{\frac{E_b}{N_0}}$$

Q.6) Quadrature phase shift keying

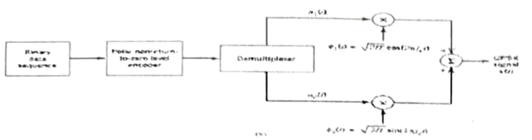
The QPSK transmitter may be viewed as two binary PSK generators that work in parallel, each at a bit rate equal to one-half the bit rate of the original binary sequence at the QPSK transmitter input.

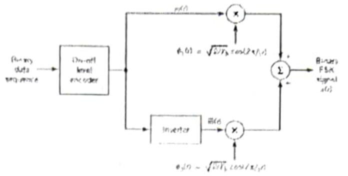
The functional composition of the QPSK receiver is as follows:

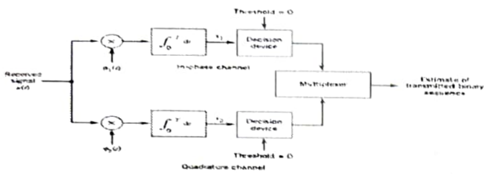
1.Pair of correlators, which have a common input x(t). The two correlators are supplied with a pair of locally generated orthonormal basis functions $\varphi_1(t)$ and $\varphi_2(t)$, which means that the receiver is synchronized with the transmitter. The correlator outputs, produced in response to the received signal x(t), are denoted by x1 and x2, respectively.

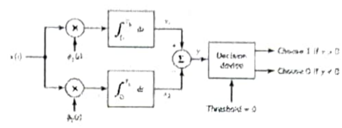
2.Pair of decision devices, which act on the correlator outputs x1 and x2 by comparing each one with a zero-threshold; here, it is assumed that the symbols 1 and 0 in the

Q.7)









The binary FSK wave can be represented as follow

$$s(t) = \begin{cases} s_1(t) = \sqrt{\frac{2E_b}{T_b}} \cos 2\pi f_1 t, & 0 \le t \le T_b, \text{ for symbol } 1 \\ s_2(t) = \sqrt{\frac{2E_b}{T_b}} \cos 2\pi f_2 t, & 0 \le t \le T_b, \text{ for symbol } 0 \end{cases}$$

Let $\phi_1(t)$ & $\phi_2(t)$ are the basis function defined as,

$\phi_1(t) = \sqrt{\frac{2}{T_b}} \cos 2\pi f_1 t$ & $\phi_2(t) = \sqrt{\frac{2}{T_b}} \cos 2\pi f_2 t$.

We can write s(t) as,

$$s(t) = \begin{cases} s_1(t) = \sqrt{E_b}\,\phi_1(t) & \text{for symbol '1'} \\ s_2(t) = \sqrt{E_b}\,\phi_2(t) & \text{for symbol '0'} \end{cases}$$

* The detector consists of two correlators that are tuned to two different frequencies
* A correlator consists of a multiplier followed by an Integrator (LPF).
* The o/p of top & bottom correlator be denoted by x_1 & x_2 respectively. The x_1 & x_2 are given to subtractor, the o/p of subtractor $l = x_1 - x_2$.
* If $(x_1 - x_2) > 0$ i-e $l > 0$, decision is taken in favour of symbol '1'.
* If $(x_1 - x_2) < 0$ i-e $l < 0$, the decision is taken in favour of symbol '0'.
* If $(x_1 - x_2) = 0$, i-e $l = 0$, the decision is arbitrary.

Let carrier power required be P,

then $E_b = P T_b$.

Bit interval $T_b = \frac{1}{\text{bit rate}} = \frac{1}{10^6} = 10^{-6}$ sec.

$$\left(\frac{E_b}{N_0}\right) = \frac{P \times 10^{-6}}{2 \times 10^{-12}} = 0.5\, P \times 10^{+6}$$

Hence, $P_e = \frac{1}{2} \operatorname{erfc} \sqrt{0.5 \times P \times 10^6} \le 10^{-4}$

Given the complementary error function,

$\operatorname{erfc}(3.5) = 0.00025$

$\sqrt{0.5 \times P \times 10^6} \ge 3.5$

Q.8) Carrier power $\boxed{P \ge 24.5\,\mu W}$

Q.9)

Nyquist Condition for Zero ISI. A necessary and sufficient condition for $x(t)$ to satisfy

$$x(nT) = \begin{cases} 1, & n = 0 \\ 0, & n \neq 0 \end{cases} \qquad (9.2.6)$$

is that its Fourier transform $X(f)$ must satisfy

$$\sum_{m=-\infty}^{\infty} X\left(f + \frac{m}{T}\right) = T. \qquad (9.2.7)$$

Therefore, the necessary and sufficient conditions for Equation (9.2.6) to be satisfied is that

$$z_n = \begin{cases} T & n = 0 \\ 0, & n \neq 0 \end{cases}, \qquad (9.2.15)$$

which, when substituted into Equation (9.2.12), yields

$$Z(f) = T, \qquad (9.2.16)$$

or equivalently,

$$\sum_{m=-\infty}^{\infty} X\left(f + \frac{m}{T}\right) = T. \qquad (9.2.17)$$

It is clear that there exists only one $X(f)$ that results in $Z(f) = T$, namely,

$$X(f) = \begin{cases} T & |f| < W, \\ 0, & \text{otherwise} \end{cases} \qquad (9.2.18)$$

or $X(f) = T\Pi\left(\frac{f}{2W}\right)$, which results in

$$x(t) = \text{sinc}\left(\frac{t}{T}\right). \qquad (9.2.19)$$

- The Eye Pattern is used to study the effect of ISI in baseband digital transmission.
- When the sequence is transmitted over a baseband binary data transmission system of Fig. 4.6.1 the signal obtained at the output i.e. $y(t)$ is a continuous time signal as shown in Fig. 4.6.1. Ideally this signal should go high and low depending on the symbol that was transmitted. But because of the nature of transmission channel, the signal becomes continuous with increasing and decreasing amplitudes. Fig. 4.6.1(a) shows the binary sequence that is transmitted and Fig. 4.6.1 (b) shows the signal $y(t)$ obtained at the output. Fig. 4.6.1 (b) also shows various sampling instants t_1, t_2, t_3 .... etc. Thus based on the signal obtained over the period T_b between two sampling instants, decision is taken by the decision device. If we cut the signal $y(t)$ shown in Fig. 4.6.1 (b) in each interval (T_b) and place it over one another, then we obtain the diagram as shown in Fig. 4.6.1 (c). This diagram is called Eye pattern of the signal $y(t)$.

The name 'eye' is given because it looks like an eye. This pattern can also be obtained on CRO if we apply $y(t)$ to one of the input channels and apply an external trigger signal of $1/T_b$ Hz. This makes one sweep of beam equal to T_b seconds. Therefore the pattern shown in Fig. 4.6.1 (c) will be obtained. When there are large number of bits of the sequence, then eye patterns will be as shown in Fig. 4.6.1 (d).

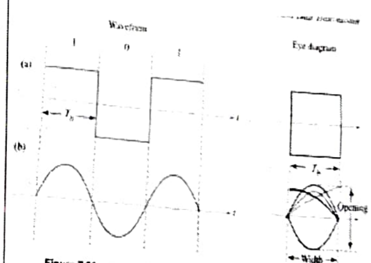
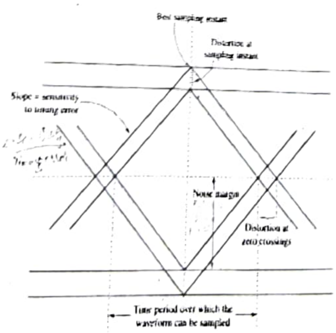


Figure 7.20 (a) and (b) Received waveforms and their eye diagrams.

Q.10)



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HOD-ECE

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

ASSIGNMENT -3 QUESTIONS

Academic Year	2020-2021		
Batch	2018-2022		
Year/Semester/section	III/VI/ A&B		
Subject Code-Title	18EC61-Digital Communication		
Name of the Instructor	Mrs. SANGEETHA.V	Dept	ECE

Assignment No: 3
Date of Issue:16.07.2021

Total marks:10
Date of Submission:26.07.2021

Sl.No	Assignment Questions	K Level	CO	Marks
1.	The binary sequence 0010110 is the input to the precoder whose output is used to modulate a duobinary transmitting filter. Identify the precoded sequence, transmitted amplitude levels, the received signal levels and the decoded sequence.	Applying K3	CO4	2
2.	Write a note on channel equalization and with a neat diagram explain the concept of equalization using a linear transversal filter.	Applying K3	CO4	2
3.	Make use of the block diagram of Direct sequence spread spectrum and write in detail.	Applying K3	CO5	2
4.	A 3-stage shift register with a linear feedback generates the sequence : 01011100101110 , Slove the following: (i) Period of the given infinite sequence. (ii) Balance property, Run property and Autocorrelation property.	Applying K3	CO5	2
5.	Construct the 4 stage linear feedback shift register with 1stand 4thstage is connected to Modulo-2 adder. Output of Modulo-2 is connected to 1st stage input. Solve the output PN sequence ,chip duration and period of PN sequence if chip rate is 10^{7}chips/sec, also draw the schematic arrangement.	Applying K3	CO5	2

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ASSIGNMENT-3 ANSWER KEY

Academic Year	2020-2021		
Batch	2018-2022		
Year/Semester/section	III/VI/ A&B		
Subject Code-Title	18EC61-Digital Communication		
Name of the Instructor	Mrs. Sangeetha. V	Dept	ECE

Q.1)

Sequences	$k=-1$	$k=0$	$k=1$	$k=2$	$k=3$	$k=4$	$k=5$	$k=6$
Binary sequence $\{b_k\}$		0	0	1	0	1	1	0
Precoded sequence $\{d_{k-1}\}$		1	1	1	0	0	1	0
Precoded sequence $d_k = b_k \oplus d_{k-1}$	1	1	1	0	0	1	0	0
Two level sequence $\{a_k\}$	+1	+1	+1	−1	−1	+1	−1	−1
Two level sequence $\{a_{k-1}\}$		+1	+1	+1	−1	−1	+1	−1
Duobinary encoder output $c_k = a_k + a_{k-1}$		+2	+2	0	−2	0	0	−2
Magnitude of $\{c_k\}$ i.e. $\{\lvert c_k\rvert\}$		+2	+2	0	+2	0	0	+2
Output of decoder obtained by applying equation 4.4.8 to $\{c_k\}$ above		0	0	1	0	1	1	0

Q.2)

In practice we often encounter channels whose frequency response characteristics are either unknown or change with time. For example, in data transmission over the dial-up telephone network, the communication channel will be different every time we dial a number, because the channel route will be different. Once a connection is made, however, the channel will be time-invariant for a relatively long period of time. This is an example of a channel whose characteristics are unknown a priori. Examples of time-varying channels are radio channels, such as ionospheric propagation channels. These channels are characterized by time-varying frequency response characteristics. These types of channels are examples where the optimization of the transmitting and receiving filters, as described in Section 8.6.1, is not possible.

Under these circumstances, we may design the transmitting filter to have a square-root raised cosine frequency response; i.e.,

$$G_T(f) = \begin{cases} \sqrt{X_{rc}(f)}\, e^{-j2\pi f t_0}, & |f| \le W \\ 0, & |f| > W \end{cases}$$

Let us now consider the design of a linear equalizer from a time-domain viewpoint. We noted previously that in real channels, the ISI is limited to a finite number of samples, say L samples. As a consequence, in practice the channel equalizer is approximated by a finite duration impulse response (FIR) filter, or transversal filter, with adjustable tap coefficients $\{c_n\}$, as illustrated in Figure 8.37. The time delay τ between adjacent taps may be selected as large as T, the symbol interval, in which case the FIR equalizer is called a *symbol-spaced equalizer*. In this case the input to the equalizer is the sampled sequence given by Equation (8.6.19). However, we note that when $1/T < 2W$, frequencies in the received signal above the folding frequency $1/T$

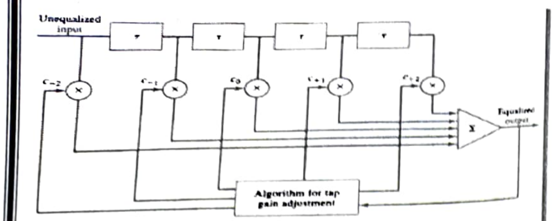
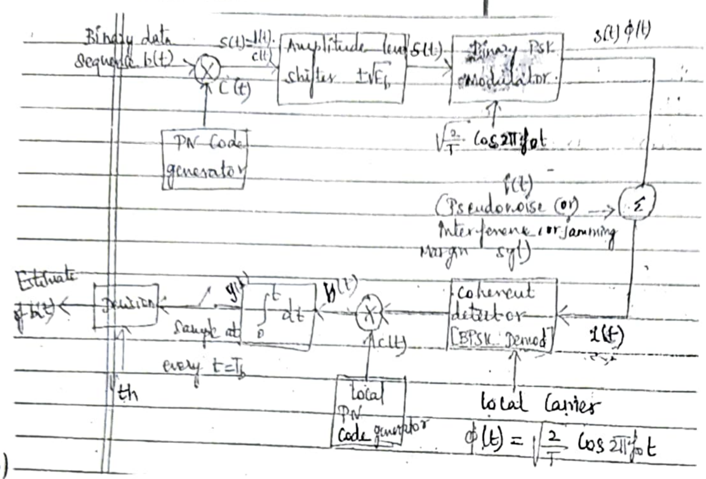


Figure 8.37 Linear transversal filter.



Q.3)

Solution:

(a) The given sequence is

0 1 0 1 1 1 0 0 1 0 1 1 1 0

← One period →

Q4) The given sequence has a period $L = 7$, because after every seven bits, the pattern repeats. This is also in agreement with $L = 2^n - 1$, when $n = 3$.

Balance Property: In one period of the sequence, we find that

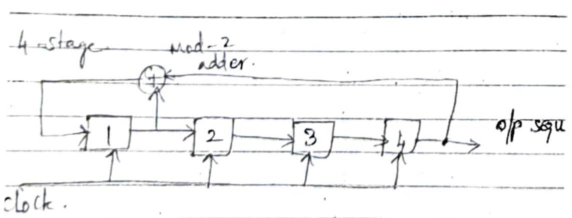
(i) the number of 1s = 4 (which is in agreement with number of 1s = 2^{n-1}).

(ii) the number of 0s = 3 (which is in agreement with number of 0s = $2^{n-1} - 1$). Thus, we find that number of 0s and number of 1s differ by one.

$$\text{Total number of runs} = \frac{L+1}{2}$$

$$= \frac{7+1}{2} = 4$$

Run Property:



Q.5)

- The generated PN sequence is 000111101011001
- Auto correlation sequence is $R_c(t)$= 1 for t=0,7,14…

  -1/7 for otherwise

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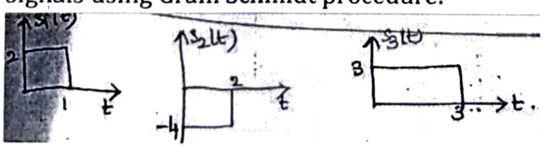
K.S. INSTITUTE OF TECHNOLOGY, BANGALORE - 560109
I SESSIONAL TEST QUESTION PAPER 2020 – 21 EVEN SEMESTER

SET-A

USN | | | | | | | | | |

Degree	:	B.E	Semester	:	VI
Branch	:	ECE	Course Code	:	18EC61
Course Title	:	DIGITAL COMMUNICATION	Date	:	24.5.2021
Duration	:	90 Minutes	Max Marks	:	30

Note: Answer ONE full question from each part.

Q No.	Question	Marks	CO mapping	K-Level
	PART-A			
1(a)	**Obtain** the Hilbert Transform for the following signal (i)$\delta(t)$ (ii) $\cos 2\pi fct + \sin 2\pi fct$ (iii) $1\ \pi t$	6	CO1	Applying K3
(b)	**Make use of** concept of Pre envelope and Complex Envelope and write in detail.	6	CO1	Applying K3
(c)	**Develop** the power spectral density of Manchester code with related equations and wave form.	6	CO1	Applying K3
	OR			
2(a)	For the binary bit stream 10011011 **Construct** the following data format (i) Polar NRZ (ii)Unipolar RZ (iii) Manchester format	6	CO1	Applying K3
(b)	**Identify** and prove the three properties of Hilbert Transform.	6	CO1	Applying K3
(c)	**Develop** an expression for power spectral density of NRZ Bipolar format.	6	CO1	Applying K3
	PART-B			
3(a)	**Make use of** the concept of vector space representation write the following (i) Absolute Vector (or) Norm vector (ii) Relationship between signal energy and its vector.(iii) Euclidean distance.	6	CO2	Applying K3
(b)	**Develop** the procedure for Gram Schmidt orthogonalization procedure.	6	CO2	Applying K3
	OR			
4(a)	**Construct** the orthonormal basis function for the following set of signals using Gram Schmidt procedure. 	6	CO2	Applying K3
(b)	**Make use of** the Geometric representation of signal, **Identify** that energy of signal is equal to the squared length of vector representing it.	6	CO2	Applying K3

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Module Co-ordinator

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

I-INTERNAL TEST QUESTION PAPER 2020-21– EVEN SEMESTER

SET-A **SCHEME AND SOLUTION**

Course Title: Digital Communication **Maximum Marks: 30**

Course Code: 18EC61 **Year / Semester: III/VI**

Question Number	POINTS	Marks
1a)	Hilbert Transform of the following signal (i)δ(t)=H[δ(t)]= (2M)	6M
1b)	Pre-envelope (see below)	6M
1c)	Manchester format (see below)	6M

1a) Hilbert Transform of the following signal (i)δ(t)=H[δ(t)]= (2M)

$x(t) = \delta(t)$

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

(ii)H[$\cos 2\pi f_c t + \sin 2\pi f_c t$] = $\sin 2\pi f_c t - \cos 2\pi f_c t$ (2M)

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

$\hat{x}(t) = \frac{1}{\pi t} * \frac{1}{\pi t}$ $\quad -\frac{1}{j\pi t} \xleftrightarrow{FT} \text{sgn}(f)$ or

(iii)H[$\frac{1}{\pi t}$] = $\text{sgn}(t) \xleftrightarrow{FT} \frac{1}{j\pi f}$, $\quad \frac{1}{\pi t} \xleftrightarrow{FT} -j\,\text{sgn}(f)$ (2M)

1b)

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

Apply Fourier transform on both the sides,

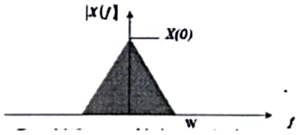
$$X_+(f) = X(f) + j[-j\,\text{sgn}(f)X(f)]$$

$$X_+(f) = \begin{cases} 2X(f), f > 0 \\ X(0), f = 0 \\ 0, f < 0 \end{cases}$$

The pre-envelope $x_-(t)$ for negative frequencies of the signal is given by

$$x_-(t) = x(t) - j\hat{x}(t)$$

$$X_-(f) = \begin{cases} 0, f > 0 \\ X(0), f = 0 \\ 2X(f), f < 0 \end{cases}$$



1c)

Manchester format

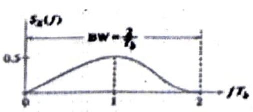
$A_k = \begin{cases} \pm a, & \text{symbol 1} \\ \mp a, & \text{symbol 0.} \end{cases}$ 1M

$V(f) = T_b \sin\left(\frac{\pi f T_b}{2}\right) \text{sinc}\left(\frac{\pi f T_b}{2}\right).$

$R_A(n) = \begin{cases} a^2, & n = 0 \\ 0, & n \neq 0. \end{cases}$ 3M

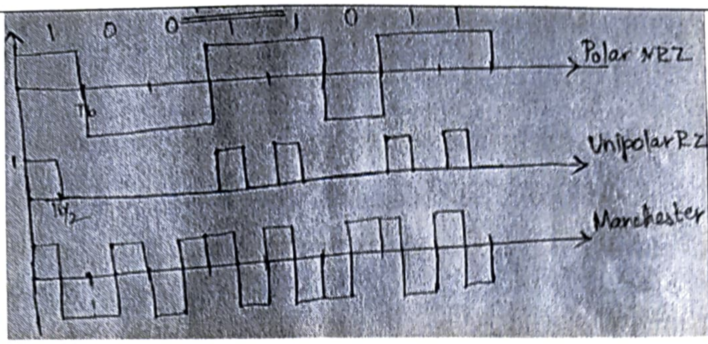
PSD

$S_X(f) = a^2 T_b \text{sinc}^2\left(\frac{f T_b}{2}\right) \left(\sin^2\left(\frac{\pi f T_b}{2}\right)\right).$ 2M



Normalized power spectrum of Manchester format.

2a)



6M

2b)

Properties of Hilbert transform :

Statement:

(1). "A signal x(t) and its Hilbert transform x^(t)have the same amplitude spectrum".

Proof: The magnitude of −jsgn(f) is equal to 1 for all frequencies f. Therefore x(t) and x^(t) have the same amplitude spectrum. That is X (f) = X (f) ^ for all f

6M

Property 2 : If $\hat{g}(t)$ is the Hilbert transform of g(t), then the Hilbert transform $\hat{g}(t)$ is − g(t)

We know that the Hilbert transformation is equivalent to passing g(t) through a line two port device with a transfer function equal to − j sgn(f). A twice Hilbert transform therefore equivalent to passing g(t) through cascade of a linear two port devices. Th overall transfer function of a cascaded linear two port devices is given by

$$[-j\,\mathrm{sgn}(f)]^2 = -1 \quad \text{for all } f$$

Since the output of above expression is − 1 we can say that Hilbert transform of $\hat{g}(t)$ − g(t)

Property 3 : A signal g(t) and its Hilbert transform $\hat{g}(t)$ are orthogonal

Let us see following equations.

$$\int_{-\infty}^{\infty} g(t)\hat{g}(t)\,dt = \int_{-\infty}^{\infty} G(f)\,\hat{G}(-f)\,df$$

From equations (3) and (4) we have

$$\int_{-\infty}^{\infty} g(t)\hat{g}(t)\,dt = j\int_{-\infty}^{\infty} \mathrm{sgn}(f)G(f)G(-f)\,df$$

$$= j\int_{-\infty}^{\infty} \mathrm{sgn}(f)G(f)\,G^*(f)\,df$$

where $G^*(f) = G(-f)$ for real valued signal. The integrand in the right hand side equation (6) is an odd function of f because it is product of the odd function sgn(f) a the even function $|G(f)|^2$. Hence, the integral is zero and we get.

$$\int_{-\infty}^{\infty} g(t)\hat{g}(t) = 0$$

6M

2c)

$P(A_k = a) = \frac{1}{4}$, for symbol 1

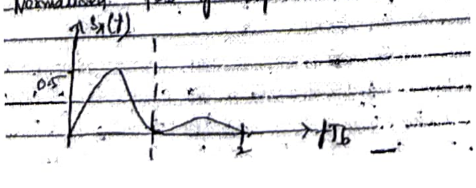
$P(A_k = -a) = \frac{1}{4}$

$P(A_k = 0) = 1/2$, for symbol 0.

$$R_A(n) = \begin{cases} \frac{a^2}{2}; & n = 0; \\ -\frac{a^2}{4}, & |n| = 1 \\ 0, & |n| > 1. \end{cases}$$

$S_x(f) = a^2 T_b \,\mathrm{sinc}^2(f T_b) \sin^2(\pi f T_b)$

Normalised PSD of bipolar NRZ format



3a) **6M**

(i) Absolute vector.

$$\|s_i^2\| = s_i^T s_i = \sum_{j=1}^{N} s_{ij}^2 = E_i$$

(ii) Signal Energy and its Vector.

$$E_i = \int_0^T \left[\sum_{j=1}^{N} s_{ij}\phi_j(t)\right]\left[\sum_{K=1}^{N} s_{ik}\phi_k(t)\right]dt$$

$$E_i = \sum_{j=1}^{N} s_{ij}^2 \Rightarrow E_i = \|s_i^2\|$$

Euclidean Distance:

The Euclidean Distance between the two signal vectors is given as

$$d_{ik} = \|s_i - s_k\|$$

Here d_{ik} → Euclidean distance between s_i & s_k.

Squared Euclidean distance will be,

$$\|s_i - s_k\|^2 = \sum_{j=1}^{N} (s_{ij} - s_{kj})^2$$

$$E_i = \int_0^T s_i^2(t)\,dt = \|s_i\|^2$$

$$\|s_i - s_k\|^2 = \int_0^T [s_i(t) - s_k(t)]^2 dt.$$

angle θ_{ik} between two vectors s_i and s_k is given as,

$$\cos\theta_{ik} = \frac{s_i^T s_k}{\|s_i\|\|s_k\|}$$

3b) **6M**

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

$$s_1(t) = \sqrt{E_1}\phi_1(t) = s_{11}(t)\phi_1(t)$$

We may thus introduce a new intermediate function

$$g_2(t) = s_2(t) - s_{21}\phi_1(t)$$

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

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

$$s_{ij} = \int_0^T s_i(t)\phi_j(t)\,dt, \quad j = 1, 2, \ldots, i-1$$

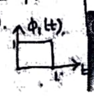
$$\phi_i(t) = \frac{g_i(t)}{\sqrt{\int_0^T g_i^2(t)\,dt}}, \quad j = 1, 2, \ldots, N$$

4a) **6M**

$$\phi_1(t) = \frac{s_1(t)}{s_{11} = \sqrt{E_1}}, \quad E_1 = \int_0^2 s_1^2(t)\,dt = 4.$$

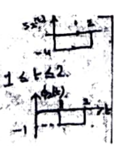
$$\phi_1(t) = \frac{2}{\sqrt{4}}, \quad 0 \le t \le 1.$$

$$\boxed{\phi_1(t) = 1}, \quad 0 \le t \le 1$$



$$\phi_2(t) = \frac{s_2(t) - s_{21}\phi_1(t)}{\sqrt{E_2 - s_{21}^2}},$$

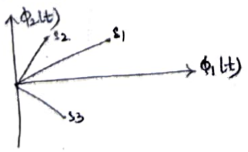
$$\phi_2(t) = \frac{-4-0}{\sqrt{32-16}} = -1, \quad 1 \le t \le 2.$$



6M

$$s_1(t) = s_{11}\phi_1(t) + s_{12}\phi_2(t)$$
$$s_2(t) = s_{21}\phi_1(t) + s_{22}\phi_2(t)$$
$$s_3(t) = s_{31}\phi_1(t) + s_{32}\phi_2(t)$$

4b)



Signal Energy and its Vector.

$$E_i = \int_0^T \left[\sum_{j=1}^{N} s_{ij}\phi_j(t)\right]\left[\sum_{K=1}^{N} s_{ik}\phi_k(t)\right]dt$$

$$E_i = \sum_{j=1}^{N} s_{ij}^2 \Rightarrow E_i = \|s_i^2\|$$

V. S

COURSE IN-CHARGE

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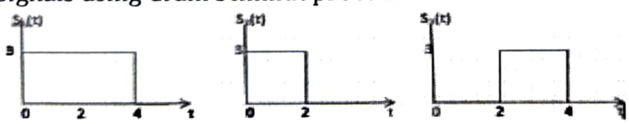
KSIT

SET-B

USN										

Degree	:	**B.E**	**Semester**	:	**VI**
Branch	:	**ECE**	**Course Code**	:	**18EC61**
Course Title	:	**DIGITAL COMMUNICATION**	**Date**	:	**24.5.2021**
Duration	:	**90 Minutes**	**Max Marks**	:	**30**

Note: Answer ONE full question from each part.

Q No.	Question	Marks	CO mapping	K-Level
	PART-A			
1(a)	**Solve** the(i) Hilbert transform of s(t)=cos2πfct+ sin2πfct (ii) Pre envelope and complex envelop of s(t)=cos(2πfct + φ) m(t).	6	CO1	Applying K3
(b)	**Identify** and prove all the properties of Hilbert Transform.	6	CO1	Applying K3
(c)	**Develop** the power spectral density of Unipolar code with related equations and wave form.	6	CO1	Applying K3
	OR			
2(a)	**Develop** an expression for power spectral density of NRZ polar format.	6	CO1	Applying K3
(b)	**Make use of** concept of Pre envelope and Complex Envelope and write in detail.	6	CO1	Applying K3
(c)	**Construct** for the given binary data 10000001101 (i) HDB3 signal (ii) Polar RZ (iii) Unipolar NRZ (iii) Split phase Manchester.	6	CO1	Applying K3
	PART-B			
3(a)	**Identify** the procedure for Gram Schmidt orthogonalization procedure.	6	CO2	Applying K3
(b)	**Construct** the orthonormal basis function for the following set of signals using Gram Schmidt procedure. 	6	CO2	Applying K3
	OR			
4(a)	With necessary representation when N=2, M=3, **construct** the geometric representation of signal.	6	CO2	Applying K3
(b)	**Make use of** the concept of vector space representation write the following (i) Absolute Vector (or) Norm vector (ii) Relationship between signal energy and its vector.(iii) Euclidean distance.	6	CO2	Applying K3

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K.S.INSTITUTE OF TECHNOLOGY, BENGALURU – 560109

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

I-INTERNAL SESSIONAL TEST QUESTION PAPER 2020-21– EVEN SEMESTER

SET-B

SCHEME AND SOLUTION

Course Title: Digital Communication **Maximum Marks: 30**

Course Code: 18EC61 **Year / Semester: III/VI**

Question Number	POINTS	Marks
1a)		6M

a) Pre-envelope

W.K.T $g_+(t)$ (or) $s_+(t) = s(t) + j\hat{s}(t)$ —— ①

$H[s(t)] = \hat{s}(t) = H[\cos[2\pi f_c t + \phi]]m(t)$

$\hat{s}(t) = m(t)\sin(2\pi f_c t + \phi)$

sub $s(t)$ & $\hat{s}(t)$ in equation ①

$s_+(t) = m(t)\cos[2\pi f_c t + \phi] + j\,m(t)\sin(2\pi f_c t + \phi)$

$$\boxed{s_+(t) = m(t)\, e^{j(2\pi f_c t + \phi)}}$$

b) Complex envelope :-

$$\tilde{s}(t) = s_+(t)\, e^{-j2\pi f_c t}$$

$$= m(t)\cdot e^{-j2\pi f_c t}\cdot e^{j(2\pi f_c t + \phi)}$$

$$= m(t)\cdot \cancel{e^{-j2\pi f_c t}}\cdot \cancel{e^{+j2\pi f_c t}}\cdot e^{j\phi}$$

$$\boxed{\tilde{s}(t) = m(t)\cdot e^{j\phi}}$$

$$x(t) = \cos 2\pi f t + \sin 2\pi f t$$

$$\hat{x}(t) = \cos\left(2\pi f t - \frac{\pi}{2}\right) + \sin\left(2\pi f t - \frac{\pi}{2}\right)$$

$$\boxed{\hat{x}(t) = \sin 2\pi f t - \cos 2\pi f t}$$

Question Number	POINTS	Marks
1b)		6M

Properties of Hilbert transform :

Statement:

(1). “A signal x(t) and its Hilbert transform x˜(t)have the same amplitude spectrum”.

Proof: The magnitude of –jsgn(f) is equal to 1 for all frequencies f. Therefore x(t) and x˜(t) have the same amplitude spectrum. That is X (f) = X (f) ˜ for all f

Property 2 : If $\hat{g}(t)$ is the Hilbert transform of g(t), then the Hilbert transform $\hat{g}(t)$ is – g(t).

We know that the Hilbert transformation is equivalent to passing g(t) through a line two port device with a transfer function equal to – j sgn(f). A twice Hilbert transform therefore equivalent to passing g(t) through cascade of a linear two port devices. T overall transfer function of a cascaded linear two port devices is given by

$$[-j\,\text{sgn}(f)]^2 = -1 \quad \text{for all } f$$

Since the output of above expression is – 1 we can say that Hilbert transform of $\hat{g}(t)$ – g(t)

Property 3 : A signal g(t) and its Hilbert transform $\hat{g}(t)$ are orthogonal

Let us see following equations.

$$\int_{-\infty}^{\infty} g(t)\hat{g}(t)\,dt = \int_{-\infty}^{\infty} G(f)\,\hat{G}(-f)\,df$$

From equations (3) and (4) we have

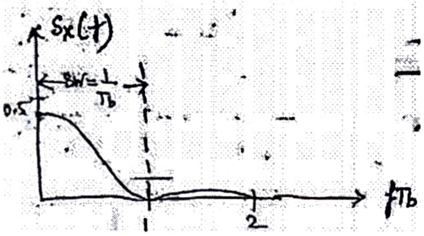
$$\int_{-\infty}^{\infty} g(t)\hat{g}(t)\,dt = j\int_{-\infty}^{\infty} \text{sgn}(f)G(f)G(-f)\,df$$

$$= j\int_{-\infty}^{\infty} \text{sgn}(f)G(f)\,G^*(f)\,df$$

<table>
<tr><td></td><td>where $G^*(f)=G(-f)$ for real valued signal. The integrand in the right hand side equation (6) is an odd function of f because it is product of the odd function sgn(f) a the even function $|G(f)|^2$. Hence, the integral is zero and we get,

$\int_{-\infty}^{\infty} x(t)\hat{x}(t) = 0$</td><td></td></tr>
<tr><td>1c)</td><td>$A_k = \begin{cases} +a & \text{for symbol 1} \\ 0 & \text{for symbol 0} \end{cases}$ $\quad R_A(n) = \begin{cases} \frac{a^2}{2} & \text{for } n=0 \\ \frac{a^2}{4} & \text{for } n\neq 0 \end{cases}$

$S_X(f) = \frac{a^2}{4} T_b \operatorname{sinc}^2(fT_b) + \frac{a^2}{4}\delta(f)$


</td><td>6M</td></tr>
<tr><td>2a)</td><td>PSD of Polar format

$A_k = \begin{cases} +a, & \text{symbol 1} \\ -a, & \text{symbol 0.} \end{cases}$

$V(f) = T_b \operatorname{sinc}(fT_b)$

$R_A(n) = \begin{cases} a^2, & n=0 \\ 0, & n\neq 0. \end{cases}$

PSD of $S_X(f) = a^2 T_b \operatorname{sinc}^2(fT_b)$.</td><td>6M</td></tr>
<tr><td>2b)</td><td>$x_+(t) = x(t) + j\hat{x}(t)$

Apply Fourier transform on both the sides,

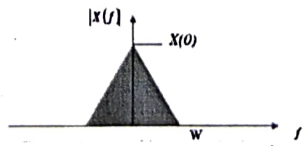
$X_+(f) = X(f) + j[-j\operatorname{sgn}(f)X(f)]$

$X_+(f) = \begin{cases} 2X(f), & f>0 \\ X(0), & f=0 \\ 0, & f<0 \end{cases}$

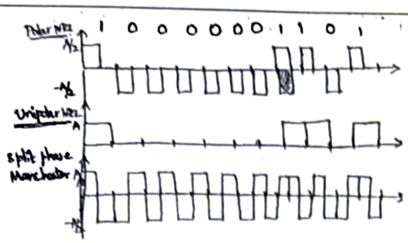
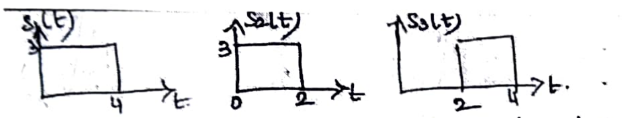
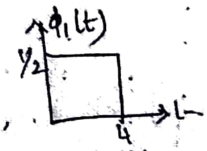
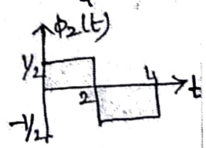
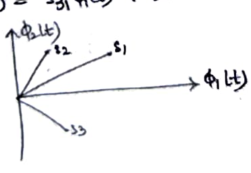
The pre-envelope $x_-(t)$ for negative frequencies of the signal is given by

$x_-(t) = x(t) - j\hat{x}(t)$

$X_-(f) = \begin{cases} 0, & f>0 \\ X(0), & f=0 \\ 2X(f), & f<0 \end{cases}$


</td><td>6M</td></tr>
<tr><td>2c)</td><td>HDB3

1 0 0 0 0 0 0 1 1 0 1
0 0 0 V
+ 0 0 0 + 0 0 − + 0 +</td><td>6M</td></tr>
</table>

3a)		6M
	$s_1(t) = \sqrt{E_1}\,\phi_1(t) = s_{11}(t)\phi_1(t)$ $s_{21} = \int_0^T s_2(t)\phi_1(t)\,dt$ We may thus introduce a new intermediate function $g_2(t) = s_2(t) - s_{21}\phi_1(t)$ $\phi_2(t) = \dfrac{g_2(t)}{\sqrt{\int_0^T g_2^2(t)\,dt}}$ $g_i(t) = s_i(t) - \sum_{j=1}^{i-1} s_{ij}\phi_j(t)$ $s_{ij} = \int_0^T s_i(t)\phi_j(t)\,dt, \quad j = 1, 2, \ldots, i-1$ $\phi_i(t) = \dfrac{g_i(t)}{\sqrt{\int_0^T g_i^2(t)\,dt}}, \quad i = 1, 2, \ldots, N$	
3b)	 $s_2(t)$ & $s_3(t)$ are linearly independent ∴ 2 basis function. $\phi_1(t) = 1/2, \quad 0 \le t \le 4$ $0, \quad$ otherwise.  $\phi_2(t) = 1/2, \quad 0 \le t \le 2$ $-1/2, \quad 2 \le t \le 4$ 	6M
4a)	$s_1(t) = s_{11}\phi_1(t) + s_{12}\phi_2(t)$ $s_2(t) = s_{21}\phi_1(t) + s_{22}\phi_2(t)$ $s_3(t) = s_{31}\phi_1(t) + s_{32}\phi_2(t)$ 	6M
4b)	(i) Absolute vector. $\lVert s_i^2 \rVert = s_i^T s_i = \sum_{j=1}^{N} s_{ij}^2 = E_i$ (ii) Signal Energy and its vector. $E_i = \int_0^T \left[\sum_{j=1}^{N} s_{ij}\phi_j(t)\right]\left[\sum_{k=1}^{N} s_{ik}\phi_k(t)\right] dt$ $E_i = \sum_{j=1}^{N} s_{ij}^2 \Rightarrow E_i = \lVert s_i^2 \rVert$	6M

	signal energy and its vector. $E_i = \int_0^T \left[\sum_{j=1}^{N} s_{ij}\phi_j(t)\right]\left[\sum_{k=1}^{N} s_{ik}\phi_k(t)\right]dt$ $E_i = \sum_{j=1}^{N} s_{ij}^2 \Rightarrow E_i = \lVert s_i^2 \rVert$		

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II SESSIONAL TEST QUESTION PAPER 2020 – 21 EVEN SEMESTER

SET A

USN

Degree	: B.E	Semester :	VI A & B
Branch	: Electronics and Communication Engg	Course Code :	18EC61
Course Title	: Digital Communication	Date :	28/06/21
Duration	: 90 Minutes	Max Marks :	30

Note: Answer ONE full question from each part.

Q No.	Question	Marks	CO mapping	K-Level
	PART-A			
1(a)	**Make use of** block diagram of BFSK transmitter and receiver write in detail.	6	CO3	Applying K3
(b)	An FSK system transmits binary data at a rate of 10^6 bits per second. Assuming channel noise is additive white Gaussian with zero mean and PSD $2\text{x}10^{-20}$watts/Hz, determine the average probability of error. Assume coherent detection and amplitude of received sinusoidal signal for both symbol 1 &0 to be 1.2 μv. Take erf(3)=0.99998.	6	CO3	Applying K3
(C)	**Make use of** block diagram of DPSK transmitter and receiver write in detail.	6	CO3	Applying K3
	OR			
2(a)	**Develop** the expression for probability of error of a coherent BPSK technique.	6	CO3	Applying K3
(b)	**Construct** the in phase and quadrature components of a QPSK signal for the binary sequence 110010111.	6	CO3	Applying K3
(C)	**Make use of** block diagram of QPSK transmitter and receiver write in detail with waveform.	6	CO3	Applying K3
	PART-B			
3(a)	**Make use of** the maximum likelihood detection process and obtain the decision rule.	6	CO2	Applying K3
(b)	**Construct** a neat block diagram of the digital PAM transmission through band limited baseband channels and write the expression for ISI.	6	CO4	Applying K3
	OR			
4(a)	The Random process $x(t)=S_i(t)+ w(t)$ is received by a bank of correlators. The o/p of the correlators is $X_j=S_{ij}+w_j, j=1,2,..N$,the noise w(t) is white Gaussian noise of zero mean &PSD of $N_0/2$. i. **Develop** mean value of X_j ii. **Develop** variance of X_j iii. **Develop** X_j are mutually uncorrelated.	6	CO2	Applying K3
(b)	**Develop** Nyquist criterion for zero ISI and Give an example of the pulse with zero ISI.	6	CO4	Applying K3

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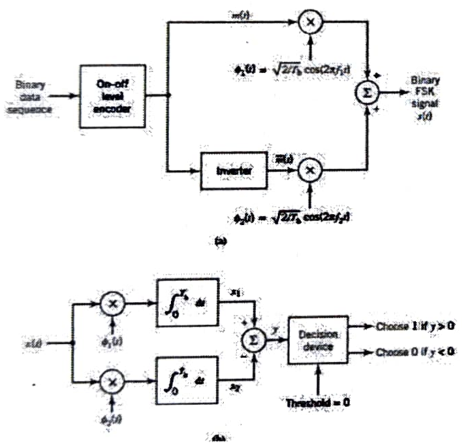
Department of Electronics and Communication Engineering
II SESSIONAL TEST QUESTION PAPER 2020 – 21 EVEN SEMESTER

SET A

SCHEME AND SOLUTION

Degree : **B.E**		**Semester :**	**VI**
Branch : **ECE**		**Course Code :**	**18EC61**
Course Title : **Digital Communication**		**Max Marks :**	**30**

<table>
<tr><th>Q. NO</th><th>POINTS</th><th>MARKS</th></tr>
<tr><td>1a)</td><td>



The binary FSK wave can be represented as follows

$$s(t) = \begin{cases} s_1(t) = \sqrt{\frac{2E_b}{T_b}} \cos 2\pi f_1 t, & 0 \le t < T_b, \text{ for symbol 1} \\ s_2(t) = \sqrt{\frac{2E_b}{T_b}} \cos 2\pi f_2 t, & 0 \le t \le T_b, \text{ for symbol 0.} \end{cases}$$

Let $\phi_1(t)$ & $\phi_2(t)$ are the basis function defined as,

$$\phi_1(t) = \sqrt{\frac{2}{T_b}} \cos 2\pi f_1 t \ \& \ \phi_2(t) = \sqrt{\frac{2}{T_b}} \cos 2\pi f_2 t.$$

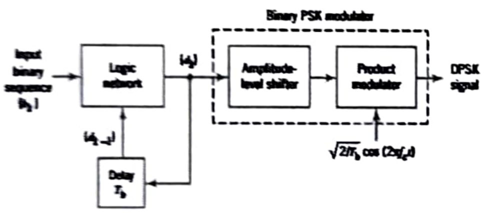
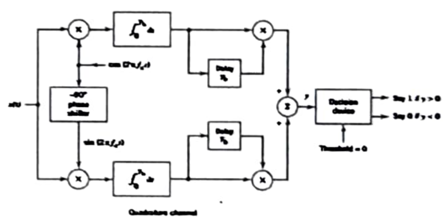
We can write $s(t)$ as,

$$s(t) = \begin{cases} s_1(t) = \sqrt{E_b}\, \phi_1(t) & \text{for symbol '1'} \\ s_2(t) = \sqrt{E_b}\, \phi_2(t) & \text{for symbol '0'} \end{cases}$$

* The detector consists of two correlators tuned to two different frequencies
* A correlator consists of a multiplier followed by an Integrator (LPF).
* The o/p of top & bottom correlator be denoted by x_1 & x_2 respectively. The x_1 & x_2 are given to subtractor. The o/p of subtractor. $l = x_1 - x_2$.
* If $(x_1 - x_2) > 0$ i.e $l > 0$, decision is taken in favour of symbol '1'.
* If $(x_1 - x_2) < 0$ i.e $l < 0$, the decision is taken in favour of symbol '0'.
* If $(x_1 - x_2) = 0$, i.e $l = 0$, the decision is arbitrary.

</td><td>6M

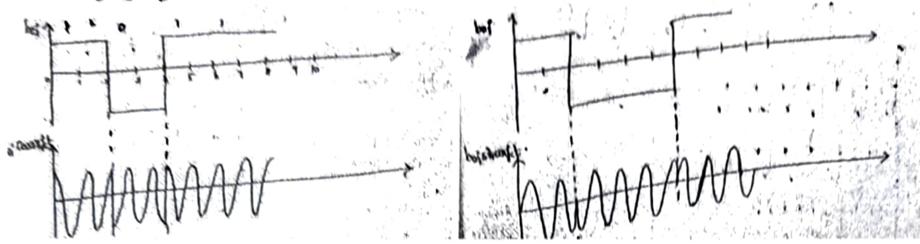
6M</td></tr>
<tr><td>1b)</td><td></td><td></td></tr>
</table>

	* Bit duration : $T_b = \frac{1}{\text{data bits}} = \frac{1}{10^6} = 10^{-6}$ secs * Signal energy per bit $E_b = \frac{1}{2}(\text{signal amplitude})^2 \times T_b$ $= \frac{1}{2}(1.2\times10^{-4})^2 \times 10^{-6} = 0.72\times10^{-14}$ Joule. The average probability of error for coherent PSK is $P_e = \frac{1}{2}\text{erfc}\left(\sqrt{\frac{E_b}{2N_0}}\right)$ Given : $\frac{N_0}{2} = 2\times10^{-20}$ watts/Hz. $\therefore N_0 = 4\times10^{-20}$ watts/Hz. $P_e = \frac{1}{2}\text{erfc}\left(\sqrt{\frac{0.72\times10^{-14}}{8\times10^{-20}}}\right)$ $= \frac{1}{2}\text{erfc}\left(\sqrt{0.09\times100}\right)$ $= \frac{1}{2}\text{erfc}(3)$. From error function $\text{erf}(3) = 0.99998$. $\therefore$ Complementary error function $\text{erfc}(3) = 1 - \text{erf}(3) = 1 - 0.99998 = 0.00002$. $\therefore P_e = 0.00001$ $\boxed{P_e = 1\times10^{-5}}$	6M
1c)	Differential encoding starts with an arbitrary first bit, serving as the reference bit; to this end, symbol 1 is used as the reference bit. Generation of the differentially encoded sequence then proceeds in accordance with a two-part encoding rule as follows: 1. If the new bit at the transmitter input is 1, leave the differentially encoded symbol unchanged with respect to the current bit. 2. If, on the other hand, the input bit is 0, change the differentially encoded symbol with respect to the current bit. The differentially encoded sequence, denoted by {dk}, is used to shift the sinusoidal carrier phase by zero and 180o, representing symbols 1 and 0, respectively. Thus, in terms of phase-shifts, the resulting DPSK signal follows the two-part rule: 1. To send symbol 1, the phase of the DPSK signal remains unchanged. 2. To send symbol 0, the phase of the DPSK signal is shifted by 180°.   	6M
2a)	**Probability of error calculation for BPSK** The received signal x(t) is given as $x(t)=s(t)+w(t)$ let us assume that symbol 0 or $s_2(t)$ is transmitted then $E[x_1] = -\sqrt{E_b}$ $Var[x_1]=N_0/2$ $P_e(0) = \frac{1}{\sqrt{\pi N_0}}\int_0^{\infty}\exp\left[-\frac{(x_1+\sqrt{E_b})^2}{N_0}\right]dx_1$ $u = \frac{x_1+\sqrt{E_b}}{\sqrt{N_0}}$ $dx_1 = \sqrt{N_0}\,du$ $P_e(0) = \frac{1}{\sqrt{\pi}}\int_{\sqrt{E_b/N_0}}^{\infty}\exp(-u^2)\,du$ $\qquad P_e(0) = \frac{1}{2}\text{erfc}\left(\sqrt{\frac{E_b}{N_0}}\right)$ $P_e(1) = \frac{1}{\sqrt{\pi N_0}}\int_{-\infty}^{0}\exp\left[-\frac{(x_1-\sqrt{E_b})^2}{N_0}\right]dx_1$ $\qquad P_e = P_e(0) = P_e(1) = \frac{1}{2}\text{erfc}\sqrt{\frac{E_b}{N_0}}$	6M

2b) Solution: 6M

$\{b_i\} = \{1\ 1\ 0\ 0\ 1\ 0\ 1\ 1\ 1\}$

$\{b_{ei}\} = \{1\ 0\ 1\ 1\ 1\}$, $\{b_{oi}\} = \{1\ 0\ 0\ 1\}$.



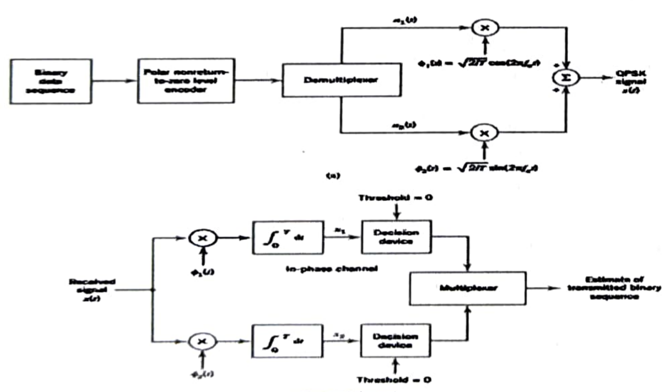
2c) 6M

Quadrature phase shift keying

The QPSK transmitter may be viewed as two binary PSK generators that work in parallel, each at a bit rate equal to one-half the bit rate of the original binary sequence at the QPSK transmitter input.

The functional composition of the QPSK receiver is as follows:

1. Pair of correlators, which have a common input x(t). The two correlators are supplied with a pair of locally generated orthonormal basis functions $\varphi_1(t)$ and $\varphi_2(t)$, which means that the receiver is synchronized with the transmitter. The correlator outputs, produced in response to the received signal x(t), are denoted by x1 and x2, respectively.
2. Pair of decision devices, which act on the correlator outputs x1 and x2 by comparing each one with a zero-threshold; here, it is assumed that the symbols 1 and 0 in the



3a) 6M

$$\boxed{P_e\left(\hat{m}_i/x\right) = 1 - P\left(m_i\,\text{sent}/x\right)} \longleftarrow (1)$$

1 − Probability of estimating or identifying the actual sent message

To minimize the avg P_e, we use optimum decision rule (i.e) $\hat{m} = m_i$ if

$P(m_i \text{ sent}/x) > P(m_k \text{ sent}/x) \;\forall k \neq i,\; k = 1, 2 \ldots M$

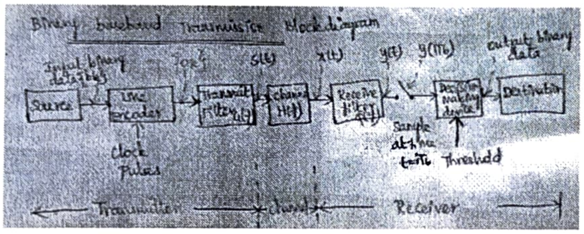
$L(m_k) = -2 \sum_{j=1}^{N} x_j s_{kj} + E_k$

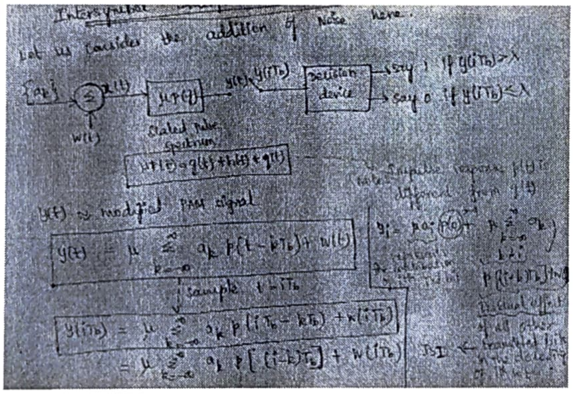
The observation vector x lies in region Z_i if

$\left(\sum_{j=1}^{N} x_j s_{kj} - \frac{1}{2} E_k\right)$ is maximum for $k = i$.

$\therefore L(m_k)$ is maximum.

3b) | 6M





4a) | 6M

$$\mu_{X_j} = E[X_j] = E[s_{ij} + W_j] = s_{ij} + E[W_j] = s_{ij}$$

$$\sigma^2_{X_j} = \mathrm{var}[X_j] = E[(X_j - s_{ij})^2] = E[W_j^2]$$

$$\sigma^2_{X_j} = E\left[\int_0^T W(t)\phi_j(t)\,dt \int_0^T W(u)\phi_j(u)\,du\right] = E\left[\int_0^T\int_0^T \phi_j(t)\phi_j(u)W(t)W(u)\,dt\,du\right]$$

$$\sigma^2_{X_j} = \int_0^T\int_0^T \phi_j(t)\phi_j(u)E[W(t)W(u)]\,dt\,du = \int_0^T\int_0^T \phi_j(t)\phi_j(u)R_W(t,u)\,dt\,du$$

$$R_W(t,u) = \left(\frac{N_0}{2}\right)\delta(t-u)$$

$$\sigma^2_{X_j} = \frac{N_0}{2}\int_0^T\int_0^T \phi_j(t)\phi_j(u)\delta(t-u)\,dt\,du = \frac{N_0}{2}\int_0^T \phi_j^2(t)\,dt$$

$$\sigma^2_{X_j} = \frac{N_0}{2}, \quad \text{for all } j$$

4b)	**Nyquist Condition for Zero ISI.** A necessary and sufficient condition for $x(t)$ to satisfy $$x(nT) = \begin{cases} 1, & n = 0 \\ 0, & n \neq 0 \end{cases} \quad (9.2.6)$$ is that its Fourier transform $X(f)$ must satisfy $$\sum_{m=-\infty}^{\infty} X\left(f + \frac{m}{T}\right) = T. \quad (9.2.7)$$ Therefore, the necessary and sufficient conditions for Equation (9.2.6) to be satisfied is that $$z_n = \begin{cases} T & n = 0 \\ 0, & n \neq 0 \end{cases} \quad (9.2.15)$$ which, when substituted into Equation (9.2.12), yields $$Z(f) = T, \quad (9.2.16)$$ or equivalently, $$\sum_{m=-\infty}^{\infty} X\left(f + \frac{m}{T}\right) = T. \quad (9.2.17)$$ It is clear that there exists only one $X(f)$ that results in $Z(f) = T$, namely, $$X(f) = \begin{cases} T & \lvert f \rvert < W, \\ 0, & \text{otherwise} \end{cases} \quad (9.2.18)$$ or $X(f) = T\Pi\left(\frac{f}{2W}\right)$, which results in $$x(t) = \operatorname{sinc}\left(\frac{t}{T}\right). \quad (9.2.19)$$	6M

V. Sai
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Module Co-ordinator

HoD

K.S. INSTITUTE OF TECHNOLOGY, BANGALORE - 560109

II SESSIONAL TEST QUESTION PAPER 2020 – 21 EVEN SEMESTER

SET B

USN

Degree	:	B.E	Semester	:	VI A & B
Branch	:	Electronics and Communication Engg	Course Code	:	18EC61
Course Title	:	Digital Communication	Date	:	28/06/21
Duration	:	90 Minutes	Max Marks	:	30

Note: Answer ONE full question from each part.

Q No.	Question	Marks	CO mapping	K-Level
	PART-A			
1(a)	A binary data is transmitted over an AWGN channel using BPSK at a rate of 1 Mbps. It is desired to have average probability of error $Pe<10^{-4}$. Noise PSD is $No/2=10^{-12}$ W/Hz. **Determine** the average carrier power required at the receiver input, if the detector is of coherent type. Take erfc(3.5)=0.00025.	6	CO3	Applying K3
(b)	**Make use of** block diagram of DPSK transmitter and receiver write in detail.	6	CO3	Applying K3
(C)	**Make use of** block diagram of BPSK transmitter and receiver write in detail.	6	CO3	Applying K3
	OR			
2(a)	**Develop** the expression for probability of error of a coherent BFSK technique.	6	CO3	Applying K3
(b)	**Construct** the generation and of differentially encoded sequence , Transmitted phase, Decision rule and detection for the binary sequence 101101.	6	CO3	Applying K3
(C)	**Develop** a systematic procedure for constructing M-ary QAM constellation for M=16.	6	CO3	Applying K3
	PART-B			
3(a)	**Make use of** the Matched Filter, write the statement and prove their properties.	6	CO2	Applying K3
(b)	**Develop** Nyquist criterion for zero ISI and Give an example of the pulse with zero ISI.	6	CO4	Applying K3
	OR			
4(a)	**Develop** the expressions for mean and variance of the correlator outputs. Also show that correlator outputs are statistically independent.	6	CO2	Applying K3
(b)	**Construct** a neat block diagram of the digital PAM transmission through band limited baseband channels and write the expression for ISI.	6	CO4	Applying K3

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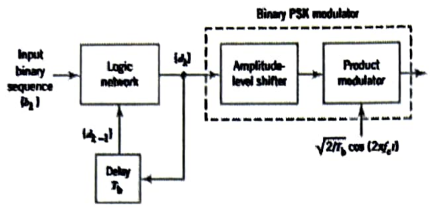
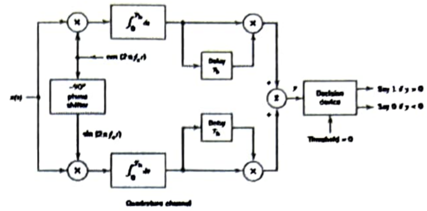
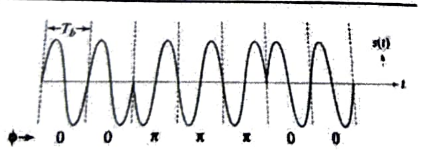
II SESSIONAL TEST QUESTION PAPER 2020 – 21 EVEN SEMESTER

SET B

SCHEME AND SOLUTION

Degree	:	**B.E**	**Semester**	:	**VI**
Branch	:	**ECE**	**Course Code**	:	**18EC61**
Course Title	:	**Digital Communication**	**Max Marks**	:	**30**

Q. NO.	POINTS	MARKS
1a)	Let Carrier power required be P, then $E_b = PT_b$. Bit interval $T_b = \frac{1}{\text{bit rate}} = \frac{1}{10^6} = 10^{-6}$ sec. $\left(\frac{E_b}{N_0}\right) = \frac{P\times10^{-6}}{2\times10^{-12}} = 0.5\,P\times10^{+6}$ Hence, $P_e = \frac{1}{2}\,\text{erfc}\sqrt{0.5\times P\times10^{6}} \le 10^{-4}$ Using the complementary error function, $\text{erfc}(3.5) = 0.00025$ $\sqrt{0.5\times P\times10^{6}} \geq 3.5$ Carrier power $\boxed{P \geq 24.5\,\mu W}$	6M
1b)	Differential encoding starts with an arbitrary first bit, serving as the reference bit; to this end, symbol 1 is used as the reference bit. Generation of the differentially encoded sequence then proceeds in accordance with a two-part encoding rule as follows: 1. If the new bit at the transmitter input is 1, leave the differentially encoded symbol unchanged with respect to the current bit. 2. If, on the other hand, the input bit is 0, change the differentially encoded symbol with respect to the current bit. The differentially encoded sequence, denoted by {dk}, is used to shift the sinusoidal carrier phase by zero and 180o, representing symbols 1 and 0, respectively. Thus, in terms of phase-shifts, the resulting DPSK signal follows the two-part rule: 1. To send symbol 1, the phase of the DPSK signal remains unchanged. 2. To send symbol 0, the phase of the DPSK signal is shifted by 180°.	6M

1c)	 		6M
2a)	Probability of error in BPSK let $x(t)$ be the received BPSK sig $\boxed{x(t) = S(t) + W(t)}$ $x = \begin{cases} S_1(t) + W(t) & \text{for symbol '1'} \\ S_2(t) + W(t) & \text{for symbol '0'} \end{cases}$ Conditional PDF $f_L(l/0) = \frac{1}{\sqrt{2\pi\sigma^2}} \cdot e^{-\frac{(l-\mu)^2}{2\sigma^2}}$ $= \frac{1}{\sqrt{2\pi N_0}} \cdot e^{-\frac{(l+\sqrt{E_b})^2}{2N_0}}$ $= \frac{1}{\sqrt{2\pi N_0}} e^{-\left[\frac{l+\sqrt{E_b}}{\sqrt{2N_0}}\right]^2}$ Then average $P_e = P(0)P_e(0) + P(1)P_e(1)$ $= \frac{1}{2}\left[\frac{1}{2}\text{erfc}\left(\sqrt{\frac{E_b}{2N_0}}\right)\right] + \frac{1}{2}\left[\frac{1}{2}\text{erfc}\left(\sqrt{\frac{E_b}{2N_0}}\right)\right]$ $\boxed{P_e = \frac{1}{2}\text{erfc}\left(\sqrt{\frac{E_b}{2N_0}}\right)}$ signal space diagram for coherent BFSK		6M
2b)	$k \rightarrow$: −1, 0, 1, 2, 3, 4, 5 Binary data $\{b_k\}$: 1 0 1 1 0 1 Differentially encoded data $\{d_k\}$: 1 1 0 0 0 1 1 Phase of the DPSK wave (rad) : 0 0 π π π 0 0 		6M
2c)	Stage 1: First quadrant constellation $\begin{bmatrix}11\\10\end{bmatrix}$ $\begin{bmatrix}10 & 11\end{bmatrix} \rightarrow \begin{bmatrix}1110 & 1111\\1010 & 1011\end{bmatrix}$ Top to bottom, Left to right, First quadrant $\begin{bmatrix}11\\10\end{bmatrix}$ $\begin{bmatrix}01 & 00\end{bmatrix} \rightarrow \begin{bmatrix}1101 & 1100\\1001 & 1000\end{bmatrix}$ Stage 2: Second quadrant constellation Top to bottom, Left to right, Second quadrant		6M

	$\begin{bmatrix}00\\01\end{bmatrix} \begin{bmatrix}01 & 00\end{bmatrix} \rightarrow \begin{bmatrix}0001 & 0000\\0101 & 0100\end{bmatrix}$ Top to bottom Left to right Third quadrant Stage 3: Third quadrant constellation $\begin{bmatrix}00\\01\end{bmatrix} \begin{bmatrix}10 & 11\end{bmatrix} \rightarrow \begin{bmatrix}0010 & 0011\\0110 & 0111\end{bmatrix}$ Top to bottom Left to right Fourth quadrant  Stage 4: Fourth quadrant constellation	
3a)	**Property 1:** the spectrum of the o/p of the matched filter with i/p signal being the signal to which it is matched is proportional to the energy spectral density of the i/p signal expect for a time delay factor. **Proof :** Let $s_0(t)$ be the o/p signal having the Fourier transform $S_0(f)$. Then in frequency domain the o/p of the filter is $S_0(f)= S(f)\, H_{opt}(f)$ Substituting for $H_{opt}(f)$, we get $S_0(f) = S(f)\, S^*(f)e^{-j2\pi fT}$ $=\lvert S(f)\rvert^2\, e^{-j2\pi fT}$ **Property 2:** The output filter of a matched filter is proportional to shifted version of the auto co relation function of the i/p signal to which the filter is matched. **Proof :** Let the auto correlation function of S(t) be Rs(τ). We know that energy spectral density and auto correlation function of a finite energy signal are Fourier transform pair. $\lvert S(f)\rvert^2 = \int_{-\infty}^{\infty} R_s(\tau)e^{-j2\pi f\tau}\,d\tau$ and $R_s(\tau) = \int_{-\infty}^{\infty} \lvert S(f)\rvert^2 e^{j2\pi f\tau}\,df$ **Property 3:** The output signal to noise ratio of a matched filter depends only on the ratio of the signal energy to the power spectral density of the white noise at the filter i/p. **Proof:** The transfer function of the matched filter is given as $c = S^*(f)e^{-j2\pi fT}$ Power spectral density of the input white noise is No/2. Hence the power spectral density of the noise at the filter o/p is . $No/2. \lvert H_{opt}(f)\rvert^2$ $\frac{N_0}{2}\int_{-\infty}^{\infty} \lvert H_{opt}(f)\rvert^2 df$ **$s(t)$ by Parseval's theorem is** $E \triangleq \int_{-\infty}^{\infty} \lvert s(t)\rvert^2 dt = \int_{-\infty}^{\infty} \lvert S(f)\rvert^2 df \quad \lvert H_{opt}(f)\rvert^2 = \lvert S(f)\rvert^2$	6M

$$E = \int_{-\infty}^{\infty} |H_{\text{opt}}(f)|^2 df \quad \frac{N_0}{2} E$$

The normalized o/p signal power is $|s_o(T)|^2 = E^2$

3b) **6M**

Nyquist Condition for Zero ISI. A necessary and sufficient condition for $x(t)$ to satisfy

$$x(nT) = \begin{cases} 1, & n = 0 \\ 0, & n \neq 0 \end{cases} \tag{9.2.6}$$

is that its Fourier transform $X(f)$ must satisfy

$$\sum_{m=-\infty}^{\infty} X\left(f + \frac{m}{T}\right) = T. \tag{9.2.7}$$

Therefore, the necessary and sufficient conditions for Equation (9.2.6) to be satisfied is that

$$z_n = \begin{cases} T & n = 0 \\ 0, & n \neq 0 \end{cases} \tag{9.2.15}$$

which, when substituted into Equation (9.2.12), yields

$$Z(f) = T, \tag{9.2.16}$$

or equivalently,

$$\sum_{m=-\infty}^{\infty} X\left(f + \frac{m}{T}\right) = T. \tag{9.2.17}$$

It is clear that there exists only one $X(f)$ that results in $Z(f) = T$, namely,

$$X(f) = \begin{cases} T & |f| < W, \\ 0, & \text{otherwise} \end{cases} \tag{9.2.18}$$

or $X(f) = T\Pi\left(\frac{f}{2W}\right)$, which results in

$$x(t) = \text{sinc}\left(\frac{t}{T}\right). \tag{9.2.19}$$

4a) **6M**

$$\begin{aligned} \mu_{X_j} &= E[X_j] \\ &= E[s_{ij} + W_j] \\ &= s_{ij} + E[W_j] \\ &= s_{ij} \end{aligned}$$

$$\begin{aligned} \sigma^2_{X_j} &= \text{var}[X_j] \\ &= E[(X_j - s_{ij})^2] \\ &= E[W_j^2] \end{aligned}$$

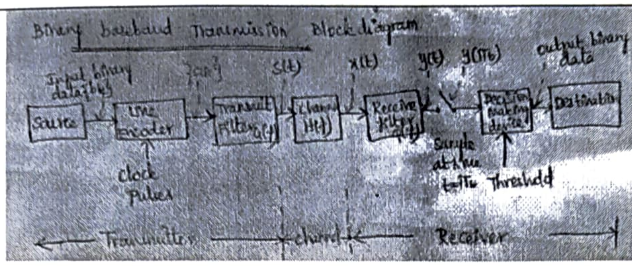
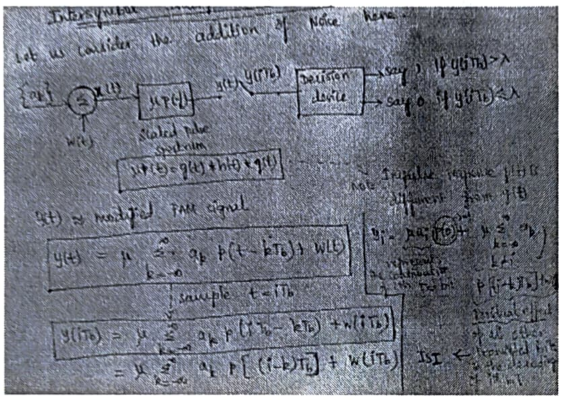
$$\begin{aligned} \sigma^2_{X_j} &= E\int_0^T W(t)\phi_j(t)\,dt \int_0^T W(u)\phi_j(u)\,du \\ &= E\left[\int_0^T\int_0^T \phi_j(t)\phi_j(u)W(t)W(u)\,dt\,du\right] \end{aligned}$$

$$\begin{aligned} \sigma^2_{X_j} &= \int_0^T\int_0^T \phi_j(t)\phi_j(u)E[W(t)W(u)]\,dt\,du \\ &= \int_0^T\int_0^T \phi_j(t)\phi_j(u)R_W(t,u)\,dt\,du \end{aligned}$$

$$R_W(t,u) = \left(\frac{N_0}{2}\right)\delta(t-u)$$

$$\begin{aligned} \sigma^2_{X_j} &= \frac{N_0}{2}\int_0^T\int_0^T \phi_j(t)\phi_j(u)\delta(t-u)\,dt\,du \\ &= \frac{N_0}{2}\int_0^T \phi_j^2(t)\,dt \end{aligned}$$

$$\sigma^2_{X_j} = \frac{N_0}{2}, \quad \text{for all } j$$

4b)	 	6M

Course In-charge

Module - Co-ordinator

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K.S. INSTITUTE OF TECHNOLOGY, BANGALORE - 560109
III SESSIONAL TEST QUESTION PAPER 2020 – 21 EVEN SEMESTER

SET A

USN | | | | | | | | | |

Degree	: B.E		Semester :	VI A & B
Branch	: Electronics and Communication Engg		Course Code :	18EC61
Course Title	: Digital Communication		Date :	05/08/21
Duration	: 90 Minutes		Max Marks :	30

Note: Answer ONE full question from each part.

Q No.	Question	Marks	CO mapping	K-Level
	PART-A			
1(a)	**Make use of** the properties of Maximum length sequence of Spread spectrum and write in detail.	6	CO5	Applying K3
(b)	**Construct** the 4 stage linear feedback shift register with 1st and 4th stage is connected to Modulo-2 adder. Output of Modulo-2 is connected to 1st stage input. Slove the output PN sequence and the autocorrelation sequence.	6	CO5	Applying K3
(C)	**Construct** a neat block diagram of the frequency hopped spread spectrum and write in detail about the generation and reconstruction.	6	CO5	Applying K3
	OR			
2(a)	**Make use of** any two applications of DS Spread spectrum and write in detail.	6	CO5	Applying K3
(b)	**Construct** with the neat block diagram of the generation of direct sequence spread spectrum signal with the relevant waveforms.	6	CO5	Applying K3
(C)	A 3-stage shift register with a linear feedback generates the sequence: 01011100101110, **Slove** the following, i) Period of the given infinite sequence. (ii) Balance property and Run property	6	CO5	Applying K3
	PART-B			
3(a)	**Make use of** the design of bandlimited signals with controlled ISI and write the time domain and frequency domain characteristics of a duo binary signal.	6	CO4	Applying K3
(b)	The binary sequence 0010110 is the input to the precoder whose output is used to modulate a Duo binary transmitting filter. **Identify** the precoded sequence, transmitted amplitude levels, the received signal levels and the decoded sequence.	6	CO4	Applying K3
	OR			
4(a)	**Make use of** a channel equalization and with a neat diagram write the concept of equalization using a linear transversal filter.	6	CO4	Applying K3
(b)	**Make use of** an adaptive equalizers and write the linear adaptive equalizer based on the MSE criterion.	6	CO4	Applying K3

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COURSE IN CHARGE

2/8
Module Coordinator

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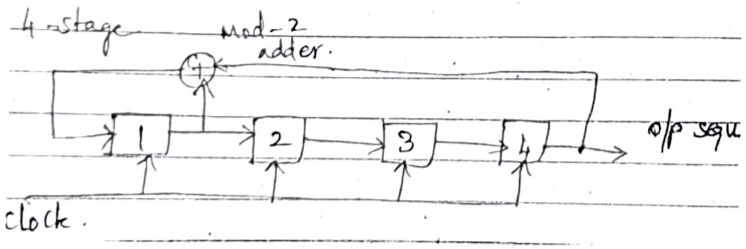
K.S. INSTITUTE OF TECHNOLOGY, BANGALORE - 560109

III SESSIONAL TEST QUESTION PAPER 2020 – 201EVEN SEMESTER

SET A

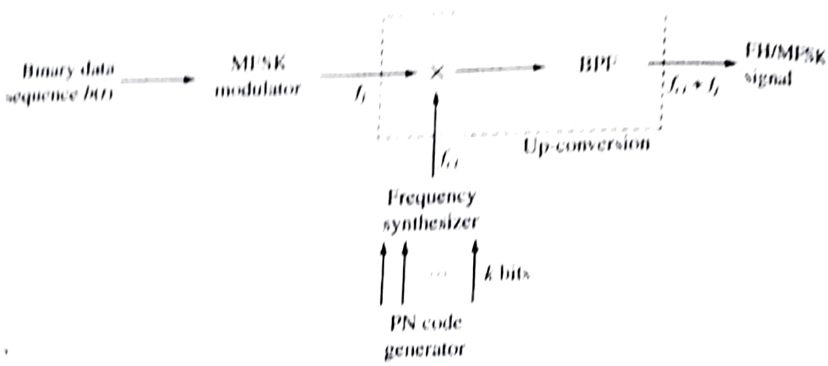
SCHEME AND SOLUTION

Degree	:	**B.E**	**Semester**	:	**VI**
Branch	:	**ECE**	**Course Code**	:	**18EC61**
Course Title	:	**Digital Communication**	**Max Marks**	:	**30**

Q. NO .	POINTS	MARKS
1a)	1. *Balance property*: In each period of a maximum length sequence, the number of 1s is always more by one number than the number of 0s. This property is called balance property. The balance property ensures that the probability of occurrence of symbol 0 and symbol 1 are equal. For an ML sequence generated by a n-stage shift register with linear feedback: (i) Period $= 2^n - 1$ bits (ii) Number of 1s $= 2^{n-1}$ (iii) Number of 0s $= 2^{n-1} - 1$ 2. *Run property*: A run is defined as a sequence of single type (1s or 0s) of binary digits. The appearance of an alternate digit in a sequence starts a new run. The length of the run is the number of digits in the run. Among the runs of 1s and 0s in each period of ML sequence, it is seen that about one-half the runs of each type (1s or 0s) are of length 1, about one-fourth are of length 2, one-eighth are of length of 3, and so on. For an ML sequence generated by an n-stage linear feedback shift register, the total number of runs is $(L+1)/2$, where $L = 2^n - 1$. 3. *Autocorrelations property*: Let $\{C_0, C_1, C_2 \dots C_{L-1}\}$ be an ML sequence of period $L = 2^n - 1$, generated by an n-stage linear feedback shift register. Then, the normalized circular or cyclic *autocorrelation* function of the sequence is defined as follows: $$R_c(\tau) = \frac{1}{L}\sum_{i=0}^{L-1} C_i C_{(i \oplus \tau) \bmod L}, \quad \tau = 0, 1, \dots, L-1$$	6M
1b)	 • The generated PN sequence is 000111101011001 • Auto correlation sequence is $R_c(t)$= 1 for t=0,7,14… -1/7 for otherwise	6M

1c)

6M



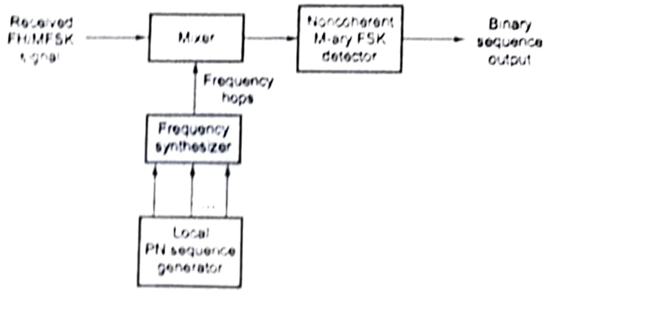
Operation

1. The input binary data sequence is applied to the M-ary FSK modulator. This modulator output is the particular frequency (out of 'M' frequencies) depending upon the input symbol.
2. The output of FSK modulator is then applied to a mixer. The other input to the mixer is particular frequency from frequency synthesizer.
3. The output of frequency synthesizer at particular instant is the frequency slot or 'hop'. This hop is mixed with the FSK signal.
4. The output of the mixer is the 'sum' frequency component of FSK signal and frequency hop from synthesizer. This signal is FH/MFSK signal and is transmitted over the wideband channel.

- The frequency hops (or slots) given to the mixer are generated by the frequency synthesizer. The inputs of the frequency synthesizer are controlled by pseudo-noise (PN) sequence generator. The 'l' successive bits of PN sequence generator control the frequency hops generated by synthesizer.
- Since the bits of PN sequence generator change randomly, the frequency hops generated also change randomly.
- Since 'l' bits of PN sequence generator control the frequency hops, there will be distinct '2^l' frequency hops generated. Therefore the total bandwidth of the output signal will be equal to the sum of individual frequency hops. This bandwidth goes in the range of GHz. Therefore the bandwidth of frequency hops signals are very large.

Operation

1. The received FH/MFSK signal is applied to the mixer. The output of frequency synthesizer is also given to the mixer. The sum and difference frequencies are generated by the mixer.
2. Only difference frequencies are allowed to pass out of the mixer. Those difference frequencies are exactly the M-ary FSK signals.
3. These signals are given to the non-coherent M-ary FSK detector. The detector detects particular symbol transmitted.



6M

2a)	The most important application of spread-spectrum technique is in the field of secure communication, where it has to provide immunity against jamming and consequently to ensure low probability of interception. Some of the other applications are: (i) *Code-division multiple access* (CDMA), also known as spread *spectrum multiple access* (SSMA). (ii) *Multipath suppression* and (iii) Ranging using *direct-sequence spread-spectrum* technique.	

CDMA

Multipath Suppression

In a mobile communication environment, the transmitted signal reaches the receiver input via more than one path. In addition to the direct path, indirect paths arise due to reflection caused by scatterers in the form of trees, buildings, moving vehicles etc. Thus, the received signal has a direct path component and several other indirect path components. The components from different paths would have been subjected to different attenuations and delays. Consequently, the different components may interfere constructively or destructively. Ultimately, the amplitude of the received signal goes on varying. This is termed as fading.

In a slow fading channel, if direct sequence spread-spectrum modulation is used and if the reflected signals at the receiver input are delayed by more than one chip duration of the PN code, then the reflected components are uncorrelated with the receiver PN code and are eliminated.

In a fast frequency-hop spread-spectrum system also, the effect of multipath is reduced.

Range Determination using Direct-Sequence Spread-Spectrum

In this application, only the PN sequence is transmitted. The reflected signal is received and correlated with delayed version of the same sequence. The delay D for which the correlator output is maximum corresponds to two-way path delay of the signal. The range d of the target is

$$d = \frac{1}{2}cD$$

where c is velocity of light.

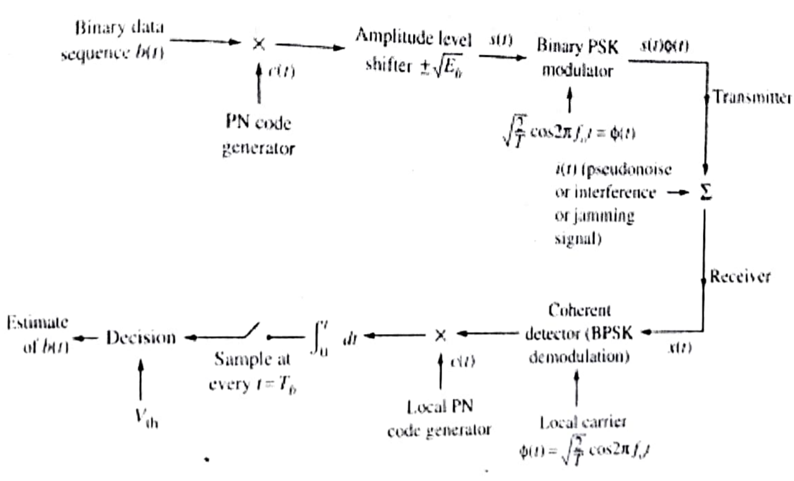
The precision of the measurement depends on the chip duration T_c and hence, range d is given by

$$d = \frac{c}{2}[D \pm T_c]$$

It may be noted that measurement accuracy improves if T_c is decreased relative to D.

6M

2b)



6M

- Direct sequence spread spectrum explanation and waveforms

2c)

Solution:

(a) The given sequence is

0 1 0 1 1 1 0 0 1 0 1 1 1 0

← One period →

The given sequence has a period $L = 7$, because after every seven bits, the pattern repeats. This is also in agreement with $L = 2^n - 1$, when $n = 3$.

Balance Property: In one period of the sequence, we find that
(i) the number of 1s = 4 (which is in agreement with number of 1s = 2^{n-1}).
(ii) the number of 0s = 3 (which is in agreement with number of 0s = $2^{n-1} - 1$). Thus, we find that number of 0s and number of 1s differ by one.

Run Property:

$$\text{Total number of runs} = \frac{L+1}{2}$$

$$= \frac{7+1}{2} = 4$$

6M

Part-B

3a)

Time Domain Criterion

From equation 4.2.9 we know that the second term (summation) must be zero to eliminate effect of ISI. This is possible if the received pulse p(t) is controlled such that,

$$\boxed{p[(i-k)T_b] = \begin{cases} 1 & \text{for } i = k \\ 0 & \text{for } i \neq k \end{cases}} \qquad (4.3.1)$$

If p(t) satisfies the above condition, then we get a signal which is free from ISI. i.e.,

$$y(t_i) = \mu A_i \qquad \text{from equation 4.2.10}$$

Hence equation 4.3.1 gives the condition for perfect reception in absence of noise. Equation 4.3.1 is the condition in time domain. This condition gives more useful criteria in frequency domain.

Criterion in Frequency Domain

- Let $p(nT_b)$ represent the impulses at which p(t) is sampled for decision. These samples are taken at the rate of T_b. Fourier spectrum of these impulses is given as

$$P_\delta(f) = f_b \sum_{n=-\infty}^{\infty} P(f - nf_b) \qquad \text{... (4.3.2)}$$

This means the spectrums of p(t) are periodic with period f_b. Here note that the sampling frequency (instants) is f_b. Here $P_\delta(f)$ represents the spectrum of $p(nT_b)$, and P(f) is the spectrum of p(t).

- We can think of $p(nT_b)$ as the infinite length of impulses with period T_b, which are weighted with amplitudes of p(t). i.e.,

$$p_\delta(t) = \sum_{n=-\infty}^{\infty} p(nT_b)\,\delta(t - nT_b) \qquad \text{... (4.3.3)}$$

- Fourier transform of $p_\delta(t)$ becomes,

$$P_\delta(f) = \int_{-\infty}^{\infty} p_\delta(t) e^{-j2\pi ft}\, dt$$

$$= \int_{-\infty}^{\infty} \left[\sum_{n=-\infty}^{\infty} p(nT_b)\,\delta(t-nT_b) \right] e^{-j2\pi ft}\,dt$$

- Let $n = i - k$ in above equation,

$$P_\delta(f) = \int_{-\infty}^{\infty} \sum_{k=-\infty}^{\infty} p[(i-k)T_b]\,\delta[t-(i-k)T_b]\,e^{-j2\pi ft}\,dt$$

- Now let us apply the condition of equation 4.3.1 to above equation,

$$P_\delta(f) = \begin{cases} \int_{-\infty}^{\infty} p(0)\,\delta(t)\,e^{-j2\pi ft}\,dt & \text{for } i = k \\ \int_{-\infty}^{\infty} 0 \cdot \delta(t)\,e^{-j2\pi ft}\,dt & \text{for } i \neq k \end{cases}$$

$$\therefore \quad P_\delta(f) = \int_{-\infty}^{\infty} p(0)\,\delta(t)\,e^{-j2\pi ft}\,dt \quad \text{for } i = k$$

$$= p(0) \int_{-\infty}^{\infty} \delta(t)\,e^{-j2\pi ft}\,dt$$

An integration in above equation is the fourier transform of $\delta(t)$, which is 1. Hence

$$P_\delta(f) = p(0) \quad \text{for } i = k$$

$$= 1 \qquad \text{by normalization of } p(0) \qquad \dots (4.3.1)$$

- Hence equation 4.3.2 becomes (with $P_\delta(f) = 1$),

$$1 = f_b \sum_{n=-\infty}^{\infty} P(f - nf_b)$$

or $$\sum_{n=-\infty}^{\infty} P(f - nf_b) = \frac{1}{f_b} \qquad \dots (4.3.5)$$

Since $\frac{1}{f_b} = T_b$,

$$\boxed{\sum_{n=-\infty}^{\infty} P(f - nf_b) = T_b} \qquad \dots (4.3.6)$$

This is the frequency domain condition for zero ISI. Above equation is called Nyquist pulse shaping criterion for baseband transmission.

6M

3b)

Sequences	$k=-1$	$k=0$	$k=1$	$k=2$	$k=3$	$k=4$	$k=5$	$k=6$
Binary sequence $\{b_k\}$		0	0	1	0	1	1	0
Precoded sequence $\{d_{k-1}\}$		1	1	1	0	0	1	0
Precoded sequence $d_k = b_k \oplus d_{k-1}$	1	1	1	0	0	1	0	0
Two level sequence $\{a_k\}$	+ 1	+ 1	+ 1	− 1	− 1	+ 1	− 1	− 1
Two level sequence $\{a_{k-1}\}$		+ 1	+ 1	+ 1	− 1	− 1	+ 1	− 1
Duobinary encoder output $c_k = a_k + a_{k-1}$		+ 2	+ 2	0	− 2	0	0	− 2
Magnitude of $\{c_k\}$ i.e. $\{\lvert c_k \rvert\}$		+ 2	+ 2	0	+ 2	0	0	+ 2
Output of decoder obtained by applying equation 4.4.8 to $\{c_k\}$ above		0	0	1	0	1	1	0

6M

4a)

Let us now consider the design of a linear equalizer from a time-domain viewpoint. We noted previously that in real channels, the ISI is limited to a finite number of samples, say L samples. As a consequence, in practice the channel equalizer is approximated by a finite duration impulse response (FIR) filter, or transversal filter, with adjustable tap coefficients $\{c_n\}$, as illustrated in Figure 8.37. The time delay τ between adjacent taps may be selected as large as T, the symbol interval, in which case the FIR equalizer is called a *symbol-spaced equalizer*. In this case the input to the equalizer is the sampled sequence given by Equation (8.6.19). However, we note that when $1/T < 2W$, frequencies in the received signal above the folding frequency $1/T$

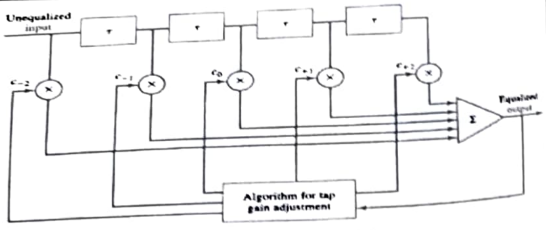


Figure 8.37 Linear transversal filter.

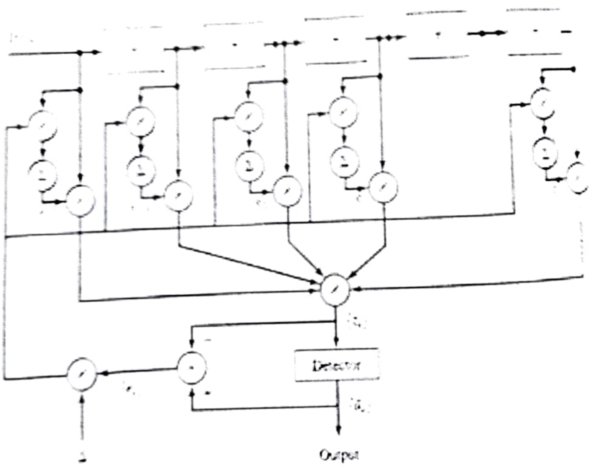
6M

4b)

Block diagram

The adaptive equalizer shown in figure below is a tapped-delay-line filter. It consists of set of delay elements and variable multipliers. The sequence $x(nT)$ is applied to the input of the adaptive filter. The output $y(nT)$ of the adaptive filter will be,

$$y(nT) = \sum_{i=0}^{M} w_i \, x(nT - iT)$$



In practice we often encounter channels whose frequency response characteristics are either unknown or change with time. For example, in data transmission over the dial-up telephone network, the communication channel will be different every time we dial a number, because the channel route will be different. Once a connection is made, however, the channel will be time-invariant for a relatively long period of time. This is an example of a channel whose characteristics are unknown a priori. Examples of time-varying channels are radio channels, such as ionospheric propagation channels. These channels are characterized by time-varying frequency response characteristics. These types of channels are examples where the optimization of the transmitting and receiving filters, as described in Section 8.6.1, is not possible.

Under these circumstances, we may design the transmitting filter to have a square-root raised cosine frequency response; i.e.,

$$G_T(f) = \begin{cases} \sqrt{X_{rc}(f)}\, e^{-j2\pi f t_0}, & |f| \le W \\ 0, & |f| > W \end{cases}$$

Course in charge

Module Coordinator 2/8

HOD 2/8

K.S. INSTITUTE OF TECHNOLOGY, BANGALORE - 560109

III SESSIONAL TEST QUESTION PAPER 2020 – 21 EVEN SEMESTER

SET B

USN

Degree	:	B.E			
Branch	:	Electronics and Communication Engg	Semester	:	VI A & B
Course Title	:	Digital Communication	Course Code	:	18EC61
Duration	:	90 Minutes	Date	:	05/08/21
			Max Marks	:	30

Note: Answer ONE full question from each part.

Q No.	Question	Marks	CO mapping	K-Level
	PART-A			
1(a)	**Make use of** any two applications of DS Spread spectrum and write in detail.	6	CO5	Applying K3
(b)	For a linear feedback shift register with three stages(m=3),evaluate the maximum length sequence for feedback taps(3,1).Draw the schematic arrangements and verify any two properties of PN sequence generated output.	6	CO5	Applying K3
(C)	**Construct** with the neat block diagram of the generation of direct sequence spread spectrum signal with the relevant waveforms.	6	CO5	Applying K3
	OR			
2(a)	**Construct** a neat block diagram of the frequency hopped spread spectrum and write in detail about the generation and reconstruction.	6	CO5	Applying K3
(b)	**Make use of** the properties of Maximum length sequence of Spread spectrum and write in detail.	6	CO5	Applying K3
(C)	A PN sequence is generated using a feedback shift register of length 4.Find the generated output if the initial content of the shift register are 1000.If the chip rate is 10^7 chips/sec. calculate the chip and PN sequence duration and period of PN sequence. Draw its schematic arrangement.	6	CO5	Applying K3
	PART-B			
3(a)	**Make use of** an adaptive equalizers and write the linear adaptive equalizer based on the MSE criterion.	6	CO4	Applying K3
(b)	**Make use of** a channel equalization and with a neat diagram write the concept of equalization using a linear transversal filter.	6	CO4	Applying K3
	OR			
4(a)	The binary sequence 0010110 is the input to the precoder whose output is used to modulate a Duo binary transmitting filter. **Identify** the precoded sequence, transmitted amplitude levels, the received signal levels and the decoded sequence.	6	CO4	Applying K3
(b)	**Make use of** the design of bandlimited signals with controlled ISI and write the time domain and frequency domain characteristics of a duo binary signal.	6	CO4	Applying K3

Mail ID: dcece2020@gmail.com

V. S.

Course in charge   Module Coordinator 2/8   HOD 2/8

K.S. INSTITUTE OF TECHNOLOGY, BANGALORE - 560109

III SESSIONAL TEST QUESTION PAPER 2020 – 21EVEN SEMESTER

SET B

SCHEME AND SOLUTION

Degree	:	B.E	Semester	:	VI
Branch	:	ECE	Course Code	:	18EC61
Course Title	:	Digital Communication	Max Marks	:	30

Q. NO.	POINTS	MARKS
1a)		6M

The most important application of spread-spectrum technique is in the field of secure communication, where it has to provide immunity against jamming and consequently to ensure low probability of interception. Some of the other applications are:

(i) *Code-division multiple access* (CDMA), also known as spread *spectrum multiple access* (SSMA),

(ii) *Multipath suppression* and

(iii) Ranging using *direct-sequence spread-spectrum* technique.

CDMA

Multipath Suppression

In a mobile communication environment, the transmitted signal reaches the receiver input via more than one path. In addition to the direct path, indirect paths arise due to reflection caused by scatterers in the form of trees, buildings, moving vehicles etc. Thus, the received signal has a direct path component and several other indirect path components. The components from different paths would have been subjected to different attenuations and delays. Consequently, the different components may interfere constructively or destructively. Ultimately, the amplitude of the received signal goes on varying. This is termed as fading.

In a slow fading channel, if direct sequence spread-spectrum modulation is used and if the reflected signals at the receiver input are delayed by more than one chip duration of the PN code, then the reflected components are uncorrelated with the receiver PN code and are eliminated.

In a fast frequency-hop spread-spectrum system also, the effect of multipath is reduced.

Range Determination using Direct-Sequence Spread-Spectrum

In this application, only the PN sequence is transmitted. The reflected signal is received and correlated with delayed version of the same sequence. The delay D for which the correlator output is maximum corresponds to two-way path delay of the signal. The range d of the target is

$$d = \frac{1}{2}cD$$

where c is velocity of light.

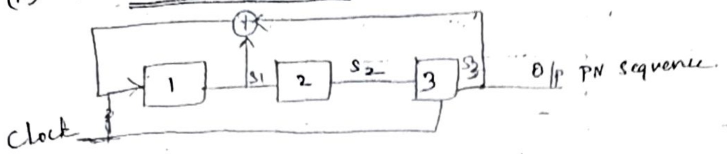
The precision of the measurement depends on the chip duration T_c and hence, range d is given by

$$d = \frac{c}{2}[D \pm T_c]$$

It may be noted that measurement accuracy improves if T_c is decreased relative to D

1b)		6M

(ii) To obtain PN Sequence :-



State of the flip flop

S_1	S_2	S_3	$S_1 \oplus S_3$	O/P PN sequence S_3
1	0	0	1+0=1	0
1	1	0	1+0=1	0
1	1	1	1+1=0	1
0	1	1	0+1=1	1
1	0	1	1+1=0	1
0	1	0	0+0=0	0
0	0	1	0+1=1	1
1	0	0		0 ← sequence repeat here.

(1) Balance property :-

In each period number of 1's is always one more than number of 0's.

No. of 1's is = 4

No. of 0's is = 3.

This satisfies balance property.

2) Run property :-

Here $m = 3$.

$N = 2^{m-1} = 4$ runs.

These are,

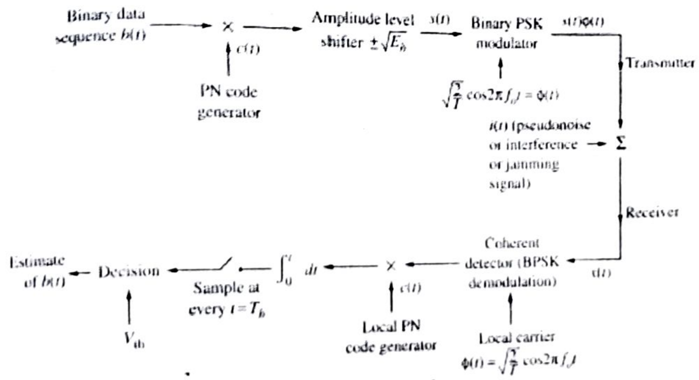
$C_n = \{\underbrace{0\,0}_{Run1}\ \underbrace{1\,1\,1}_{Run2}\ \underbrace{0}_{Run3}\ \underbrace{1}_{4}\}$

(i) Here two runs are of length 1. (One half of the runs of 1's & 0's)

ii) Here one run is of length '2' (One fourth of the runs of 1's and 0's).

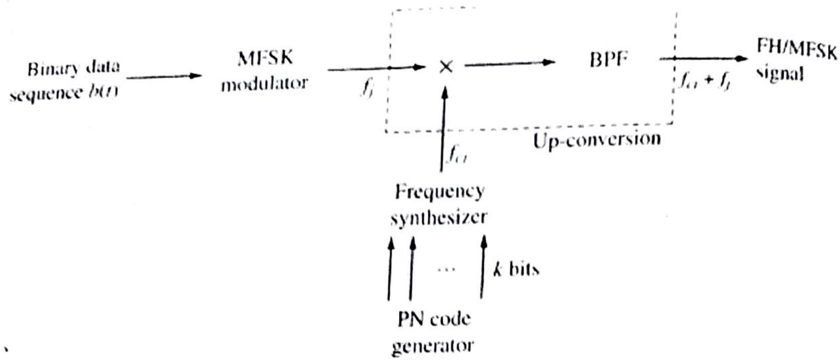
∴ Run property also satisfied.

1c)		6M



- Direct sequence spread spectrum explanation and waveforms

2a) 6M



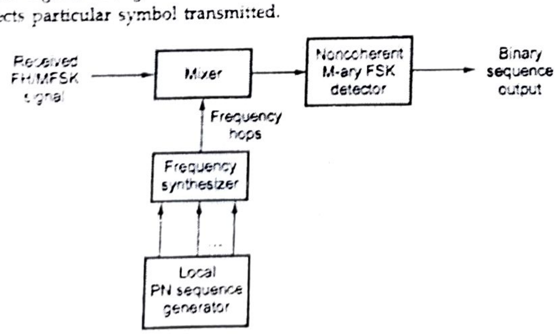
Operation

1. The input binary data sequence is applied to the M-ary FSK modulator. This modulator output is the particular frequency (out of 'M' frequencies) depending upon the input symbol.
2. The output of FSK modulator is then applied to a mixer. The other input to the mixer is particular frequency from frequency synthesizer.
3. The output of frequency synthesizer at particular instant is the frequency slot or 'hop'. This hop is mixed with the FSK signal.
4. The output of the mixer is the 'sum' frequency component of FSK signal and frequency hop from synthesizer. This signal is FH/MFSK signal and is transmitted over the wideband channel.

- The frequency hops (or slots) given to the mixer are generated by the frequency synthesizer. The inputs of the frequency synthesizer are controlled by pseudo-noise (PN) sequence generator. The 't' successive bits of PN sequence generator control the frequency hops generated by synthesizer.
- Since the bits of PN sequence generator change randomly, the frequency hops generated also change randomly.
- Since 't' bits of PN sequence generator control the frequency hops, there will be distinct '2^t' frequency hops generated. Therefore the total bandwidth of the output signal will be equal to the sum of individual frequency hops. This bandwidth goes in the range of GHz. Therefore the bandwidth of frequency hops signals are very large.

Operation

1. The received FH/MFSK signal is applied to the mixer. The output of frequency synthesizer is also given to the mixer. The sum and difference frequencies are generated by the mixer.
2. Only difference frequencies are allowed to pass out of the mixer. Those difference frequencies are exactly the M-ary FSK signals.
3. These signals are given to the non-coherent M-ary FSK detector. The detector detects particular symbol transmitted.



2b) 6M

1. *Balance property*: In each period of a maximum length sequence, the number of 1s is always more by one number than the number of 0s. This property is called balance

property. The balance property ensures that the probability of occurrence of symbol 0 and symbol 1 are equal.

For an ML sequence generated by a n-stage shift register with linear feedback

(i) Period $= 2^n - 1$ bits

(ii) Number of 1s $= 2^{n-1}$

(iii) Number of 0s $= 2^{n-1} - 1$

2. *Run property:* A run is defined as a sequence of single type (1s or 0s) of binary digits. The appearance of an alternate digit in a sequence starts a new run. The length of the run is the number of digits in the run. Among the runs of 1s and 0s in each period of ML sequence, it is seen that about one-half the runs of each type (1s or 0s) are of length 1, about one-fourth are of length 2, one-eighth are of length of 3, and so on.

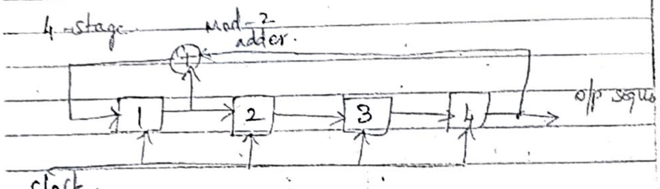
For an ML sequence generated by an n-stage linear feedback shift register, the total number of runs is $(L + 1)/2$, where $L = 2^n - 1$.

3. *Autocorrelations property:* Let $\{C_0, C_1, C_2 \ldots C_{L-1}\}$ be an ML sequence of period $L = 2^n - 1$, generated by an n-stage linear feedback shift register. Then, the normalized circular or cyclic *autocorrelation* function of the sequence is defined as follows:

$$R_c(\tau) = \frac{1}{L}\sum_{i=0}^{L-1} C_i C_{(i \oplus \tau) \bmod L} \qquad \tau = 0, 1, \ldots, L-1$$

2c) | 6M

(i) To obtain the PN sequence :-



A four-stage shift register to generat

Thus the generated PN sequence is,
0 0 0 1 1 1 1 0 1 0 1 1 0 0 1 ...

(ii) To obtain chip duration :-

The chip rate is $R_c = 10^7$ chips/sec.

hence the chip duration is,

$$T_c = \frac{1}{R_c} = \frac{1}{10^7} \text{ sec} = 0.1 \mu\text{sec}$$

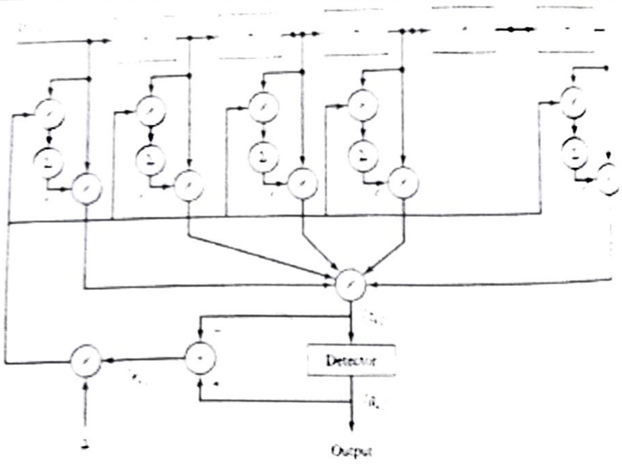
Part-B

3a) | 6M

Block diagram

The adaptive equalizer shown in figure below is a tapped-delay-line filter. It consists of set of delay elements and variable multipliers. The sequence $x(nT)$ is applied to the input of the adaptive filter. The output $y(nT)$ of the adaptive filter will be,

$$y(nT) = \sum_{i=0}^{M} w_i \, x(nT - iT)$$



In practice we often encounter channels whose frequency response characteristics are either unknown or change with time. For example, in data transmission over the dial-up telephone network, the communication channel will be different every time we dial a number, because the channel route will be different. Once a connection is made, however, the channel will be time-invariant for a relatively long period of time. This is an example of a channel whose characteristics are unknown a priori. Examples of time-varying channels are radio channels, such as ionospheric propagation channels. These channels are characterized by time-varying frequency response characteristics. These types of channels are examples where the optimization of the transmitting and receiving filters, as described in Section 8.6.1, is not possible.

Under these circumstances, we may design the transmitting filter to have a square-root raised cosine frequency response; i.e.,

$$G_T(f) = \begin{cases} \sqrt{X_{rc}(f)}\, e^{-j2\pi f t_0}, & |f| \le W \\ 0, & |f| > W \end{cases}$$

Let us now consider the design of a linear equalizer from a time-domain viewpoint. We noted previously that in real channels, the ISI is limited to a finite number of samples, say L samples. As a consequence, in practice the channel equalizer is approximated by a finite duration impulse response (FIR) filter, or transversal filter, with adjustable tap coefficients $\{c_n\}$, as illustrated in Figure 8.37. The time delay τ between adjacent taps may be selected as large as T, the symbol interval, in which case the FIR equalizer is called a ***symbol-spaced equalizer***. In this case the input to the equalizer is the sampled sequence given by Equation (8.6.19). However, we note that when $1/T < 2W$, frequencies in the received signal above the folding frequency $1/T$

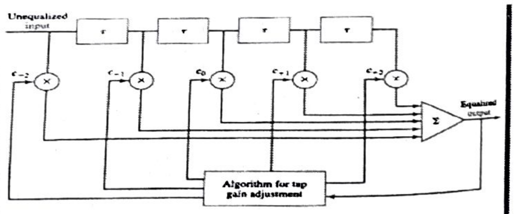


Figure 8.37 Linear transversal filter

6M

3b)

Sequences	$k=-1$	$k=0$	$k=1$	$k=2$	$k=3$	$k=4$	$k=5$	$k=6$
Binary sequence $\{b_k\}$		0	0	1	0	1	1	0
Precoded sequence $\{d_{k-1}\}$		1	1	1	0	0	1	0
Precoded sequence $d_k = b_k \oplus d_{k-1}$	1	1	1	0	0	1	0	0
Two level sequence $\{a_k\}$	+ 1	+ 1	+ 1	− 1	− 1	+ 1	− 1	− 1
Two level sequence $\{a_{k-1}\}$		+ 1	+ 1	+ 1	− 1	− 1	+ 1	− 1
Duobinary encoder output $c_k = a_k + a_{k-1}$		+ 2	+ 2	0	− 2	0	0	− 2
Magnitude of $\{c_k\}$ i.e. $\{\lvert c_k\rvert\}$		+ 2	+ 2	0	+ 2	0	0	+ 2
Output of decoder obtained by applying equation 4.4.8 to $\{c_k\}$ above		0	0	1	0	1	1	0

4a) **Time Domain Criterion** 6M

From equation 4.2.9 we know that the second term (summation) must be zero to eliminate effect of ISI. This is possible if the received pulse p(t) is controlled such that,

$$\boxed{p\left[(i-k)T_b\right] = \begin{cases} 1 & for\ i = k \\ 0 & for\ i \neq k \end{cases}} \qquad \text{... (4.3.1)}$$

If p(t) satisfies the above condition, then we get a signal which is free from ISI. i.e.,

$$y(t_i) = \mu A_i \qquad \text{from equation 4.2.10}$$

Hence equation 4.3.1 gives the condition for perfect reception in absence of noise. Equation 4.3.1 is the condition in time domain. This condition gives more useful criteria in frequency domain.

4b) **Criterion in Frequency Domain** 6M

- Let $p(nT_b)$ represent the impulses at which p(t) is sampled for decision. These samples are taken at the rate of T_b. Fourier spectrum of these impulses is given as

$$P_\delta(f) = f_b \sum_{n=-\infty}^{\infty} P(f - nf_b) \qquad \text{... (4.3.2)}$$

This means the spectrums of p(t) are periodic with period f_b. Here note that the sampling frequency (instants) is f_b. Here $P_\delta(f)$ represents the spectrum of $p(nT_b)$, and P(f) is the spectrum of p(t).

- We can think of $p(nT_b)$ as the infinite length of impulses with period T_b, which are weighted with amplitudes of p(t). i.e.,

$$p_\delta(t) = \sum_{n=-\infty}^{\infty} p(nT_b)\,\delta(t - nT_b) \qquad \text{... (4.3.3)}$$

- Fourier transform of $p_\delta(t)$ becomes,

$$P_\delta(f) = \int_{-\infty}^{\infty} p_\delta(t)\, e^{-j2\pi ft}\, dt$$

$$= \int_{-\infty}^{\infty} \left[\sum_{n=-\infty}^{\infty} p(nT_b)\,\delta(t - nT_b)\right] e^{-j2\pi ft}\, dt$$

- Let $n = i - k$ in above equation,

$$P_\delta(f) = \int_{-\infty}^{\infty} \sum_{k=-\infty}^{\infty} p\left[(i-k)T_b\right] \delta\left[t-(i-k)T_b\right] e^{-j2\pi ft}\, dt$$

- Now let us apply the condition of equation 4.3.1 to above equation,

$$P_\delta(f) = \begin{cases} \int_{-\infty}^{\infty} p(0)\,\delta(t)\, e^{-j2\pi ft}\, dt & for\ i = k \\ \int_{-\infty}^{\infty} 0\ \delta(t)\, e^{-j2\pi ft}\, dt & for\ i \neq k \end{cases}$$

$$\therefore \quad P_\delta(f) = \int_{-\infty}^{\infty} p(0)\,\delta(t)\, e^{-j2\pi ft}\, dt \quad for\ i = k$$

$$= p(0) \int_{-\infty}^{\infty} \delta(t)\, e^{-j2\pi ft}\, dt$$

An integration in above equation is the fourier transform of $\delta(t)$, which is 1. Hence

$$P_\delta(f) = p(0) \quad for\ i = k$$

$$= 1 \qquad \text{by normalization of } p(0) \qquad \text{... (4.3.4)}$$

- Hence equation 4.3.2 becomes (with $P_\delta(f) = 1$),

$$1 = f_b \sum_{n=-\infty}^{\infty} P(f - nf_b)$$

or

$$\sum_{n=-\infty}^{\infty} P(f - nf_b) = \frac{1}{f_b} \qquad \text{... (4.3.5)}$$

Since $\frac{1}{f_b} = T_b$,

$$\boxed{\sum_{n=-\infty}^{\infty} P(f - nf_b) = T_b} \qquad \text{... (4.3.6)}$$

This is the frequency domain condition for zero ISI. Above equation is called Nyquist pulse shaping criterion for baseband transmission.

Course in charge   Module Coordinator 9/8   HOD 9/8

K.S. INSTITUTE OF TECHNOLOGY, BANGALORE

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGG

Course: Digital Communicaion **sem:VI** **sec:A&B**

Sl No.	USN No.	Sl No.	USN	Name	IA1	IA2	IA3	A1	A2	A3	Average Assignment	Average of three IA's	Final IA(Assignment+IA)
1	1KS18EC001	1	1KS18EC001	A N BHOOMIKA CHOWDARY	29	29	30	10	10	10	10	29	39
2	1KS18EC002	2	1KS18EC002	ABHISHEK.V	28	23	30	10	10	10	10	27	37
3	1KS18EC003	3	1KS18EC003	ADITHI.S	29	27	27	10	10	10	10	28	38
4	1KS18EC004	4	1KS18EC004	AISHWARYA BANDIG	29	28	26	10	10	8	9	28	37
5	1KS18EC005	5	1KS18EC005	AISHWARYA R	28	23	28	10	10	10	10	26	36
6	1KS18EC006	6	1KS18EC006	AKASH R	27	22	27	10	9	10	10	25	35
7	1KS18EC007	7	1KS18EC007	AKHILA V	25	20	22	10	10	9	10	22	32
8	1KS18EC008	8	1KS18EC008	ANAGHA S	24	21	29	10	10	10	10	25	35
9	1KS18EC009	9	1KS18EC009	ANANYA ANANTH	28	26	26	10	10	10	10	27	37
10	1KS18EC010	10	1KS18EC010	ASHRITHA S C	28	26	27	10	10	10	10	27	37
11	1KS18EC011	11	1KS18EC011	AYEESHA RUMAN	28	27	28	10	10	10	10	28	38
12	1KS18EC012	12	1KS18EC012	C A SUSHMA	28	27	28	10	10	10	10	28	38
13	1KS18EC013	13	1KS18EC013	C M CHAITHANYA VARDHAN	22	21	25	8	8	8	8	23	31
14	1KS18EC014	14	1KS18EC014	CHANDAN Y C	29	25	29	10	10	10	10	28	38
15	1KS18EC015	15	1KS18EC015	CHARAN G	26	26	28	10	10	10	10	27	37
16	1KS18EC016	16	1KS18EC016	CHINNAPU CHARAN TEJA REDDY	27	21	27	10	10	9	10	25	35
17	1KS18EC017	17	1KS18EC017	CHITHRITHA G R	29	28	29	10	10	10	10	29	39
18	1KS18EC018	18	1KS18EC018	DARSHAN V	28	23	27	10	10	10	10	26	36
19	1KS18EC019	19	1KS18EC019	DARSHAN S	29	25	27	10	10	10	10	27	37
20	1KS18EC020	20	1KS18EC020	DEEKSHA S N	28	21	28	10	10	10	10	26	36
21	1KS18EC021	21	1KS18EC021	DEEPTHI ANDANI	27	22	26	10	10	10	10	25	35
22	1KS18EC022	22	1KS18EC022	DHANUSHREE C	28	27	29	10	10	10	10	28	38

23	1KS18EC023	23	1KS18EC023	DHEERAJ M S	29	29	30	10	10	10	10	29	39
24	1KS18EC024	24	1KS18EC024	DHRITHIRHUTH RAJANNA	28	26	29	10	10	10	10	28	38
25	1KS18EC025	25	1KS18EC025	DINESH KUMAR NAYAK	26	22	28	10	10	10	10	25	35
26	1KS18EC026	26	1KS18EC026	DIVAKARBABU Y	26	26	28	10	10	9	10	27	37
27	1KS18EC027	27	1KS18EC027	G.J.NITHIN	29	29	28	10	10	9	10	29	39
28	1KS18EC028	28	1KS18EC028	GANESH P	29	29	28	10	10	10	10	29	39
29	1KS18EC029	29	1KS18EC029	GOKUL G	26	28	26	10	10	10	10	27	37
30	1KS18EC030	30	1KS18EC030	HARSH SHARMA	28	27	28	10	10	10	10	28	38
31	1KS18EC031	31	1KS18EC031	HARSHITHA S	29	28	20	10	10	10	10	26	36
32	1KS18EC032	32	1KS18EC032	JAHNAVI A P	29	25	27	10	10	9	10	27	37
33	1KS18EC033	33	1KS18EC033	JANHAVI K P	29	26	28	10	10	10	10	28	38
34	1KS18EC034	34	1KS18EC034	JHANAVI V	29	27	28	10	10	10	10	28	38
35	1KS18EC035	35	1KS18EC035	JISHNU S	28	26	28	10	10	10	10	27	37
36	1KS18EC036	36	1KS18EC036	JYOTSNA B UPADHYE	27	28	28	9	10	10	10	28	38
37	1KS18EC037	37	1KS18EC037	K RISHIKA RAVI	29	21	27	10	10	9	10	26	36
38	1KS18EC038	38	1KS18EC038	KARISHMA M	28	26	24	10	9	10	10	26	36
39	1KS18EC039	39	1KS18EC039	KOMALA K V	28	27	27	10	10	10	10	27	37
40	1KS18EC040	40	1KS18EC040	LAVANYA M	29	25	27	10	10	10	10	27	37
41	1KS18EC041	41	1KS18EC041	M.NIHITHA YADAV	28	26	28	10	10	10	10	27	37
42	1KS18EC042	42	1KS18EC042	MAHANTH SAI M	29	26	27	10	10	10	10	27	37
43	1KS18EC043	43	1KS18EC043	MANOJ G S	27	14	25	8	8	9	8	22	30
44	1KS18EC044	44	1KS18EC044	MEGHA R	26	26	28	10	10	10	10	27	37
45	1KS18EC045	45	1KS18EC045	MEGHANA B S	29	29	29	10	10	10	10	29	39
46	1KS18EC046	46	1KS18EC046	MEGHANA GOWDA V	28	27	28	10	10	9	10	28	38
47	1KS18EC047	47	1KS18EC047	MOHAMMED FAIZAN	29	26	27	10	10	10	10	27	37
48	1KS18EC048	48	1KS18EC048	MONISHA B R	29	28	27	10	10	10	10	28	38
49	1KS18EC049	49	1KS18EC049	N S V JASHWANTH	28	27	27	10	10	10	10	27	37
50	1KS18EC050	50	1KS18EC050	NAGA OMKAR N	29	29	29	10	10	10	10	29	39
51	1KS18EC051	51	1KS18EC051	NAGASHREE A	29	26	29	10	10	10	10	28	38
52	1KS18EC052	52	1KS18EC052	NAMITH R	28	28	27	10	10	10	10	28	38

53	1KS18EC053	53	1KS18EC053	NAVYA M S	29	27	28	10	10	9	10	28	38
54	1KS18EC054	54	1KS18EC054	NIHARIKA S A	29	28	29	10	9	10	10	29	39
55	1KS18EC055	55	1KS18EC055	NIROSHA G J	29	21	28	10	10	9	10	26	36
56	1KS18EC056	56	1KS18EC056	NISHANTH J RAO	28	24	27	10	10	9	10	26	36
57	1KS18EC057	57	1KS18EC057	P SAI GOVARDHAN	28	28	28	10	9	10	10	28	38
58	1KS18EC058	58	1KS18EC058	PARIKSHITH S	28	29	29	10	10	10	10	29	39
59	1KS18EC059	59	1KS18EC059	PAVAN KUMAR P	28	21	26	10	9	8	9	25	34
60	1KS18EC060	60	1KS18EC060	POOJA S	29	27	28	10	10	10	10	28	38
61	1KS18EC061	61	1KS18EC061	PRAKRUTHI S H	26	19	27	10	10	10	10	24	34
62	1KS18EC063	62	1KS18EC063	PUNEETH M	29	26	24	10	10	9	10	26	36
63	1KS18EC064	63	1KS18EC064	PURUSHOTHAM V R	29	26	28	10	10	10	10	28	38
64	1KS18EC066	64	1KS18EC066	RAGHAVENDRA.K.P	29	27	28	10	10	10	10	28	38
65	1KS18EC067	65	1KS18EC067	RAGHU B T	29	26	28	10	9	10	10	28	38
66	1KS18EC068	66	1KS18EC068	RAJ KRISHNA	28	27	25	10	10	10	10	27	37
67	1KS18EC069	67	1KS18EC069	RAJATH S BHUSHAN	16	20	24	10	10	10	10	20	30
68	1KS18EC070	68	1KS18EC070	RAM BAHADUR MAHARA	27	25	28	10	10	10	10	27	37
69	1KS18EC071	69	1KS18EC071	RASETTY SANDEEP	26	26	24	9	10	8	9	25	34
70	1KS18EC073	70	1KS18EC073	RITHVIK P	28	27	28	10	10	10	10	28	38
71	1KS18EC074	71	1KS18EC074	S MANOJ	29	24	28	10	10	10	10	27	37
72	1KS18EC075	72	1KS18EC075	S RAHUL	29	27	25	10	10	9	10	27	37
73	1KS18EC076	73	1KS18EC076	S TUSHAR HARINATH	29	28	28	10	10	10	10	28	38
74	1KS18EC077	74	1KS18EC077	SAGAR T C	26	21	26	10	10	9	10	24	34
75	1KS18EC078	75	1KS18EC078	SANJANA B	29	21	29	10	10	9	10	26	36
76	1KS18EC079	76	1KS18EC079	SANKET B PASCHAPU	28	21	25	10	10	9	10	25	35
77	1KS18EC080	77	1KS18EC080	SHASHANK H K	28	20	22	8	9	8	9	23	32
78	1KS18EC081	78	1KS18EC081	SHEETAL N GOWDA	29	26	28	10	10	10	10	28	38
79	1KS18EC082	79	1KS18EC082	SHIVA SHANKAR.B	29	27	28	10	10	10	10	28	38
80	1KS18EC083	80	1KS18EC083	SHREYA V DEV	29	28	26	10	10	9	10	28	38
81	1KS18EC084	81	1KS18EC084	SHREYAS C	28	27	28	10	10	10	10	28	38
82	1KS18EC085	82	1KS18EC085	SHREYAS D R	29	29	28	10	10	10	10	29	39

83	1KS18EC086	83	1KS18EC086	SHRIKANTH C K	28	20	26	10	9	9	9	25	34
84	1KS18EC087	84	1KS18EC087	SIRI RAVINATH	27	20	27	10	10	10	10	25	35
85	1KS18EC088	85	1KS18EC088	SIRISHA.M	29	29	29	10	10	9	10	29	39
86	1KS18EC090	86	1KS18EC090	SOMASHEKAR M	29	25	28	10	10	9	10	27	37
87	1KS18EC091	87	1KS18EC091	SUDHEER B	29	27	29	10	10	10	10	28	38
88	1KS18EC092	88	1KS18EC092	SUJAY R	29	26	29	10	10	10	10	28	38
89	1KS18EC093	89	1KS18EC093	SUPRIYA S	28	22	27	10	10	10	10	26	36
90	1KS18EC094	90	1KS18EC094	SURAJ V GHORPADE	28	29	29	10	10	10	10	29	39
91	1KS18EC095	91	1KS18EC095	SUSHMA.A.V	29	27	27	10	10	10	10	28	38
92	1KS18EC096	92	1KS18EC096	SUSHMITHA R	28	20	28	10	10	10	10	25	35
93	1KS18EC097	93	1KS18EC097	THANUSH R S	27	21	27	10	10	10	10	25	35
94	1KS18EC098	94	1KS18EC098	THANUSHREE D	28	26	29	10	10	10	10	28	38
95	1KS18EC099	95	1KS18EC099	VAISHNAVI G	27	22	28	10	10	10	10	26	36
96	1KS18EC100	96	1KS18EC100	VAKKALA GADDA ANIL	25	26	16	9	8	8	8	22	30
97	1KS18EC101	97	1KS18EC101	VANDANA K	28	20	27	10	10	10	10	25	35
98	1KS18EC102	98	1KS18EC102	VARSHINI.B.M	29	27	29	10	10	10	10	28	38
99	1KS18EC103	99	1KS18EC103	VASANTH PAI.M	29	28	28	10	10	10	10	28	38
100	1KS18EC104	100	1KS18EC104	VIJAY BABU K	29	19	23	10	10	10	10	24	34
101	1KS18EC105	101	1KS18EC105	VINAY K	29	26	28	10	10	9	10	28	38
102	1KS18EC106	102	1KS18EC106	VINAY S	29	26	27	9	10	10	10	27	37
103	1KS18EC108	103	1KS18EC108	VISHAL MADHUSUDAN	28	28	28	10	10	10	10	28	38
104	1KS18EC109	104	1KS18EC109	VISHWAS P	29	24	29	10	10	9	10	27	37
105	1KS18EC110	105	1KS18EC110	VIVEKGOWDA J	28	26	27	10	10	10	10	27	37
106	1KS18EC111	106	1KS18EC111	VRINDHA SHAM BHATT	29	26	29	10	10	10	10	28	38
107	1KS19EC400	107	1KS19EC400	HEMANTHA V	27	20	27	10	10	9	10	25	35
108	1KS19EC401	108	1KS19EC401	KARTHIK B P	27	20	27	10	10	9	10	25	34
109	1KS19EC402	109	1KS19EC402	KRISHNAPRASAD B	25	21	22	10	10	10	10	23	33
110	1KS19EC403	110	1KS19EC403	NAVEEN G	27	26	22	10	10	10	10	25	35
111	1KS19EC405	111	1KS19EC405	PRUTHVI DINESH	27	24	26	10	10	9	10	26	35
112	1KS19EC406	112	1KS19EC406	RAGHOTHAM C G	28	28	28	10	10	10	10	28	38

113	1KS19EC407	113	1KS19EC407	SADANA M	28	25	26	10	10	9	10	26	36
114	1KS19EC408	114	1KS19EC408	SINDHU G	28	25	25	10	10	10	10	26	36
115	1KS19EC409	115	1KS19EC409	VARSHA M S	22	16	22	9	10	10	10	20	30

KS INSTITUTE OF TECHNOLOGY, BANGALORE

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

18EC61-DIGITAL COMMUNICATION

1. Let denote the Hilbert transform of a Fourier transformable signal g(t). Show that $\frac{d\hat{g}(t)}{dx}$ is equal to the Hilbert transform of $\frac{dg(t)}{dt}$.

2. A randomly generated data stream consists of equiprobable binary symbols 0 and 1. It is encoded into a polar NRZ waveform with each binary symbol being defined as follows:
 a. Sketch the waveform so generated, assuming that the data stream is 00101110.
 b. Derive an expression for the power spectral density of this signal and sketch it.

3. Determine the pre-envelope g+(t) corresponding to each of the following two signals:
 a. g(t) = sinc(t)
 b. $g(t) = [1 + k\cos(2\pi f_m t)]\cos(2\pi fct)]$
Show that the complex envelope of the sum of two narrowband signals (with the same carrier frequency) is equal to the sum of their individual complex envelopes.

4. Let a narrow-band signal s(t) be expressed in the form

$$s(t) = s_I(t)\cos(2\pi f_c t) - s_Q(t)\sin(2\pi f_c t)$$

Using S+(f) to denote the Fourier transform of the pre-envelope of s+(t), show that the Fourier transforms of the in-phase component sI(t) and quadrature component sQ(t) are given by

$$S_I(f) = \frac{1}{2}[S_+(f+f_c) + S_+^*(-f+f_c)]$$

$$S_Q(f) = \frac{1}{2j}[S_+(f+f_c) - S_+^*(-f+f_c)]$$

5. The rectangular RF pulse

$$x(t) = \begin{cases} A\cos(2\pi f_c t), & 0 \le t \le T \\ 0, & \text{elsewhere} \end{cases}$$

is applied to a linear filter with impulse response

$$h(t) = x(T-t)$$

Assume that the frequency fc equals a large integer multiple of 1/T. Determine the response of the filter and sketch it.

K.S. INSTITUTE OF TECHNOLOGY, BANGALORE - 560109

DEARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

TEACHING AND LEARNING

PEDAGOGY REPORT-1

Academic Year	20-21
Name of the Faculty	V.SANGEETHA
Course Name /Code	DIGITALCOMMUNICATION/18EC61
Semester/Section	VI/B
Activity Name	Kahoot Quiz
Topic Covered	Digital Communication Introduction ,Hilbert Transform
Date	07/05/2021
No. of Participants	59
Objectives/Goals	To analyse students understanding level of basics of Digital communication and Hilbert Transform,
ICT Used	Laptop, Microsoft Teams

Appropriate Method/Instructional materials/Exam Questions

1) 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	30	Ans:4
2)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	30	4
3)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	30	1
4)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	30	3
5)Alternate Mark Inversion (AMI) is also known as	a. Pseudo ternary coding	b. Manchester coding	c. Polar NRZ format	d. None of the above	30	1
6) Properties of Hilbert transform are:	a. The signal and its Hilbert transform have same energy	b. The signal and its Hilbert transform are mutually diagonal	b. The signal and its Hilbert transform are mutually	d. None of the above	30	3

	density spectrum		diagonal			
7) Hilbert transform may be used in	a. Generation of SSB signals	b. Representation of band pass signals	c. Designing of minimum phase type filters	d. All of the above	30	1
8) In Hilbert transform of a signal, the phase angles of all components of a given signal are shifted by	a. +/- π	b. +/- π/4	c. +/- π/2	d. Any angle from 00 to 3600	30	3
9)Signum function sgn(f), for f>0, f=0 and f<0, has the values:	a. -1 to +1	b. +1, 0, -1 respectively	c. -∞ to + ∞	d. 0 always	30	2
10)The Hilbert transform of the signal sinω1t + sinω2t is	a. sinω1t + sinω2t	b. -cosω1t - cosω2t	c. sinω2t + cosω2t	d. sinω1t + sinω1t	30	2

Relevant PO's	PO's-1,3,10
Significance of Results/Outcomes	Understood the Basics of Digital communication, Hilbert Transform
Reflective Critique	

Proofs (Photographs/Videos/Reports/Charts/Models)

DC-Quiz-1(18EC61)

Played on	7 May 2021
Hosted by	Sangeetha_V
Played with	59 players
Played	10 of 10

Overall Performance

Total correct answers (%)	35.93%
Total incorrect answers (%)	64.07%
Average score (points)	3039.07 points

Feedback

Number of responses	0		
How fun was it? (out of 5)	0.00 out of 5		
Did you learn something?	0.00% Yes	0.00% No	
Do you recommend it?	0.00% Yes	0.00% No	
How do you feel?	0.00% Positive	0.00% Neutral	0.00% Negative

V. Sa[illegible]

Signature of Course In charge

Signature of HOD

K.S. INSTITUTE OF TECHNOLOGY, BANGALORE - 560109

DEARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

TEACHING AND LEARNING

PEDAGOGY REPORT-I

Academic Year	20-21
Name of the Faculty	V.SANGEETHA
Course Name /Code	DIGITALCOMMUNICATION/18EC61
Semester/Section	VI/A
Activity Name	Kahoot Quiz
Topic Covered	Digital Communication Introduction ,Hilbert Transform
Date	04/05/2021
No. of Participants	54
Objectives/Goals	To analyse students understanding level of basics of Digital communication and Hilbert Transform
ICT Used	Laptop, Microsoft Teams

Appropriate Method/Instructional materials/Exam Questions

1) 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	30	Ans:4
2)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	30	4
3)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	30	1
4)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	30	3
5)Alternate Mark Inversion (AMI) is also known as	a. Pseudo ternary coding	b. Manchester coding	c. Polar NRZ format	d. None of the above	30	1
6) Properties of Hilbert transform are:	a. The signal and its Hilbert transform have same energy	b. The signal and its Hilbert transform are mutually diagonal	b. The signal and its Hilbert transform are mutually	d. None of the above	30	3

	density spectrum		diagonal			
7) Hilbert transform may be used in	a. Generation of SSB signals	b. Representation of band pass signals	c. Designing of minimum phase type filters	d. All of the above	30	1
8) In Hilbert transform of a signal, the phase angles of all components of a given signal are shifted by	a. +/- π	b. +/- π/4	c. +/- π/2	d. Any angle from 00 to 3600	30	3
9)Signum function sgn(f), for f>0, f=0 and f<0, has the values:	a. -1 to +1	b. +1, 0, -1 respectively	c. -∞ to + ∞	d. 0 always	30	2
10)The Hilbert transform of the signal sinω1t + sinω2t is	a. sinω1t + sinω2t	b. -cosω1t - cosω2t	c. sinω2t + cosω2t	d. sinω1t + sinω1t	30	2

Relevant PO's	PO's-1,3,10
Significance of Results/Outcomes	Understood the Basics of Digital communication, Hilbert Transform
Reflective Critique	

Proofs (Photographs/Videos/Reports/Charts/Models)

DC-Quiz-1(18EC61)

Played on	4 May 2021
Hosted by	Sangeetha_V
Played with	64 players
Played	1 of 10

Overall Performance

Total correct answers (%)	0.00%
Total incorrect answers (%)	100.00%
Average score (points)	0.00 points

Feedback

Number of responses	0		
How fun was it? (out of 5)	0.00 out of 5		
Did you learn something?	0.00% Yes	0.00% No	
Do you recommend it?	0.00% Yes	0.00% No	
How do you feel?	0.00% Positive	0.00% Neutral	0.00% Negative

V. Sa

Signature of Course In charge

Signature of HOD

KS INSTITUTE OF TECHNOLOGY, BANGALORE

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

18EC61-DIGITAL COMMUNICATION

EXHAUSTIVE QUESTION BANK

MODULE-I

1) What is Hilbert Transform? Obtain the Hilbert Transform of the signal g(t)=sin2πfct.
2) Define the following: (i) Hilbert Transform (ii) Pre-Envelope (iii) Complex Envelope (iv) Canonical representation of band pass signal.
3) Specify the properties of Hilbert Transform and state how does it differ from Fourier Transform.
4) Define Hilbert transform and also explain its properties.
5) List all the properties of Hilbert transform and prove the properties of it.
6) Find the Hilbert Transform for the following signal (i)δ(t) (ii) cos $2\pi fct$ + sin $2\pi fct$ (iii) 1 πt
7) Obtain the Hilbert transform of the following: (i) x(t)=cos2πfct+sin2πfct (ii) x(t)= $e^{-j2\pi fct}$
8) For the binary data 10110010 draw the following data formats.(i) Polar NRZ (ii) Bipolar (iii) Manchester (iv) Unipolar RZ.
9) For the binary sequence 1001001 draw the waveforms using (i) Unipolar NRZ (ii) Polar RZ(iii) Bipolar NRZ (iv) Split phase Manchester.
10) Obtain the power spectral density expression for Bipolar NRZ format and draw the PSD curve.
11) Draw the Polar NRZ and Polar RZ digital formats for the binary data b(k)=11010.
12) Consider a random binary sequence where bits are statistically independent and equally likely. Determine the power spectral density for the sequence represented in Unipolar NRZ format.
13) Obtain an expression for power spectral density of NRZ polar format.
14) Draw the power spectra for different binary data formats .Explain Manchester code with related equations and waveform.
15) Write note on (i) HDB3 signalling (ii) BNZS
16) Obtain the HDB3 signalling for the following data 11000000001100000010
17) Write the procedure for complex envelope representation of signal and system.

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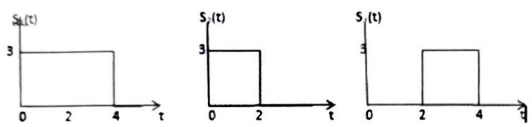
DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

18EC61-DIGITAL COMMUNICATION

EXHAUSTIVE QUESTION BANK

MODULE-II

1. Identify the procedure for Gram Schmidt orthogonalization procedure.
2. Show that it is possible to construct a set of N orthonormal basis functions from linearly independent signals.
3. Construct the orthonormal basis function for the following set of signals using gram schmidt procedure.



4. The Random process $x(t)=S_i(t)+w(t)$ is received by a bank of correlators.The o/p of the correlators is $X_j=S_{ij}+w_j, j=1,2,..N$,the noise w(t) is white Gaussian noise of zero mean &PSD of $N_0/2$.

   (i) Develop mean value of X_j
   (ii) Develop variance of X_j
   (iii) Develop X_j are mutually uncorrelated.

5. With necessary representation when N=2,M=3 construct the geometric representation of signal.

6. Explain Maximum Likelihood decoding technique.

7. What is correlation Receiver ?explain with block diagram.

8. Explain matched filter in detail.

9. State and prove the properties of Matched Filter.

10. Find the output of Matched filter & determine the maximum value of SNR if input S(t) is a rectangular pulse of amplitude A and duration T.

11. Explain the maximum likelihood detection process and obtain the decision rule.

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

18EC61-DIGITAL COMMUNICATION

EXHAUSTIVE QUESTION BANK

MODULE-III

1) Develop the expression for probability of error of a coherent BPSK technique.
2) Make use of block diagram of DPSK transmitter and receiver write in detail.
3) Construct the generation of differentially encoded sequence for the binary sequence 101101.
4) Make use of block diagram of QPSK transmitter and receiver write in detail with waveform.
5) Make use of block diagram of BFSK transmitter and receiver write in detail.
6) Develop a systematic procedure for constructing M-ary QAM constellation for M=16.
7) With a neat block diagram concept, explain the coherent BFSK transmitter and receiver with waveform.
8) An FSK system transmits binary data at a rate of 106 bits per second. Assuming channel noise is additive white Gaussian with zero mean and PSD 2x10-20watts/Hz, determine the average probability of error. Assume coherent detection and amplitude of received sinusoidal signal for both symbol 1 &0 to be 1.2 μv. Take erf(3)=0.99998.
9) A binary data is transmitted over an AWGN channel using BPSK at arate of 1 Mbps. It is desired to have average probability of error Pe<10-4. Noise PSD is No/2=10-12 W/Hz. Determine the average carrier power required at the receiver input, if the detector is of coherent type. Take erfc(3.5)=0.00025.
10) Binary data are transmitted at a rate of 106 bit per second over a microwave link. Assuming channel noise is AWGN with zero mean and power spectral density at the receiver input, is 10-10 Watts per Hz, find the average carrier power required to maintain an average probability of error Pe ≤ 10-4 for coherent binary FSK. Determine the minimum channel bandwidth required.
11) Construct the in phase and quadrature components of a QPSK signal for the binary sequence 110010111.

In a QPSK modulation scheme the input binary sequence{bi}={11001011101}.Give the de-multiplexed sequence{bei},{boi}.Assume NRZ polar waveform. Construct the sequences{bi},{bei},{boi}.

Mrs.Sangeetha.V , Assistant Professor, ECE, KSIT

KS INSTITUTE OF TECHNOLOGY, BANGALORE

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

18EC61-DIGITAL COMMUNICATION

EXHAUSTIVE QUESTION BANK

MODULE-IV

1. Construct a neat block diagram of the digital PAM transmission through band limited baseband channels and write the expression for ISI.
2. Explain eye pattern in detail with diagram.
3. Develop Nyquist criterion for zero ISI and Give an example of the pulse with zero ISI.
4. Explain the design of bandlimited signals with controlled ISI and Summarize the time domain and frequency domain characteristics of a duo binary signal.
5. The binary sequence 0010110 is the input to the precoder whose output is used to modulate a duobinary transmitting filter. Identify the precoded sequence, transmitted amplitude levels, the received signal levels and the decoded sequence.
6. Write a note on channel equalization and with a neat diagram explain the concept of equalization using a linear transversal filter.
7. Make use of the concept of ZFE applied on transversal filter.
8. Write a note on adaptive equalizers and Explain the linear adaptive equalizer based on the MSE criterion.
9. Write a note on adaptive equalization.
10. The binary sequence 011100101 is applied to the input the input to duo binary transmitting filter.
11. Construct the modified duo binary coder output and output of decoder.

KS INSTITUTE OF TECHNOLOGY, BANGALORE

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

18EC61-DIGITAL COMMUNICATION

EXHAUSTIVE QUESTION BANK

MODULE-V

1. Construct with the neat block diagram of the generation of direct sequence spread spectrum signal with the relevant waveforms.
2. Identify the difference between slow and fast frequency hopping.
3. Construct with a neat block diagram of the frequency hopped spread spectrum.
4. In a direct sequence spread spectrum modulation, it is required to have a jamming margin greater than 26dB.the ratio Eb/N0 is set at 10. Solve the minimum processing gain and the minimum number of stages required to generate the maximum length sequence.
5. Construct the 4 stage linear feedback shift register with 1st and 4th stage is connected to Modulo-2 adder. Output of Modulo-2 is connected to 1st stage input. Sol the output PN sequence and the autocorrelation sequence.
6. A 3-stage shift register with a linear feedback generates the sequence : 01011100101110 ,Solve the following (i) Period of the given infinite sequence. (ii) Balance property and Run property.
7. Make use of the properties of Maximum length sequence of Spread spectrum and write in detail.
8. Select any two applications of DS Spread spectrum and write in detail.
9. Define Jamming margin (in dB) for spread spectrum system and A slow FH/MFSK system has the following parameters: The number of bits per MFSK symbol=4,The number of MFSK symbols per hop=6.Calculate the processing gain of the system.

10. In a direct sequence spread spectrum modulation, it is required to have a jamming margin greater than 26 dB. The ratio Eb/No is set as 10.Determine the minimum processing gain and minimum number of stages required to generate the maximum length sequence.

Mrs.Sangeetha.V , Assistant Professor, ECE, KSIT

Sixth Semester B.E. Degree Examination, Dec.2019/Jan.2020
Digital Communication

Time: 3 hrs. Max. Marks: 80

Note: Answer any FIVE full questions, choosing ONE full question from each module.

Module-1

1 a. Define Hilbert transform. State the properties of it. **(04 Marks)**

b. Obtain the Hilbert transform of

i) $x(t) = (\text{Cos } 2\pi Ft + \text{Sin } 2\pi Ft)$

ii) $x(t) = c^{-j2\pi Ft}$ **(04 Marks)**

c. Explain canonical representation of band pass signal. **(08 Marks)**

OR

2 a. Derive the expression for the complex low pass representation of bandpass systems. **(08 Marks)**

b. For the given data stream 11011100. Sketch the line code

i) Unipolar NRZ
ii) Polar NRZ
iii) Unipolar RZ
iv) Bipolar NRZ **(04 Marks)**

c. Draw the power spectra of NRZ unipolar and NRZ polar format. **(04 Marks)**

Module-2

3 a. Show that the energy of a signal is equal to squared length of the signal vector. **(08 Marks)**

b. Obtain the decision rule for maximum likelihood decoding and explain the correlation receiver. **(08 Marks)**

OR

4 a. Explain the correlation receiver using product integrator and matched filter. **(08 Marks)**

b. Three signals $s_1(t)$, $s_2(t)$ and $s_3(t)$ are shown in Fig.Q.4(b). Apply Gram Schmidt procedure to obtain an orthonormal basis for the signals. Express signals $s_1(t)$, $s_2(t)$ and $s_3(t)$ in terms of orthonormal basis functions. **(08 Marks)**

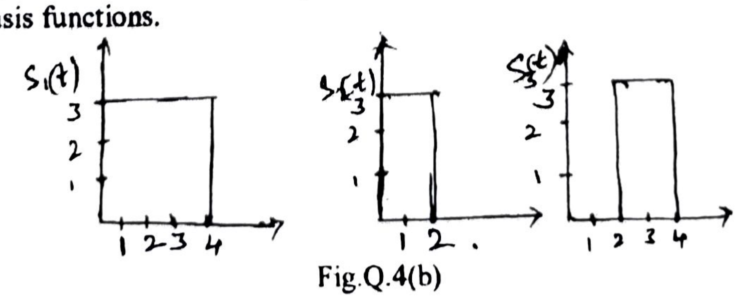


Fig.Q.4(b)

Module-3

5 a. With necessary diagrams, explain the generation and reception of BPSK signal. **(10 Marks)**

b. Given the binary data 10010011, draw the BPSK and DPSK waveforms. **(06 Marks)**

OR

6 a. Derive the expression for error probability of BFSK. (08 Marks)

b. With block diagram explain generation and detection of DPSK. (08 Marks)

Module-4

7 a. What is ISI? Obtain the expression of output of a filter with intersymbol interference. (08 Marks)

b. Explain the Nyquist criterion for distortionless baseband binary transmission and obtain the ideal solution for zero ISI. (08 Marks)

OR

8 a. Draw and explain the time-domain and frequency domain of duobinary and modified duobinary signal. (08 Marks)

b. What is channel equalization? With a neat diagram, explain the concept of equalization using a linear transversal filter. (08 Marks)

Module-5

9 a. Draw the 4 stage linear feedback shift register with 1^{st} and 4^{th} state is connected to Modulo-2 adder. Output of Modulo-2 is connected to 1^{st} stage input. Find the output PN sequence and write the autocorrelation function with initial state 1000. (06 Marks)

b. Explain the generation of direct sequence spread spectrum with relevant waveforms and spectrums. (07 Marks)

c. Write a short note on application of spread spectrum in wireless LAN's. (03 Marks)

OR

10 a. With necessary block diagram, explain the transmitter and receiver of frequency hop spread spectrum. (08 Marks)

b. With a neat block diagram, explain the CDMA system based on IS-95. (08 Marks)

K.S.Institute of Technology,Bangalore -109

Department of Electronics and Communication Engg
6th sem Course End Survey 2020-21

Course : DIGITAL COMMUNICATION-2021 **Course Code :18EC61**

Q1.To What Extent you are able to understand roles of each of the basic building blocks of a digital communication system?
Q2.Would you be able to find the PSD of any line coding Techniques?
Q3.To what extent to understand the Optimum receiver,Matched Filter?
Q4.Rate your understanding of the concept and procedure of Gram schmidt Orthogonalization procedure?
Q5.To what extent you understand the spread spectrum modulation and its advantages?

Sl No	Date	Name of the Student	USN	semester and section	Faculty Name	Q1	Q2	Q3	Q4	Q5
1	8-11-2021 15:22:58	hdhfhdfh	fhffd	hfhf	Mrs.V.Sangeetha	3	3	3	3	3
2	8-13-2021 13:44:20	SHREYAS D R	1KS18EC085	6th B	Mrs.V.Sangeetha	3	3	3	3	3
3	8-13-2021 13:49:23	Dhrithirhuth rajanna	1KS18EC024	6th A	Mrs.V.Sangeetha	3	3	3	3	3
4	8-13-2021 13:57:25	Siri ravinath	1KS18EC087	6th B	Mrs.V.Sangeetha	2	3	2	3	2
5	8-13-2021 14:10:18	Megha R	1KS18EC044	6th A	Mrs.V.Sangeetha	2	2	2	2	2
6	8-13-2021 14:10:39	K RISHIKA RAVI	1KS18EC037	6th A	Mrs.V.Sangeetha	3	3	3	3	3
7	8-13-2021 14:12:23	Ashritha S C	1KS18EC010	6th A	Mrs.V.Sangeetha	3	3	3	3	3
8	8-13-2021 14:12:24	Navya MS	1KS18EC053	6th A	Mrs.V.Sangeetha	3	3	3	3	3
9	8-13-2021 14:14:15	Karishma M	1KS18EC038	6th A	Mrs.V.Sangeetha	3	3	3	3	3
10	8-13-2021 14:25:08	N Naga Omkâr	1KS18EC050	6th A	Mrs.V.Sangeetha	3	3	3	3	3
11	8-13-2021 14:26:35	Raj Krishna	1KS18EC068	6th B	Mrs.V.Sangeetha	3	3	3	3	3
12	8-13-2021 14:37:11	Deeksha S N	1KS18EC020	6th A	Mrs.V.Sangeetha	3	3	2	2	3
13	8-13-2021 14:37:30	AKASH CHANDRAF	1KS16EC005	6th B	Mrs.V.Sangeetha	3	3	3	3	3
14	8-13-2021 14:42:21	Vivek gowda j	1KS18EC110	6th B	Mrs.V.Sangeetha	3	2	3	3	3
15	8-13-2021 14:42:56	Thanush RS	1KS18EC097	6th	Mrs.V.Sangeetha	3	3	3	3	3
16	8-13-2021 15:01:27	Vishwas P	1KS18EC109	6th B	Mrs.V.Sangeetha	2	2	1	1	3
17	8-13-2021 15:04:14	Darshan s	1KS18EC019	6th A	Mrs.V.Sangeetha	2	3	2	3	3
18	8-13-2021 15:04:27	Deepthi Andani	1KS18EC021	6th A	Mrs.V.Sangeetha	3	3	3	3	3
19	8-13-2021 15:18:38	Chinnapu charan Te	1KS18EC016	6th A	Mrs.V.Sangeetha	2	2	2	2	2
20	8-13-2021 15:20:27	Darshan v	1KS18EC018	6th A	Mrs.V.Sangeetha	2	2	2	2	2
21	8-13-2021 15:21:48	Meghana B S	1KS18EC045	6th A	Mrs.V.Sangeetha	3	3	3	3	3
22	8-13-2021 15:21:59	Chithritha G R	1KS18EC017	6th A	Mrs.V.Sangeetha	2	2	2	2	2
23	8-13-2021 15:23:03	Dhanushree.C	1KS18EC022	6th A	Mrs.V.Sangeetha	2	2	2	2	2
24	8-13-2021 15:23:41	ANAGHA.S	1KS18EC008	6th A	Mrs.V.Sangeetha	2	2	2	2	2
25	8-13-2021 15:34:28	Sujay. R	1KS18EC092	6th B	Mrs.V.Sangeetha	3	3	3	3	3

26	8-13-2021 15:39:59	Sirisha.M	1KS18EC088	6th B	Mrs.V.Sangeetha	3	3	3	3	3
27	8-13-2021 15:40:06	Sanjana.B	1KS18EC078	6th B	Mrs.V.Sangeetha	3	3	3	3	3
28	8-13-2021 15:41:32	Akhila V	1KS18EC007	6th A	Mrs.V.Sangeetha	3	3	3	3	3
29	8-13-2021 15:47:31	Vaishnavi G	1KS18EC099	6th B	Mrs.V.Sangeetha	3	3	3	3	3
30	8-13-2021 15:47:40	VIJAYBABU K	1KS18EC104	6th B	Mrs.V.Sangeetha	2	2	2	2	2
31	8-13-2021 15:53:47	AKASH R	1KS18EC006	6th A	Mrs.V.Sangeetha	2	2	3	3	3
32	8-13-2021 15:55:46	Jahnavi AP	1KS18EC032	6th A	Mrs.V.Sangeetha	3	3	3	3	3
33	8-13-2021 15:57:04	Jhanavi V	1KS18EC034	6th A	Mrs.V.Sangeetha	3	3	3	3	3
34	8-13-2021 16:05:14	Abhishek V	1KS18EC002	6th A	Mrs.V.Sangeetha	2	2	2	2	2
35	8-13-2021 16:43:28	RIthvik P	1KS18EC073	6th B	Mrs.V.Sangeetha	3	3	2	2	3
36	8-13-2021 16:44:44	SHIVA SHANKAR B	1KS18EC082	6th B	Mrs.V.Sangeetha	3	3	3	3	3
37	8-13-2021 17:31:03	Prakruthi S H	1KS18EC061	6th B	Mrs.V.Sangeetha	3	3	3	3	3
38	8-13-2021 17:39:28	Divakar babu y	1KS18EC026	6th A	Mrs.V.Sangeetha	2	2	2	2	2
39	8-13-2021 22:39:27	Krishnaprasad B	1KS19EC402	6th B	Mrs.V.Sangeetha	3	3	3	3	3
40	8-13-2021 22:39:43	Karthik B P	1KS19EC401	6th B	Mrs.V.Sangeetha	2	2	2	2	2
41	8-14-2021 13:48:52	NSV JASHWANTH	1KS18EC049	6th A	Mrs.V.Sangeetha	3	3	3	3	3
42	8-14-2021 15:45:18	Sindhu.G	1KS19EC408	6th B	Mrs.V.Sangeetha	3	3	3	3	3
43	8-15-2021 13:58:34	Monisha B R	1KS18EC048	6th A	Mrs.V.Sangeetha	3	3	3	3	3
44	8-16-2021 0:12:31	Shashank HK	1KS18EC080	6th B	Mrs.V.Sangeetha	3	3	2	2	2
45	8-16-2021 9:28:40	Thanushree D	1KS18EC098	6th B	Mrs.V.Sangeetha	3	2	2	2	3
46	8-17-2021 10:45:36	Ananya Ananth	1KS18EC009	6th A	Mrs.V.Sangeetha	3	3	3	3	3
47	8-17-2021 10:45:41	Mohammed Faizan S	1KS18EC047	6th A	Mrs.V.Sangeetha	2	2	2	2	2
48	8-17-2021 10:46:03	Chandan Y C	1KS18EC014	6th A	Mrs.V.Sangeetha	3	3	3	3	3
49	8-17-2021 10:46:29	P Sai Govardhan	1KS18EC057	6th A	Mrs.V.Sangeetha	3	2	3	3	3
50	8-17-2021 10:47:21	Janhavi K P	1KS18EC033	6th A	Mrs.V.Sangeetha	3	3	3	3	3
51	8-17-2021 10:47:34	Parikshith S	1KS18EC058	6th A	Mrs.V.Sangeetha	3	3	3	3	3
52	8-17-2021 10:47:53	S RAHUL	1KS18EC075	6th B	Mrs.V.Sangeetha	2	3	2	2	2
53	8-17-2021 10:50:02	Vasanth.pai.m	1KS18EC103	6th B	Mrs.V.Sangeetha	3	3	3	3	3
54	8-17-2021 10:51:37	Bhoomika	1KS18EC001	6th A	Mrs.V.Sangeetha	3	3	3	3	3
55	8-17-2021 10:52:11	AISHWARYA BAND	1KS18EC004	6thA	Mrs.V.Sangeetha	3	3	3	3	3
56	8-17-2021 10:54:39	Aishwarya. R	1KS18EC005	6th A	Mrs.V.Sangeetha	3	3	3	3	3
57	8-17-2021 10:56:31	Harshitha S	1KS18EC031	6th A	Mrs.V.Sangeetha	3	3	3	3	3
58	8-17-2021 10:58:09	Somashekar M	1KS18EC090	6th B	Mrs.V.Sangeetha	2	2	2	2	2
59	8-17-2021 10:58:26	Nihiha	1KS18EC041	6th A	Mrs.V.Sangeetha	2	2	2	2	2
60	8-17-2021 10:58:42	Gokul.G	1KS18EC029	6th A	Mrs.V.Sangeetha	3	2	2	2	2
61	8-17-2021 11:00:10	S manoj	1KS18EC074	6th B	Mrs.V.Sangeetha	3	2	2	2	2
62	8-17-2021 11:06:04	Ganesh P	1KS18EC028	6th A	Mrs.V.Sangeetha	3	3	3	3	3
63	8-17-2021 11:10:22	Charan G	1KS18EC015	6th A	Mrs.V.Sangeetha	3	3	3	3	3
64	8-17-2021 11:13:10	Vrindha Sham Bhatt	1KS18EC111	6th B	Mrs.V.Sangeetha	2	2	2	2	2
65	8-17-2021 11:20:32	C A Sushma	1KS18EC012	6th A	Mrs.V.Sangeetha	2	2	2	2	2
					Mrs.V.Sangeetha	3	2	2	2	2
					Mrs.V.Sangeetha	3	2	2	2	2
					Mrs.V.Sangeetha	3	3	3	3	3
					Mrs.V.Sangeetha	3	3	3	3	3

66	8-17-2021 11:21:30	Harsh Sharma	1KS18EC030	6th A	Mrs.V.Sangeetha	3	3	3	3	3
67	8-17-2021 11:23:37	RAGHOTHAM C G	1KS19EC406	6th B	Mrs.V.Sangeetha	3	3	3	3	3
68	8-17-2021 11:24:11	Varshini BM	1KS18EC102	6th B	Mrs.V.Sangeetha	3	3	3	3	3
69	8-17-2021 11:25:15	Dinesh Kumar Nayal	1KS18EC025	6th A	Mrs.V.Sangeetha	3	3	3	3	3
70	8-17-2021 11:37:13	Nagshree.a	1KS18EC051	6th A	Mrs.V.Sangeetha	2	2	3	2	3
71	8-17-2021 11:38:31	Jishnu S	1KS18EC035	6th A	Mrs.V.Sangeetha	2	2	2	2	2
72	8-17-2021 12:11:41	Vishal .M	1KS18EC108	6th	Mrs.V.Sangeetha	2	2	2	2	2
73	8-17-2021 12:27:49	Adithi S	1KS18EC003	6th A	Mrs.V.Sangeetha	2	2	2	2	2
74	8-17-2021 12:47:24	Hemantha.V	1KS19EC400	6th B	Mrs.V.Sangeetha	2	2	2	2	2
75	8-17-2021 13:35:33	Raghu B T	1KS18EC067	6th B	Mrs.V.Sangeetha	3	2	2	2	2
76	8-17-2021 15:35:06	Sadhana M	1KS19EC407	6th B	Mrs.V.Sangeetha	3	3	3	3	3
77	8-17-2021 15:38:39	Rajath S Bhushan	1KS18EC069	6th B	Mrs.V.Sangeetha	3	3	3	3	3
78	8-17-2021 16:40:41	Raghavendra K P	1KS18EC066	6th B	Mrs.V.Sangeetha	2	2	2	2	2
79	8-17-2021 17:04:59	Manoj G S	1KS18EC043	6th A	Mrs.V.Sangeetha	3	3	3	3	3
80	8-17-2021 19:27:32	Pruthvi Dinesh	1KS19EC405	6th B	Mrs.V.Sangeetha	3	3	3	3	3
81	8-17-2021 19:54:12	Suraj V Ghorpade	1KS18EC094	6th B	Mrs.V.Sangeetha	3	3	3	3	3
82	8-18-2021 9:59:11	SUDHEER B	1KS18EC091	6th B	Mrs.V.Sangeetha	3	2	3	3	2
					No.of 1s	**0**	**0**	**1**	**1**	**0**
					Total	**82**	**82**	**82**	**82**	**82**
					percentage	**100**	**100**	**98.78**	**98.7805**	**100**
					Average	**99.5122**				

K.S. INSTITUTE OF TECHNOLOGY, BANGALORE
DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGG

YEAR / SEMESTER	III/VI
COURSE TITLE	Digital Communication
COURSE CODE	18EC61
ACADEMIC YEAR	2020-21
BATCH	2018-22

O	Significance
Le vel	and above students should have scored >= 60% of Total
Le vel	to 59% of students should have scored >= 60% of Total
vel 1	to 54% of students should have scored >= 60% of Total

For Direct attainment , 50% of CIE and 50% of SEE marks are consider
For indirect attainment, Course end survey is considered.
CO attainment is 90%of direct attainment + 10% of Indirect atttainm
PO attainment = CO-PO mapping strength/3 * CO attainment .

Sl. N O.	USN	NAME	IA1							Assignment 1							IA2										Assignment 2										IA3							Assignment 3							EXTERNAL MARKS			
			IA1	CO 1	Scores	Target 60%	CO 2	Scores	Target 60 %	A1	CO 1	Scores	Target 60%	CO 2	Scores	Target 60%	IA2	CO 2	Scores	Target 60 %	CO 3	Scores	Target 60 %	CO 4	Scores	Target 60 %	A2	CO 2	Scores	Target 60%	CO 3	Scores	Target 60 %	CO 4	Scores	Target 60%	IA3	CO 4	Scores	Target 60%	CO 5	Scores	Target 60 %	A3	CO 4	Scores	Target 60 %	CO 5	Scores	Target 60 %	SEE	SEE	Scores	Target 60 %
	Maximum Marks		30	18			12			10	6			4			30	6			18			6			10	2			6			2			30	12			18			10	6			4			50	60		
1	1KS18EC00	A N BHOOMIKA	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	29	6	3	Y	17	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	30	12	3	Y	18	3	Y	10	6	3	Y	4	3	Y	35	42	3	Y
2	1KS18EC00	ABHISHEK.V	28	16	3	Y	12	3	Y	10	6	3	Y	4	3	Y	23	6	3	Y	17	3	Y	0	0	N	10	2	3	Y	6	3	Y	2	3	Y	30	12	3	Y	18	3	Y	10	6	3	Y	4	3	Y	32	38	3	Y
3	1KS18EC00	ADITHI.S	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	27	6	3	Y	16	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	27	11	3	Y	16	3	Y	10	6	3	Y	4	3	Y	28	34	2	N
4	1KS18EC00	AISHWARYA BANDIGANI	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	28	6	3	Y	17	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	26	10	3	Y	16	3	Y	8	4	3	Y	4	3	Y	26	31	1	N
5	1KS18EC00	AISHWARYA R	28	16	3	Y	12	3	Y	10	6	3	Y	4	3	Y	23	6	3	Y	11	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	28	11	3	Y	17	3	Y	10	6	3	Y	4	3	Y	29	35	2	N
6	1KS18EC00	AKASH R	27	15	3	Y	12	3	Y	10	6	3	Y	4	3	Y	22	6	3	Y	11	3	Y	5	3	Y	9	1	1	N	6	3	Y	2	3	Y	27	11	3	Y	16	3	Y	10	6	3	Y	4	3	Y	23	28	0	N
7	1KS18EC00	AKHILA V	25	13	3	Y	12	3	Y	10	6	3	Y	4	3	Y	20	6	3	Y	9	1	N	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	22	5	0	N	17	3	Y	9	5	3	Y	4	3	Y	28	34	2	N
8	1KS18EC00	ANAGHA S	24	13	3	Y	11	3	Y	10	6	3	Y	4	3	Y	21	6	3	Y	10	2	N	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	29	11	3	Y	18	3	Y	10	6	3	Y	4	3	Y	27	32	1	N
9	1KS18EC00	ANANYA ANANTH	28	16	3	Y	12	3	Y	10	6	3	Y	4	3	Y	26	6	3	Y	15	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	26	9	3	Y	17	3	Y	10	6	3	Y	4	3	Y	26	31	1	N
10	1KS18EC01	ASHRITHA S C	28	16	3	Y	12	3	Y	10	6	3	Y	4	3	Y	26	6	3	Y	15	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	27	10	3	Y	17	3	Y	10	6	3	Y	4	3	Y	29	35	2	N
11	1KS18EC01	AYEESHA RUMAN	28	16	3	Y	12	3	Y	10	6	3	Y	4	3	Y	27	6	3	Y	16	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	28	11	3	Y	17	3	Y	10	6	3	Y	4	3	Y	29	35	2	N
12	1KS18EC01	C A SUSHMA	28	16	3	Y	12	3	Y	10	6	3	Y	4	3	Y	27	6	3	Y	16	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	28	11	3	Y	17	3	Y	10	6	3	Y	4	3	Y	22	26	0	N
13	1KS18EC01	C M CHAITHANY	22	12	3	Y	10	3	Y	8	4	3	Y	4	3	Y	21	5	3	Y	14	3	Y	2	0	N	8	1	1	N	5	3	Y	2	3	Y	25	11	3	Y	14	3	Y	8	4	3	Y	4	3	Y	13	16	0	N
14	1KS18EC01	CHANDAN Y C	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	25	5	3	Y	15	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	29	12	3	Y	17	3	Y	10	6	3	Y	4	3	Y	29	35	2	N
15	1KS18EC01	CHARAN G	26	14	3	Y	12	3	Y	10	6	3	Y	4	3	Y	26	6	3	Y	15	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	28	11	3	Y	17	3	Y	10	6	3	Y	4	3	Y	26	31	1	N
16	1KS18EC01	CHINNAPU CHARAN	27	15	3	Y	12	3	Y	10	6	3	Y	4	3	Y	21	6	3	Y	10	2	N	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	27	11	3	Y	16	3	Y	9	5	3	Y	4	3	Y	26	31	1	N
17	1KS18EC01	CHITHRITH A G R	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	28	6	3	Y	17	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	29	11	3	Y	18	3	Y	10	6	3	Y	4	3	Y	34	41	3	Y
18	1KS18EC01	DARSHAN V	28	16	3	Y	12	3	Y	10	6	3	Y	4	3	Y	23	4	3	Y	14	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	27	11	3	Y	16	3	Y	10	6	3	Y	4	3	Y	25	30	1	N
19	1KS18EC01	DARSHAN S	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	25	6	3	Y	13	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	27	12	3	Y	15	3	Y	10	6	3	Y	4	3	Y	35	42	3	Y
20	1KS18EC02	DEEKSHA S N	28	16	3	Y	12	3	Y	10	6	3	Y	4	3	Y	21	6	3	Y	10	2	N	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	28	11	3	Y	17	3	Y	10	6	3	Y	4	3	Y	20	24	0	N
21	1KS18EC02	DEEPTHI ANDANI	27	15	3	Y	12	3	Y	10	6	3	Y	4	3	Y	22	5	3	Y	12	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	26	11	3	Y	15	3	Y	10	6	3	Y	4	3	Y	30	36	3	Y
22	1KS18EC02	DHANUSHREE C	28	16	3	Y	12	3	Y	10	6	3	Y	4	3	Y	27	6	3	Y	16	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	29	11	3	Y	18	3	Y	10	6	3	Y	4	3	Y	21	25	0	N
23	1KS18EC02	DHEERAJ M S	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	29	6	3	Y	17	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	30	12	3	Y	18	3	Y	10	6	3	Y	4	3	Y	39	47	3	Y
24	1KS18EC02	DHRITHIRHUTH	28	16	3	Y	12	3	Y	10	6	3	Y	4	3	Y	26	6	3	Y	15	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	29	12	3	Y	17	3	Y	10	6	3	Y	4	3	Y	25	30	1	N

25	1KS18EC02	DINESH KUMAR	26	14	3	Y	12	3	Y	10	6	3	Y	4	3	Y	22	6	3	Y	11	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	28	11	3	Y	17	3	Y	10	6	3	Y	4	3	Y	31	37	3	Y
26	1KS18EC02	DIVAKARBABU Y	26	15	3	Y	11	3	Y	10	6	3	Y	4	3	Y	26	6	3	Y	15	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	28	11	3	Y	17	3	Y	9	5	3	Y	4	3	Y	32	38	3	Y
27	1KS18EC02	G.J.NITHIN	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	29	6	3	Y	17	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	28	11	3	Y	17	3	Y	9	5	3	Y	4	3	Y	26	31	1	N
28	1KS18EC02	GANESH P	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	29	6	3	Y	17	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	28	11	3	Y	17	3	Y	10	6	3	Y	4	3	Y	34	41	3	Y
29	1KS18EC02	GOKUL G	26	14	3	Y	12	3	Y	10	6	3	Y	4	3	Y	28	6	3	Y	16	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	26	12	3	Y	14	3	Y	10	6	3	Y	4	3	Y	31	37	3	Y
30	1KS18EC03	HARSH SHARMA	28	16	3	Y	12	3	Y	10	6	3	Y	4	3	Y	27	6	3	Y	16	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	28	11	3	Y	17	3	Y	10	6	3	Y	4	3	Y	37	44	3	Y
31	1KS18EC03	HARSHITHA S	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	28	6	3	Y	16	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	15	0	0	N	15	3	Y	10	6	3	Y	4	3	Y	39	47	3	Y
32	1KS18EC03	JAHNAVI A P	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	25	6	3	Y	14	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	27	11	3	Y	16	3	Y	9	5	3	Y	4	3	Y	27	32	1	N
33	1KS18EC03	JANHAVI K P	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	26	6	3	Y	15	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	28	11	3	Y	17	3	Y	10	6	3	Y	4	3	Y	26	31	1	N
34	1KS18EC03	JHANAVI V	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	27	6	3	Y	16	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	28	11	3	Y	17	3	Y	10	6	3	Y	4	3	Y	24	29	0	N
35	1KS18EC03	JISHNU S	28	16	3	Y	12	3	Y	10	6	3	Y	4	3	Y	26	6	3	Y	15	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	28	11	3	Y	17	3	Y	10	6	3	Y	4	3	Y	36	43	3	Y
36	1KS18EC03	JYOTSNA B UPADHYE	27	15	3	Y	12	3	Y	9	5	3	Y	4	3	Y	28	6	3	Y	17	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	28	11	3	Y	17	3	Y	10	6	3	Y	4	3	Y	30	36	3	Y
37	1KS18EC03	K RISHIKA RAVI	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	21	6	3	Y	10	2	N	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	27	11	3	Y	16	3	Y	9	5	3	Y	4	3	Y	26	31	1	N
38	1KS18EC03	KARISHMA M	28	16	3	Y	12	3	Y	10	6	3	Y	4	3	Y	26	6	3	Y	15	3	Y	5	3	Y	9	1	1	N	6	3	Y	2	3	Y	26	10	3	Y	16	3	Y	10	6	3	Y	4	3	Y	24	29	0	N
39	1KS18EC03	KOMALA K V	28	16	3	Y	12	3	Y	10	6	3	Y	4	3	Y	27	6	3	Y	16	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	27	11	3	Y	16	3	Y	10	6	3	Y	4	3	Y	22	26	0	N
40	1KS18EC04	LAVANYA M	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	25	6	3	Y	14	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	27	10	3	Y	17	3	Y	10	6	3	Y	4	3	Y	29	35	2	N
41	1KS18EC04	M.NIHITHA YADAV	28	16	3	Y	12	3	Y	10	6	3	Y	4	3	Y	26	6	3	Y	15	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	28	11	3	Y	17	3	Y	10	6	3	Y	4	3	Y	33	40	3	Y
42	1KS18EC04	MAHANTH SAI M	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	26	6	3	Y	15	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	27	11	3	Y	16	3	Y	10	6	3	Y	4	3	Y	28	34	2	N
43	1KS18EC04	MANOJ G S	27	15	3	Y	12	3	Y	8	4	3	Y	4	3	Y	14	0	0	N	9	1	N	5	3	Y	8	1	1	N	5	3	Y	2	3	Y	25	10	3	Y	15	3	Y	9	5	3	Y	4	3	Y	29	35	2	N
44	1KS18EC04	MEGHA R	26	16	3	Y	10	3	Y	10	6	3	Y	4	3	Y	26	6	3	Y	14	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	28	11	3	Y	17	3	Y	10	6	3	Y	4	3	Y	27	32	1	N
45	1KS18EC04	MEGHANA B S	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	29	6	3	Y	17	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	29	12	3	Y	17	3	Y	10	6	3	Y	4	3	Y	26	31	1	N
46	1KS18EC04	MEGHANA GOWDA V	28	16	3	Y	12	3	Y	10	6	3	Y	4	3	Y	27	6	3	Y	16	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	28	11	3	Y	17	3	Y	9	5	3	Y	4	3	Y	27	32	1	N
47	1KS18EC04	MOHAMMED FAIZAN	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	26	6	3	Y	15	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	27	10	3	Y	17	3	Y	10	6	3	Y	4	3	Y	24	29	0	N
48	1KS18EC04	MONISHA B R	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	28	6	3	Y	17	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	27	11	3	Y	16	3	Y	10	6	3	Y	4	3	Y	33	40	3	Y
49	1KS18EC04	N S V JASHWANT	28	16	3	Y	12	3	Y	10	6	3	Y	4	3	Y	27	6	3	Y	15	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	27	10	3	Y	17	3	Y	10	6	3	Y	4	3	Y	33	40	3	Y
50	1KS18EC05	NAGA OMKAR N	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	29	6	3	Y	17	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	29	12	3	Y	17	3	Y	10	6	3	Y	4	3	Y	38	46	3	Y
51	1KS18EC05	NAGASHREE A	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	26	6	3	Y	15	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	29	11	3	Y	18	3	Y	10	6	3	Y	4	3	Y	34	41	3	Y
52	1KS18EC05	NAMITH R	28	16	3	Y	12	3	Y	10	6	3	Y	4	3	Y	28	6	3	Y	16	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	27	10	3	Y	17	3	Y	10	6	3	Y	4	3	Y	22	26	0	N
53	1KS18EC05	NAVYA M S	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	27	6	3	Y	15	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	28	12	3	Y	16	3	Y	9	5	3	Y	4	3	Y	27	32	1	N
54	1KS18EC05	NIHARIKA S A	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	28	6	3	Y	16	3	Y	6	3	Y	9	1	1	N	6	3	Y	2	3	Y	29	11	3	Y	18	3	Y	10	6	3	Y	4	3	Y	35	42	3	Y
55	1KS18EC05	NIROSHA G J	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	21	6	3	Y	9	1	N	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	28	11	3	Y	17	3	Y	9	5	3	Y	4	3	Y	25	30	1	N
56	1KS18EC05	NISHANTH J RAO	28	16	3	Y	12	3	Y	10	6	3	Y	4	3	Y	24	6	3	Y	12	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	27	10	3	Y	17	3	Y	9	5	3	Y	4	3	Y	21	25	0	N
57	1KS18EC05	P SAI GOVARDHA	28	16	3	Y	12	3	Y	10	6	3	Y	4	3	Y	28	6	3	Y	16	3	Y	6	3	Y	9	1	1	N	6	3	Y	2	3	Y	28	10	3	Y	18	3	Y	10	6	3	Y	4	3	Y	32	38	3	Y
58	1KS18EC05	PARIKSHITH S	28	16	3	Y	12	3	Y	10	6	3	Y	4	3	Y	29	6	3	Y	17	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	29	11	3	Y	18	3	Y	10	6	3	Y	4	3	Y	34	41	3	Y
59	1KS18EC05	PAVAN KUMAR P	28	16	3	Y	12	3	Y	10	6	3	Y	4	3	Y	21	6	3	Y	10	2	N	5	3	Y	9	1	1	N	6	3	Y	2	3	Y	26	11	3	Y	15	3	Y	8	4	3	Y	4	3	Y	21	25	0	N
60	1KS18EC06	POOJA S	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	27	6	3	Y	15	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	28	11	3	Y	17	3	Y	10	6	3	Y	4	3	Y	32	38	3	Y
61	1KS18EC06	PRAKRUTHI S H	26	14	3	Y	12	3	Y	10	6	3	Y	4	3	Y	19	6	3	Y	8	0	N	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	27	10	3	Y	17	3	Y	10	6	3	Y	4	3	Y	30	36	3	Y
62	1KS18EC06	PUNEETH M	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	26	6	3	Y	15	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	24	8	3	Y	16	3	Y	9	5	3	Y	4	3	Y	29	35	2	N
63	1KS18EC06	PURUSHOTHAM V R	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	26	6	3	Y	15	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	28	11	3	Y	17	3	Y	10	6	3	Y	4	3	Y	29	35	2	N
64	1KS18EC06	RAGHAVENDRA.K.P	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	27	6	3	Y	17	3	Y	4	3	Y	10	2	3	Y	6	3	Y	2	3	Y	28	11	3	Y	17	3	Y	10	6	3	Y	4	3	Y	33	40	3	Y
65	1KS18EC06	RAGHU B T	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	26	6	3	Y	15	3	Y	5	3	Y	9	1	1	N	6	3	Y	2	3	Y	28	11	3	Y	17	3	Y	10	6	3	Y	4	3	Y	30	36	3	Y

66	1KS18EC06	RAJ KRISHNA	28	16	3	Y	12	3	Y	10	6	3	Y	4	3	Y	27	6	3	Y	15	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	25	11	3	Y	14	3	Y	10	6	3	Y	4	3	Y	26	31	1	N
67	1KS18EC06	RAJATH S BHUSHAN	16	11	3	Y	5	0	N	10	6	3	Y	4	3	Y	20	6	3	Y	14	3	Y	0	0	N	10	2	3	Y	6	3	Y	2	3	Y	24	6	1	N	18	3	Y	10	6	3	Y	4	3	Y	19	23	0	N
68	1KS18EC07	RAM BAHADUR	27	15	3	Y	12	3	Y	10	6	3	Y	4	3	Y	25	6	3	Y	14	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	28	11	3	Y	17	3	Y	10	6	3	Y	4	3	Y	22	26	0	N
69	1KS18EC07	RASETTY SANDEEP	26	14	3	Y	12	3	Y	9	5	3	Y	4	3	Y	26	5	3	Y	16	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	24	10	3	Y	14	3	Y	8	4	3	Y	4	3	Y	21	25	0	N
70	1KS18EC07	RITHVIK P	28	16	3	Y	12	3	Y	10	6	3	Y	4	3	Y	27	6	3	Y	16	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	28	11	3	Y	17	3	Y	10	6	3	Y	4	3	Y	31	37	3	Y
71	1KS18EC07	S MANOJ	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	24	6	3	Y	13	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	28	11	3	Y	17	3	Y	10	6	3	Y	4	3	Y	32	38	3	Y
72	1KS18EC07	S RAHUL	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	27	6	3	Y	16	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	25	10	3	Y	15	3	Y	9	5	3	Y	4	3	Y	28	34	2	N
73	1KS18EC07	S TUSHAR HARINATH	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	28	6	3	Y	16	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	28	11	3	Y	17	3	Y	10	6	3	Y	4	3	Y	29	35	2	N
74	1KS18EC07	SAGAR T C	26	15	3	Y	11	3	Y	10	6	3	Y	4	3	Y	21	6	3	Y	10	2	N	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	26	11	3	Y	15	3	Y	9	5	3	Y	4	3	Y	22	26	0	N
75	1KS18EC07	SANJANA B	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	21	6	3	Y	9	1	N	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	29	11	3	Y	18	3	Y	9	5	3	Y	4	3	Y	32	38	3	Y
76	1KS18EC07	SANKET B PASCHAPUR	28	16	3	Y	12	3	Y	10	6	3	Y	4	3	Y	21	6	3	Y	10	2	N	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	25	8	3	Y	17	3	Y	9	5	3	Y	4	3	Y	23	28	0	N
77	1KS18EC08	SHASHANK H K	28	16	3	Y	12	3	Y	8	4	3	Y	4	3	Y	20	6	3	Y	9	1	N	5	3	Y	9	1	1	N	6	3	Y	2	3	Y	22	10	3	Y	12	3	Y	8	4	3	Y	4	3	Y	23	28	0	N
78	1KS18EC08	SHEETAL N GOWDA	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	26	6	3	Y	15	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	28	11	3	Y	17	3	Y	10	6	3	Y	4	3	Y	37	44	3	Y
79	1KS18EC08	SHIVA SHANKAR.B	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	27	6	3	Y	16	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	28	11	3	Y	17	3	Y	10	6	3	Y	4	3	Y	28	34	2	N
80	1KS18EC08	SHREYA V DEV	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	28	6	3	Y	16	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	26	11	3	Y	15	3	Y	9	5	3	Y	4	3	Y	24	29	0	N
81	1KS18EC08	SHREYAS C	28	16	3	Y	12	3	Y	10	6	3	Y	4	3	Y	27	6	3	Y	16	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	28	11	3	Y	17	3	Y	10	6	3	Y	4	3	Y	30	36	3	Y
82	1KS18EC08	SHREYAS D R	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	29	6	3	Y	17	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	28	11	3	Y	17	3	Y	10	6	3	Y	4	3	Y	32	38	3	Y
83	1KS18EC08	SHRIKANTH C K	28	16	3	Y	12	3	Y	10	6	3	Y	4	3	Y	20	6	3	Y	9	1	N	5	3	Y	9	1	1	N	6	3	Y	2	3	Y	26	10	3	Y	16	3	Y	9	5	3	Y	4	3	Y	20	24	0	N
84	1KS18EC08	SIRI RAVINATH	27	15	3	Y	12	3	Y	10	6	3	Y	4	3	Y	20	6	3	Y	9	1	N	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	27	11	3	Y	16	3	Y	10	6	3	Y	4	3	Y	25	30	1	N
85	1KS18EC08	SIRISHA.M	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	29	6	3	Y	17	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	29	11	3	Y	18	3	Y	9	5	3	Y	4	3	Y	37	44	3	Y
86	1KS18EC09	SOMASHEKAR M	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	25	6	3	Y	14	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	28	11	3	Y	17	3	Y	9	5	3	Y	4	3	Y	34	41	3	Y
87	1KS18EC09	SUDHEER B	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	27	6	3	Y	16	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	29	11	3	Y	18	3	Y	10	6	3	Y	4	3	Y	35	42	3	Y
88	1KS18EC09	SUJAY R	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	26	6	3	Y	15	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	29	11	3	Y	18	3	Y	10	6	3	Y	4	3	Y	31	37	3	Y
89	1KS18EC09	SUPRIYA S	28	16	3	Y	12	3	Y	10	6	3	Y	4	3	Y	22	6	3	Y	11	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	27	10	3	Y	17	3	Y	10	6	3	Y	4	3	Y	32	38	3	Y
90	1KS18EC09	SURAJ V GHORPADE	28	16	3	Y	12	3	Y	10	6	3	Y	4	3	Y	29	6	3	Y	17	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	29	11	3	Y	18	3	Y	10	6	3	Y	4	3	Y	36	43	3	Y
91	1KS18EC09	SUSHMA.A V	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	27	6	3	Y	16	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	27	10	3	Y	17	3	Y	10	6	3	Y	4	3	Y	31	37	3	Y
92	1KS18EC09	SUSHMITHA R	28	16	3	Y	12	3	Y	10	6	3	Y	4	3	Y	20	6	3	Y	9	1	N	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	28	11	3	Y	17	3	Y	10	6	3	Y	4	3	Y	35	42	3	Y
93	1KS18EC09	THANUSH R S	27	15	3	Y	12	3	Y	10	6	3	Y	4	3	Y	21	6	3	Y	10	2	N	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	27	11	3	Y	16	3	Y	10	6	3	Y	4	3	Y	28	34	2	N
94	1KS18EC09	THANUSHREE D	28	17	3	Y	11	3	Y	10	6	3	Y	4	3	Y	26	6	3	Y	15	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	29	11	3	Y	18	3	Y	10	6	3	Y	4	3	Y	31	37	3	Y
95	1KS18EC09	VAISHNAVI G	27	17	3	Y	10	3	Y	10	6	3	Y	4	3	Y	22	6	3	Y	11	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	28	11	3	Y	17	3	Y	10	6	3	Y	4	3	Y	27	32	1	N
96	1KS18EC10	VAKKALA GADDA	25	14	3	Y	11	3	Y	9	5	3	Y	4	3	Y	26	6	3	Y	16	3	Y	4	3	Y	8	1	1	N	5	3	Y	2	3	Y	16	6	1	N	10	2	N	8	4	3	Y	4	3	Y	17	20	0	N
97	1KS18EC10	VANDANA K	28	16	3	Y	12	3	Y	10	6	3	Y	4	3	Y	20	6	3	Y	9	1	N	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	27	11	3	Y	16	3	Y	10	6	3	Y	4	3	Y	30	36	3	Y
98	1KS18EC10	VARSHINI.B .M	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	27	6	3	Y	16	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	29	11	3	Y	18	3	Y	10	6	3	Y	4	3	Y	30	36	3	Y
99	1KS18EC10	VASANTH PAI.M	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	28	6	3	Y	16	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	28	11	3	Y	17	3	Y	10	6	3	Y	4	3	Y	21	25	0	N
#	1KS18EC10	VIJAY BABU K	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	19	6	3	Y	8	0	N	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	23	6	1	N	17	3	Y	10	6	3	Y	4	3	Y	28	34	2	N
#	1KS18EC10	VINAY K	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	26	6	3	Y	16	3	Y	4	3	Y	10	2	3	Y	6	3	Y	2	3	Y	28	11	3	Y	17	3	Y	9	5	3	Y	4	3	Y	28	34	2	N
#	1KS18EC10	VINAY S	29	17	3	Y	12	3	Y	9	5	3	Y	4	3	Y	26	6	3	Y	16	3	Y	4	3	Y	10	2	3	Y	6	3	Y	2	3	Y	27	11	3	Y	16	3	Y	10	6	3	Y	4	3	Y	28	34	2	N
#	1KS18EC10	VISHAL MADHUSUD	28	16	3	Y	12	3	Y	10	6	3	Y	4	3	Y	28	6	3	Y	16	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	28	11	3	Y	17	3	Y	10	6	3	Y	4	3	Y	27	32	1	N
#	1KS18EC10	VISHWAS P	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	24	3	1	N	15	3	Y	6	3	Y	10	2	3	Y	6	3	Y	2	3	Y	29	11	3	Y	18	3	Y	9	5	3	Y	4	3	Y	24	29	0	N
#	1KS18EC11	VIVEKGOWDA J	28	16	3	Y	12	3	Y	10	6	3	Y	4	3	Y	26	6	3	Y	15	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	27	11	3	Y	16	3	Y	10	6	3	Y	4	3	Y	29	35	2	N
#	1KS18EC11	VRINDHA SHAM	29	17	3	Y	12	3	Y	10	6	3	Y	4	3	Y	26	6	3	Y	15	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	29	11	3	Y	18	3	Y	10	6	3	Y	4	3	Y	34	41	3	Y

#	1KS19EC40	HEMANTHA V	27	15	3	Y	12	3	Y	10	6	3	Y	4	3	Y	20	6	3	Y	10	2	N	4	3	Y	10	2	3	Y	6	3	Y	2	3	Y	27	11	3	Y	16	3	Y	9	5	3	Y	4	3	Y	19	23	0	N
#	1KS19EC40	KARTHIK B P	27	15	3	Y	12	3	Y	10	6	3	Y	4	3	Y	20	6	3	Y	9	1	N	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	27	11	3	Y	16	3	Y	9	5	3	Y	4	3	Y	21	25	0	N
#	1KS19EC40	KRISHNAPRASAD B	25	13	3	Y	12	3	Y	10	6	3	Y	4	3	Y	21	6	3	Y	10	2	N	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	22	8	3	Y	14	3	Y	10	6	3	Y	4	3	Y	23	28	0	N
#	1KS19EC40	NAVEEN G	27	15	3	Y	12	3	Y	10	6	3	Y	4	3	Y	26	6	3	Y	16	3	Y	4	3	Y	10	2	3	Y	6	3	Y	2	3	Y	22	6	1	N	16	3	Y	10	6	3	Y	4	3	Y	23	28	0	N
#	1KS19EC40	PRUTHVI DINESH	27	15	3	Y	12	3	Y	10	6	3	Y	4	3	Y	24	6	3	Y	15	3	Y	3	1	N	10	2	3	Y	6	3	Y	2	3	Y	26	10	3	Y	16	3	Y	9	5	3	Y	4	3	Y	21	25	0	N
#	1KS19EC40	RAGHOTHA M C G	28	16	3	Y	12	3	Y	10	6	3	Y	4	3	Y	28	6	3	Y	17	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	28	11	3	Y	17	3	Y	10	6	3	Y	4	3	Y	19	23	0	N
#	1KS19EC40	SADANA M	28	16	3	Y	12	3	Y	10	6	3	Y	4	3	Y	25	5	3	Y	15	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	26	10	3	Y	16	3	Y	9	6	3	Y	4	3	Y	15	18	0	N
#	1KS19EC40	SINDHU G	28	16	3	Y	12	3	Y	10	6	3	Y	4	3	Y	25	6	3	Y	14	3	Y	5	3	Y	10	2	3	Y	6	3	Y	2	3	Y	25	9	3	Y	16	3	Y	10	6	3	Y	4	3	Y	17	20	0	N
#	1KS19EC40	VARSHA M S	22	18	3	Y	4	0	N	9	5	3	Y	4	3	Y	16	6	3	Y	10	2	N	0	0	N	10	2	3	Y	6	3	Y	2	3	Y	21	5	0	N	16	3	Y	10	6	3	Y	4	3	Y	26	31	1	N
	CO				CO1			CO2				CO1			CO2				CO2			CO3			CO4				CO2			CO			CO4				CO4			CO5				CO4			CO5				SEE	
	Number of Not Attemp					0			0				0			0				0			0			0				0			0			0				0			0				0			0				0
	Score index & No of Y				3	115		2.9	##			3.0	115		3	115			3	80		3	92			##			3	104		3	##		3	115			3	108		3	##			3	##		3	115			1.7	44
	No. of N's					0			2				0			0				1			23			5				11			0			0				7			1				0			0				71
	CO Attainment					100			98				100			100				99			80			96				90			##			100				94			99				##			100				38
	Level					3			3				3			3				3			3							3			3							3			3				3			3				0

CO	CIE	SEE	DIRECT ATTAINMENT	Level	INDIRECT ATTAINMENT	Final Att
CO1	100.00	38	69.13	3	3	3
CO2	96.87	38	67.56	3	3	3
CO3	90.00	38	64.13	3	3	3
CO4	97.39	38	67.83	3	3	3
CO5	99.57	38	68.91	3	3	3
AVERAGE						3.0

CO	Score index out of 3
CO1	2.33
CO2	2.52
CO3	2.17
CO4	2.26
CO5	2.33

Co-Po Mapping Table

CO'S	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	_	_	_	_	_	_	_	_	_	3	2
CO2	3	2	1	_	_	_	_	_	_	_	_	_	3	2
CO3	3	2	_	_	_	_	_	_	_	_	_	_	3	2
CO4	3	2	1	_	_	_	_	_	_	_	_	_	3	2
CO5	3	2	1	_	_	_	_	_	_	_	_	_	3	2
AVG	3.00	2.0	1.0	_	_	_	_	_	_	_	_	_	3.0	2.0

PO Attainment

CO'S	CO Attainment	CO RESULT	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3.0	Y	3.0	2.0	##	_	_	_	_	_	_	_	_	_	#	##
CO2	3.0	Y	3.0	2.0	##	_	_	_	_	_	_	_	_	_	#	##
CO3	3.0	Y	3.0	2.0	_	_	_	_	_	_	_	_	_	_	#	##
CO4	3.0	Y	3.0	2.0	##	_	_	_	_	_	_	_	_	_	#	##
CO5	3.0	Y	3.0	2.0	##	_	_	_	_	_	_	_	_	_	#	##
Average			3	2	1	_	_	_	_	_	_	_	_	_	3	2

Module - 2

Signaling over AWGN Channels

The conversion of analog waveforms into coded pulses represents the transition from analog communications to digital communications.

This transition has been empowered by several factors:

1) Ever- increasing advancement of digital silicon chips, digital signal processing, and computers, which in turn, has prompted further enhancement in digital silicon chips, thereby repeating the cycle of improvement.
2) Improved reliability, which is afforded by digital communications to a much greater extent than is possible with analog communications.
3) Broadened range of multiplexing of users, which is enabled by the use of digital modulation techniques.
4) Communication networks, for which in one form or another, the use of digital ~~modulation~~ ~~techniques~~. communications is the preferred choice.

For an illustrative example, consider the remote connection of two digital computers, with one computer acting as the information source by calculating digital outputs based on observations and inputs fed into it;

* The other computer acts as the recipient of the information. The source o/p consists of a sequence of 1s & 0s, with each binary symbol being emitted every T_b seconds.

* The transmitting part of the digital communication system takes the 1s and 0s emitted by the source computer and encodes them into distinct signals denoted by $s_1(t)$ and $s_2(t)$, respectively, which are suitable for transmission over the analog channel.

Geometric Representation of signals

Representation of signals as vectors is generally known as geometric representation of signals.

* A set of M finite energy signals $s_i(t)$, $i=1,2\dots M$ defined over the time interval $0 \le t \le T$ seconds of which $N \le M$ signals are linearly independent, then each signal $s_i(t)$ can be represented as a linear combination of 'N' orthonormal functions $\phi_1(t), \phi_2(t) \dots \phi_N(t)$.
* Let there be M number of energy signals which forms the input signal set i.e,

$$S_i(t) = \{ S_1(t), S_2(t) \dots S_M(t) \}$$

* Let these signals be represented interms of 'N' number of orthonormal basis functions.

i.e $$\phi_j(t) = \{ \phi_1(t), \phi_2(t) \dots \phi_N(t) \}.$$

Then the linear relationship between $S_i(t)$ and $\phi_j(t)$ can be written as,

$$S_i(t) = S_{i1}\phi_1(t) + S_{i2}\phi_2(t) \dots S_{iN}\phi_N(t)$$

$$= \sum_{j=1}^{N} S_{ij}\phi_j(t), \quad \begin{cases} 0 \le t \le T, \\ i = 1,2\dots M. \end{cases}$$

where, S_{ij} called coefficients of expansion and defined as,

$$S_{ij} = \int_0^T S_i(t)\,\phi_j(t)\,dt \quad \begin{cases} i = 1,2\dots M \\ j = 1,2,\dots N \end{cases}$$

Since the basis functions $\phi_1(t), \phi_2(t) \ldots \phi_N(t)$ are orthonormal they satisfy,

$$\int_0^T \phi_i(t)\phi_j(t)\,dt = \delta_{ij} = \begin{cases} 1 & \text{if } i=j \\ 0 & \text{if } i\neq j \end{cases}$$

where $\delta_{ij} \rightarrow$ Kronecker delta.

* The first condition of above equation states that each basis function is <u>normalized</u> to have <u>unit energy</u>.
* The second condition states that the basis functions $\phi_1(t), \phi_2(t) \ldots, \phi_N(t)$ are orthogonal with respect to each other over $0 \leq t \leq T$.

i.e $\int_0^T \phi_i(t)\phi_j(t)\,dt = 0.$

An Example of Two Dimensional Signal space with three symbols.

* Let us consider the vector space representation of $M=3$ message symbols with the help of $N=2$. orthonormal basis functions.

$$\therefore \quad s_i(t) = \sum_{j=1}^{2} s_{ij}(t)\phi_j(t). \qquad i=1,2,3.$$

$$= s_{i1}(t)\phi_1(t) + s_{i2}(t)\phi_2(t).$$

$$s_1(t) = s_{11}(t)\phi_1(t) + s_{12}(t)\phi_2(t)$$

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

$$s_3(t) = s_{31}(t)\phi_1(t) + s_{32}(t)\phi_2(t).$$

Note that each of $s_1(t)$, $s_2(t)$ or $s_3(t)$ are expressed interms of $\phi_1(t)$ and $\phi_2(t)$. Thus $s_1(t)$ can be represented as a vector in ϕ_1-ϕ_2 signal space.

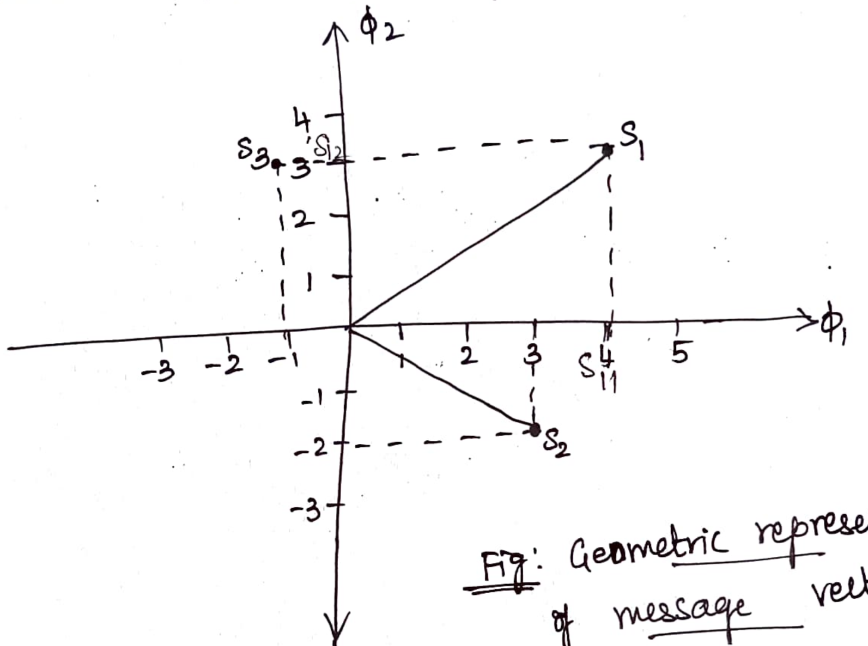


Fig: Geometric representation of message vectors.

* Above Fig. shows three message vectors s_1, s_2 & s_3. The position of these vectors depend upon the coefficients $s_{11}, s_{12}, s_{21}, s_{22}$ ... etc. Here ϕ_1 & ϕ_2 are perpendicular to each other, since they are orthogonal.
* The $\phi_1 - \phi_2$ signal is called Euclidean space. The above figure shows two dimensional Euclidean space.

Signal vector and signal space:-

Signal $s_i(t)$ can then be completely described by the vector s_i with its coefficients as defined below..

$$s_i = \begin{bmatrix} s_{i1} \\ s_{i2} \\ \vdots \\ s_{iN} \end{bmatrix}, \quad i = 1, 2 \cdots M.$$

* Vector s_i is called signal vector.
* s_i can also be regarded as a point with coordinates $s_{i1}, s_{i2} \cdots s_{iN}$ in an N-dimensional Euclidean space

Thus signal $s_1(t), \cdots s_M(t)$ can be considered as M points represented by vectors $s_1, s_2 \cdots s_M$ in an N dimensional Euclidean space with reference to the axes defined by $\phi_1, \phi_2 \cdots \phi_N$.

* The N dimensional Euclidean space is also called signal space and the representation of signals in an N-dimensional signal space is also called as signal constellation.

Absolute value (or) Norm of vector:-

Consider the vector s_i, which is completely determined by its coefficients. i.e.,

$$s_i = \begin{bmatrix} s_{i1} \\ s_{i2} \\ \vdots \\ s_{iN} \end{bmatrix} \quad \text{and} \quad i = 1, 2 \cdots M.$$

The Product $\|s_i\|^2$ is given as,

$$\|s_i\|^2 = s_i^T s_i$$

$$= [s_{i1}, s_{i2}, s_{i3} \cdots s_{iN}] \begin{bmatrix} s_{i1} \\ s_{i2} \\ s_{i3} \\ \vdots \\ \vdots \\ s_{iN} \end{bmatrix}$$

$$= s_{i1}^2 + s_{i2}^2 + s_{i3}^2 + \cdots + s_{iN}^2$$

$$= \sum_{j=1}^{N} s_{ij}^2 \quad \& \; i = 1, 2 \ldots M.$$

Here $\|s_i\|$ is called absolute value or norm of a vector s_i. It is basically length of the vector. And $\|s_i\|^2$ is the squared length of the vector. It is defined to be the inner product or dot product of s_i with itself.

* Relationship between Signal Energy and its vector.

W.K.T

The Energy of signal $s_i(t)$ is defined as,

$$E_i = \int_0^T s_i^2(t)\,dt.$$

Sub/: $s_i(t) = \sum_{j=1}^{N} s_{ij}\phi_j(t)$ in above equation.

$$E_i = \int_0^T \left[\sum_{j=1}^{N} s_{ij}\phi_j(t)\right]\left[\sum_{k=1}^{N} s_{ik}\phi_k(t)\right]dt.$$

Note: due to two summations, two indices 'j' & 'k' used.

Interchanging the order of summation and integration, we get,

$$E_i = \sum_{j=1}^{N}\sum_{k=1}^{N} s_{ij}s_{ik}\int_0^T \phi_j(t)\phi_k(t)\,dt.$$

By using orthonormal property of basis function,

$$\int_0^T \phi_j(t)\phi_k(t)\,dt = \begin{cases} 1, & j=k \\ 0, & j\neq k \end{cases}$$

$$E_i = \begin{cases} \sum_{j=1}^{N}\sum_{k=1}^{N} s_{ij}s_{ik}, & \text{if } j=k \\ 0, & \text{if } j\neq k. \end{cases}$$

$$= \sum_{j=1}^{N}\sum_{j=1}^{N} s_{ij}s_{ij}, \quad \text{with } k=j.$$

$$\therefore \boxed{E_i = \sum_{j=1}^{N} s_{ij}^2}$$

By using absolute value it becomes. $E_i = \sum_{j=1}^{N} s_{ij}^2 = \|s_i\|^2$.

$$\therefore \boxed{E_i = \|s_i\|^2}$$

It shows that the signal energy is equal to squared length of the signal vector.

$\because \|s_i\|^2 = s_i^T s_i$, $\boxed{E_i = s_i^T s_i}$

Euclidean Distance :-

The Euclidean Distance between the two signal vectors is given as,

$$d_{ik} = \|s_i - s_k\|$$

Here $d_{ik} \rightarrow$ Euclidean distance between s_i & s_k.

* Squared Euclidean distance will be,

$$\|s_i - s_k\|^2 = \sum_{j=1}^{N} (s_{ij} - s_{kj})^2$$

$$\because \quad E_i = \int_0^T s_i^2(t)\,dt = \|s_i\|^2.$$

$$\|s_i - s_k\|^2 = \int_0^T [s_i(t) - s_k(t)]^2 dt.$$

The angle θ_k between two vectors s_i and s_k is given as,

$$\cos\theta_{ik} = \frac{s_i^T s_k}{\|s_i\|\|s_k\|}$$

When $s_i^T s_k = 0$, the two vectors are orthogonal or perpendicular to each other, then $\theta_{ik} = 90^\circ$.

For prescribed i, the set of coefficients $\{s_{ij}\}_{j=1}^{N}$ may be viewed as an N- dimensional signal vector, denoted by s_i.

The important point to note here is that the vector s_i bears a one-to-one relationship with the transmitted signal $s_i(t)$:

* Given the N elements of the vector s_i operating as input, Fig ① shows to generate the signal $s_i(t)$, which follows directly from equation $s_i(t) = \sum_{j=1}^{N} s_{ij}\phi_j(t)$, This figure consists of a bank of N multipliers with each multiplier having its own basis function followed by a summer. The scheme of figure ① may be viewed as a synthesizer.

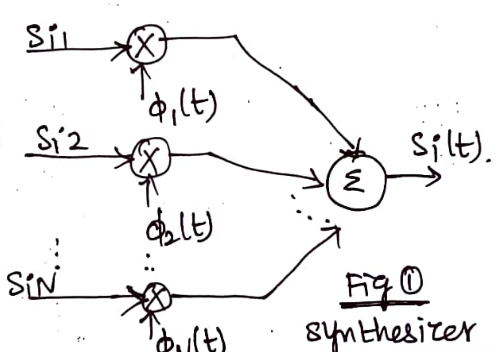


Fig ① synthesizer for generating the signal $s_i(t)$

* Conversely, given the signals $s_i(t)$, $i = 1, 2, \cdots M$, operating as input, we use figure ② to calculate the coefficients $s_{i1}, s_{i2}, \cdots s_{iN}$ which follows from equation $s_{ij} = \int_0^T s_i(t)\phi_j(t)dt$. This second scheme consists of a bank of N product integrators or correlators with a common input, and with each one of them supplied with its own basis function. It is viewed as an analyzer.

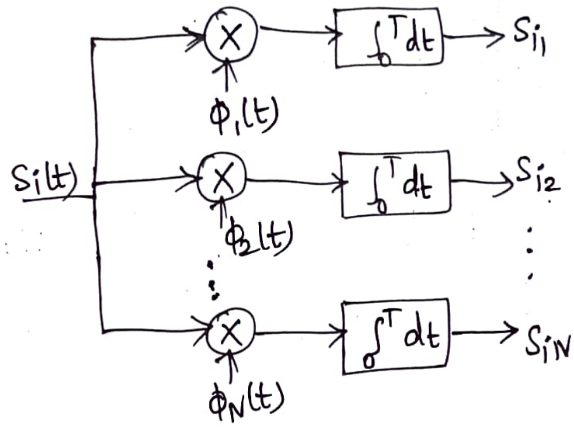


Fig ②
Analyzer for reconstructing the signal vector $\{s_i\}$

Gram-schmidt Orthogonalization Procedure

Gram-schmidt procedure allows us to determine a finite set of N orthonormal functions such that each $s_i(t)$ can be expressed as a linear combinations of these N orthonormal functions.

* Let $\phi_1(t), \phi_2(t) \dots \phi_N(t)$ be the N orthonormal functions to be determined such that we can express $s_i(t)$, $i=1,2..M$ as follows:

$$s_1(t) = s_{11}\phi_1(t) + s_{12}\phi_2(t) + \dots + s_{1N}\phi_N(t) \quad \text{—①}$$

$$s_2(t) = s_{21}\phi_1(t) + s_{22}\phi_2(t) + \dots + s_{2N}\phi_N(t) \quad \text{—②}$$

$$s_3(t) = s_{31}\phi_1(t) + s_{32}\phi_2(t) + \dots + s_{3N}\phi_N(t) \quad \text{—③}$$

$$\vdots$$

$$s_M(t) = s_{M1}\phi_1(t) + s_{M2}\phi_2(t) + \dots + s_{MN}\phi_N(t) \quad \text{—④}$$

which can also be represented in a compact form as

$$s_i(t) = \sum_{j=1}^{N} s_{ij}\phi_j(t), \quad 0 \le t \le T, \quad i=1,2 \dots M. \quad \text{—⑤}$$

where, $\int_0^T \phi_i(t)\phi_j(t)dt = \begin{cases} 1 & \text{if } i=j \\ 0 & \text{if } i \ne j \end{cases}$

Gram-schmidt method proceeds as follows :

Step 1 :-

In equation ① set all coefficients $s_{ij}=0$ except s_{11}.

Then we have $s_1(t) = s_{11}\,\phi_1(t)$

and $\phi_1(t) = \dfrac{s_1(t)}{s_{11}}$ but $\phi_1(t)$ is normalized.

Hence

$$\int_0^T \phi_1(t).\phi_1(t).dt = \int_0^T \frac{s_1(t)}{s_{11}}.\phi_1(t).dt.$$

$$\int_0^T \phi_1^2(t).dt = \int_0^T \frac{s_1(t)}{s_{11}}.\frac{s_1(t)}{s_{11}}.dt.$$

$$\int_0^T \phi_1^2(t).dt = \int_0^T \frac{s_1^2(t)}{s_{11}^2}dt.$$

$$\int_0^T \phi_1^2(t).dt = \frac{1}{s_{11}^2}\int_0^T s_1^2(t).dt.$$

$$= \frac{\int^T}{s_{11}^2}$$

$$\because \int \phi_1^2(t)dt = 1$$

$$1 = \frac{\int_0^T s_1^2(t).dt}{s_{11}^2}$$

$$s_{11}^2 = \int_0^T s_1^2(t)\,dt$$

$$\boxed{s_{11} = \sqrt{\int_0^T s_1^2(t).dt} \text{ or } \sqrt{E_1}} \text{ and } \phi_1(t) = \frac{s_1(t)}{s_{11}} \quad \text{— ⑥}$$

Step 2 :-

In equation ② we set all coefficients except s_{21} and s_{22} to zero. Then,

$$s_2(t) = s_{21}\,\phi_1(t) + s_{22}\,\phi_2(t) \quad \text{— ⑦}$$

Multiply both sides by $\phi_1(t)$ and integrating over the interval T,

$$\int_0^T s_2(t)\,\phi_1(t)\,dt = \int_0^T s_{21}\,\phi_1(t)\,\phi_1(t)\,dt + \int_0^T s_{22}\,\underbrace{\phi_2(t)\,\phi_1(t)}\,dt$$

$$= \int_0^T s_{21}\,\underbrace{\phi_1^2(t)}_{=1}\,dt + \int_0^T s_{22}\cdot 0$$

$$= \int_0^T s_{21}\cdot 1$$

$$\therefore\ \boxed{s_{21} = \int_0^T s_2(t)\,\phi_1(t)\,dt} \quad \text{— (8)}$$

Thus s_{21} is known. s_{22} is evaluated as follows. Rewriting equation (7) we get,

$$s_2(t) - s_{21}\phi_1(t) = s_{22}\phi_2(t). \quad \text{— (9)}$$

squaring and integrating equation

$$\int_0^T [s_2(t) - s_{21}\phi_1(t)]^2\,dt = \int_0^T s_{22}^2\,\underbrace{\phi_2^2(t)}_{=1}\,dt$$

$$= s_{22}^2$$

$$\therefore\ s_{22} = \sqrt{\left[\int_0^T [s_2(t) - s_{21}\phi_1(t)]^2\,dt\right.} \quad \text{— (10)}$$

Since both s_{21} and s_{22} are known, $\phi_2(t)$ can be written from equation (7) as,

$$\phi_2(t) = \frac{1}{s_{22}}\left[s_2(t) - s_{21}\phi_1(t)\right]$$

$$= \frac{1}{s_{22}}\left[s_2(t) - \frac{s_{21}s_1(t)}{s_{11}}\right] \quad \text{— (11)}$$

Step 3 :- From equation (3) we write $s_3(t)$ as

$$s_3(t) = s_{31}\phi_1(t) + s_{32}\phi_2(t) + s_{33}\phi_3(t). \quad \text{— (12)}$$

Setting s_{34}, s_{35} etc to zero, Then,

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

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

[Note: By using $s_{ij} = \int_0^T s_i(t)\,\phi_j(t)\,dt$

$$S_{33}^2 = \int_0^T \left[s_3(t) - s_{31}\phi_1(t) - s_{32}\phi_2(t)\right]^2 dt$$

$$s_{33} = \left[\int_0^T \left[s_3(t) - s_{31}\phi_1(t) - s_{32}\phi_2(t)\right]^2 dt\right]^{1/2} \quad \text{— (13)}$$

using equations (11) onwards, we get

$$\phi_3(t) = \frac{s_3(t) - s_{31}\phi_1(t) - s_{32}\phi_2(t)}{s_{33}} \quad \text{— (14)}$$

Step 4 :-

The procedure mentioned in the above steps is continued till we find 'N' orthonormal basis functions $\phi_1(t), \phi_2(t), \ldots \phi_N(t)$ and coefficients s_{ij}.

Generalized equation for orthonormal basis function $\phi_i(t)$ as,

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

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

and $$s_{ij} = \int_0^T s_i(t)\,\phi_j(t)\,dt , \quad j = 1, 2 \ldots i-1.$$

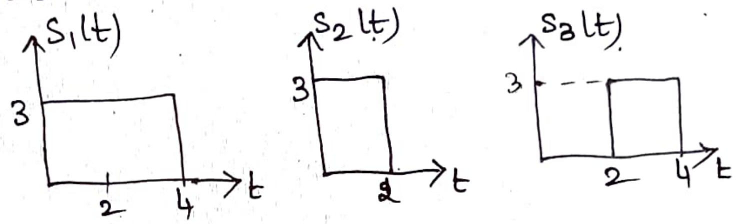
The dimension N is less than or equal to the number of given signals, M, depending on one of two possibilities:

* The signals $s_1(t), s_2(t) \ldots s_M(t)$ form a linearly independent set, in which case $N = M$.
* The signals $s_1(t), s_2(t) \ldots s_M(t)$ are not linearly independent, in which case $N < M$ and the intermediate function $g_i(t)$ is zero for $i > N$.

Problems :-

1) Three signals $s_1(t)$, $s_2(t)$ & $s_3(t)$ are shown in Figure. Apply Gram-schmidt procedure to obtain an orthonormal basis for the signal.

Sol:



Soln :- here only $s_2(t)$ and $s_3(t)$ are linearly independent $\therefore$ we have two basis function.

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

$$s_{11} = \sqrt{\int_0^T (s_1(t))^2 \, dt}$$

$$= \sqrt{[9t]_0^4} = \sqrt{36}.$$

$$\phi_1(t) = \frac{3}{\sqrt{36}}$$

$$\boxed{\phi_1(t) = \frac{1}{2}}, \quad 0 \le t \le 4.$$

$$\phi_2(t) = \frac{s_2(t) - s_{21}\phi_1(t)}{\sqrt{E_2 - s_{21}^2}}$$

$$s_{21} = \int_0^2 s_2(t) \cdot \phi_1(t) \cdot dt$$

$$= \int_0^2 3 \cdot \frac{1}{2} \cdot dt$$

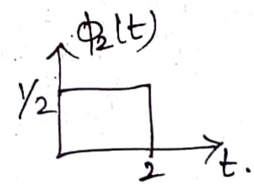
$$= \frac{3}{2}[t]_0^2 = 3 //.$$

$$E_2 = \int_0^2 s_2^2(t)\,dt = \int_0^2 3^2 dt = [9t]_0^2 = 9 \times 2 = 18 //$$

$$\phi_2(t) = \frac{3 - 3 \cdot \frac{1}{2}}{\sqrt{18 - 3^2}}, \quad 0 \le t \le 2$$

$$= \frac{\cancel{3}/2}{\cancel{3}}$$

$$\boxed{\phi_2(t) = 1/2}$$



Formula :-

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

2) $E_i = \int_0^T s_i^2(t)\,dt.$

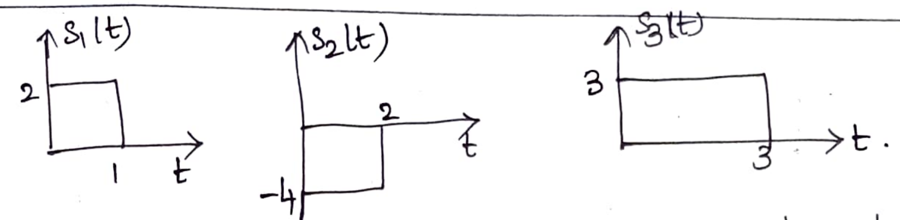
3) $\phi_1(t) = \frac{s_1(t)}{s_{11}}$

4) $s_{11} = \sqrt{\int_0^T s_1^2(t)\,dt}$ (or) $\sqrt{E_1}$

5) $\phi_2(t) = \frac{s_2(t) - s_{21}\phi_1(t)}{\sqrt{E_2 - s_{21}^2}}$

6) $s_{21} = \int_0^T s_2(t)\,\phi_1(t)\,dt.$

2)

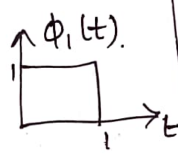


Soln :- All three signals are linearly independent

$\therefore$ There are 3 orthonormal basis function.

$\phi_1(t) = \dfrac{s_1(t)}{s_{11} = \sqrt{E_1}}$, $E_1 = \int_0^2 s_1^2(t)\,dt = 4.$

$\phi_1(t) = \dfrac{2}{\sqrt{4}}$, $0 \le t \le 1.$

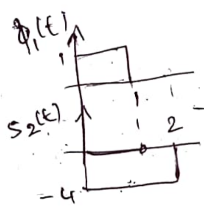


$\boxed{\phi_1(t) = 1}$, $0 \le t \le 1$

$\phi_2(t) = \dfrac{s_2(t) - s_{21}\phi_1(t)}{\sqrt{E_2 - s_{21}^2}}$, $E_2 = \int_0^2 (-4)^2\,dt = 32$

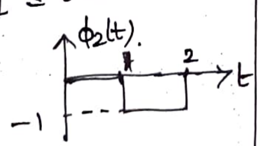
$= \dfrac{-4 - (-4 \times 1)}{\sqrt{32 - 16}}$, $s_{21} = \int_0^1 -4.1.dt = -4$, $0 \le t \le 1$

$= 0$, $0 \le t \le 1.$



$\therefore \phi_2(t) = \dfrac{-4 - 0}{\sqrt{32 - 16}}$

$= -1$, $1 \le t \le 2.$



$\phi_3(t) = \dfrac{s_3(t) - s_{31}\phi_1(t) - s_{32}\phi_2(t)}{\sqrt{E_3 - s_{31}^2 - s_{32}^2}}$

$= 3 - 3 - 0 = 0$, $0 \le t \le 1$

$E_3 = \int_0^3 3^2 . dt = 27.$

$s_{31} = \int_0^1 3.1.dt$

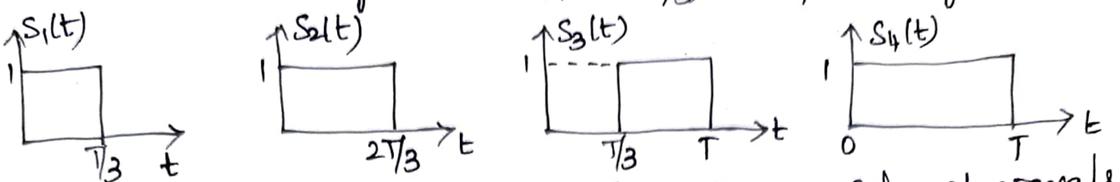
$= 3$, $0 \le t \le$.

0, else.

$s_{32} = \int_1^2 3.(-1)dt$

$= -3[t]_1^2 = -3,$

3) Consider the signals $s_1(t)$, $s_2(t)$, $s_3(t)$ and $s_4(t)$ as given below.



Find an orthonormal basis for these set of signals using gram-schmidt orthogonalization procedure.

Solution :-

here $s_4(t) = s_1(t) + s_3(t)$. This means all four signals are not linearly independent. Gram-schmidt orthoganalization procedure is carried out for a subset which is linearly independent. Here $s_1(t)$, $s_2(t)$ and $s_3(t)$ are linearly independent. Hence we will find three orthonormal basis function.

To get $\phi_1(t)$:-

$$\phi_1(t) = \frac{s_1(t)}{\sqrt{E_1}}, \quad E_1 = \int_0^{T/3} s_1^2(t)\, dt$$

$$= \int_0^{T/3} 1^2\, dt$$

$$= [T]_0^{T/3} = T/3.$$

$$= \begin{cases} \frac{1}{\sqrt{T/3}}, & \text{for } 0 \le t \le T/3 \\ 0, & \text{elsewhere} \end{cases}$$

To obtain $\phi_2(t)$:-

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

$$= \int_0^{2T/3} 1 \cdot \frac{1}{\sqrt{T/3}} \cdot dt = \left[\sqrt{\frac{3}{T}} \cdot T\right]_0^{T/3}$$

$$= \sqrt{\frac{3}{T}} \cdot \frac{T}{3} = \sqrt{\frac{T}{3}}$$

$$s_{21}\phi_1(t) = \begin{cases} \sqrt{\frac{T}{3}} \times \sqrt{\frac{3}{T}}, & 0 \le t \le T/3 \\ 0, & \text{elsewhere} \end{cases}$$

$$= \begin{cases} 1, & 0 \le t \le T/3 \\ 0, & \text{elsewhere.} \end{cases}$$

$$\phi_2(t) = \frac{s_2(t) - s_{21}\phi_1(t)}{\sqrt{E_2 - s_{21}^2}}$$

$$E_{g_2} = \int_{T/3}^{2T/3} (1)^2\, dt,$$

$$\boxed{E_2 = \frac{T}{3}}$$

$$g_2 = s_2(t) - s_{21}\phi_1(t).$$

$$= \begin{cases} 0, & 0 \le t \le T/3 \\ 1, & T/3 \le t \le \frac{2T}{3} \\ 0, & t > 2T/3. \end{cases}$$

$$\therefore \phi_2(t) = \frac{g_2(t)}{\sqrt{E_{g_2}}} = \begin{cases} \frac{1}{\sqrt{T/3}}, & \frac{T}{3} < t < 2T/3 \\ 0, & \text{elsewhere} \end{cases}$$

To obtain $\phi_3(t)$:-

W.K.T
$$g_i(t) = s_i(t) - \sum_{j=1}^{i-1} s_{ij}\,\phi_j(t) \quad , \quad i=1,2 \ldots N.$$

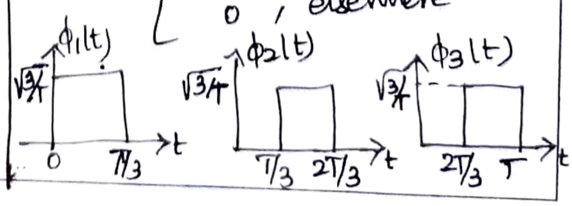
with $N=3$.
$$g_i(t) = s_i(t) - \sum_{j=1}^{i-1} s_{ij}\,\phi_j(t) \quad , \quad i=1,2,3.$$
$$g_3(t) = s_3(t) - \sum_{j=1}^{2} s_{3j}\,\phi_j(t)$$
$$= s_3(t) - \left[s_{31}\,\phi_1(t) + s_{32}\,\phi_2(t) \right].$$

W.K.T
$$s_{ij} = \int_0^T s_i(t)\,\phi_j(t)\,dt.$$
$$\therefore s_{31} = \int_0^T s_3(t)\,\phi_1(t)\,dt = 0$$ since there is no overlap between $s_3(t)$ and $\phi_1(t)$.
$$s_{32} = \int_0^T s_3(t)\,\phi_2(t)\,dt = \int_{T/3}^{2T/3} (1) \times \sqrt{\frac{3}{T}}\,dt$$
$$= \sqrt{\frac{3}{T}} \cdot \frac{T}{3} = \sqrt{\frac{T}{3}}.$$

here $s_{31}\phi_1(t) = 0$ since $s_{31} = 0$.
$$s_{32}\,\phi_2(t) = \begin{cases} \sqrt{\frac{T}{3}} \cdot \sqrt{\frac{3}{T}} , & \frac{T}{3} \le t \le \frac{2T}{3} \\ 0 , & \text{elsewhere.} \end{cases}$$
$$= \begin{cases} 1 , & \frac{T}{3} \le t \le \frac{2T}{3} \\ 0 , & \text{elsewhere.} \end{cases}$$

Sub/: in $g_3(t) = s_3(t) - s_{31}\phi_1(t) - s_{32}\phi_2(t)$
$$= s_3(t) - s_{32}\,\phi_2(t).$$
$$g_3(t) = \begin{cases} 0 , & 0 \le t \le \frac{2T}{3} \\ 1 , & \frac{2T}{3} \le t \le T \\ 0 , & t \ge T \end{cases}$$

$$\therefore E_{g_3} = \int_0^T g_3^2(t)\,dt$$
$$= \int_{T/3}^{2T/3} (1)^2\,dt.$$
$$= \frac{T}{3}.$$
$$\phi_3(t) = \frac{g_3(t)}{\sqrt{E_{g_3}}}$$
$$= \begin{cases} \frac{1}{\sqrt{T/3}} , & \frac{2T}{3} \le t \le T \\ 0 , & \text{elsewhere} \end{cases}$$



Module-2

Conversion of the continuous AWGN channel into a Vector channel

* Let us consider that the noisy received signal $x(t)$ in accordance with the AWGN channel is defined by a random process,

$$\boxed{x(t) = s_i(t) + w(t)}, \quad \begin{cases} 0 \le t \le T \\ i = 1, 2 \cdots M. \end{cases} \quad \text{— (1)}$$

where $w(t) \rightarrow$ Sample function of white Gaussian noise process $W(t)$ of zero mean and power spectral density $\frac{N_0}{2}$.

* This received signal is applied to a bank of correlators as shown below.

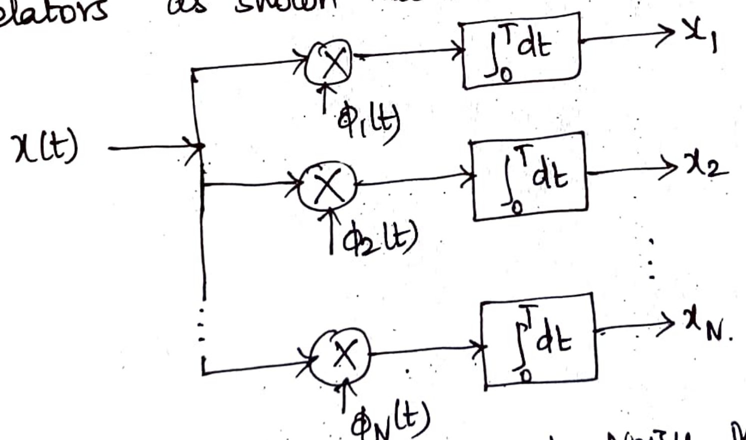


Fig: Response of correlators to Noisy input (or) Bank of N product integrators (or) correlators.

The o/p of each correlators is a random variable which is given as,

$$x_j = \int_0^T x(t)\, \phi_j(t)\, dt$$

$$= \int_0^T [s_i(t) + w(t)]\, \phi_j\, dt.$$

$$= \int_0^T s_i(t)\phi_j(t)dt + \int_0^T w(t)\phi_j(t)\cdot dt$$

$$\boxed{x_j = s_{ij} + w_j}, \quad j = 1, 2 \dots N. \quad \text{——} \ (2)$$

* Let the new random process be defined as,

$$x'(t) = x(t) - \sum_{j=1}^{N} x_j \phi_j(t) \quad \text{——} \ (3)$$

sub/: (1) in (3)

$$x'(t) = s_i(t) + w(t) - \sum_{j=1}^{N} (s_{ij} + w_j)\phi_j(t)$$

$$= s_i(t) + w(t) - \sum_{j=1}^{N} [s_{ij}\phi_j(t)] - \sum_{j=1}^{N} w_j \phi_j(t).$$

$$= \cancel{s_i(t)} + w(t) - \cancel{s_i(t)} - \sum_{j=1}^{N} w_j \phi_j(t) \qquad \because \sum_{j=1}^{N} s_{ij}\phi_j(t) = s_i(t)$$

$$= w(t) - \sum_{j=1}^{N} w_j \phi_j(t).$$

$$= w'(t).$$

hence $\boxed{x'(t) = w'(t)}$ $\therefore$ depends on the channel noise $w(t)$

from equation (3),

$$x(t) = \sum_{j=1}^{N} x_j \phi_j(t) + x'(t) \quad \text{——}$$

$$= \sum_{j=1}^{N} x_j \phi_j(t) + w'(t). \qquad \because \boxed{x'(t) = w'(t)}$$

here $w'(t)$ is totally due to noise process $w(t)$ at the input of correlators.

* The correlator outputs $x_1, x_2, \dots x_N$ are Gaussian random variables. They are characterized completely by mean and variance.

Statistical characterization of the correlator outputs

* Let $X(t)$ denote the random process, and $x(t)$ its sample function.
* Let X_j denote the random variable and x_j its sample value.
* According to AWGN model $X(t)$ is a Gaussian Process. Hence, X_j is characterized completely by its mean and variance.

* To obtain mean value of X_j

$$\mu_{X_j} = E[X_j]$$
$$= E[S_{ij} + W_j]$$
$$= E[S_{ij}] + E[W_j]$$
$$= S_{ij} + 0.$$

here mean value of AWGN is zero. hence $E[W_j] = 0$.

$$\therefore \boxed{\mu_{X_j} = S_{ij}}$$

Note:- Expected value of constant is constant itself.

* To obtain variance of X_j

variance is given as,

$$\sigma_{X_j}^2 = Var[X_j]$$
$$= E[(X_j - \mu_{X_j})^2]$$
$$= E[(X_j - S_{ij})^2]$$
$$= E[(\cancel{S_{ij}} + W_j - \cancel{S_{ij}})^2]$$
$$= E[W_j^2]$$

$$\boxed{\because X_j = S_{ij} + W_j}$$

(or)

$$\sigma_{X_j}^2 = Var[X_j]$$
$$= Var[S_{ij} + W_j]$$
$$= Var[S_{ij}] + Var[W_j]$$
$$= 0 + \frac{N_0}{2}$$

Note:- variance of constant term is zero.

W.K.T $W_j = \int_0^T w(t) \cdot \phi_j(t)$. sub/. in above equation

$$\sigma_{X_j}^2 = E\left[\int_0^T W(t)\,\phi_j(t)\,dt \int_0^T W(u)\,\phi_j(u)\,du\right]$$

$$= E\left[\int_0^T\int_0^T \phi_j(t)\,\phi_j(u)\,W(t)\,W(u)\cdot dt\,du\right]$$

Interchanging the order of integration and expectation,

$$\sigma_{X_j}^2 = \int_0^T\int_0^T \phi_j(t)\,\phi_j(u)\,E\left[W(t)\,W(u)\right]\cdot dt\,du$$

here $E[W(t)\,W(u)] \rightarrow$ autocorrelation of the noise process $W(t)$.

i.e $E[W(t)\,W(u)] = R_W(t,u)$

The noise process is stationary and $R_W(t,u)$ depends only on the difference $t-u$. This autocorrelation function is expressed interms of power spectral density for white Gaussian noise as,

$$\boxed{R_W(t,u) = \frac{N_0}{2}\,\delta(t-u).}$$

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

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

since above equation has non-zero value only at $t=u$.

W.K.T $\int_0^T \phi_j^2(t)\,dt = 1$.

$$\therefore \sigma_{X_j}^2 = \frac{N_0}{2}\cdot 1$$

$$\boxed{\sigma_{X_j}^2 = \frac{N_0}{2}}$$ for all j.

Thus, the variance of correlator output is equal to power spectral density of additive white noise process.

* <u>To show that x_j are mutually uncorrelated</u>

The covariance of x_j and x_k is given as,

$$\text{Cov}[x_j x_k] = E[(x_j - \mu_{x_j})(x_k - \mu_{x_k})]$$

since $\mu_{x_j} = S_{ij}$ and $\mu_{x_k} = S_{ik}$ above equation becomes,

$$\text{Cov}[x_j x_k] = E[(x_j - S_{ij}) \cdot (x_k - S_{ik})]$$

here $x_j - S_{ij} = W_j$ and $x_k - S_{ik} = W_k$. Then above equation becomes,

$$\text{Cov}[x_j x_k] = E[W_j W_k]$$

$$= E\left[\int_0^T W(t)\,\phi_j(t)\,dt \int_0^T W(u)\,\phi_k(u)\,du\right]$$

$$= E\left[\int_0^T \int_0^T \phi_j(t)\,\phi_k(u)\,W(t)\,W(u)\,dt\,du\right]$$

Interchanging the order of integration and expectation,

$$\text{Cov}[x_j x_k] = \int_0^T \int_0^T \phi_j(t)\,\phi_k(u)\,E[W(t)W(u)]\,dt\,du.$$

here $E[W(t)\,W(u)] = R_W(t-u) = \frac{N_0}{2}\,\delta(t-u)$

$$\text{Cov}[x_j x_k] = \int_0^T \int_0^T \phi_j(t)\,\phi_k(u)\,dt\,du \cdot \frac{N_0}{2}\,\delta(t-u).$$

above equation become non-zero only for $t = u$. hence,

$$\text{Cov}[x_j x_k] = \frac{N_0}{2} \int_0^T \phi_j(t)\,\phi_k(t)\,dt.$$

when, $j \neq k$

$$= \frac{N_0}{2} \times 0$$

$$\boxed{\text{Cov}[x_j x_k] = 0}$$ Thus x_j are mutually orthogonal.

If Gaussian random variables are uncorrelated, they are also statistically independent.

Hence, the Gaussian random variables $\{X_j\}, j=1, \dots N$ are statistically independent with mean and variance given by S_{ij} and $\frac{N_0}{2}$ respectively.

The set of N correlator outputs can be expressed as a vector X of N random variables as defined below.

$$X = \begin{bmatrix} X_1 \\ X_2 \\ \vdots \\ X_N \end{bmatrix}$$

Since X_j are statistically independent, the conditional probability density function $f_X(x|m_i)$, of vector X given that the symbol m_i or signal $S_i(t)$ is transmitted, can be expressed as the product of conditional probability density functions of its individual components.

That is,

$$f_X(\mathbf{x}|m_i) = \prod_{j=1}^{N} f_{X_j}(x_j|m_i), \quad i=1,2 \dots M.$$

Where

$\mathbf{x}$ is a sample value vector of the random vector X

$\mathbf{x}_j$ is a sample value of the random variable X_j.

The conditional Probability density functions $f_{\mathbf{X}}(x|m_i)$, are called likelihood functions.

* A Gaussian random variable is completely described by its mean and variance. Hence each random variable X_j, with mean S_{ij} and variance $N_0/2$, has the probability density function given by,

$$f_{X_j}(x_j|m_i) = \frac{1}{\sqrt{\pi N_0}} \exp\left[-\frac{1}{N_0}(x_j - s_{ij})^2\right], \quad i = 1,2 \ldots M, \quad j = 1,2 \ldots N.$$

Sub/: the above in likelihood functions of an AWGN channel are defined by,

$$f_X(x|m_i) = (\pi N_0)^{-N/2} \cdot \exp\left[-\frac{1}{N_0}\sum_{j=1}^{N}(x_j - s_{ij})^2\right], \quad i = 1,2 \ldots M. \quad \text{—— (A)}$$

W.K.T. the Pdf of Gaussian Random variable is given by,

$$f_X(x_j/m_i) = \frac{1}{\sqrt{2\pi\sigma_X^2}} \cdot e^{\frac{-(x_j - \mu)^2}{2\sigma_X^2}}$$

Sub/: the mean and variance,

$$\therefore f_{X_j}(x_j/m_i) = \frac{1}{\sqrt{\pi N_0}} \cdot e^{-\frac{(x_j - s_{ij})^2}{2\frac{N_0}{2}}}$$

~~sub/: in~~ Conditional Pdf $f_X(x/m_i)$ provides the very characterization of an AWGN channel.

$f_X(x/m_i)$ depends on observation vector x given the transmitted message symbol m_i.

* But however at the Rx the situation is not that the given observation vector X and it is required to estimate the message symbol m_i that is responsible for generating 'x'.

* likelihood function denoted by $l(m_i)$ and defined by,

$$l(m_i) = f_x(x|m_i), \quad i = 1,2 \ldots M.$$

* In Practice, log-likelihood functions are more convenient and denoted by $L(m_i)$ and defined by,

$$L(m_i) = \ln l(m_i), \quad i = 1,2 \ldots M.$$

Where, $\ln \rightarrow$ natural logarithm.

Apply natural log on both sides of equation (A),

$$\ln[f_x(x|m_i)] = \ln(\pi N_0)^{-N/2} \cdot \underbrace{\ln e}_{=1} \left[\frac{-1}{N_0} \cdot \sum_{j=1}^{N} (x_j - s_{ij})^2\right]$$

$$= \underbrace{-\frac{N}{2} \ln(\pi N_0)}_{\text{1st term}} \underbrace{- \frac{1}{N_0} \cdot \sum_{j=1}^{N} (x_j - s_{ij})^2}_{\text{second term}}$$

* Ignore the first term since it is a constant,

$$\therefore L(m_i) = \ln[f_x(x|m_i)] = -\frac{1}{N_0} \sum_{j=1}^{N} (x_j - s_{ij})^2,$$

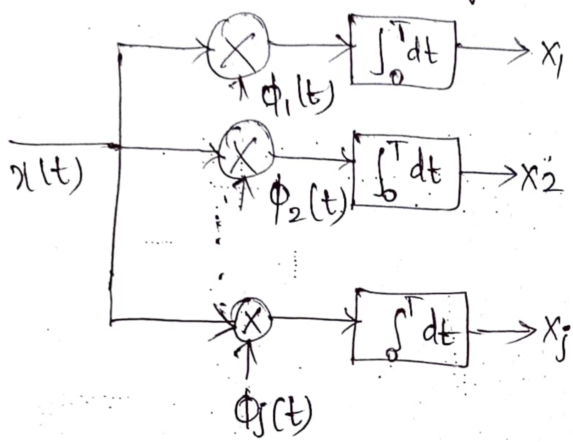
$$i = 1,2 \ldots M.$$

Continuation of Module - 2

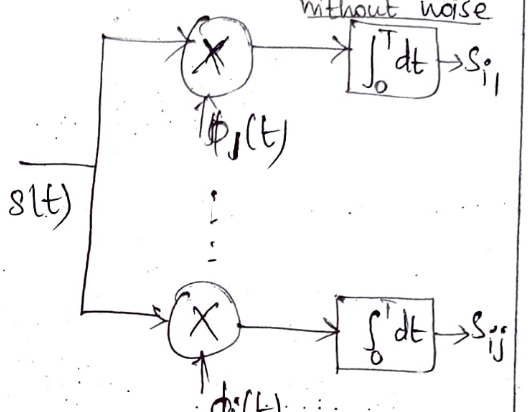
Optimum Receivers Using coherent Detection

Maximum Likelihood Decoding technique is used to design the Receiver.

W.K.T the normal coherent receiver (i.e) the analyzer to reconstruct the signal is,

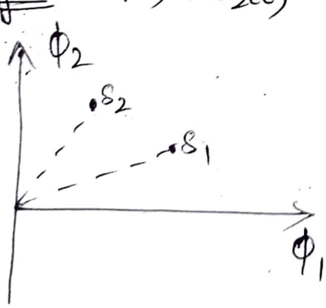


Actual signal reconstruction without noise

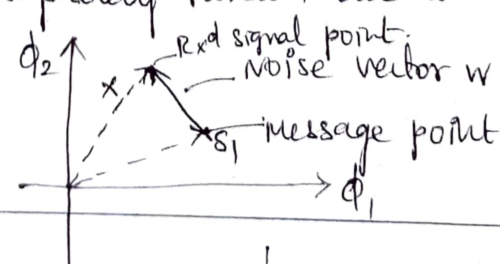


Note :- we have represented the signal $s_i(t)$ by a point in a Euclidean space of dimension $N \leq M$. we refer it as txd signal point (or) message point. The set of message points corresponding to the set of Txd signals $\{s_i(t)\}_{i=1}^{M}$ is called as message constellation

eg.1: $s_1(t)$ & $s_2(t)$



|||ly the Rxd signal x(t) can also be represented but here received vector $x_j = s_{ij} + w_j$. (i.e) the orientation is completely random due to noise.



* The Receiver should minimize the P_e in the decision making process.

Given the observation vector X, suppose we make the decision as $\hat{m}$, then the P_e in this decision is

$$\boxed{P_e\left(\hat{m}_i / x\right) = 1 - P\left(m_i \text{sent} / x\right)} \quad \text{—} ①$$

1 – Probability of estimating or Identifying the actual sent message

* To minimize the avg P_e, we use optimum decision rule (i.e) $\hat{m} = m_i$ if

$$P\left(m_i \text{ sent} / x\right) \geq P\left(m_k \text{ sent} / x\right) \; \forall k \neq i, \; k = 1, 2 \ldots M \quad ②$$

(i.e) Assume the probability of the txd message vector is maximum than other message vector.

Note: $P(m_i) > P(m_k)$

This is referred to as the maximum a posteriori probability. (MAP) rule.

The above decision rule (i.e) equation ② can be expressed more explicitly interms of the prior probabilities & the likelihood functions using Bayes' rule:

W.K.T Baye's Rule: $P(A/B) = \dfrac{P(B/A) \cdot P(A)}{P(B)}$

(i.e) $\dfrac{\pi_k \cdot f_X(x/m_i)}{f_X(x)}$ is maximum for $k = i$,

where,

$\pi_k \rightarrow$ Prior prob. of txd symbol m_k.

$f_X(x/m_i) \rightarrow$ Conditional pdf of random observation vector 'x' given the txn of symbol m_K.

$f_X(x) \rightarrow$ unconditional pdf of x.

(i.e) we can restate the decision rule as,

$\hat{m} = m_i$ if $L(m_k)$ is maximum for $k = i$,

This decision rule is known as Maximum likelihood Rule.

* The decoder which implements this rule is called maximum likelihood decoder.

where MLD computes log-likelihood functions as metrics of all the M possible message symbols, compare them, and then decides in favour of the maximum.

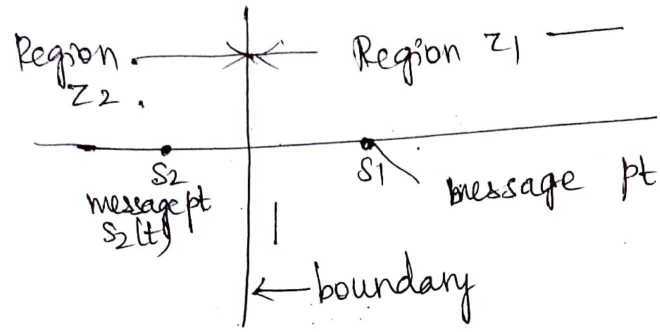
→ It is useful to have a graphical interpretation of the maximum likelihood decision rule.

* Let Z denote the N-dimensional space of all possible observation vectors X and we refer to this space as the observation space.

* The total observation space 'Z' is partitioned into M decision regions (where M-signal array).

(i.e) $Z_1, Z_2 \ldots Z_M$.

for eg:- if $M=2$, then we have $S_1(t)$ & $S_2(t)$ and they are represented by '1' basis function, then we have two-decision region



If Rx^d vector x falls in region Z_1 then we decide the Tx^d signal is $S_1(t)$. III^ly if it falls in region Z_2, then tx^d is $S_2(t)$.

*From log-likelihood function defined for an AWGN channel (ie) $L(m_k) = \sum_{j=1}^{N} (x_j - S_{kj})^2$

$L(m_k)$ maximum only when $\sum_{j=1}^{N} (x_j - S_{kj})^2$ is minimized by the choice of $k=i$.

[(i.e) if error is less than the likeliness of the Rx^d vector & Tx^d vector will be more].

we can write $\sum_{j=1}^{N} (x_j - S_{kj})^2$ as

$$= \sum_{j=1}^{N} x_j^2 - 2 \sum_{j=1}^{N} x_j \cdot S_{kj} + \sum_{j=1}^{N} S_{kj}^2$$

It is independent of index k pretaining to the tx^d signal vector S_k ∴ we can ignore them.

Represents the energy of tx^d signal.

$$L(m_k) = 2 \sum_{j=1}^{N} x_j s_{kj} + E_k.$$

∴ The observation vector x lies in region Z_i if

$\left(\sum_{j=1}^{N} x_j s_{kj} - \frac{1}{2} E_k \right)$ is maximum for $k = i$.

∴ $L(m_k)$ is maximum.

Correlation Receiver

* The optimum receiver for an AWGN channel is correlation Receiver.

It consists of two subsystems.

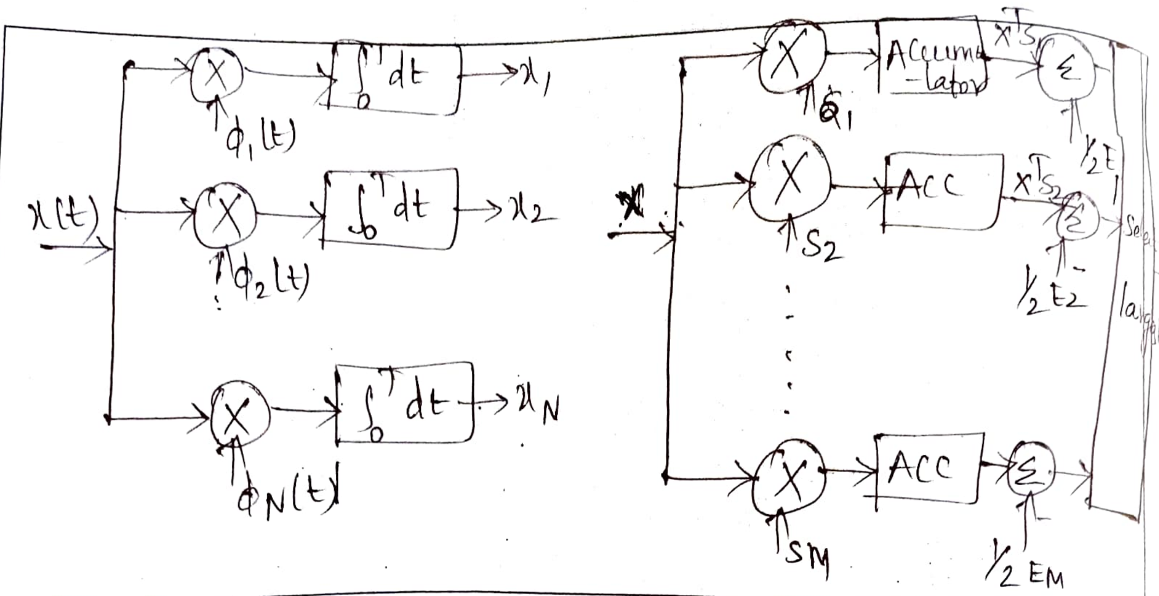
① Detector :- Consists of M correlators supplied with a set of orthonormal basis functions.

② Maximum - likelihood decoder :- which operates on the Received vector x to produce an estimate $\hat{m}$ of the txd symbol m_i in such a way to minimize avg P.e.

* In accordance with max likelihood decision rule the decoder should

$$\boxed{L(m_i) = \sum_{j=1}^{N} x_j s_{ij} - \frac{1}{2} \sum_{j=1}^{N} s_{ij}^2}$$

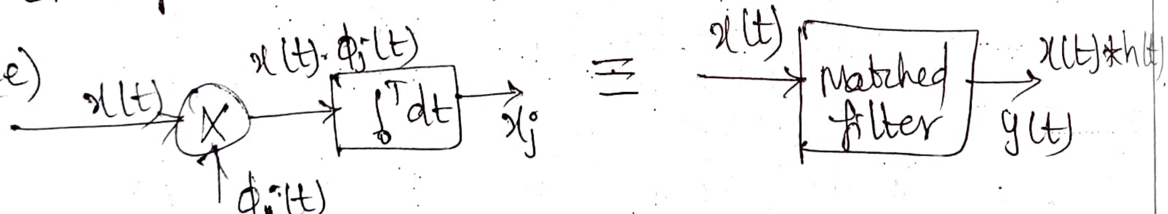
* Multiply observation vector 'x' with corresponding signal vector s_i.
* The result product is successively summed in accumulators.



Matched Filter Receiver

* Instead of using correlators in the Rx^r, an alternative method of implementing it is to used LTI filter with impulse response $h_j(t)$.

(i.e)



$$\therefore y_j(t) = \int_{-\infty}^{\infty} x(\tau)\cdot h_j(t-\tau)\,d\tau.$$

But the integral is evaluated over the symbol duration T (ie) $0 \le t \le T$ replace τ by t

$$\therefore y_j(T) = \int_0^T x(t)\cdot h_j(T-t)\,dt. \quad \text{—— (1)}$$

WKT

$$x_j = \int_0^T x(t)\cdot \phi_j(t)\cdot dt \quad \text{—— (2)}.$$

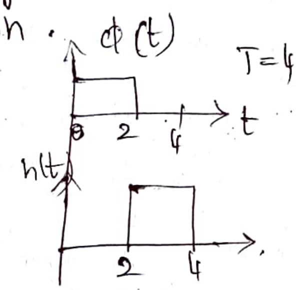
① & ② can be equated if

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

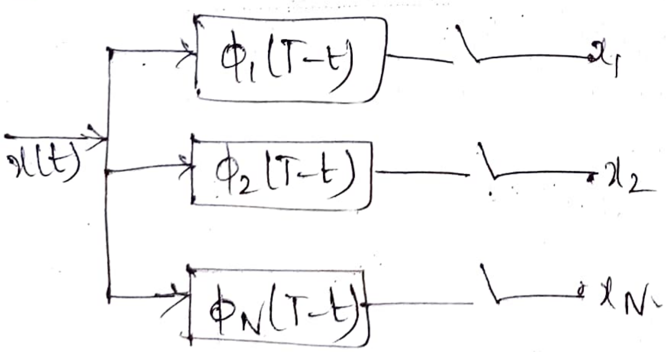
(i.e) $\boxed{h_j(t) = \phi_j(T-t)}$.

Note :- Given a pulse signal $\phi_1(t)$ occupying in the interval $0 \le t \le T$, a LTI filter is said to be matched to the signal $\phi(t)$ if its impulse response $h(t)$ satisfies the condition.

$$\boxed{h(t) = \phi(T-t)}$$



This LTI filter is defined as Matched filter. optimum Receiver using matched filter is called Matched filter Rx



Definition of Matched filter :-

A matched filter is a linear filter designed to provide the maximum output SNR for a given txd signal & WKT the txd signal is $s(t) + w(t)$

$$SNR = \frac{E}{\frac{N_0}{2}}$$

$E \rightarrow$ signal power = Energy of signal $s(t)$

$\frac{N_0}{2} \rightarrow$ Noise power

Properties of Matched filter :-

① The SNR of the MF depends upon the ratio of the signal energy to the PSD of white noise at the filter o/p.

Proof :-

$$x(t) \rightarrow \boxed{\begin{matrix} MF \\ h(t) \end{matrix}} \rightarrow \underbrace{s(t) * h(t)}_{\text{signal component}} + \underbrace{w(t) * h(t)}_{\text{Noise Component}}$$

signal component

$$= S(f) \cdot H(f).$$

$$\text{signal power} = \int_{-\infty}^{\infty} |H(f) \cdot S(f)|^2 \, df.$$

$$\int_{-\infty}^{\infty} |H(f) \cdot S(f)|^2 df \leq \int_{-\infty}^{\infty} |H(f)|^2 \cdot df \cdot \int_{-\infty}^{\infty} |S(f)|^2 df.$$

$$\leq \int_{-\infty}^{\infty} |S(f)|^2 df \cdot \int_{-\infty}^{\infty} |H(f)|^2 df \quad \text{—— ①}$$

Noise component $W(f) \cdot H(f)$

$$\text{Noise power} = \frac{N_0}{2} \cdot \int_{-\infty}^{\infty} |H(f)|^2 df \quad \text{—— ②}$$

ratio of ① & ② is

$$SNR \leq \frac{\int_{-\infty}^{\infty} |S(f)|^2 df \cdot \int_{-\infty}^{\infty} |H(f)|^2 df}{\frac{N_0}{2} \cdot \int_{-\infty}^{\infty} |H(f)|^2 df}$$

$$SNR \leq \frac{E}{\frac{N_0}{2}} \qquad \boxed{Max(SNR) = \frac{2E}{N_0}}$$

Property ②

The maximum signal component occurs at $t=T$ & has magnitude E (ie) energy of signal $x(t)$.

Proof :- WKT Rxd signal is $x(t) \longrightarrow \boxed{\begin{matrix}MF \\ h(t)\end{matrix}} \longrightarrow \begin{matrix}y(t) \\ x_0(t)\end{matrix}$

$$X_0(f) = S(f) \cdot H(f) + W(f) \cdot H(f).$$

WKT

$$h(t) = s(T-t)$$

$$H(f) = S^*(f) \cdot e^{-j2\pi fT}$$

Sub/: $H(f)$

$$X_0(f) = |S(f)|^2 \cdot e^{-j2\pi fT}$$

WKT $$x_0(t) = \int_{-\infty}^{\infty} X_0(f) \cdot e^{j2\pi ft} \cdot df.$$

$$= \int_{-\infty}^{\infty} |S(f)|^2 \cdot e^{j2\pi f(t-T)} df.$$

at $t=T$ $$x_0(T) = \int_{-\infty}^{\infty} |S(f)|^2 df.$$

$$\boxed{x_0(T) = E}$$ //.

Property ③ :- The o/p signal of MF is proportional to a shifted version of the Auto correlation function of the input signal to which the filter is matched.

Proof :- Signal component $S(f) \cdot H(f)$

signal component $\{ X_0(f) \} = S(f) \cdot H(f)$.

$$x_0(t) = \int_{-\infty}^{\infty} |S(f)|^2 \cdot e^{-j2\pi fT} \cdot e^{j2\pi ft} \cdot df$$

$$= \int_{-\infty}^{\infty} |S(f)|^2 \cdot e^{j2\pi f(t-T)} \cdot df \quad \text{—} ①$$

Let $\psi(f) = |S(f)|^2$ represents ESD / PSD of signal $S(f)$ WKT the relationship b/w PSD of ACF is

$$ACF \xleftrightarrow{FT} PSD$$

$$\therefore R(\tau) = \int_{-\infty}^{\infty} |S(f)|^2 e^{j2\pi f\tau} \cdot df \quad \text{—} ②$$

then $\psi(f) = \int_{-\infty}^{\infty} R(\tau) \cdot e^{-j2\pi f\tau} \cdot d\tau$.

Comparing equation

$$\boxed{x_0(t) = R(t-T)}$$

(2) Let $s(t)$ be a rectangular pulse of Amplitude A and duration T seconds, applied to the input of a filter matched to $s(t)$. Determine the output signal to noise ratio $(SNR)_0$ of the filter at $t=T$ in terms of noise power spectral density.

Solution:- $(SNR)_0$ of the matched filter at $t=T$ is

$$\frac{2E}{N_0}$$

∴ Computation of E:

$$E = \int_0^T s^2(t)\,dt = \int_0^T A^2\,dt = A^2T$$

Thus,

$(SNR)_0$ at $t=T$ is $\dfrac{2E}{N_0} = \dfrac{2A^2T}{N_0}$ //.

(3) A finite energy signal $s(t)$ is given by

$$s(t) = \begin{cases} A, & 0 \le t \le T \\ 0, & \text{otherwise} \end{cases}$$

Determine the spectrum of the o/p of the filter matched to $s(t)$.

Solution:- Let F.T of $s(t)$ be $S(f)$.

W.K.T $H(f) = S^*(f)\, e^{-j2\pi fT}$

The o/p of the MF is $s_0(t) = s(t) * h(t)$.