CURRICULUM AND SYLLABUS

FOR

M. TECH

IN

COMMUNICATION SYSTEMS

(With Effect from Academic Year 2024 - 25)

DEPARTMENT of ELECTRONICS ENGINEERING
SARDAR VALLABHBHAI NATIONAL INSTITUTE OF TECHNOLOGY,
SURAT-395 007, GUJARAT.

SARDAR VALLABHBHAI NATIONAL INSTITUTE OF TECHNOLOGY (SVNIT-Surat), SURAT

VISION

To be one of the leading Technical Institutes disseminating globally acceptable education, effective industrial training and relevant research output.

MISSION

To be a globally accepted centre of excellence in technical education catalyzing absorption, innovation, diffusion and transfer of high technologies resulting in enhanced quality for all the stake holders.

DEPARTMENT OF ELECTRONICS ENGINEERING

MISSION

The mission of the Department of Electronics Engineering is to contribute to society and industry through excellence in education, research, innovations, and ethics by stakeholders.

VISION

The vision of the Department of Electronics Engineering is to aim to achieve quality in education and research to create leading Electronics engineers, researchers, and entrepreneurs.

DEPARTMENT OF ELECTRONICS ENGINEERING
SARDAR VALLABHBHAI NATIONAL INSTITUTE OF TECHNOLOGY
SURAT-395007

M. Tech. Programme (COMMUNICATION SYSTEMS)

Program Educational Objectives (PEOs):

1. Graduates formulate, analyse and solve real-life engineering problems applying the basic knowledge of Electronics Engineering. (**Knowledge**)
2. Graduates become researcher or design professionals for sustainable state of the art products as per market trends. (**Skill**)
3. Graduates take gainful employment for manufacturing functions or do the technology transfer or develop the industry. (**Technical Contribution-Industry**)
4. Graduates become entrepreneurs in engineering sector or involve in spreading his skill and experience globally. (**Technical Contribution - Society**).

Program Outcomes (POs):

PO1:	To carry out multidisciplinary research / Investigations and complex real life problems solving capability
PO2:	To write and present a substantial technical report/research article
PO3:	To Demonstrate a higher level of professional skills over the areas of advanced communication technologies and networks
PO4:	To Apply appropriate methodology and modern engineering/IT tools to meet the international standards in the area of advanced communication technologies and networks
PO5:	To inculcate research attributes and approach through industry oriented internships and projects.(Team work and Finance management)
PO6:	To perform environment supportive professional and ethical responsibility of the society.
PO7:	To engage in self-improvement through continuous professional development and life-long learning.

Course Structure and Scheme of Evaluation (Semester wise)

M. Tech. I (EC), I Semester (Communication Systems)											
Sr. No.	Course Name	Code	Teaching Scheme			Credit	Examination Scheme (Marks)				Notional hours of Learning (Approx.)
			L	T	P		Th	Tut	Pr	Tot.	
1	RF Circuits & Systems	ECCS101	3	0	0	03	100	--	--	100	55
2	Advance Optical Communication Systems	ECCS103	3	0	0	03	100	--	--	100	55
3	Advance DSP	ECCS105	3	0	0	03	100	--	--	100	55
4	Elective-I	ECCS1XX	3	0	0	03	100	--	--	100	55
5	Elective-II	ECCS1XX	3	0	0	03	100	--	--	100	55
6	Communication Lab-I	ECCS107	0	0	6	03	--	--	150	150	100
7	Seminar	ECCS109	0	0	4	02			100	100	70
	Total		**15**	**0**	**10**	**20**	**500**	**--**	**250**	**750**	**445**
Total Contact Hours per week: **25**											

M. Tech. I (EC), II Semester (Communication Systems)											
Sr. No.	Course Name	Code	Teaching Scheme			Credit	Examination Scheme (Marks)				Notional hours of Learning (Approx.)
			L	T	P		Th	Tut	Pr	Tot.	
1	Image Processing and Computer Vision	ECCS102	3	0	0	03	100	--	--	100	55
2	Wireless Communication	ECCS104	3	0	0	03	100	--	--	100	55
3	Institute Elective-III	ECCS1XX	3	0	0	03	100	--	--	100	55
4	Elective-IV	ECCS1XX	3	0	0	03	100	--	--	100	55
5	Elective-V	ECCS1XX	3	0	0	03	100	--	--	100	55
6	Communication Lab-II	ECCS106	0	0	6	03	--	--	150	150	100
7	Mini Project	ECCS108	0	0	4	02			100	100	70
	Total		**15**	**0**	**10**	**20**	**500**	**--**	**250**	**750**	**445**
Total Contact Hours per week: **25**											

M. Tech. II (EC), III Semester (Communication Systems)												
Sr. No.	**Course Name**	**Code**	**Teaching Scheme**			**Credit**	**Examination Scheme (Marks)**				**Notional hours of Learning (Approx.)**
			L	**T**	**P**		**Th**	**Tut**	**Pr**	**Tot.**	
1	Dissertation Phase-1	ECCS201	0	0	28	14	-	-	350	350	560
2	MOOC Course – I*	φ	-	-	-	3/4	100	-	-	-	70/80
3	MOOC Course – II*	φ	-	-	-	3/4	100	-	-	-	70/80
		Total	**0**	**0**	**28**	**20/21/ 22**	**200**	**-**	**350**	**550**	**700/ 720**
Total Contact Hours per week: **28 + NPTEL (Course Hours) × 2**											

***** NPTEL, SWAYAM and other Massive Open Online Course (MOOC) approved by DAAC

φ As per 66th IAAC, Dated 20th March, 2024, Resolution No. 66.34 and 61st Senate resolution No. 4, 25th April, 2024

M. Tech. II (EC), IV Semester (Communication Systems)											
Sr. No.	**Course Name**	**Code**	**Teaching Sch.**			**Credit**	**Examination Scheme (Marks)**				**Notional hours of Learning (Approx.)**
			L	**T**	**P**		**L**	**T**	**P**	**Total**	
1	Dissertation Phase-2	ECCS202	0	0	40	20	-	-	600	600	800
		Total	**0**	**0**	**40**	**20**	**-**	**-**	**600**	**600**	**800**
Total Contact Hours per week: **40**											

LIST OF SUBJECTS FOR ELECTIVE - I & II: (Semester – I)		
(1)	Information Theory & Coding	ECCS111
(2)	Digital Satellite Communication	ECCS113
(3)	Cognitive Radio	ECCS115
(4)	Probability and Random Processes	ECCS117
(5)	Antenna Theory and Design	ECCS119
(6)	Machine learning and Applications	ECCS121
(7)	Digital VLSI Design	ECVL101
(8)	Embedded Systems	ECVL105
(9)	Semiconductor IC Technology	ECVL111

LIST OF SUBJECTS FOR INSTITUE ELECTIVE-III (Semester – II)		
(1)	Deep Learning, Theory and Practice	ECCS172
(2)	Internet of Things, Technologies and Applications	ECCS174

LIST OF SUBJECTS FOR ELECTIVE- IV &V (Semester – II)		
(1)	Optical Networks	ECCS112
(2)	Estimation and Detection Theory	ECCS114
(3)	Microwave Integrated Circuits	ECCS116
(4)	Photonic Integrated Circuits	ECCS118
(5)	Ad-Hoc Networks	ECCS120
(6)	MIMO Technology	ECCS122
(7)	Global Navigation Satellite System	ECCS124
(8)	Optical Wireless Communication	ECCS126
(9)	5G Wireless Technologies	ECCS128
(10)	Speech Processing and Applications	ECCS130
(11)	Real Time Systems	ECVL104
(12)	VLSI Architecture for DSP	ECVL114

CORE COURSES: SEMESTER – I

M. Tech. I (Communication systems) Semester – I

RF Circuits And Systems

L	T	P	Credit
3	0	0	03

ECCS101 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Describe the Guided Wave solutions (TE, TM, and TEM), transmission line parameters and various components.
CO2	Classify the various active and passive components and circuits based on their design and working.
CO3	Use the appropriate portion of electromagnetic theory and its application to antennas
CO4	Analyse the transmission lines and their parameters using the Smith Chart, radiation principle of antennas, MIC components and circuits.
CO5	Evaluate the resonance frequency of cavity Resonators and the associated modal field.

2. Syllabus:

INTRODUCTION **(02 Hours)**

Circuit-Field Relations, RF Behavior of Passive Components, Chip Components.

TRANSMISSION LINE ANALYSIS **(10 Hours)**

Transmission line equations. Voltage and current waves. Solutions for different terminations. Transmission-line loading. Impedance transformation and matching. Smith Chart, Quarter-wave and half-wave transformers, the Multiple Reflection Viewpoint, Binomial and Tchebeyshev transformers. Single and double stub matching.

SINGLE- AND MULTIPORT NETWORKS **(02 Hours)**

Basic Definitions, Interconnecting Networks, Network Properties and Application, Scattering Parameters- Definition and Meaning of S- Parameters.

RF FILTERS DESIGN **(07 Hours)**

Basic Resonator and Filter Configurations, Special Filter Realizations.

MICROWAVE WAVEGUIDES AND COMPONENTS **(07 Hours)**

Introduction, Rectangular Waveguides, Rectangular Cavity Resonators, Circular waveguides, radiation from rectangular and circular apertures, Radiation from sectoral and pyramidal horns.

POWER DIVIDERS AND DIRECTIONAL COUPLERS **(05 Hours)**

The T Junction Power Divider, The Wilkinson Power Divider, The Quadrature (90°) Hybrid, Coupled Line Directional Couplers.

RADIATION **(06 Hours)**

Potential functions and the electromagnetic field, Oscillating electric dipole- derivations for E and H field components in spherical coordinate systems, Power Radiated by a current element, Application to antennas, Radiation from quarter wave monopole and half wave dipoles, Derivation for radiation resistance, application of reciprocity theorem to antennas, equality of directional patterns and effective lengths of transmitting and receiving antennas, directional properties of dipole antennas, antenna feeding methods. Antenna parameters and definitions.

MICROSTRIP ANTENNAS (06 Hours)

Basic characteristics of microstrip antennas, feeding methods, methods of analysis, design of rectangular and circular patch antennas.

(Total Contact Time: 45 Hours)

3. BOOKS RECOMMENDED

1. Ludwig Reinhold and Bretchko Powel, "RF Circuit Design", Pearson Education, Reprint 2004
2. Pozar M. David, "Microwave Engineering", John Wiley & Sons, Inc., 1999
3. Liao Samuel, "Microwave Devices and Circuits". Pearson Education, Second Reprint, 2006
4. Bhat Bharathi and Koul Shibon,"Stripline Like Transmission Lines For MIC", New Age International, Reprint 2003.
5. C. A. Balanis, "Antenna Theory and Design", 3rd Ed., John Wiley & Sons., 2005.

M.Tech. I (Communication systems) Semester – I

Advance Optical Communication Systems

L	T	P	Credit
3	0	0	03

ECCS103 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Understand how light transmission occurs in fiber with different effects.
CO2	Classify, characterize and compare the different types of effects in fiber, passive and active optical components.
CO3	Apply/ Analyse the concepts of light transmission in SMF/WDM optical communication system and analyse effect of operational parameters in fiber, optical components, link and WDM system.
CO4	Estimate and evaluate fiber link and its design parameters.
CO5	Design optical communication systems.

2. Syllabus:

REVIEW OF FIBER OPTIC COMMUNICATION **(06 Hours)**

Elements Of Fiber Optic Communication, Light Transmission Basics, Optical Spectrum, Propagation Of Light In Fiber, Types of Fiber, Attenuation, Dispersion.

PASSIVE AND ACTIVE OPTICAL COMPONENTS **(10 Hours)**

Principle And Operation Of Optical Source, Detectors, Couplers, Isolators, Circulators, Modulators, Multiplexers, Filters, Switches, Amplifiers.

WDM SYSTEM DESIGN **(10 Hours)**

WDM System Classification, Applications and Advantages, WDM System Model, System Requirements, Optical System Design Considerations, Power Budget, Bandwidth Budget, OSNR Based DWDM System Design, System Performance Measurement Parameters, Power Penalty In System.

DISPERSION MANAGEMENT **(04 Hours)**

Need of Dispersion Management, Pre-Compensation, Post Compensation, Dispersion Compensation Techniques

OPTICAL SYSTEMS **(05 Hours)**

Direct Intensity Modulation (D-IM), Subcarrier Intensity Modulation, Coherent and Phase-modulated Systems.

NONLINEARITIES **(06 Hours)**

Distortion In Signal Due To Nonlinearities In Fibers, Self-Phase Modulation, Cross Phase Modulation, Stimulated Raman Scattering, Stimulated Brillouin Scattering, Four Wave Mixing, Optical Solitons.

RECENT ADVANCEMENTS IN OPTICAL COMMUNICATION **(04 Hours)**

Visible Light Communication, Wireless Optical Communication, LiFi, Free Space Optics, Passive Optical Networks, Free Space Optics.

(Total Contact Time: 45 Hours)

3. BOOKS RECOMMENDED

1. Senior J. M., "Optical Fiber Communication - Principle And Practice", PHI, 3rd Ed., 2018
2. Gerd Kaiser, "Optical Fiber Communication", McGraw Hill, 5th Ed., 2017.
3. T. L. Singhal, "Optical Fiber Communications: Principles and Applications", Cambrige, 1st Ed., 2017.
4. Agrawal G.P., "Fiber Optic Communication Systems", John Wiley & Sons, 4th Ed., 2015.
5. Ramaswami Rajiv and Sivarajan K. N., "Optical Networks: A Practical Perspective", Elsevier, Morgan Kaufmann Publishers, 3rd Ed., 2012.
6. Gp Capt KS Mathur (Retd.), “Fiber Optics Fundamentals and Advances in Optical Communications”, Bluerose Publishers Pvt. Ltd., 1st Ed., 2021.

M.Tech. I (Communication systems) Semester – I

Advance DSP

L	T	P	Credit
3	0	0	03

ECCS105 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Describe different type of signals and systems, and analyze different system characteristics therein
CO2	Understand the concept of FIR, IIR, linear prediction filter, power spectrum estimation
CO3	Solve the problem related to different filtering techniques and power spectrum estimation
CO4	Compare and Analyze different filtering techniques
CO5	Design different filtering techniques for different signal processing applications

2. Syllabus:

REVIEW OF DISCRETE SIGNAL REPRESENTATION AND ANALYSIS (06 Hours)

Continuous and discrete time signals, noise signal, different type of signals, operations of signals: addition, subtraction, multiplication, scaling, magnification, decimation, interpolation, differentiation and integration, static and dynamic system, LTI system, DFT and FFT

TIME AND FREQUENCY-DOMAIN DESIGN TECHNIQUES FOR IIR AND FIR FILTERS (09 Hours)

FIR And IIR Filter Specifications, FIR Filter Design- Fourier series method and Frequency Sampling Method, Design Of IIR Digital Filters: Butterworth, Chebyshev And Elliptic Approximations, Low Pass, Band Pass, Band Stop And High Pass Filters, Bilinear Transformation Method

EFFECT OF FINITE REGISTERS LENGTH (04 Hours)

Number Representation, Quantization Error, Round-Off Error, Overflow Error, Limit Cycle, System Noise behaviour, Noise Filtering By LSI System, Noise in a Cascade Of 2nd Order Filter, Stability of Linear Filter

MULTIRATE SIGNAL PROCESSING (05 Hours)

General Rate-Changing System, Integer-Factor Interpolation and Decimation and Rational-Factor Rate Changing, Efficient Multirate Filter Structures, Over sampling D/As, Perfect-Reconstruction Filter Banks and Quadrature Mirror Filters.

OPTIMAL FILTERING OF RANDOM SIGNALS (08 Hours)

Innovations Representation of a Stationary Random Process, Prediction, linear prediction: forward and backward methods, Linear prediction based filter analysis, Prediction error, Levinson recursion method for solving Toeplitz system of equations, AR and ARMA Filter, MLE and MAP, LMS and RLS adaptive filters.

POWER SPECTRUM ESTIMATION/ANALYSIS (06 Hours)

Non-parametric method, Parametric method, periodogram, Eigen analysis for spectral Estimation.

APPLICATION OF DSP **(07 Hours)**

Speech signal processing: Time domain processing of speech, methods for extracting the parameters, Filter bank analysis of speech, radar signal processing, musical sound processing, recent applications.

(Total Contact Time: 45 Hours)

3. BOOKS RECOMMENDED

1. Salivahanan S, “Digital Signal Processing”, Fourth Edition, Tata McGraw-Hill, 2019.

2. Rabiner L. R. and Gold B., “Theory and Applications Of Digital Signal Processing”, First Edition, Prentice Hall, 1992.

3. Oppenheim A. V. and Schafer, “Discrete Time Signal Processing”, Pearson, Third edition, 2014.

4. Proakis John G. and Manolakis D.G., “Digital Signal Processing: Principle, Algorithms and Applications”, Fourth Edition, Pearson, 2006.

5. Kay, Steven M “Fundamentals of statistical signal processing”, Prentice Hall, 1998.

6. L. R. Rabiner and R. W. Schafer, Digital Processing of Speech Signals, Pearson Education India, First Edition, 2003.

Other Reference Books:

1. Mitra Sanjit K.,“Digital Signal Processing - A computer Based Approach”, McGraw-Hill,2007

M.Tech. I (Communication systems) Semester – I

Communication Lab – I

L	T	P	Credit
0	0	6	03

ECCS107 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Understand the basic concepts and advancements in RF Circuits, DSP and fiber optic communication systems.
CO2	Demonstrate the device characteristics linearity in various signal and systems analog and digital modulation schemes in fiber optics
CO3	Interpret the RF Circuits and waveguides, MultiMate signal processing model and fiber optic communication system models by using the simulation software.
CO4	Design and analyse the operating principle of RF Circuits and systems, wavelets and single channel fiber optic communication systems
CO5	Design and analyse the operating principle of RF Circuits and systems, Multirate filters for 2D signal processing in WDM solutions systems and the effect of nonlinearity in optical fiber

2. List of Experiments:

RF Circuits & Systems

01) Study of Microwave Bench.
02) Plot of Standing Wave Pattern and Finding VSWR for Different Loads.
03) Characteristics of Waveguide Directional Coupler.
04) Solving Problems Using Z – Match Software for Smith Chart.
05) Measurement of Insertion Loss and VSWR of Bandstop Filter Using Simulated Network Analyzer.
06) Measurement of Transmission Loss and Reflection Loss for 50 Ohms Microstrip Line.
07) Determination of Resonance Frequency of Microstrip Ring Resonator and Calculation of Relative Dielectric Constant of Substrate.
08) Measurement of Power Division, Isolation and Return Loss of A 3 dB Power Divider.
09) Measurement of Coupling and Isolation Loss of a Backward Wave Microstrip Direction Coupler.
10) Measurement of Gain of Microstrip LNA Amplifier.
11) Study of Microwave Communication Link.

Advance Digital Signal Processing

01) Write a MATLAB Program to Get Fourth Order Butterworth Filter.
02) Write a MATLAB Program for Interpolation and Decimation.
03) Write a MATLAB Program to Decimate by Factor of Eight in Two Stages.
04) Write a MATLAB Program for Power Spectral Density of Signal with Random Noise and

Draw Spectrum of Chirped Signal.

05) Write A MATLAB Program to Plot the Zeros and Poles of System and Comment on Stability.

06) Write A MATLAB Program to Pass Various Sinusoids of Freq. 50 Hz, 200 Hz and 300 Hz Through Band Pass Filter Having Cutoff Freq. Wn = [0.125, 0.275]; Generated Through Kaiser Window. Draw Its Freq. Spectrum and Output in Time Domain.

07) Write A MATLAB Program for Generation of Moving Average Filter Which Is Basic Low Pass Filter.

08) Write A MATLAB Program for Haar Wavelet Signal Decomposition and Reconstruction.

09) Write A MATLAB Program for DFT Filter Bank Realization.

10) Mini Projects.

Advance Optical Communication

01) Setting-Up A Fiber Optic Analog Link Using OFT Kit.

02) Setting-Up A Fiber Optic Digital Link Using OFT Kit.

03) Finding The Losses and NA for Given Optical Fiber Using OFT Kit.

04) Study of The Splicing Kit, Light Source and Power Meter.

05) Dispersion Comparison Using FOTX-RX Using FOT Kit.

06) TDM Frame Generation and Transmission-Reception Using FOT Kit.

07) Performance Analysis of Single Channel Fiber Optic Communication Link Using Optisystem 17.0.

08) Performance Analysis of Fiber Optic Communication Link with FEC Coder and Decoder Using Optisystem 17.0.

09) Performance Analysis Of Multichannel WDM Link Using Optisystem 17.0..

10) Performance Analysis Of Bidirectional DWDM Link Using Optisystem 17.0..

11) Performance Analysis Of Analog And CATV Transmission Using Optisystem 17.0..

12) Mini Project

M.Tech. I (Communication systems) Semester – I

Seminar

L	T	P	Credit
0	0	4	02

ECCS109 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Identify the plan of action from the real-world technical aspects to develop a thought process and basic understanding and extract a detailed literature survey
CO2	Comprehend the detailed design for proof-of-concept, related data, and results to come to some concluding remarks.
CO3	Write the report with well-organised motivational aspects, technical aspects, and comprehension with proficiency in English.
CO4	Develop the effective and innovative presentation using modern tools/software.
CO5	Deliver the oral presentation with the soft skills of listening, debating, answering etc.

ELECTIVE COURSES I & II: SEMESTER - I

M.Tech. I (Communication systems) Semester – I	L	T	P	Credit
Information Theory and Coding	3	0	0	03

ECCS111 **Scheme**

1. **Course Outcomes (COs):**

At the end of the students will be able to:

CO1	Understand the notion of information in a mathematically sound way.
CO2	Illustrate entropy, joint entropy, relative entropy, conditional entropy, and channel capacity of a system.
CO3	Analyze lossless data compression techniques with varying efficiencies as per problem requirements.
CO4	Evaluate decoding strategies for block codes, linear codes, cyclic codes and BCH codes for detection and correction of errors.
CO5	Design convolutional Encoding and Decoding that meets design objectives like required protection for detection and correction of errors.

2. **Syllabus:**

INFORMATION THEORY (06 Hours)

Introduction to Information Theory, Entropy, Properties of Entropy, Measures for Continuous, Random Variable, Relative Entropy, Conditional and Joint Entropy, Measure of Information, Average Information, Extension of Zero Memory Source.

SOURCE CODING (12 Hours)

Properties of Codes, Variable Length Codes, Uniquely Decodable Codes, Kraft's Inequality, Prefix Codes, Average Length of a Code, Shannon’s First Theorem, Shannon’s Encoding Algorithm, Shanon-Fano Codes, Huffman's Codes, Arithmetic Codes, Lempel Ziv, Run Length Code, Code Efficiency and Redundancy, Practical Application of Source Coding: JPEG Compression.

CHANNEL MODELS AND CHANNEL CAPACITY (08 Hours)

Discrete Communication Channels, Continuous Channels, Entropy Functions and Equivocation, Mutual Information, Channel Capacity, redundancy and efficiency of channels, Symmetric channels, Binary Symmetric Channel, Binary Erasure Channel, Noise-Free Channel, Cascaded channels, Binary asymmetric channel, Shannon theorem

BLOCK CODES AND LINEAR CODES (06 Hours)

Introduction to Galois Field, Single Parity Check Codes, Product Codes, Hamming Codes, Minimum Distance of Block Codes, Linear Block Codes, Generator Matrices, Parity Check Matrices, Encoder, Standard array and Syndrome decoding, Error Correction and Error Detection Capabilities.

CYCLIC and BCH CODES (08 Hours)

Introduction to Cyclic Codes, Generator Polynomial, Syndrome Polynomial and Matrix Representation, Fire Code, Golay Code, CRC Codes and Circuit Implementation of Cyclic Codes, Introduction to BCH Codes: Generator Polynomials, Multiple Error Correcting BCH Codes, Decoding of BCH Codes, Introduction to Reed Solomon (RS) Codes.

CONVOLUTION CODE **(05 Hours)**

Introduction to Convolutional Codes, Trellis Codes: Generator Polynomial Matrix and Encoding using Trellis, Vitrebi Decoding, Introduction to Turbo Codes, Introduction to Trellis Coded Modulation (TCM), Introduction to Space Time Block Codes (STBC).

(Total Contact Time: 45 Hours)

3. BOOKS RECOMMENDED

1. Ranjan Bose, “Information theory, coding and cryptography”, Tata McGraw-Hill,3rd Edition, 2016

2. T. M. Cover and J. A. Thomas, “Elements of Information Theory“, 2nd Ed., John Wiley & Sons, New Jersey, USA, 2006.

3. Salvatore Gravano,“Introduction to Error Control Codes”, Oxford University Press,1st Edition,2007

4. Shu Lin and Daniel Costello, “Error Control Coding”, 2nd Ed., by Pearson, 2004.

5. Todd K. Moon, “Error Correcting Coding”, Wiley India Edition,2006

M.Tech. I (Communication systems) Semester – I

Digital Satellite Communication

L	T	P	Credit
3	0	0	03

ECCS113 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Describe terminology relating to Satellite system communication, orbital mechanism, orbital effects on communication etc.
CO2	Apply satellite communication techniques incorporating advanced satellite multiple accesses schemes, modulation and coding schemes.
CO3	Analyse satellite link budget, C/I calculations
CO4	Classify the state-of-the-art access schemes, coding schemes, functionality of satellite systems,
CO5	Design problem based on, satellite networking, Navigation and satellite personal communications.

2. Syllabus:

COMMUNICATION SATELLITE : ORBIT AND DESCRIPTION **(05 Hours)**

Orbit Period & Velocity, Effects Of Orbital Inclination, Azimuth & Elevation, Coverage Angle & Slant Range, Eclipse, Placement Of A Satellite In A Geostationary Orbit, Satellite Description.

EARTH STATION **(06 Hours)**

Earth Station Antenna, High Power Amplifier, Low Noise Amplifier, Upconvertrer, Down Converter, Monitoring & Control, Reliability.

SATELLITE LINK **(06 Hours)**

Basic Link Analysis, Interference Analysis, Rain-Induced Attenuation, Rain-Induced Cross Polarization Interference, System Availability, Satellite Links Design, Satellite-Satellite Link Using Lasers.

FREQUENCY DIVISION MULTIPLE ACCESS **(04 Hours)**

FDM-FM-FDMA, SCPC, FM-FDMA TV, Companded FDM-FM-FDMA And SSB-AM-FDMA, Intermodulation Products, Resulting From Amplitude Nonlinearity And from both Amplitude & Phase Nonlinearities, Optimized C / I Plus Noise Ratio.

TIME DIVISION MULTIPLE ACCESS **(08 Hours)**

TDMA Frame Structure, TDMA Burst Structure, TDMA Frame Efficiency, TDMA Super frame Structure, Frame Acquisition & Synchronization, Satellite Position Determination, Burst Time Plan, Control & Coordination By The Reference Station, TDMA Timing, TDMA Equipment, Advanced TDMA Satellite Systems.

EFFICIENT TECHNIQUES: DEMAND ASSIGNMENT MULTIPLE ACCESS & DIGITAL SPEECH INTERPOLATION **(05 Hours)**

The Erlang B Formula, Types Of Demand Assignments, DAMA Characteristics, Real –Time Frame Reconfiguration, DAMA Interfaces, SCPC–DAMA, SPADE, Digital Speech Interpolation.

SATELLITE SPREAD SPECTRUM COMMUNICATIONS (05 Hours)

Direct Sequence Spread Spectrum System, Direct Sequence Code Division Multiple Access, Frequency Hop Spread Spectrum Systems, Frequency Hop Code Division Multiple Access, DS Acquisition & Synchronization, FH Acquisition & Synchronization, Satellite On-Board Processing.

MOBILE SATELLITE NETWORKS (03 Hours)

Operating Environment, MSAT Network Concept, CDMA MSAT Network, Statistics of Mobile Propagation.

SATELLITE APPLICATION AND CHALLENGES (03 Hours)

VSAT, Radarsat, GPS, Navigation, Interferences

(Total Contact Time: 45 Hours)

3. BOOKS RECOMMENDED

1. Pratt T. and Bostian C. W., "Satellite Communications" John Wiley & Sons, 2nd Ed., 2003.
2. HaTri. T., "Digital Satellite Communications", McGraw-Hill, 2nd Ed., Reprint 2017
3. Roddy Dennis, "Satellite Communications", McGraw-Hill, 4th Ed., 2006,
4. Tomasi Wayne, "Advanced Electronic Communication Systems", PHI, 6th Ed., 2014
5. Nagaraja N.S., "Elements Of Electronic Navigation", TMH, 2nd Ed., 2000.

M.Tech. I (Communication systems) Semester – I

Cognitive Radio

L	T	P	Credit
3	0	0	03

ECCS115 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Explain the fundamentals of SDR and CR with basic differences.
CO2	Compare the optimum spectrum sensing techniques
CO3	Analyse the sensing accuracy versus sensing overhead for given conditions.
CO4	Evaluate the performance of spectrum sensing and spectrum management techniques over cognitive radio
CO5	Design and analysis of performance parameters over CR architecture for the given techniques and parameters

2. Syllabus:

SOFTWARE DEFINED RADIO (SDR) **(09 Hours)**

Essential functions of the SDR, SDR architecture, design principles of SDR, traditional radio implemented in hardware and SDR, transmitter architecture and its issues, A/D & D/A conversion, parameters of practical data converters, techniques to improve data converter performance, complex ADC and DAC architectures, digital radio processing, reconfigurable wireless communication systems.

COGNITIVE RADIO (CR) FEATURES AND CAPABILITIES **(10 Hours)**

CR functions, CR architecture, components of CR, CR cycle, CR and dynamic spectrum access, interference temperature, CR architecture for next generation networks, CR standardization, Concept of primary and secondary users, Licensed and unlicensed spectrums in CR.

SPECTRUM SENSING AND IDENTIFICATION **(09 Hours)**

Primary signal detection, energy detector, cyclostationary feature detector, matched filter, cooperative sensing, spectrum opportunity, spectrum opportunity detection, fundamental trade-offs: performance versus constraint, sensing accuracy versus sensing overhead.

SPECTRUM MANAGEMENT OF COGNITIVE RADIO NETWORKS **(08 Hours)**

Spectrum decision, spectrum sharing and spectrum mobility, mobility management of heterogeneous wireless networks, research challenges in CR Spectrum switching

COGNITIVE RADIO NETWORKS (CRN) ARCHITECTURE **(09 Hours)**

Terminal architecture of CRN, diversity radio access networks, routing in CRN, Control of CRN, Self-organization in mobile communication networks, security in CRN, cooperative communications, cooperative wireless networks, user cooperation and cognitive systems.

(Total Contact Time: 45 Hours)

3. BOOKS RECOMMENDED

1. Kwang-Cheng Chen and Ramjee Prasad, "Cognitive Radio Networks", John Wiley & Sons, Ltd, 2009.
2. Alexander M. Wyglinski, Maziar Nekovee, and Y. Thomas Hou, "Cognitive Radio Communications and Networks - Principles and Practice", Elsevier Inc., 2010.
3. Bruce Fette, "Cognitive radio technology", Elsevier, 2nd edition, 2009.
4. Jeffrey H. Reed "Software Radio: A Modern Approach to radio Engineering", Pearson Education Asia, 2006.
5. Linda Doyle, "Essentials of Cognitive Radio", Cambridge University Press, 2009.

M.Tech. I (Communication systems) Semester – I

Probability and Random Processes

L	T	P	Credit
3	0	0	03

ECCS117 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Explain Sample space and events Combinatorics, Joint and conditional probabilities
CO2	Compare CDF, PDF and established a relation between PDF and CDF.
CO3	Classify Stationary, Nonstationary, Strict-Sense and Wide-Sense Stationary Processes
CO4	Analyze Autocovariance, Power Spectral Density, Joint Statistical Averages of Two Random Processes, Crosscorrelation And Crosscovariance, Ergodicity etc.
CO5	Evaluate response of linear systems through random signals though various output parameters.

2. Syllabus:

INTRODUCTION TO PROBABILITY THEORY **(05 Hours)**

Sets, fields, sample space and events, axiomatic definition of probability. Combinatorics, Joint and conditional probabilities, Independence, total probability, Bayes' rule

RANDOM VARIABLES **(12 Hours)**

Cumulative Distribution Function, Probability Density Function. Relation Between Probability And Probability Density, Joint Cumulative Distribution And Probability Density, Characteristic functions and moment generating functions, Average Value And Variance Of A Random Variable, Gaussian Probability Density, Error Function, Rayleigh Probability Density,Mean And Variance Of The Sum Of Random Variables, Correlation Between Random Variables, Central Limit Theorem, liner minimum mean square error and orthogonality principle, Chebysev inequality Sequences Of Random Variables, Convergence Of Sequences Of Random Variables. Weak law of large number.

STOCHASTIC PROCESSES **(10 Hours)**

Stationary, Nonstationary, Strict-Sense and Wide-Sense Stationary Processes, Gaussian Processes, Poisson Process and the Markov Process.

EXPECTED VALUES OF A RANDOM PROCESS **(10 Hours)**

The Mean Value, Autocorrelation, Autocovariance, Power Spectral Density, Joint Statistical Averages of Two Random Processes, Cross-correlation And Cross-covariance, Ergodicity, Mean Square Continuity, Mean Square Derivative And Mean Square Integral Of Stochastic Processes, Ergodic Processes. White noise process and white noise sequence.

RANDOM PROCESS THROUGH LINEAR SYSTEMS **(08 Hours)**

Response of Linear Systems to Random Signals, Stationarity of the Output, Autocorrelation and Power Spectral Density of the Output, Examples with White Noise as the Input, Interpretation of the PSD, Bandlimited Random Processes, Weiner Filtering, Optimum Linear Systems, The Kalman Filter.

(Total Contact Time: 45 Hours)

3. BOOKS RECOMMENDED

1. Papoulis,“Probability, Random Variables And Stochastic Processes”, McGraw-Hill,4th Ed, 2017.
2. Alberto Leon-Garcia, Probability, Statistics, and Random Processes for Electrical Engineering, Pearson, 3rd Ed, 2008.
3. Sheldon M. Ross Introduction to Probability Models Academic Press, 2014.
4. Steven Kay, Intuitive Probability and Random Processes using MATLAB, 2006.
5. Vijay K. Rohatgi, A.K. Md. Ehsanes Salehi, An Introduction to Probability and Statistics, Wiley, 2011.
6. Hayes Monson H.,“Statistical Digital Signal Processing”, John Wiley,1st Ed.,1996.

M.Tech. I (Communication systems) Semester – I

Antenna Theory And Design

L	T	P	Credit
3	0	0	03

ECCS119 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Describe the working principle of different antennas.
CO2	Apply the developed theories to model different radiating systems.
CO3	Compare the various antennas in terms of their design, functionality, use etc.
CO4	Evaluate the radiation and impedance characteristics of aperture, broadband, microstrip antennas and arrays.
CO5	Design suitable antennas and validate their performance for antenna arrays and smart antennas, mathematically analyze the types of antenna arrays.

2. Syllabus:

FUNDAMENTAL PARAMETERS OF ANTENNAS **(06 Hours)**

Radiation Pattern, Radiation Power Density, Radiation Intensity, Beamwidth, Directivity, Antenna Efficiency, Gain, Beam Efficiency, Bandwidth, Polarization, Input Impedance, Antenna Radiation Efficiency, Antenna Vector Effective Length and Equivalent Areas, Maximum Directivity and Maximum Effective Area, Friis Transmission Equation and Radar Range Equation.

RADIATION INTEGRALS AND POTENTIAL FUNCTIONS **(07 Hours)**

Vector Potential A for an Electric Current Source J, Vector Potential F for a Magnetic current Source M, Electric and Magnetic Fields for Electric (J) and Magnetic (M) Current Sources, Solution of the inhomogeneous Vector Potential Wave Equation, Far-field Radiation, Duality Theorem, Reciprocity and Reaction Theorems

LINEAR WIRE AND LOOP ANTENNA **(06 Hours)**

Infinitesimal dipole, Finite-length Dipole, Linear Elements near Conductors, Dipoles for Mobile Communication, Small Circular Loop, Circular Loop of Constant Current Folded Dipole.

APERTURE AND HORN ANTENNAS **(06 Hours)**

Huygens' Principle, Radiation from Rectangular and Circular Apertures, Design Considerations, Babinet's Principle, Radiation from Sectoral and Pyramidal Horns, Design Concepts.

REFLECTOR ANTENNAS **(05 Hours)**

Parabolic Reflector, Paraboloidal Reflector, Aperture Pattern of Large Circular Apertures with Uniform Illumination, Off axis operation of Paraboloidal Reflectors, Cassegrain feed system.

BROADBAND ANTENNAS AND MATCHING TECHNIQUES **(05 Hours)**

Broadband concept, Log-periodic antennas, Frequency independent antennas. Matching Techniques, Travelling Wave Antennas

MICROSTRIP ANTENNAS **(04 Hours)**

Basic characteristics of microstrip antennas, Feeding methods, Methods of Analysis, Design of Rectangular and Circular Patch Antennas.

ANTENNA ARRAYS ANALYSIS AND SYNTHESIS **(06 Hours)**

Two-Element Array, N-Element Linear Array: Uniform Amplitude and Spacing, N-Element Linear Array: Uniform Spacing, Nonuniform Amplitude, Planar Array, Circular Array, Continuous Sources, Schelkunoff Polynomial Method, Fourier Transform Method.

(Total Contact Time: 45 Hours)

3. BOOKS RECOMMENDED

1. C. A. Balanis, “Antenna Theory and Design”, 4th Ed., John Wiley & Sons., 2016.
2. J.D. Krauss, “Antennas for all Applications”, 3rd Ed., Tata McGraw-Hill, 2008.
3. W. L. Stutzman, and G. A. Thiele, “Antenna Theory and Design”, 2nd Ed., John Wiley & Sons, 1998.
4. R. S. Elliot, “Antenna Theory and Design”, Revised edition, Wiley-IEEE Press., 2003.
5. Harish A. R. and Sachindananda M., "Antennas and Wave Propagation", Oxford University Press, 1st Ed., 2007.

M.Tech. I (Communication systems) Semester – I

Machine Learning and Applications

L	T	P	Credit
3	0	0	03

ECCS121 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Understand fundamentals of Machine Learning and classify machine learning algorithms into supervised and unsupervised.
CO2	Solve problems using various machine learning techniques.
CO3	Analyze a given problem and determine which algorithm to use.
CO4	Evaluate performance of different ML algorithms and select suitable algorithm for a given problem.
CO5	Design applications using various ML algorithms to solve real life problems.

2. Syllabus:

INTRODUCTION TO MACHINE LEARNING AND PREREQUISITES **(11 Hours)**

Definition and history of machine learning, Types of Machine Learning: Supervised, Unsupervised, and Reinforcement Learning, Applications of Machine Learning, Essential mathematics for machine learning: linear algebra and probability theory, Bayesian learning, Naïve Bayes, Normal density and discriminant function.

SUPERVISED MACHINE LEARNING ALGORITHMS **(13 Hours)**

Regression: Linear regression, Multiple linear regression, Polynomial regression, Ridge regression, Lasso Regression. Classification: Perceptron criteria, Logistic Regression, Multi-class logistic regression (one-vs-all), K-nearest neighbours (KNN), Linear support vector machine (SVM), Kernel SVM, Linear Machine with hinge loss, Decision trees and random forests.

UNSUPERVISED MACHINE LEARNING ALGORITHMS **(12 Hours)**

Clustering: K-Means clustering, Fuzzy K-means clustering, Mean shift clustering, Hierarchical clustering, DBSCAN, Gaussian mixture model, Expectation Maximization Algorithm. Dimensionality Reduction: Dimensionality Problem, Principal component analysis (PCA), t-Distributed Stochastic Neighbour Embedding (t-SNE), Linear Discriminant Analysis (LDA). Anomaly Detection.

INTRODUCTION TO DEEP LEARNING **(09 Hours)**

Neural Networks: Biological Neurons vs. Artificial Neurons, Perceptron, Learning XOR, Multilayer perceptron (MLP), Feed forward neural networks, Activation Functions: Sigmoid, Tanh, ReLU, etc. Training Neural Networks: Forward and backward propagation, Gradient Descent, Optimization algorithms, Loss functions, Overfitting and Regularization (Dropout, Batch Normalization). CONVOLUTIONAL NEURAL NETWORKS: Convolution, Cross correlation, building blocks of CNN, MLP vs CNN, Popular CNN models, Vanishing and Exploding Gradient.

(Total Contact Time: 45 Hours)

3. BOOKS RECOMMENDED

1. C. M. Bishop, “Pattern Recognition and Machine Learning”, Springer, 2nd Ed., 2011.
2. Kevin P. Murphy, Machine Learning: A Probabilistic Perspective, The MIT Press, 2012.
3. Ethem Alpaydin, Introduction to Machine Learning, The MIT Press, 4th Ed, 2020.
4. Mehryar Mohri, Afshin Rostamizadeh, Ameet Talwalkar, Foundations of Machine Learning, The MIT Press, 2nd Ed, 2018.
5. Ian Goodfellow, Yoshua Bengio and Aaron Courville, Deep Learning, MIT Press, 2016.

M.Tech. I (Communication systems) Semester – I

Digital VLSI Design

L	T	P	Credit
3	0	0	03

ECVL101 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Understand VLSI design flow and CMOS inverter
CO2	Implement CMOS combinational and Sequential logic
CO3	Analyze circuit characteristic
CO4	Evaluate circuit performance
CO5	Design digital subsystems

2. Syllabus:

INTRODUCTION TO VLSI DESIGN (04 Hours)

Historical Perspective, Design Hierarchy, Concepts Of Regularity, Modularity And Locality, VLSI Design Challenges, Introduction of VLSI Design Flow:, From Custom to Semi Custom and Structured Array Design Approaches, Custom Circuit Design, Cell-Based Design Methodology: Standard Cell, Compiled Cells, Macrocells, Megacells and Intellectual Property, Semi-Custom Design Flow; Array-Based Implementation Approaches: Pre-Diffused (or Mask-Programmable) Arrays, Pre-Wired Arrays.

CMOS INVERTER BASICS and COMBINATIONAL LOGIC CIRCUIT (09 Hours)

Brief introduction to MOS transistor models and SPICE parameters; process parameters and design rules. Introduction, The Static CMOS Inverter — An Intuitive Perspective, Evaluating the Robustness of the CMOS Inverter (The Static Behavior): Switching Threshold, Noise Margins, Robustness Revisited; Performance of CMOS Inverter (The Dynamic Behavior): Computing the Capacitances, Propagation; Delay: First-Order Analysis, Propagation Delay from a Design Perspective; Power, Energy and Energy- Delay: Dynamic Power Consumption, Static Consumption, Perspective: Technology Scaling and its Impact on the Inverter Metrics. CMOS Combinational Logic Circuits, Complex Logic Circuits, Layout Techniques, Behavior Of MOS Logic Elements, CMOS Pass Gate and Transmission Gate, Design of combinational circuit using pseudo-nMOS and DCVSL and DSL logic gates. CPL, DPTL and swing restored pass transistor logic styles

SEQUENTIAL LOGIC CIRCUIT (08 Hours)

Timing Metrics for Sequential Circuits, Classification of Memory Elements; Static Latches and Registers: The Bistability Principle, Multiplexer-Based Latches, Master-Slave Edge-Triggered Register, Low-Voltage Static Latches, Static SR Flip-Flops—Writing Data by Pure Force; Dynamic Latches and Registers: Dynamic Transmission-Gate Edge-triggered Registers, C2MOS—A Clock-Skew Insensitive Approach, True Single-Phase Clocked Register (TSPCR); Alternative Register Styles: Pulse Registers, Sense-Amplifier Based Registers; Pipelining (An approach to optimize sequential circuits): Latch- vs. Register-Based Pipelines, NORA-CMOS—A Logic Style for Pipelined Structures; Non-Bistable Sequential Circuits: The Schmitt Trigger, Monostable Sequential Circuits, Astable Circuits; Perspective: Choosing a Clocking Strategy,

DYNAMIC LOGIC CIRCUIT **(05 Hours)**

Dynamic Logic (Basic Principles), Speed and Power Dissipation of Dynamic Logic, logic styles including np, Domino, NORA and TSPC logic, Issues in Dynamic logic due to charge sharing and race conditions, Cascading Dynamic Gates; Perspectives: How to Choose a Logic Style

CIRCUIT CHARACTERIZATION, PERFORMANCE ESTIMATION AND TESTING **(6 Hours)**

Interconnect, Estimation of Interconnect Parasitic, Delay Estimation, Logical Efforts And Transistor Sizing, Power Dissipation, Design Margin, Reliability, Testing: Introduction, Automatic Test pattern Generation (ATPG), Design for Test (DFT), Buit-in self Test (BIST)

DIGITAL SUBSYSTEM DESIGN **(13 Hours)**

Design of IO buffers and on chip load drivers; PLL, clock generation and clock buffering; design of memory cells and sense amplifiers. Design of adders - Ripple carry, Manchester carry, carry look ahead, carry select and carry save. Design of multipliers (for unsigned and signed) - sequential, parallel, carry save, Booth multipliers; Wallace tree structures. Design of shifters and floating point arithmetic units

(Total Contact Time: 45 Hours)

3. <u>BOOKS RECOMMENDED</u>

1. Rabaey Jan M., Chandrakasan Anantha and Borivoje Nikolic, "Digital Integrated Circuits (Design Perspective)", 2nd Ed., Prentice Hall of India, 2016 (Reprint).
2. Kang and Leblebici,"CMOS Digital Integrated Circuits: Analysis and Design", Tata McGraw-Hill, 4th Edition, 2019
3. Baker R. Jacob, Li H. W. & Boyce D. E.,"CMOS Circuit Design, Layout And Simulation", Wiley, 4th Edition, 2009.
4. Weste and Harris,"CMOS VLSI Design: A Circuits and Systems Perspective", Pearson Education, 4th Edition, 2020.
5. Pucknell and Eshraghian: "Basic VLSI Design", Prentice Hall of India, 3rd Edition, 2003

M.Tech. I (Communication systems) Semester – I

Embedded Systems

L	T	P	Credit
3	0	0	03

ECVL105 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Understand Embedded systems and describe CPU architectures and variety of microcontrollers.
CO2	Describe CPU processor, its modes, exception handling, instruction pipelining and basic programming.
CO3	Implementation with Assembly and C language programming for ARM Cortex-M.
CO4	Analyze 32-bit ARM microcontroller architecture, External Memory, Counters & Timers, Serial Data Input/Output and Interrupts. Design for interfacing Keys, LED/LCD Displays, ADC And DAC.
CO5	Design a typical cost-effective real-world embedded system with appropriate hardware/software components and embedded OS.

2. Syllabus:

INTRODUCTION TO EMBEDDED SYSTEMS **(08 Hours)**

Overview and Characteristics of Embedded Systems, Classification and Application Areas, Process of Embedded System Development, RISC Vs CISC CPU Architectures, 8/16/32 bit Microcontrollers Family, Components in embedded system development environment (IDE)

ARM CORTEX M3/M4 ARCHITECTURE **(10 Hours)**

Overview of ARM Cortex family, Operation modes and states, Registers, Special Registers, Floating point Registers, Memory system and MPU, Exception and interrupts, System control block, OS Support features, ARM Instruction Set Architecture, Arithmetic and Logic, Load and Store, Branch and Conditional Execution.

PROGRAMMING CORTEX M3/M4 IN ASSEMBLY and C **(10 Hours)**

Structured Programming, Subroutines, 64-bit Data Processing, Mixing C and Assembly, Interrupt and NVIC, Fixed-point and Floating-point Arithmetic, Writing optimized ARM assembly/C code, Exception and fault handling routines.

USING EMBEDDED OS **(08 Hours)**

Introduction to Embedded OS, Task and Threads, Creation of Threads, Inter-thread communications, Signal event, Semaphores, Message queue, OS based programming examples.

PERIPHERAL INTERFACING **(09 Hours)**

General-purpose I/O, General-purpose Timers, Real-time Clock (RTC), Direct Memory Access (DMA), Analog-to-Digital Converter (ADC), Digital-to-Analog Converter (DAC), Serial Communication interface such as UART, I2C, SPI, Ethernet, CAN etc.

(Total Contact Time: 45 Hours)

3. BOOKS RECOMMENDED

1. Joseph Yiu, “A definitive guide to the ARM-Cortex M3 and Cortex-M4 Processors”, 3rd Ed., Newnes, 2013
2. A.N.Sloss, D.Symes and C. Wright, “ARM System Developer’s Guide: Designing and Optimizing System Software”, Elsevier, 2004
3. Y. Zhu, “Embedded Systems with Arm Cortex-M3 Microcontrollers in Assembly Language and C”, E-Man Press LLC, 2014
4. Wayne Wolf, “Computers as Components: Principles of Embedded Computing System Design (The Morgan Kaufmann Series in Computer Architecture and Design)”, 2nd Edition, 2008
5. Prasad K. V. K. K., “Embedded / Real-Time Systems: Concepts, Design And Programming”, DreamTech Press, 2005

M.Tech. I (Communication systems) Semester – I	L	T	P	Credit
Semiconductor IC Technology	3	0	0	03

ECVL111 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Describe and analyze material processing techniques and Pattern Transfer process
CO2	Explain, and compare the concept behind thin film deposition, and characterization techniques.
CO3	Describe and compare metal contact formation, interconnect, bonding and packaging.
CO4	Demonstrates different fabrication, characterization, and metallization techniques.
CO5	Design basic semiconductor devices and their characterization.

2. Syllabus:

INTRODUCTION TO MICROELECTRONIC FABRICATION AND MATERIALS (08 Hours)

Semiconductor substrate: Crystal structure, Crystal defects, Crystal growth, Wafer fabrication and basic properties of Silicon Wafers, Wafer cleaning, and native oxide removal, Substrates beyond Silicon, Surface reactions, Dopants, Defects in epitaxial growth, Clean Room, and Safety requirements. Diffusion, Thermal Oxidation, Ion implantation, Etching.

MASK FABRICATION AND ADVANCED LITHOGRAPHY TECHNIQUES (05 Hours)

Overview, Optical lithography, Photoresist, Mask Development, Patterning Strategies, Electron beam lithography process, EUV Lithography, X-ray lithography, and Other advanced lithography systems

THIN-FILM TECHNOLOGIES (09 Hours)

Physical Vapor Deposition: Evaporation Systems, Sputtering systems, and state-of-art Systems. Chemical Vapor Deposition: CVD system, Advanced CVD systems: LPCVD, UHCVD, AACVD, and advanced systems.

Epitaxial Deposition: MOCVD, MBE, and CBE.

Solution-Based Deposition Techniques: Electrodeposition, Spin Casting, Printing, Layer-by-Layer Deposition, Colloidal Synthesis.

MEMS FABRICATION TECHNIQUES (05 Hours)

Silicon Pressure Sensors, Micro-Electro-Mechanical Systems, Micromachining Techniques, Isotropic Etching and Anisotropic Etching, Wafer Bonding, and LIGA Processes.

NANOSCALE DEVICE CHARACTERIZATION TECHNIQUES (09 Hours)

X-ray diffraction, X-ray photoelectron Spectroscopy, Spectroscopic Ellipsometry, Field Emission Scanning Electron Microscope, Transmission Electron Microscope, Atomic Force Microscope, Raman Spectroscopy, UV-Vis Measurement, Photo-Luminescence, Hall Measurement, Capacitance Voltage Measurement and Current-voltage measurement.

PROCESS INTEGRATION **(04 Hours)**

Contacts and metallization: Junction and oxide isolation, Si on insulator, Schottky and Ohmic contacts, Multilevel metallization. CMOS technologies: Device behavior, Basic 3 μm technologies, Device scaling. Circuit Manufacturing: Yield, Particle control, Design of experiments, computer-integrated manufacturing.

INTERCONNECTS, BONDING, AND PACKAGING: **(05 Hours)**

Metallization, Silicides, CVD Tungsten Plug Process, Gold Wire Bonding and Other Bonding Technologies, Package Types, Assembly Techniques, Package Fabrication Technology, Package Design Considerations.

(Total Contact Time: 45 Hours)

3. BOOKS RECOMMENDED

1. Stephen A. Campbell, “The Science and Engineering of Microelectronic Fabrication”, 2nd edition Oxford University Press, 2006.
2. S.M. Sze (Ed), “VLSI Technology”, McGraw Hill, 1998.
3. Hrundle, Evans, Wilson, “Encyclopedia of Material Characterization”, Elsevier, 2005
4. D. K. Schroder, “Semiconductor Material and Device Characterization”, Wiley Interscience, 2016
5. James Plummer, M. Deal and P.Griffin, “Silicon VLSI Technology”, Prentice Hall, 2016
6. Rebeiz, G.M., RF MEMS: Theory Design and Technology, Wiley 2004
7. Stephen A. Campbell, “Fabrication engineering at the Mocto- and NanoScale”, 4th edition Oxford University Press, 2013.

4. Additional Resources

1. Relevant Journals and Conference publications.

CORE COURSES: SEMESTER – II

M.Tech. I (Communication systems) Semester – II

Image Processing And Computer Vision

L	T	P	Credit
3	0	0	03

ECCS102 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Understand the basics of image formation, image processing and apply image enhancement both in spatial and frequency domains.
CO2	Analyse causes for image degradation and apply restoration techniques.
CO3	Evaluate different image segmentation techniques and develop solutions using Mathematical morphology concepts.
CO4	Understand the image representation and description techniques.
CO5	Analyse and evaluate different reflectance models and techniques to reconstruct 3D surfaces from 2D Images.

2. Syllabus:

IMAGE PROCESSING SYSTEM **(04 Hours)**

Camera Model, Image Representation, Image Sampling, Quantization, Resolution, Human Visual System, Classification of Digital Images, Image Types, Elements of an Image-processing System, Image File Formats, Relationships Between Pixels-Nearest Neighbour, Adjacency, Connectivity, Regions, and Boundaries; Distance Measures.

IMAGE ENHANCEMENT & IMAGE TRANSFORMS **(10 Hours)**

Image Enhancement in spatial domain, Enhancement through Point Operation, Histogram Manipulation, Gray-level Transformation, Neighbourhood Operation, filtering operation in spatial domain, Bit-plane Slicing, Enhancement in the Frequency Domain,2D Convolution, 2D Discrete Fourier Transform, Homomorphic Filter, Zooming Operation,

IMAGE RESTORATION/DENOISING AND IMAGE REPRESENTATION & DESCRIPTION **(10 Hours)**

Linear, Position-Invariant Degradations, Estimating the Degradation Function, Inverse Filtering, Minimum Mean Square Error (Wiener) Filtering, Constrained Least Squares Filtering Classification of Noise in Image, Median Filtering, Trimmed Average Filter, Adaptive filters, Performance Metrics in Image Restoration, Applications of Digital Image Restoration. Image Image Compression Fundamentals, study of Image representation and description techniques.

IMAGE SEGMENTATION AND MATHEMATICAL MORPHOLOGY **(06 Hours)**

Point, Line, and Edge Detection, Thresholding, Region-Based Segmentation, Basic Morphological Operations-Opening, Closing Operators, Dilation and Erosion, Morphological Algorithms, Applications.

IMAGE FORMATION **(05 Hours)**

Pinhole and Perspective Projection, Image Magnification, Vanishing Point, Image Formation using Lenses, Gaussian Lens Law, Focal Length, Two Lens System, Aperture of the Lens, Lens Defocus, Blur Circle, Depth of Field, Lens Related Issues.

RECONSTRUCTION **(10 Hours)**

Light Flux, Radiant Intensity, Surface Irradiance, Scene Radiance, BRDF, Reflectance Models, Surface Orientation, Reflectance Map, Photometric Stereo, Shape from Shading, Depth from Focus, Depth from Defocus.

(Total Contact Time: 45 Hours)

3. <u>BOOKS RECOMMENDED</u>

1. R. C. Gonzalez, R. E. Woods, Digital Image Processing, Pearson Education. 4rd Ed.,2017
2. Jain A.K., Fundamentals of Digital Image Processing, Prentice-Hall, 2002.
3. Sonka M. Hlavac V., Boyle R., Image Processing, Analysis and Machine Vision, Cengage Learning, 2nd Ed. Indian Reprint, 2009.
4. Manas Kamal Bhuyan, Computer Vision and Image Processing Fundamentals and Applications, Taylor & Francis, CRC Press, 2020.
5. Pratt W.K., Digital Image Processing, John Wiley, IV Edition, 2007.
6. Berthold Horn, Robot vision, MIT press, 1986.
7. Richard Hartley, Andrew Zisserman, Multiple view geometry in computer vision, Cambridge university press, 2003.

M.Tech. I (Communication systems) Semester – II

Wireless Communication

L	T	P	Credit
3	0	0	03

ECCS104 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Describe and classify the channel models, modulation schemes like spread spectrum and multicarrier modulation.
CO2	Demonstrate the concept of spread spectrum technology, multicarrier modulation scheme, OFDM and MIMO to develop a wireless communication link.
CO3	Analyze the impact of various types of fading (large-scale, shadowing, and small-scale) on wireless communication systems and propose mitigation techniques.
CO4	Evaluate the performance of different modulation schemes in terms of bit error rate and signal quality in varying environments.
CO5	Design and simulate a wireless communication system incorporating advanced techniques like spread spectrum, OFDM and MIMO to address real-world communication challenges.

2. Syllabus:

GENERAL CONSIDERATIONS **(10 Hours)**

General considerations about radio waves over wireless channel, Radio wave propagation and the atmosphere, basic propagation mechanisms, classification of fading channels, large scale fading, shadowing, small-scale fading and multipath, statistics of fading coefficient, BER of wired and wireless communication system, diversity, power profile, delay spread, coherence bandwidth, Doppler, Doppler spectrum.

SPREAD SPECTRUM MODULATION **(12 Hours)**

Basic principle of Orthogonality, spreading code, CDMA, generation and properties of PN sequence, random spreading sequence and their properties, advantages of CDMA, rake receiver, performance analysis of CDMA downlink and uplink scenarios, near far problem in CDMA

Multi-carrier Modulation and OFDM **(13 Hours)**

Introduction to Multicarrier modulation, multicarrier transmission and reception scheme, bottleneck in multi-carrier modulation scheme, introduction to OFDM, OFDM transmission and reception schemes, cyclic prefix, carrier frequency offset in OFDM, PAPR in OFDM, SC-FDMA.

MIMO **(10 Hours)**

Introduction spatial multiplexing, MIMO system model, zero forcing receiver, MIMO-MMSE receiver, SVD based optimal MIMO transmission and reception, optimal power allocation in MIMO, space time coding, Non-linear MIMO receiver-V-BLAST, MIMO beam forming, MIMO-OFDM

(Total Contact Time: 45 Hours)

3. BOOKS RECOMMENDED

1. T. S. Rappaport, “Wireless Communications: Principles and Practice”, Pearson Education, 2nd Edition, 2010.
2. Molisch Andreas F, “Wireless Communications”, Wiley, 2nd Edition, 2011.
3. Goldsmith Andrea, “Wireless Communications”, Cambridge University Press,2002.
4. Yong Soo Cho, Jaekwon Kim, Won Young Yang, and Chung G. Kang, "MIMO-OFDM Wireless Communications with MATLAB" Wiley, 1st Edition, 2010.
5. Upena Dalal, “Wireless Communication”, Oxford University Press, 1st Edition, 2008.

M.Tech. I (Communication systems) Semester – II

Communication Lab – II

L	T	P	Credit
0	0	6	03

ECCS106 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Review of basic fundamental concepts of a digital image processing.
CO2	Implement the techniques for image enhancement and techniques for spatial and frequency domain processing restoration techniques and morphological techniques
CO3	Explain and analyze wired and wireless channel models and their impact on wireless
CO4	Apply the principles of spread spectrum communication and CDMA to design and evaluate wireless communication systems.
CO5	Evaluate and design advanced wireless communication techniques such as OFDM and MIMO for optimizing performance in practical scenarios.

2. List of Experiments

Image Processing and Computer Vision

01) Spatial Gray Level Resolution and Zooming, Shrinking, Bilinear Interpolation
02) Creation of Negative Image and Gamma Correction
03) Thresholding Applied to Image
04) Bit Plane Slicing of an Image
05) Histogram Equalization and Matching for B/W and Color Images, Finding Mean and Variance
06) Noise Generation in The Image Using Gaussian Noise and Salt & Pepper Noise, Finding Mean and Variance
07) Noise Reduction Using Median Filter
08) Periodic Noise Reduction Using Notch Filter
09) High Pass and Low Pass Filter Applied to Image
10) Function Implementation for Reading, Writing & Rotating Images
11) Point Detection and Edge Detection of the Image
12) Correlation Between Two Images
13) Pseudo Color Processing

Wireless Communication

01) Assess the Bit Error Rate (BER) Performance of Digitally Modulated Symbols Under Additive White Gaussian Noise (AWGN) for Different Signal-to-Noise Ratios (SNR).
02) Estimate the Path Loss Exponent for a Wireless Communication System Using the Minimum Mean Square Error (MMSE) Method (Linear Regression).
03) Evaluate and Compare the BER Performance of Wired and Wireless Communication

Systems Under Varying SNR Conditions.

04) Evaluate and Compare the Performance of Diversity Techniques in a Wireless Communication System Under Varying SNR Conditions.

05) Implement and Assess the Performance of a Code Division Multiple Access (CDMA) Transmitter and Receiver.

06) Implement a Rake Receiver for CDMA and Evaluate Its Performance.

07) Implement a Multicarrier Modulation (MCM) Transmitter and Receiver and Analyze their Performance.

08) Implement an Orthogonal Frequency Division Multiplexing (OFDM) Transmitter and Receiver and Evaluate Their Performance.

09) Implement a Single Carrier Frequency Division Multiple Access (SC-FDMA) Transmitter and Receiver and Assess Its Performance.

10) Implement a Multiple Input Multiple Output (MIMO) Communication System Using Zero Forcing and Minimum Mean Square Error (MMSE) Receivers, and Evaluate their Performance.

M.Tech. I (Communication systems) Semester – II

Mini Project

L	T	P	Credit
0	0	4	02

ECCS108 **Scheme**

1. <u>Course Outcomes (COs):</u>

At the end of the students will be able to:

CO1	Explain the plan of action prototype system that addresses a specific problem or requirement within the domain of communication systems.
CO2	Understand and modify design (for existing product) including all aspects of products , material, process, resources and standards etc.
CO3	Analyse and validate software and hardware selection.
CO4	Evaluate effectiveness of practicality with respect to industry level implementation of the prototype system involving system design aspect.
CO5	Design prototype with experimental result, future scalability considerations of the developed prototype and Implement final working model/software.

ELECTIVE COURSES- III, IV & V: SEMESTER – II

M.Tech. I (Communication systems) Semester – II

Deep Learning Theory and Practice

L	T	P	Credit
3	0	0	03

ECCS172 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Explain the basic concepts in Neural Networks and applications.
CO2	Understand general terms and background of deep learning and to know the main techniques in deep learning.
CO3	Implement deep neural network system.
CO4	Identify the deep learning algorithms which are more appropriate for various types of learning tasks in various domains.
CO5	Design deep learning algorithms and solve real-world problems.

2. Syllabus:

INTRODUCTION **(09 Hours)**

Introduction to Deep Learning, Bayesian Learning, Decision Surfaces, Linear Classifiers, Linear Machines with Hinge Loss, Optimization Techniques, Gradient Descent, Batch Optimization

NEURAL NETWORK **(09 Hours)**

Introduction to Neural Network, Multilayer Perceptron, Back Propagation Learning, Unsupervised Learning with Deep Network, Auto encoders

CONVOLUTIONAL NEURAL NETWORKS **(10 Hours)**

Convolutional Neural Network, Building blocks of CNN, Transfer Learning, Revisiting Gradient Descent, Momentum Optimizer, RMSProp, Adam, Effective training in DeepNet- early stopping, Dropout, Batch Normalization, Instance Normalization, Group Normalization

DEEP LEARNING **(10 Hours)**

Recent Trends in Deep Learning Architectures, Residual Network, Skip Connection Network, Fully Connected CNN etc., Classical Supervised Tasks with Deep Learning, Image Denoising, Semantic Segmentation, Object Detection etc.

LSTM AND GENERATIVE MODELS **(07 Hours)**

LSTM Networks Generative Modeling with DL, Variational Autoencoder, Generative Adversarial Network Revisiting Gradient Descent, Momentum Optimizer, RMSProp, Adam

(Total Contact Time: 45 Hours)

3. BOOKS RECOMMENDED

1. Deep Learning- Ian Goodfelllow, Yoshua Benjio, Aaron Courville, The MIT Press. Year 2023
2. Understanding Machine Learning: From Theory to Algorithms by Shai Shalev-Shwartz, Shai Ben-David, Year 2014

3. Pattern Classification- Richard O. Duda, Peter E. Hart, David G. Stork, John Wiley & Sons Inc. Year 2012
4. Yegnanarayana, B., Artificial Neural Networks PHI Learning Pvt. Ltd, 2009.
5. Golub, G., H., and Van Loan,C.,F., Matrix Computations, JHU Press,2013.
6. Satish Kumar, Neural Networks: A Classroom Approach, Tata McGraw-Hill Education, 2004

M.Tech. I (Communication systems) Semester – II

Internet of Things, Technologies and Applications

L	T	P	Credit
3	0	0	03

ECCS174 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Describe sensor data available on the Internet for analysis and visualization.
CO2	Demonstrate basic measurement tools to determine the real-time performance of packet-based networks.
CO3	Examine how to communicate with other mobile devices using various communication platforms such as Bluetooth and Wi-Fi.
CO4	Evaluate trade-offs in interconnected wireless embedded sensor networks.
CO5	Create end-to-end IoT applications, working as a team.

2. Syllabus:

INTRODUCTION TO IOT **(06 Hours)**

IOT Architecture, Major components of IoT, IoT Design Methodologies, IoT Entities, IOT Software Development Platforms (Python/C/C++), Data acquisition: Sensors, Actuators, Gateways, Cloud, Mobile/Web Applications

MACHINE-TO-MACHINE COMMUNICATIONS **(09 Hours)**

Wired Communication Protocols, Role of M2M in IoT, Machine-to-Machine Communication: IEEE 802.15.4, Zigbee, Z-Wave, MQTT/MQTT-SN, COAP, 6LoWPAN, RPL.

NETWORKING IN IOT **(09 Hours)**

Real-time networking, Soft and real time, quality of service/information, resource reservation and scheduling, and performance measurements, Introduction to SDN, SDN and NFV for IoT

COMPUTING IN IOT **(08 Hours)**

Data Handling and Analytics, Cloud Computing, Sensor-Cloud, Fog Computing, IoT Security

IOT SYSTEM DESIGN **(07 Hours)**

Logical Design using Python, Linux-based Edge Device—Raspberry Pi, Integration of Sensors and Actuators with Arduino, Raspberri Pi, Tools for IoT

IOT SYSTEM DESIGN **(06 Hours)**

Logical Design using Python, Linux-based Edge Device—Raspberry Pi, Integration of Sensors and Actuators with Arduino, Raspberri Pi, Tools for IoT

(Total Contact Time: 45 Hours)

3. BOOKS RECOMMENDED

1. Pethuru Raj and Anupama C. Raman, "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", 1st Ed., CRC Press, 2017.
2. ArshdeepBahga and Vijay Madisetti, "Internet of Things: A Hands-on Approach", 1st Ed., Universities Press, x 2014.
3. Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stefan Avesand, Stamatis Karnouskos and David Boyle, “From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence”, 1st Ed., Academic Press, 2014.
4. Simone Cirani, Gianluigi Ferrari,Marco Picone, Luca Veltri, “Internet of Things Architectures, Protocols and Standards”, Wiley, 2019.
5. Rahul Dubey, “An Introduction to Internet of Things: Connecting Devices, Edge Gateway, and Cloud with Applications”, 1st Ed., 2019.

M.Tech. I (Communication systems) Semester – II

Optical Networks

L	T	P	Credit
3	0	0	03

ECCS112 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Classify the Architectures of the Client Layers in Optical Layer, Frame Structures and Protocols. for Optical Networks
CO2	Comprehend PON and FSO Technologies and their Components to Compute Range Budget For These Networks.
CO3	Apply the Network Control And Management Strategies to Wavelength Routed Optical Networks.
CO4	Evaluate Protection in SONET/SDH, Point-To-Point Links, Ring Interconnection Protection in The Client Layers
CO5	Analyse OTDM, Optical AND Gates, OPS, Optical PLL, Tuneable Delays For Future Optical Networks.

2. Syllabus:

INTRODUCTION **(06 Hours)**

Network terminologies, OSI model, Telecommunications Network Architecture, Services: Circuit Switching, and Packet Switching, Multiplexing Techniques, Second-Generation Optical Networks, The Optical Layer, Transparency and Network Evolution, WDM Networking Evolution, Point-to-Point WDM Systems, Wavelength Add/Drop Multiplexer (WADM), Fiber and Wavelength Cross connects, Broadcast-and-Select Networks, Wavelength-Routed (Wide-Area) Optical Network, WDM Economics.

OPTICAL METRO AND TRANSPORT NETWORKS **(07 Hours)**

Client Layers of the Optical Layer, SONET/SDH, Multiplexing, SONET/SDH Layers, Optical Transport Network, ATM, FDDI, Ethernet, IP, OTN.

OPTICAL ACCESS NETWORKS **(06 Hours)**

Fibber to the Curb (FTTC), PON Evolution, PON Technologies, OLT, Splitters, ONU, PON Range Budget, TPON, GPON, WDM PON and other Networks, Free Space optics (FSO), Free Space Optical Networks.

WAVELENGTH ROUTED OPTICAL NETWORKS **(05 Hours)**

Optical Routers and Optical Switches, Wavelength continuity constraint, Basics of Wavelength Conversion, Wavelength Conversion Techniques, Optoelectronic Approach, Optical Gating, Interferometric Technique, Wave Mixing, Converter Switches.

NETWORK CONTROL AND MANAGEMENT **(08 Hours)**

Basic Functions of Network Control and Management, Dynamic Routing and Wavelength Assignment, Fixed Routing and Fixed-Alternate-Path Routing, Adaptive Routing Based on Global Information, Adaptive Routing Based on Neighborhood Information, Adaptive Routing Based on

Local Information, various resource reservation techniques and fault management.

NETWORK SURVIVABILITY **(07 Hours)**

Basic Concepts, Protection and Restoration, Protection in SONET/SDH, Point-to-Point Links, Ring Interconnection Protection in the Client Layers: Resilient Packet Rings, Ethernet, MPLS, IP etc., Optical Layer Protection Schemes, GMPLS Protection.

FUTURE OPTICAL NETWORKS **(06 Hours)**

Photonic Packet Switching (OPS) Optical Time Division Multiplexing (OTDM), Bit Interleaving, Packet Interleaving, Optical AND Gates, Synchronization, Tunable Delays, Optical Phase Lock Loop, Optical Packet Switching (OPS) and Optical Burst Switching.

(Total Contact Time: 45 Hours)

3. BOOKS RECOMMENDED

1. Ramaswami Rajiv and Sivarajan K. N., "Optical Networks: A Practical Perspective", Elsevier, Morgan Kaufmann Publishers, 3rd Ed., 2012..
2. Biswanath Mukherjee, “Optical WDM Networks”, 1st Ed., Springer; 2006.
3. Hemani Kaushal, V.K. Jain, SubratKar, “Free Space Optical Communication”, 1st Ed., Springer, 2017.
4. Volkmar Bruckner, “Elements of Optical Networking, Basics and Practice of Glass Fiber Optical Data Communication” , Springer Vieweg 2nd Edition 2024
5. C. S. Murthy & M. Gurusamy, “WDM Optical Networks”, 1st Ed., PHI, 2002.

M.Tech. I (Communication systems) Semester – II

Estimation & Detection Theory

L	T	P	Credit
3	0	0	03

ECCS114 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Describe the basic concepts of signal estimation and linear prediction.
CO2	Apply estimation algorithms for engineering problems
CO3	Analyse performance of different estimation algorithms.
CO4	Evaluate performance of estimation algorithms.
CO5	Design estimator for the problems of interest.

2. Syllabus:

LINEAR PREDICTION **(19 Hours)**

Linear Prediction and Optimum Linear Filters, Forward and Backward Linear Prediction, Solution of The Normal Equations-Levinson-Durbin and Schur Algo, Pede's Approximation, AR Lattice and ARMA Process and Lattice Ladder Filter, Wiener Filter, Kalman Filter, Adaptive Filter, Linear Mean Square Estimation, Estimation Error, Least Square Errors, Minimum Mean Square Error.

ESTIMATION **(09 Hours)**

Estimation Based on Statistical Analysis, Bayesian Estimation, MAP and ML Detection Rules, Cramer-Rao Inequality.

SPECTRUM ESTIMATION **(05 Hours)**

APPLICATIONS OF ESTIMATION THEORY **(13 Hours)**

Wireless Channel Estimation, Pilot Based and Training Sequence Based Estimation And Blind Estimation, Estimation Theory Applied For Speech, Image And Video Compression Coding, Time Delay Estimation, Velocity Estimation, Detection of Signal In Gaussian Noise.

(Total Contact Time: 45 Hours)

3. BOOKS RECOMMENDED

1. Steven M. Key, "Fundamentals of Statistical Signal Processing (Volume II): Detection Theory", 3rd Ed., Prentice Hall PTR, Reprint 2022
2. Steven M. Key, "Fundamentals of Statistical Signal Processing (Volume I): Estimation Theory", 3rd Ed., Prentice Hall PTR, reprint 2012
3. Anderson B. D. O and Moore J. B.,"Optimal Filtering",Prentice-Hall,1981

4. Ljung L.,“System Identification Theory For The User”,Prentice-Hall,2006
5. Maybeck P. S.,“Stochastic Models, Estimation And Control, Vol. 1, 2, 3”,Academic Press,1999
6. Saeed V. Vaseghi,“Advanced Digital Signal Processing And Noise Reduction”, Wiley, 2nd Edition,2008.
7. Monson Hayes,“Statistical Digital Signal Processing And Modeling”, John Wiley & Sons Inc., 1st Edition,2002
8. Proakis John and Manolakis,“Digital Signal Processing”,Prentice-Hall, 3rd Edition, 2007

M.Tech. I (Communication systems) Semester – II

Microwave Integrated Circuits

L	T	P	Credit
3	0	0	03

ECCS116 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Define the various attributes of different types of transmission lines
CO2	Classify the different types of transmission lines, matching networks and circuits
CO3	Apply the knowledge of all aspects, design factors and properties of MICs.
CO4	Analyze the behaviour of MIC and their noise model.
CO5	Evaluate/Determine the working and design parameters of MIC, mixers, oscillators, amplifiers.

2. Syllabus:

INTRODUCTION TO MICROWAVE INTEGRATED CIRCUITS (03 Hours)

Introduction to Monolithic Microwave Integrated Circuits (MMICs), their advantages over discrete circuits, MMIC fabrication techniques, thick and thin film technologies and materials, encapsulation and mounting of active devices, Microstrips on semiconductor substrates.

MICRO-STRIP LINES (03 Hours)

Planar transmission lines for MICs. Method of Conformal transformation for microstrip analysis, concept of effective dielectric constant, Effective dielectric constant for microstrip, Losses in Microstrip.

SLOT LINES (04 Hours)

Slot Line Approximate analysis and field distribution, Transverse resonance method and evaluation of slot line impedance, comparison with Microstrip line.

FINE LINES AND COPLANAR LINES (03 Hours)

Conventional TCP/IP Protocols, Indirect TCP, Snooping TCP, Mobile TCP, Other Transport Layer Protocols for Mobile Networks, Flow control, Congestion control, Error Control.

LUMPED ELEMENTS FOR MICS (04 Hours)

Use of Lumped Elements, Capacitive elements, Inductive elements, and Resistive elements.

MATCHING AND BIASING NETWORKS (03 Hours)

Impedance Matching using Discrete Components, Microstrip Line Matching Networks

FUNDAMENTALSOF CMOS TRANSISTORS FOR RFIC DESIGN (05 Hours)

MOSFET Basics, MOSFET Models, Fundamentals of Stability, Determination of Stable and Unstable Regions, Stability Consideration for N-Port Circuits, Noise Figure Circles, Constant VSWR Circles. Broadband, High Power and Multistage Amplifiers, Low Noise Amplifier Design.

MICROWAVE IC DESIGN AND MEASUREMENT TECHNIQUES (05 Hours)

MIC Measurement, Testing and Applications: MIC measurement system, measurement techniques – S parameter measurement, noise measurement, MIC applications.

SUBSTRATE INTEGRATED CIRCUITS (07 Hours)

Substrate Integrated Waveguide, Substrate Integrated Image Guide, Substrate Integrated Non-radiative Dielectric Guide, Substrate Integrated Feeding Network, Substrate Integrated Divider, Substrate Integrated Phase Shifter, Substrate Integrated Coupler, Substrate Integrated Circuit–Related Transition.

METAMATERIAL-BASED COMPACT MICROWAVE AND MILLIMETRE WAVE CIRCUIT DESIGN (08 Hours)

Designs of True-Time-Delay Lines and Phase Shifters based on CRLH TL Unit Cells, Perfect Metamaterial Absorbers in Microwave and Terahertz Bands, Metamaterial-Based Compact Filter Design, Magnetically Tunable Unidirectional Electromagnetic Devices Based on Magnetic Surface Plasmon, Compact Coplanar Waveguide Metamaterial-Inspired Lines and its use in Highly Selective and Tunable Bandpass Filters.

(Total Contact Time: 45 Hours)

3. BOOKS RECOMMENDED

1. K.C. Gupta, “Microwave Integrated Circuits”, 1st Ed., Wiley eastern Pvt. Ltd., 1975.
2. K.C. Gupta, R. Garg, I. J. Bahl, “Microstrip Lines and Slot Lines”, 1st Ed., Artech House.
3. T. H. Lee, “The Design of CMOS radio Frequency Integrated Circuits”, 2nd Ed., Cambridge, 2004.
4. Xun-Ya Jiang, “Metamaterials” 1st Ed., Intech, 2012.
5. Yu Jian Cheng, “Substrate Integrated Antennas and Arrays”, 1st Ed., CRC Press, 2016.

4. REFERANCE BOOK

1. Bharathi Bhat, Shiban Koul, “Stripline-like transmission Lines for Microwave Integrated Ciruits”, 1st Ed., New Age International (P) Ltd. Publishers, 2007
2. Ricardo Marques, Ferran Martin, Mario Sorolla, “Materials with Negative Parameters”, 1st Ed., Wiley Interscience, 2001.
3. David M. Pozar, “Microwave Engineering”, 4th Ed., John Wiley & Sons, 2011

M.Tech. I (Communication systems) Semester – II

Photonic Integrated Devices and Systems

L	T	P	Credit
3	0	0	03

ECCS118 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Describe the working and construction of various Acoustic optic devices and their fabrication.
CO2	Apply the concept of the optical waveguides to analyze different coupling methods.
CO3	Analyze the advanced optical sources and detectors, OIC and monolithic systems.
CO4	Evaluate the parameters for optical sensors for different types of measurements
CO5	Design Bio photonic applications of micro and Nano photonics.

2. Syllabus:

OPTICAL WAVEGUIDE THEORY **(07 Hours)**

Planar waveguides: Step-index and graded-index waveguides, guided and radiation modes. Strip and channel waveguides, anisotropic waveguides, segmented waveguide; electro-optic and acousto-optic waveguide devices.

ACOUSTO OPTIC DEVICES AND FABRICATION **(08 Hours)**

Directional couplers, optical switch; phase and amplitude modulators, filters, etc. junction, power splitters, Arrayed waveguide devices, fiber pig tailing, Fabrication of integrated optical waveguides and devices

WAVEGUIDE CHARATERIZATION **(09 Hours)**

Waveguide characterization, end-fire and prism coupling; grating and tapered couplers, nonlinear effects in integrated optical waveguides.

NEW MATERIALS AND PROCESS TECHNOLOGIES **(08 Hours)**

New materials and process technologies for optical device fabrication, advanced optical sources & detectors, amplifiers, their reliability issues, Optical integrated circuits, hybrid & monolithic systems, optical inter-connects, materials and processing for OEIC.

OPTICAL SENSORS **(07 Hours)**

Optical sensors intrinsic & extrinsic, principles of pressure, temperature, displacement and velocity measurements

ADVANCED TOPICS MICRO AND NANOPHOTONICS **(06 Hours)**

Photonic crystals and MOEMS, Bio-photonic applications, recent developments in PICs.

(Total Contact Time: 45 Hours)

3. BOOKS RECOMMENDED

1. Robert Hansberger, “Integrated optics: Theory and technology” 6th Ed., Springer, 2009.
2. T. Tamir, “Guided wave opto-electronics' ', 2nd Ed., Springer Verilag, 1990.
3. H. Nishihara, M. Haruna, and T. Suhara, “Optical Integrated Circuits”, 1st Ed., McGraw-Hill Professional, 1989.
4. Yariv, A., & Yeh, P. “Photonics: Optical Electronics in Modern Communications”, 6th Ed., Oxford university Press (2006).
5. Madeleine Glick, Ling Liao, Katharine Schmidtke, “Integrated Photonics for Data Communication Applications” Elsevier, 1st Edition - July 26, 2023,

M.Tech. I (Communication systems) Semester – II

Ad-Hoc Networks

L	T	P	Credit
3	0	0	03

ECCS120 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Show the basic knowledge of architecture, issues, protocols of Mobile Adhoc Networks and the standard Adhoc networks-Bluetooth, WiFI, WiMax, WSN etc.
CO2	Explain differences between fixed and Adhoc network protocols, mobility constraints and dynamic approaches in Adhoc Networks.
CO3	Apply protocols and techniques in MANETs, developing algorithms for recent standard Adhoc networks overcoming the constraints
CO4	Evaluate various techniques and protocols/algorithms, case study and problem solving as per given data.

2. Syllabus:

INTRODUCTION **(04 Hours)**

Introduction To Generations In Wireless Systems, Introduction To Mobile Ad-Hoc Networks (MANETS), Classification Of Mobile Data Networks, MANET issues, Wireless Channel Related Issues

MAC LAYER ISSUES OF ADHOC NETWORKS **(04 Hours)**

CSMA with Hidden and Exposed Terminal Issues, MACA and MACAW protocols

NETWORK LAYER ISSUES IN ADHOC NETWORKS **(06 Hours)**

Challenges, Proactive and Reactive Algorithms, Limitations of Bellman Ford Algorithm, DSDV, WRP, CGSR protocols, DSR, AODV, Location aided, hybrid protocols, multicast protocols

TRANSPORT LAYER ISSUES **(06 Hours)**

Challenges, data flow control mechanisms, congestion control protocols, security aspects

BLUETOOTH **(06 Hours)**

Bluetooth Network Structure: Piconet & Scatternet, Bluetooth Specifications, Bluetooth Protocol Stack, Bluetooth Media Access Control Consideration, Asynchronous Connectionless And Synchronous Connection Oriented Communication Link, Modified Bluetooth

WIFI - IEEE802.11 STANDARDS **(04 Hours)**

Various 802.11 Protocols (a to s), WiFi Architecture, Security Enhancement, QoS Enhancement, Physical & MAC Layer Aspects Of 802.11 a,b,g,n; WiFi MAC: Point Coordinate Function, Distributed Coordinate Function, Hybrid Coordinate Function

WiMAX - IEEE802.16 STANDARDS **(05 Hours)**

Various 802.16 (a to e) Protocols, WiMAX Air Interface / Physical Layer, WiMAX Architecture, WiMAX Protocol Architecture, WiMAX And WiFi Interworking, WiMAX Mode: TDD And FDD, QoS In

WiMAX

WIRELESS SENSOR NETWORK **(06 Hours)**

Sensor node architecture, Sensor Network architecture, Zigbee IEEE 802.15.4, Mobile Computing Aspects, Introduction to IoT

UWB **(02 Hours)**

UWB Air Interface

IEEE802.20 AND BEYOND **(02 Hours)**

(Total Contact Time: 45 Hours)

3. BOOKS RECOMMENDED

1. C.Siva RamaMurthy, B.S.manoj, “Adhoc Wireless Networks-Architectures and Protocols”, Pearson, 1st Ed 2007
2. Toh C. K.“Ad-hoc Mobile Wireless Networks-Protocol and Systems”, LPE, Pearson Education, 2nd Edition, 2009
3. Upena Dalal,“Wireless Communication”, Oxford University, 1st Edition, 2009
4. Taieb Znati, Kazem Sohraby, Daniel Minoli, “Wireless Sensor Networks: Technology, Protocols and Applications, Wiley publications, 1st Edition, January 2010
5. Sudip Misra, Isaac Woungang, Subhas Chandra Misra (Editors) “Guide to Wireless Adhoc Networks” Springerlink, 2009 (Open Access)
6. Jonathan Loo, Jesus Hamilton Ortiz, Jaime Lloret Mauri (Editors), “Mobile Adhoc Networks”, CRC Press, 1st Edition, 2012 (Open Access)

M.Tech. I (Communication systems) Semester – II

MIMO Technology

L	T	P	Credit
3	0	0	03

ECCS122 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Describe basic terminologies associated with MIMO technology and understand the advancements in the technology.
CO2	Apply the developed fading concepts in MIMO system analysis.
CO3	Analyse various performance metrices for MIMO System.
CO4	Evaluate performance trade-offs in MIMO technology.
CO5	Design space time codes and optimum MIMO Communication systems under given conditions.

2. Syllabus:

INTRODUCTION TO MULTI ANTENNA SYSTEM (03 Hours)

Need for MIMO Systems, MIMO wireless communication, Benefits of MIMO technology, Basic Building Block, MIMO channel & signal model, Error/Outage Probabilities over fading channels, Multiple antennas in wireless Communication, A fundamental Trade-off, MIMO transceiver design, Applications of MIMO systems.

CLASSICAL AND GENERALIZED FADING DISTRIBUTIONS (07 Hours)

Introduction to fading distributions, Classical fading distributions, Generalized fading distributions

MIMO CHANNEL MODELLING (08 Hours)

Physical channel modelling: Electromagnetic Models, Geometry Based Models, Empirical Models,. Analytical MIMO channel modelling: Fully correlated MIMO channels, separately correlated MIMO channel model, Uncorrelated MIMO channel model.

MIMO CHANNEL CAPACITY (10 Hours)

Power allocation in MIMO System: Uniform, Adaptive and Near optimal power allocation, Capacity of simplified MIMO channels: Capacity for deterministic and random channels, Capacity of i.i.d., separately correlated and keyhole Raleyigh fading MIMO channel.

SPACE TIME CODES (08 Hours)

Design criteria for space time codes, Transmit Diversity for two antennas: The Alamouti Scheme-Transmission scheme, Optimal receiver for Alamouti Scheme, Performance analysis of Alamouti Scheme, Orthogonal Space Time Block codes (OSTBC), Space time trellis codes: Design principle, Representation of Space-Time trellis code for PSK constellations, Performance Analysis for Space-Time Trellis codes, Comparison of Space -Time Block & Trellis Codes.

MIMO DETECTION TECHNIQUES **(07 Hours)**

ML detection, Linear suboptimal detection: zero forcing and MMSE detection technique, Sphere decoding Advanced MIMO detection techniques: Successive Interference Cancellation, Lattice reduction-based detector

ADVANCE TOPICS IN MIMO WIRELESS COMMUNICATION **(02 Hours)**

Space time block coded spatial modulation, MIMO based cooperative communication, Large scale MIMO systems, MIMO cognitive radios

(Total Contact Time: 45 Hours)

3. <u>BOOKS RECOMMENDED</u>

1. Rakesh Singh Kshetrimayum, “Fundamentals of MIMO Wireless Communications,” Cambridge University Press, 2017
2. Ezio Biglieri, R.Calderbank, Anthony C., Andrea Goldsmith, Arogyaswami Paulraj, H. Vincent Poor, “MIMO Wireless Communications”, Cambridge University Press, 2007.
3. H. Khaleghi Bizaki, “MIMO Systems, Theory and Applications”, Intech, 2011.
4. Mohinder Jankiraman, “Space-Time Codes and MIMO Systems”, Artech House, Boston, London, 2004.
5. Tolga m. Duman, Ali Ghrayeb, “Coding for MIMO Communication Systems”, 1st Ed., John Wiley & Sons Ltd., 2007.
6. Savo G. Glisic, “Advanced Wireless Communications”, John Wiley & Sons, 2007.

M.Tech. I (Communication systems) Semester – II

Global Navigation Satellite Systems

L	T	P	Credit
3	0	0	03

ECCS124 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Understand global as well regional navigation systems.
CO2	Apply knowledge of different signal and system structures of diverse navigation systems.
CO3	Analyze position of GNSS receiver using acquisition and tracking.
CO4	Evaluate various GNSS positioning techniques.
CO5	Design GNSS based solution for societal applications.

2. Syllabus:

INTRODUCTION TO GNSS **(06 Hours)**

Introduction to GNSS systems, GNSS terminologies, GNSS Architecture, Augmentation System, Various Navigation Systems: Global Navigation systems: GPS, GLONASS, GALILEO, Beidou Regional Navigation systems: QZSS, IRNSS/NavIC, GNSS System Architecture & Signals, Error correction coding, Navigation Message Structures, Frequency band allocation

GNSS SIGNAL STRUCTURE AND PROPAGATION **(09 Hours)**

Satellite orbits: MEO, GEO, GSO, visibility of satellites, Ranging stations, Power budget and received signal levels, Ionospheric and Tropospheric propagation of GNSS signals and introduced errors, Multipath propagation and introduced errors, Total Error budget, CNR of received signal, Interference from other GNSS signals, Spectrum of GNSS signals, PRN codes, baseband and passband structure and mathematical representation of GNSS signals.

NAVIGATION RECEIVERS **(11 Hours)**

Generalized GNSS Receiver Architecture, IF and baseband signal processing, IF/baseband filtering, Different Acquisition techniques, GNSS Signal Tracking, Signal tracking loops (DLL, PLL, FLL), Navigation Data Demodulation, Decoding and Processing, Measurement of pseudo range

POSITION DETERMINATION TECHNIQUES **(08 Hours)**

Principle of GNSS Operation: Satellite constellation and Dilution of Precision, Trilateration Concept, Ephemeris and Almanac, Determination of satellite position, velocity, visibility and ground tracks, Use of Pseudo-Ranges in Position Calculation: Estimation accuracy and precision of pseudo range, Position, Velocity and Time determination techniques, Errors in GNSS measurements and its mitigation

TECHNOLOGIES FOR ADVANCED RECEIVERS AND AUGMENTED SYSTEMS **(09 Hours)**

Jamming and Interference, GNSS Spoofing & Receiver Anti Spoofing Techniques, Challenges and techniques for weak signal acquisition and tracking, carrier measurement aiding, Dual frequency receivers, Basic Concepts of Differential GNSS (DGNSS), Real Time and Post Processing DGNSS: Real Time Kinematics (RTK), Need for Augmentation Systems, Satellite-Based Augmentation Systems (SBAS), Ground-Based Augmentation Systems (GBAS), GNSS Networks, Signal properties and receiver processing of BOC-modulated navigation signals

APPLICATIONS OF GNSS **(04 Hours)**

Aviation Ground-based Augmentation, Marine Navigation, Space Navigation, Vehicle Navigation, Precision Agriculture, Military Applications, Geodesy, Surveying and Mapping, Atmospheric and Ionospheric Science

(Total Contact Time: 45 Hours)

3. BOOKS RECOMMENDED

1. John W. Betz, "Engineering Satellite-based Navigational Timing", IEEE Press, 442 Hoes Lane, Piscataway, NJ 08854, 2015.
2. Elliott_D._Kaplan, Christopher_Hegarty “Understanding GPS Principles and Applications”, 3rd Ed., Archtech House, Artech House, 2017.
3. Pratap Misra, Per Enge, “Global Positioning System_ Signals, Measurements, and Performance”, 1st Ed., Ganga-Jamuna Press, 2006.
4. Scott Madry, “Global Navigation Satellite Systems and Their Applications”, Springer series 10058, 2015.
5. Teunissen, Montenbruck, “Handbook of Global Navigation Satellite Systems”, 1st Ed., Springer-Verlag, 2017.

M.Tech. I (Communication systems) Semester – II

Optical Wireless Communication

L	T	P	Credit
3	0	0	03

ECCS126 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Describe atmospheric channels for the intended terrestrial free space optical link
CO2	Apply the concepts of OWC to calculate the system performance under background noise effects.
CO3	Analyse various modulation/demodulation techniques in designing of transmitter/receiver for OWC system.
CO4	Compare various detection techniques under different atmospheric conditions
CO5	Evaluate the OWC system under different weather conditions.

2. Syllabus:

INTRODUCTION **(06 Hours)**

General introduction, optical channel - Beam divergence, atmospheric losses, weather condition influence, atmospheric turbulence effects viz., scintillation, beam wander, beam spreading, etc.

CHANNEL MODELLING **(08 Hours)**

Linear time invariant model, channel transfer function, optical transfer function, models of turbulence induced fading viz., lognormal, exponential, K distribution, I- distribution, gamma-gamma distribution, Optical wave models - Plane, spherical and Gaussian, range equation, transmitting and receiving antenna gains.

BACKGROUND NOISE EFFECTS **(07 Hours)**

Background noise source, detector FOV, diffraction limited FOV, spatial modes, background noise power calculation.

MODULATION TECHNIQUES **(08 Hours)**

Power efficiency, BW efficiency, bit versus symbol error rates, error rate evaluation for isochronous modulation schemes viz., M-PPM, OOK, mxn PAPM schemes, subcarrier modulation, an isochronous modulation schemes - DPPM, DHPIM, DAPPM, psd and bandwidth requirement.

DETECTION TECHNIQUES **(09 Hours)**

Photon counter, PIN/APD, PMT, coherent techniques viz., homodyne and heterodyne, bit error rate evaluation in presence of atmospheric turbulence, concept of adaptive threshold.

WEATHER IMPAIRMENTS **(07 Hours)**

Effect of turbulence and weather conditions viz., drizzle, haze fog on error performance and channel capacity, link availability.

(Total Contact Time: 45 Hours)

3. BOOKS RECOMMENDED

1. Z. Ghassemlooy, W. Popoola, S. Rajbhandari, “Optical Wireless Communications”,2nd Ed., CRC Press, 2019.
2. L. C. Andrews, R.L.Phillips, “Laser Beam Propagation through Random Media”, 2nd Ed., SPIE Press, USA, 2005.
3. J. H. Franz, V. K. Jain, “Optical Communications: Components and Systems”, 1st Ed., Narosa Publishing House, 2000.
4. D. Chadha, “Terrestrial Wireless Optical Communication”, 1st Ed., Tata McGraw-Hill, 2012.
5. Ivan B. Djordjevic , “Advanced Optical and Wireless Communications Systems”, 2nd Edition, Springer, 2022.
6. Ramaswami Rajiv and Sivarajan K. N., "Optical Networks: A Practical Perspective", Elsevier, Morgan Kaufmann Publishers, 3rd Ed., 2012

M.Tech. I (Communication systems) Semester – II

5G Wireless Technologies

L	T	P	Credit
3	0	0	03

ECCS128 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Understand and describe the key components, architectures, technical specifications, functions of 5G wireless networks and interactions in enabling 5G services.
CO2	Compare and contrast different 5G radio access technologies (e.g., mMTC, URLLC, eMBB) and their applications and analyze their suitability for various applications, considering factors like latency, reliability, and data rate requirements.
CO3	Apply knowledge of 5G principles, channel models, propagation characteristics to solve basic network design problems, such as coverage planning or capacity estimation.
CO4	Analyze the trade-offs between different 5G deployment strategies and evaluate their suitability for various applications and environments
CO5	Design and simulate a basic 5G network solution for a given scenario, considering factors like coverage, capacity, path loss, fading, antenna configurations, cost, and user requirements.

2. Syllabus:

INTRODUCTION **(04 Hours)**

A vision for 5G, Key disruptive system concept trends; Performance limitations, new design principles, and three paradigm shifts; Critical usage scenarios in 5G: Crowded local access, Bursty IoT, Ultra-reliable and low latency communications; Spectrum: Spectrum for 4G, Spectrum challenges in 5G, 5G spectrum landscape and requirements.

5G RADIO ACCESS **(06 Hours)**

Evolution of mobile communication; 5G New Radio Access Technology; 5G NR Global view; NR-Physical Layer: Radio Protocol Architecture; NR PHY-Key Technology components: Modulation, Waveform, Multiple Antennas, Channel Coding; Physical Time Fr Resource; Physical signal; Duplexing scheme; Frame Structure; Physical Layer Challenges.

MULTICARRIER AND NR WAVEFORMS **(07 Hours)**

Multicarrier waveforms: OFDM based waveforms, Filterbank based waveforms; Single carrier DFTS-OFDM; NR Waveform: Waveform design requirements for 5G NR, Key performance indicator for NR waveform design, Waveform comparisons for NR; Suitability of OFDM for NR; Scalable OFDM for NR.

NEW 5G AIR INTERFACE: CHALLENGES FOR EFFICIENT MULTI-SERVICE COEXISTENCE **(06 Hours)**

Core services and their associated KPIs: Core services, Key performance indicators, KPI relevance to core services; Challenges for 5G design below 6 GHz: Design methodology, Service integration drivers, Link level and System level challenges.

5G WIRELESS CHANNEL AND PROPAGATIN MODELS **(06 Hours)**

Introduction; Modeling requirements and scenarios: Channel model requirements, Propagation scenarios; The METIS channel models: Map-based model, Stochastic model; Millimeter-wave channel experimental measurements and results interpretation; Quasi-deterministic approach for millimeter-wave channel modeling; Q-D channel models implementation.

5G ARCHITECTURE **(06 Hours)**

Introduction, NFV and SDN, Basics about RAN architecture; High-level requirements for the 5G architecture; Functional architecture and 5G flexibility; Integration of LTE and new air interface to fulfill 5G requirements, Physical architecture and 5G deployment.

MACHINE TYPE COMMUNICATION **(02 Hours)**

Use cases and categorization of MTC, MTC requirements; Fundamental techniques for MTC: Data and control for short packets, non-orthogonal access protocols; Massive MTC.

DEVICE TO DEVICE COMMUNICATION **(03 Hours)**

D2D from 4G to 5G: D2D standardization: 4G LTE D2D, D2D in 5G: research challenges; Radio resource management for mobile broadband D2D, RRM techniques for mobile broadband D2D, RRM and system design for D2D, 5G D2D RRM concept.

mmWAVE COMMUNICATION **(03 Hours)**

Spectrum and regulations; Channel propagation; Hardware technologies for mmW systems; Deployment scenarios; Architecture and mobility: Dual connectivity, Mobility, Beamforming, Beam finding; Physical layer techniques: Duplex scheme, Transmission schemes.

WIRELESS BEYOND 5G **(02 Hours)**

A vision for wireless beyond 5G; Expectations and challenges for wireless beyond 5G: Joint Communication and Sensing, Space-Air-Ground Communication, Semantic Communication, Data-Driven Communication System Design.

(Total Contact Time: 45 Hours)

3. BOOKS RECOMMENDED

1. Angeliki Alexiou, “5G Wireless Technologies”, 1st Edition, The Institution of Engineering and Technology, 2017.
2. Afif Osseiran, Jose F. Monserrat, Patrick Marsch, “5G Mobile and Wireless Communication Technologies, Cambridge University Press, 2016.
3. Ali Zaidi, Fredrik Athley, Jonas Medbo, Ulf Gustavsson, Giuseppe Durisi, Xiaoming Chen, “5G Physical Layer, Principles, Models and Technology, Components, Academic Press, 2018.
4. Saad Z. Asif, “5G Mobile Communications: Concepts and Technologies”, CRC Press, 2019.
5. Hrishikesh Venkatarman and Ramona Trestian, “5G Radio Access Networks: Centralized RAN, Cloud-RAN and Virtualization of Small Cells”, CRC Press, 2017.

M.Tech. I (Communication systems) Semester – II

Speech Processing and Applications

L	T	P	Credit
3	0	0	03

ECCS130 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Define the fundamentals of speech processing.
CO2	Describe the different parameters of speech signal.
CO3	Apply different algorithm to extract different speech parameters.
CO4	Analyze different speech processing algorithm.
CO5	Design a speech based system for different applications.

2. Syllabus:

INTRODUCTION **(05 Hours)**

Speech processing applications, Stationary and non-stationary signal, Stationary and non-stationary analysis of speech signal, Representation of speech signal.

SPEECH FUNDAMENTAL **(06 Hours)**

Basic concepts: speech production and speech perception, Speech production model, Articulatory phonetics and speech sounds, Pitch frequency and Formant frequency, Speech segmentation: voiced, unvoiced and silence, vowel, semi-vowel, consonants, diphthongs, nasal etc.

TIME DOMAIN ANALYSIS OF SPEECH SIGNAL **(06 Hours)**

Short-term processing of speech signal, Window function, Time domain analysis, Short-time energy, Short-time autocorrelation, Short-time zero crossing, Pitch estimation, Speech vs silence classification based on short-time energy and zero crossing rate.

FREQUENCY DOMAIN ANALSIS OF SPEECH SIGNAL **(06 Hours)**

Discrete Fourier Transform, Short-term Fourier transform (STFT), Filter-bank analysis, Spectrogram analysis, Cepstrum analysis, Pitch and formant estimation

LINEAR PREDICTION ANALYSIS **(10 Hours)**

Prediction, Linear prediction, Prediction model: All pole model and Pole zero model; Autocorrelation and covariance method; Levinson-Durbin algorithm; Inverse filtering; LP residual; Pitch frequency and formant frequency analysis using LP analysis.

SPEECH PATHOLOGY DETECTION **(06 Hours)**

Feature investigation, Feature extraction: Mel frequency cepstral coefficient (MFCC) and Linear prediction coefficient (LPC), Nonlinear features, Modelling (training/classification) based on machine learning and deep learning

SPEECH EMOTION CLASSIFICATION **(06 Hours)**

Effect of emotional state on speech signal, Pitch and formant analysis for different emotions, Significance of databases: acted, evoked and natural, Emotion impacted feature extraction, feature selection, Machine learning and deep learning based emotion classification.

(Total Contact Time: 45 Hours)

3. BOOKS RECOMMENDED

1. L. R. Rabiner and R. W. Schafer, "Digital Processing of Speech Signals", 1st Ed., Pearson Education India, 2003.
2. J. Benetsy, M. M. Sondhi and Y. Huang, "Springer Handbook of Speech Processing", 1st Ed., Springer Verlag, 2008.
3. J. R. Deller, Jr., J. H. L. Hansen and J. G. Proakis "Discrete-Time Processing of Speech Signals", Wiley- IEEE Press, IEEE Edition, NY, USA, 1999.
4. D. O'Shaughnessy, "Speech Communications: Human and Machine", 2nd Ed., University Press, 2005.
5. Thomas F Quatieri, "Discrete-Time Speech Signal Processing – Principles and Practice", 1st Ed., Pearson Education, 2006.
6. Gold, B., Morgan, N., & Ellis, D., "Speech and audio signal processing: processing and perception of speech and music" John Wiley & Sons, 2011.

M.Tech. I (Communication systems) Semester – II

Real Time Systems

L	T	P	Credit
3	0	0	03

ECVL104 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Describe the foundation for programming languages developed for real time programming.
CO2	Apply real time operating systems and their functions.
CO3	Analyze the real time network.
CO4	Evaluate the real time systems with regard to keeping time and resource restrictions.
CO5	Design real time applications with RTOS.

2. Syllabus:

INTRODUCTION TO REAL-TIME SYSTEMS **(09 Hours)**

Hard versus Soft Real Time Systems, Reference Models of Real Time Systems, Operating System Services, I/O Subsystems, Network Operations Systems, Real Time Embedded Systems, Operating Systems Interrupt Routines in RTOS Environments, RTOS Task Scheduling Models, Interrupt Latency and Response Time, Standardization Of RTOS

REAL-TIME SCHEDULING AND SCHEDULABILITY ANALYSIS **(10 Hours)**

Task, Process and Threads, Commonly Used Approaches To Real Time Scheduling, Clock-Driven Scheduling, Priority Driven Scheduling Of Periodic Tasks, Hybrid Scheduler, Event Driven Schedules.

Earliest Dead Line First (EDF) Scheduling, Rate Monotonic Algorithm (RMA), Real Time Embedded Operating Systems: Standard & Perspective, Real Time Operating Systems: Scheduling Resource Management Aspects, Quasi-Static Determining Bounds On Execution Times

RESOURCE SHARING AMONG REAL-TIME TASKS **(12 Hours)**

Data Sharing by Multiple Tasks And Routines Inter Process Communication, Handling Resources Sharing and Dependencies Among Real-time Tasks, Resource Sharing Among real Time tasks, Priority Inversion, Priority Inheritance Protocol (PIP), Highest Locker Protocol (HLP), Priority Ceiling Protocol (PCP), Different Types of Priority Inversion Under PCP, Important Features of PCP, Handling Task Dependencies,

DISTRIBUTED REAL-TIME SYSTEMS, MULTIPROCESSOR REAL-TIME SYSTEMS **(07 Hours)**

Multiprocessor and Distributed system, Partitioned scheduling, Global scheduling, Semi-partitioned scheduling, Distributed scheduling, Load balancing

REAL TIME COMMUNICATION AND DATABASE **(07 Hours)**

Real time traffic, Real-time data link layer, Protocols: CAN, Time-triggered protocol (TTP), Real-time ethernet, Real-time IEEE 802.11, Mobile Wireless Sensor Network

(Total Contact Time: 45 Hours)

3. <u>BOOKS RECOMMENDED</u>

1. Rajib Mall, “Real Time Systems Theory and Practice”, 1st Ed., Pearson Education, 2007.
2. Brian Amos, “Hands-On RTOS with Microcontrollers: Building real-time embedded systems using FreeRTOS, STM32 MCUs, and SEGGER debug tools”, 1 st Edition, Packt Publishing, 2020.
3. K. Erciyes, “Distributed Real-Time Systems-Theory and Practice”, Springer Cham, 1 st Edition, 2019.
4. Liu Jane, “Real-time Systems”, 1st Ed., Pearson Education India, 2006.
5. Xiaocong Fan, “Real-Time Embedded System-Design Principles and Engineering Practices”. 1st Edition, Newnes, 2015

M.Tech. I (Communication systems) Semester – II

VLSI Architecture For DSP

L	T	P	Credit
3	0	0	03

ECVL114 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Describe DSP algorithms using data flow graphs and various VLSI architectures for signal processing.
CO2	Apply fast convolution methods for optimization.
CO3	Analyze critical path algorithm and strength reduction.
CO4	Evaluate signal processing architectures based on area and power.
CO5	Design VLSI architectures for the signal processing based on specifications.

2. Syllabus:

DSP CONCEPTS **(10 Hours)**

Linear system theory, DFT, FFT, DCT realization of digital filters. Typical DSP algorithms, DSP applications, Data flow graph presentation of DSP algorithm.

ARCHITECTURAL ISSUES **(13 Hours)**

Binary Adders, Binary multipliers, Multiply Accumulator (MAC) and Sum of Product (SOP). Pipelining and Parallel Processing, Retiming, Unfolding, Folding, Register Minimization Technique and Systolic architecture design, Coordic Architecture, Distributed Arithmetic Architecture.

FAST CONVOLUTION **(11 Hours)**

Cook-Toom algorithm modified Cook-Toom algorithm, Winograd algorithm, modified Winograd algorithm, Algorithmic strength reduction in filters and transforms, DCT and inverse DCT, parallel FIR filters.

POWER ANALYSIS IN DSP SYSTEMS **(11 Hours)**

Multiprocessor and Distributed system, Partitioned scheduling, Global scheduling, Semi-partitioned scheduling, Distributed scheduling, Load balancing

(Total Contact Time: 45 Hours)

3. BOOKS RECOMMENDED

1. Keshap K. Parhi, “VLSI Digital Signal Processing Systems, Design and Implementation”, 1st Ed., John Wiley, 2007.
2. Keshab K. Parhi and Takao Nishitani, Marcel Dekker “Digital Signal Processing for Multimedia Systems”, 1st Ed., CRC Press, 1999.
3. U. Meyer-Baese, “Digital Signal processing with Field Programmable Arrays”, 3rd Ed., Springer, 2007.

4. V. K. Madisetti, “VLSI Digital Signal Processors: An Introduction to Rapid Prototyping and Design Synthesis”, IEEE Press, New York, 1995.
5. S. Y. Kung, H. J. Whitehouse, “VLSI and Modern Signal Processing”, 1st Ed., Prentice Hall, 1985.

M.Tech. I (Communication systems) Semester – III

Dissertation Phase-I

L	T	P	Credit
0	0	28	14

ECCS201 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Identify any latest topic of interest from the real-world technical problems to develop a thought process for design solution with basic understanding.
CO2	Extract a detailed literature survey related to the given problem and Apply the concepts for the solution to the given problem in terms of specifications, design, component selection etc.
CO3	Synthesize or Implement the model/prototype of the work.
CO4	Write the well organised report with compiled results and comprehension with proficiency in English.
CO5	Develop the effective and innovative presentation using modern tools/software.

M.Tech. I (Communication systems) Semester – IV

Dissertation Phase-II

L	T	P	Credit
0	0	40	20

ECCS202 **Scheme**

1. Course Outcomes (COs):

At the end of the students will be able to:

CO1	Analyze and implement the proposed work.
CO2	Compare the existing techniques/methods with proposed work.
CO3	Evaluate the results in terms of the performance parameters and further optimize the work for better solution.
CO4	Write the well organised report with implemented results and comprehension with proficiency in English.
CO5	Attain the skills to solve real world problem in relevant area.

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