M. Tech. DIGITAL ELECTRONICS & COMMUNICATION (DEC)

Program Structure (Applicable to 2023 admission onwards)

YEAR	FIRST SEMESTER						SECOND SEMESTER					
	SUB CODE	SUBJECT NAME	L	T	P	C	SUB CODE	SUBJECT NAME	L	T	P	C
I	MAT 5131	Probability And Random Processes	3	1	0	4	ECE 5212	Optical Communication	4	0	0	4
	ECE 5112	Digital VLSI Design	3	1	0	4	ECE 5213	Advanced Modulation and Coding Techniques	3	1	0	4
	ECE 5113	Processor Architecture and Applications	4	0	0	4	ECE ****	Program Elective-I	4	0	0	4
	ECE 5114	Wireless Communication	3	1	0	4	ECE ****	Program Elective-II	4	0	0	4
	ECE 5115	Detection and Estimation Theory	3	1	0	4	ECE ****	Program Elective-III	4	0	0	4
	HUM 5071	Research Methodology & Technical Communication*	1	0	3	-	*** ****	Open Elective	3	0	0	3
	ECE 5141	Digital VLSI Design Lab	0	0	6	2	HUM 5071	Research Methodology and Technical Communication*	1	0	3	2
	ECE 5142	Digital Communication Lab-I	0	0	3	1	ECE 5243	Digital Communication Lab-II	0	0	6	2
	Total		**17**	**4**	**12**	**23**			23	1	9	**27**
	THIRD AND FOURTH SEMESTER											
II	ECE 6091	Project Work and Industrial Training							**0**	**0**	**0**	**25**

*TAUGHT IN BOTH SEMESTERS AND EVALUATED AND CREDITED IN THE SECOND SEMESTER

PROGRAM ELECTIVES		OPEN ELECTIVE	
COURSE CODE	**COURSE TITLE**	**COURSE CODE**	**COURSE TITLE**
ECE 5401	Advanced Digital Signal Processing	ECE 5301	ARM Processor and Application
ECE 5402	Advances in Circuit Elements	ECE 5302	Nano Electronics
ECE 5403	Analog VLSI For Signal Processing	ECE 5303	Neural Networks and Fuzzy Logic
ECE 5404	CAD For VLSI		
ECE 5405	Cryptography & Network Security		
ECE 5406	Communication Networks And Protocols		
ECE 5407	High Speed Digital Design		
ECE 5408	Large Area Micro Electronics		
ECE 5409	MEMS Technology		
ECE 5410	Microwave and Millimeter Wave Antenna		
ECE 5411	Nano - Photonics		
ECE 5412	Nonlinear Fiber Optics		
ECE 5413	Quantum Information Science		
ECE 5414	RF Microelectronics Chip Design		
ECE 5415	Spread Spectrum Communication		
ECE 5416	System On Chip Design		
ECE 5417	VLSI Physical Design and Verification		
ECE 5418	VLSI Testing & Testability		

SEMESTER I

MAT 5131 PROBABILITY AND RANDOM PROCESSES [3 1 0 4]

CO 1	Use the fundamental knowledge of stochastic processes, formulate the real life problems and determine the long term probabilities.
CO 2	Estimate the various performance measures of a queueing system based on Poison Processes
CO 3	Identify a good model to a random process using the goodness properties of estimators
CO 4	Build time series models for linear random and non-stationary processes.
CO 5	Estimate the signal parameters using the statistical properties.

Stochastic Processes – types, fundamental concepts, limiting and transient behaviour. Poisson process – properties. Birth-death models, Queueing models-performance measures. Estimation-properties of estimators, methods of estimation, Time series models-linear and non-stationary processes.
*Self-Directed Learning: Fourier analysis of deterministic signals-DFT and periodogram, Spectral densities and representations, Wiener-Khinchin theorem, Harmonic processes, SARIMA models.

References:

1. Stewart, William J. Probability, Markov chains, queues, and simulation: the mathematical basis of performance modeling. Princeton university press, 2009.
2. Tangirala, Arun K. Principles of system identification: theory and practice. CRC Press, 2018.
3. U. Narayan Bhat, "An introduction to queueing theory: modeling and analysis in applications", Birkhäuser, 2015.
4. *Casella, George, and Roger L. Berger. Statistical inference. Cengage Learning, 2021.
5. A. Papoulis and S.U. Pillai, "Probability, Random Variables and Stochastic Processes", McGraw Hill, 2002.
6. *P. Z. Peebles Jr., "Probability, Random Variables and Random Signal Principles", McGraw Hill International Edition, 2001, Singapore.
7. https://onlinecourses.nptel.ac.in/noc22_ch19/preview

ECE 5112 DIGITAL VLSI DESIGN [3 1 0 4]

CO 1	Design combinational and sequential circuits for VLSI and evaluate their performance
CO 2	Describe the fabrication of MOS and CMOS circuits in silicon and discuss related issues
CO 3	Develop layouts for VLSI circuits as per the design specifications and estimate the parasitic values
CO 4	Design VLSI subsystems and memory circuits
CO 5	Analyze the impact of interconnect parasitic on the circuit performance

MOS Transistor theory, Inverters, Combinational and Sequential Digital circuit design, VLSI Fabrication and Layouts, CMOS/Bulk technology, SOI technology. Basic circuit concepts and performance estimation; Design Margins and Reliability; Alternatives to CMOS Logic, BiCMOS logic; Subsystems design and Building Blocks; Semiconductor memories.
*Self-Directed Learning: Coping with interconnects in VLSI

References:
1. *Jan M, Rabaey, et al, Digital Integrated Circuits: A Design Perspective, Prentice Hall, 2003.
2. Neil Weste and K. Eshragian, Principles of CMOS VLSI Design: A System Perspective, Pearson Education, 2000.
3. Sung, Mo Kang and Yosuf Leblebici, CMOS Digital Integrated Circuits: Analysis and Design, TMH, 2003
4. Douglas A Pucknell and Kamran Eshraghian, Basic VLSI Design *PHI,* 2005.
5. Wayne, Wolf, Modern VLSI design: System on Silicon Pearson Education, 2005.

ECE 5113 PROCESSOR ARCHITECTURE AND APPLICATIONS [4 0 0 4]

CO 1	Build processor data path and control with simple and multicycle implementation
CO 2	Analyze memory hierarchy, cache optimization, MMU and I/O Interfacing
CO 3	Illustrate instruction level parallelism with advanced techniques for instruction delivery
CO 4	Apply different protocols for enforcing coherence in multiprocessor parallel architectures.
CO 5	Discuss architecture of digital signal processors and its features, apply processors for real time problem solving like filtering, speech and image processing etc.

Introduction, data path, control, pipelining. Building a Data path, a simple implementation scheme for R instructions, memory related, branch / jump instructions, ALU control, a multi cycle Implementation. Pipelining basics, hazards, pipelined data path and control, data hazards, forwarding, stalls, branch hazards, HDL model of a pipeline, advanced Pipelining, Pentium 4 pipelining. Basics of cache, cache architecture, cache optimization, MMU, programmed I /O, Interrupt I/O, DMA. Concepts of Instruction level parallelism & Challenges, dynamic Scheduling, advanced techniques for Instruction delivery and speculation, limitations of ILP. A taxonomy of parallel architectures, shared memory architectures, basics of cache coherence protocols, basics of Vector Processor, MSP 430 – Architecture, features. Basic architectural features of digital signal processors, computational building blocks, data representation and arithmetic, finite word length effects, addressing modes, architecture of TMS 320C62x / 64x / 67x processor and its features, DSP development tools, Code Composer Studio & Simulink, applications of DSP Processors.
*Self-Directed Learning: Introduction to Code Composer Studio & Simulink

References:
1. David A. Patterson & John L. Hennessy, “Computer Organization and Design-The Hardware/Software Interface”, ARM Edition, Elsevier, 2014.
2. John L. Hennessy and David A. Patterson, “Computer Architecture-A Quantitative Approach”, Fourth Edition, Elsevier, 2007.
3. Phil Lapsley, “DSP Processor Fundamentals”, IEEE Press, 1997.
4. Sen M. Kuo, Woon Seng Gan, “Digital Signal Processors”, Pearson, 2005.
5. Andrew N. Sloss, Dominic Symes, Chris Wright, “ARM System Developer’s Guide” Elsevier, 2004
6. *Texas Instruments Code Composer Studio https://www.ti.com/tool/CCSTUDIO

ECE 5114 WIRELESS COMMUNICATION [3 1 0 4]

CO 1	Describe time varying communication channels and discuss empirical models of wireless communication channels
CO 2	Develop mathematical models of time varying wireless communication channels
CO 3	Estimate information carrying capacity of wireless channels.
CO 4	Discuss the performance of different 5G Digital modulation schemes in wireless communication scenarios.
CO 5	Analyze diversity techniques employed in wireless communication

Modeling of wireless channels, Wide-sense stationary uncorrelated scattering assumption; characterizing key parameters of wireless channels, wireless channel discretization and discrete-time representation. Non-coherent and coherent reception. Time and Frequency diversity. Rake receiver. Channel capacity; Data transmission using multiple carriers and challenges. OFDM, challenges in multicarrier modulation, MIMO systems and space time coding**,** smart antennas.

*Self-Directed Learning: Fundamentals of 5G wireless Communications

References:

1. Goldsmith, Andrea. Wireless communications. Cambridge university press, 2005.
2. Robert W Heath Jr. “Foundations of MIMO Communications” Cambridge University press 2017.
3. *Gordon L Stuber “Principles of Mobile Communication” 4th edition Springer, 2017.
4. D. Tse and P. Vishwanath, Fundamentals of Wireless Communication, Cambridge University Press, 2005
5. T. S. Rappaport, Wireless Communication: Principles and Practice, Pearson, 2002
6. J. G. Proakis and M. Salehi, Digital Communications, McGraw-Hill, 2008

ECE 5115 DETECTION AND ESTIMATION THEORY [3 1 0 4]

CO 1	Explain elements of signal detection and estimation principles
CO 2	Mathematically formulate a signal detection and parameter estimation problem
CO 3	Design and develop optimal detection and estimation methods for a given problem
CO 4	Characterize the performance of optimal detectors
CO 5	Characterize and evaluate performance bounds of estimators

Classical detection and estimation theory and techniques, Qualities of good estimators, Cramer-Rao bound. Signal representation; Karhunen-Loeve series expansion method. Detection of signals and signal parameter estimation. Applications to binary digital communication systems. Signal detection in discrete time. Estimation of signal parameters; Detection of signals in colored noise. Filtering techniques, Wiener-Hopf equations.

*Self-Directed Learning: Kalman filters

References:

1. Vincent Poor H, An Introduction to Signal Detection and Estimation, *Springer, Second Edition, 1998*
2. Van Trees H L, Detection Estimation and Modulation Theory – Part I, *John Wiley, New York, 2002*.
3. Steven M Kay, Fundamentals of Statistical Signal Processing, Volume 1: Estimation Theory, *Pearson Education*, 2013
4. Steven M Kay, Fundamentals of Statistical Signal Processing, Volume 2: Detection Theory, *Pearson Education*, 2013

5. Mourad Barkat, Signal Detection and Estimation, *Artech House, Second Edition, 2005*
6. * https://archive.nptel.ac.in/courses/108/105/108105059/

HUM 5071 RESEARCH METHODOLOGY AND TECHNICAL COMMUNICATION [1 0 3 2]

CO 1	Recognize the concepts of research and identify the types of research
CO 2	Identify the problem and develop the research design to a problem
CO 3	Demonstrate effective mechanics of writing reports/manuscripts
CO 4	Exhibit effective technical presentation skills
CO 5	Develop a good research proposal

Research Methodology: Basic concepts: Types of research, Significance of research, Research framework. Sources of data, Methods of data collection. Research formulation: Components, selection and formulation of a research problem, Objectives of formulation, and Criteria of a good research problem. Research hypothesis: Criterion for hypothesis construction, Nature of hypothesis, Characteristics and Types of hypothesis, Elements of research design, Introduction to various sampling methods Sources of data, Collection of data, Research reports, references styles, Effective Presentation techniques, Research Ethics.

References:

1. Sekaran, U., & Bougie, R. (2016). Research methods for business: A skill building approach. John Wiley & Sons.
2. Zikmund, W. G., Babin, B. J., Carr, J. C., & Griffin, M. (2013). Business research methods. Cengage Learning.
3. Creswell, J. W., & Creswell, J. D. (2017). Research design: Qualitative, quantitative, and mixed methods approaches. Sage Publications.
4. Donald R Cooper & Pamela S Schindler, Business Research Methods, McGraw Hill International, 2018.

ECE 5141 DIGITAL VLSI DESIGN LAB [0 0 6 2]

CO 1	Explain various modelling styles of Verilog HDL.
CO 2	Apply FSM encoding techniques to implement optimization algorithms for digital VLSI design
CO 3	Design digital VLSI circuits and optimize their performance using EDA tools.
CO 4	Develop the test environment for functional verification of a digital system using System Verilog.
CO 5	Effectively communicate the results and their analysis both as an individual as well as a team member highlighting the societal, ethical, and environmental impacts.

Introduction to ASIC Design flow using Cadence tool. RTL modelling of Combinational and Sequential Digital circuits using Verilog. Synthesise and Implement various logic circuits in Artix-7/Basys-3 FPGA boards. Synthesize Mealy and Moore FSMs to implement Algorithms. Functional verification of Digital Systems and memory using SystemVerilog. Synthesis of digital circuits in Cadence Genus tool using hardware aware HDL modelling, optimizing performance, power and area.

References:

1. Charles Roth, Lizy Kurian John, Byeong Kil Lee, Digital System Design Using Verilog, 1st Edition, 2016.
1. Samir Palnitkar, "Verilog HDL: a guide to digital design and synthesis", Prentice Hall Professional, 2003.

3. Ashok B Mehta, “Introduction to System Verilog”, Springer, Netherlands, 2022.
4. Spear, Chris, “SystemVerilog for verification: a guide to learning the testbench language features” Springer Science & Business Media, 2008.
5. Digital Lab Manual, Revision 2.0, University Support Team, Cadence, Bengaluru, 2017.

ECE 5142 DIGITAL COMMUNICATION LAB-I [0 0 3 1]

CO 1	Perform wireless communication simulation using MATLAB/LabView/HFSS tools.
CO 2	Design QAM Mod & Demod and validate the performance using USRPs and design MIMO antennas using HFSS
CO 3	Model and simulate UWB antennas using HFSS.
CO 4	Performance investigation of different 5G Digital modulation schemes in wireless communication scenarios using HFSS or USRP
CO 5	Effectively communicate the results and their analysis both as an individual as well as a team member highlighting the societal, ethical, and environmental impacts.

Impact of Thermal Noise on Communication System Performance using Simulink. Rayleigh and Rician Fading and generating distributions using MATLAB. BPSK Modulator and Demodulator over AWGN Channel (MATLAB/ NI LabView), QPSK Modulator and Demodulator over AWGN and Rayleigh Channel (NI LabView), Design a 16 QAM Modulation and Demodulation scheme using (NI LabView). BER analysis of co-operative communication over Rayleigh fading channel. Real time demonstration using USRP 2901. Design of a Microstrip Antenna using HFSS, Design of an UWB Microstrip Antenna using HFSS.

Mini project: Wireless Physical layer design/ Antenna Design.

References:

1. Simulation of Digital Communication Systems using MATLAB: Mathuranathan Viswanathan. 2013.
2. R. W. Heath Jr. Introduction to Wireless Digital Communication: A Signal Processing Perspective, course notes for EE 371C taught at The University of Texas at Austin.
3. R. W. Heath Jr. EE 371C / EE 381V: Wireless Communications Lab.
4. An Introduction to HFSS: Fundamental Principles, Concepts, and Use: California State University Handbook.
5. Wireless Research Handbook “National Instruments” LabView.

SEMESTER II

ECE 5212 OPTICAL COMMUNICATION [4 0 0 4]

CO 1	Describe concept of infinite conducting planes , Eigen value equation for planar dielectric waveguide.
CO 2	Analyze optical fiber waveguide, Attenuation, distortion in optical fibers. Analyze intermodal and intramodal dispersion.
CO 3	Develop model for EDFA
CO 4	Illustrate coherent detection of advanced modulation formats used in optical fiber communication
CO 5	Discuss optical modulators, optical measurements

Introduction, Planar waveguide, Infinite conducting planes, Field components in an infinite conducting planes, Characteristics of different modes and problems, Ray of propagation of light through planar waveguide, Electromagnetic theory of propagation of light through planar waveguide, Eigen value equation for different modes, Types of optical fibres, modes, Elements of transmission link, Concept of V number, Signal degradation in optical fibres, dispersion, optical sources and detectors, Concept of optical amplification, Modelling of EDFA, Semiconductor optical amplifier, Analog and digital communication system, Coherent detection of Amplitude, Phase and Frequency Shift Keying, Optical CDMA, Measurement of optical attenuation , dispersion, Wireless optical communication.
*Self-Directed Learning: Wave propagation through anisotropic media.

References:

1. Keiser, “Optical Fiber Communication”, Tata McGraw Hill, New Delhi, 2013.
2. M. Sathish Kumar, “Fundamentals of Optical Fiber Communication”, Prentice Hall of India, New Delhi. Second Edition, 2019.
3.Ghatak and K. Thyagarajan, “Introduction to Fiber Optics”, Cambridge University Press, NY, 1998.
4. G.P Agarwal, Nonlinear Opticas, Elsevier, 4th edition, 2010.
5. *José M. Carcione, “Wave Fields in Real Media Wave Propagation in Anisotropic, Anelastic, Porous and Electromagnetic Media”, Elsevier, 3rd Edition 2014.

ECE 5213 ADVANCED MODULATION AND CODING TECHNIQUES [3 1 0 4]

CO 1	Discuss the challenges of Advanced Modulation and Coding schemes
CO 2	Describe various types of STC and STBCs in 5G systems
CO 3	Discuss Spatial Multiplexing and Spatial Modulation technology for 5G and beyond
CO 4	Analyze and characterize cooperative media based index modulation and demodulation technology for B5G Applications
CO 5	Implementation of advanced codes for 5G and beyond techniques

Understanding of Advanced Modulation Schemes, Wide-sense stationary uncorrelated scattering assumption; MIMO Modeling. characterizing key parameters of wireless channels using STBC, Alamouti Space time coding and uses. MIMO based Cooperative Communication using Relay technologies. Spatial Modulation and Its extensions. Time and Frequency diversity alterations. Body area networks and use of Enhanced spatial modulation to improve the energy efficiency. LDPC based MIMO systems and space time coding**,** smart antennas. 5G and Beyond communications.
*Self-Directed Learning: Coding Techniques for Wireless Communications.

Reference:

1. Yong Soo Cho, Jaekwon Kim, Won Young Yang, Chung G. Kang, "MIMO OFDM Wireless Communications with MATLAB., Wiley publications, 2010.
2. Ezio Biglieri et.al, "MIMO Wireless communications" Cambridge publishing, 2007.
3. Tolga M Duman and Ali Ghrayeb, "Coding for MIMO Communications" Wiley publications, 2006.
4. Robert Heath Jr, "Foundations of MIMO Communication" Cambridge Publications, 2018.
5. Anirban bhowal and Rakesh Singh Kshetrimayum, "Advanced Spatial Modulation Systems" signal and Communication technology series, Springer 2021.
6. *Andrew Thangaraj, "LDPC and Polar Codes for 5G" NPTEL SWAYAM course, 2018.

ECE 5243 DIGITAL COMMUNICATION LAB-II [0 0 6 2]

CO 1	Perform MIMO AF/DF wireless communication simulation using MATLAB/LabView.
CO 2	Design Spatial Mod & Demod , BAN, with and without LDPC and validate the performance using USRPs and design MIMO antennas using HFSS
CO 3	Model and simulate millimetre antennas using HFSS.
CO 4	Implement diversity techniques employed in wireless communication using HFSS or USRP.
CO 5	Effectively communicate the results and their analysis both as an individual as well as a team member highlighting the societal, ethical, and environmental impacts.

MIMO based cooperative communication using relay technologies, Spatial modulation, Body area networks and enhanced spatial modulation for energy efficiency. LDPC coded modulation schemes for 5G. Flexible MMIMO antenna design for millimeter wave, Tera hertz antenna design, MIMO Diversity parameter characterization. Implementation of a mini-project

References:

1. L. Malaviya, R. K. Panigrahi, and M. V. Kartikeyan, 'MIMO Antennas for Wireless Communication: Theory and Design, CRC Press, 1st edition, 2020
2. T. M. Duman and A Ghrayeb, 'Coding for MIMO Communications', Wiley, 2006
3. A. Bhowal and R S Kshetrimayum, 'Advanced Spatial Modulation Systems - Signal and Communication Technology Series', Springer, 2021

SECOND YEAR

ECE 6091 PROJECT WORK & INDUSTRIAL TRAINING [0 0 0 25]

CO 1	Review technical literature and other sources of information.
CO 2	Apply comprehensive knowledge of mathematics, statistics, natural science and engineering principles to solve real life problems.
CO 3	Formulate, and analyze complex problems using appropriate computational and analytical techniques.
CO 4	Evaluate the environmental and societal impact of the proposed solution.
CO 5	Communicate effectively on complex engineering matters with technical and non-technical audiences.

Students are expected to work for about 40 to 50 weeks under a guide from the department on a project relevant to the curent research trends and/or to the industry requirements. The work is expected to showcase the knowledge gained by them through two semesters of coursework as well as through a literature survey pertaining to the project. The work can be carried out in the home institution, an industry, any research laboratory of repute, or other premier institutions.

References:

1. Lab manuals associated with EDA tools/Soft computing tools etc.
3. Company/Industry user manual and their internal document.
4. IEEE Xplore/Scopus/WOS Indexed Journal articles/review articles/case studies/conference proceedings etc.
5. Associated Reference books.