FRANCIS XAVIER ENGINEERING COLLEGE
AUTONOMOUS INSTITUTION
ACCREDITED BY NBA
ISO 9001:2015 Certified | DST-FIST Supported Institution
Recognized under Section 2(f) & 12(B) of the UGC Act, 1956
Vannarpettai, Tirunelveli - 627003, Tamil Nadu

Department of Electronics and Communication Engineering

M.E – Communication Systems

R 2024 - Curriculum and Syllabi -PG

CHOICE BASED CREDIT SYSTEM AND OBE

Vision of the Department

To develop Electronics and Communication Engineers by permeating with proficient morals, to be recognized as an adroit engineer worldwide and to strive endlessly for excellence to meet the confronts of our modern society by equipping them with changing technologies, professionalism, creativity research, employability, analytical, practical skills and to excel as a successful entrepreneur.

Mission of the Department

- To provide excellence through effective and qualitative teaching-learning process that equips the students with adequate knowledge and to transform the students' lives by nurturing the human values to serve as a precious resource for Electronics and Communication Engineering and nation.
- To enhance the problem solving and lifelong learning skills that will enable by edifying the students to pursue higher studies and career in research.
- To create students with effective communication skills, the abilities to lead ethical values in order to fulfill the social needs

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PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO1: Core Competence: To demonstrate core competence in mathematics, basic sciences and engineering concepts, that apply to communication systems engineering knowledge and/or also to pursue advanced study or research.

PEO2: Design and Analysis: To demonstrate good skills to comprehend communication engineering trade-offs, forecast, analyse, design, and synthesize data and technical concepts to create novel solutions for real life problems.

PEO3: Develop multi skills & Professionalism:

To have a successful career by meeting the demand driven needs of communication systems industries/ profession, with multi-disciplinary projects, adhering to ethical standards with social responsibility

PROGRAMME SPECIFIC OUTCOMES (PSOs)

PSO1:The ability to apply basic mathematics and sciences to analyse, design and implement application specific systems for complex engineering problems, pertaining to analog and digital domains in communication systems engineering and its allied fields.

PSO2: The ability to adapt to latest industrial sophistications, tools and technology in communication systems engineering and its allied fields.

PSO3: Excellent compliance to function in multi-disciplinary environment, exhibiting good interpersonal and leadership skills with an understanding of societal and ecological issues, adhering to ethical engineering practice.

PROGRAMME OUTCOMES (POS)

Engineering Graduates will be able to:

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

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

3. Design/development of solutions: Design solutions for complex engineering problems and design 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.

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

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

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

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

8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

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

10. Communication: Communicate effectively on complex engineering activities with the engineering community 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.

11. Project management and finance: Demonstrate knowledge and understanding of the engineering 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.

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

Mapping with PO Vs PEO, PSO

PO	PEO1	PEO2	PEO3	PSO1	PSO2	PSO3
1		H		H		
2		H		M		
3		L	H			H
4	H	L			H	
5			M	H		
6			L			M
7			L		H	
8	L				H	
9	L			M		M
10	M			M		M
11	M				H	
12	L	M	H			M

Contribution L: Low / Reasonable M: Medium / Significant H:High / Strong

FRANCIS XAVIER ENGINEERING COLLEGE

M.E. – COMMUNICATION SYSTEMS - REGULATIONS 2024

Choice Based Credit System and Outcome Based Education

SUMMARY OF CREDIT DISTRIBUTION

S.No	Category	Credits Per Semester				Total Credits	Credits in %
		I	II	III	IV		
1	ES	3				3	4.2%
2	PC	17	11	3		31	43.6%
3	PE	3	9	6		18	25.3%
4	EEC		0	7	12	19	26.7%
Total		23	20	16	12	71	100%

Minimum Number of Credits to be Acquired: 71

ES - Engineering Sciences

PC - Professional Core

PE - Professional Elective

EEC - Employability Enhancement Courses

FRANCIS XAVIER ENGINEERING COLLEGE

M.E. – COMMUNICATION SYSTEMS - REGULATION 2024

Choice Based Credit System and Outcome Based Education

I- IV Semester Curriculum and Syllabi 2024

SEMESTER I

S.No	Course Code	Course Name	Category	Contact Periods	L	T	P	C
Theory Courses								
1	24MA1256	Applied Mathematics for Communication Engineers	ES	3	3	0	0	3
2	24CS1601	Advanced Radiation systems	PC	3	3	0	0	3
3	24CS1602	Advanced Wireless Communication	PC	3	3	0	0	3
4	24CS1603	Advanced Digital Signal Processing	PC	3	3	0	0	3
5	24CS1604	Advanced Digital Communication Techniques	PC	3	3	0	0	3
6	24CS1605	Research Methodology for Engineers	PC	3	3	0	0	3
7		Professional Elective I	PE	3	3	0	0	3
Practical Courses								
1	24CS1611	Communication Systems Laboratory I	PC	4	0	0	4	2
			Total	**25**	**21**	**0**	**4**	**23**

SEMESTER II

S.No	Course Code	Course Name	Category	Contact Periods	L	T	P	C
Theory Courses								
1	24CS2601	Optical Communication Networks	PC	3	3	0	0	3
2	24CS2602	MIC and RF Transceiver Design	PC	3	3	0	0	3
3	24CS2603	5G Networks	PC	3	3	0	0	3
4		Professional Elective II	PE	3	3	0	0	3
5		Professional Elective III	PE	3	3	0	0	3
6		Professional Elective IV	PE	3	3	0	0	3
Practical Courses								
1	24CS2611	Communication Systems Laboratory II	PC	4	0	0	4	2

Total	**22**	**18**	**0**	**4**	**20**

SEMESTER III

S.No	Course Code	Course Name	Category	Contact Periods	L	T	P	C
Theory Courses								
1	24CS3607	Machine Learning in Communication Networks	PC	3	3	0	0	3
2		Professional Elective V	PE	3	3	0	0	3
3		Professional Elective VI	PE	3	3	0	0	3
Practical Courses								
1	24CS3901	Dissertation I	EEC	12	0	0	12	6
2	24CS3902	Term paper writing	EEC	1	0	0	2	1
		Total		**22**	**9**	**0**	**14**	**16**

SEMESTER IV

S.No	Course Code	Course Name	Category	Contact Periods	L	T	P	C
Practical Courses								
1	24CS4901	Dissertation II	EEC	24	0	0	24	12
		Total		**24**	**0**	**0**	**24**	**12**

Minimum Number of Credits to be acquired: 71

List of Professional Electives Courses

S.No	Course Code	Course Name	Semester	L	T	P	C
Professional Elective I							
1	24CS1701	Communication Network Security	I	3	0	0	3
2	24CS1702	Advanced Multimedia Compression Techniques	I	3	0	0	3
3	24CS1703	Advanced Digital Image Processing	I	3	0	0	3
4	24CS1704	VLSI Design for Signal Processing	I	3	0	0	3
5	24CS1705	High performance FPGA System Design	I	3	0	0	3
Professional Elective II							
1	24CS2701	Advanced Wireless Sensor Networks and WBAN	II	3	0	0	3
2	24CS2702	Massive MIMO and Millimeter Wave Communication	II	3	0	0	3
3	24CS2703	MIMO OFDM Systems	II	3	0	0	3
4	24CS2704	High Performance Analog IC Design	II	3	0	0	3
Professional Elective III							
1	24CS2705	Advanced Integrated SOC Design Techniques	II	3	0	0	3
2	24CS2706	Modern IOT	II	3	0	0	3
3	24CS2707	Real Time Embedded Systems	II	3	0	0	3
4	24CS2708	Smart Antennas	II	3	0	0	3
Professional Elective IV							
1	24CS2709	VLSI Circuit Test and Verification Techniques	II	3	0	0	3
2	24CS2710	Modern Satellite Systems	II	3	0	0	3
3	24CS2711	Network Routing Algorithms	II	3	0	0	3
4	24CS2712	Remote Sensing	II	3	0	0	3
Professional Elective V							
1	24CS3701	Embedded Wireless Sensor Networks	III	3	0	0	3
2	24CS3702	DSP Processor Architecture and Programming	III	3	0	0	3
3	24CS3703	RF And Radiation System Design	III	3	0	0	3
4	24CS3704	High Speed Communication Networks	III	3	0	0	3
Professional Elective VI							
1	24CS3705	Cooperative Communication	III	3	0	0	3

2	24CS3706	VLSI Architecture for Image and Video Processing	III	3	0	0	3
3	24CS3707	Mobile Robotics	III	3	0	0	3
4	24CS3708	Advanced Radar and Navigational AIDS	III	3	0	0	3

Semester I

S.No	Course Code	Course Name	Category	Contact Periods	L	T	P	C
Theory Courses								
1	24MA1256	Applied Mathematics for Communication Engineers	ES	3	3	0	0	3
2	24CS1601	Advanced Radiation systems	PC	3	3	0	0	3
3	24CS1602	Advanced Wireless Communication	PC	3	3	0	0	3
4	24CS1603	Advanced Digital Signal Processing	PC	3	3	0	0	3
5	24CS1604	Advanced Digital Communication Techniques	PC	3	3	0	0	3
6	24CS1605	Research Methodology for Engineers	PC	3	3	0	0	3
7		Professional Elective I	PE	3	3	0	0	3
Practical Courses								
1	24CS1611	Communication Systems Laboratory I	PC	4	0	0	4	2
			Total	**25**	**21**	**0**	**4**	**23**

24MA1256	APPLIED MATHEMATICS FOR COMMUNICATION ENGINEERS	L	T	P	C
		3	0	0	3

Prerequisites for the course

- The pre-requisite knowledge required by the Students to study this Course are Numerical Methods, Probability and Random Processor.

Objectives

1. To demonstrate various analytical skills in applied mathematics and extensive experience with the statistics of problem solving and logical thinking applicable in communication engineering.
2. To identify, formulate, abstract and solve problems in electrical engineering using mathematical tools.
3. To demonstrate various numerical solutions of Differential equation applicable in communication engineering.
4. To identify the probability and Random process variable application.
5. To study about the Queuing model

UNIT I	LINEAR ALGEBRA	9

Vector Spaces-Norms-Inner Products-Eigen Values using transformation-QR Factorization-Generalized Eigen Vectors-Canonical Forms-Single value decomposition and Applications-Pseudo inverse-Least Square approximation

UNIT II	LINEAR PROGRAMMING	9

Formulation-Graphical Solution-Simplex Method-Big M Method-Transportation Problem-Assignment models

UNIT III	NUMERICAL SOLUTION OF ORDINARY DIFFERENTIAL EQUATIONS	9

Runge-Kutta method of fourth order for system of IVPs-Numerical stability of Runge-Kuttamethod-Adams-Bashforth multistep method-shooting method BVP- Finite Difference method and collocation method

UNIT IV	PROBABILITY AND RANDOM VARIABLES	9

Probability- Random Variables- Probability function- Two dimensional random variables- Joint distribution – Marginal and conditional distributions- Function of two dimensional Random variables- Regression curve-correlation

UNIT V	QUEUEING MODELS	9

Poisson process- Markovian queues- Single and Multi –server models- Little's formula Steady state analysis

Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	Formative Assessment Test (10 Marks)	End Semester Exams (60 Marks)
1.Description Questions 2.Formative Multiple choice questions	1.Assignment 2.Online Quizzes 3.Problem solving Activities	1.Description Questions 2.Formative Multiple choice questions

Outcomes

Upon completion of the course, the students will be able to:

CO256. 1 To be able to analyze the fundamental of Linear algebra
CO256. 2 To be able to analyze the linear programming.
CO256. 3 To be able to design numerical solution
CO256. 4 To be able to analyze the performance of Probability and Random variable.
CO256. 5 To be able to analyzeQueuing model .

Text Books

1. **Bronson, R. and Costa, G. B., "Linear Algebra", 2nd Edition, Academic Press, 2007.**
2. **Burden, R. C. and Faires, J. D., "Numerical Analysis ", 9th Edition, Cengage Learning, 2016.**
3. **Gross, D., Shortle, J.F., Thompson, J. M. and Harris, C. M., "Fundamentals of Queueing Theory ", 4th Edition, Wiley, 2014.**

Reference Books

1. **Johnson, R.A., Miller, I and Freund J., "Miller and Freund's Probability and Statistics for Engineers", Pearson Education, Asia, 8th Edition, 2015.**
2. **Sastry, S. S., "Introductory Methods of Numerical Analysis ", 5th Edition, PHI Learning, 2015..**

Web Resources

- https://nptel.ac.in/courses/111/105/111105124/
- https://nptel.ac.in/courses/111/105/111105035/
- https://nptel.ac.in/courses/108/108/108108109/

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	3	2			1				2	3	3	1	2	
2	3	2	2	1	2				2		3	3			1
3	3	1	1		2					2	1	3	1		
4	3	3	2		2			1		2	2	3		2	1
5	2	3	2	1						2	3	3	3	1	2

24CS1601	ADVANCED RADIATON SYSTEMS	L	T	P	C
		3	0	0	3

Prerequisites for the course

- The pre-requisite knowledge required by the Students to study this Course are RF and Microwave System, Antenna and Amplifiers.

Objectives

1. To understand the antenna fundamentals.
2. To understand about the antenna elements
3. To understand the various components that constitute an antenna array.
4. To know the basic patch techniques needed for evaluating the performance antenna.
5. To know the concepts electromagnetic radiation and antenna design.

UNIT I	ANTENNA FUNDAMENTALS	9

Antenna fundamental parameters: Radiation pattern, power density, radiation intensity, directivity, gain, bandwidth, polarization, radiation efficiency, effective aperture. Reciprocity theorem, Matching techniques, Balance to unbalance transformer, Introduction to numerical techniques.

UNIT II	ANTENNA ELEMENTS	9

Single antenna element– monopole, dipole. Micro-strip patch antenna, Slot antenna; Horn antenna; Reflector antenna, aperture blockage, and design consideration, Practical Design- High gain antenna for satellite applications, Simulations.

UNIT III	ANTENNA ARRAY	9

Introduction, Two element array, linear antenna arrays, General structure of broadside, end-fire array, Yagi-uda antenna array.Smart antenna for Mobile stations

UNIT IV	PATCH PERFORMANCE ENHANCEMENT	9

Miniaturization- Shorting and loading of antenna, Meandering, Fractal techniques, Bandwidth Improvement- Multilayer substrate antenna,Excitation techniques;Rectangular patch, Circular patch, Micro-strip dipole Radiation Mechanism from patch Application of Micro-strip array antenna.

UNIT V	ANTENNA MEASUREMENTS AND DESIGN	9

Antenna measurement and instrumentation – Gain, Impedance and antenna factor measurement; Antenna Design, EM simulation with CST Microwave studio, Antenna Prototype development of antenna for wireless application.

	Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	Formative Assessment Test (10 Marks)	End Semester Exams (60 Marks)
1.Description Questions 2.Formative Multiple choice questions	1.Assignment 2.Online Quizzes 3.Problem solving Activities	1.Description Questions 2.Formative Multiple choice questions

Outcomes

Upon completion of the course, the students will be able to:

CO601. 1 To be able to analyze the fundamental of antenna system
CO601. 2 To be able to analyze the antenna elements.
CO601. 3 To be able to design antenna array
CO601. 4 To be able to analyze the performance of Micro-strip antenna and its characteristics.
CO601. 5 To be able to analyze antenna measurements and design.

Text Books

1. **Hubregt.J.Visser "Antenna Theory and Applications" 1st Edition, John Wiley & Sons Ltd, Newyork,2012.**

2. **Zhijun Zhang" Antenna Design for Mobile Devices" 1st Edition, John Wiley & Sons (Asia) Ltd, Newyork,2011.**

Reference Books

1. **Xavier Begaud, "Ultra Wide Band Antennas" , 1st Edition, ISTE Ltd and John Wiley & Sons Ltd, Newyork,2013.**
2. **Balanis.A, "Antenna Theory Analysis and Design", John Wiley and Sons, New York, 1982.**
3. **Krauss.J.D, "Antennas", II edition, John Wiley and sons, New York, 1997.**
4. **I.J. Bahl and P. Bhartia," Micro-strip Antennas",Artech House,Inc.,1980**
5. **W.L.Stutzman and G.A.Thiele,"Antenna Theory and Design", 2nd Edition, John Wiley & Sons Inc.,1998.**
6. **S.Drabowitchet.al.:,"Modern Antennas", 2nd Edition Springer science business Media, Inc.2005.**

Web Resources

- https://interferencetechnology.com/antenna-fundamentals/
- https://www.antenna-theory.com/basics/main.php
- https://www.3ds.com/products-services/simulia/products/cst-studio-suite/

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	3	2			1				2	3	3	1	2	
2	3	2	2	1	2				2		3	3			1
3	3	1	1		2					2	1	3	1		
4	3	3	2		2			1		2	2	3		2	1
5	2	3	2	1						2	3	3	3	1	2

24CS1602	ADVANCED WIRELESS COMMUNICATION	L	T	P	C
		3	0	0	3

Prerequisites for the course

- The pre-requisite knowledge required by the Students to study this Course is basic knowledge in Wireless Communication.

Objectives

1. Understand the basics of propagation of EM signals and its mechanisms in Wireless channels.
2. Learn the capacity equations of wired and wireless channels.
3. Study the various diversity and equalization techniques.
4. Explore the fundamentals of spatially diversified Communication systems.
5. Realize the concepts of Multi-user systems

UNIT I	WIRELESS PROPOGATION CHANNELS AND MODELS	9

Propagation Mechanisms – reflection, diffraction, scattering indoor and outdoor propagation models, Small –scale fading, Multipath fading distributions, Rayleigh, Rician, Nakagami distribution, Clarkes's fading model ,Link power budget analysis,Propagation of EM signals in wireless channel,Reflection, diffraction and Scattering, Free space model,Two ray propagation model,Channel classification-channel models, COST-231 Hata model, Longley-Rice Model,NLOS Multipath Fading Models:Rayleigh, Rician, Nakagami, Composite Fading, Shadowing Distributions and Link power budget Analysis		
UNIT II	**CAPACITY OF WIRELESS CHANNELS**	**9**
Capacity in AWGN, Capacity of flat fading channel,Channel and System Model,Channel Distribution Information (CDI) Known,Channel Side Information at Transmitter and Receiver.Capacity with Receiver Diversity,CapacityComparisons,Capacity of frequency selective fading channels,Time-Invariant Channels, Time-Varying Channels.		
UNIT III	**DIVERSITY AND EQUALIZATION**	**9**
Realization of independent fading paths,Receiver Diversity: Introduction,Receiver Diversity: System model,Selection Combining, Threshold Combining,Maximum-ratio Combining,Equal gain Combining,Transmitter Diversity :Introduction,Channel known at transmitter,Channel unknown at the transmitter: Alamouti scheme and Equalization.Directly linear and non linear equalizers in communication Receiver,Algorithms for Adaptive Equalization, timing and tracking.		
UNIT IV	**MIMO COMMUNICATIONS**	**9**
Fundamentals of MIMO,Narrowband MIMO Model,and Parallel Decomposition of the MIMO channel,MIMO channel capacity, Static Channels,FadingChannels,MIMO Diversity Gain, Beam forming and Diversity-Multiplexing trade-offs,Space time Modulation and coding,ML Detection and Pairwise Error Probability,Rank and Determinant Criterion, Space-Time Trellis,BlockCodes,Spatial Multiplexing and BLAST Architectures.		
UNIT V	**MULTI USER SYSTEMS**	**9**
Review of Multiple Access Techniques-FDMA, TDMA, CDMA,Space-Division, Hybrid Techniques, Scheduling, Power control,Downlink (Broadcast) Channel Capacity: Channel Model,Channel Capacity in AWGN,Common Data, Capacity in fading, capacity with multiple antennas and uplink (Broadcast) Channel Capacity,Channel Capacity in AWGN,Capacity in fading,capacity with multiple antennas,Uplink/Downlink Duality, multiuser diversity and MIMO-MU systems		
	Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	**Formative Assessment Test (10 Marks)**	**End Semester Exams (60 Marks)**
1.Description Questions **2.Formative Multiple choice questions**	**1.Assignment** **2.Online Quizzes** **3.Problem solving Activities**	**1.Description Questions** **2.Formative Multiple choice questions**

Outcomes

Upon completion of the course, the students will be able to:

CO602. 1	Use the various fading models for performance analysis of wireless communication systems.
CO602. 2	Design a wireless communication system of desired capacity
CO602. 3	Design the equalization techniques in advanced algorithms for automation of wireless receivers.

CO602. 4	Analyze the applications involving multi antenna systems.
CO602. 5	Interpret the Multiuser transceiver concepts.

Text Books

1. **Andrea Goldsmith, Wireless Communications, Cambridge University Press, 2007.**
2. **Rappaport. T.S., "Wireless Communication", Pearson Education, 2003.**

Reference Books

1. **Andreas.F. Molisch, "Wireless Communication" John Wiley, India, 2006..**
2. **Arogyaswami Paulraj, et al, "Introduction to Space-Time Wireless Communications", Cambridge University Press, 2003.**
3. **Simon Haykin& Michael Mohar, "Modern Wireless Communications" Pearson Education, 2007.**
4. **Gordon L. Stuber, "Principles of Mobile Communication", Springer International Ltd., 2001.**

Web Resources

- http://www.nptelvideos.in/2012/11/advanced-3g-and-4g-wireless-mobile.html
- https://www.egr.msu.edu/~tongli/Introduction-WCN.pdf

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	3										3	1	2	
2	3		3									3	2		3
3				3								3			
4	3				3	3						3		2	1
5				3	3	3	3					3	3	1	2

24CS1603	ADVANCED DIGITAL SIGNAL PROCESSING	L	T	P	C
		3	0	0	3

Prerequisites for the course

- The pre-requisite knowledge required by the students to study this Course is basic knowledge in Signal Processing.

Objectives

1. The student understands mathematical description and modelling of discrete time random signals.
2. The Student will be able to understand the spectral estimation
3. The student is conversant with important concepts in various types of filters.
4. The student learns various adaptive filters and its applications.
5. The student is familiar with multirate concepts, techniques and wavelet transforms

UNIT I	DISCRETE RANDOM SIGNAL PROCESSING	9

Discrete Random Processes- Ensemble Averages, Stationary processes, Bias and Estimation, Auto covariance, Autocorrelation, Parseval's theorem, Wiener-Khintchine relation, White noise, Power Spectral Density, Spectral factorization, Filtering Random Processes, Special types of Random Processes – ARMA, AR, MA –Harmonic Process

UNIT II	SPECTRAL ESTIMATION	9

Estimation of spectra from finite duration signals, Nonparametric methods – Periodogram, Modified periodogram, Bartlett, Welch and Blackman-Tukey methods, Parametric methods – ARMA, AR and MA model based spectral estimation, Solution using Levinson-Durbin algorithm

UNIT III	LINEAR ESTIMATION AND PREDICTION	9

Linear prediction – Forward and Backward prediction, Solution of Prony's normal equations, Least mean-squared error criterion, Wiener filter for filtering and prediction, FIR and IIR Wiener filters, Discrete Kalman filter

UNIT IV	ADAPTIVE FILTERS	9

FIR adaptive filters – adaptive filter based on steepest descent method- Widrow-Hoff LMS algorithm, Normalized LMS algorithm, Adaptive channel equalization, Adaptive echo cancellation, Adaptive noise cancellation, RLS adaptive algorithm.

UNIT V	MULTIRATE DIGITAL SIGNAL PROCESSING AND WAVELET TRANSFORM	9

Multirate system –Decimator, Interpolators – Polyphase structure - Multistage implementation of multirate system – Wavelet transform: Discrete Wavelet transform one dimension (Haar Wavelet transform) - wavelet packets - Application to subband coding

	Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	Formative Assessment Test (10 Marks)	End Semester Exams (60 Marks)
1.Description Questions 2.Formative Multiple choice questions	1.Assignment 2.Online Quizzes 3.Problem solving Activities	1.Description Questions 2.Formative Multiple choice questions

Outcomes

Upon completion of the course, the students will be able to:

CO603. 1 To understand the various special types of Random Processes in communication receiver

CO603. 2 To understand the Power Spectrum

CO603. 3 To design optimum filters in various applications of signal processing

CO603. 4 To design adaptive filters

CO603. 5 To understand multirate systems and wavelet transforms.

Text Books

1. **1.Monson H. Hayes, 'Statistical Digital Signal Processing and Modeling, Wiley India (P) Ltd. 2008**
2. **P. P. Vaidyanathan, "Multirate Systems and Filter Banks", Prentice Hall, 1992.**

Reference Books

1. **Simon Haykin , Telagarapu Prabhaka "Adaptive Filter Theory" Prentice Hal,2014**
2. **Saeed V. Vaseghi "Advanced digital signal processing and noise reduction: fourth edition , Wiley , 2008**
3. **John.G.Proakis, Dimitris.G.Manolakis "Digital signal Processing-Prinicples,Algorithms and Applications"Pearson,2014**

Web Resources

- https://nptel.ac.in/courses/117/101/117101001/
- http://www.nptelvideos.in/2012/12/advanced-digital-signal-processing.html

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	3	1								3	3	1	2	
2	3	3	1								3	3			3
3	3	3	1								3	3	3	2	
4	3	3	1								3	3			1
5	3	3	1								3	3	3	1	2

24CS1604	ADVANCED DIGITAL COMMUNICATION TECHNIQUES	L	T	P	C
		3	0	0	3

Prerequisites for the course

- The pre-requisite knowledge required by the students to study this Course is basic knowledge in Digital Communication.

Objectives

1. To extend the theory of Constant envelope modulation to M-ary schemes and to familiarize the concept of Spread Spectrum.
2. To develop the mathematical and algorithmic foundations of the error detecting and error correcting codes used in modern communications systems.
3. To demonstrate the concept of Convolution coding in form of Tree diagram and trellis code.
4. To study about the Viterbi algorithm in Turbo coding
5. To develop the spread spectrum signal concept in Digital communication.

UNIT I	DETECTION	9

Pass band Transmission model - Gram Schmidt orthogonalization procedure, Geometric Interpretation of signals, Response of bank of correlators to a noisy input-Detection of Known signals in noise - correlation Receiver- Matched Filter Receiver - Detection of signals with unknown phase- Probability of error.

UNIT II	CONSTANT ENVELOPE MODULATION	9

Advantages of Constant Envelope Modulation - Minimum Shift Keying- Gaussian Minimum Shift Keying- M-ary Pulse Amplitude Modulation - M-ary Quadrature Amplitude Modulation – M-ary Phase Shift Keying- M-ary Frequency Shift Keying, Non Coherent modulation Techniques.

UNIT III	CONVOLUTIONAL CODING	9

Representation of codes using Polynomial- State diagram- Tree diagram- and Trellis diagram – Maximum likelihood Decoding – Distance properties - Sequential decoding. Coded modulation for bandwidth-constrained channels-Trellis coded modulation- Set Partitioning, Four state trellis-coded modulation with 8-PSK signal constellation, Eight-state trellis code for coded 8-PSK modulation, Eight-state trellis for rectangular QAM signal constellations.

UNIT IV	TURBO CODING	9

Introduction-Turbo Encoder- UMTS Turbo Code- cdma2000 Turbo Code - Turbo Decoder, Iterative Turbo Decoding Principles; Modifications of the MAP Algorithm-The Soft-Output Viterbi Algorithm (SOVA);Turbo Coded BPSK Performance over Gaussian channels, Turbo Coding Performance over Rayleigh Channels.

UNIT V	SPREAD SPECTRUM SIGNALS FOR DIGITAL COMMUNICATION	9

Model of spread Spectrum Digital Communication System-Direct Sequence Spread Spectrum Signals- Error rate performance of the coder- Generation of PN Sequences and its properties - Frequency Hopped Spread Spectrum Signals- Performance of FH Spread Spectrum Signals in an AWGN Channel- CDMA system based on FH spread spectrum signals- Synchronization of Spread Spectrum Systems.

Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	Formative Assessment Test (10 Marks)	End Semester Exams (60 Marks)
1.Description Questions 2.Formative Multiple choice questions	1.Assignment 2.Online Quizzes 3.Problem solving Activities	1.Description Questions 2.Formative Multiple choice questions

Outcomes

Upon completion of the course, the students will be able to:

CO604. 1	To Narrate coherent and non coherent detection in detail
CO604. 2	Analyze the performance of a pass band digital communication system in terms of error rate and spectral efficiency
CO604. 3	Identify the major classes of error detecting and error correcting codes and how they are used in practice.
CO604. 4	Explain the concepts of Turbo coding.
CO604. 5	To Apply Spread Spectrum Techniques in Wireless Communication Technologies

Text Books

1. Simon Haykin, "Digital Communications", John Wiley, 2006.
2. Simon Haykin, " Digital Communication System", Wiley Student Edition, 2013
3. Bernard Sklar., "Digital Communications", Pearson Education, second edition, 2001

Reference Books

1. John G. Proakis., "Digital Communication", McGraw Hill Publication, 4th edition, 2001

2. **S.Lin&D.J.Costello, Error Control Coding (2/e) Pearson, 2005.**
3. **L. Hanzo, T.H. Liew&B.L. Yeap, "Turbo Coding, Turbo Equalization & Space-Time Coding", Wiley, 2002.**
4. **Theodore S.Rappaport., "Wireless Communications", Pearson Education, 2nd edition 2002.**
5. **Stephen G. Wilson., "Digital Modulation and Coding", Pearson Education, First Indian Reprint,2003.**
6. **9. Rodger E. Ziemer, Roger L. Peterson, David E. Borth , "Introduction to Spread Spectrum Communications", Prentice Hall,1995.**

Web Resources

- https://onlinecourses.nptel.ac.in/noc17_ee17/
- https://eprints.soton.ac.uk/271238/2/Turbo-coding-equalization-chapter-1-3-13-18.pdf

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	3	1								3	3	1	2	
2	3	3	1							2	1	3			3
3	3	3	1								2	3	3	2	
4	3	3	1							2	3	3			1
5	3	3	1								3	3	3	1	2

24CS1605	RESEARCH METHODOLOGY FOR ENGINEERS	L	T	P	C
		3	0	0	3

Prerequisites for the course

NIL

Objectives

1. To understand some basic concepts of engineering research and its methodologies.
2. To identify various sources of information for literature review.
3. To familiarize the various procedures for analysis and optimization of research techniques
4. To understand report writing and presentation skills.
5. To understand about intellectual property rights

UNIT I	INTRODUCTION TO RESEARCH METHODOLOGY	9

Research –types of research-research process, engineering research- objectives, motivation, types, research question , formulating a research problem

UNIT II	LITERATURE REVIEW	9

New and Existing Knowledge, Analysis and Synthesis, Types of Publications, Bibliographic Databases, Measures of Research impact, keywords, Types of Plagiarism, Software Used for Identifying Plagiarism Techniques to Avoid Plagiarism, ethics in engineering research

UNIT III	ANALYSIS AND OPTIMIZATION	9

Research tools, Statistics-one dimensional, two dimensional, multidimensional, Optimization Methods – Two parameter, multi parameter, cost function. Survey research methods

UNIT IV	TECHNICALWRITING /PRESENTATION	9

Technical writing – attributes and reasons, writing strategies, Journal Paper: Structure and Approach, Language Skills, Writing Style, and Editing, Rules of Mathematical Writing, Attributions and Citations, Acknowledgments, patents.

UNIT V	INTELLECTUAL PROPERTY RIGHTS	9

Introduction, Significance, Requirements for Patentability, Application Preparation and Filing, Forms of IPR, IPR and Licensing, patent – examples

	Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	Formative Assessment Test (10 Marks)	End Semester Exams (60 Marks)
1.Description Questions 2.Formative Multiple choice questions	1.Assignment 2.Online Quizzes 3.Problem solving Activities	1.Description Questions 2.Formative Multiple choice questions

Outcomes

Upon completion of the course, the students will be able to:

CO605.1 Demonstrate the concepts of engineering research and its methodologies.

CO605.2 Understand the various methods used to collect the data for research.

CO605.3 Formulate appropriate research problem and conduct the experiments using analysis and optimization

CO605.4 Write quality research in engineering.

CO605.5 Understand the concepts of intellectual property rights.

Text Books

1. Dipankar Deb, Rajeeb Dey, Valentina E. Balas.”Engineering Research Methodology A Practical Insight for Researchers”,Springer.2019
2. David V. Thiel, “Research Methods for Engineers”,Cambridge university press,2014
3. Vinayak Bairagi Mousami V. Munot ,”Research Methodology A Practical And Scientific Approach”, CRC Press, 2019

Reference Books

1. Ranjit Kumar,“Research Methodology a step-by-step guide for beginners” SAGE publications, Fifth edition,2019

Web Resources

- https://nptel.ac.in/courses/107/108/107108011/
- https://onlinecourses.swayam2.ac.in/cec20_hs17/preview

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	3	1								3	3	2	1	1
2	3	3	1								3	3	2	1	1
3	3	3	1								3	3	2	1	1
4	3	3	1								3	3	2	1	1
5	3	3	1								3	3	2	1	1

1→Low 2→Medium 3→High

24CS1611	COMMUNICATION SYSTEMS LABORATORY - I	L	T	P	C
		4	0	4	2

Prerequisites for the course

- The pre-requisite knowledge required by the Students to study this Course is basic knowledge in Digital Communication lab.

Objectives

1. To analyze the performance of error control codes and spectral estimation
2. To design and test LMS , RLS algorithm and BER
3. To analyze lossless coding techniques and OFDM transceiver design..
4. To design the radiation pattern of antenna.
5. To design and estimate the cancellation and fractal structure of antenna

S.No	List of Experiments	CO
1	Design and performance analysis of error control encoder and decoder (CRC and Convolution Codes)	1
2	Design and Analysis of Spectrum Estimators (Bartlett, Welch) .	1
3	Channel equalizer design (LMS, RLS algorithms)	2
4	BER performance Analysis of M-ary digital Modulation Techniques (coherent & non coherent) in AWGN Environment .	2
5	Design and performance analysis of Lossless Coding Techniques - Huffman Coding and Lempel Ziv Algorithm..	3
6	OFDM transceiver design .	3
7	Design 2D Radiation Pattern of the antenna.	4

8	Design 3D Radiation Pattern of the antenna.	**4**
9	Construction and simulation of a Fractal Structure	**4**
10	Noise / Echo cancellation .(LMS / RLS algorithms)	**5**
		Total Periods :60

Suggestive Assessment Methods

Lab Components Assessments (50 Marks)	**End Semester Exams (50 Marks)**
1.Experiment 2.Model lab exam	1.End semester lab exam

Outcomes

Upon completion of the course, the students will be able to:

CO611. 1 To analyze the performance of error control codes and spectral estimation
CO611. 2 To design and test LMS , RLS algorithm and BER.
CO611. 3 To analyze lossless coding techniques and OFDM transceiver design
CO611. 4 To design the radiation pattern of antenna the desired frequencies
CO611. 5 To design and estimate the cancellation and fractal structure of antenna

Software Requirements

Software Requirement:

- **CST Studio**
- SCILAB

Reference Books

1. **J.G.Proakis, M.Salehi, —Fundamentals of Communication Systems‖, Pearson Education 2014.**
2. **Simon Haykin, —Communication Systems‖, 4th Edition, Wiley, 2014**
3. **B.P.Lathi, —Modern Digital and Analog Communication Systems‖, 3rd Edition, Oxford University Press, 2007.**

Web Resources

- **vlab.co.in/ba-nptel-labs-electronics-and-communications**
- **https://nptel.ac.in/courses/117/102/117102059/**
- **https://nptel.ac.in/courses/117/101/117101002/**

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	1		2							2					
2	2									2			2		
3		2												2	
4	1		2							1					1

5		2	1									3	1	2

SEMESTER II

S.No	Course Code	Course Name	Category	Contact Periods	L	T	P	C
Theory Courses								
1	24CS2601	Optical Communication Networks	PC	3	3	0	0	3
2	24CS2602	MIC and RF Transceiver Design	PC	3	3	0	0	3
3	24CS2603	5G Network	PC	3	3	0	0	3
4		Professional Elective II	PE	3	3	0	0	3
5		Professional Elective III	PE	3	3	0	0	3
6		Professional Elective IV	PE	3	3	0	0	3
Practical Courses								
1	24CS2611	Communication Systems Laboratory II	PC	4	0	0	4	2
			Total	**22**	**18**	**0**	**4**	**20**

24CS2601	OPTICAL COMMUNICATION NETWORKS	L	T	P	C
		3	0	0	3

Prerequisites for the course

1. The pre-requisite knowledge required by the Students to study this Course is basic knowledge in Advanced Wireless Communication and Communication Systems Laboratory I.

Objectives

1. Make students to learn the basic optical components for realizing any optical function.
2. Enable the students to identify and formulate different networking topologies.
3. Enable the students to design Optical Network Routing Algorithms.
4. Make the students to apply the basic Networking knowledge to realize any sort of end to end communication and analyze the time division multiplexing in optical domain.
5. Make the students to manage the optical networks in its configuration, fault and performance.

UNIT I	OPTICAL SYSTEM COMPONENTS	9

Light propagation in optical fibers – Loss & bandwidth, Dispersion effects, Non-Linear effects; Solitons- Optical Network Components – Couplers, Isolators & Circulators, Multiplexers & Filters, Optical Amplifiers, Switches, Wavelength Converters.

UNIT II	OPTICAL NETWORK ARCHITECTURES	9

Introduction to Optical Networks: SONET / SDH standards, Metropoliton Area Networks, Layered Architecture- Broadcast and Select Networks– Topologies for Broadcast Networks, Media Access Control Protocols, Testbeds for WDM; Outline of Wavelength Routing Architecture.

UNIT III	WAVELENGTH ROUTING NETWORKS	9

Optical layer, Node Designs, Routing and Wavelength Assignment, Virtual topology design problem,Regular virtual topology design- Predetermined Virtual topology and Light path routes- Architectural variations.

UNIT IV	PACKET SWITCHING AND ACCESS NETWORKS	9

Photonic Packet Switching – OTDM, Multiplexing and Demultiplexing, Synchronisation, Broadcast OTDM networks, Switch-based networks- Access Networks – Network Architecture overview, OTDM networks- Optical Access Network Architectures- Future Access Networks, FTTH Scenario in India and Foreign Countries.

UNIT V	NETWORK DESIGN AND MANAGEMENT	9

Transmission System Engineering – System model, Power penalty - transmitter, receiver, Optical amplifiers, crosstalk, dispersion- Wavelength stabilization; Overall design considerations- Control and Management – Network management functions, Configuration management, Performance management, Fault management, Optical safety.

Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	Formative Assessment Test (10 Marks)	End Semester Exams (60 Marks)
1.Description Questions 2.Formative Multiple choice questions	1.Assignment 2.Online Quizzes 3.Problem solving Activities	1.Description Questions 2.Formative Multiple choice questions

Outcomes

Upon completion of the course, the students will be able to:

CO601. 1 Apply knowledge of basic optical components for realizing any optical function.

CO601. 2 Identify and formulate different networking Topologies.

CO601. 3 Design Optical Network Routing Algorithms.

CO601. 4 Apply the basic Networking knowledge to realize any sort of end to end communication and Analyze the Time division multiplexing in optical domain.

CO601. 5 Manage the optical networks in its configuration, fault and performance.

Reference Books

1. **Rajiv Ramaswami, Kumar N. Sivarajan and Galen H. Sasaki "Optical Networks : A Practical Perspective", Harcourt Asia Pvt. Ltd., Third Edition 2010.**
2. **Mohammad Ilyas, Hussein T. Mouftah, "Handbook of Optical Communication Networks", Taylor and Francis, First edition, 2007.**
3. **C.Siva Ram Moorthy and Mohan Gurusamy, "WDM Optical Networks :Concept, Design and Algorithms", Prentice Hall of India, First Edition, 2002.**
4. **Biswanath Mukherjee, "Optical Communication Networks", McGrawHill Revised Edition 2006.**
5. **P.E. Green, Jr., "Fiber Optic Networks", Prentice Hall, NJ, 1993. 6. Rajiv Ramaswami and Kumar N. Sivarajan, "Optical Networks : A Practical Perspective", Harcourt Asia Pvt. Ltd., First Edition 1997.**
6. **Rajiv Ramaswami, Kumar N. Sivarajan and Galen H. Sasaki "Optical Networks : A Practical Perspective", Harcourt Asia Pvt. Ltd., First Edition 2005.**

Web Resources

- www.nextgenerationoptical.com
- http://www.lightwaveonline.com
- http://aicte-stream/Nptel Lecture by Dr. MukundaRao.

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	2	1	1		1				2	1	2	1	2	
2	3	2	1	1						2	1	2	2		3
3	3	2	2	1		1				2	1	2		2	
4	3	2	1	1						2	1	2			1
5	3	2	2	1		1				2	1	2	3	1	2

24CS2602	MIC AND RF TRANSCEIVER DESIGN	L	T	P	C
		3	0	0	3

Prerequisites for the course

1. The pre-requisite knowledge required by the Students to study this Course is basic knowledge in Microwave Engineering

Objectives

1. To design and analyze different microwave components
2. To use SMITH chart to analyze the region of stability and instability for designing amplifiers and oscillators.
3. Design of RF circuits and RFIC system
4. Design passive and active microwave Circuits and MIC Systems
5. Deign the system using MMIC Technologies.

UNIT I	MICROWAVE TRANSISTOR AND AMPLIFIER DESIGN	9

Power Gain Equations- Stability Considerations- Constant gain circles:Unilateral case- Unilateral Gain- Constant Gain circles:Bilateral case- Operating and Available Power Gain Circles- DC Bias Networks

UNIT II	MICROWAVE HIGHPOWER AMPLIFIER AND OSCILLTOR DESIGN	9

Noise in Two port Network- Constant Noise Figure Circles- Broadband Amplifier Design- Highpower Amplifier Design, Two stage amplifier design- One Port Negative-Resisatance Oscillators- Two Port Negative-Resistance Oscillators- Oscillator design using large signal measurements- Oscillator Configurations

UNIT III	TRANSCEIVER ARCHITECTURES	9
Noise Figure, Effects of Nonlinearity, Harmonic Distortion, Gain Compression, Cross Modulation, Intermodulation, Cascaded Nonlinear Stages AM/PM Conversion, Sensitivity and Dynamic Range, Transceiver Architectures-General Considerations, Heterodyne Receivers, , Direct Conversion Receivers, Image Reject Receivers, Low-Receivers, Transmitter Architectures - General Considerations-Direct and Two Step up conversion		
UNIT IV	**MICROWAVE PASSIVE CIRCUITS**	**9**
Overview of Planar Transmission Lines- Design Parameters for Strip lines and Microstrips - Realization of L&C by Low Impedance, High Impedance method and STUB method - LPF, BPF Design - Branch Line Coupler, Rat-Race Coupler, Power Dividers.		
UNIT V	**SYSTEM DESIGN USING MMIC TECHNOLOGY**	**9**
Analysis of MMIC Technology -Micro Machined Antennas - Micro Electro Mechanical System Antennas, Design issues in Phased Array Radar- Satellite Transponder -Integrated electronic warfare T/R modules - Avionic Systems Integration.		
	Total Periods	**45**

Suggestive Assessment Methods		
Continuous Assessment Test (30 Marks)	**Formative Assessment Test (10 Marks)**	**End Semester Exams (60 Marks)**
1.Description Questions 2.Formative Multiple choice questions	**1.Assignment 2.Online Quizzes 3.Problem solving Activities**	**1.Description Questions 2.Formative Multiple choice questions**

Outcomes

Upon completion of the course, the students will be able to:

CO602. 1 Perform transistor analysis and be able to design amplifiers and oscillators at microwave frequencies

CO602. 2 Perform gain analysis and be able to design amplifiers and oscillators at microwave frequencies.

CO602. 3 Design RF front-end for the required performance.

CO602. 4 Design an MIC circuit for the required performance.

CO602. 5 Design application specific MIC Systems.

Text Books

1. **Jia Sheng Hong, M. J. Lancaster, "Microstrip Filters for RF/Microwave Applications", John Wiley & Sons, 2001**
2. **Guillermo Gonzalez, "Microwave Transistor Amplifiers – Analysis and Design", II Edition, Prentice Hall, New Jersy**
3. **Thomas H.Lee, "Planar Microwave Engineering", Cambridge University Press, 2004**
4. **Reinhold.Ludwig and PavelBretshko, "RF Circuit Design", Pearson Education, Inc., 2006**
5. **B.Razavi,"RF Micro electronics", Pearson Education, Second Edition, 2012**

Reference Books

1. **Jia Sheng Hong, M. J. Lancaster, "Microstrip Filters for RF/Microwave Applications", John Wiley & Sons, 2001**
2. **Guillermo Gonzalez, "Microwave Transistor Amplifiers – Analysis and Design", II Edition, Prentice Hall, New Jersy**
3. **Thomas H.Lee, "Planar Microwave Engineering", Cambridge University Press, 2004**

4. **Reinhold.Ludwig and PavelBretshko, "RF Circuit Design", Pearson Education, Inc., 2006**
5. **B.Razavi,"RF Micro electronics", Pearson Education, Second Edition, 2012**

Web Resources

- http://www.analog.com/library/.../archives/.../EDCh%204%20rf%20if.pdf
- http://www.highfrequencyelectronics.com/Archives/Aug11/HFE0811_Maloratsky.pdf
- http://adsabs.harvard.edu/abs/1987maa..agar.....D

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	2	1	1		1				2	1	2	1	2	
2	3	2	1	1						2	1	2			3
3	3	2	2	1		1				2	1	2	3	2	
4	3	2	1	1						2	1	2			1
5	3	2	2	1		1				2	1	2	3	1	2

24CS2603	5G NETWORKS	L	T	P	C
		3	0	0	3

Prerequisites for the course

- The pre-requisite knowledge required by the Students to study this Course is basic knowledge in Computer Networks and Wireless Communication

Objectives

1. To study about advanced wireless network, 5G and Evolutions.
2. To study about Physical Architecture and 5G Network architecture,
3. To study about multi-carrier waveforms FBMC and GFDM.
4. To study about Multiple Access Techniques in 5G.
5. To study about the MTC and D2D communication

UNIT I	INTRODUCTION TO 5G AND BEYOND	9

5G characteristics and requirements, Applications, Case studies, 5G channel models: METIS channel models, Map-based model, stochastic model, Comparison of Models

UNIT II	5G ARCHITECTURE	9

Introduction, NFV and SDN, Basics about RAN architecture, High –level requirements for the 5G architecture, Functional architecture and 5G flexibility, Functional split criteria, Functional Split Alternatives, Functional optimization for specific applications, Integration of LTE and new air interface to fulfill 5G requirements, Enhanced Multi-RAT Coordination features, Physical architecture and 5G deployment.

UNIT III	MULTI-CARRIER WAVE FORMS FOR 5G	9

Filter-bank based multi-carrier (FBMC)- Principles, Transceiver block diagram, Frame structure, Resource structure, allocation, mapping.Universal filtered multi carrier (UFMC)- Principles, Transceiver structure, Frame and Resource structure, allocation, mapping. Generalized frequency division multicarrier (GFDM) –Principles, Transceiver Block diagram, Frame structure, Resource structure, allocation, mapping, MIMO-GFDM

UNIT IV	MULTIPLE ACCESS TECHNIQUES IN 5G	9

Challenges in OFDM- NOMA – Principle- Superposition Coding, Successive Interference Cancellation, Power Domain NOMA, Sparse Code NOMA - types, Power Domain Sparse Code NOMA, Cooperative NOMA – Benefits and Challenges

UNIT V	COOPERATIVE COMMUNICATION	9

Machine Type Communication (MTC), Device to Device Communication (D2D), 5G Narrowband IoT, Cloud Computing architecture and Protocols, Relaying: Cooperative NOMA- Benefits and Challenges, Half duplex relaying, Full duplex relaying, Amplify and forward relaying, Decode and forward relaying, Decode and forward relaying with PLNC, BER Analysis, Capacity Analysis.

	Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	Formative Assessment Test (10 Marks)	End Semester Exams (60 Marks)
1.Description Questions 2.Formative Multiple choice questions	1.Assignment 2.Online Quizzes 3.Problem solving Activities	1.Description Questions 2.Formative Multiple choice questions

Outcomes

Upon completion of the course, the students will be able to:

CO603. 1	Able to analyze the performance of different channel models adopted in 5G wireless systems
CO603. 2	Able to design a transceiver for Multicarrier waveforms.
CO603. 3	Able to analyze multiple access techniques in 5G networks
CO603. 4	Able to design a pilot, estimate channels and analyze capacity for single cell and multi cell Massive MIMO.
CO603. 5	Able to analyze different types of cooperative communications

Text Books

1. **AfifOsseiran, Jose.F.Monserrat and Patrick Marsch, "5G Mobile and Wireless Communications Technology", Cambridge University Press, 2016.**
2. **Robert W. Heath Jr., Nuria González-Prelcic, SundeepRangan, WonilRohand Akbar M. Sayeed, "An Overview of Signal Processing Techniques for Millimeter Wave MIMO Systems", IEEE Journal of Selected Topics in Signal Processing, Vol. 10, No. 3, April 2016.**
3. **Min ChulJu and Il-Min Kim, "Error Performance Analysis of BPSK Modulation in PhysicalLayer Network-Coded Bidirectional Relay Networks", IEEE Transactions on Communications,Vol. 58, No. 10, October 2010.**

Reference Books

1. **Shengli Zhang, Soung-Chang Liew, Patrick P.Lam, "Physical Layer Network Coding", Mobicom _06, Proceeding of the 12th International Conference on Mobile Computing and Networking, pp.358-365, Los Angeles, CA, USA, Sep.23-29,2006.**

2. **ThomasL. Marzetta, ErikG. Larsson, HongYang, HienQuocNgo,"Fundamentals of Massive MIMO", Cambridge University Press, 1stEdition, 2016**
3. **AfifOsseiran, Jose F. Monserrat, Patrick Marsch, " 5G Mobile and Wireless Communications Technology", Cambridge University Press, 2nd edition, 2011**
4. **Erik Dahlman, Stefan Parkvall, Johan Sköld, "5G NR: The Next Generation Wireless Access Technology", Elsevier, 1stEdition, 2016.**
5. **Jonathan Rodriguez." Fundamentals of 5G Mobile Networks", Wiley, 1stEdition, 2010.**

Web Resources

- https://nptel.ac.in/courses/117/104/117104099/
- https://nptel.ac.in/courses/117/102/117102062/
- https://nptel.ac.in/noc/courses/noc18/SEM1/noc18-cs09/

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	3	3	3	2						2	2	1	2	
2	3	3	3	3	2						2	2			3
3	3	3	3	3	2						2	2	3	2	
4	3	3	3	3	3						2	2			1
5	3	3	3	3	2						2	2	3	1	2

24CS2611	COMMUNICATION SYSTEMS LABORATORY - II	L	T	P	C
		4	0	4	2

Prerequisites for the course

- The pre-requisite knowledge required by the Students to study this Course is basic knowledge in Communication Systems lab I.

Objectives

1. To simulate the performance of EZW and Characterization of wireless communication signals
2. To analyze Additive Correlated / Uncorrelated White Noise and Estimation techniques
3. To design and determine the characteristics of CDMA system and SPIHT.
4. To design and simulate dipole and horn antenna
5. To design and simulate patch antenna and Audio and speech compression algorithms.

S.No	List of Experiments	CO
1	Simulation of Wavelet Transform Based Image Coding Algorithm-EZW.	1
2	Study the Spectral Characterization of wireless communication signals.	2
3	Simulation of spatially separated Signal in the presence of Additive Correlated / Uncorrelated White Noise..	2

4	Analysis of performance of the Estimation techniques - MLE, MMSE, Bayes Estimator, MAP Estimator, Expectation Maximization (EM) algorithm .	**2**
5	Simulation and performance evaluation of a CDMA System .	**3**
6	Simulation of Wavelet Transform Based Image Coding Algorithm-SPIHT.	**3**
7	Design and simulate the Dipole antenna.	**5**
8	Design and simulate the Horn antenna.	**5**
9	Design and simulate the Patch antenna.	**4**
10	Simulation of Audio and speech compression algorithms a) Companding techniques. b) Linear Predictive Coding techniques.	**4**
		Total Periods :60

Suggestive Assessment Methods

Lab Components Assessments (50 Marks)	**End Semester Exams (50 Marks)**
1.Experiment 2.Model lab exam	1.End semester lab exam

Outcomes

Upon completion of the course, the students will be able to:

CO611. 1 Analyze the performance of EZW and Characterization of wireless communication signals
CO611. 2 Analyse Additive Correlated / Uncorrelated White Noise and Estimation techniques
CO611. 3 Design characteristics of CDMA system and SPIHT.
CO611. 4 Design and simulate dipole and horn antenna.
CO611. 5 Design and simulate patch antenna and Audio and speech compression algorithms.

Laboratory Requirements

Software Requirement:

- **CST Studio**
- SCILAB

Reference Books

1. **J.G.Proakis, M.Salehi, —Fundamentals of Communication Systems‖, Pearson Education 2014.**
2. **Simon Haykin, —Communication Systems‖, 4th Edition, Wiley, 2014**
3. **B.P.Lathi, —Modern Digital and Analog Communication Systems‖, 3rd Edition, Oxford University Press, 2007.**

Web Resources

- **https://nptel.ac.in/courses/108/101/108101112/**
- **https://nptel.ac.in/courses/108/102/108102420/**
- **https://nptel.ac.in/content/storage2/courses/117105083/pdf/ssg_m9l29.pdf**

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	1		2							2			1	2	
2	2									2			2		3
3		2												2	
4	1		2							1				2	1
5		2	1										3	1	2

SEMESTER III

S.No	Course Code	Course Name	Category	Contact Periods	L	T	P	C
Theory Courses								
1	24CS3607	Machine Learning in Communication Networks	PC	3	3	0	0	3
2		Professional Elective V	PE	3	3	0	0	3
3		Professional Elective VI	PE	3	3	0	0	3
Practical Courses								
1	24CS3901	Dissertation I	EEC	12	0	0	12	6
2	24CS3902	Term Paper Writing	EEC	1	0	0	2	1
			Total	**18h + 8 weeks**	**6**	**0**	**14**	**16**

24CS3607	MACHINE LEARNING IN COMMUNICATION NETWORKS	L	T	P	C
		3	0	0	3

Prerequisites for the course

- The pre-requisite knowledge required by the students to study this Course is basic knowledge in Artificial Intelligence.

Objectives

1. To understand the concepts of Supervised and Unsupervised Learning.
2. To explore the different supervised learning techniques including ensemble methods
3. To learn different aspects of unsupervised learning and reinforcement learning
4. To learn the role of probabilistic methods for machine learning
5. To understand the basic concepts of neural networks and deep learning

UNIT I	MACHINE LEARNING BASICS	9

Supervised and Unsupervised learning, Capacity, Over fitting and Under fitting, Cross Validation, Linear regression, Logistic Regression, Regularization, Naive Bayes, Principle Component Analysis, Support Vector Machines (SVM), Decision tree, Random forest, K-Means Clustering, k nearest neighbor.

UNIT II	NEURAL NETWORKS	9

Feed forward Networks, Back propagation, Convolutional Neural Networks-LeNet, AlexNet, ZFNet, VGGNet, GoogLeNet, ResNet, Visualizing Convolutional Neural Networks, Guided Back propagation, Recurrent Neural Network (RNN).

UNIT III	DISTRIBUTED ML AND REINFORCEMENT LEARNING	9

Distributed optimization in resource-constrained systems, Communication-Efficient Distributed Edge Learning, Federated learning, Decentralized learning, Low-latency and on-device AI; Reinforcement Learning - Markov decision processes, Q-learning and Policy Optimization methods, Deep Reinforcement Learning (DRL), Multi-agent systems

UNIT IV	ML IN WIRELESS PHYSICAL LAYER SYSTEM DESIGN	9

Machine Learning in Channel Estimation, Feedback, and Signal Detection-Compressive sensing and pilot Estimation. Physical layer communications-Use of auto encoders for data transmission, Modulation, Channel coding, Modulation / Signal and Constellation classification, Localization, Spectrum Sensing using Deep Learning.

UNIT V	ML IN WIRELESS SYSTEMS AND SECURITY	9

LOS and NLOS channel classification, Water-filling power allocation for 5G systems, Optimization for OFDM and MIMO-OFDM systems. Optimization in beamformer design – Robust receive beamforming, Transmit downlink beamforming. IoT Application: MCU-Net, Radar for target detection, Array Processing, MUSIC, ML in Side channel analysis.

	Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	Formative Assessment Test (10 Marks)	End Semester Exams (60 Marks)
1.Description Questions 2.Formative Multiple choice questions	1.Assignment 2.Online Quizzes 3.Problem solving Activities	1.Description Questions 2.Formative Multiple choice questions

Outcomes

Upon completion of the course, the students will be able to:

CO603. 1	Familiar with the different machine learning techniques and their use cases.
CO603. 2	In a position to formulate Neural Network based problems corresponding to different applications.
CO603. 3	In a position to formulate reinforcement learning concepts based problems corresponding to wireless applications.
CO603. 4	Able to evaluate machine learning techniques that are useful to solve wireless physical layer problems.
CO603. 5	In a position to read current research papers, understand the issues and implement the machine learning based real time solution approaches.

Text Books

1. **Ian Good fellow, Yoshua Bengio, and Aaron Courville, "Deep learning", Cambridge, MA", MIT Press, 2017.**

2. **Tom M. Mitchell, "Machine Learning", McGraw Hill, 1997.**
3. **Ethem Alpaydın, "Introduction to machine learning", MIT Press, 3rd Edition, 2014.**

Reference Books

6. **Richard S. Sutton, Andrew G. Barto, "Reinforcement Learning, An Introduction", · 2018**
7. **Xu Wang , Sen Wang, Xingxing Liang , Dawei Zhao, Jincai Huang, XinXu , Bin Dai , and Qiguang Miao , "Deep Reinforcement Learning: A Survey", IEEE Transactions On Neural Networks And Learning Systems, 2017**

Web Resources

- https://nptel.ac.in/courses/106106139
- https://nptel.ac.in/courses/106106184
- https://nptel.ac.in/courses/106105152

24CS3902	TERM PAPER WRITING	L	T	P	C
		0	0	2	1

In this course, students will develop their scientific and technical reading and writing skills that they need to understand and construct research articles. A term paper requires a student to obtain information from a variety of sources (i.e., Journals, dictionaries, reference books) and then place it in logically developed ideas. The work involves the following steps:

1. Selecting a subject, narrowing the subject into a topic
2. Stating an objective.
3. Collecting the relevant bibliography (atleast 15 journal papers)
4. Preparing a working outline.
5. Studying the papers and understanding the authors contributions and critically analysing each paper. 6. Preparing a working outline
7. Linking the papers and preparing a draft of the paper.
8. Preparing conclusions based on the reading of all the papers.
9. Writing the Final Paper and giving final Presentation

Please keep a file where the work carried out by you is maintained. Activities to be carried out

Activity	Instructions	Submission week	Evaluation
Selection of area of interest and Topic Stating an Objective	You are requested to select an area of interest, topic and state an objective	2nd week	3 % Based on clarity of thought, current relevance and clarity in writing
Collecting Information about your area & topic	1. List 1 Special Interest Groups or professional society 2. List 2 journals 3. List 2 conferences, symposia or workshops 4. List 1 thesis title 5. List 3 web presences (mailing lists, forums, news sites)	3rd week	3% (the selected information must be area specific and of international and national standard)

		6. List 3 authors who publish regularly in your area 7. Attach a call for papers (CFP) from your area.		
	Collection of Journal papers in the topic in the context of the objective – collect 20 & then filter	• You have to provide a complete list of references you will be using- Based on your objective -Search various digital libraries and Google Scholar • When picking papers to read - try to: • Pick papers that are related to each other in some ways and/or that are in the same field so that you can write a meaningful survey out of them, • Favour papers from well-known journals and conferences, • Favour "first" or "foundational" papers in the field (as indicated in other people's survey paper), • Favour more recent papers, • Pick a recent survey of the field so you can quickly gain an overview, • Find relationships with respect to each other and to your topic area (classification scheme/categorization) • Mark in the hard copy of papers whether complete work or section/sections of the paper are being considered	4th week	6% (the list of standard papers and reason for selection)
	Reading and notes for first 5 papers	Reading Paper Process • For each paper form a Table answering the following questions: • What is the main topic of the article? • What was/were the main issue(s) the author said they want to discuss? • Why did the author claim it was important? • How does the work build on other's work, in the author's opinion? • What simplifying assumptions does the author claim to be making? • What did the author do? • How did the author claim they were going to evaluate their work and compare it to others? • What did the author say were the limitations of their research? • What did the author say were the important directions for future research? Conclude	5th week	8% (the table given should indicate your understanding of the paper and the evaluation is based on your conclusions about each paper)

	with limitations/issues not addressed by the paper (from the perspective of your survey)		
Reading and notes for next5 papers	Repeat Reading Paper Process	6th week	8% (the table given should indicate your understanding of the paper and the evaluation is based on your conclusions about each paper)
Reading and notes for final 5 papers	Repeat Reading Paper Process	7th week	8% (the table given should indicate your understanding of the paper and the evaluation is based on your conclusions about each paper)
Draft outline 1 and Linking papers	Prepare a draft Outline, your survey goals, along with a classification / categorization diagram	8th week	8% (this component will be evaluated based on the linking and classification among the papers)
Abstract	Prepare a draft abstract and give a presentation	9th week	6% (Clarity, purpose and conclusion) 6% Presentation & Viva VoceIntroduction Background
Introduction Background	Write an introduction and background sections	10th week	5% (clarity)
Sections of the paper	Write the sections of your paper based on the classification / categorization diagram in keeping with the goals of your survey	11th week	10% (this component will be evaluated based on the linking and classification among the papers)
Your conclusions	Write your conclusions and future work	12th week	5% (conclusions – clarity and your ideas)
Final Draft	Complete the final draft of your paper	13th week	10% (formatting, English, Clarity and linking) 4% Plagiarism Check Report
Seminar	A brief 15 slides on your paper	14th week	10% (based on presentation and Viva-voce)

Total : 30 Periods

SEMESTER IV

S.No	Course Code	Course Name	Category	Contact Periods	L	T	P	C
Practical Courses								
1	24CS4901	Dissertation II	EEC	24	0	0	24	12
			Total	**24**	**0**	**0**	**24**	**12**

List of Professional Electives Courses

S.No	Course Code	Course Name	Semester	L	T	P	C
Professional Elective I							
1	24CS1701	Communication Network Security	I	3	0	0	3
2	24CS1702	Advanced Multimedia Compression Techniques	I	3	0	0	3
3	24CS1703	Advanced Digital Image Processing	I	3	0	0	3
4	24CS1704	VLSI Design for Signal Processing	I	3	0	0	3
5	21CS1705	High Performance FPGA System Design	I	3	0	0	3
Professional Elective II							
1	24CS2701	Advanced Wireless Sensor Networks and WBAN	II	3	0	0	3
2	24CS2702	Massive MIMO and Millimeter Wave Communication	II	3	0	0	3
3	24CS2703	MIMO OFDM Systems	II	3	0	0	3
4	24CS2704	High Performanc Analog IC Design	II	3	0	0	3
Professional Elective III							
1	24CS2705	Advanced Integrated SOC Design Techniques	II	3	0	0	3
2	24CS2706	Modern IOT	II	3	0	0	3
3	24CS2707	Real Time Embedded Systems	II	3	0	0	3
4	24CS2708	Smart Antennas	II	3	0	0	3
Professional Elective IV							
1	24CS2709	VLSI Circuit Test and Verification Techniques	II	3	0	0	3
2	24CS2710	Modern Satellite Systems	II	3	0	0	3

3	24CS2711	Network Routing Algorithms	II	3	0	0	3
4	24CS2712	Remote Sensing	II	3	0	0	3
Professional Elective V							
1	24CS3701	Embedded Wireless Sensor Networks	III	3	0	0	3
2	24CS3702	DSP Processor Architecture and Programming	III	3	0	0	3
3	24CS3703	RF and Radiation System Design	III	3	0	0	3
4	24CS3704	High Speed Communication Networks	III	3	0	0	3
Professional Elective VI							
1	24CS3705	Cooperative Communication	III	3	0	0	3
2	24CS3706	VLSI Architecture for Image and Video Processing	III	3	0	0	3
3	24CS3707	Mobile Robotics	III	3	0	0	3
4	24CS3708	Advanced Radar and Navigational AIDS	III	3	0	0	3

List of Professional Electives I

S.No	Course Code	Course Name	Semester	L	T	P	C
1	24CS1701	Communication Network Security	I	3	0	0	3
2	24CS1702	Advanced Multimedia Compression Techniques	I	3	0	0	3
3	24CS1703	Advanced Digital Image Processing	I	3	0	0	3
4	24CS1704	VLSI Design for Signal Processing	I	3	0	0	3
5	21CS1705	High Performance FPGA System Design	I	3	0	0	3

24CS1701	COMMUNICATION NETWORK SECURITY	L	T	P	C
		3	0	0	3

Prerequisites for the course

- The pre-requisite knowledge required by the Students to study this Course is basic knowledge in Network security.

Objectives

1. To learn security mechanisms and techniques to provide security services.
2. To be exposed to symmetric & asymmetric key algorithms and key management aspects.
3. To be aware of the need for security in different layers and wireless network security.
4. To study the various network and Web security.
5. To be aware about the wireless network security.

UNIT I	SECURITY SERVICES AND MECHANISMS	9

Security Goals, Types of Attacks: Passive attack, active attack, attacks on confidentiality, attacks on Integrity and availability. Security services – Confidentiality, Integrity, Authentication, Non repudiation& Access control and Mechanisms- Encipherment, Data Integrity, Digital Signature, Authentication Exchange, Traffic Padding, Routing Control , Notarization & Access Control.

UNIT II	SYMMETRIC & ASYMMETRIC KEY ALGORITHMS	9

Substitutional Ciphers, Transposition Ciphers, Stream and Block Ciphers, Data Encryption Standards (DES), Advanced Encryption Standard (AES), RC4, Principle of Asymmetric key algorithms, RSA Cryptosystem.

UNIT III	INTEGRITY, AUTHENTICATION AND KEY MANAGEMENT	9

Message Integrity, Hash functions: SHA, Digital signatures: Digital signature standards, Authentication: Entity Authentication: Biometrics, Key management Techniques.

UNIT IV	NETWORK SECURITY , FIREWALLS AND WEB SECURITY	9

Introduction on Firewalls, Types of Firewalls, Firewall Configuration and Limitation of Firewall. IP Security Overview, IP security Architecture, authentication Header, Security payload, security associations, Key Management. Web security requirement, secure sockets layer, transport layer security.

UNIT V	WIRELESS NETWORK SECURITY	9

Security Attack issues specific to Wireless systems: Worm hole, Tunnelling, DoS. WEP for Wi-Fi network, Security for 4G networks: Secure Ad hoc Network, Secure Sensor Network.

	Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	Formative Assessment Test (10 Marks)	End Semester Exams (60 Marks)
1.Description Questions 2.Formative Multiple choice questions	1.Assignment 2.Online Quizzes 3.Problem solving Activities	1.Description Questions 2.Formative Multiple choice questions

Outcomes

Upon completion of the course, the students will be able to:

CO701. 1 Identify and differentiate security attacks.

CO701. 2 Apply various Encryption, Authentication and Digital Signature Algorithms

CO701. 3 Configure firewalls based on the security requirements and secure the perimeter.

CO701. 4 Deal with different general purpose and application specific Security Protocols and Techniques.

CO701. 5 Provide security services at different layers for various network architectures.

Text Books

1. **Behrouz A. Forouzan , Debdeep Mukhopadhyay,"Cryptography and Network security", Tata McGraw- Hill, Second Edition, 2011.**
2. **William Stallings, "Cryptography and Network security: Principles and Practice", Prentice Hall of India, New Delhi, Sixth Edition, 2013.**
3. **AtulKahate , "Cryptography and Network security", Tata McGraw- Hill, Third Edition, 2008**

Reference Books

1. **R.K.Nichols and P.C. Lekkas ," Wireless Security Models, Threats and Solutions", Tata McGraw- Hill, First Edition, 2006.**
2. **H. Yang et al., "Security in Mobile Ad Hoc Networks: Challenges and Solution", IEEE Wireless Communications, Feb. 2004.**
3. **L. Zhou and Z. J. Haas , "Securing Ad Hoc Networks", IEEE Network Magazine, vol. 13, no. 6, pp. 24-30, December 1999.**
4. **David Boyle and Thomas Newe, "Securing Wireless Sensor Networks – Security Architecture", Journal of networks, Vol.3. No. 1. pp. 65 -76, Jan 2008**
5. **Perrig, A., Stankovic, J. And Wagner, D., "Security in Wireless Sensor Networks", Communications of the ACM, Vol. No.47, Issue. 6, pp 53-57, 2004**

Web Resources

- http://highered.mcgraw-hill.com/sites/0072870222/student_view0/
- http://williamstallings.com/Crypto/Crypto4e.html

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	3	2							2	2	3	1	2	
2	3	3	2	1	2						2	3	2		1
3	3	3	3		2					2	2	3		2	
4	3	3	2		2					2	2	3			1
5	3	3	2	1						2	2	3	3	1	2

24CS1702	ADVANCED MULTIMEDIA COMPRESSION TECHNIQUES	L	T	P	C
		3	0	0	3

Prerequisites for the course

- The pre-requisite knowledge required by the Students to study this Course is basic knowledge in Multimedia compression.

Objectives

1. To get familiarized with the multimedia concepts
2. To get acquainted with various compression techniques for text.
3. To study the various compression techniques in audio,

4. To understand the various compression techniques in image
5. To get familiarized with various video compression methods.

UNIT I	MULTIMEDIA CONCEPTS	9

Special features of Multimedia – Graphics and Image Data Representations – Fundamental Concepts in Video and Digital Audio – Storage requirements for multimedia applications -Need for Compression - Taxonomy of compression techniques – Overview of source coding, source models, scalar and vector quantization theory – Evaluation techniques – Error analysis and methodologies.

UNIT II	TEXT COMPRESSION	9

Compaction techniques – Huffman coding – Adaptive Huffman Coding – MNP5-Adaptive Arithmetic coding — Dictionary techniques – LZW –WINRAR – exe compressors

UNIT III	AUDIO COMPRESSION	9

Audio compression techniques - μ- Law and A- Law companding. Frequency domain and filtering – Basic sub-band coding –speech coding standard – G.722 – Audio coding standard– MPEG 4 audio, speech compression techniques – Formant and CELP Vocoders.-AAC- Dolby AC 3

UNIT IV	IMAGE COMPRESSION	9

Lapped transforms – LOT-LBT- Transform based image compression –JPEG-Embedded zero tree coding - fractal based image compression – partitioned IFS- Design of Filter banks – Wavelet based compression: Implementation using filters – EZW, SPIHT coders – JBIG, JBIG2 standards.

UNIT V	VIDEO COMPRESSION	9

Video compression techniques and standards –MPEG – 4 and 7 – Motion estimation and compensation techniques – H.261 Standard – DVI technology – PLV performance – DVI real time compression – Packet Video.-Fractal based video compression – Quadtree PIFS.

Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	Formative Assessment Test (10 Marks)	End Semester Exams (60 Marks)
1.Description Questions 2.Formative Multiple choice questions	1.Assignment 2.Online Quizzes 3.Problem solving Activities	1.Description Questions 2.Formative Multiple choice questions

Outcomes

Upon completion of the course, the students will be able to:

CO702. 1 To analyze the requirement of compression in different real time applications.
CO702. 2 To Apply various compaction techniques for text compression.
CO702. 3 To understand the performance of audio compression techniques.
CO702. 4 To study the performances of various algorithms for image compression
CO702. 5 To analyze the different standards applicable for video compression.

Text Books

1. **1.David Salomon, "Data Compression – The Complete Reference", Springer Verlag, New York Inc., Fourth Edition, 2014.**
2. **Khalid Sayood,"Introduction to Data Compression", Morgan Kauffman Harcourt India, Fourth Edition, 2012**

Reference Books

1. **K.R.Rao, P.C.Yip, " The transform and data compression handbook" CRC Press ,2018**
2. **Yun Q.Shi and Huifang Sun,"Image and Video Compression for Multimedia Engineering - Fundamentals,**
3. **Algorithms & Standards", CRC press, Second Edition, 2008**
4. **Mark S.Drew and Ze-NianLi,"Fundamentals of Multimedia", Prentice Hall, 2009.**

Web Resources

- https://www.pearsonhighered.com/assets/ sample Chapter/0/1/3/2/ 0132406426.pdf
- https://book.systemsapproach.org/data/multimedia.html

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	3	1								3	3	1	2	
2	3	3	1								3	3			3
3	3	3	1								3	3	3	2	
4	3	3	1								3	3			1
5	3	3	1								3	3	3	1	2

24CS1703	ADVANCED DIGITAL IMAGE PROCESSING	L	T	P	C
		3	0	0	3

Prerequisites for the course

- The pre-requisite knowledge required by the Students to study this Course is basic knowledge in Digital Image Processing.

Objectives

1. To understand the image fundamentals.
2. To understand the various image segmentation techniques.
3. To extract features for image analysis.
4. To introduce the concepts of image registration and image fusion.
5. To illustrate 3D image visualization

UNIT I	FUNDAMENTALS OF DIGITAL IMAGE PROCESSING	9

Elements of visual perception, brightness, contrast, hue, saturation, mach band effect, 2D image transforms-DFT, DCT, KLT,SVD. Image enhancement in spatial and frequency domain, Review of Morphological image processing

UNIT II	SEGMENTATION	9

Edge detection, Thresholding, Region growing, Fuzzy clustering, Watershed algorithm, Active contour models, Texture feature based segmentation, Graph based segmentation, Wavelet based Segmentation - Applications of image segmentation.

UNIT III	FEATURE EXTRACTION	9
First and second order edge detection operators, Phase congruency, Localized feature extraction - detecting image curvature, shape features, Hough transform, shape skeletonization, Boundary descriptors, Moments, Texture descriptors- Autocorrelation, Co-occurrence features, Runlength features, Fractal model based features, Gabor filter, wavelet features.		
UNIT IV	**REGISTRATION AND IMAGE FUSION**	**9**
Registration - Preprocessing, Feature selection - points, lines, regions and templates Feature correspondence - Point pattern matching, Line matching, Region matching, Template matching. Transformation functions - Similarity transformation and Affine Transformation. Resampling – Nearest Neighbour and Cubic Splines. Image Fusion - Overview of image fusion, pixel fusion, wavelet based fusion -region based fusion.		
UNIT V	**3D IMAGE VISUALIZATION**	**9**
Sources of 3D Data sets, Slicing the Data set, Arbitrary section planes, The use of color, Volumetric display, Stereo Viewing, Ray tracing, Reflection, Surfaces, Multiple connected surfaces, Image processing in 3D, Measurements on 3D images.		
	Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	Formative Assessment Test (10 Marks)	End Semester Exams (60 Marks)
1.Description Questions 2.Formative Multiple choice questions	1.Assignment 2.Online Quizzes 3.Problem solving Activities	1.Description Questions 2.Formative Multiple choice questions

Outcomes

Upon completion of the course, the students will be able to:

CO703. 1 Explain the fundamentals digital image processing.
CO703. 2 Describe image various segmentation for image analysis.
CO703. 3 Describe image various feature extraction techniques for image analysis.
CO703. 4 Discuss the concepts of image registration and fusion.
CO703. 5 Explain 3D image visualization.

Text Books

1. **Ardeshir Goshtasby, " 2D and 3D Image registration for Medical, Remote Sensing and Industrial Applications",John Wiley and Sons,2005.**
2. **Anil K. Jain, Fundamentals of Digital Image Processing', Pearson Education, Inc., 2002.**

Reference Books

1. **John C.Russ, "The Image Processing Handbook", CRC Press,2007.**
2. **Mark Nixon, Alberto Aguado, "Feature Extraction and Image Processing", Academic Press,2008.**
3. **Rafael C. Gonzalez, Richard E. Woods, Digital Image Processing', Pearson, Education, Inc.,Second Edition, 2004.**
4. **Rick S.Blum, Zheng Liu, "Multisensor image fusion and its Applications", Taylor& Francis,2006.**

Web Resources

- https://onlinecourses.nptel.ac.in/noc19_ee55/preview
- https://en.unisi.it/ugov/degreecourse/89770
- http://cloudportal.sathyabama.ac.in/coursematerial_staging/uploads/SECA7022.pdf

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	3								2	2	1	2		1
2	3	3	2							1	3			3	2
3	3	2	3							2	2	3	2		
4	3	3								2	2			1	
5	3	3	2							1	3	3	1	2	3

24CS1704	VLSI DESIGN FOR SIGNAL PROCESSING	L	T	P	C
		3	0	0	3

Prerequisites for the course

- The pre-requisite knowledge required by the Students to study this Course is basic knowledge in VLSI Design.

Objectives

1. To familiarize various representation methods of DSP algorithms, understand the significance of the iteration bound and to calculate the same for a given single-rate and/or multi-rate DFG.
2. To understand retiming and pipelining and parallel processing.
3. To understand algorithms unfolding and folding on a given DFG.
4. To understand the concepts of fast convolution, pipelining and parallel processing for FIR and IIR filters
5. To signify and calculate the effects of numerical strength reduction, scaling and round-off noise for a given digital filter with limited word length.

UNIT I	INTRODUCTION TO SIGNAL PROCESSING	9

Typical DSP Algorithms – DSP Application Demands and Scaled CMOS Technologies - Representations of DSP Algorithms - Data-Flow Graph Representations. Introduction -Loop Bound and Iteration Bound -Algorithms for Computing Iteration Bound: Longest Path Matrix and Multiple Cycle Mean algorithms - Iteration Bound of Multi-rate Data Flow Graphs

UNIT II	PIPELINING, PARALLEL PROCESSING AND RETIMING	9

Pipelining, Parallel processing and Retiming- Introduction to Retiming -Definitions and Properties - Solving Systems of Inequalities - The Bellman-Ford Algorithm - The Floyd Warshall Algorithm- Retiming Techniques.

UNIT III	UNFOLDING AND FOLDING	9

Introduction, An Algorithm for Unfolding, Properties of Unfolding, Critical Path, Unfolding, and Retiming, Applications of Unfolding, Introduction, Folding Transformation, Register Minimization Techniques, Register Minimization in Folded Architectures.

UNIT IV	FAST CONVOLUTION, PIPELINING AND PARALLEL PROCESSING FOR FIR AND IIR FILTERS	9

Fast convolution – Cook-Toom algorithm, modified Cook-Toom algorithm, Pipelined and parallel recursive filters – Look-Ahead pipelining in first-order IIR filters, Look-Ahead pipelining with powerof-

2 decomposition, Clustered look-ahead pipelining, Parallel processing of IIR filters, combined pipelining and parallel processing of IIR filters		
UNIT V	**NUMERICAL STRENGTH REDUCTION, SCALING AND ROUNDING NOISE**	**9**
Introduction, Numerical strength reduction – subexpression elimination, multiple constant multiplication, Scaling and Rounding Noise, State Variable Description of Digital Filters, Scaling and Rounding Noise Computation, Rounding Noise in Pipelined IIR Filters		
	Total Periods	**45**

Suggestive Assessment Methods		
Continuous Assessment Test (30 Marks)	**Formative Assessment Test (10 Marks)**	**End Semester Exams (60 Marks)**
1.Description Questions 2.Formative Multiple choice questions	**1.Assignment 2.Online Quizzes 3.Problem solving Activities**	**1.Description Questions 2.Formative Multiple choice questions**

Outcomes

Upon completion of the course, the students will be able to:

Text Books

1. **Keshab K. Parhi, VLSI Digital Signal Processing Systems: Design and Implementation, Reprint, Wiley, Inter Science, 2014.**
2. **John G. Proakis, Dimitris K Manolakis, Digital Signal Processing: Principles, Algorithms and Applications, Prentice Hall, Fourth Edition, 2015.**

Reference Books

3. **Mohammed Ismail and Terri Fiez, Analog VLSI Signal and Information Processing, McGraw-Hill, 2014.**
4. **S.Y. Kung, H.J. White House, T. Kailath, VLSI and Modern Signal Processing, PHI, 2010.**
5. **S. K. Mitra, Digital Signal Processing –A Computer Based Approach, Fourth Edition, McGraw-Hill, 2010.**

Web Resources

- https://nptel.ac.in/courses/106/105/106105173/
- https://onlinecourses.nptel.ac.in/noc24_cs11/preview
- https://nptel.ac.in/courses/106/106/106106184/

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	3													
2	3	3	2										2		
3	3	3												1	
4	3	2	1										2		
5	3	2													

24CS1705	HIGH PERFORMANCE FPGA SYSTEM DESIGN	L	T	P	C
		3	0	0	3

Prerequisites for the course

The pre-requisite knowledge required by the Students to study this Course is basic knowledge in Digital Logic Design, VLSI DESIGN

Objective

- Understand and critically compare state-of-the-art design automation methodologies.
- Use computer aided design tools to synthesize a design written in VHDL and generate a bitstream for execution on an FPGA.
- Verify hardware designs at several levels in the design flow.
- Understand the need for and application of different optimization techniques, and their relative interaction within computer aided design tools.
- Take advantage of pre-existing intellectual property to reduce design time and produce more optimal results.

UNIT I	OVERVIEW OF ASIC TYPES, DESIGN FLOW, AND CMOS CIRCUIT DESIGN	9

Types of ASICs - Design flow – CMOS transistors- CMOS Design rules –Combinational logic Cell Sequential logic cell - Transistor as Resistors - Transistor parasitic capacitance – Logical effort - Library cell design – Library architecture.

UNIT II	INTEGRATED SYSTEM-ON-CHIP DESIGN FOR VOICE OVER IP	9

Voice over IP SOC - Intellectual Property – SOC Design challenges- Methodology and design-FPGA to ASIC conversion – Design for integration-SOC verification-Set top box SOC.

UNIT III	MODERN PHYSICAL DESIGN AND LOW POWER TECHNIQUES	9

Over view of physical design flow- tips and guideline for physical design- modern physical design techniques- power dissipation-low power design techniques and methodologies-low power design tools- tips and guideline for low power design.

UNIT IV	ESSENTIAL PRINCIPLES OF VHDL AND FPGA DESIGN	9

VHDL essentials: Entity: model interface, Architecture, Process, Variable types and operators, Decisions and Loops - Hierarchical design – Debugging models: Assertions – Basic data types, Simulation and Test benches - Libraries – Synthesis – Place and route – VHDL issues for FPGA design.

UNIT V	FPGA INTERFACE DESIGN TECHNIQUES	9

Serial Communication: RS232 – Camera Link Interface - ADC interface – High-speed Data Converter Using Parallel and Serial Interface - PS/2 Mouse Interface – PS/2 Keyboard Interface, VGA Interface.

	Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	Formative Assessment Test (10 Marks)	End Semester Exams (60 Marks)
1.Description Questions 2.Formative Multiple choice questions	1.Assignment 2.Online Quizzes • 3.Problem solving Activities	1.Description Questions • 2.Formative Multiple choice questions

Outcomes

Upon completion of the course, the students will be able to:

CO1	Explain the need for programmable devices.

CO2	Express the IC fabrication techniques vis-à-vis CMOS switch.
CO3	Explain the low power design techniques and methodologies.
CO4	Write VHDL programs for optimised system design using FPGA
CO5	Interface basic devices to FPGA in designing digital systems.

Text Books

1. M.J.S. Smith, "Application Specific Integrated Circuits", Pearson Education, 2020 [Unit- I-III]
2. Peter Wilson, "Design Recipes for FPGAs: Using Verilog and VHDL", Elsevier (Newnes), 2015 (Second Edition). [Unit- IV- V]

Reference Books

1. Wayne Wolf, —FPGA-Based System Design, Prentice Hall PTR, 2019.
2. Farzad Nekoogar and Faranak Nekoogar, —From ASICs to SOCs: A Practical Approach, Prentice Hall PTR, 2003

Web Resources

1. www.vhdl.org/rassp/vhdl/guidelines/DesignReq.pdf [Unit- I- V]
2. https://nptel.ac.in/courses/117/108/117108040/# [Unit- I- V]

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	3		2	2						1	1	3	
2	3	2	2	2							1	1	3	
3	3	2	2	2	3						1	1	3	
4	3	3	3	2							1	1	3	
5	3	3	3	2							1	1	3	

List of Professional Electives II

S.No	Course Code	Course Name	Semester	L	T	P	C
1	24CS2701	Advanced Wireless Sensor Networks and WBAN	II	3	0	0	3
2	24CS2702	Massive MIMO and Millimeter Wave Communication	II	3	0	0	3
3	24CS2703	MIMO OFDM Systems	II	3	0	0	3
4	24CS2704	High Performance Analog IC Design	II	3	0	0	3

24CS2701	ADVANCED WIRELESS SENSOR NETWORKS AND WBAN	L	T	P	C
		3	0	0	3

Prerequisites for the course

- The pre-requisite knowledge required by the Students to study this Course is basic knowledge in Wireless networks, computer networks, Networking.

Objectives

1. To understand the overview of Wireless Sensor Network
2. To analyse the MAC and Routing methods.
3. To Design the Architecture of MAC protocol.
4. To analyse the infrastructure establishment and Data Management.
5. To identify the necessity of WBAN.

UNIT I	OVERVIEW OF WIRELESS SENSOR NETWORKS	9

Challenges for Wireless Sensor Networks-Characteristics requirements-required mechanisms, Difference between mobile ad-hoc and sensor networks, Applications of sensor networks- case study, Enabling Technologies for Wireless Sensor Networks

UNIT II	MAC AND ROUTING	9

Single-Node Architecture - Hardware Components, Energy Consumption of Sensor Nodes, Operating Systems and Execution Environments, Network Architecture - Sensor Network Scenarios, Optimization Goals and Figures of Merit, Gateway Concepts. Physical Layer and Transceiver Design Considerations

UNIT III	ARCHITECTURES	9

MAC Protocols for Wireless Sensor Networks, IEEE 802.15.4, ZigBee, Low Duty Cycle Protocols and Wakeup Concepts - S-MAC, The Mediation Device Protocol, Wakeup Radio Concepts, Address and Name Management, Assignment of MAC Addresses, Routing Protocols- Energy Efficient Routing, Geographic Routing.

UNIT IV	INFRASTRUCTURE ESTABLISHMENT AND DATA MANAGEMENT	9

Topology Control, Clustering, Time Synchronization, Localization and Positioning-Data management in WSN, Storage and indexing in sensor networks, Query processing in sensor, Data aggregation.

UNIT V	WIRELESS BODY AREA NETWORK	9

Introduction to WBAN Standard-Architecture-WBAN layers- Network and MAC Protocol Design for WBAN-Energy Management in WBAN-Performance Analysis of WBAN- Miniaturized Antennas Implanted Antennas- PHY layer for UWB WBAN. Case study using Simulation Tools.

	Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	Formative Assessment Test (10 Marks)	End Semester Exams (60 Marks)
1.Description Questions 2.Formative Multiple choice questions	1.Assignment 2.Online Quizzes 3.Problem solving Activities	1.Description Questions 2.Formative Multiple choice questions

Outcomes

Upon completion of the course, the students will be able to:

CO701. 1 Ability to demonstrate an understanding of the different components of WSN and WBAN

CO701. 2 Ability to demonstrate an understanding of the different implementation challenges and the solution approaches

CO701. 3	Ability to design and implement protocols suitable to sensor communication scenario using design tools and characterize them
CO701. 4	Ability to appreciate the need for designing energy efficient sensor nodes and protocols for prolonging network lifetime.
CO701. 5	Ability to understand the practical design issues and find out different implementation tools for improving the overall performance of body area network.

Text Books

1. **Holger Karl & Andreas Willig, "Protocols and Architectures for Wireless Sensor Networks",John Wiley, 2005.**
2. **Ian F. Akyildiz, Mehmet Can Vuran, "Wireless Sensor Networks" John Wiley, 2010**

Reference Books

1. **Yingshu Li, My T. Thai, Weili Wu, "Wireless Sensor Networks and Applications" Springer, 2008.**
2. **Huan-Bang Li, Kamya Yekeh Yazdandoost Bin-Zhen, "Wireless Body Area Networks", River Publishers, 2010.**
3. **Kasun Maduranga Silva Thotahewa(Author), Jean-Michel Redoute (Author), Mehmet RasitYuce, "Ultra Wideband Wireless Body Area Networks", Springer, 2016.**

Web Resources

- https://nptel.ac.in/courses/106/105/106105160/
- https://nptel.ac.in/noc/courses/noc18/SEM1/noc18-cs09/

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	3	3			1				3	3	3	1	2	
2	3	3	3	1	3				3		3	3	2		3
3	3	1	1		3					3	1	3		2	
4	3	3	3		3			1		3	3	3			1
5	3	3	3	1						3	3	3	3	1	2

24CS2702	MASSIVE MIMO AND MILLIMETER WAVE COMMUNICATION	L	T	P	C
		3	0	0	3

Prerequisites for the course

- The pre-requisite knowledge required by the Students to study this Course is basic knowledge in Advanced Wireless Communication.

Objectives

1. To understand the principles and challenges involved in the design of Massive MIMO systems.
2. To understand the propagation aspects of Millimeter wave signals and the fundamentals of Millimeter wave devices and circuits.
3. To understand the various components of Millimeter wave MIMO systems.
4. To understand the Millimeter wave communication systems.

5. To understand the Millimeter wave MIMO systems.

UNIT I	INTRODUCTION	9

MIMO wireless communication- MIMO channel and signal model- A fundamental trade-off- MIMO transceiver design- MIMO in wireless networks- Large MIMO systems: Opportunities in large MIMO systems- Channel hardening in large dimensions- Technological challenges and solution approaches.

UNIT II	MIMO ENCODING AND DETECTION	9

Spatial multiplexing- Space-time coding: Space-time block codes, High-rate NO-STBCs, NO-STBCs from CDAs, Spatial modulation: SM, SSK, GSM- MIMO detection- Optimum detection- Linear detection- Interference cancelation-LR-aided linear detection

UNIT III	mmWAVE PROPAGATION	9

Millimeter wave characteristics- millimeter wave wireless, implementation challenges, Radio wave propagation for mm wave: Large scale propagation channel effects, small scale channel effects, Outdoor and Indoor channel models, Emerging applications of millimeter wave communications.

UNIT IV	mmWAVE COMMUNICATION SYSTEMS	9

Modulations for millimeter wave communications: OOK, PSK, FSK, QAM, OFDM, Millimeter wave link budget, Transceiver architecture, Transceiver without mixer, Receiver without Oscillator, millimeter wave calibration, production and manufacture, Millimeter wave design considerations

UNIT V	mmWAVE MIMO SYSTEMS	9

Massive MIMO Communications, Spatial diversity of Antenna Arrays, Multiple Antennas, Multiple Transceivers, Noise coupling in MIMO system, Potential benefits for mm wave systems, Spatial, Temporal and Frequency diversity, Dynamic spatial, frequency and modulation allocation, Beamforming for MmWave communications: Analogbeamforming, digital beamforming and hybrid Beamforming.

	Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	Formative Assessment Test (10 Marks)	End Semester Exams (60 Marks)
1.Description Questions 2.Formative Multiple choice questions	1.Assignment 2.Online Quizzes 3.Problem solving Activities	1.Description Questions 2.Formative Multiple choice questions

Outcomes

Upon completion of the course, the students will be able to:

CO702. 1 Ability to appreciate Massive MIMO: characteristics and implementation challenges.
CO702. 2 Understand the need and impact of different detection approaches.
CO702. 3 Understand the need and impact of different precoding approaches.
CO702. 4 Ability to characterize propagation issues at Millimeter wave frequencies.
CO702. 5 Ability to estimate link budget and identity Millimeter wave devices and circuits Specifications.

Text Books

1. **Chockalingam and B. Sundar Rajan, "Large MIMO Systems ", Cambridge University Press, 2014.**

2. **Ezio Biglieri, Robert Calderbank, Anthony Constantinides, Andrea Goldsmith, Arogyaswami Paulraj, Vincent Poor, "MIMO Wireless Communications", Cambridge University Press, 2006.**
3. **T.S. Rappaport, R.W. Heath Jr., R.C. Daniels and J.N. Murdock, "Millimeter Wave Wireless Communications: Systems and Circuits", 2015.**

Reference Books

1. **I. Robertson, N. Somjit and M. Chongcheawchamnan, "Microwave and Millimetre-Wave Design for Wireless Communications", 2016.**
2. **AlxelJantsch, "Modeling Embedded Systems and SOC's. Concurrency and Time in Models of Computation", MK, 2004.**
3. **K.C. Huang, Z. Wang, "Millimeter Wave Communication Systems", Wiley-IEEE Press, 2011.**
4. **Robert W. Heath, Robert C. Daniel, James N. Theodore S. Rappaport, Murdock,"Millimeter Wave Wireless Communication", Prentice Hall, 2014.**
5. **Xiang, W; Zheng, K; Shen, X.S; "5G Mobile Communications", Springer, 2016**

Web Resources

- https://nptel.ac.in/courses/117/105/117105139/
- https://onlinecourses.nptel.ac.in/noc24_ee12/preview

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	3	3	3							1	3	1		
2	3	3	3	3							1	3			3
3	3	3	3	3							1	3	3	2	
4	3	3	3	3							1	3		2	1
5	3	3	3	3							1	3	3		2
6	3	3	3	3							1	3	1	2	

24CS2703	MIMO OFDM SYSTEMS	L	T	P	C
		3	0	0	3

Prerequisites for the course

- The pre-requisite knowledge required by the Students to study this Course is basic knowledge in Wireless Communication.

Objectives

1. To describe the concepts of MIMO OFDM Wireless communication systems.
2. To determine the capacity of MIMO OFDM system for a given power delay profile of the MIMO channel
3. To study the SISO and MIMO channel model
4. To Estimate the channel impulse response using least square, MMSE and Robust MMSE estimation algorithms

5. To Estimate and correct the timing and frequency offset in the signal received in the MIMO OFDM receivers and Analyze the performance of MIMO OFDM physical channel in Wi-Max/LTE wireless standards.

UNIT I	ST CHANNEL AND SIGNAL MODELS	9

Introduction-physical scattering model for ST channels, Extended channel models, Statistical properties of H, Sampled Signal model for SISO, SIMO, MISO and MIMO,ST multiuser and ST interference channels, ST channel estimation

UNIT II	CAPACITY OF WIRELESS CHANNELS	9

AWGN channel capacity-Resources of AWGN Channel, Linear time invariant guassian channels, Capacity of fading channels.

UNIT III	SISO AND MIMO CHANNEL MODELS	9

SISO channel models-Indoor and outdoor models**.** MIMO channel models-Statistical MIMO model, 1-METRO MIMO, SCM MIMO channel model.

UNIT IV	OFDM AND ITS SYNCHRONIZATION	9

Single Carrier Vs Multi Carrier Transmission, Basic principle of OFDM, OFDMA, Effect and Estimation Techniques for STO and CFO.

UNIT V	CHANNEL ESTIMATION	9

Pilot structure, Training symbol based channel estimation, DFT based and Decision directed Channel estimation. Advanced channel estimation techniques.

	Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	Formative Assessment Test (10 Marks)	End Semester Exams (60 Marks)
1.Description Questions 2.Formative Multiple choice questions	1.Assignment 2.Online Quizzes 3.Problem solving Activities	1.Description Questions 2.Formative Multiple choice questions

Outcomes

Upon completion of the course, the students will be able to:

CO703. 1	The student would be able to analyze the complexity of MIMO OFDM spatial multiplexing receivers.
CO703. 2	The student would be able to study the channel capacity of SISO and SIMO systems.
CO703. 3	The student would be able to analyze the SISO and MIMO models.
CO703. 4	The student would be able to fundamentals of OFDM and Its synchronization.
CO703. 5	The student would be able to analyse the channel estimation techniques.

Text Books

1. **Chockalingam and B. Sundar Rajan, "Large MIMO Systems ", Cambridge University Press, 2014.**
2. **Ezio Biglieri, Robert Calderbank, Anthony Constantinides, Andrea Goldsmith, Arogyaswami Paulraj, Vincent Poor, "MIMO Wireless Communications", Cambridge University Press, 2006.**

T.S. Rappaport, R.W. Heath Jr., R.C. Daniels and J.N. Murdock, "Millimeter Wave Wireless Communications: Systems and Circuits", 2015.

Reference Books

1. **Robertson, N. Somjit and M. Chong cheawchamnan, "Microwave and Millimetre-Wave Design for Wireless Communications", 2016.**
2. **Alxel Jantsch, "Modeling Embedded Systems and SOC's. Concurrency and Time in Models of Computation", MK, 2004.**
3. **K.C. Huang, Z. Wang, "Millimeter Wave Communication Systems", Wiley-IEEE Press, 2011.**
4. **Robert W. Heath, Robert C. Daniel, James N. Theodore S. Rappaport, Murdock,"Millimeter Wave Wireless Communication", Prentice Hall, 2014.**
5. **Xiang, W; Zheng, K; Shen, X.S; "5G Mobile Communications", Springer, 2016**

Web Resources

- https://nptel.ac.in/courses/117/104/117104115/
- https://nptel.ac.in/noc/courses/noc17/SEM2/noc17-ee19/

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	3	3	3							1	3	1	2	
2	3	3	3	3							1	3	2		3
3	3	3	3	3							1	3	3		
4	3	3	3	3							1	3		2	1
5	3	3	3	3							1	3	3		

24CS2704	HIGH PERFORMANCE ANALOG IC DESIGN	L	T	P	C
		3	0	0	3

Prerequisites for the course

The pre-requisite knowledge required by the Students to study this Course is basic knowledge in Analog Electronics

Objectives

1. To learn about the characteristics and model of MOS devices
2. To familiarize the concepts of analog CMOS circuits, switches and current mirrors
3. To gain knowledge on CMOS amplifiers, Op Amps and their characteristics
4. To analyze the frequency response of amplifiers, representation of noise and effect of feedback
5. To learn the concepts of switched capacitor circuits

UNIT I	FUNDAMENTALS AND ADVANCED CONCEPTS IN MOS ANALOG DESIGN	9

Introduction to Analog Design - General consideration of MOS devices – MOS IV Characteristics – Second Order Effects-MOS Device Model – MOS device layout - Device capacitance- Small signal model- Spice models- NMOS versus PMOS devices – Long channel versus short channel devices

UNIT II	ADVANCED MOS DEVICES AND CURRENT REFERENCE CIRCUIT DESIGN	9
MOS Transistor - nMOS and pMOS Transistor – MOS Switch- MOS Diode- Current Sinks and Sources - Basic current mirrors - Cascode current mirrors -Active current mirrors - Current and voltage references – Bandgap references		
UNIT III	**ADVANCED CMOS AMPLIFIER AND OP-AMP DESIGN TECHNIQUES**	**9**
Differential amplifiers – Cascode amplifiers – Current amplifiers – Output amplifiers - High gain amplifier architectures – Design of CMOS OpAmps- Design of two stage OpAmps – Cascode OpAmps – High speed/frequency OpAmps – Differential output OpAmps - micropower OpAmps- Low noise OpAmps – Low voltage OpAmps.		
UNIT IV	**AMPLIFIER STAGES, NOISE ANALYSIS, AND FEEDBACK EFFECTS IN CMOS DESIGN**	**9**
General considerations - Miller Effect and Association of Poles with Nodes, Common source stage - Source followers - Common gate stage - Cascode stage - Differential pair - Noise - Statistical characteristics of noise - Representation of noise in circuits - Noise in single stage amplifiers - Noise in differential pairs - Noise Bandwidth- Feedback topologies - Effect of loading - Effect of feedback on Noise.		
UNIT V	**SWITCHED CAPACITOR CIRCUITS AND CMOS PROCESSING TECHNOLOGY**	**9**
Switched capacitor circuits - Switched capacitor amplifiers - Switched capacitor integrators- z- Domain models of two phase switched capacitor circuits – First order switched capacitor circuits-Second order switched capacitor circuits- CMOS processing technology – Layout and packaging		
	Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	Formative Assessment Test (10 Marks)	End Semester Exams (60 Marks)
1.Description Questions 2.Formative Multiple choice questions	1.Assignment 2.Online Quizzes 3.Problem solving Activities	1.Description Questions 2.Formative Multiple choice questions

Outcomes

Upon completion of the course, the students will be able to:

CO1	Analyze the characteristics and model of MOS devices
CO2	Elucidate the concepts of analog CMOS circuits, switches and current mirrors
CO3	Design various types of CMOS amplifiers and OpAmps
CO4	Determine of the frequency response of amplifiers, representation of noise and effect of feedback
CO5	Design various levels of switched capacitor circuits

Text Books

1. Behzad Razavi, “Design of Analog CMOS Integrated Circuits”, Tata McGraw Hill, 2001, 33rd reprint, 2016 [Unit I-V].

Reference Books

1. Phillip Allen and Douglas Holmberg "CMOS Analog Circuit Design" Second Edition, Oxford University Press, 2004.
2. R. Jacob Baker, "CMOS: Circuit Design, Layout, and Simulation", Wiley – Blackwell, 2019.
3. A.B.Bhattacharyya, "Compact MOSFET Models for VLSI Design", John Wiley & Sons Ltd., 2009.
4. Paul R. Gray, Paul J. Hurst, Stephen H. Lewis, Robert G. Meyer, Analysis and Design of Analog Integrated Circuits, 5th Edition, Wiley, 2009
5. Mikael Sahrling, "Analog Circuit Simulators for IC Designers", Springer, 2020.

Web Resources

1. https://nptel.ac.in/courses/117/101/117101105/
2. https://onlinecourses.nptel.ac.in/noc21ee51/preview

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
1	2	3	3	2	2								3	
2	2	3	3	2									3	
3	3	3	2	2			2	1					3	
4	2	3	2	2			2	1					3	
5	1	3	3	2	2		1	1					3	

List of Professional Electives III

S.No	Course Code	Course Name	Semester	L	T	P	C
1	24CS2705	Advanced Integrated SOC Design Techniques	II	3	0	0	3
2	24CS2706	Modern IOT	II	3	0	0	3
3	24CS2707	Real Time Embedded Systems	II	3	0	0	3
4	24CS2708	Smart Antennas	II	3	0	0	3

24CS2705	ADVANCED INTEGRATED SOC DESIGN TECHNIQUES	L	T	P	C
		3	0	0	3

Prerequisites for the course

- Basics of Digital System Deign

Objectives

1. Exploring Design Strategies for ASICs.
2. Understanding NISC Approaches in SoC Design.
3. Integrating HDL Coding Techniques.
4. Optimizing SoC Architectures for Low Power.
5. Applying Advanced Synthesis and Verification Methods.

UNIT I	**ASIC TYPES AND SOC DESIGN METHODOLOGIES**	**9**
Overview of ASIC types, design strategies, CISC, RISC and NISC approaches for SOC architectural issues and its impact on SoC design methodologies, Application Specific Instruction Processor (ASIP)concepts.		
UNIT II	**MODELING NISC ARCHITECTURES AND SYSTEMS**	**9**
NISC Control Words methodology, NISC Applications and Advantages, Architecture Description Languages (ADL) for design and verification of Application Specific Instruction- set Processors (ASIP), No-Instruction-Set-computer (NISC)- design flow, modelling NISC architectures and systems, use of Generic Netlist Representation - A formal language for specification, compilation and synthesis of embedded processors.		
UNIT III	**ADVANCED SIMULATION AND DESIGN TECHNIQUES FOR VLSI AND SOC SYSTEMS**	**9**
Different simulation modes, behavioural, functional, static timing, gate level, switch level, transistor/circuit simulation, design of verification vectors, Low power FPGA, Reconfigurable systems, SoC related modelling of data path design and control logic, Minimization of interconnects impact, clock tree design issues.		
UNIT IV	**LOW POWER SOC DESIGN AND DIGITAL SYSTEMS**	**9**
Design synergy, Low power system perspective- power gating, clock gating, adaptive voltage scaling (AVS), Static voltage scaling, Dynamic clock frequency and voltage scaling (DCFS), building block optimisation, building block memory, power down techniques, power consumption verification.		
UNIT V	**ADVANCED CONCEPTS IN VLSI DESIGN AND OPTIMIZATION**	**9**
Role and Concept of graph theory and its relevance to synthesizable constructs, Walks, trails paths, connectivity, components, mapping/visualization, nodal and admittance graph. Technology independent and technology dependent approaches for synthesis, optimisation constraints, Synthesis report analysis, Single core and Multi core systems, dark silicon issues, HDL coding techniques for minimization of power consumption, Fault tolerant designs.		
Total Periods		**45**

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	**Formative Assessment Test (10 Marks)**	**End Semester Exams (60 Marks)**
1.Description Questions	**1.Assignment** **2.Online Quizzes**	**1.Description Questions**

2.Formative Multiple choice questions	3.Problem solving Activities	2.Formative Multiple choice questions

Outcomes

Upon completion of the course, the students will be able to:

CO1: Analyze and apply various design strategies in ASIC development, optimizing for performance, area efficiency, and power consumption.

CO2: Gain a comprehensive understanding of No Instruction Set Computer (NISC) approaches and their implications in System-on-Chip (SoC) design.

CO3: Acquire proficiency in integrating advanced Hardware Description Language (HDL) coding techniques.

CO4: Apply techniques to optimize System-on-Chip (SoC) architectures for low power consumption.

CO5: Apply advanced synthesis and verification methods to ensure the correctness, functionality, and timing closure of VLSI and SoC designs.

Text Books

1. Hubert Kaeslin, “Digital Integrated Circuit Design: From VLSI Architectures to CMOS Fabrication”, Cambridge University Press 2008.

2. B. Al Hashimi, “System on Chip-Next Generation Electronics”, The IET 2006

Reference Books

1. RochitRajsuman, “System-on- a-chip: Design and Test”, Advantest America R & D Centre, 2000

2. P Mishra and N Dutt, “Processor Description Languages”, Morgan Kaufmann 2008

3. Michael J. Flynn and Wayne Luk, “Computer System Design: System-on-Chip”. Wiley, 2011

Web Resources

1. https://youtu.be/PRQXzjTrCJY?feature=shared

2. https://youtu.be/YQwU30mptYg?feature=shared

3. https://youtu.be/2MM8mmTXi08?feature=shared

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	3		2	2						1	1	3	

2	3	2	2	2							1	1	3	
3	3	2	2		3						1	1	3	
4	3	3	3	2							1	1	3	
5	3	3	3	2							1	1	3	

24CS2706	**MODERN IOT**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Prerequisites for the course

- The pre-requisite knowledge required by the Students to study this Course is basic knowledge in Embedded Systems.

Objectives

1. Assess the genesis and impact of IoT applications, architectures in real world.
2. Illustrate diverse methods of deploying smart objects and connect them to network.
3. Compare different Application protocols for IoT.
4. Infer the role of Data Analytics and Security in IoT.
5. Identify sensor technologies for sensing real world entities and understand the role of IoT in various domains of Industry.

UNIT I	**INTRODUCTION TO IOT ARCHITECTURES**	**9**

Genesis of IoT, IoT and Digitization, IoT Impact, Convergence of IT and IoT, IoT Challenges, IoT Network Architecture and Design, Drivers Behind New Network Architectures, Comparing IoT Architectures, A Simplified IoT Architecture, The Core IoT Functional Stack, IoT Data Management and Compute Stack.

UNIT II	**IOT SENSORS AND ACTUATORS**	**9**

Smart Objects: The "Things" in IoT, Sensors, Actuators, and Smart Objects, Sensor Networks, Connecting Smart Objects, Communications Criteria, IoT Access Technologies.

UNIT III	**IOT COMMUNICATION PROTOCOLS**	**9**

IP as the IoT Network Layer, The Business Case for IP, The need for Optimization, Optimizing IP for IoT, Profiles and Compliances, Application Protocols for IoT, The Transport Layer, IoT Application Transport Methods

UNIT IV	**IMPACT OF IOT ON DATA ANALYITICS**	**9**

Data and Analytics for IoT, An Introduction to Data Analytics for IoT, Machine Learning, Big Data Analytics Tools and Technology, Edge Streaming Analytics, Network Analytics, Securing IoT, A Brief History of OT Security, Common Challenges in OT Security, How IT and OT Security Practices and Systems Vary, Formal Risk Analysis Structures: OCTAVE and FAIR, The Phased Application of Security in an Operational Environment

UNIT V	**DESIGNING IOT APPLICATIONS USING ARDUINO AND RASPBERRY PI**	**9**

IoT Physical Devices and Endpoints - Arduino UNO: Introduction to Arduino, Arduino UNO, Installing the Software, Fundamentals of Arduino Programming. IoT Physical Devices and Endpoints - RaspberryPi: Introduction to RaspberryPi, About the RaspberryPi Board: Hardware Layout, Operating

Systems on RaspberryPi, Configuring RaspberryPi, Programming RaspberryPi with Python, Wireless Temperature Monitoring System Using Pi, DS18B20 Temperature Sensor, Connecting Raspberry Pi via SSH, Accessing Temperature from DS18B20 sensors, Remote access to RaspberryPi, Smart and Connected Cities, An IoT Strategy for Smarter Cities, Smart City IoT Architecture, Smart City Security Architecture, Smart City Use-Case Examples.

Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	**Formative Assessment Test (10 Marks)**	**End Semester Exams (60 Marks)**
1.Description Questions **2.Formative Multiple choice questions**	**1.Assignment** **2.Online Quizzes** **3.Problem solving Activities**	**1.Description Questions** **2.Formative Multiple choice questions**

Outcomes

Upon completion of the course, the students will be able to:

CO706. 1 Interpret the impact and challenges posed by IoT networks leading to new architectural models.

CO706. 2 Compare and contrast the deployment of smart objects and the technologies to connect them to network.

CO706. 3 Appraise the role of IoT protocols for efficient network communication.

CO706. 4 Elaborate the need for Data Analytics and Security in IoT.

CO706. 5 Illustrate different sensor technologies for sensing real world entities and identify the applications of IoT in Industry.

Text Books

1. **David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Robert Barton, Jerome Henry,"IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things", 1 stEdition, Pearson Education (Cisco Press Indian Reprint). (ISBN: 978-9386873743)**
2. **Srinivasa K G, "Internet of Things",CENGAGE Leaning India, 2017**
3. **ArshdeepBahga, Vijay Madisetti —Internet of Things – A hands-on approach, Universities Press, 2015.**

Reference Books

1. **Vijay Madisetti and ArshdeepBahga, "Internet of Things (A Hands-on-Approach)", 1 st Edition, VPT, 2014. (ISBN: 978-8173719547)**
2. **Raj Kamal, "Internet of Things: Architecture and Design Principles", 1st Edition, McGraw Hill Education, 2017. (ISBN: 978-9352605224)**

Web Resources

1. https://onlinecourses.nptel.ac.in/noc24_cs17/preview
2. https://www.coursera.org/specializations/iot
3. https://www.edx.org/course/introduction-to-the-internet-of-things-iot

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	3	3		3	2				2		2	1	2	
2	3	3	3		3	2				2		2	2		3

3	3	3	3		3	2				2		2			
4	3	3	3		3	2				2		2		2	1
5	3	3	3		3	2				2		2	3	1	2

24CS2707	REAL TIME EMBEDDED SYSTEMS	L	T	P	C
		3	0	0	3

Prerequisites for the course

- The pre-requisite knowledge required by the Students to study this Course is basic knowledge in Microprocessors & Microcontrollers.

Objectives

1. To gain knowledge on popular embedded processors
2. To understand the Networking in Embedded systems.
3. To acquire essential skills for developing an embedded system.
4. To understand the RTOS concepts in depth
5. To develop skills in working with µc/OS–II RTOS

UNIT I	EMBEDDED PROCESSORS	9

Embedding Computers- Characteristics of Embedded Computing Applications– Challenges in Embedded Computing System-Performance in Embedded Computing- ARM processor fundamentals and architecture-Registers-CPSR-Pipelining- Exceptions, Interrupts, and the Vector Table- ARM instruction set - LPC 244x Family ARM processor- Block diagram & Features -Peripherals – Introduction to ARM 9, ARM Cortex M3

UNIT II	EMBEDDED NETWORKING	9

Basic protocol concepts- Port and Bus-based I/O – Memory mapped I/O & Standard I/O- Microprocessor interfacing: Interrupts, DMA - Arbitration - Serial protocols: I^2C, CAN, Ethernet, Fieldbus, USB- Parallel protocols: PCI, ARM bus – Wireless protocols – IrDA, Bluetooth, IEEE 802.11- Memory hierarchy and cache- Development and Debugging-System-Level Performance Analysis-Design Example: Alarm Clock

UNIT III	EMBEDDED PROGRAM DESIGN AND ANALYSIS	9

Program design – Model of programs – Assembly and Linking – Basic compilation techniques – Analysis and optimization of program level & software performance, execution time, power, energy and program size – Program validation and testing – Design example : Software Modem

UNIT IV	RTOS CONCEPTS AND µC/OS-II	9

Foreground/Background process – Resources – Tasks – Multitasking – Priorities – Schedulers – Real time priority based scheduling – Rate Monotonic Scheduling, Earliest Deadline First Scheduling -Kernel – Exclusion – Intertask communication – Interrupts – Clock ticks – Introduction to µC/OS-II-Features, Goals- µC/OS– II Kernel structure – µC/OS– II Initialization – Starting µC/OS– II.

UNIT V	µC/OS-II FUNCTIONS	9

Task Management: Creating Tasks – Task Stacks – Stack Checking – Task's Priority – Suspending Task – Resuming Task. Time Management: Delaying a Task – Resuming a Delayed Task – System Time. Event Control Blocks- Placing a Task in the ECB Wait List – Removing a Task from an ECB wait List . Memory Management: Memory Control Blocks – Creating Partition- Obtaining a Memory Block – Returning a Memory Block

	Total Periods	**45**
Suggestive Assessment Methods		
Continuous Assessment Test (30 Marks)	**Formative Assessment Test (10 Marks)**	**End Semester Exams (60 Marks)**
1.Description Questions 2.Formative Multiple choice questions	**1.Assignment 2.Online Quizzes 3.Problem solving Activities**	**1.Description Questions 2.Formative Multiple choice questions**

Outcomes

Upon completion of the course, the students will be able to:

CO707. 1 Understand the concept of embedded systems in popular embedded ARM family processors

CO707. 2 Apply apt interfacing protocols in networking embedded processors.

CO707. 3 Understand how embedded programs can be designed and analysed for performance.

CO707. 4 Learn the real time operating system concepts and how to apply them in µC/OS-II

CO707. 5 Learn to perform task, time and memory management in µC/OS-II

Text Books

1. **Andrew N.Sloss, "ARM System Developers Guide-Designing and Optimizing System Software", Elsevier**
2. **Lyla B. Das, "Embedded System", Pearson, 2013**
3. **Frank Vahid, Tony Givargis, "Embedded System Design", Wiley Student Edition,2001.**
4. **Wayne wolf, "Computer as Components-Principles of Embedded Computing System Design" Elsevier, 2nd edition**
5. **Jean J. Labrosse," MicroC/OS – II The Real Time Kernel", CMP Books, 2nd Edition 1998**

Reference Books

1. **David E. Simon, "An Embedded Software Primer", Pearson Education, 2007.**
2. **Phillip A. Laplante, "Real–Time Systems Design and Analysis", John Wiley & Sons, Inc, 2008.**
3. **Steve Health, " Embedded Sytem Design", Elsevier, Second edition, 2004**

Web Resources

- https://www.dauniv.ac.in/public/frontassets/coursematerial/embeddedsystems/Chap_5L24Ems
- https://www.digimat.in/nptel/courses/video/106105193/L09.html

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	1		2		1		2		1	3		2	1	2	
2	2	2	2				2		1	3		2	2		3
3	1		3	2	3	1	2		1	3		2	3	2	
4			3	2	1	1	2		1	3		2		2	1
5			3	2	1	1	2		1	3		2	3	1	2

24CS2708	**SMART ANTENNAS**	**L**	**T**	**P**	**C**

		3	**0**	**0**	**3**

Prerequisites for the course

- The pre-requisite knowledge required by the Students to study this Course is basic knowledge in RF and Microwave System, Antenna and Amplifiers.

Objectives

1. To give insight of basics of physics and radiation phenomena
2. To give a thorough understanding of the radiation characteristics and antenna parameters
3. To create awareness about propagation of radio waves.
4. To select appropriate antenna applications
5. To design dipole, Yagi and patch antenna for a small application

UNIT I	**ANTENNA FUNDAMENTALS**	**9**

Definition of antenna parameters –Radiation pattern, Gain, Directivity, Effective aperture, Radiation Resistance, Band width, Beam width, Input Impedance, Polarization Radiation power density and intensity,Solid angle and beam width. Polarization mismatch, Antenna noise temperature.

UNIT II	**ARRAYS**	**9**

Linear array, Pattern multiplication, Broadside and End fire array – Concept of Phased arrays, Adaptive array, Binomial array.

UNIT III	**SPECIAL ANTENNAS**	**9**

Huygens's principle, Uniqueness theorem, Field Equivalence principle and Duality theorem, Babinet's Principle - Slot antenna. Horn Antennas, Spiral antenna, helical antenna, LPDA. - Reconfigurable antenna.

UNIT IV	**ANTENNA MEASUREMENTS**	**9**

Antenna Measurements - Gain, Radiation pattern, Polarization, VSWR,directivity measurement, Micro-strip antenna measurement and calculation

UNIT V	**SMART ANTENNA SYSTEMS AND PROPAGATION**	**9**

Switched beam antenna: Single beam directional antenna, multi beam directional antenna, Single user beam forming, Multi- user beam forming, Modes of propagation , Structure of atmosphere , Ground wave propagation ,Tropospheric propagation , Duct propagation, Troposcatter propagation ,Sky wave propagation.

Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	**Formative Assessment Test (10 Marks)**	**End Semester Exams (60 Marks)**
1.Description Questions **2.Formative Multiple choice questions**	**1.Assignment** **2.Online Quizzes** **3.Problem solving Activities**	**1.Description Questions** **2.Formative Multiple choice questions**

Outcomes

Upon completion of the course, the students will be able to:

CO708. 1	Students able to determine the characteristics Impedance and Propagation constant of transmission lines and to explain the process of radiation
CO708. 2	Students able to calculate various matching impedance and losses in transmission lines, explain the behavior of an antenna in terms of its parameters
CO708. 3	Students able to determine the radiation fields of antennas and Compute the fields

CO708. 4	Students able to analyze the nature of the wave propagation in various layers of atmosphere
CO708. 5	Students able to Study the measurement of antenna parameters using various methods

Text Books

1. **Edward C.Jordan and Keith G.Balmain" Electromagnetic Waves and Radiating Systems" Prentice Hall of India, 2006**
2. **R.E.Collin,"Antennas and Radiowave Propagation", McGraw Hill 1985**

Reference Books

1. **Constantine.A.Balanis "Antenna Theory Analysis and Design", Wiley Student Edition, 2006.**
2. **Rajeswari Chatterjee, "Antenna Theory and Practice" Revised Second Edition New Age International Publishers, 2006.**
3. **H.Sizun "Radio Wave Propagation for Telecommunication Applications", First Indian Reprint, Springer Publications, 2007.**

Web Resources

- https://www.ofcom.org.uk/research-and-data/technology/general/emerging-tech/smart-antennas
- https://searchmobilecomputing.techtarget.com/definition/smart-antenna

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	3	3			1				3	3	3	1	2	
2	3	3	2	1	3				3		2	2	2		3
3	2	1	1		3					3	1	3	1	1	
4	3	3	3		3			1		3	3	2		2	1
5	3	3	3	1						3	3	3	3	1	2

List of Professional Electives IV

S.No	Course Code	Course Name	Semester	L	T	P	C
1	24CS2709	VLSI Circuit Test and Verification Techniques	II	3	0	0	3
2	24CS2710	Modern Satellite Systems	II	3	0	0	3
3	24CS2711	Network Routing Algorithms	II	3	0	0	3
4	24CS2712	Remote Sensing	II	3	0	0	3

24CS2709	VLSI CIRCUIT TEST AND VERIFICATION TECHNIQUES	L	T	P	C
		3	0	0	3

Prerequisites for the course

The pre-requisite knowledge required by the Students to study this Course is basic knowledge in Basic Electronics

Objectives

1. Understanding VLSI Testing Processes and Equipment.
2. Simulating Fault Logic and Testability Measures.
3. Analyzing Combinational Circuit Test Generation.
4. Analyzing Sequential Circuit Test Generation.
5. Applying Memory Testing Principles.

UNIT I	**FUNDAMENTALS OF VLSI TESTING AND FAULT MODELING**	**9**

Introduction- Principle of testing, Types of testing, Automatic test equipment, Electrical parametric testing. Fault modeling – Defects, errors and faults, Functional vs Structural testing, Levels of fault models, Glossary of fault models, Single stuck-at faults.

UNIT II	**SIMULATION AND TESTABILITY MEASURES FOR VLSI DESIGN VERIFICATION**	**9**

Simulation for design verification, test evaluation, modelling circuits for simulation, Algorithms for true value simulation and fault simulation, Statistical methods for fault simulation. Testability measures- SCOAP- Controllability and observability, Combinational and Sequential SCOAP measures.

UNIT III	**ADVANCED ALGORITHMS AND TECHNIQUES IN VLSI TESTING**	**9**

Algorithms and Representations, Redundancy Identification (RID), Testing as a Global Problem, Significant Combinational ATPG Algorithms, Test Generation Systems, Test Compaction.

UNIT IV	**ADVANCED ATPG TECHNIQUES FOR SEQUENTIAL CIRCUITS**	**9**

ATPG for Single-Clock Synchronous circuits, Time-Frame Expansion Method, Simulation- Based Sequential Circuit ATPG.

UNIT V	**ADVANCED CONCEPTS IN MEMORY TESTING AND FAULT ANALYSIS**	**9**

Memory Density and Defect Trends, Faults, Memory Test Levels, March Test Notation, Fault Modeling. Case studies of Testing of Sensor chips, High voltage interface controllers, Case Studies on Transition Fault Test Generation for At-speed Scan Testing, Implementation combinational and sequential circuits testing for simple design.

Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	**Formative Assessment Test (10 Marks)**	**End Semester Exams (60 Marks)**
1.Description Questions	**1.Assignment** **2.Online Quizzes**	**1.Description Questions**

2.Formative Multiple choice questions	**3.Problem solving Activities**	**2.Formative Multiple choice questions**

Outcomes

Upon completion of the course, the students will be able to:

CO1: Understanding of the VLSI testing process, including the utilization of various test equipment and the fundamentals of fault modeling.
CO2: Simulate fault logic and assess testability measures to ensure the reliability and functionality of VLSI circuits.
CO3: Ability to analyze and generate tests for combinational circuits, ensuring thorough coverage and fault detection.
CO4: Skills in analyzing and generating tests for sequential circuits, focusing on advanced fault detection techniques.
CO5: Apply fundamental principles of memory testing, enhancing their ability to ensure the integrity and performance of memory components in VLSI systems.

Text Books

1. M.L. Bushnell and V.D. Agrawal, "Essentials of Electronic Testing for Digital, Memory and Mixed-Signal VLSI Circuits", Kluwar Academic Publishers, 2004.

2. Zainalabe Navabi, "Digital System Test and Testable Design: Using HDL Models and Architectures", Springer, 2010.

Reference Books

1. Paul M. Jr. Brown "A Guide to Analog ASICs", Academic Press 2012.

2. N.K. Jha and S.G. Gupta, "Testing of Digital Systems", Cambridge University Press, 2003.

3. P. K. Lala, "Digital Circuit Testing and Testability", Academic Press, 2002.

Web Resources

1. https://youtu.be/Abld-fSxjNM?feature=shared

2. https://youtu.be/O5lyBoWR-PA?feature=shared

3. https://youtu.be/sA6yZAnx5QU?feature=shared

CO Vs PO Mapping and CO Vs PSO Mapping

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PO 12**	**PSO1**	**PSO2**	**PSO3**
1	3	2											3		
2	3	2			1								3	1	
3	3	2	2	2									3	2	
4	3	2	2	2									3	2	

5	3	2										3	2	

24CS2710	MODERN SATELLITE SYSTEMS	L	T	P	C
		3	0	0	3

Prerequisites for the course

- The pre-requisite knowledge required by the Students to study this Course is basic knowledge in Wireless Communication.

Objectives

1. To analyse the performance of any satellite network
2. To apply the orbital concepts in navigational systems
3. To understand the remote sensing system and technique.
4. To apply the concept of broadcast systems.
5. To learn about the satellite networking system with IPV6.

UNIT I	NAVIGATION, TRACKING AND SAFETY SYSTEMS	9

Global Navigation Satellite Systems - Basic concepts of GPS. Space segment, Control segment, User segment, GPS constellation, GPS measurement characteristics, Selective Availability (SA), Anti spoofing (AS). Applications of Satellite and GPS for 3D position, Velocity, determination as function of time, Interdisciplinary applications. Regional Navigation Systems- Distress and Safety- COSPAS-SARSAT- INMARSAT Distress System- Location - Based service.

UNIT II	INERTIAL NAVIGATION AND DIFFERENTIAL GPS SYSTEMS	9

Introduction to Inertial Navigation- Inertial Sensors - Navigation Coordinates-System Implementations- System-Level Error Models- Introduction to Differential GPS- LADGPS- WADGPS-WAAS - GEO Uplink Subsystem (GUS) - GEO Uplink Subsystem (GUS) Clock Steering Algorithms - GEO Orbit Determination – Problems.

UNIT III	REMOTE SENSING SYSTEMS AND TECHNIQUES	9

Introduction - Commercial Imaging - DigitalGlobe – GeoEye - Meteorology - Meteosat - Land Observation – Landsat Remote Sensing Data- Sensors- Overview - Optical Sensors: Cameras- Non-Optical Sensors- Image Processing - Image Interpretation- System Characteristics.

UNIT IV	BROADCAST SYSTEMS	9

Introduction - Satellite Radio Systems - XM Satellite Radio Inc. - Sirius Satellite Radio -Worldspace - Direct Multimedia Broadcast- MBCO and TU Multimedia - European Initiatives - Direct-to-Home Television - Implementation Issues - DTH Services- Representative DTH Systems - Military Multimedia Broadcasts - US Global Broadcast Service (GBS)- Business TV(BTV), GRAMSAT, Specialized services – E –mail, Video conferencing, Internet.

UNIT V	SATELLITE NETWORKING SYSTEM WITH IPV6	9

Overview of IPv6 and its benefits for Satellite Networks - Migration and Coexistence- IPv6 Addressing Mechanisms Addresses for Hosts and Routers- IPv6 Infrastructure - Routing and Route Management- Configuration Methods Dynamic Host Configuration Protocol for IPv6 - IPv6 and Related Protocols- IPv6 Header Format- Traffic Classes.

	Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	Formative Assessment Test (10 Marks)	End Semester Exams (60 Marks)

1.Description Questions 2.Formative Multiple choice questions	**1.Assignment 2.Online Quizzes 3.Problem solving Activities**	**1.Description Questions 2.Formative Multiple choice questions**

Outcomes

Upon completion of the course, the students will be able to:

CO710. 1 Analyze different navigational services
CO710. 2 Apply remote sensing concepts for different applications
CO710. 3 Acquire knowledge on satellite broadcast systems
CO710. 4 Acquire knowledge on satellite broadcast systems
CO710. 5 Evaluate the performance of satellite networks

Text Books

1. **Mohinder S. Grewal, "Global Positioning Systems, Inertial Navigation, and Integration." California State University at Fullerton, A John Wiley & Sons, Inc. Publication, First Edition, 2004.**
1. **Madhavendra Richharia, "Satellite systems for personal Applications" , A John Wiley and Sons, Ltd., Publication, Third Edition, 2010**

Reference Books

1. **Daniel Minoli, "Satellite Systems Engineering in an IPv6 Environment", CRC Press, First Edition, 2009 .**
2. **Dennis Roddy, "Satellite Communication", McGraw Hill International, Forth Edition, 2006.**
3. **Wilbur L. Pritchard, Hendri G. Suyderhoud, Robert A. Nelson, "Satellite Communication Systems Engineering", Prentice Hall, First Edition, 2007.**

Web Resources

- http://www.cl.cam.ac.uk/techreports/UCAM-CL-TR-696.pdf
- http://www.siriusxm.com/
- http://www.ciscopress.com/articles/article.asp?p=31948&seqNum=3

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	1	2	2	2	2	1					2	1	1	2	
2	2	3	1	2	2		1		1		1	3			3
3	2	2	1	2	1	2						2		2	
4	3	3	2	2	1	1					1	1	2		2
5	2	2	1	2	1	1					2	1	3	3	2

24CS2711	**NETWORK ROUTING ALGORITHMS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Prerequisites for the course

- The pre-requisite knowledge required by the Students to study this Course is basic knowledge in Advanced Wireless Communication.

Objectives

1. To get familiarized with different protocols in internet routing and optical WDM networks.
2. To get acquainted with the concepts of supporting protocols in Mobile-IP networks.
3. To differentiate the routing processes involved in mobile ad-hoc networks and wireless sensor networks from conventional networks.
4. To understand the concept routing in mobile ad –hoc networks.
5. To understand the concept of routing in wireless sensor networks.

UNIT I	ROUTING IN TELEPHONE NETWORKS AND INTERNET	9

General Classification of routing, Routing in telephone networks, Dynamic Non-hierarchical Routing (DNHR), Trunk status map routing (TSMR), Real-Time Network Routing (RTNR), Hierarchical routing. Exterior Routing Protocols: Exterior Gateway Protocol (EGP) and Border Gateway Protocol (BGP). Multicast Routing: Pros and cons of Multicast and Multiple Unicast Routing, Distance Vector Multicast Routing Protocol (DVMRP), Multicast Open Shortest Path First (MOSPF), MBONE, Core Based Tree Routing.

UNIT II	ROUTING IN OPTICAL WDM NETWORKS	9

Classification of RWA algorithms, RWA algorithms, Fairness and Admission Control, Distributed Control Protocols, Permanent Routing and Wavelength Requirements, Wavelength Rerouting- Benefits and Issues, Light path Migration, Rerouting Schemes, Algorithms- AG, MWPG.

UNIT III	ROUTING IN MOBILE - IP NETWORKS	9

Macro-mobility Protocols, Micro-mobility protocol: Tunnel based: Hierarchical Mobile IP, Intra domain Mobility Management, Routing based: Cellular IP, Handoff Wireless Access Internet Infrastructure (HAWAII).

UNIT IV	ROUTING IN MOBILE AD –HOC NETWORKS	9

Internet based mobile ad-hoc networking, communication strategies, routing algorithms – Table-driven routing - Destination Sequenced Distance Vector (DSDV), Source initiated on-demand routing- Dynamic Source Routing (DSR), Ad-hoc On-demand Distance Vector (AODV) routing, Hierarchical based routing- Cluster Head Gateway Switch Routing (CGSR) and Temporally-Ordered Routing Algorithm (TORA), Quality of Service.

UNIT V	ROUTING IN WIRELESS SENSOR NETWORKS	9

Routing Protocols- Energy-Efficient Routing - Power-Aware Many-to-Many Routing (PAMR), Low-Energy Adaptive Clustering Hierarchy (LEACH), Geographic Routing.Data-centric protocols, Hierarchical protocols, Location-based protocols - directed Diffusion, Network flow and QoS-aware protocols.

	Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	Formative Assessment Test (10 Marks)	End Semester Exams (60 Marks)
1.Description Questions 2.Formative Multiple choice questions	1.Assignment 2.Online Quizzes 3.Problem solving Activities	1.Description Questions 2.Formative Multiple choice questions

Outcomes

Upon completion of the course, the students will be able to:

CO711. 1	Identify various routing schemes and their applications to the real world circuit-switched networks
CO711. 2	To understand various routing techniques in optical WDM networks
CO711. 3	To Explore the various routing protocols of mobile ip networks.
CO711. 4	To learn some routing protocols of mobile adhoc networks.
CO711. 5	To understand various routing protocols of wireless sensor networks.

Text Books

1. **M. Steen Strub, "Routing in Communication network", Prentice –Hall International, New York, 1995.**
2. **S. Keshav, "An engineering approach to Computer Networking: ATM Networks, the Internet and the Telephone Network", Addison Wesley 1997.**
3. **William Stallings, "High speed Networks TCP/IP and ATM Design Principles", Prentice-Hall, Second Edition, 2002.**
4. **C. E. Perkins, "Ad hoc Networking", Addison-Wesley, 2001**
5. **C.Siva Ram Murthy and B.S.Manoj, "Ad hoc Wireless Networks Architectures and protocols", Pearson Education, Second Edition, 2007**

Reference Books

1. **Kazem Sohraby, Daniel Minoli and TaiebZnati, "Wireless Sensor Networks", A John Wiley & Sons Inc. Publication, First Edition, 2007.**
2. **Holger Karl and Andreas Willig, "Protocols and Architectures for Wireless Sensor Networks", John Wiley, 2007.**
3. **Ian F. Akyildiz, Jiang Xie and ShantidevMohanty, "A Survey of mobility Management in Next generation All IP- Based Wireless Systems", IEEE Wireless Communications Aug.2004, pp 16-28.**
4. **A.T Campbell et al., "Comparison of IP Micromobility Protocols," IEEE Wireless Communications Vol No.9, Issue 1, Feb.2002, pp 72-82.**
5. **C.Siva Rama Murthy and Mohan Gurusamy, "WDM Optical Networks – Concepts, Design and Algorithms",Prentice Hall of India Pvt. Ltd, 2002.**

Web Resources

- http://users.ecs.soton.ac.uk/sqc/EL336/CNL-10.pdf
- http://www.cs.ccsu.edu/~stan/classes/CS490/Slides/Networks4-Ch4-4.pdf
- http://www.cse.iitk.ac.in/users/dheeraj/cs425/lec12.html/
- http://www.csi.ucd.ie/staff/jmurphy/networks/csd8_7-routing.pdf

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	2	3	2							1	3	1	2	
2	3	2	3	2							1	3	2		3
3	3	2	3	2							1	3		2	
4	3	2	3	2							1	3	2		1
5	3	2	3	2							1	3	1	1	2
6	3	2	3	2							1	3	1	2	

24CS2712	REMOTE SENSING	L	T	P	C
		3	0	0	3

Prerequisites for the course

- The pre-requisite knowledge required by the Students to study this Course is basic knowledge in Total Quality Management.

Objectives

1. To gain knowledge in the concepts and laws related to remote sensing..
2. To understand the characteristics of different types of remote sensors.
3. To explain the characteristics of different types of remote sensors..
4. To explain the concepts of Geographical Information System
5. To know the concepts of Remote Sensing and GIS applications

UNIT I	PHYSICS OF REMOTE SENSING	9

Remote sensing - Definition - Components - Electromagnetic spectrum - Basic wave theory - Particle theory - Stefan Boltzman law - Wien's-Displacement law - Radiometric quantities - Effects of atmosphere - Scattering - Different types - Absorption - Atmospheric window - Energy interaction with surface features - Spectral reflectance of vegetation, soil and water - Atmospheric influence on spectral response patterns - Multi concept in Remote sensing.

UNIT II	. Remote Sensors and Systems	9

Sensors- types and its reolutions, Thermal infrared sensors, Radar and microwave radiometers, Multispectral Remote Sensing systems – data collection, multispectral imaging using detectors, scanning mirrors, linear arrays, scanners. Thermal Remote sensing- properties, laws, data collection and examples.

UNIT III	PLATFORMS	9

Orbit elements - Types of orbits - Motions of planets and satellites - Launch of space vehicle - Orbit perturbations and maneuvers - Escape velocity - Types and characteristics of different remote sensing platforms - Sun synchronous and geosynchronous satellites.

UNIT IV	Geographical Information System	9

GIS concepts, map projection and coordinate system., Spatial and non spatial data, Vector and raster data structures, Vector data analysis – buffering and overlaying, Raster data analysis – local, neighborhood, zonal operations and distance measure operations,

UNIT V	Remote Sensing and GIS applications	9

Monitoring changes in global vegetation cover: EM spectrum of vegetation. Vegetation indices. Biophysical properties and processes of vegetation. Classification systems. Global vegetation and land cover mapping programmes.

Surface and ground water resources: Remote sensing of inland water quality and sediment load. Mapping watersheds and groundwater recharge and discharge site at the regional scale.

Remote sensing of urban environments: Urbanization, land use and land cover, critical environmental assessment and disaster emergency response.

Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	Formative Assessment Test (10 Marks)	End Semester Exams (60 Marks)
1.Description Questions 2.Formative Multiple choice questions	1.Assignment 2.Online Quizzes 3.Problem solving Activities	1.Description Questions 2.Formative Multiple choice questions

Outcomes	
Upon completion of the course, the students will be able to:	
CO712. 1	Understand the concepts and laws related to remote sensing..
CO712. 2	Understand the characteristics of different types of remote sensors.
CO712. 3	Understand the characteristics of different types of remote sensors..
CO712. 4	Understand the concepts of Geographical Information System
CO712. 5	Demonstrate the Remote Sensing and GIS applications

Text Books

1. **Burrough, P. A. and McDonnell, R. A., Principles of Geographic Information Systems, Oxford University Press, New York, 2001.**
2. **2. John R Jensen, —Remote Sensing of the Environment: An Earth Resource Perspective (2nd Edition, 2006) Pearson Publication**
3. **Lillesand T M, and Kiefer R W, "Remote Sensing and Image interpretation", John Wiley & Sons, 6th edition, 2015.**

Reference Books

1. **Samuel Purkis and Victor Klemas, — Remote Sensing and Global Environmental Change‖ (2011), Wiley-Blackwell, A John Wiley & Sons, Ltd.**
2. **Thomas Lillesand, Ralph W. Kiefer, Jonathan Chipman, —Remote Sensing and Image Interpretation, 6th Edition(2008) John Wiley & Sons, Publications**
3. **George Joseph, "Fundamentals of Remote Sensing", Universities Press (India) Pvt Ltd, Hyderabad, 3rd edition, 2018.**

Web Resources

- https://nptel.ac.in/courses/105108077
- https://onlinecourses.nptel.ac.in/noc22_ce84/preview

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	1	2	2	2							2	1	1	2	
2	2	3	1	2							1	3	2		3
3	2	2	1	2							1	2		2	
4	3	3	2	2							1	1	2		3
5	2	2	1	2							2	1	2	1	1

List of Professional Electives V

S.No	Course Code	Course Name	Semester	L	T	P	C
1	24CS3701	Embedded Wireless Sensor Networks	III	3	0	0	3
2	24CS3702	DSP Processor Architecture and Programming	III	3	0	0	3
3	24CS3703	RF and Radiation System Design	III	3	0	0	3
4	24CS3704	High Speed Communication Networks	III	3	0	0	3

24CS3701	EMBEDDED WIRELESS SENSOR NETWORKS	L	T	P	C
		3	0	0	3

Prerequisites for the course

- The pre-requisite knowledge required by the Students to study this Course is basic knowledge in Advanced Wireless Communication, Advanced Wireless Network and Communication Systems Laboratory I..

Objectives

1. Make students to learn the basic of wireless sensor networks.
2. Enable the students to understand the sensor network components, architecture and design principles of WSN
3. Enable the students to know the need of Physical layer design challenges and MAC Protocols
4. Make the students to design the Smart Sensors.
5. Make the students to apply the basic Embedded knowledge to Implement WSN.

UNIT I	OVERVIEW OF WIRELESS SENSOR NETWORKS	9

Challenges for Wireless Sensor Networks - Characteristics requirements - Required mechanisms, Difference between mobile ad-hoc and sensor networks- Enabling Technologies for Wireless Sensor Networks. Single-Node Architecture - Hardware Components - Energy Consumption Sensor Nodes Operating Systems and Execution Environments - Sensor Node Examples: EYES, MICA, MICAZ motes.

UNIT II	NETWORK ARCHITECTURE	9

Sensor Network Scenarios – Optimization goals and Figure of Merit – Design principles for WSNs – Gateway concepts.

UNIT III	PHYSICAL LAYER AND MAC PROTOCALS	9

Wireless Channel and communication fundamentals – Physical layer and transceiver design considerations in WSN – Fundamentals of MAC Protocols- Low duty cycle protocols and wakeup concepts – Contention based protocols - Schedule based protocols – IEEE 802.15.4 MAC protocol.

UNIT IV	SMART SENSORS	9

Introduction to Smart Sensors – Signal Conditioning Circuits – Architecture of Smart Sensors Humidity Sensors – Soil Moisture Sensors– Temperature Sensors – Color Sensors –Level Sensors.

UNIT V	APPLICATIONS AND PROTOCOL IMPLEMENTATIONONWSN	9

Home control - Medical Applications - Civil and Environmental Engineering applications – Wildfire monitoring - Habitat monitoring. Embedding LEACH protocol on ARM7 TDM microcontroller using embedded C language - Embedding Cryptographic algorithms on ARM 7 TDM microcontroller using embedded C language – FPGA based customizable event driven architecture.

Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	Formative Assessment Test (10 Marks)	End Semester Exams (60 Marks)

1.Description Questions 2.Formative Multiple choice questions	**1.Assignment 2.Online Quizzes 3.Problem solving Activities**	**1.Description Questions 2.Formative Multiple choice questions**

Outcomes

Upon completion of the course, the students will be able to:

CO701. 1 Explain the basics of wireless sensor networks.

CO701. 2 Discuss about the sensor network components, architecture and design principles of WSN.

CO701. 3 Explain the need of Physical layer design challenges and MAC Protocols.

CO701. 4 Design the Smart Sensors.

CO701. 5 Apply the basic Embedded knowledge to implement WSN.

Text Books

1. **Feng Zhao & Leonidas J. Guibas, "Wireless Sensor Networks- An Information Processing Approach", Elsevier,2007.**
2. **KazemSohraby, Daniel Minoli, &TaiebZnati, "Wireless Sensor Networks- Technology, Protocols and Applications", John Wiley,2012.**

Reference Books

1. **Anna Hac, "Wireless Sensor Network Designs", John Wiley,2003.**
2. **BhaskarKrishnamachari, "Networking Wireless Sensors", Cambridge Press,2005.**
3. **Mohammad Ilyas and ImadMahgaob, "Handbook of Sensor Networks: Compact Wireless and Wired Sensing Systems", CRC Press, 2005.**

Web Resources

- https://nptel.ac.in/courses/106/105/106105160/
- https://www.youtube.com/watch?v=sx0UPzztC5o
- https://www.youtube.com/watch?v=rmqlEWtmyUo

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	2	1	1		1				2	1	2	1	2	
2	3	2	1	1						2	1	2	2		3
3	3	2	2	1		1				2	1	2		3	
4	3	2	1	1						2	1	2			1
5	3	2	2	1		1				2	1	2	2	2	2

24CS3702	**DSP PROCESSOR ARCHITECTURE AND PROGRAMMING**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Prerequisites for the course

- The pre-requisite knowledge required by the Students to study this Course is basic knowledge in DSP.

Objectives

1. To know various DSP architectures and their applications.
2. To become skilled at the architectural features of DSP processors.

3. To address the issues of how to interface memory, peripherals onto DSP processors.
4. To understand the concept of ADSP BF532 processor.
5. To apply the coding in ADSP BF532 processor.

UNIT I	OVERVIEW OF DIGITAL SIGNAL PROCESSING	9

Advantages of DSP over analog systems, salient features and characteristics of DSP systems, applications of DSP systems. Common features of DSP processors, numeric representations in DSP processor, data path of a DSP processor, memory structures in DSP processors, VLIW architecture, special addressing modes in DSP processors, pipelining concepts, on-chip peripherals found in DSP processors

UNIT II	TMS320C5X PROCESSOR	9

Architecture – Assembly language syntax - Addressing modes – Assembly language Instructions - Pipeline structure, Operation – Block Diagram of DSP starter kit – Application Programs for processing real time signals

UNIT III	TMS320C6748 PROCESSOR	9

Architecture – DSP subsystem: Mega module, memory map, advanced event triggering-DMA subsystem-System Interconnect-System Memory-DSP memories, shared RAM memory, external memories, internal peripherals, peripherals- Memory protection unit- device clocking-power management- Instruction set -addressing modes-Assembly language Instructions - application programs

UNIT IV	ADSP BF532 PROCESSOR	9

Features-architecture overview-Blackfin processor core-DMA controllers-Timers-serial port interface-parallel peripheral interface-dynamic power management-Serial port controller - UART port controller - Real- time clock

UNIT V	PROGRAMMING USING ADSP BF533 PROCESSOR	9

Assembly language syntax– program flow control-load/store- move- stack control-control code bit management logical operations-bit operations- shift / rotate operations- arithmetic operations- external event management – cache control –video pixel operations- vector operations-parallel issue instructions, applications programs.

Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	Formative Assessment Test (10 Marks)	End Semester Exams (60 Marks)
1.Description Questions 2.Formative Multiple choice questions	1.Assignment 2.Online Quizzes 3.Problem solving Activities	1.Description Questions 2.Formative Multiple choice questions

Outcomes

Upon completion of the course, the students will be able to:

CO702. 1	Analyze the data addressing capabilities of programmable DSP processors.
CO702. 2	Narrate the architectures of programmable TMS320C5X DSP processors.
CO702. 3	Narrate the architectures of programmable TMS320C6748 DSP processors.
CO702. 4	Narrate the architectures of programmable BF532 DSP processors
CO702. 5	Create application oriented programming using BF533 DSP processors.

Text Books

1. **Avatar Singh and S.Srinivasan, "Digital signal processing", Thomson books, 2004.**
2. **K.K Parhi, "VLSI DSP Systems", John Wiley, 2008.**

Reference Books

1. **http://www.analog.com/static/imported-files/processor_manuals/bf533_hwr_Rev3.4.pdf**
2. **http://read.pudn.com/downloads111/doc/462495/Analog%20Devices%20Blackfin.pdf**
3. **http://www.analog.com/static/imported-files/data_sheets/ADSP-BF531_BF532_BF533.pdf**
4. **http://www.ti.com/lit/ug/spru732j/spru732j.pdf**
5. **https://www.analog.com/en/products/adsp-bf532.html#product-documentation**
6. **https://www.analog.com/media/en/dsp-documentation/processor-manuals/ADSP-BF533_hwr_rev3.6.pdf**

Web Resources

- https://nptel.ac.in/content/storage2/courses/108105057/Pdf/Lesson-7.pdf
- https://onlinecourses.nptel.ac.in/noc19_ee70/preview
- https://www.kdkce.edu.in/pdf/DSP_Processor___Architecture_compressed.pdf

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3											3	1	2	
2	3		3	2							2	3	2		3
3	3		3	2						1		3		2	
4	3		3	2							2	3	2		1
5	3		3	3							1	3	1	1	2

24CS3703	RF AND RADIATION SYSTEM DESIGN	L	T	P	C
		3	0	0	3

Prerequisites for the course

- The pre-requisite knowledge required by the Students to study this Course is basic knowledge in Radiation System.

Objectives

1. To understand the design of RF circuits and RFIC system
2. To design passive and active microwave Circuits and MIC Systems
3. To understand Special antennas and Smart antennas.

UNIT I	RF CIRCUIT DESIGN	9

Amplifiers: Operating and Available Power Gain Circles, Noise Figure Circles, Constant VSWR Circles, Broadband Amplifiers, High-Power Amplifiers, Multistage Amplifiers. Oscillators And Mixers, Transceiver Architectures: Noise Figure, Effects of Nonlinearity, Harmonic Distortion, Gain Compression, Cross Modulation, Intermodulation, Cascaded Nonlinear Stages AM/PM Conversion, Sensitivity and Dynamic Range.

UNIT II	MICROWAVE PASSIVE CIRCUITS	9

Overview of Planar Transmission Lines- Design Parameters for Strip lines and Microstrips - Realization of L&C by Low Impedance, High Impedance method and STUB method - LPF, BPF Design - Branch Line Coupler, Rat- Race Coupler, Power Dividers.

UNIT III	SYSTEM DESIGN USING MMIC TECHNOLOGY	9

Analysis of MMIC Technology -Micro Machined Antennas - Micro Electro Mechanical System Antennas, Design issues in Phased Array Radar- Satellite Transponder -Integrated electronic warfare T/R modules – Avionic Systems Integration.

UNIT IV	SPECIAL ANTENNAS	9

Antenna fundamental parameters - Need of metamaterial structures, Advantages of metamaterial structures. Design of the metamaterial antennas, Fractal antennas, sinuous antennas, EBG structure, PBG structures. CNT antennas.

UNIT V	SMART ANTENNAS AND ANTENNA SIMULATION	9

Introduction to Smart Antennas, Beam Forming, Estimation of DOA, AOA. Introduction to numerical techniques- FEM, FDTD, MoM. Introduction to simulators- Design of Microstrip antennas using Simulators. Simulation of Metamaterial Unit Cell, Fractal Structures.

Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	Formative Assessment Test (10 Marks)	End Semester Exams (60 Marks)
1.Description Questions 2.Formative Multiple choice questions	1.Assignment 2.Online Quizzes 3.Problem solving Activities	1.Description Questions 2.Formative Multiple choice questions

Outcomes

Upon completion of the course, the students will be able to:

CO703. 1	Design RF Amplifiers, Oscillators, and Mixers
CO703. 2	Design an MIC circuit for the required performance
CO703. 3	Design application specific MIC Systems
CO703. 4	Design and analyze metamaterial antennas, and Fractal antennas.
CO703. 5	Create any type of antenna using simulation tools..

Text Books

1. **Reinhold.Ludwig and PavelBretshko, "RF Circuit Design", Pearson Education, Inc., 2006**
2. **B.Razavi,"RF Micro electronics", Pearson Education, Second Edition, 2012**
3. **D.M.Pozar, "Microwave Engineering", 4th Edition, John Wiley & sons, Inc., 2011.**
4. **T.Lee,"Design of CMOS RF Integrated Circuits", Cambridge ,First Edition, 2004**

Reference Books

1. **Ravender Goyal, "Monolithic MIC; Technology & Design", Artech House, 1989.**
2. **Balanis.A, "Antenna Theory Analysis and Design", John Wiley and Sons, New York, Fourth Edition, 2012.**
3. **Kraus. J.D, "Antennas", John Wiley and sons, New York, Second edition, 1997.**

Web Resources

1. http://www.phd.etfbl.net/files/Works_PDF/Poprzen%20Nemanja%20.pdf
2. http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=1189650
3. http://www.ece.iit.edu/~pfelber/fractalantennas.pdf
4. https://nptel.ac.in/courses/106106046/
5. https://onlinecourses.nptel.ac.in/noc18_cs26/

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	2	2	1	1					2	2	3	1	2	
2	3	2	2	2	2					2	2	3			1
3	3	3	2	2	2					2	2	3		1	
4	2	3	3	2	1					2	2	3	2		1
5	2	2	2	2	2					1	2	3	1	1	2

24CS3704	HIGH SPEED COMMUNICATION NETWORKS	L	T	P	C
		3	0	0	3

Prerequisites for the course

- The pre-requisite knowledge required by the Students to study this Course is basic knowledge in Communication Networks.

Objectives

1. To understand the high speed network architectures
2. To study high speed access and admission control
3. To understand shaping and scheduling algorithms
4. To discuss queuing and congestion control for high speed architectures
5. To understand flow and congestion control

UNIT I	HIGH SPEED NETWORK ARCHITECTURE	9

Frame Relay Networks – Asynchronous transfer mode – ATM Protocol Architecture, ATM logical Connection, ATM Cell – ATM Service Categories – AAL, High Speed LANs: Emergence of High-Speed LANs, Gigabit Ethernet, WDM systems, Optical LANs, SONET.

UNIT II	ADMISSION AND ACCESS CONTROL	9

CAC for ATM VBR Services - Worst-Case Traffic Model and CAC, Effective Bandwidth, - Guaranteed Quality of Service, Controlled-Load Service, ATM Traffic Contract and Control Algorithms - Traffic Contract, PCR Conformance, SCR, and BT, Cell Delay Variation Tolerance, Generic Cell Rate Algorithm.

UNIT III	SHAPING AND SCHEDULING	9

An ATM Shaping Multiplexer -Dual Leaky Bucket, Algorithm, An Integrated Packet Shaper - Basics, Integrating Traffic Shaping and WFI Scheduling, Logical Structure and implementation of the WFI Packet Shaper, Packet Scheduling – FIFO, RR, Rate-Controlled Static Priority, GPS-WFQ, Virtual Clock, Self-Clocked Fair Queuing, Worst-case Fair Weighted Fair Queuing, Scheduling Algorithm - Shaped Virtual Clock Algorithm

UNIT IV	QUEUING &BUFFER MANAGEMENT	9

Conceptual Framework and Design Issues, Sequencer - Store Cells in Logical Queues, Sort Priorities Using a Sequencer, RAM-Based Searching Engine - Hierarchical Searching, Design of the RSE, RSE Operations, Write-in Operation, Reset Operation, Search Operation: A Look at ATM Networks - Self-

Calibrating Pushout, TCP/IP over ATM_UBR, Dynamic Threshold with Single Loss Priority, A Look at the Internet - Tail Drop, Drop on Full, Random Early Detection, Differential Dropping: RIO, LQD.

UNIT V	FLOW AND CONGESTION CONTROL	9

Window-Based Flow Control, Rate-Based Flow Control, Predictive Control Mechanism, ATM Networks - ABR Flow Control, TCP/IP Networks - TCP Congestion Control - TCP with Explicit Congestion Notification, Rate-Based Flow Control Scheme, Frame Relay Congestion Control.

Total Periods 45

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	Formative Assessment Test (10 Marks)	End Semester Exams (60 Marks)
1.Description Questions 2.Formative Multiple choice questions	1.Assignment 2.Online Quizzes 3.Problem solving Activities	1.Description Questions 2.Formative Multiple choice questions

Outcomes

Upon completion of the course, the students will be able to:

CO704. 1 To Differentiate architectures of various protocols

CO704. 2 To Apply techniques involved to support real-time traffic and access control

CO704. 3 To understand different scheduling employed to support high speed architectures

CO704. 4 To understand the framework required to solve queuing and buffer management in high speed networks

CO704. 5 To Compare the different mechanisms available for provision of flow and congestion control in high speed networks

Text Books

1. **Jean Walrand and PravinVariaya, "High Performance Communication Networks",Morgankaufmann Publishers, Second Edition, 2000**
2. **H. Jonathan Chao and XiaoleiGuo, "Quality of Service Control in High-Speed Networks", John Wiley & Sons, Inc., First Edition, 2002**

Reference Books

1. **William Stallings, "High Speed Networks and Internet", Pearson Education, Second Edition, 2002.**
2. **Rainer Handel, Manfred N Huber and Stefan Schroder, "ATM Networks - Concepts, Protocols Applications", Addison Wesley, New York, Third Edition 1999.**
3. **Leon Garcia and Widjaja, "Communication Network", Tata McGraw Hill, New Delhi,Second Edition, 2003**

Nader .F..Mir ," Computer Communication Networks" Pearson education 2014

Web Resources

- https://nptel.ac.in/content/storage2/courses/106105080/pdf/M1L1.pdf
- https://nptel.ac.in/courses/106/105/106105082/
- https://onlinecourses.nptel.ac.in/noc20_cs23/preview

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	3	1								3	3	1	2	

2	3	3	1								3	3			1
3	3	3	1								3	3		2	
4	3	3	1								3	3	2		1
5	3	3	1								3	3	1	1	2

List of Professional Electives VI

S.No	Course Code	Course Name	Semester	L	T	P	C
1	24CS3705	Cooperative Communication	III	3	0	0	3
2	24CS3706	VLSI Architecture for Image and Video Processing	III	3	0	0	3
3	24CS3707	Mobile Robotics	III	3	0	0	3
4	24CS3708	Advanced Radar and Navigational AIDS	III	3	0	0	3

24CS3705	COOPERATIVE COMMUNICATION	L	T	P	C
		3	0	0	3

Prerequisites for the course

- The pre-requisite knowledge required by the Students to study this Course is basic knowledge in Wireless Communication

Objectives

1. Enable the student to understand the evolving paradigm of cooperative communication,
2. To understand the challenges and trade-offs involved in cooperative communication networks.
3. Expose the student to the usage of various Relay selection schemes according to the Requirement
4. Serve as a platform to design novel cooperative protocols and routing algorithms.
5. To design routing algorithms for cooperative communication

UNIT I	INTRODUCTION TO COOPERATIVE COMMUNICATIONS SYSTEMS AND COOPERATIVE DIVERSITY	9

Cooperation in Wireless Network, Cooperation protocols - Hierarchical cooperation, Cooperative Communications with single relay; Multi-node cooperative communications Capacity theorems for the relay channel, spatial diversity in wireless networks, Cooperative strategies and capacity theorems for relay networks, Capacity bounds for cooperative diversity

UNIT II	COOPERATIVE DEMODULATION	9

Modulation and demodulation for cooperative diversity in wireless systems, performance of cooperative demodulation with decode-and-forward relays, Symbol error probabilities for general cooperative links

UNIT III	COOPERATIVE SPACE-TIME CODING	9
Space-Time Codes for High Data Rate Wireless Communication, Distributed space-time-coded protocols, Fading relay channels: performance limits and space-time signal design, Space-time diversity enhancements using collaborative communications		
UNIT IV	**DISTRIBUTED COOPERATIVE ROUTING**	**9**
Network Model, Cooperation based routing protocol, Source–channel coding with cooperation, Broadband cooperative communications - System model - Cooperative protocol and relay assignment scheme		
UNIT V	**CHANNEL ACCESS ISSUE**	**9**
Cooperative Multiple Access Communication ,Relay channel and protocol ,Relay selection, Energy efficiency, Content-aware Cooperative multiple access protocol		
	Total Periods	**45**

Suggestive Assessment Methods		
Continuous Assessment Test (30 Marks)	**Formative Assessment Test (10 Marks)**	**End Semester Exams (60 Marks)**
1.Description Questions **2.Formative Multiple choice questions**	**1.Assignment** **2.Online Quizzes** **3.Problem solving Activities**	**1.Description Questions** **2.Formative Multiple choice questions**

Outcomes	
Upon completion of the course, the students will be able to:	
CO302. 1	Evaluate the different cooperative communication protocols and their trade-offs.
CO705. 2	Analyse the performance of Cooperative demodulation techniques
CO705. 3	Enhance the diversity using collaborative communication
CO705. 4	Modelling the broadband cooperative communication
CO705. 5	Analyse the performance of cooperative multiple access protocol

Text Books

1. K.J.R. Liu, A.K. Sadek, W. Su, A. Kwasinski, Cooperative Communications and Networking, Cambridge University Press, 2016
2. Mischa Dohler, Yonghui Li, "Cooperative Communications: Hardware, Channel & PHY", John Wiley & Sons, 2010
3. Yan Zhang, Hsiao-Hwa Chen, Mohsen Guizan, "Cooperative Wireless Communications "'Auerbach Publications 2017
4. S. Haykin and K.J.R. Liu, Eds., Handbook on Array Processing and Sensor Networks, IEEE Wiley, 2019.

Reference Books

1. K.J.R. Liu and B. Wang, Cognitive Radio Networking and Security: A Game Theoretical View, Cambridge University Press, 2010.
2. H. V. Zhao, W.S. Lin, and K.J.R. Liu, Behavior Dynamics in Media-Sharing Social Networks, Cambridge University Press, 2011Cambridge University Press, 2016
3. Kwang-Cheng Chen and Ramjee Prasad, "Cognitive Radio Networks", John Wiley & Sons, 2009

Web Resources

1. https://www.jhuapl.edu/Content/techdigest
2. https://www.commsp.ee.ic.ac.uk/~wiser/publications

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	1		2							2			1	2	
2	2									2			3		1
3		2												3	
4	1		2							1					1
5		2	1										1		2

24CS3706	VLSI ARCHITECTURE FOR IMAGE AND VIDEO PROCESSING	L	T	P	C
		3	0	0	3

Prerequisites for the course

- The pre-requisite knowledge required by the Students to study this Course is basic knowledge in Mathematics.

Objectives

1. To provide the basic understanding of the digital image formation and visualization.
2. To provide the visualization of relationships between spatial and frequency.
3. To provide the understanding of mapping the signal processing techniques to the digital image.
4. To provide an idea of multimedia data (image, video).
5. To provide an exposure to various image and video compression standards

UNIT I	FUNDAMENTALS OF IMAGE PROCESSING AND IMAGE TRANSFORMS	9

Basic steps of Image processing system sampling and quantization of an Image –Basic relationship between pixels Image Transforms: 2 –D Discrete Fourier Transform, Discrete Cosine Transform (DCT), Discrete Wavelet transforms

UNIT II	IMAGE PROCESSING TECHNIQUES	9

Image Enhancement: Spatial Domain methods: Histogram Processing, Fundamentals of Spatial Filtering, Smoothing Spatial filters, Sharpening Spatial filters Frequency Domain methods: Basics of filtering in frequency domain, image smoothing, image sharpening, selective filtering Image Segmentation: Segmentation concepts, point, line and Edge detection, Thresholding, region based segmentation

UNIT III	IMAGE COMPRESSION	9

Image compression fundamentals –coding Redundancy, spatial and temporal redundancy. Compression models: Lossy and Lossless, Huffmann coding, Arithmetic coding, LZW coding, run length coding, Bit Plane coding, transform coding, predictive coding , wavelet coding, JPEG standards

UNIT IV	BASIC STEPS OF VIDEO PROCESSING	9

Analog video, Digital Video, Time varying Image Formation models : 3D motion models, Geometric Image formation , Photometric Image formation, sampling of video signals, filtering operations

UNIT V	2-D MOTION ESTIMATION	9

Optical flow, general methodologies, pixel based motion estimation, Block matching algorithm, Mesh based motion Estimation, global Motion Estimation, Region based motion estimation, multi resolution

motion estimation. Waveform based coding, Block based transform coding, predictive coding, Application of motion estimation in video coding. Blocks of a VLSI circuit: Computer architecture, memory architectures, communication interfaces, mixed signal interfaces.

Total Periods	**45**

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	Formative Assessment Test (10 Marks)	End Semester Exams (60 Marks)
1.Description Questions 2.Formative Multiple choice questions	**1.Assignment 2.Online Quizzes 3.Problem solving Activities**	**1.Description Questions 2.Formative Multiple choice questions**

Outcomes

Upon completion of the course, the students will be able to:

CO706. 1	Apply spatial and frequency domain image filters for image enhancement.
CO706. 2	Comprehend image degradation models for image restoration and color space transforms for color image processing.
CO706. 3	Interpret and apply edge detection, image segmentation and representation for image recognition.
CO706. 4	Demonstrate the use of image and video processing algorithms for different applications
CO706. 5	Apply various image and video compression standards.

Text Books

1. **Gonzalez and Woods ,"Digital Image Processing ", 3rdedition , Pearson**
2. **Yao wang, Joem Ostarmann and Ya –quin Zhang, "Video processing and communication ",1st edition , PHI**
3. **Essentials of VLSI Circuits and Systems, K. Eshraghian, Douglas A. Pucknell, Sholeh Eshraghian, 2005, PHI Publications.**

Reference Books

1. **M. Tekalp ,"Digital video Processing", Prentice Hall International.**
2. **Anerozdemi R,"Inverse Synthetic Aperture Radar Imaging with MATLAB Algorithms",John Wiley & Sons**
3. **3.Chris Solomon, Toby Breckon ,"Fundamentals of Digital Image Processing A Practical Approach with Examples in Matlab",John Wiley & Sons**

Web Resources

- https://nptel.ac.in/noc/courses/noc20/SEM1/noc20-ee44/
- https://nptel.ac.in/courses/108/105/108105118/

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	2								1	2	3	1	2	
2	3	2	2								2	3	3		1
3	3	2								1	2	3		3	
4	3	2	2							1	2	3			

5	3	2	2							1	2	3			2

24CS3707	MOBILE ROBOTICS	L	T	P	C
		3	0	0	3

Prerequisites for the course

- The pre-requisite knowledge required by the Students to study this Course is basic knowledge in Robotics.

Objectives

1. The course will give students an opportunity to design and fabricate a mobile robotic platform and program it to apply learned theoretical concepts in practice as a project.
2. To understand the concept of mobile robot kinematics and dynamics.
3. To apply the concept of Robotic Perception.
4. To understand and estimation methods of Localization.
5. To understand the concept planning and Navigation.

UNIT I	ROBOT LOCOMOTION	9

Types of locomotion, hopping robots, legged robots, wheeled robots, stability, manoeuvrability, controllability.

UNIT II	MOBILE ROBOT KINEMATICS AND DYNAMICS	9

Forward and inverse kinematics, holonomic and nonholonomic constraints, kinematic models of simple car and legged robots, dynamics simulation of mobile robots.

UNIT III	ROBOTIC PERCEPTION	9

Proprioceptive/ Exteroceptive and passive/active sensors, performance measures of sensors, sensors for mobile robots like global positioning system (GPS), Doppler effect-based sensors, vision based sensors, uncertainty in sensing, filtering;

UNIT IV	LOCALIZATION	9

Odometric position estimation, belief representation, probabilistic mapping, Markov localization, Bayesian localization, Kalman localization, positioning beacon systems.

UNIT V	INTRODUCTION TO PLANNING AND NAVIGATION	9

Path planning algorithms based on A-star, Dijkstra, Voronoi diagrams, probabilistic roadmaps (PRM), rapidly exploring random trees (RRT), Markov Decision Processes (MDP), stochastic dynamic programming (SDP).

Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	Formative Assessment Test (10 Marks)	End Semester Exams (60 Marks)
1.Description Questions 2.Formative Multiple choice questions	1.Assignment 2.Online Quizzes 3.Problem solving Activities	1.Description Questions 2.Formative Multiple choice questions

Outcomes

Upon completion of the course, the students will be able to:

CO707. 1	Understand the different types of mobile robots and functional design
CO707. 2	Analyzing Robot Kinematics and dynamics through different manipulators and end effectors
CO707. 3	Understand various sensors and applications
CO707. 4	Analyzing the robotic localization & mapping
CO707. 5	Analyzing path planning and navigation of robots

Text Books

1. **R. Siegwart, I. R. Nourbakhsh, "Introduction to Autonomous Mobile Robots", The MIT Press, 2011.**
2. **Peter Corke , Robotics, Vision and Control: Fundamental Algorithms in MATLAB, Springer Tracts in Advanced Robotics, 2011.**
3. **S. M. LaValle, "Planning Algorithms", Cambridge University Press, 2006. (Available online http://planning.cs.uiuc.edu/)**
4. **Thrun, S., Burgard,W., and Fox, D., Probabilistic Robotics. MIT Press, Cambridge, MA, 2005.**

Reference Books

1. **Melgar, E. R., Diez, C. C., Arduino and Kinect Projects: Design, Build, Blow Their Minds, 2012.**
2. **H. Choset, K. M. Lynch, S. Hutchinson, G. Kantor, W. Burgard, L. E. Kavraki, and S. Thrun, Principles of Robot Motion: Theory, Algorithms and Implementations, PHI Ltd., 2005L. Fausett, Fundamentals of Neural Networks, Prentice Hall**

Web Resources

- https://nptel.ac.in/courses/106/105/106105173/
- https://onlinecourses.nptel.ac.in/noc24_cs11/preview
- https://nptel.ac.in/courses/106/106/106106184/

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	3	3	3	3						2	1	1	2	
2	3	3	3	3	3						2	1	3		1
3	3	3	3	3	3						2	1		3	
4	3	3	3	3	3						2	1	2		
5	3	3	3	3	3						2	1			2

24CS3708	ADVANCED RADAR AND NAVIGATIONAL AIDS	L	T	P	C
		3	0	0	3

Prerequisites for the course

- The pre-requisite knowledge required by the Students to study this Course is basic knowledge in Radar.

Objectives

1. To review the fundamentals of RADAR
2. To learn the MTI and Pulse Doppler RADAR
3. To understand the concept of RADAR signal processing.
4. To apply and learn the Navigation and Remote sensing RADARS.
5. To apply the concept through Navigation AIDS.

UNIT I	INTRODUCTION TO RADAR	9

Derivation of Radar Equation- Radar Block Diagram- Radar Frequencies –Applications of Radar – The Origins of Radar. The Radar Equation. Introduction- Detection of Signals in Noise- Receiver Noise and the Signal-to-Noise Ratio-Probability Density Functions- Probabilities of Detection and False Alarm-Integration of Radar Pulses- Radar Cross Section of Targets- Radar cross Section Fluctuations-Transmitter Power-Pulse Repetition Frequency- Antenna Parameters- System losses – Other Radar Equation Considerations.

UNIT II	MTI AND PULSE DOPPLER RADAR	9

Doppler and MTI Radar- Delay –Line Cancellers- Staggered Pulse Repetition Frequencies –Doppler Filter Banks - Digital MTI Processing - Moving Target Detector - Limitations to MTI Performance - MTI from a Moving Platform (AMIT) – Pulse Doppler Radar – Other Doppler Radar Topics.

UNIT III	RADAR SIGNAL PROCESSING	9

Phenomenology: Resolution, spatial frequency, Fourier transform, sampling, vector representation of signals, data integration and correlation. Signal models: Amplitude model, clutter model, noise model, jamming model, frequency model, spatial model Signal conditioning: Sampling, Digital I/Q Modulation.

UNIT IV	NAVIGATIONAL AND REMOTE SENSING RADARS	9

Introduction – Airport Radars – MET Radar – Airbone Radar- Doppler Navigation – Navy Radar – Remote Sensing Radar- Pattern Synthesis – Phased Array – CW Radar – Imaging Radar – Monopulse Radar Imaging –Multifunction Array Radar

UNIT V	NAVIGATIONAL AIDS	9

Elementary ideas of Navigation Aids: VOR, DVOR, TACAN, ILS and MLS, Hyperbolic Navigation (LORAN, DECA, OMEGA). GPS, DGPS, Automatic Direction finder.

	Total Periods	45

Suggestive Assessment Methods

Continuous Assessment Test (30 Marks)	Formative Assessment Test (10 Marks)	End Semester Exams (60 Marks)
1.Description Questions 2.Formative Multiple choice questions	1.Assignment 2.Online Quizzes 3.Problem solving Activities	1.Description Questions 2.Formative Multiple choice questions

Outcomes

Upon completion of the course, the students will be able to:

CO708. 1	Analyze the Fundamentals of RADAR Systems.
CO708. 2	Analyse MTI and pulse DOPPLER radar.
CO708. 3	Create the algorithm for RADAR signal processing
CO708. 4	Analyse Navigational and Remote Sensing RADAR
CO708. 5	Apply the learnt algorithms to analyze navigational aids

Text Books

1. **Merrill. I. Skolnik, "Introduction to RADAR Systems", Tata McGraw Hill, Third Edition, 2001.**
2. **Mark. A.Richards, "Fundamentals of Radar Signal Processing", Tata McGraw Hill, First Edition, 2005.**
3. **Dr.A.K. Sen and Dr.A.B. Bhattacharya, "Radar Systems and Radio Aids to Navigation", Khanna Publishers, 2003.**

Reference Books

1. **Steven M.Kay, " Fundamentals of Statistical Signal Processing", Vol III Detection Theory, Prentice Hall Inc, First Edition, 2013.**
2. **Roger J Suullivan, "Radar Foundations for Imaging and Advanced Topics", SciTech Publishing, First Edition, 2004**
3. **N.S. Nagaraja, "Elements of Electronic Navigation", TMH, Second Edition, 2004.**
4. **Peyton Z Peebles Jr, "Radar Principles", Wiley Inter Science, First Edition, 2004.**

Web Resources

- http://books.google.co.in/books/about/Radar_Engineering.html?id=B6jIxVqT130C
- https://archive.org/details/RadarAidsToNavigation
- https://www.jlab.org/ir/MITSeries/V2.pdf

CO Vs PO Mapping and CO Vs PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	3	2	2	2								1		2	
2	3	3	3	3	2							1	3		1
3	3	3	3	2	2							1		3	
4	3	3	3	3	2							1	2		
5	3	3	3	3	3							1			2