B. Tech.

in

ELECTRONICS AND COMMUNICATION ENGINEERING

CURRICULUM 2022-23

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY KARNATAKA,

SURATHKAL – 575025

National Institute of Technology Karnataka, Surathkal

Vision

To facilitate transformation of students into good human beings, responsible citizens & competent professionals, focusing on the assimilation, generation and dissemination of knowledge.

Mission

- Impart quality education to meet the needs of profession and society, and achieve excellence in teaching-learning and research.
- Attract and develop talented and committed human resources, and provide an environment conducive to innovation, creativity, team-spirit and entrepreneurial leadership.
- Facilitate effective interactions among faculty and students, and foster networking with alumni, industries, institutions and other stake-holders.
- Practice and promote high standards of professional ethics, transparency and accountability.

Department of Electronics and Communication Engineering, NITK Surathkal

Vision

To be a model for academic excellence in the area of Electronics & Communication Engineering.

Mission

M1. Impart quality teaching-learning-experience with state-of-the-art curriculum.

M2. Enhance Research, Consultancy and Outreach activities.

M3. Increase the visibility of academic programs globally and attract talent at all levels.

M4. Foster sustained interaction with the alumni, industries, R & D organizations, world class universities and other stakeholders to stay relevant in the globalized environment.

Bachelor of Technology in Electronics and Communication Engineering

Program Educational Objectives (PEOs)

PEO1: Practice Electronics and Communication engineering in a successful professional career.

PEO2: Pursue higher education and / or research for professional development.

PEO3: Contribute as an individual or a team member with demonstrable attributes in lifelong learning for the welfare of the society.

Program Outcomes (POs)

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

PO2: **Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.

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

PO4: **Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5: **Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

PO6: **The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7: **Environment and Sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

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

PO9: **Individual and Team Work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

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

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

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

Program Specific Outcomes (PSOs)

PSO1: Possess sound theoretical and practical knowledge of Electronics and Communication Engineering.

PSO2: Devise and deliver efficient solutions to challenging problems in Electronics and Communication Engineering.

BTech (ECE) Curriculum

Course Structure:

Basic Science Core (BSC)

CY110	Chemistry	(3-0-0) 3
CY111	Chemistry Laboratory	(0-0-3) 2
MA110	Engineering Mathematics – I	(3-0-0) 3
MA111	Engineering Mathematics – II	(3-0-0) 3
PH110	Physics	(3-1-0) 4
PH111	Physics Laboratory	(0-0-2) 1

Engineering Science Core (ESC)

CS110	C Programming	(3-0-0) 3
CS111	C Programming Lab	(0-0-3) 2
ME110	Elements of Mechanical Engg.	(2-0-0) 2
ME111	Engineering Graphics	(1-0-3) 3
WO110	Engineering Mechanics	(3-0-0) 3

Humanities and Social Science Core (HSC)

SM110	Professional Communication	(3-0-0) 3
SM300	Engineering Economics	(3-0-0) 3
SM302	Principles of Management	(3-0-0) 3

Program Core (PC)

EC101	Joy of Electronics and Communication	(2-0-3) 4
EC102	Circuits and Systems	(3-1-0) 4
EC200	Digital System Design	(3-1-0) 4
EC201	Analog Electronics	(3-1-0) 4
EC202	Analog and Digital Communication	(3-1-0) 4
EC203	Linear Algebra and Probability Theory	(3-1-0) 4
EC204	Digital System Design Lab	(0-0-3) 2
EC205	Analog Electronics Lab	(0-0-3) 2
EC206	Microprocessors	(3-1-0) 4
EC207	Electromagnetic Waves and Transmission Lines	(3-1-0) 4
EC208	Digital Signal Processing	(3-1-0) 4
EC209	Control Systems	(3-1-0) 4
EC210	Microprocessors Lab	(0-0-3) 2
EC211	Digital Signal Processing Lab	(0-0-3) 2
EC300	VLSI Design	(3-1-0) 4
EC301	RF Components and Circuits	(3-1-0) 4
EC302	VLSI Design Lab	(0-0-3) 2
EC303	Communication Lab-I	(0-0-3) 2
EC304	Communication Lab-II	(0-0-3) 2

Program Specific Electives (PSE)

EC340	Computer Organization and Architecture	(3-1-0) 4
EC341	Computer Arithmetic	(3-1-0) 4
EC342	Embedded System Design	(2-0-3) 4
EC343	FPGA based System Design	(2-0-3) 4
EC344	Analog Integrated Circuits	(3-1-0) 4
EC345	Data Structures and Algorithms	(3-0-2) 4
EC346	Foundations of Machine Learning	(3-1-0) 4
EC347	Speech and Audio Processing	(3-1-0) 4
EC348	Image and Video Processing	(3-1-0) 4
EC349	Applied Number Theory	(3-1-0) 4
EC350	Numerical Analysis	(3-1-0) 4
EC351	Satellite Communications	(3-1-0) 4
EC352	Principles of Modern Radar and Techniques	(3-1-0) 4
EC353	Modern Electronic Navigation Systems	(3-1-0) 4
EC354	Communication Networks	(3-1-0) 4
EC355	Wireless Mobile Communication	(3-1-0) 4
EC356	Information Theory and Coding	(3-1-0) 4
EC357	Adhoc and Sensor Networks	(3-1-0) 4
EC358	Multimedia Communication Techniques	(3-1-0) 4
EC359	Software Defined and Cognitive Radio	(3-1-0) 4
EC360	Machine Learning for Wireless Communication Systems	(3-1-0) 4
EC361	Sparse Representations and Compressive Sensing	(3-1-0) 4
EC362	Deep Reinforcement Learning	(3-1-0) 4
EC363	Machine Leaarming Applications in Radar Signal Procesing	(3-1-0) 4
EC440	VLSI CAD	(3-1-0) 4
EC441	Mixed Signal Design	(3-1-0) 4
EC442	Advanced Computer Architecture	(3-1-0) 4
EC443	VLSI Testing and Testability	(3-1-0) 4
EC444	Synthesis and Optimization of Digital Circuits	(3-1-0) 4
EC445	Techniques in Low Power VLSI	(3-1-0) 4
EC446	Submicron Devices	(3-1-0) 4
EC447	Active Filters	(3-1-0) 4
EC448	Heterogeneous and Parallel Computing	(3-1-0) 4
EC449	Algorithms and Architectures for Signal Processing	(3-1-0) 4
EC450	Analog and Digital Filter Design	(3-1-0) 4
EC451	Advanced Digital Signal Processing	(3-1-0) 4
EC452	Real Time Signal Processing	(3-1-0) 4
EC453	Fourier and Wavelet Signal Processing	(2-0-3) 4
EC454	Mathematical Algorithms for Signal Processing	(3-1-0) 4
EC455	Digital Signal Compression	(3-1-0) 4
EC456	Dynamical Systems, Chaos and Fractals	(3-1-0) 4
EC457	Statistical Analysis	(3-1-0) 4
EC458	Stochastic Processes	(3-1-0) 4
EC459	Optimization	(3-1-0) 4
EC460	Neural Networks and Deep Learning	(3-1-0) 4
EC461	Spread Spectrum Communication	(3-1-0) 4
EC462	Error Control Coding	(3-1-0) 4
EC463	Optical Communication Systems and Networks	(3-1-0) 4
EC464	Radar Signal Processing	(3-1-0) 4
EC465	Algorithms for Parameter and State Estimation	(3-1-0) 4
EC466	Detection and Estimation Theory	(3-1-0) 4
EC467	Advanced Topics in Communication Engineering	(3-1-0) 4
EC468	Signal Integrity and EMI/ EMC	(3-1-0) 4
EC469	Introduction to Photonics	(3-1-0) 4
EC470	MIMO Communication Systems	(3-1-0) 4
EC471	RF IC Design	(3-1-0) 4
EC472	Principles of Modern Radar-Advanced Techniques	(3-1-0) 4

EC473	Electronic Defense Systems	(3-1-0) 4
EC474	Principles of Modern Sonar Systems	(3-1-0) 4
EC475	Advanced Electromagnetics	(3-1-0) 4
EC476	Milimeter Wave Communication	(3-1-0) 4
EC477	Imaging, Informatics and Computational Physics	(3-1-0) 4
EC478	Complex Analysis and Applications	(3-1-0) 4
EC479	Computational Inverse Problems and Applications	(3-1-0) 4
EC480	Remote Sensing: Principles, Techniques & Applications	(3-1-0) 4
EC481	Advanced Deep Learning and Applications	(3-1-0) 4
EC280	Mini Project in Electrical Circuits and Systems	(0-0-3) 2
EC281	Mini Project in Digital System Design	(0-0-3) 2
EC380	Mini Project in Communication Systems and Networks	(0-0-3) 2
EC381	Mini Project in Microprocessor and Embedded Systems	(0-0-3) 2
EC382	Mini Project in Analog System Design	(0-0-3) 2
EC383	Mini Project in VLSI Design	(0-0-3) 2
EC384	Mini Project in RF Design	(0-0-3) 2
EC385	Mini Project in Digital Signal Processing	(0-0-3) 2
EC386	Mini Project in Image Processing	(0-0-3) 2
EC387	Mini Project in AI and Machine Learning	(0-0-3) 2
EC388	Mini Project in Photonics	(0-0-3) 2
EC497	Cornerstone/capstone Project	4

Project (MP)

EC498	Major Project	6

Mandatory Learning Courses (MLC)

CV110	Environmental Sciences	(1-0-0) 1
SM111	Professional Ethics & Human Values	(1-0-0) 1
EC390	Seminar	1
EC490	Practical Training	2
UC401	Liberal Arts courses/ cocurricular/ extra-curricular activities	10
UC100	Introduction to Design Thinking	(2-0-0) 2

Honor Courses (Hn)

Students opting for honors degree shall do their Major Project in the department

EC702	Analog Integrated Circuit Design	(4-0-0) 4
EC703	VLSI Data Converters	(4-0-0) 4
EC704	VLSI Design Automation	(4-0-0) 4
EC733	Optical Networks and Switching	(4-0-0) 4
EC734	Signal Detection and Estimation	(4-0-0) 4
EC761	Information Processing and Compression	(4-0-0) 4
EC762	Pattern Recognition and Machine Learning	(4-0-0) 4
EC763	Optimization	(4-0-0) 4
EC792	High Performance Computing Architectures	(4-0-0) 4
EC801	Logic Synthesis Techniques	(4-0-0) 4
EC803	Microelectronic Devices	(4-0-0) 4
EC804	Digital VLSI Testing & Testability	(4-0-0) 4
EC808	CMOS RF Integrated Circuits	(4-0-0) 4
EC832	MIMO Communication Systems	(4-0-0) 4
EC834	Error Control Coding	(4-0-0) 4
EC836	Radar Signal Processing and Applications	(4-0-0) 4
EC839	Nano-Photonics	(4-0-0) 4
EC840	Millimetre Wave Communications	(4-0-0) 4
EC841	Cryptography	(4-0-0) 4
EC864	Speech and Audio Processing	(4-0-0) 4
EC866	Deep Learning and Applications	(4-0-0) 4
EC872	Nonlinear Dynamics, Chaos and Fractals	(4-0-0) 4
EC873	Computational Imaging and Physics	(4-0-0) 4
EC875	Probabilistic Models in Machine Learning	(4-0-0) 4

Minor Courses (Mn) (All branches except for EEE)

EC391M	Analog Electronic Circuits	(3-0-0) 3
EC392M	Digital Electronics	(3-0-0) 3
EC393M	Signals and Systems	(3-0-0) 3
EC394M	Communication Systems	(3-0-0) 3
EC395M	Data Communication and Networks	(3-0-0) 3

Department specific course for Interdisciplinary Machine Learning Minor

EC500M	Machine Learning for Electronics and Communication Engineering	(3-1-0) 4

Suggested Plan of Study:

Semester →	I	II	III	IV	V	VI	VII	VIII
1	CY110	MA111	EC200	EC206	SM300	SM302	Elective	Elective
2	CY111	PH110	EC201	EC207	EC300	EC304	Elective	Elective
3	MA110	PH111	EC202	EC208	EC301	Elective	Elective	Elective
4	CS110	ME110	EC203	EC209	EC302	Elective	Elective	EC498
5	CS111	ME111	EC204	EC210	EC303	Elective	EC498	
6	WO110	SM110	EC205	EC211	Elective	Elective	EC490	
7	EC101	EC102	Elective	Elective	Elective		UC401	
8	CV110	SM111			EC390			
9	UC100							

Requirements for B.Tech. in Electronics and Communication Engineering:

Courses	Minimum Credit Requirements
Foundation Courses: Basic Science Courses(BSC): 16 Engineering Science Courses (ESC): 13 Humanities and Social Science Courses (HSC): 09	38
Program Core Courses (PC)	62
Elective Courses (Ele) Programme Specific Electives, Mini Projects (0 – 6 credits), MOOC Courses (0 – 8 credits)	39
Major Project (MP)	06
Mandatory Learning Courses (MLC)	16
Total	**161**

Requirement for Honors:

Minimum No. of Courses to be Registered	Minimum Credits to be earned
04	16

Requirement for Minors:

Minimum No. of Courses to be Registered	Minimum Credits to be earned
05	15

EC100 ELEMENTS OF ELECTRONICS & COMMUNICATION ENGINEERING (2-0-0) 2
(For Computer Science, Mechanical, Civil, Mining, Metallurgy, Chemical Engineering branches only)

Course Outcomes:
CO1: Understand the working of a few basic elements used in E&C Engg. and a few commonly used electronic circuits and systems.
CO2: Apply mathematical concepts to model the basic elements and simple circuits.
CO3: Analyze the basic elements and appreciate their applications.
CO4: Design simple electronic circuits for a given application to the first order.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	-	-	-	-	-	-	-	-	-	-	-	-
CO2	3	3	-	-	-	-	-	-	-	-	-	-	-	-
CO3	3	3	-	-	-	-	-	-	-	-	-	-	-	-
CO4	3	3	-	-	-	-	-	-	-	-	-	-	-	-

Course Contents
RC & RL Circuits – low pass, high pass, transient analysis for pulse input; Diode: Principle, Characteristics, Applications & Types, Transistor: Principle, Operation, Biasing (DC analysis of CE, CB and CC configuration), Transistor as a switch; Digital Circuits: Basic Logic gates, Universal gates, Boolean Algebra, Combinational circuits, Op-amps & their Applications, Introduction to few systems (only Block level) : ADC, DAC, Linear power supply, SMPS, UPS, Principles of Communication Systems.

References
Albert Malvino, Electronic Principles, Tata McGraw Hill, 1995
Boylstead and Nashelsky, Electronic Devices and Circuits, PHI, 1998
George Kennedy & Bernard Davis, Electronic Communication System, Tata McGraw Hill, 1996
Wayne Tomasi, Electronic Communication Systems, Pearson Education, 2003
Ramakant A Gayakwad, OP-AMPS and Linear Integrated Circuits, Prentice Hall, 1999

EC101 JOY OF ELECTRONICS AND COMMUNICATION (2-0-3) 4

CO1: Able to operate typical laboratory equipments like function generator, digital storage oscilloscope, power supply, multimeter etc.and identify, select and use components like resistors, capacitors, inductors, diodes and transistors.
CO2: Able to rigup the given circuits on breadbord and test them.
CO3: Able to analyze the simple electronic circuits and debug the circuits.
CO4: Able to implement electronic circuits on PCB and test.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	-	-	-	-	-	-	-	-	-	-	3	-
CO2	1	2	-	-	2	-	-	-	3	2	-	-	3	-
CO3	1	2	-	-	-	-	-	-	3	2	-	-	3	1
CO4	1	2	-	-	2	-	-	-	3	2	-	-	3	1

Course Contents
Study and hands on exposure of electronic devices, instruments and circuits required for system design. Validation of relevant concepts using hardware/software tools.

References
Class notes and lab manual

EC102 CIRCUITS AND SYSTEMS **(3-1-0) 4**

Course Outcomes:
CO1: Analyze Electrical circuits – Steady state and transient.
CO2: Analyze the behavior of continuous-time signals.
CO3: Apply time domain techniques to analyze LTI systems.
CO4: Apply transform domain techniques to analyze signals & systems.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	-	-	-	-	-	-	-	-	-	-	2	1
CO2	2	3	-	-	-	-	-	-	-	-	-	-	2	1
CO3	2	3	-	-	-	-	-	-	-	-	-	-	2	2
CO4	2	3	-	-	-	-	-	-	-	-	-	-	2	2

Course Contents
DC Circuit Analysis - Circuit concept, circuit elements, independent and dependent sources, network reduction techniques (star-delta), network equations, node voltage and mesh current analysis, Network Theorems - Superposition, Thevenin's and Maximum power transfer theorems. First order systems - Analysis of RL and RC circuits, representation of systems using differential equations, solution of differential equations, Transient and steady state response, time constant, initial conditions, coupled circuits. Laplace Transform: Definition and properties, inverse transforms, partial fraction expansion. Second order systems - RLC circuits, characteristic equation, damping, natural frequency, time domain specifications of systems. Transform domain analysis of circuits, equivalent sources for initial conditions, transform circuits, Impedance functions and Network Theorems, transfer function, impulse response, convolution, linear time invariant systems, poles and zeros, stability, steady state sinusoidal response. Discrete time signals - sampling of sinusoids, complex exponentials and phasor, Spectrum representation – spectrum of sum of sinusoids, Periodic signals, Fourier series representation, sinusoidal synthesis, spectrum view on sampling, aliasing, sampling theorem, reconstruction. Discrete time systems – moving average filter, general FIR filter, impulse response, implementation of FIR filter, convolution, linear time-invariant systems, frequency response of FIR systems, examples of FIR filtering in signal denoising

References
W.Nillson and SA Riedel, Electric Circuits, PHI, 2000
RC.Dorf and J.A. Svoboda, Introduction to Electric Circuits, Wiley, 2009
Mc Chellan, R.W. Schafer & Yoder, Signal Processing First, Pearson 2003.

EC200 DIGITAL SYSTEM DESIGN **3-1-0 (4)**

Course Outcomes:
CO1: Understand combinational and sequential circuits using basic digital circuit elements.
CO2: Design digital systems by using basic digital circuit elements for a set of specifications.
CO3: Model digital systems using HDL given a set of specifications.
CO4: Apply the knowledge of basic digital circuit elements to design of computer architecure components.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	-	-	-	-	-	-	-	-	-	-	2	2
CO2	2	3	-	-	-	-	-	-	-	-	-	-	2	2
CO3	2	3	-	-	2	-	-	-	-	-	-	-	2	2
CO4	2	3	-	-	2	-	-	-	-	-	-	-	2	2

Course Contents
Introduction to Digital Systems and Boolean Algebra Binary, Logic Minimization and Implementation, Karnaugh-maps, NAND and NOR implementation, Quine-McCluskey method, Logic families, Combinational Logic Multi level gate circuits, Parity circuits and comparators, Representation of signed numbers, Introduction to HDL (VHDL

/Verilog), Register transfer language, Sequential Logic Latches and flip-flops, Registers and counters, HDL description of sequential circuits, State Machine Design, State machine as a sequential controller, Moore and Mealy state machines, Derivation of state graph and tables, Sequence detector, equivalent state machines, State machine modelling based on HDL, Linked state machines, Advanced Topics: Static and Dynamic hazards; race free design;

References

Charles. H. Roth, Jr., Fundamentals of Logic Design, Fifth Edition, Thomson Brooks /Cole, 2005. J.F.Wakerly, Digital Design Principles and Practices, PH, 1999.
D.D. Givone, Digital Principles and Design, TMH, 2002
Morris. M. Mano, Michael D. Ciletti, Digital Design, Fourth Edition, Prentice-Hall India. 2008.
S. Palnitkar, Verilog HDL: A Guide to Digital Design and Synthesis, Second Edition, Pearson Education, 2004.
S. Brown and Z. Vranesic, Fundamentals of digital logic with Verilog design, Third Edition, McGraw-Hill, 2013
Charles. H. Roth, Jr., Digital System Design using VHDL, Indian Edition, Thomson Brooks /Cole, 2006.

EC201 ANALOG ELECTRONICS 3-1-0 (4)

Course Outcomes:

CO1: Able to analyse two-port networks and model LTI systems using equivalent two-port network.
CO2: Able to analyze the effects of negative/positive feedback on circuits.
CO3: Able to design a few linear and non-linear analog systems using opamps by building appropriate feed-back network around the opamps.
CO4: Able to analyze the effects of non-idealities of opamps on circuit performance.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	-	-	-	-	-	-	-	-	-	-	3	1
CO2	3	2	-	-	-	-	-	-	-	-	-	-	3	1
CO3	3	2	-	-	-	-	-	-	-	-	-	-	3	2
CO4	3	2	-	-	-	-	-	-	-	-	-	-	3	2

Course Contents

Voltage and current sources, Controlled sources, Two port networks:, ladder networks, Feedback Concepts: Feedback topologies, Positive and Negative feedback, Sensitivity factor, Basic amplifiers and their two port representation, Effect of Negative feedback on basic amplifiers, Instability in amplifiers, Barkhousen condition for Oscillations, Nyquist stability criterion, Operational Amplifiers, Non-idealities of opamps and their effects: Finite gain, finite bandwidth, Offset voltages and currents, Common-mode rejection ratio, Power supply rejection ratio, Slew rate, Filters : Second order filter transfer function (low pass, high pass, band pass and band reject) , Butterworth response, Emulation of inductor using Transconductors,, Sallen-Key biquadratic filters, Tow-Thomas biquad, Realization of higher order filters, All-pass filter (active phase shifters), Comparator, Schmitt trigger (inverting & non inverting), astable multivibrator, Triangular wave generator, Precision rectifiers, Voltage Controlled Oscillators, Phase Locked Loops

References

Behzad Razavi, Fundamentals of Microelectronics, Second edition, Wiley, 2013
A. Sedra, K. Smith, Microelectronic Circuits: Theory and Applications OUP 6th Ed. 2013
Sergio Franco, Design with OPAMPS and Linear Integrated circuits, Tata McGraw Hill, 2002.

EC202 ANALOG & DIGITAL COMMUNICATION (3-1-0)4

Course Outcomes:

CO1: Understand and analyze baseband signals in the time & frequency domain and compare and contrast various analog and digital modulation and demodulation techniques.
CO2: Understand and design trade-offs and evaluate the performance of analog and digital communication systems.
CO3: Design simple circuits for analog and digital modulation and demodulation.
CO4: To analyze the influence of noise on the performance of analog & digital communication systems including transmitters & receivers.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	2	2	2	-	-	-	-	-	-	2	3	3
CO2	2	3	3	1	2	-	-	-	-	-	-	-	2	2
CO3	2	3	3	2	2	2	-	-	-	-	-	-	2	2
CO4	3	3	2	2	2	-	-	-	-	-	-	-	2	2

Course Contents

Review of Communication Signals and Systems, Amplitude Modulation, Analytical signals, Complex envelope representation, FDM, Super Heterodyne receiver, Angle Modulation: FM and PM signal generation, Demodulation of FM signals, FM broadcasting, and FM stereo, Noise Performance of Analog Communication Systems, Capture effect, Pre-emphasis and De-emphasis in FM Systems. Digital Communications: Sampling theorem for low pass & band pass signals; Baseband Modulation: Pulse modulation, Pass band Modulation: ASK, FSK,PSK, M-ary systems. Matched filter, Correlation receiver, performance of optimum detector, Synchronization. CPM, Digital Transmission through Band-limited AWGN Channels: Zero-ISI (Nyquist criterion), Partial response signals, Detection of partial response signals, Maximum likelihood sequence detection, Error probability, Channel Equalization: ZF, MSE, Adaptive Equalizers.

References

M. F. Mesiya, "Contemporary Communication Systems", McGrawHill, 2013.

Taub and Schilling, "Principles of Communication systems", Second Edition, Tata McGrawHill, 2006 (34th reprint).

Proakis and Salehi, "Fundamentals of Communication Systems", Second Edition, Pearson International, 2014.

U. Madhow, "Fundamentals of Digital Communication," Cambridge University Press, 2008.

Won Y Yang , Prashanth Kumar H., "MATLAB/Simulink for Digital Communication", Second Edition, SIP-Hongrung (S. Korea), 2012.

Simon Haykin, "Communication Systems", Fourth Edition, Wiley, 2000.

EC203 LINEAR ALGEBRA AND PROBABILITY THEORY (3-1-0) 4

Course Outcomes:

CO1: Able to analyze different probability distributions of one random variable.

CO2: Able to analyze vector spaces and probability distributions in vector spaces.

CO3: Able to analyze linear transformations and probability distributions of linear transformations.

CO4: Able to use mathematical models for Electronics applications such as noise modeling, data compression etc.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	-	-	-	-	-	-	-	-	-	-	1	1
CO2	3	2	-	-	-	-	-	-	-	-	-	-	1	1
CO3	3	2	-	-	-	-	-	-	-	-	-	-	1	1
CO4	3	2	-	-	-	-	-	-	-	-	-	-	2	2

Course Contents

System of Equations, basic solutions, Echelon matrices, Linear independence, Rank, Inverse, Similarity, Eigen value analysis and Diagonalization, Vector Spaces: Linear Transformations, Subspaces, Linear Independence, Basis, Orthogonal Transformations. Probability – Review of probability, Joint and Conditional probability, Bayes theorem. Random Variable - Definition, discrete and continuous, probability distribution and density, mass functions, Joint and conditional distributions, Expectation, random vectors, vectorised expectation – mean and covariance, Random processes – definition, characterization, Stationarity. Gaussian random process, Central limit theorem.

References

Gilbert Strang: Linear algebra and its applications, Thomson Brooks, 2006.

Edgar G. Goodaire, Linear Algebra: A Pure & Applied First Course, World Scientific, 2014.

Dimitri P. Bertsekas, John N. Tsitsiklis, Introduction to Probability, 2nd Ed, Athena Scientific, 2008.

Alberto Leon-Garcia, Probability, Statistics, and Random Processes for Electrical Engineering, 3rd Ed, Addison-Wesley, 1994.
A Papoulis , S Pillai, Probability, Random Variables and Stochastic Processes, 4th Ed, McGraw-Hill, 2002.

EC204 DIGITAL SYSTEM DESIGN LAB **(0-0-3) 2**

Course Outcomes:
CO1: Understand the design flow involved in the design of Digital Systems.
CO2: Design and test simple combinational and sequential logic circuits using SSI and MSI ICs.
CO3: Model and simulate using simple combinational and sequential logic circuits using HDL.
CO4: Design and analyze basic digital systems for the given specifications.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	-	-	-	-	1	1	-	-	-	2	2
CO2	3	2	2	-	-	-	-	1	3	-	-	-	2	2
CO3	3	2	2	-	3	-	-	1	3	-	-	-	2	2
CO4	3	2	3	-	3	-	-	1	3	-	-	-	2	2

Course Contents
Experiments using basic logic gates; Design of combinational circuits using HDL. Design of adders and magnitude comparators; realization using multiplexers and other approaches; Design of sequential circuits including flip-flops, counters and registers.

References
Class notes & Lab manual

EC205 ANALOG ELECTRONICS LAB **(0-0-3) 2**

Course Outcomes:
CO1: Understand the concepts of circuit analysis methods such as DC, AC and transient.
CO2: Design and analyze a few diode based circuits and analyze the effects of negative/positive feedback on circuits.
CO3: Design and analyze system level opamp circuits for linear and nonlinear applications.
CO4: Debug and Evaluate the circuits through simulation softwares and hardware design.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	-	-	-	-	-	-	-	-	-	-	3	1
CO2	3	2	-	-	-	-	-	-	3	2	-	-	3	1
CO3	3	2	2	-	-	-	-	-	3	2	-	-	3	2
CO4	3	2	-	-	3	-	-	-	3	2	-	-	3	2

Course Contents
Design of full wave rectifier; Regulated Power Supply, Design with RC circuits – AC analysis, OPAMPS Linear applications, OPAMP non-linear applications. ***Simulation Experiments:*** Above experiments will be validated through simulation.

References
Class notes & Lab manual

EC206 MICROPROCESSORS (3-1-0) 4

Course Outcomes:

CO1: Have an insight to the stored program concept, computer organization, specifications of an Instruction Set Architecture.
CO2: Have an understanding of family of ARM processors, the organization and working of a typical ARM processor.
CO3: Write assembly language programs for ARM processors.
CO4: Interface peripherals and handle interrupts and exception in ARM processors.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	-	-	-	-	-	-	-	-	-	-	2	2
CO2	3	3	-	-	-	-	-	-	-	-	-	-	2	2
CO3	2	2	-	-	1	-	-	-	-	-	-	-	2	2
CO4	2	3	-	-	1	-	-	-	-	-	-	-	2	2

Course Contents

Introduction to computer organization, CISC and RISC processors, concept of pipelining, concept of Microcomputer and microcontroller. Introduction to ARM based processor: Processor overview, introduction to programming model, processor and memory organization, concept of stack, introduction to processor instruction set, addressing modes, instruction encoding. Processor implementation, organization and execution: Instruction datapath, timing, processor modes, exceptions, protected mode operation. Hardware interfacing: Introduction to memory, IO interfacing, Concepts of memory mapped and IO, mapped IO.

References

Steve Furber, "ARM System Architecture", Edison Wesley Longman, 1996.
William Hohl, "ARM Assembly Language- Fundamentals and Techniques ", CRC Press, 2009
Andrew N. Sloss, Dominic Symes, Chris Wright, "ARM System Developer's Guide: Designing and Optimizing System Software", Elsevier, 2004.
D.A. Patterson and J. Hennessy, Computer Organization & Design, The Hardware/software interface, Elsevier Inc, ARM Edition, 2010.
Lab manuals Online ARM programming reference and guide

EC207 ELECTROMAGNETIC WAVES AND TRANSMISSION LINES (3-1-0) 4

Course Outcomes:

CO1: Differentiate between circuit theory and field theory concepts and understand the concepts of electrodynamics by deriving and solving the Maxwell's equation. Derive and solve the wave equation to understand the concepts of plane wave propagation in various media and polarization.
CO2: Analyse the wave propagation on transmission lines and solve the transmission line problems analytically and graphically using Smith Chart. Understand the wave propagation on metallic and dielectric waveguides at higher frequencies.
CO3: Recognise the significance of impedance matching and design various matching circuits.
CO4: Apply the concepts of electrodynamics for understanding antenna radiation characteristics and other wireless communication systems.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	-	-	-	-	-	-	-	-	-	-	3	1
CO2	3	2	-	-	-	-	-	-	-	-	-	-	3	1
CO3	3	2	-	-	-	-	-	-	-	-	-	-	3	2
CO4	3	2	-	-	-	-	-	-	-	-	-	-	3	2

Course Contents

Review of coordinate systems, vector calculus, static electric and magnetic Fields; derivation and solution to Maxwell's Equations. Plane wave propagation in different media. Power and Poynting's Theorem. Reflection, Transmission, and Refraction of Waves at Media Interfaces, Polarization. Comparison of circuit and field theory concepts. Guided Waves in Transmission Lines, Smith Charts, Transients in Transmission Lines, Impedance matching, Metallic Waveguides, Introduction to planar and dielectric Waveguides.

References

Martin A. Plonus, Applied Electromagntics, McGrawHill, 1988
Matthew N. O. Sadiku, Elements of Electromagnetics 6th Edition, Oxford University Press 2015
Umran S. Inan and Aziz Inan, Engineering Electromagnetics, Prentice Hall, 1999
David H. Staelin, Ann W. Morgenthaler, Jin Au Kong, Electromagnetic Waves, Prentice Hall, 1994.
John D Ryder, Networks, Lines and Fields, Second Edition, 2015.
Basu B. N, Engineering Electromagnetics Essentials, Universities Press, 2015.

EC208 DIGITAL SIGNAL PROCESSING (3-1-0) 4

Course Outcomes:

CO1: Understand basic concepts of Digital Signal Processing.
CO2: Understand and analyze Z- Transform, DTFT, DFT and FFT algorithms along with their applications.
CO3: Design and analyze FIR and IIR filters.
CO4: Apply DSP algorithms for Speech and Audio applications.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	-	-	-	-	-	-	-	-	-	-	1	1
CO2	3	2	-	-	-	-	-	-	-	-	-	-	1	1
CO3	3	2	-	-	-	-	-	-	-	-	-	-	1	1
CO4	3	2	-	-	-	-	-	-	-	-	-	-	2	2

Course Contents

Time domain analysis of discrete-time systems - Basic discrete time signals, operations and properties, mathematical view, Introduction to sampling, Nyquist theorem. Systems – properties, linear time invariant systems, impulse response, convolution, causality and stability. Difference equations. Transform domain analysis of discrete-time systems -Z Transform – definition and properties, ROC, transfer function, poles and zeroes, application to discrete systems.
Representation of systems – signal flow graph, realization of z-domain transfer function. Frequency domain analysis of discrete-time systems -Fourier series and fourier transform. Relation between continuous and discrete time spectra, aliasing, reconstruction. DFS properties, Properties and applications of DTFT. Relationship between time, Z and frequency domains, Relation between frequency domain representation in continuous and discrete domain.
Sampling in frequency domain, DFT, Properties of DFT. Linear convolution using DFT. FFT- DIT and DIF, Basics of Multirate signal processing Decimation and interpolation. Digital Filter Design- Characteristics of Digital Filters, Filter structures, FIR filter design – window method, frequency sampling method, Relation between S and Z domains, IIR filter design – Butterworth and Chebyshev

References

J. G. Proakis and D. G. Manolakis, Digital Signal Processing Principles, Algorithms and Applications Fourth Edition, 2011
A. V. Oppenheim and R.W. Schafer, Discrete Time Signal Processing, 2002
Paolo Prandoni and Martin Vetterli, Signal Processing for Communications, (http://www.sp4comm.org/download.html), 2013
Ifeachor and Jervis, DSP – A practical approach, Pearson, 2002

EC209 CONTROL SYSTEMS (3-1-0) 4

Course Outcomes:

CO1: Model LTI control systems through block diagrams, signal-flow graphs, linear differential equation and state- variable model.
CO2: Understand the transient and the steady state behaviour of systems, and the need for the feedback control for shaping the response.
CO3: Understand the concept of stability and analyze the stability using various techniques such as Routh Hurvitz, Root-locus, Bode plot.
CO4: Design Controllers and compensators to stabilze a given linear feed-back control system.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	-	-	-	-	-	-	-	-	-	-	2	2
CO2	3	3	-	-	-	-	-	-	-	-	-	-	2	2
CO3	3	3	-	-	-	-	-	-	-	-	-	-	2	2
CO4	3	3	-	-	-	-	-	-	-	-	-	-	2	2

Course Contents

History of control and feedback, linear systems, dynamic systems, modeling and analysis, electrical and mechanical systems, block diagram and signal flow graphs, continuous and discrete time representation, time domain and frequency domain analysis, root-locus, Bode plot, phase and gain margins, polar plots, Nyquist plots, concept of stability, controllability, observability, transfer function approach to modeling, transient analysis and frequency domain analysis, quantization and error effects, design of control systems, design specifications, lead and lag compensator, PI, PD, PID controllers, state-space representation of dynamic systems, state space transfer function, design based on state space models, quadratic optimum control.

References

Bernard Friedland, Control System Design: An Introduction to State-Space Methods, Dover 2005.
Farid Golnaraghi, Benjamin C. Kuo; Automatic Control Systems, 9th ed, John Wiley & Sons, 2010.
Katsuhiko Ogata; Modern Control Engineering, 5th ed, Pearson India Education Services Pvt Ltd, 2015.
Richard C. Dorf, Robert H. Bishop; Modern Control Systems, 12th ed, Pearson Education Limited, 2014.

EC210 MICROPROCESSOR LAB (0-0-3) 2

Course Outcomes:

CO1: Understand the programmer's model of ARM processor and its instruction Set.
CO2: Write efficient assembly language Program for ARM processor and execute it on the simulator.
CO3: Interface the peripherals and download programs on to the evaluation board.
CO4: Implement a term project using ARM microcontroller.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	-	-	-	-	-	-		-	-	-	2	
CO2	3	3	1	-	-	-	-	-	2	-	-	-	2	1
CO3	2	2	1	-	-	-	-	-	2	-	-	-	2	1
CO4	2	3	2	2	-	2	2	-	3	2	2	-	2	2

Course Contents

The lab experiments will introduce students to assembly language programming and embedded programming. Students will create embedded programs on an ARM processor to generate analog traces, interface to peripherals. Advanced experiments will explore performance issues.

References

Class notes and Lab manual.

EC211 DIGITAL SIGNAL PROCESSING LAB (0-0-3) 2

Course Outcomes:

CO1: Understanding of basic DSP tools and algorithms.
CO2: Design and simulate signal processing algorithms in MATLAB/Octave/Python or similar software tools.
CO3: Implement DSP algorithms in a DSP Processor.
CO4: Apply theoretical Concepts to practical applications.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	-	-	3	-	-	-	2	-	-	-	2	2
CO2	3	3	-	-	3	-	-	-	2	-	-	-	2	2
CO3	3	2	-	-	3	-	-	-	2	-	-	-	2	2
CO4	3	2	1	-	3	-	-	-	2	1	-	-	2	2

Course Contents

Simulation exercises on linear equation solvers: Digital Filter Design, DFT and spectral analysis, identification of sinusoids in noise. Speech processing, Image processing, Real time experiments using fixed point DSP processor (Assembly language programming) Waveform generation, Data I/O effect of sampling and quantization, Digital Filter Implementation FIR and IIR filter, Implementation of FFT.

References

Class notes and Lab manual.

EC300 VLSI DESIGN **(3-1-0) 4**

Course Outcomes:

CO1: To understand basics of MOSFET and analysis of NMOS & CMOS inverters.
CO2: Able to understand Fabrication process for Very Large Scale Integrated (VLSI) circuits.
CO3: Able to design and implement digital circuits at transistor-level in CMOS technology. To understand parasitic elements associated with CMOS circuits, to optimize VLSI circuit performance.
CO4: Able to understand and design basic VLSI sub-systems & architecture

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	-	-	-	-	-	-	-	-	-	-	3	1
CO2	3	2	-	-	-	-	-	-	-	-	-	-	3	1
CO3	3	2	-	-	-	-	-	-	-	-	-	-	3	2
CO4	3	2	-	-	-	-	-	-	-	-	-	-	3	2

Course Contents

Introduction to MOSFETs, MOSFET Equivalent Circuits. MOSFET logic circuits: NMOS inverter, CMOS inverter, CMOS Processing Technology. Layout design rules. CAD tools for VLSI Design. MOSFET Logic gates. CMOS combinational, sequential logic circuits, Flip flop and latch timings, Clocking. Circuit characterization and performance estimation: Resistance, capacitance estimation, Switching characteristics, Delay models. Power dissipation, Packaging, Scaling of MOS transistor dimensions. CMOS subsystem design. Datapath operations: Addition, Multiplication, Counters, Shifters, Memory elements.

References

Jan M. Rabaey, A. Chandrakasan, and B. Nikolic, Digital Integrated Circuits: A design Perspective, Pearson Education, 2002
S. M. Kang & Y. Leblebici, CMOS Digital Integrated Circuits, McGraw Hill, 2002
Ken Martin, Digital Integrated Circuit Design, Oxford Press, 2000.
Neil H. E. Weste, David Money Harris, Integrated Circuit Design, Fourth Edition, 2011

EC301 RF COMPONENTS AND CIRCUITS **(3-1-0) 4**

Course Outcomes:

CO1: Design and study the characteristics of antennas.
CO2: Ability to design an matching network based on high frequency components and Properly utilize RF/microwave CAD software.
CO3: Ability to design active and passive RF components and analyze their performance metrics and parameters.
CO4: Design RF functional blocks and circuits.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	1	-	-	-	-	-	-	-	2	2
CO2	3	2	2	1	1	-	-	-	-	-	-	-	2	2
CO3	3	2	2	1	1	-	-	-	-	-	-	-	2	2
CO4	3	2	2	1	1	-	-	-	-	-	-	-	2	2

Course Contents

Review of Electromagnetic Theory, Hertzian Dipole; Antenna Characteristics, Wireless Systems and Friis Transmission Formula; Types of Antennas, Antenna Arrays, Microstrip antennas; Radio wave propagation. Impedance matching, S-parameters, passive and active microwave components. Ferrite devices, microwave filters, noise and nonlinearity, mixers and amplifiers. Introduction to radar systems.

References

C. A. Balanis, Antenna Theory: Analysis and Design. 4th edition. John Wiley, 2012.
Harish, A.R.; Sachidananda, M., Antennas and Wave Propagation, Oxford University Press, 2007
Warren Stutzman and Gary Thiele, Antenna Theory and Design, 3rd edition, John Wiley & Sons, 2013.
David M. Pozar, Microwave Engineering, 4th Edition, Wiley, 2011
Samuel Y. Liao, Microwave Devices and Circuits, Pearson, 3rd Edition, 2008
M. Kulkarni, Microwave and Radar Engineering, Umesh Publishing House, 5th Edition, 2014.

EC302 VLSI DESIGN LAB **(0-0-3) 2**

Course Outcomes:

CO1: Understand MOS transistor theory & MOS characteristics through SPICE analysis.
CO2: Create the physical layout of VLSI circuits.
CO3: Analyze the effects of parasitics on circuit performance.
CO4: Create, verify and characterize CMOS VLSI systems using CAD tools.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	-	-	3	-	-	2	3	-	-	-	3	1
CO2	3	2	-	-	3	-	-	2	3	-	-	-	3	1
CO3	3	2	-	-	3	-	-	2	3	-	-	-	3	2
CO4	3	2	-	-	3	-	-	2	3	-	-	-	3	2

Course Contents

Design, Simulation and layout of basic digital blocks, Design project using EDA tools

References

Class notes and Lab manual.

EC303 COMMUNICATION LAB- I **(0-0-3) 2**

Course Outcomes:

CO1: Understand IC data sheets and develop hardware laboratory skills.
CO2: Design and implement basic communication circuits.
CO3: Demonstrate the working of designed circuits, measure the outputs and record the observations.
CO4: Implement simple communication circuits for real life applications.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	-	-	3	-	-	-	1	2	-	1	2	2
CO2	2	3	-	-	3	-	-	-	3	2	-	1	2	2
CO3	2	3	-	-	3	-	-	-	3	2	-	2	3	3
CO4	2	3	2	-	3	1	1	1	3	2	2	2	3	3

Course Contents

Design experiments (both hardware design and simulation) to support the contents of Analog and Digital communication and Electromagnetic Waves and Transmission Lines, Use of Simulation tools to simulate and verify various fundamental ideas in the above courses.

References

Class notes & Lab manual

EC304 COMMUNICATION LAB- II (0-0-3) 2

Course Outcomes:

CO1: Develop simulation skills of digital communication systems using Matlab and Simulink.
CO2: Measure and characterize microwave circuits and antennae through microwave waveguide set up.
CO3: Design, implement, test and demonstrate basic digital communication circuits.
CO4: Implement simple digital communication circuits for real life applications.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	-	3	-	-	1	3	1	-	-	2	1
CO2	3	2	2	-	3	-	-	1	3	1	-	-	3	2
CO3	3	3	2	-	3	-	-	1	3	1	-	-	3	3
CO4	3	3	2	-	3	1	1	1	3	2	2	2	3	3

Course Contents

Design experiments (both hardware design and simulation) to support the contents of Electromagnetic Waves and Transmission Lines, RF Circuits and Components, Communication networks Use of Simulation tools to simulate and verify various fundamental ideas in the above courses.

References

Class notes & Lab manual

EC340 COMPUTER ORGANIZATION AND ARCHITECTURE (3-1-0) 4

Course Outcomes:

CO1: Understand the architecture of a basic computer system and its components, and the role of performance in designing computer systems.
CO2: Understand memory hierarchy design and its impact on overall processor performance.
CO3: Design ALU. processor data path and control path.
CO4: Design pipeline processor including hazard detection logic.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	-	-	-	-	-	-	-	-	-	2	2	-
CO2	3	2	2	-	2	-	-	-	-	-	-	2	2	-
CO3	3	3	3	-	3	-	-	-	-	-	-	2	2	2
CO4	3	3	3	3	3	-	-	-	-	-	-	2	2	2

Course Contents

Digital Computer Organization, CPU Design, CPU Design Tirning and Control, Micro programmed Control, Pipeline Concept, Memory Organization, Cache Memory Architecture, RAM Architecture SRAM and DRAM Architectures, Secondary Storage Organization.

References

John Hayes, Computer Architecture and Organization, 3rd Ed. McGraw Hill 2017.

John Hennessy and David Patterson, Computer Architecture - A Quantitative Approach 6th Edition, Morgan Koufmann, 2017

John Hennessy and David Patterson, Computer Architecture - A Quantitative Approach 5th Edition, Morgan Koufmann, 2011

EC341 COMPUTER ARITHMETIC (3-1-0) 4

Course Outcomes:

CO1: Understand various types representations for numbers and sources of errors in arithmetic.
CO2: Evaluate algorithms for fast arithmetic and evalaution of functions.
CO3: Design of fast adders.
CO4: Design of multiplication and division circuits.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	-	-	-	-	-	-	-	-	-	-	2	2	-
CO2	3	2	-	-	1	-	-	-	-	-	-	2	2	-
CO3	3	3	2	2	2	-	-	-	-	-	-	2	2	2
CO4	3	3	3	3	2	-	-	-	-	-	-	2	2	2

Course Contents

Number Representation : Numbers and Arithmetic, Representing Signed Number, Redundant Number Systems, Residue Number Systems, Double base number systems, Addition/Subtraction: Basic Addition and Counting, Carry-Look ahead Adder, Variations in Fast Adders, Multi-Operand Addition, Multiplication: Basic Multiplication Schemes, High-Radix Multipliers, Tree and Array Multipliers, Variations in Multipliers, Division: Basic Division Schemes, High-Radix Dividers, Variations in Dividers, Division by Convergence, Real Arithmetic: Representing the Real Numbers, Floating-Point Arithmetic, Arithmetic Errors and Error Control, Precise and Certifiable Arithmetic, Function Evaluation: Square-Rooting Methods, The CORDIC Algorithms, Variations in Function Evaluation, Arithmetic by Table Lookup, Implementation Topics : High Throughput Arithmetic, Low-Power Arithmetic, Fault-Tolerant Arithmetic, Past, Present, and Future

References

I. Koren, Computer Arithmetic Algorithms, 2nd Edition, A. K. Peters (part of CRC Press), 2002

M. Ercegovac and T. Lang, Digital Arithmetic, Morgan Kaufman, 2003.

B. Parhami, Computer Arithmetic: Algorithms and Hardware Design, Oxford University Press 2000.

Literature from the web including the proceedings of IEEE Intl. Conference on Computer Arithmetic.

EC342 EMBEDDED SYSTEM DESIGN (2-0-3) 4

Course Outcomes:

CO1: Understand the differences between the general computing system and the embedded system, also recognize the classification of embedded systems.
CO2: Analyze various components of embedded hardware and software.
CO3: Design a medium complexity embedded system under specified design constraints.
CO4: Analyze various examples of embedded systems based on their design and identify its performance critical points.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	1	-	-	-	-	-	-	-	-	-	3	-
CO2	3	2	2	-	-	-	-	-	-	-	-	-	3	-
CO3	3	3	3	3	1	-	-	-	-	-	2	1	3	3
CO4	3	3	1	-	-	-	-	-	-	-	-	-	3	3

Course Contents

Introduction: Overview of embedded systems, embedded system design challenges, common design metrics and optimizing. Survey of different embedded system design technologies & trade-offs. Embedded microcontroller cores, embedded memories, Examples of embedded systems. Architecture for embedded system, High performance processors – strong ARM processors, programming, interrupt structure, I/O architecture, Technological aspects of embedded systems: interfacing between analog and digital blocks, signal conditioning, Digital signal processing, Subsystem interfacing, interfacing with external systems. Software aspects of embedded systems: real time programming languages and operating systems for embedded systems – RTOS requirements, kernel types, scheduling, context switching, latency, inter-task communication and synchronization, Case studies.

References

Jack Ganssle, The Art of Designing Embedded Systems, Elsevier, 1999.
J.W. Valvano, Embedded Microcomputer System: Real Time Interfacing, Brooks/Cole, 2000.
David Simon, An Embedded Software Primer, Addison Wesley, 2000.
H. Kopetz, Real-time Systems, Kluwer, 1997
R. Gupta, Co-synthesis of Hardware and Software for Embedded Systems, Kluwer 1995.
Gomaa, Software Design Methods for Concurrent and Real-time Systems, Addison-Wesley, 1993.
Steve Furber, "ARM System Architecture", Edison Wesley Longman, 1996.
Andrew N. Sloss, Dominic Symes, Chris Wright, "ARM System Developer's Guide: Designing and Optimizing System Software", Elsevier, 2004.

EC343 FPGA BASED SYSTEM DESIGN **(2-0-3) 4**

Course Outcomes:

CO1: Design simple digital systems given a set of specifications.
CO2: Model digital systems using HDL given a set of specifications.
CO3: Appreciate architecture of FPGAs and implement digital sub-systems using FPGAs.
CO4: Design and Implement digital system using FPGAs for target application.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	2	-	2	-	-	-	-	-	-	2	2	-
CO2	3	3	2	2	3	-	-	-	-	-	-	2	2	1
CO3	1	3	2	2	3	-	-	-	-	-	-	-	2	2
CO4	3	3	3	3	3	-	-	-	2	2	-	-	2	3

Course Contents

Digital system design options and trade-offs, Design methodology and technology overview, High Level System Architecture and Specification: Behavioral modeling and simulation, Hardware description languages, combinational and sequential design, state machine design, synthesis issues, test benches. Overview of FPGA architectures and technologies: FPGA Architectural options, granularity of function and wiring resources, coarse vs fine grained, vendor specific issues (emphasis on Xilinx and Altera), Logic block architecture: FPGA logic cells, timing models, power dissipation I/O block architecture: Input and Output cell characteristics, clock input, Timing, Power dissipation, Programmable interconnect - Partitioning and Placement, Routing resources, delays; Applications - Embedded system design using FPGAs, DSP using FPGAs, Dynamic architecture using FPGAs, reconfigurable systems, application case studies. Simulation / implementation exercises of combinational, sequential and DSP kernels on Xilinx / Altera boards.

References

M.J.S. Smith, Application Specific Integrated Circuits, Pearson, 2000
Peter Ashenden, Digital Design using VHDL, Elsevier, 2007
Peter Ashenden, Digital Design using Verilog, Elsevier, 2007
Clive Maxfield, The Design Warriors's Guide to FPGAs, Elsevier, 2004

EC344 ANALOG INTEGRATED CIRCUITS (3-1-0) 4

Course Outcomes:
CO1: Understand the importance of the MOSFET as a component in analog VLSI circuits.
CO2: Analyze MOSFET based circuits for DC operating point and small-signal behaviour.
CO3: Design single ended and differential amplifiers.
CO4: Design two stage fully differential amplifier and evaluate its performance for closed loop applications.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	-	-	-	-	-	-	-	-	-	-	2	1
CO2	2	2	-	-	-	-	-	-	-	-	-	-	2	1
CO3	2	3	1	2	-	-	-	-	-	-	-	-	2	2
CO4	2	3	2	2	-	-	-	-	-	-	-	-	2	2

Course Contents

MOSFET - Review of current equation, regions of operation, small signal model. Current mirrors, Single-ended amplifiers: CS amplifier CG and CD amplifiers, CMOS differential amplifiers: DC analysis and small signal analysis of differential amplifier with Resistive load, current mirror load and current source load, Input common-mode range and Common-mode feedback circuits. OTAs vs Opamps. Slew rate, CMRR, PSRR. Two stage amplifiers, Compensation in amplifiers (Dominant pole compensation).

References

Behzad Razavi, Fundamentals of Microelectronics, Second edition, Wiley, 2013
Sedra and Smith, Microelectronics Circuits, Oxford Univ. Press, 2004

EC345 DATA STRUCTURES AND ALGORITHMS (3-0-2) 4

Course Outcomes:
CO1: Analyze basic runtime of a computer program.
CO2: Implement basic data structures and algorithms.
CO3: Implement graph based data structures and algorithms.
CO4: Formulate a computation problem in terms of data structures and algorithms.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	-	-	-	-	-	-	2	-	-	-	3	3
CO2	3	2	-	-	1	-	-	-	2	-	-	-	3	3
CO3	3	2	-	-	1	-	-	-	2	-	-	-	3	3
CO4	3	2	-	-	2	-	-	-	2	-	-	-	3	3

Course Contents

Algorithm analysis, Asymptotic notations. Divide and Conquer algorithms, Analysis of divide and conquer algorithms, master method, examples - merge sort, quick sort, binary search, Data structures, Linked list, stacks and queues, insertion/deletion and analysis, Binary search trees Hash Tables – hash function and properties, collision handling, bloom filters, Greedy algorithms and Dynamic programming examples. Graph traversal , DFS, BFS, shortest path algorithms Dijkstra's and Bellman Ford algorithm, Minimum spanning trees, min cut .

References
Sartaj Sahni, Data Structures, Algorithms and Applications in C++, Universities Press, 2005
A.V. Aho, J.E. Hopcroft and J. D. Ullman, Data structures and Algorithms, Pearson, 2004.
T.H.Cormen, C.E. Leiserson, R.L. Rivest, C. Stein, Introduction to Algorithms, PHI, 2004.
Mark Allen Weiss, Algorithms, Data structures and problem solving with C++, Pearson, 2002.

EC346 FOUNDATIONS OF MACHINE LEARNING (3-1-0) 4

Course Outcomes:
CO1: Understanding basic mathematical tools from Linear algebra, Probability and Optimization.
CO2: Analyzing the Practical aspects of Pattern recognition algorithms in using theoretical concepts.
CO3: Apply concepts to devise Pattern Recognition problems.
CO4: Solving computer vision problems in a wide range of applications.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	-	-	-	-	-	-	-	-	-	3	1
CO2	3	3	2	-	1	-	-	-	-	-	-	-	3	1
CO3	3	3	2	-	2	-	-	-	-	-	-	-	3	3
CO4	3	3	3	2	2	-	-	2	2	-	-	-	3	3

Course Contents
Statistical foundations, Different Paradigms of Pattern Recognition, Probability estimation, Proximity measures, Feature extraction, Feature extraction, Different approaches to Feature selection, Nearest Neighbour Classifier and variants, Efficient implementations, Prototype selection. Bayes classification. Linear models, regression, logistic regression, neural networks, objective function and learning, backpropagation. Kernel based methods, support vector machines. Dimensionality reduction, principal component analysis, reconstruction, discriminant analysis. Clustering, K-means algorithm, distance measure, objective function, initialization. Anomaly detection, recommender systems. Scaling of algorithms.

References
R. O. Duda, P. E. Hart and D. G. Stork Pattern Classification, Wiley Publications, 2001
D. McKay Information Theory, Inference, and Learning Algorithms, Cambridge University Press 2003
C. M. Bishop Pattern Recognition and Machine Learning, Springer, 2006

EC347 SPEECH AND AUDIO PROCESSING (3-1-0) 4

Course Outcomes:
CO1: Understand the concept of non stationary signals.
CO2: Learn time frequency characteristics to speech and audio signals.
CO3: Analyze speech and audio signals using tools such as LPC, Cepstrum, filterbanks etc.
CO4: Study building blocks of speech and music technology.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	-	-	-	-	-	-	-	-	-	-	3	2
CO2	3	2	-	-	-	-	-	-	-	-	-	-	3	2
CO3	3	2	-	-	-	-	-	-	-	-	-	-	3	2
CO4	3	2	1	-	-	-	-	-	-	-	-	-	3	2

Course Contents
Speech Production–human speech production mechanism, acoustic theory of speech production, digital models for speech production. Speech perception– human hearing, auditory psychophysics, JND, pitch perception, auditory masking, models for speech perception. Speech Analysis–Time and frequency domain analysis of speech, speech parameter estimation, Linear prediction. Speech compression–quality measures, waveform coding, source coders, Speech compression standards for personal communication systems. Audio processing–characteristics of audio signals, sampling, Audio compression techniques, Standards for audio compression in multimedia applications, MPEG audio encoding and decoding, audio databases and applications. Speech synthesis–text to speech synthesis, letter to sound

rules, syntactic analysis, timing and pitch segmental analysis. Speech recognition–Segmental feature extraction, DTW, HMMs, approaches for speaker, speech and language recognition and verification

References

Douglas O'Shaugnessy, Speech Communication–Human and Machine, IEEE Press, 2000
L R Rabiner, Digital Processing of Speech Signals, Pearson,1978 T.F Quatieri, Discrete-time speech signal processing: Principles and Practise Pearson,2002
Zi Nian Li, Fundamentals of Multimedia, Pearson Education, 2003

EC348 IMAGE AND VIDEO PROCESSING (3-1-0) 4

Course Outcomes:
CO1: Understand the concepts of 2D Signals & Systems, 2D sampling and analysis of 2D LTI Systems.
CO2: Understand the concepts of 2D Image Transfons and their applications.
CO3: Able to deisgn and develop algorithms for image enhacement, image restoration and image compression.
CO4: Able to deisgn and develop algorithms for segmentation and dobject detection in real- time application.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	-	-	-	-	-	-	-	-	-	3	2
CO2	3	3	2	-	-	-	-	-	-	-	-	-	3	2
CO3	3	3	2	-	2	-	-	-	-	-	-	-	3	3
CO4	3	2	3	2	2	2	-	1	1	-	-	-	3	3

Course Contents

Digital image fundamentals–image acquisition, representation, visual perception, quality measures, sampling and quantization, basic relationship between pixels, imaging geometry, color spaces, Video spaces, analog and digital video interfaces, video standards. Two dimensional systems – properties, analysis in spatial, frequency and transform domains. Image transforms - DFT, DCT, Sine, Hadamard, Haar, Slant, KL transform, Wavelet transform. Image enhancement–point processing, spatial filtering, Image restoration–inverse filtering, de-blurring Video processing–display enhancement, video mixing,video scaling, scan rate conversion, Image compression–lossless and lossy compression techniques, standards for image compression-JPEG, JPEG2000. Video compression–motion estimation, intra and interframe prediction, perceptual coding, standards-MPEG, H.264 Image segmentation–feature extraction, region oriented segmentation, descriptors, morphology, Image recognition

References

R. C. Gonzalez and R E Woods, Digital Image Processing, Pearson Education, 2002
A K Jain, Fundamentals of Digital Image Processing, Pearson Education,1989
W Pratt, Digital Image Processing, Wiley , 2001
Al Bovik, Handbook of Image and Video, Academic Press, 2000
Keith Jack, Video Demystified, LLH 2001

EC349 APPLIED NUMBER THEORY (3-1-0) 4

Course Outcomes:
CO1: Appreciate and understand the importance of the prime numbers.
CO2: Apply the techniques to solve problems in number theory.
CO3: Use computational tools to determine the patterns in the numbers.
CO4: Apply the theory and techniques to solve engineering problems.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	-	-	-	-	-	-	-	-	-	1	2	3
CO2	1	3	-	-	-	-	1	-	1	1	1	1	2	2
CO3	-	-	2	2	3	-	-	2	1	-	1	-	2	2
CO4	-	-	3	3	3	2	1	2	1	1	1	1	2	3

Course Contents

Prime numbers, Divisibility and GCD, Congruences, Powers, Fermat's Little theorem, Euler's theorem, Euler's totient function, Chinese Remainder theorem, Diophantine equations, Residue Number system (RNS), Double base number system(DBNS), Signal Processing and Number Theory: Review of DFT and circular convolution, Number theory and DFT, Consequences of Euler's theorem for Signal Processing, Communication Engg: PN sequences, Polynomials and Euclidean algorithm, Generation of PN sequences application of PN sequences.

References

Thomas Koshy, Elementary Number Theory with Applications, 2nd Ed, Associated Press, 2007.
Amos R. Omondi and Benjamin Premkumar, Residue Number Systems: Theory and Implementation, World Scientific, 2007.
Hari Krishna Garg, Digital Signal Processing Algorithms: Number Theory, Convolution, Fast Fourier Transforms, and Applications, 1st Ed, CRC Press, 2000.

EC350 NUMERICAL ANALYSIS (3-1-0) 4

Course Outcomes:

CO1: Appreciate, understand and apply the Numerical analysis theory for solving problems.
CO2: Apply the techniques to various problems of engineering and technology.
CO3: Develop numerical techniques and algorithms using computing technology.
CO4: Apply the theory and techniques to solving concrete engineering problems.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	-	-	-	-	-	-	-	-	-	-	2	1	1
CO2	1	3	-	-	-	-	1	-	1	-	-	2	1	3
CO3	-	-	3	-	2	-	-	1	1	-	1	1	1	1
CO4	-	-	1	3	-	2	-	-	-	1	-	1	1	3

Course Contents

Preliminaries on numerical analysis, Errors and measuring efficiency , Review of Linear Algebra, Iterative techniques in matrix algebra, elimination method, inverse of a matrix, ill conditioned systems, eigen values, eigen vectors, LU and QR factorization. Solving nonlinear equations, bisection, Newton's method, Mullers method, fixed point interpolation, steepest descent. Interpolation and curve fitting: interpolating polynomials, spline curves, interpolation on a surface, least square approximations. Approximation of functions: Fourier basis and orthogonal polynomials, rational function approximation. Numerical differentiation and integration, solution of ordinary differential equations: Taylor series method, Euler method, Runge-Kutta method. Solution of partial differential equations, finite element methods, optimization.

References

Francis B. Hildebrand, Introduction to Numerical Analysis, 2nd Ed, Dover.
SD Conte, C de Boor, Elementary numerical analysis: An algorithmic approach, 3rd Ed, Mc Graw Hill, 1981.
R.L. Burden & J.D. Faires, Numerical Analysis, 9th Ed, Brooks/Cole, Cengage Learning, 2011.

EC351 SATELLITE COMMUNICATIONS (3-1-0) 4

Course Outcomes:

CO1: Understand the various terminologies , needs for satellite network infrastructures.
CO2: Be able to apply the knowledge to suggest newer technologies for effective wireless communication.
CO3: Evaluate a given Satellite infrastructure for its efficiency , Power requirements, Noise and signal level calculations.
CO4: Implement a infrastructure to communicate between two remote locations.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	-	-	-	-	1	-	-	-	1	-	-	1	1
CO2	2	2	-	-	-	-	-	-	-	-	1	-	3	1
CO3	3	2	-	1	-	-	-	-	-	-	-	-	3	2
CO4	2		3	-	-	1	-	-	-	-	1	-	3	2

Course Contents

Introduction to satellite Communications, Space craft, space craft sub systems, Altitude and orbit control systems, Telemetry, tracking and command, Power Systems, Communication sub systems, description of communication systems, transponders, Space craft antennas, Equipment reliability and space qualification, Multiple access systems, FDMA, FDM/FM/FDMA, TDMA, CDMA spread spectrum transmission and reception. Applicability of CDMA to commercial systems, demand access in the INTELSAT. TDMA system, SPADE, the INMARSAT system, Earth station, Satellite television networks.

References

T. Pratt, Satellite communications, John Wiley, 2002
T. T. Ha., Digital satellite communication, Collier Macmillan, 1986

EC352 PRINCIPLES OF MODERN RADAR AND TECHNIQUES (3-1-0) 4

Course Outcomes:

CO1: To understand the elementary concepts of radar systems, radar range equation, Doppler effect, radar transmitters, receivers, and antennas.
CO2: To apply, analyse and solve problems based on the concepts associated radar systems, radar range equation, Doppler effect, radar transmitters, receivers, and antennas.
CO3: To derive the inferences from exiting radar systems, radar range equation, Doppler effect, radar transmitters, receivers, and antennas.
CO4: To design the radar systems for various applications including short range, long range, ground based and air borne radars.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	2	2	1	0	0	0	0	0	0	3	3
CO2	3	3	2	2	2	1	0	0	0	1	0	0	2	1
CO3	3	3	3	3	1	1	0	0	1	1	0	0	2	1
CO4	3	3	3	3	3	1	1	1	1	1	0	0	3	3

Course Contents

Introduction and Radar Overview, The Radar Range Equation, Radar Search and Overview of Detection in Interference; External Factors: Propagation Effects and Mechanisms, characteristics of Clutter Target Reflectivity, Target Fluctuation Models, Doppler Phenomenology and Data Acquisition Subsystems: Radar Antennas, Radar Transmitters, Radar Receivers, Radar Exciters, and The Radar Signal Processor

References

Mark A Richards, Principles of modern radar (POMR)-Basic principles(Vol-1), Scitech publishers
R. Skolnik, Modern Radar Systems, 3rd edition, Mc-Graw Hill Publishers

EC353 MODERN ELECTRONIC NAVIGATION SYSTEMS (3-1-0) 4

Course Outcomes:

CO1: To understand GNSS receivers, inertial navigation, Kalman filtering and differential GNSS.
CO2: Apply, analyse and solve problems based on the concepts associated with GNSS receivers, inertial navigation, Kalman filtering and differential GNSS.
CO3: Derive the inferences from exiting GNSS receivers, inertial navigation, Kalman filtering and differential GNSS.
CO4: Design the advanced techniques with GNSS receivers, inertial navigation, Kalman filtering and differential GNSS.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	2	2	1	0	0	0	0	0	0	3	2
CO2	3	3	2	2	2	1	0	0	0	1	0	0	2	1
CO3	3	3	3	3	2	1	0	0	1	1	0	0	2	1
CO4	3	3	3	3	3	1	1	1	1	1	0	0	1	1

Course Contents

GNSS overview: GPS, GLONASS, Galileo;Fundamentals of Satellite and Inertial Navigation, Signal Characteristics and Information Extraction; Receiver and Antenna Design.Differential GNSS. Kalman filtering, Inertial Navigation systems.

References

Mohinder S. Grewal, Lawrence R. Weill, Angus P. Andrews, Global positioning systems, intertial navigation and integration, Second edition, Wiely, 2010

EC354 COMMUNICATION NETWORKS **(3-1-0) 4**

Course Outcomes:

CO1: Understand the various terminologies , concepts and issues in modern Communication networks.
CO2: Suggest a typical solution to implement or improve an existing network.
CO3: Evaluate an existing or new communication infrastructure in terms of delay, efficiency, latency etc.
CO4: Able to create new wireless cellular networks.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	-	-	-	-	-	-	-	-	-	-	-	2	1
CO2	1	2	2	-	-	-	-	-	-	-	-	-	2	1
CO3	3	2	1	-	-	-	-	-	-	1	-	-	3	2
CO4	1	-	3	-	2	-	-	1	-	-	1	-	3	2

Course Contents

Switching techniques, Multiplexing and Multiple Access techniques, Packet Switched Networks. OSI and TCP/IP Models, Internet protocols and addressing, networking devices, data links and transmission, LANs and Network of LANS, Wireless Networks and Mobile IP, Routing and internetworking, transport and end to end protocols, congestion control techniques, Application Layer and network management, Network Security. Packet Queues and delays, Little's theorem, Birth and death process, Queuing disciplines, M/M/1 Queues, Burkes and Jackson theorems. Traffic models, ISDN, ATM Networks, Quality of service and resource allocation, VPNs and MPLS, Cellular Telephone and Optical networks, VOIP and Multimedia networking. Mobile Adhoc Networks and Wireless Sensor Networks

References

Nader F. Mir, Computer and Communication Networks, Pearson Education, 2007
Garcia and Widjaja, Communication Networks, McGraw Hill, 2006
J.F. Hayes, Modelling and analysis of Computer Comm. Networks, Plenum, 1984.
Jean Walrand & Pravin Varaiya, High Performance Communication Networks , Morgan Kaufmann Publishers, 2002

EC355 WIRELESS MOBILE COMMUNICATION **(3-1-0) 4**

Course Outcomes:

CO1: Have a good understanding of the concepts, terminologies and issues in the development of Cellular communication.
CO2: Be able to suggest typical solutions to implement Mobile Communication networks in a given geography.
CO3: Analyze a existing wireless communication network , while suggesting modified modern solutions.
CO4: Implement a modern cellular network solution, in a given geographical location, as per the needs of the society at large.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	-	-	-	-	1	-	2	-	-	-	-	2	1
CO2	-	2	3	-	-	-	-	-	-	-	-	-	2	1
CO3	3	2	2	-	-	-	-	-	-	1	-	-	3	2
CO4	2	-	3	-	-	-	-	-	2	-	-	-	3	2

Course Contents

Concepts of cellular communication, Geometry of hexagonal cells; Co-channel interference, cellular system design in worst case, co-channel interference with the use of directional antennas, Cell splitting, Frequency allocation in mobile, Power control, JDC, JDC frame structure, TDMA, TDMA frame, delayed in TDMA, advantages CDMA, Capacity Comparison of FDM /TDM systems and cellular CDMA. Standards for Wireless mobile communication, Micro cells, high way micro cells, spectral efficiency, traffic carried, Signalling and call control; Mobility management, Location tracking. Wireless data networking.

References

G.L. Sterber, Principles of Mobile Communications, Kluwer Academic, 1996.
T.S .Rappaport, Wireless communications, Principles and Practice, , Pearson Edn, 2002.
William C.Y. Lee, Mobile cellular telecommunication systems: Analog & Digital Systems, McGraw Hill, 1995.

EC356 INFORMATION THEORY AND CODING (3-1-0) 4

Course Outcomes:

CO1: Understand and solve elementary problems involving concepts of Information Quantification, Entropy, Joint and Mutual Information and Information Capacity.
CO2: Understand the principles of lossy and loss less compression. Apply, analyse and solve problems based on advanced concepts involving loss-less and lossy compression algorithms.
CO3: Derive mathematical models to describe the working of compression systems and communication systems. Derive the AWGN capacity equation and determine different regions of operation and their sigificance.
CO4: Design simple error control codes. Perform Monte Carlo simulation platforms to simulate the functioning of a few selected error control codes and analyse their performance.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	1	-	-	-	-	-	1	-	2	2	2
CO2	3	2	3	1	-	-	-	-	-	1	-	2	2	2
CO3	3	3	2	2	-	-	-	-	-	1	1	1	2	1
CO4	3	2	2	1	3	-	-	-	-	2	1	2	2	2

Course Contents

Communication systems and Information Theory, Measures of Information, Coding for Discrete sources, Discrete memory-less channels and capacity, Noisy channel coding theorem, Techniques for coding and decoding, Waveform channels, Source coding with Fidelity criterion.

References

Thomas M Cover & Joy A Thomas, Elements of Information Theory, John Wiley,1991
R.G.Gallagher, Information Theory and Reliable Communication, Addison Wesley, 1987.
A.J.Viterbi & J.K. Omura, Principles of Digital Communications and Coding, McGraw Hill, 1979.

EC357 ADHOC AND SENSOR NETWORKS **(3-1-0) 4**

Course Outcomes:
CO1: Under stand the various terminologies, algorithms and networking concepts, so as to be able to identify the various applications.
CO2: Able to analyze the algorithms when implemented in specific real life scenarios.
CO3: Evaluate a certain sensor network for its efficiency in terms of different protocols used.
CO4: Able to design a sensor network environment for atypical application.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	-	-	-	1	-	1	-	-	-	-	-	2	1
CO2	-	2	-	-	2	-	-	-	-	-	-	-	2	1
CO3	2	2	2	3	-	-	-	-	-	-	-	-	3	2
CO4	-	-	3	2	-	-	1	-	-	-	-	-	3	2

Course Contents
Mobile ad hoc networks and wireless sensor networks concepts and architectures. Routing: proactive routing, Broadcasting and multicasting, TCP over mobile ad hoc networks, Wireless LAN (WiFi) standards, Medium Access Control Protocol issues power control, spatial reusability, and QoS, Bluetooth, Wireless sensor networks architecture: hardware and software components of a sensor node, OS for WSN, WSN MAC layer strategies; naming and addressing; Clock Synchronization; Node Localization; WSN Routing.

References
C Sivarama Murthy and B S Manoj, Ad-Hoc Wireless Networks, Architectures and Protocols, PH , 2004.
Labiod.H, Wireless Adhoc and sensor networks, Wiley, 2008.
Li,X , Wireless ad hoc and sensor networks: theory and applications, Cambridge University Press,2008

EC358 MULTIMEDIA COMMUNICATION TECHNIQUES **(3-1-0) 4**

Course Outcomes:
CO1: Understand the basics of multimedia presentation, Synchronization and compression.
CO2: Design a multimedia system and Architecture for Multimedia Processing.
CO3: Understand multimedia Management, Delivery and video-conferencing standards.
CO4: Design a Multimedia Data base, analyze the image, audio and video retrival.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	-	-	-	-	-	-	-	2	-	-	2	1
CO2	2	2	-	-	-	-	-	-	-	2	-	-	2	1
CO3	2	3	-	-	-	-	-	-	-	2	-	-	2	1
CO4	2	3	-	-	-	-	-	-	-	2	-	-	2	1

Course Contents
Representation of Multimedia Data, Concept of Non-Temporal and Temporal Media, MultimediaPresentations, Synchronization. Compression of Multimedia Data, Basic concepts of Compression, Audio Compression Introduction to Speech and Audio Compression, Multimedia System Design, General Purpose Architecture for Multimedia Processing, Operating System support for Multimedia, Data, Resource Scheduling with real-time considerations, File System, I/O Device, Management, Delivery of Multimedia data, Network and Transport Protocols, QoS issues, RTP and RSVP, Video-conferencing and video-conferencing standards, Overview of Voice over IP, Multimedia Information Management, Multimedia Data base Design, Content Based Information Retrieval, Image Retrieval, Video Retrieval, Overview of MPEG-7.

References
Ralt Steinmetz and Klara Nahrstedt, Multimedia : Computing, Communication & Applications, Pearson Education Publications, 2004.

EC359 SOFTWARE DEFINED AND COGNITIVE RADIO **(3-1-0) 4**

Course Outcomes:
CO1: Learn the architecture of the wireless networks based on the cognitive radio.
CO2: Learn the hardware and software architecture of software defined radio.
CO3: Design the wireless networks based on the cognitive radio.
CO4: Design the simple digital communication systems using software defined radio.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	-	-	-	-	-	-	-	-	-	2	2	-
CO2	3	2	2	-	2	-	-	-	-	-	-	2	2	-
CO3	3	3	3	-	3	-	-	-	-	-	-	2	2	2
CO4	3	3	3	3	3	-	-	-	-	-	-	2	2	2

Course Contents
Cognitive radio: goals, benefits, definitions, architectures, Spectrum-Licensed, unlicensed, shared unlicensed, opportunistic unlicensed, Current spectral usage and issues, Regulations, regulation changes, Spectral awareness, Spectrum adaptation, Dynamic frequency selection, Spectrum Sharing priority allocation, Adaptive bandwidth control Policies, Adaptation and optimization- link adaptation, incremental redundancy, jointly adaptive source and channel coding, Digital signal processing role in SDR, Cross-layer optimization (adaptation), Current cellular cognitive features-Hand-off, Channel allocation, cellular network design, Link adaptation, incremental redundancy, Interference avoidance, detection, and cancellation, Power control, Femto cells and relation to cognitive radio. 2.5G/3G/4G cognitive features, Multi-carrier system adaptation (OFDM(A) adaptive features), Collaboration and cooperation in wireless devices, networks, and systems Interference awareness, Multi-dimensional channel variation and dispersion - relation with adaptive radio, Applications of CR into public safety and other applications of CR ,Vertical hand-off and network interoperability - network awareness, multi-tier networks, Biologically inspired cognitive features (like Bats, Ants, human being, etc)

References
Hoseyin Arslan (Ed.), "Cognitive Radio, Software Defined Radio, and Adaptive Wireless Systems," Ser. Signals and Communication Technology, xviii, I. edition, Springer, August 2007
Joseph Mitola, III, "Cognitive Radio Architecture: The Engineering Foundations of Radio XML," John Wiley and Sons Ltd., 2006.
Jeffrey H. Reed, "Software Radio: A Modern Approach to Radio Engineering," Prentice Hall PTR, 2002.
Walter H.W. Tuttlebee, "Software Defined Radio: Enabling Technologies," John Wiley and Sons Ltd., 2002.
Markus Dillinger and Kambiz Madani and Nancy Alonistioti, "Software Defined Radio: Architectures, Systems and Functions," John Wiley and Sons Ltd., 2003.

EC360 MACHINE LEARNING FOR WIRELESS COMMUNICATION SYSTEMS **(3-1-0)4**

Course Outcomes:
CO1: Apply the mathematical principles of probability, linear algebra and optimisation.
CO2: Understand the principles of machine learning and apply the fundamental principles for regression and classification.
CO3: Design and optimise intelligent mobile networks by applying the principles of machine learning.
CO4: Apply machine learning principles in the design of some physical layer techniques in wireless communications.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	-	-	-	-	-	-	-	-	-	2	2	-
CO2	3	2	2	-	2	-	-	-	-	-	-	2	2	-
CO3	3	3	3	-	3	-	-	-	-	-	-	2	2	2
CO4	3	3	3	3	2	-	-	-	-	-	-	2	2	2

Course Contents

Need for machine learning techniques in wireless communication, Introduction to machine learning, Supervised, unsupervised, and reinforcement learning, Gaussian model, HMM, Clustering, Sequence recognition and analysis, Bayesian networks, Factor graphs, Markov chain Monte Carlo (MCMC) methods, Channel modelling and prediction using machine learning algorithms, Deep learning based channel estimation, Spectrum sensing and signal identification in cognitive radios using machine learning, Machine learning techniques for adaptive modulation and coding techniques, CNN based equalizer design, DNN based channel coding techniques (LDPC and Polar codes), Machine learning algorithms for MIMO communications, Compressive sensing for wireless sensor networks, Reinforcement learning-based channel sharing in wireless vehicular networks.

References

Ruisi He, and Zhiguo Ding (Editors), "Applications of Machine Learning in Wireless Communications", IET Press, 2019.
Fa-Long Luo (Editor), "Machine Learning for Future Wireless Communications", IEEE Press & Wiley, 2020.
Osvaldo Simeone, "A Brief Introduction to Machine Learning for Engineers", Now Publishers, 2018.
A. C. Faul, "A Concise Introduction to Machine Learning", CRC Press, 2020.

EC361 SPARSE REPRESENTATIONS AND COMPRESSIVE SENSING (3-1-0) 4

Course Outcomes:
CO1: Understand the generalization from basis to frames for vector representations.
CO2: Apply different models for low dimensional signals.
CO3: Understand low dimensional signal sensing using a model.
CO4: Recover the signal that is sensed using low dimensional model.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	-	-	-	-	-	-	-	-	-	-	3	2
CO2	3	2	-	-	-	-	-	-	-	-	-	-	3	2
CO3	3	2	-	-	-	-	-	-	-	-	-	-	3	2
CO4	3	2	-	-	-	-	-	-	-	-	-	-	3	2

Course Contents

Introduction, mathematical preliminaries, Basis and Frames, Low dimensional signal models, Sensing matrices, Signal recovery via l1 minimization, Necessary and sufficient conditions for L0-L1 equivalence. RIP and random matrices. Johnson-Lindenstrauss Lemma, Stable signal recovery and restricted eigen value property. Recovery algorithms and their performance guarantees. Multiple measurement models and Applications.

References

S. Foucart and H. Rauhut, "A mathematical introduction to compressive sensing," Birkhauser Press, 2013.
M. Elad, "Sparse and Redundant Representations" Springer 2010.
H. Rauhut, "Compressive Sensing and structured random matrices",Radon series, Comp. Applied math. 2011.
Compressive Sensing Resources - http://dsp.rice.edu/cs/

EC362 DEEP REINFORCEMENT LEARNING (3-1-0) 4

Course Outcomes:
CO1: Able to understand concepts of basic and advanced reinforcement learning techniques.
CO2: Able to identification of suitable learning tasks to which these reinforcement learning techniques can be applied.
CO3: Able to identify stability/convergence and approximation properties of reinforcement learning techniques and appreciation of some of the current limitations of reinforcement learning techniques.
CO4: Able to formulate decision problems, set-up & run computational experiments, evaluation of results from experiments and their real applications.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	-	-	-	-	-	-	-	-	-	3	2
CO2	3	3	2	-	-	-	-	-	-	-	-	-	3	2
CO3	3	3	2	-	2	-	-	-	-	-	-	-	3	3
CO4	3	2	3	2	2	2	2	-	-	-	-	-	3	3

Course Contents

Introduction: Course logistics and overview. Origin and history of Reinforcement Learning research. Its connections with other related fields and with different branches of machine learning.

Markov Decision Process: Introduction to RL terminology, Markov property, Markov chains, Markov reward process (MRP). Introduction to and proof of Bellman equations for MRPs along with proof of existence of solution to Bellman equations in MRP. Introduction to Markov decision process (MDP), state and action value functions, Bellman expectation equations, optimality of value functions and policies, Bellman optimality equations.

Prediction and Control by Dynamic Programming: Overview of dynamic programming for MDP, definition and formulation of planning in MDPs, principle of optimality, iterative policy evaluation, policy iteration, value iteration, Banach fixed point theorem, proof of contraction mapping property of Bellman expectation and optimality operators, proof of convergence of policy evaluation and value iteration algorithms, DP extensions.

Monte Carlo Methods for Model Free Prediction and Control: Overview of Monte Carlo methods for model free RL, First visit and every visit Monte Carlo, Monte Carlo control, On policy and off policy learning, Importance sampling.

Temporal difference (TD Methods: Incremental Monte Carlo Methods for Model Free Prediction, Overview TD(0), TD(1) and TD(λ), k-step estimators, unified view of DP, MC and TD evaluation methods, TD Control methods - SARSA, Q-Learning and their variants.

Function Approximation Methods: Getting started with the function approximation methods, Revisiting risk minimization, gradient descent from Machine Learning, Gradient MC and Semi-gradient TD(0) algorithms, Eligibility trace for function approximation, After states, Control with function approximation, Least squares, Experience replay in deep Q-Networks.

Policy Gradients: Getting started with policy gradient methods, Log-derivative trick, Naive REINFORCE algorithm, bias and variance in Reinforcement Learning, Reducing variance in policy gradient estimates, baselines, advantage function, actor-critic methods.

References

Richard S. Sutton and Andrew G. Barto, "Reinforcement learning: An introduction", Second Edition, MIT Press, 2019.
Wiering, Marco, and Martijn Van Otterlo. "Reinforcement learning." Adaptation, learning, and optimization 12 (2012).
Li, Yuxi. "Deep reinforcement learning." arXiv preprint arXiv:1810.06339 (2018).
Goodfellow, Ian, Yoshua Bengio, and Aaron Courville. "Deep learning." MIT press, 2016. Reinforcement Learning resource: https://web.stanford.edu/class/cs234/modules.html

EC363 MACHINE LEARNING APPLICATIONS IN RADAR SIGNAL PROCESSING (3-1-0)4

Course Outcomes:

CO1: To understand the elementary concepts machine learning techniques, like regression, classification and prediction.
CO2: To apply, analyse and solve radar signal processing problems based on the concepts associated with machine learning techniques, like regression, classification and prediction.
CO3: To derive the inferences from exiting radar signal processing methods and find alternative ways utilize machine learning techniques for the same.
CO4: To design the machine learning methods various processes involved in radar signal processing.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	2	3	1	0	0	0	0	0	0	2	3
CO2	3	3	2	3	2	1	0	0	0	1	0	0	3	2
CO3	3	3	3	3	1	1	0	0	1	1	0	0	2	1
CO4	3	3	3	3	3	1	1	1	1	1	0	0	1	1

Course Contents

Review of machine learning (ML) algorithms. Applications of ML to Radar System design and analysis, processing range-Doppler using learning algorithms, various techniques applied to radar data acquisition, applications of ML algorithms to radar detection, designing ML algorithms for Radar target tracking and recognition. Principles of deep learning: various approaches of deep learning, Deep Learning Methods for Radar Detection, Classification/Estimation, and Tracking, tracking algorithms of multiple targets in multi-static configurations, Compressive-sensing-based learning technique, Through-the-wall imaging radars, MIMO radar applications, Deeplearning- based adaptive radar detection and tracking, and automotive applications.

References

Martin T. Hagan, Howard B. Demuth, Mark Hudson Beale, Orlando De Jesús, Neural Network Design, 2nd Edition, eBook. (Available for download from the author: https://hagan.okstate.edu/NNDesign.pdf)
James A., Mark A., Richards, William A., Scheer, Holm, Principles of Modern Radar, Volume I - Basic Principles, SciTech 2010.
J.D. Kelleher, Deep Learning, MIT Press, 2019. E Charniak, Introduction to Deep Learning, The MIT Press, 2018.
Lee Andrew Harrison, Introduction to Radar Using Python and MATLAB Illustrated Edition, Kindle Edition, Artech house, 2020.
Mark A. Richards - Fundamentals of Radar Signal Processing - McGraw-Hill 2014.

EC440 VLSI CAD (3-1-0) 4

Course Outcomes:

CO1: Understand and analyze various phases of physical design automation of a digital VLSI system.
CO2: Transform the Boolean/structural representation of a digital VLSI system into a graph.
CO3: Apply various physical design algorithms for partitioning, floorplanning, placement and routing of a digital system and analyze their trade-offs.
CO4: Develop a prototype EDA tool to transform a circuit level netlist into an optimized layout.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	1	1	1	-	-	-	-	-	-	1	3	-
CO2	3	3	1	3	3	-	-	-	-	-	-	2	3	1
CO3	3	3	2	3	3	1	-	-	1	1	-	2	3	2
CO4	3	3	2	3	3	1	-	1	2	2	2	3	3	2

Course Contents

Introduction to VLSI design automation: VLSI design methodologies, use of VLSI EDA tools, Algorithmic Graph Theory, computational Complexity; Partitioning: KL algorithm, FM algorithm, EIG Algorithm, Simulated Annealing. Floorplanning and placement: Sliced and non-sliced planning, Polish expression, Simulated annealing, partition based placement; ILP & mathematical programming, partition based, force directed, Fast-Place, quadratic placement algorithms. Routing: Global routing, detailed routing, graph models, Line Search, Maze Routing, Channel routing; via minimization, clock and power routing. High Level Synthesis: Introduction to HDL, HDL to DFG, operation scheduling: constrained and unconstrained scheduling, ASAP, ALAP, List scheduling, Force directed scheduling, operator binding; Static Timing Analysis: Delay models, setup time, hold time, cycle time, critical paths, Topological vs logical timing analysis, False paths, Arrival time, Required arrival Time, Slacks.Advanced VLSI Design Automation: Physical Synthesis, Optical Proximity correction, Interconnect issues

References

Naveed Sherwani, Algorithms for VLSI Physical Design Automation, 3rd ed., Kluwer Academic Pub., 1999
Majid Sarrafzadeh and C. K. Wong, An Introduction to VLSI Physical Design, McGraw Hill, 1996.
Sabih H. Gerez, Algorithms for VLSI Design Automation, John Wiley, 1998
Sung Kyu Lim, Practical Problems in VLSI Physical Design Automation, Springer, 2008
Sadiq M. Sait & Habib Youssef, VLSI Physical Design Automation: Theory and Practice, World Scientific Publishing, 1999

EC441 MIXED SIGNAL DESIGN (3-1-0) 4

Course Outcomes:
CO1: Develop basic understanding of CMOS circuit realization of ADCs and DACs.
CO2: Apply the concepts and analyze various architectures of ADCs and DACs.
CO3: Analyze and quantify the effects of non-idealities on the performance of ADCs and DACs.
CO4: Design basic ADCs and DACs.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	-	-	-	-	-	-	-	-	-	-	2	3
CO2	2	2	-	-	-	-	-	-	-	-	-	-	2	3
CO3	2	2	-	-	-	-	-	-	-	-	-	-	2	3
CO4	2	2	-	-	-	-	-	-	-	-	-	-	2	3

Course Contents
Sample and Hold Circuits: Basic S/H circuit, effect of charge injection, compensating for charge injection, bias dependency, bias independent S/H. D/A Converter – General considerations, Static non-idealities and Dynamic nonidealities; Current-steering DAC – Binary weighted DAC, Thermometer DAC, Design issues, Effect of Mismatches. A/D converter – General considerations, static and dynamic non-idealities. Flash ADC – Basic architecture, Design issues, Comparator and Latch, Effect of non-idealities, Interpolative and Folding architectures. Successive Approximation ADC; Pipeline ADC. Over sampling ADC – Noise shaping, Sigma-Delta modulator.

References
Behzad Razavi, Design of Analog CMOS Integrated Circuits McGraw-Hill International Edition 2016
David A. Johns and Ken Martin, Analog Integrated Circuit Design, John Wiley, 2002
Phillip E. Allen and Douglas R. Holberg, CMOS Analog Circuit Design, Oxford University Press, 2003.
Behzad Razavi, Principles of Data Conversion System Design, Wiley-IEEE Press, 1995
Rudy J. van de Plassche, CMOS Integrated Analog-to-Digital and Digital-to-Analog Converters, Springer, 2003

EC442 ADVANCED COMPUTER ARCHITECTURE (3-1-0) 4

Course Outcomes:
CO1: Understand basic aspects of advanced computer architectures.
CO2: Perform quantitative analysis of modern computing systems.
CO3: Evaluate the performance of available choices for exploiting parallelism in Instruction, data and memory.
CO4: Design a representative high performance computing subsystem/system within the given constraints.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	1	-	-	-	-	-	-	-	-	-	3	2
CO2	3	3	1	-	-	-	-	-	-	-	-	-	3	3
CO3	3	3	1	-	-	-	-	-	-	-	-	-	3	3
CO4	3	2	3	1	2	-	-	1	1	-	-	-	3	2

Course Contents
Instruction Level Parallelism: Pipelining, Hazards, Instruction Level Parallelism, Branch prediction, Static and Dynamic Scheduling, Speculation, Limits of ILP. Multicore Memory Hierarchy: Cache trade-offs, Basic and Advanced optimizations, Virtual Memory, DRAM optimizations. Multiprocessors: Symmetric and Distributed architectures, Cache coherence protocols - Snoopy and Directory based, ISA support for Synchronization, Memory Consistency Models. Interconnection Networks: Architectures, Topologies, Performance, Routing, Flow control, Future of NoCs.

References
John Hennessy and David Patterson, Computer Architecture - A Quantitative Approach 6th Edition, Morgan Koufmann, 2017

John Hennessy and David Patterson, Computer Architecture - A Quantitative Approach 5th Edition, Morgan Koufmann, 2011
John Paul Shen and Mikko H. Lipasti, Modern Processor Design: Fundamentals of Superscalar Processors, Tata McGraw Hill, 2013
D. A. Patterson and J. Hennessy, Computer Organization and Design, Harcourt Asia, 1998.
Behrooz Parhami, Computer Arithmetic Algorithms and Hardware Design, Oxford, 2000.

EC443 VLSI TESTING AND TESTABILITY (3-1-0) 4

Course Outcomes:
CO1: Understand the role of test generation and test application in VLSI design flow.
CO2: Analyze different fault models and test generation techniques.
CO3: Demonstrate fault list and test pattern generation for a given gate-level netlist..
CO4: Design logic subsystem conforming to testability requirements.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	-	-	-	-	-	-	-	-	-	3	1
CO2	3	3	1	-	-	-	-	-	-	-	-	-	3	1
CO3	3	3	2	-	2	-	-	-	-	-	-	-	3	3
CO4	3	2	3	1	2	-	-	1	1	-	-	-	3	3

Course Contents
Overview of testing and verification, Defects and their modeling as faults at gate level and transistor level. Functional V/s. Structural approach to testing. Complexity of testing problem. Controllability and observability. Generating test for a signal stuck-at-fault in combinational logic. Algebraic algorithms. Test optimization and fault coverage. Logic Level Simulation – Delay Models, Event driven simulation, general fault simulation (serial, parallel, deductive and concurrent). Testing of sequential circuits. Observability through the addition of DFT hardware, Adhoc and structured approaches to DFT – various kinds of scan design. Fault models for PLAs, bridging and delay faults and their tests. Memory testing, testing with random patterns. LFSRs and their use in random test generation and response compression (including MISRs), Built-in self-test.

References
M. Abramovici, M. A. Breuer, and A. D. Friedman, Digital Systems Testing and Testable Design, IEEE Press, 1994.
M. L. Bushnel and V. D. Agarwal, Essentials of Testing for Digital, Memory and Mixed – Signal VLSI Circuits, Kluwer Academic Publishers, 2000.
Ajai Jain, Learning Module for the course - VLSI Testing and Testability, IIT, Kanpur, 2001.

EC444 SYNTHESIS AND OPTIMIZATION OF DIGITAL CIRCUITS (3-1-0) 4

Course Outcomes:
CO1: Use BDD as a tool for binary logic representation and minimization.
CO2: Apply and analyze heuristic minimization algorithms to optimize 2-level and multi-level logic circuits.
CO3: Analyze algorithms to do retiming, static timing analysis and extract timing data in logic circuits.
CO4: Create an optimized logic function from an arbitrary complex logic function.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	1	1	1	-	-	-	-	1	-	1	3	-
CO2	3	3	1	3	3	-	-	-	1	1	-	2	3	1
CO3	3	3	2	3	3	-	-	-	1	1	-	2	3	2
CO4	3	3	2	3	3	-	-	-	1	1	-	3	3	2

Course Contents

Introduction to Computer aided synthesis and optimization. Hardware Modeling. Advanced Boolean Algebra and Applications – Boolean functions, representations, Shannon co-factors, satisfiability and cover, Binary Decision Diagrams, Representing Boolean functions, ROBDD, ITE operator, Variable ordering- choice of variables, application of BDD to synthesize Boolean functions, Two level combinational logic optimization, Multi-level combinational optimization. Sequential logic optimization. Cell Library Binding. Algorithms for Technology mapping – Structural and Boolean matching, Simulation & Static Timing analysis - Event driven simulation – zero delay, unit delay and nominal delay simulation, Timing analysis at the logic level, Delay models, Delay graph, static sensitization, State of the art and future trends: System level synthesis.

References

Giovanni De Micheli: "Synthesis and Optimization of Digital Circuits", McGraw Hill, 1994.
Sunil P. Khatri · Kanupriya Gulati, Editors, "Advanced Techniques in Logic Synthesis, Optimizations and Applications", Springer publications, 2011.
S. Hassoun and T. Sasao, (Editors), Logic Synthesis and Verification, Kluwer Academic publishers, 2002
Srinivas Devadas, Abhijith Ghosh and Kurt Keutzer: "Logic Synthesis", Kluwer Academic, 1998.
G. D. Hachtel and F. Somenzi, "Logic Synthesis and Verification Algorithms", Kluwer Academic Publishers, 1996.

EC445 TECHNIQUES IN LOW POWER VLSI **(3-1-0) 4**

Course Outcomes:

CO1: Understand various sources of power consumption in VLSI circuits and systems.
CO2: Understand and analyse various power estimation techniques.
CO3: Analyze various power reduction strategies at different levels of design abstractions.
CO4: Evaluate design strategies of low power VLSI circuits.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	1	-	1	-	-	-	-	-	-	1	3	-
CO2	3	3	2	2	2	-	-	-	-	-	-	2	3	1
CO3	3	3	2	3	3	-	-	-	1	1		2	3	2
CO4	3	3	3	3	3	1	2	1	2	2	2	3	3	3

Course Contents

Introduction to Low Power VLSI. Modeling and Sources of Power consumption. Power estimation at different design levels. Power optimization for combinational circuits and sequential circuits Voltage scaling Approaches. Low energy computing using energy recovery techniques. Low Power SRAM architectures. Software design for low power. Computer Aided Design Tools. Case studies Recent trends in low-power design for mobile and embedded application.

References

Kaushik Roy, Sharat Prasad, Low-Power CMOS VLSI design, John Wiley, 2000.
K.-S. Yeo and K. Roy, Low-Voltage Low-Power Subsystems, McGraw Hill, 2004.
Anantha P.Chandrakasan & Robert W. Brodersen, Low Power Digital CMOS Design, Kluwer, 1995.
Gary K. Yeap, Practical Low Power Digital VLSI Design, Kluwer Academic Publications, 1998
L. Benini and G. De Micheli, Dynamic Power Management Design Techniques and CAD Tools, Springer, 1998.
S. G. Narendra and A. Chandrakasan, Leakage in Nanometer CMOS Technologies, Springer, 2005.
Edgar Sánchez-Sinencio, Andreas G. Andreou, Low-Voltage/Low-Power Integrated Circuits and Systems: Low-Voltage Mixed-Signal Circuits IEEE Press Series on Microelectronic Systems 1999

EC446 SUBMICRON DEVICES **(3-1-0) 4**

Course Outcomes:

CO1: Understand the basic device physics of different devices such as Diodes, MOS capacitor, transistors etc. and analyze the effect of doping variation on the device characteristics.
CO2: Identify parameters that affect MOS device behaviour in submicron regime and analyze short channel effects due to device scaling.
CO3: Apply the concepts related to device physics to transistor design trade-offs and analyze the device performance.
CO4: Analyze and evaluate the impact of device variations on circuit performance and its reliability.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	1	-	-	-	-	-	-	-	-	1	3	-
CO2	3	1	1	2	1	-	-	-	-	-	-	1	3	1
CO3	3	1	1	2	1	-	-	-	-	1	-	1	3	2
CO4	3	1	3	2	1	-	-	-	-	1	-	2	3	2

Course Contents

Review of basic device physics, Electronic structure of semiconductors, Diodes, MOS capacitor. Transistor theory. Scaling - Moore's law on technology scaling, MOS device scaling theory, Short channel effects, sub threshold leakage, Punch through, DIBL, High field mobility, Velocity saturation and overshoot. Reliability. Various definitions of channel length, Performance metric of digital technology, Transistor design trade-offs, Technology case studies, Silicon on Insulator (SOI) devices, Partially depleted and fully depleted SOI, Floating body effects, SOI for low power, Interconnects in sub-micron technology, Foundry technology, International Technology Roadmap for Semiconductors (ITRS).

References

J. A. del Alamo Integrated Microelectronic Devices: Physics and Modeling, Pearson, 2017
Yaun Taur, Tak H. Ning, Fundamentals of modern VLSI devices, Cambridge university press, 1998.
B. G. Streetman & S. Banerjee, Solid State Electronic Devices, Prentice Hall, 1999.
M. K. Achuthan and K. N. Bhat, Fundamentals of Semiconductor Devices, McGraw Hill, 2006
Nandita Dasgupta, Amitava Dasgupta, Semiconductor Devices: Modelling And Technology, Phi, 2009
A. K. Dutta, Semiconductor Devices and Circuits, Oxford Univ. Press, 2008.
ITRS Road map - http://public.itrs.net/

EC447 ACTIVE FILTERS **(3-1-0) 4**

Course Outcomes:

CO1: Derive the transfer function of the filter for Butterworth and Chebyshev filter responses.
CO2: Synthesize the passive filter network for the given transfer function.
CO3: Transform a given passive filter network into Gm-C and Active-RC filter.
CO4: Design and implement a CMOS active filter and evaluate its performance.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	-	-	1	-	-	-	-	-	-	-	2	3
CO2	3	3	-	-	1	-	-	-	-	-	-	-	2	3
CO3	2	2	-	-	1	-	-	-	-	-	-	-	2	3
CO4	2	2	-	-	3	-	-	-	2	2	-	-	2	3

Course Contents

Butterworth, Chebyshev & Inverse-Chebyshev filter response and pole locations, LC ladder filter – prototype & synthesis; Frequency transformation of lowpass filter. Impedance converters; Gm-C filters – Gm-C biquad, Q enhancement, Automatic Tuning; Active-RC filters – Comparison with Gm-C filter, Issues in realizing high frequency active-RC filters, Switched Capacitor Filters.

References

R. Schaumann and M.E. Van Valkenburg, Design of Analog Filters, Oxford University Press, 2003.
P. V. Ananda Mohan, Current-Mode VLSI Analog Filters - Design and Applications, Birkhauser, 2003
M.E. Van Valkenburg, Analog Filter Design, Oxford University Press, 1995.

EC448 HETEROGENEOUS AND PARALLEL COMPUTING **(3-0-2) 4**

Course Outcomes:
CO1: Understand the heterogenous platform hardware architecture and OpenCL device architecture.
CO2: Understand concurrent execution of parallel programs in the architechture.
CO3: Write simple parallel programs like vector addition and matrix multiplication and execute in the hardware.
CO4: Analyze the various parallel programs and understand the effect of concurrency, cache etc.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	-	-	-	-	-	-	-	-	-	-	3	2
CO2	3	2	-	-	-	-	-	-	-	-	-	-	3	2
CO3	3	2	-	-	2	-	-	-	-	-	-	-	3	2
CO4	3	2	-	-	2	-	-	-	-	-	-	-	3	2

Course Contents
Heterogeneous platform and GPU architecture. Introduction to OpenCL. OpenCL device architecture. Concurrency and execution model. Programming examples like vector addition, convolution and matrix multiplication. Application case studies.

References
Benedict R. Gaster, Lee Howes, David R. Kaeli, Perhaad Mistry, Dana Schaa, "Heterogeneous Computing with OpenCL" - Revised OpenCL 1.2 Edition, Morgan Kaufmann, 2013.
Aaftab Munshi, Benedict R. Gaster, Timothy G. Mattson, James Fung, Dan Ginsburg, "OpenCL Programming Guide", Addison-Wesley, 2012.
David B. Kirk and Wen-mei W. Hwu, "Programming Massively Parallel Processors - A Hands-on Approach", Second Edition, Morgan Kaufmann, 2013.
AMD Accelerated Parallel Processing OpenCL User Guide, AMD, 2014.

EC449 ALGORITHMS AND ARCHITECTURES FOR SIGNAL PROCESSING (3-1-0) 4

Course Outcomes:
CO1: Appreciate and understand the architectures for signal processing.
CO2: Understand the notions of parallel processing for high-speed and low-power realizations.
CO3: Ability to use the computing tools for realizing the architectures for diverse applications.
CO4: Propose to develope architectures to solve concrete engineering problems.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	-	-	-	-	-	-	-	-	-	-	1	3	3
CO2	-	2	-	-	-	-	-	-	-	-	-	1	3	3
CO3	-	2	3	2	3	1	1	1	1	-	-	1	3	3
CO4	-	-	-	2	3	1	1	1	1	1	1	1	3	3

Course Contents
Representation of digital signal processing systems: block diagrams, signal flow graphs, data-flow graphs, dependence graphs; pipelining and parallel processing for high-speed and low power realizations; iteration bound, algorithms to compute iteration bound, retiming of data-flow graphs; unfolding transformation of data-flow graphs; systolic architecture design, architectures for real and complex fast Fourier transforms; stochastic logic based computing, computing digital filters, arithmetic functions and machine learning functions using stochastic computing; Neural Network architectures.

References
K.K. Parhi, VLSI Digital signal processing systems: Design and implementation, John Wiley, 1999.
Lars Wanhammar, DSP Integrated Circuits, Academic Press, 1999.
Sen M. Kuo Bob H. LeeWenshun Tian, "Real-Time Digital Signal Processing: Implementations and Applications", 2006 John Wiley & Sons, Ltd.

Roger Woods, John McAllister, Gaye Lightbody, Ying Yi, "FPGA Based Implementation of Signal Processing Systems", John Wile, 2017.
U. Meyer-Baese, "Digital Signal Processing with Field Programmable Gate Arrays", 4th Ed. Springer, 2014.

EC450 ANALOG AND DIGITAL FILTER DESIGN (3-1-0) 4

Course Outcomes:
CO1: Derive the transfer function of the filter for Butterworth and Chebyshev filter responses.
CO2: Synthesize the passive filter network for the given transfer function.
CO3: Transform a given transfer function into analog and digital filters.
CO4: Design and implement analog and digital filters and evaluate their performance.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	-	-	1	-	-	-	-	-	-	-	2	3
CO2	3	3	-	-	1	-	-	-	-	-	-	-	2	3
CO3	2	2	-	-	1	-	-	-	-	-	-	-	2	3
CO4	2	2	-	-	3	-	-	-	2	2	-	-	2	3

Course Contents
Introduction to filters and filter specifications. The Butterworth, Chebyshev, Elliptic, and Bessel filters and their realization, Frequency transformations, Analog filter design. Sampling; the Digital filter problem. IIR Filter design using the impulse invariant and bilinear transformation methods. The poles and zeros of the Butterworth and Chebyshev digital filter equivalents. Realization of Digital IIR filters Tradeoffs between aliasing and complexities of Analog filter realizations Direct design of IIR filters. FIR Filter Design: Exactly linear phase filters. Windowing methods. Kaiser window and its properties. Filter design using Kaiser window, Frequency sampling, Optimal FIR Filter design, Real-time implementation of digital filters – coefficient quantisation and finite word length effects.
References
A.Ambardar, Analog and Digital Signal Processing, Brooks Cole, 1999.
Ifeachor and Jervis, DSP – A practical approach, Pearson, 2002
Sanjit K. Mitra, Digital Signal Processing : A computer based Approach, TMH, 2002
Andreas Antoniou, Digital Filter Design, TMH

EC451 ADVANCED DIGITAL SIGNAL PROCESSING (3-1-0) 4

Course Outcomes:
CO1: Understand the concepts and algorithms for FRI sampling and FRI Reconstruction.
CO2: Relate theoretical concepts to practical applications.
CO3: Implementation of FRI algorithm for biomedical signal reconstruction.
CO4: Applications of filterbank theory and subband signal processing to image and speech processing.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	1	2	-	-	-	-	-	-	-	-	3	2
CO2	4	3	1	1	-	-	-	-	-	-	-	-	3	2
CO3	3	3	3	1	2	1	-	-	-	1	-	-	3	3
CO4	3	2	3	2	2	1	-	1	1	-	-	-	3	3

Course Contents
Power spectral estimation; Parametric and non-parametric methods of spectral estimation, Linear prediction, Higher order spectral estimation; Adaptive filters and applications. Recursive estimation and Kalman filters Multirate Signal Processing: Decimation Interpolation, DFT filter banks, QMF filter banks, Multiresolution Signal analysis wavelets theory of sub band decompositions, Sub band coding and wavelet transforms, Application of wavelet transforms.
References
P.P. Vaidyanathan, Multirate systems and Filter banks, Prentice Hall, 1993.
S.J. Orfanidis, Optimum Signal Processing, McGraw Hill, 1989.
S. Haykin, Adaptive Filter Theory, Pearson, 1996

EC452 REAL TIME SIGNAL PROCESSING (2-0-3) 4

Course Outcomes:
CO1: Understand the linear and non linear models for signal processing applications.
CO2: Analyze and understand the importance of linear models.
CO3: Analyze practical issues in implementing the linear models.
CO4: Demonstrate the implementation of linear models for real time applications.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	-	-	-	-	-	-	-	-	-	3	1
CO2	3	3	2	-	-	-	-	-	-	-	-	-	3	1
CO3	3	3	2	-	2	-	-	-	-	-	-	-	3	3
CO4	3	2	3	1	2	-	-	1	1	-	-	-	3	3

Course Contents

Introduction to DSP systems and architecture; Arithmetic: Fixed point, floating point and residue arithmetic, Cordic architectures; Real time implementation of SP algorithms on Digital Signal Processors: Architecture and programming; Real time implementation of SP algorithms on Reconfigurable architectures: Architecture and design flow; Issues in implementation of convolution, FIR, IIR and adaptive filters, DCT, Image Filtering, Dynamically reconfigurable architectures for SP, Software Configurable processors, Application case studies in multimedia compression and communication.

References

Behrooz Parhami, "Computer Arithmetic Algorithms and Hardware Design", Oxford, 2000.
Rulph Chassaing, " Digital Signal Processing and Applications with the C6713 and C6416 DSK", Wiley,2005
U. Meyer Baesse, "Digital Signal Processing with FPGAs", Springer, 2001
Shehrzad Qureshi, "Embedded Image Processing on the TMS320C6000 DSP" Springer, 2005

EC453 FOURIER AND WAVELET SIGNAL PROCESSING (3-1-0) 4

Course Outcomes:
CO1: Understand the multirate signal processing building blocks required in signal analysis.
CO2: Learn how to form signal bases with multirate building blocks.
CO3: Analyze given signal using filter banks and wavelet bases.
CO4: Do a transform domain processing and synthesize the signal.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	-	-	-	-	-	-	-	-	-	-	3	2
CO2	3	2	-	-	-	-	-	-	-	-	-	-	3	2
CO3	3	2	-	-	-	-	-	-	-	-	-	-	3	2
CO4	3	2	-	-	-	-	-	-	-	-	-	-	3	2

Course Contents

Hilbert Spaces, Review of sequences and discrete time systems, functions, DTFT, convergence, multi rate systems, polyphase representation, stochastic processes and systems. Continuous time systems, Fourier transform, definition, existence, spectral decay, Fourier series. Sampling and Interpolation–finite dimensional vectors, sequences, functions, periodic functions, approximation and compression polynomial and spline approximation. Localization and uncertainty.
Filter banks–Localization, two channel orthogonal filter banks, design, biorthogonal filter banks, design.
Local Fourier bases–N channel filter banks, exponentially modulation filter banks, cosine modulated filter banks. Wavelet bases on sequences, Tree structured filter banks, orthogonal, biorthogonal bases, wavelet packets, frames. Wavelet bases on functions–local Fourier transforms.

References

Martin Vetterli Jelena Kovacevic & Vivek K. Goyal, Foundations of Signal Processing, Cambridge University Press, 2015
J. Kovacevic, V. K. Goyal and Martin Vetterli, Fourier and Wavelet Signal Processing, Cambridge University Press, 2013

EC454 MATHEMATICAL ALGORITHMS FOR SIGNAL PROCESSING **(3-1-0) 4**

Course Outcomes:
CO1: Understand and apply the theory and concepts for solving various types of problems.
CO2: Apply the techniques to problems of engineering.
CO3: Develop algorithms using computing technology.
CO4: Apply the theory and techniques to solving concrete engineering problems.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	-	-	1	-	-	-	-	-	-	-	1	2	2
CO2	2	3	-	-	-	2			2	-	1	1	2	2
CO3	-	-	3		3	-	-	2	2	-	1	-	2	3
CO4	-	-	-	3	-	3	1	-	-	2	1	-	2	2

Course Contents
Mathematical Foundations–mathematical models, random variables and random processes, Markov and hidden Markov models. Representations and approximations - orthogonality, least squares, MMSE filtering, frequency domain optimal filtering, minimum norm solutions, Iterated reweighted least squares. Linear Operators –Operator norms, adjoint and transposes, geometry of linear equations, least squares and pseudo inverses, applications to linear models.
Subspace methods – Eigen decomposition, KL transform and low rank approximation, Eigen filters, signal subspace techniques – MUSIC, ESPRIT. SVD – matrix structure, pseudo inverse and SVD, system identification using SVD, Total least squares, partial total least squares. Special matrices–Toeplitz matrices, optimal predictors and lattice filters, circulant matrices, properties.

References
Todd Moon and WC Stirling, Mathematical Methods and Algorithms for Signal Processing, Pearson Education, 2000
Steven, M. Kay, Modern spectral estimation: theory and application, Prentice Hall, 1988

EC455 DIGITAL SIGNAL COMPRESSION **(3-1-0) 4**

Course Outcomes:
CO1: Understand the mathematical foundations of data compression and fundamental algorithms applicable for digital signal compression.
CO2: Analyze the characteristics of speech, audio, image, text, and video signals.
CO3: Apply various techniques to compress text, speech, image & video.
CO4: Analyze current standards in text, image, video and audio/speech compression.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	-	-	-	-	-	-	-	1	3	1
CO2	3	2	2	1	-	-	-	-	-	-	-	1	3	1
CO3	3	2	2	1	-	-	-	-	-	-	-	1	3	1
CO4	3	2	2	1	-	-	-	-	-	-	-	2	3	1

Course Contents
Data Compression. Speech & image waveform characterization. Predictive coding. Transform coding. Subband coding, VQ based compression, Fractal coding of images. High quality video & audio compression for digital broadcasting. Standards for digital signal compression-data, speech, audio, image & video.
References
D. Salomon, Data Compression – the complete reference, Springer, 2000.
K. Sayood, Introduction to Data Compression, Pearson Education, 2000.
M.Nelson, The data compression book, BPB Publications, 2002.
Jayant & Noll, Digital coding of waveforms-Principles and applications to speech & video, PH, 1984.

EC456 DYNAMICAL SYSTEMS, CHAOS AND FRACTALS (3-1-0) 4

Course Outcomes:
CO1: Understand the theory and concepts in dynamical syatems, chaos and fractals.
CO2: Apply the techniques to solve engineering problems.
CO3: Develop numerical techniques and algorithms using computing.
CO4: Apply the theory and techniques to solving concrete engineering problems.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	-	-	-	-	-	-	-	-	-	-	1	2	2
CO2	2	2	-	2	-	-	-	-	-	-	-	-	2	2
CO3	-	1	3		3	-	-	1	1	-	-	1	2	2
CO4	-	-	1	3	1	1	1	-	-	1	1	1	2	2

Course Contents

Preliminaries on systems, Eigen values and Eigen vectors, solutions of linear ODEs. Dynamics of linear and nonlinear systems, solutions, attractors, equilibrium point, limit cycles, stability, Linear systems: solutions, stability of autonomous systems, BIBO stability, relation to frequency domain analysis, Nonlinear systems: large-scale notions of stability (Lyapunov functions), linearization. Vector fields of nonlinear systems, limit cycles, Lorenz and Rossler equation, Chua's circuit, Discrete dynamical systems, logistic maps, two dimensional maps, bifurcations, flows, phase plane analysis. Introduction to fractals, Mandlebrot and Julia sets, iterated function systems, strange attractors, fractal dimension, stable and unstable manifolds, analysis of chaotic time series, multifractals.
Applications in control theory, signal processing, digital image modelling, synthesis and compression, chaos communication and Cryptography. Other applications in engineering, natural and social sciences, medicine, economics, ecology, bio and life sciences, and environmental sciences.

References

S. Stenberg, Dynamical systems, Dover 2010.
MW Hirsch, S. Smale, RL Devaney, Differential equations, dynamical systems, and an introduction to chaos, Academic Press. 2012.
Steven H. Strogatz, Nonlinear dynamics and chaos: with applications to physics, biology, chemistry, and engineering, West-view Press, 2015.
E. Ott, Chaos in dynamical systems, 2nd ed Cambridge University Press, 2002.
S. Wiggins, Introduction to applied nonlinear dynamical systems and chaos, Springer-Verlag, 1990.
Denny Gulick, Encounters with chaos and fractals, 2nd ed CRC Press, 2012.
J.M. Bahi, C. Guyeux, Discrete dynamical systems and chaotic machines: theory and applications, CRC Press, 2013.
M. Barnsley, Fractals everywhere, Academic Press, 1993.

EC457 STATISTICAL ANALYSIS (3-1-0) 4

Course Outcomes:
CO1: To understand statistical hypothesis testing and probability distributions.
CO2: Apply the techniques to solve statistical problems.
CO3: Using computing to develop and test methods.
CO4: Use the theory and techniques for application domain areas.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	1	-	-	-	-	-	-	-	-	2	2	2
CO2	2	3	3	1	1	-	-	-	-	-	-	1	2	2
CO3	1	-	3	1	2	2	1	2	-	1	-	1	2	2
CO4	2	1	-	3	2	2	1	-	1	1	1	2	2	2

Course Contents

Preliminaries on matrix theory and probability distributions. Sampling theory: random samples, sampling distribution, statistical inference, estimation of mean and variances, hypothesis testing, statistical tests, goodness of fit. Data analysis: correlation and regression, simple linear regression, multiple linear regressions, logistic regression, nonlinear regression. The Multivariate Normal Distribution, Estimation of the Mean Vector and the Covariance Matrix, The Distributions and Uses of Sample Correlation Coefficients, The Generalized T2-Statistic, Classification of Observations, The Distribution of the Sample Covariance Matrix and the Sample Generalized Variance, Testing the General Linear Hypothesis: Multivariate Analysis of Variance, Testing Independence of Sets of Variates, Testing Hypotheses of Equality of Covariance Matrices and Equality of Mean Vectors and Covariance Matrices, Principal Components, Canonical Correlations and Canonical Variables, The Distributions of Characteristic Roots and Vectors, Factor Analysis, Pattern of Dependence, Graphical Models.

References

Sam Kash Kachigan, Statistical Analysis: An Interdisciplinary Introduction to Univariate and Multivariate Methods, Radius Press, 1986.
RA Johnson, DW Wichern, Applied multivariate statistical analysis, 6th ed, PHI, 2012.
T. W. Anderson, An Introduction To Multivariate Statistical Analysis, 3rd Edition, Wiley, 2003.
Sam Kash Kachigan, Multivariate Statistical Analysis: A Conceptual Introduction, Radius Press, 1991.
Robert Nisbet, John Elder and Gary Miner, Handbook of Statistical Analysis and Data Mining applications, Elsevier Inc 2009.

EC458 STOCHASTIC PROCESSES (3-1-0) 4

Course Outcomes:
CO1: Understand stochastic process concepts.
CO2: Understand usage of matrix theory for implementing the Stochastic process techniques.
CO3: Demonstrate the application of conepts in Information Thoery, Network Theory and Queing theory.
CO4: Estimation of Election pre exit polls, Birth and Death rates.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	-	-	-	-	-	-	-	-	-	-	3	1
CO2	3	3	1	1	-	-	-	-	-	-	-	-	3	2
CO3	3	3	2	1	2	-	-	-	-	-	-	-	3	3
CO4	3	3	3	2	2	-	2	1	1	1	-	-	3	3

Course Contents

Review of Probability theory and stochastic processes, stochastic processes and linear systems, Gaussian random process, spectral analysis of stationary processes, Power Spectral Densities, Stationarity and Ergodicity, Poisson processes, renewal processes, Brownian motion. Optimal Linear Systems, Wiener Filters, discrete and continuous time Markov chains, discrete time branching processes, birth and death processes, random walks, large deviations and Martingales. Queueing theory Diffusion processes and stochastic differential equations, the Fokker-Planck and Langevin Equations. Applications – Modeling of neural processes, finance, and processes in natural and social sciences.

References

Richard Durrett, Essentials of Stochastic Processes (Springer Texts in Statistics) May 2001.
R G Gallager, Stochastic processes: theory for applications, 2013.
W. Paul and J. Baschnagel: Stochastic Processes – From Physics to Finance, Springer, 1999.
Frank Beichelt, L. Paul Fatti, Stochastic Processes and Their Applications, CRC Press, 2001.
Petar Todorovic, An Introduction to Stochastic Processes and Their Applications, Springer, 1992.

EC459 OPTIMIZATION (3-1-0) 4

Course Outcomes:
CO1: Understand the theory of optimization methods.
CO2: To apply theory for solving various types of optimization problems.
CO3: Develop numerical techniques and algorithms using computing tools.
CO4: Apply the theory and techniques to solving concrete engineering problems.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	-	-	-	-	-	-	-	-	-	-	1	2	2
CO2	-	2	-	-	-	-	-	-	-	1	-	2	2	2
CO3	-	-	3	-	3	1	-	1	2	-	1	-	2	2
CO4	2	-	1	3	1	1	1	1	1	2	2	2	2	2

Course Contents

Convex sets and Convex functions, Level sets and Gradients, Unconstrained Optimization: Search methods, Gradients Methods, Newton Method, Conjugate Direction Methods, Quasi-Newton Methods. Linear Programming: Standard Form Linear Programs, Simplex method, Duality and Non Simplex Methods. Nonlinear Constrained Optimization: Problems with equality constraints, Problems with Inequality Constraints, Convex Optimization Problems, Algorithms for Constrained Optimization: Projected Gradient Methods and Penalty Methods.

References

Lieven Vandenberghe and Stephen P. Boyd, Convex Optimization, Cambridge University Press, 2004.
Dimitris Bertsimas, John N. Tsitsiklis, Introduction to Linear Optimization, Athena Scientific Series, 1997.
Aharon Ben-Tal and Arkadi Nemirovski, Lectures on Modern Convex Optimization: Analysis, Algorithms, and Engineering Applications, SIAM, 2001.

EC460 NEURAL NETWORKS AND DEEP LEARNING (3-1-0) 4

Course Outcomes:

CO1: Understand the basic concepts of artificial neural networks, convolutional and recurrent network structures.
CO2: Design and implement basic artificial neural networks and convolutional Neural networks with real time applications.
CO3: Design and implement deep neural networks and advance convolutional neural networks with real applications.
CO4: Design and implement advanced Convolutional Neural networks and recurrent network structures with real applications.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	-	-	-	-	-	-	-	-	-	3	1
CO2	3	3	2	-	2	-	-	-	-	-	-	-	3	2
CO3	3	3	2	2	2	-	-	-	-	-	-	-	3	3
CO4	3	2	3	2	2	2	2	1	-	-	-	-	3	3

Course Contents

Linear Regression , Logistic regression, Basic neuron structure, Perceptron, error functions, optimization – gradient descent, Multilayer perceptron, transfer function, nonlinearities, learning, backpropagation, function approximations, overfitting, underfitting, Deep networks, challenges, regularization techniques – Norm penalties, early stopping, drop outs, dataset augmentation, bagging and ensemble methods, Convolutional Networks – Convolution, pooling, variants, transfer learning, Sequence Modeling – Recurrent neural networks, Bidirectional RNNs, architectures, LSTM, Application examples – Computer Vision, Speech recognition, NLP.

References

Simon S. Haykin, Neural Networks and Learning Machines, 3rd Ed, Pearson, 2009.
José C. Principe, Neil R. Euliano, W. Curt Lefebvre, Neural and Adaptive Systems: Fundamentals through Simulations, John Wiley and Sons, 2000.
Ian Goodfellow, Yoshua Bengio, Aaron Courville, Deep Learning, MIT Press, 2016.

EC461 SPREAD SPECTRUM COMMUNICATIONS (3-1-0) 4

Course Outcomes:

CO1: Understand the fundamentals of spread spectrum and types of spread spectrum systems.
CO2: Realize and appreciate the need of synchronization.
CO3: Learn the multiple access techniques like CDMA and compare it with other techniques.
CO4: Design the multiuser detection techniques using the principle of spread spectrum communication.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	-	-	-	-	-	-	-	-	-	2	2	-
CO2	3	2	2	1	2	-	-	-	-	-	-	2	2	-
CO3	3	2	3		2	-	-	-	-	-	-	2	2	2
CO4	3	3	3	3	2	-	-	-	-	-	-	2	2	2

Course Contents

Spread spectrum overview, Spreading techniques, Pseudo noise sequences, Direct sequence spread spectrum system, Frequency hop spread spectrum system, Hybrid systems, Synchronization, Jamming considerations, Commercial applications, Cellular systems, Performance of spread spectrum systems.

References

R.L.Peterson, Introduction to spread spectrum communication, PH,1995.
B.Sklar, Digital Communications, Pearson Education, 2001.
M.K.Simon, Spread spectrum communications Handbook, McGraw-Hill, 2001.
J.S.Lee, CDMA Systems Engineering handbook, Artech House, 1998

EC462 ERROR CONTROL CODING (3-1-0) 4

Course Outcomes:

CO1: Understand the basic mathematical concepts applicable to error control coding.
CO2: Understand and analyze the encoding/ decoding principles of various Block and Convolutional channel codes.
CO3: Apply, analyse and solve design problems related to Block and Convolutional channel codes.
CO4: Design channel codes for a few real life applications and analyze their suitability through simulations.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	1	1	-	-	-	-	-	1	-	2	2	2
CO2	3	2	3	1	-	-	-	-	-	1	-	2	2	2
CO3	3	3	2	2	-	-	-	-	-	1	1	1	2	1
CO4	3	3	2	1	3	-	-	-	-	2	1	2	2	2

Course Contents

Coding for reliable digital transmission and storage. Groups, Rings, Vector Spaces, Galois Fields, Polynomial rings, Channel models, Linear Block codes, Cyclic codes, BCH codes, Reed Solomon Codes, Berlekamp-Massey and Euclid decoding algorithm, Decoding beyond the minimum distance parameter, Applications of Reed-Solomon codes, Convolutional codes, Decoding algorithms for Convolutional codes, Viterbi, Stack and Fano algorithms, Application of Convolutional codes. Codes based on the Fourier Transform, Algorithms based on the Fourier Transform, Trellis coded modulation, Combinatorial description of Block and Convolutional codes, Algorithms for the construction of minimal and tail biting trellises, Soft decision decoding algorithms, Iterative decoding algorithms, Turbo-decoding, Two-way algorithm, LDPC codes, Use of LDPC codes in digital video broadcasting, belief propagation (BP) algorithms, Space-Time codes.

References

Shu Lin and Daniel J. Costello Jr., Error Control Coding: Fundamentals and Applications, Prentice Hall, 2003.
S. B Wicker, Error Control Systems for Digital Communication and Storage, Prentice Hall International, 1995.
Blahut R. E, Theory and Practise of Error Control Codes, Addison Wesley, 1983.

EC463 OPTICAL COMMUNICATION SYSTEMS AND NETWORKS (3-1-0) 4

Course Outcomes:
CO1: Understand the importance and working of Optical fibers, sources, detectors and passive components.
CO2: Design a fiber optic communication link and analyse its performance in terms of link and rise time budgets.
CO3: Design a WDM system.
CO4: Design and analyze optical networks.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	-	-	2	-	-	-	-	-	-	-	2	1
CO2	2	3	-	-	3	-	-	-	-	-	-	-	2	1
CO3	2	3	-	-	2	-	-	-	-	-	-	-	3	2
CO4	2	3	-	-	2	-	-	-	-	-	-	-	3	2

Course Contents
Introduction to Optical Fibers, Ray Optics-Optical Fiber Modes and Configurations. Signal degradation in Optical Fibers. Optical Sources and Detectors. Optical Communication Systems and Networks. Basic concepts of SONET/SDH Networks.

References
J.Senior, Optical Communication, Principles and Practice, Prentice Hall of India, 1994/latest edition.
Gerd Keiser, Optical Fiber Communication McGraw –Hill International, Singapore, 3rd ed., 2000/latest edition
J.Gower, Optical Communication System, Prentice Hall of India, 2001.

EC464 RADAR SIGNAL PROCESSING (3-1-0) 4

Course Outcomes:
CO1: To understand need for signal processing in radar systems, the significance of pulse compression, pulse Doppler processing and moving target indication, SAR imaging techniques and signal processing techniques for CW and FMCW scenarios.
CO2: To apply, analyse and solve problems based on the concepts associated pulse compression, pulse Doppler processing and moving target indication, SAR imaging techniques and signal processing techniques for CW and FMCW scenarios.
CO3: To derive the inferences from exiting pulse compression, pulse Doppler processing and moving target indication, SAR imaging techniques and signal processing techniques for CW and FMCW scenarios.
CO4: To design the solutions for various applications of radar signal processing

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	1	3	1	0	0	0	0	0	0	3	2
CO2	3	3	2	2	3	1	0	0	0	1	0	0	2	1
CO3	3	3	3	3	1	1	0	0	1	1	0	0	2	1
CO4	3	3	3	3	3	1	1	1	1	1	0	0	1	1

Course Contents
Introduction to Radar Systems and Signal Processing, Signal Models, Pulsed Radar Data Acquisition Radar Waveforms, Doppler Processing, Detection Fundamentals, Introduction to Synthetic Aperture Imaging, and Introduction to Beamforming and Space-Time Adaptive Processing.
References
Mark A Richards, Fundamentals of radar signal Processing, McGraw Hill edition, 2nd edition, 2013
Peebles P. Z, Radar Principles, John Wiley and Sons, 1998

EC465 ALGORITHMS FOR PARAMETER AND STATE ESTIMATION (3-1-0) 4

Course Outcomes:

CO1: To understand the elementary concepts Bayesian and Non Bayesian parameter and state estimation methods, Kalman filter and other state estimators.

CO2: To apply, analyse and solve problems based on the concepts associated Bayesian and Non Bayesian parameter and state estimation methods, Kalman filter and other state estimators.

CO3: To derive the inferences from exiting Bayesian and Non Bayesian parameter and state estimation methods, Kalman filter and other state estimators.

CO4: To design the solutions for parameter and state estimation problems for various applications.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	2	3	1	0	0	0	0	0	0	2	3
CO2	3	3	2	3	2	1	0	0	0	1	0	0	2	2
CO3	3	3	3	3	1	1	0	0	1	1	0	0	3	1
CO4	3	3	3	3	3	1	1	1	1	1	0	0	1	1

Course Contents

Maximum likelihood (ML) estimation, Maximum a posteriori (MAP) estimation, Least squares (LS) estimation, Minimum mean square error (MMSE) estimation, Linear MMSE (LMMSE) estimation. LS estimation for linear and nonlinear systems, modelling stochastic dynamic systems, the Kalman filter for discrete time linear dynamic systems with Gaussian noise. Steady state filters for noisy dynamic systems, adaptive multiple model estimation techniques. Nonlinear estimation techniques, computational aspects of discrete time estimation.

References

Y. Bar-Shalom, X. Rong Li and T. Kirubarajan, Estimation with Applications to Tracking and Navigation, John Wiley & Sons, 2001.

F. L. Lewis, Optimal Estimation, John Wiley & Sons, 1986.

R. G. Brown and P. Y. C. Hwang, Introduction to Random Signals and Applied Kalman Filtering, John Wiley & Sons, 1992.

EC466 DETECTION AND ESTIMATION THEORY (3-1-0) 4

Course Outcomes:

CO1: Knowledge of hypothesis testing techniques and estimation algorithms.

CO2: Ability to apply hypothesis testing techniques for detection of signals and ability to apply estimation algorithms.

CO3: Ability to analyze the statistical performance of detection and estimation algorithms.

CO4: Ability to evaluate the various algorithms for the given problem in detection or estimation.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	3	1	-	-	-	-	-	1	-	-	3	2
CO2	3	2	3	2	1	-	-	-	-	1	-	1	2	3
CO3	3	3	2	1	-	-	-	-	-	1	-	-	2	3
CO4	3	2	3	2	-	-	-	-	-	-	-	1	2	3

Course Contents

Preliminaries on probability and random processes. Hypothesis testing: Neyman-Pearson theorem, likelihood ratio test and generalized likelihood ratio test, uniformly most powerful test, multiple-decision problem, detection of deterministic and random signals in Gaussian noise, detection in nonGaussian noise, sequential detection. Parameter estimation: unbiasedness, consistency, Cramer-Rao bound, sufficient statistics, Rao-Blackwell theorem, best linear unbiased estimation, maximum likelihood estimation, method of moments. Bayesian estimation: MMSE and MAP estimators, Levinson-Durbin and innovation algorithms, Wiener filter, Kalman filter. Applications in Wireless Communication, Radar Systems, Speech, Image and Video processing and applications relevant to Engineering.

References
Steven Kay, Fundamentals of Statistical Signal Processing - Detection Theory (Vol. 2), Prentice Hall, 1998.
Steven Kay, Fundamentals of Statistical Signal Processing - Estimation Theory (Vol. 1), Prentice Hall, 1993.
H. V. Poor, An Introduction to Signal Detection and Estimation, Springer-Verlag, 2nd edition, 1994.
H. L. Van Trees, Detection, Estimation and Modulation Theory, Parts 1 and 2, John Wiley Inter- Science, 2002
M. D. Srinath, P. K. Rajasekaran and R. Vishwanathan, An Introduction to Statistical Signal Processing with Applications, Prentice-Hall, 1996.
Kailath,T. and Hassibi, Linear Estimation, Pearson, 2000.

EC467 ADVANCED TOPICS IN COMMUNICATION ENGINEERING (3-1-0) 4

Course Outcomes:
CO1: Understand and solve elementary problems involving concepts of Communication Engineering, Fading Channels, Detection, Estimation and Filtering Theory.
CO2: Understand the principles of various schemes used for enhancing communication efficiency by employing OFDM, MIMO Communication and Synchronization codes.
CO3: Conduct detailed mathematical analyses of schemes used to improve the throughput and reliability of Wireless Communication.
CO4: Perform Monte Carlo simulation platforms to simulate the functioning of selected Detection, Estimation and Filtering schemes, OFDM systems and Space Time Codes.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	1	1	1	-	-	-	-	1	-	2	3	3
CO2	3	2	3	1	-	1	-	-	-	1	-	2	2	2
CO3	3	3	2	2	-	-	-	-	-	1	1	1	2	1
CO4	3	3	2	1	3	1	-	-	-	2	1	2	3	3

Course Contents
Fading Channels, characterizing Mobile radio propagation, Signal time spreading, time variance of channel, mitigating the degradation effects of fading, characterizing fading channels, Fundamentals of Statistical Detection Theory, Baye's Theorem, Decision theory, Neyman Pearson Theorem, Receiver operating characteristics, Bayes's risk. Multiple hypothesis testing, minimum Baye's risk detection for binary hypothesis and multiple hypothesis, Orthogonal Frequency Division Multiplexing, OFDM transmission technique, synchronization, modulation, demodulation, amplitude limitation of OFDM signals. Space Time Wireless Communications, Introduction, space time propagation, space time channel and signal models, spatial diversity, space time OFDM

References
J.G.Proakis & M.Salehi, Digital Communication, 5th edition, McGraw Hill 2007.
Stevan M Kay, Fundamentals of Statistical signal processing, Vol. II, Detection Theory, PHI, 1998.
A.Paulraj, R.Nabar & D.Gore, ,Introduction to Space Time Wireless Communications, Cambridge University, 2003.

EC468 SIGNAL INTEGRITY AND EMI/EMC (3-1-0) 4

Course Outcomes:
CO1: Understand how a PCB functions using transmission line theory, how RF energy is created and creating optimal PCB design.
CO2: Analyze grounding and shielding techniques for PCBs, Backplanes, servers, and enclosures.
CO3: Design techniques to minimize radiation/susceptibility for both digital and analog PCBs.
CO4: Solve how to overcome radiation problems with PCBs that interface with connectors, cables, and hardware slots.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	-	-	-	-	-	-	-	-	-	1	1
CO2	3	3	1	-	-	-	-	-	-	-	-	-	1	1
CO3	2	3	2	-	1	-	-	-	-	-	-	-	2	1
CO4	2	3	3	1	2	-	-	-	-	-	-	-	2	1

Course Contents

Fundamentals, Basics of EMI/EMC: coupling mechanisms, why to consider EMC, typical sources and victims, time domain vs. frequency domain, near vs. far field, non-ideal components, controlling signal return currents, differential vs. common mode currents, radiation and pickup from loop and dipoles, the "hidden schematic" idea, etc. High Speed/Frequency Effects In Electronic Circuits, Components In RF/EMI/ EMC /Si, Transmission Lines: Controlling Propagation, Matching, Signal Integrity Parameters, undesired effects, propagation time and delay, reflections and ringing, crosstalk (near and far) and jitter. Delays. Jitter. Signal ground versus safety ground, grounding strategies, ground loops, techniques to minimize ground impedance Grounding, Filtering, Printed Circuit Boards (PCBs), Shielding, Cables, Transients, Diagnostics and Troubleshooting Techniques.

References

Huray P.G.: The Foundations of Signal Integrity. J. Wiley & Sons, Hoboken, 2010
Hall S.H., Heck H.L.: Advanced Signal Integrity for High-Speed Digital Designs. Wiley-IEEE Press, 2009.
Bogatin E.: Signal Integrity – Simplified. Prentice Hall, 2004.
Johnson H. W.: High Speed Signal Propagation: Advanced Black Magic. Prentice Hall, 2003.
Caniggia S., Maradei F.: Signal Integrity and Radiated Emission of High-Speed Digital Systems. John Wiley & Sons, 2009.

EC469 INTRODUCTION TO PHOTONICS (3-1-0) 4

Course Outcomes:

CO1: Develop the knowledge of analyzing transmission properties of optical waveguides.
CO2: Describe the mechanisms contributing to signal degradation in optical transmission links.
CO3: Application of active and passive photonic components.
CO4: Analyze various properties of modern optical fibres and photonic crystals.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	1	1	-	-	-	-	-	1	2	-	2	2
CO2	3	3	1	1	-	-	-	-	-	1	2	-	2	2
CO3	3	3	1	1	-	-	-	-	-	1	2	-	2	2
CO4	3	3	2	1	-	-	-	-	-	1	2	-	2	2

Course Contents

Photonic Crystals: Electromagnetic wave in periodic medium, Symmetry, 1D photonic crystals: photonic band gap, omnidirectional reflector, 2D photonic crystals: photonic crystal waveguides, micro cavity, negative refraction, self-collimation, photonic crystal fibre, One-way waveguide, 3D photonic crystals: self-assembled photonic crystal, holographically fabricated photonic crystal. Plasmonics, - Optics in metal, Surface Plasmon polariton, Localized surface plasmon, Phonon polariton, Plasmon waveguides, Transmission through sub-wavelength aperture, Enhancement of fluorescence and nonlinearity, Applications in Biomedical Engineering. Metamaterials, Effective medium theory, Negative refractive index, Super lens, Transformation optics, Invisibility cloak.

References

Lukas Novotny and Bert Hecht, Principles of Nano-Optics, Cambridge University Press, 2012
Herve Rigneault, Jean-Michel Lourtioz, Claude Delalande, Juan Ariel Levenson, Nanophotonics, Wiley-ISTE, 2006.
Mark L. Brongersma, Pieter G. Kik, Surface Plasmon Nanophotonics, Springer, 2007
P.N. Prasad, Nanophotonics, John Wiley and Sons, 2004
John D. Joannopoulos, Robert D. Meade, Joshua N. Winn, Photonic Crystals, Princeton University Press Princeton, NJ, USA 2008.

EC470 MIMO COMMUNICATION SYSTEMS (3-1-0) 4

Course Outcomes:

CO1: Understand the fundamentals and need for MIMO communication systems.
CO2: Analyze the Mobile radio propagation, fading, diversity concepts and the channel modeling.
CO3: Summarize the principles and applications of wireless systems and standards.
CO4: Apply the concepts and techniques from MIMO theory to communication systems design.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	-	-	-	-	-	-	-	-	-	2	2	-
CO2	3	2	2	2	2	-	-	-	-	-	-	2	2	-
CO3	3	3	2	2	2	-	-	-	-	-	-	2	2	2
CO4	3	3	3	3	2	-	-	-	-	-	-	2	2	2

Course Contents

Overview of fundamentals of Digital Communications, The Wireless Channel, Detection, Diversity and Channel Uncertainty, Capacity of Wireless channels, Spatial Multiplexing and Channel modelling, Capacity and Multiplexing architectures, Diversity-Multiplexing trade-off and Universal Space Time Codes, Multi-user Communication.

References

D. Tse, Pramod Viswanath, Fundamentals of Wireless Communications, Cambridge University Press, 2005.
E. Biglieri, Coding for Wireless Channels, Springer, 2007
E. Biglieri et al., MIMO Wireless Communications, Cambridge University Press, 2007.

EC471 RF IC DESIGN (3-1-0) 4

Course Outcomes:

CO1: Understand RF Design issues and required circuit theory.
CO2: Design RF Transciever Architectures.
CO3: Ability to design an matching network based on high frequency components and Properly utilize RF/microwave CAD software.
CO4: Design RF functional blocks and circuits.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	1	-	-	-	-	-	-	-	2	2
CO2	3	2	2	1	1	-	-	-	-	-	-	-	2	2
CO3	3	2	2	1	1	-	-	-	-	-	-	-	2	2
CO4	3	2	2	1	1	-	-	-	-	-	-	-	2	2

Course Contents

Basic concepts in RF Design – harmonics, gain compression, desensitization, blocking, cross modulation, intermodulation, inter symbol interference, noise figure, Friis formula, sensitivity and dynamic range; Receiver architectures – heterodyne receivers, homodyne receivers, image-reject receivers, digital-IF receivers and subsampling receivers; Transmitter architectures – direct-conversion transmitters, two-step transmitters; Low noise amplifier (LNA) – general considerations, input matching, CMOS LNAs; Down conversion mixers – general considerations, spur-chart, CMOS mixers; Oscillators – Basic topologies, VCO, phase noise, CMOS LC oscillators; PLLs – Basic concepts, phase noise in PLLs, different architectures.

References

Behzad Razavi, RF Microelectronics, Prentice Hall PTR, 1997
Thomas H. Lee, The design of CMOS radio-frequency integrated circuit, Cambridge University Press, 2006
Chris Bowick, RF Circuit Design, Newnes, 2007

EC472 PRINCIPLES OF MODERN RADAR - ADVANCED TECHNIQUES (3-1-0) 4

Course Outcomes:

CO1: To understand the elementary concepts of advanced pulse compression techniques, optimal MIMO waveform design, synthetic aperture radar and array processing.
CO2: Apply, analyse and solve problems based on the concepts associated with advanced pulse compression. techniques, optimal MIMO waveform design, synthetic aperture radar and array processing.
CO3: Derive the inferences from exiting the advanced radar advanced pulse compression techniques, optimal MIMO waveform design, synthetic aperture radar and array processing.
CO4: Design the advanced radar pulse compression systems optimal MIMO waveform design, synthetic aperture radar and array processing.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	2	2	1	0	0	0	0	0	0	3	2
CO2	3	3	2	2	2	1	0	0	0	1	0	0	1	2
CO3	3	3	3	3	1	1	0	0	1	1	0	0	2	1
CO4	3	3	3	3	3	1	1	1	1	1	0	0	1	1

Course Contents

Advanced Techniques in Modern Radar, Advanced Pulse Compression Waveform Modulations and Techniques, Optimal and Adaptive MIMO Waveform Design, MIMO Radar, Synthetic Aperture Radar, Array Processing and Interference, Mitigation Techniques, Human Detection With Radar: Dismount Detection, Advanced Processing Methods for Passive Bistatic Radar Systems

References

Melvin, William L., and James Scheer. Principles of modern radar: advanced techniques. SciTech Pub., 2013.
Scheer, Jim, and William A. Holm. Principles of modern radar. Edited by Mark A. Richards, and William L. Melvin. Vol. 1. Raleigh, NC, USA: SciTech Pub., 2010.

EC473 ELECTRONIC DEFENCE SYSTEMS (3-1-0) 4

Course Outcomes:

CO1: To understand the elementary concepts of Electronic defence systems (ECM methods, ECCM methods, ESM methods and Radar warning receivers).
CO2: To apply, analyse and solve problems based on the concepts associated with Electronic defence systems (ECM methods, ECCM methods, ESM methods and Radar warning receivers etc.).
CO3: To derive the inferences from exiting Electronic defence systems (ECM methods, ECCM methods, ESM methods and Radar warning receivers etc.).
CO4: To design the solutions for various applications of electronic defence systems.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	3	1	0	0	0	0	0	0	3	2
CO2	3	3	2	2	3	1	0	0	0	1	0	0	2	1
CO3	3	3	3	3	1	1	0	0	1	1	0	0	2	1
CO4	3	3	3	3	3	1	1	1	1	1	0	0	1	1

Course Contents

Electronic Defence: Introduction, Systems in use in Armed forces; Sensors: Radar Sensors, Infrared sensors; Weapon systems: Artillery systems, missile systems; Electronic Intercept Systems: Introduction The Equation of a Passive System, Radar Warning Receivers; Electronic Countermeasures Systems Introduction, Operational Jamming Modes: SPJ, SOJ, and EJ, Onboard ECM Systems, .Electronic Counter-Countermeasures Systems: Introduction, Search Radar Counter-Countermeasures; New Electronic Defence Techniques and Technologies: Introduction, New Electronic Defence Architectures, ESM Antennas, Wideband Front End and Digital Receiver.

References

Filippo Neri, Introduction to Electronic Defence Systems, Second Edition, Artech House, London,

EC474 PRINCIPLES OF MODERN SONAR SYSTEMS (3-1-0)4

Course Outcomes:

CO1: To understand the elementary concepts of sonar systems (passive and active), acoustic arrays, reverberation, underwater noise characteristic and application of sonar systems.
CO2: Apply, analyse and solve problems based on the concepts associated with sonar systems (passive and active), acoustic arrays, reverberation, underwater noise characteristic and application of sonar systems.
CO3: Derive the inferences from exiting sonar systems (passive and active), acoustic arrays, reverberation, underwater noise characteristic and application of sonar systems.
CO4: Design the advanced sonar systems (passive and active), acoustic arrays for various applications.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	3	1	0	0	0	0	0	0	2	3
CO2	3	3	2	2	3	1	0	0	0	1	0	0	2	1
CO3	3	3	3	3	1	1	0	0	1	1	0	0	2	1
CO4	3	3	3	3	3	1	1	1	1	1	0	0	1	1

Course Contents

Sound: wave motion, sound pressure etc. Arrays: Need for projector arrays, Need for hydrophone arrays etc. Propagation of Sound in the Sea : Propagation loss, Losses: Spreading losses, Absorption losses. Target Strength: Definition, Formulae, Measurement, Dependence on pulse type and duration. Noise in Sonar Systems: Sources of nose, Thermal noise, Noise from the sea, Noise from a vessel. Reverberation: Sources of reverberation, Scattering and reflection; The Sonar Equations: What are they? What are their uses? The basic sonar equation, The basic passive equation; Passive Sonar: Radiated noise, Radiated noise: source level,nature of radiated noise. Active sonar: Pulse types, CW processing, FM processing, Active sonar equations.

References

A. D. Waite, Sonar for practicing Engineers, 3rd edition, Wiley, 2002.
Principles of sonar performance modelling, Michel A Ainslie, Springer,2010.

EC475 ADVANCED ELECTROMAGNETICS (3-1-0) 4

Course Outcomes:

CO1: Apply knowledge of mathematics, physics and engineering fundamentals to solving complex problems involving plane wave propagation in various media, antennas and electromagnetic compatibility.
CO2: Interpret solutions to complex electromagnetic problems using mathematics, physics and Maxwell's equations.
CO3: Apply appropriate techniques to solve transmission line, antenna and optical fibre related practical problems and select to use appropriate software and hardware tools.
CO4: Apply simple modeling techniques to solve a wide variety of research problems.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	-	-	-	-	-	-	-	-	-	1	1
CO2	3	3	1	-	-	-	-	-	-	-	-	-	1	1
CO3	2	3	2	-	2	-	-	-	-	-	-	-	2	2
CO4	1	3	3	1	3	-	-	-	-	-	-	-	2	2

Course Contents

Circuit-field relationship, electrical properties of matter, review of wave propagation, polarization and reflection, EM Theorems, Dielectric waveguides, surface waves, leaky waves, artificial impedance surfaces, Electromagnetic scattering-cylindrical wave radiation by Infinite line source, planar surface wave scattering, circular cylinder and sphere scattering, volume scattering, particle scattering, Introduction to metamaterials-characterization and dispersion relations of left handed materials, EM problems solving Computational EM-differential and integral techniques-FDTD and Method of moments, Green's function technique-Series and closed forms, Identities, scalar Helmholtz equations, dyadic Greens function, Green's function for planar layered media.

References

C. A. Balanis, Advanced Electromagnetics, Second edition, John Wiley & Sons, Inc., 2012.
R.F. Harrington, Time Harmonic Electromagnetic Fields, IEEE Press, 1961(First published)
Kong, J. A. Electromagnetic Wave Theory. Cambridge, MA: EMW Publishing, 2000.

EC476 MILLIMETER WAVE COMMUNICATION (3-1-0) 4

Course Outcomes:
CO1: Exposure of mm-wave communication system for single carrier, and multicarrier modulation schemes.
CO2: Understand the fundamental channel models for millimeter wave systems.
CO3: Study various applications of modern MIMO systems and evaluate the performance of multiantenna millimeter set-up.
CO4: Analyse concept of beam steering, and beam forming techniques.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	1	1	_	_	_	_	_	1	2	_	2	2
CO2	3	3	1	1	_	_	_	_	_	1	2	_	2	2
CO3	3	3	1	1	_	_	_	_	_	1	2	_	2	2
CO4	3	3	2	1	_	_	_	_	_	1	2	_	2	2

Course Contents
Millimeter wave characteristics and implementation challenges, radio wave propagation for mm wave, Millimeter wave generation and amplification, HEMT, transistor configurations, Analog mm wave components, Consumption factor theory, Trends and architectures for mm wave wireless, ADC's and DAC's, Modulation for millimeter wave communications, Millimeter wave link budget, Transceiver architecture, Massive MIMO Communications, Potential benefits for mm wave systems, Spatial, Temporal and Frequency diversity, Dynamic spatial, frequency and modulation allocation, Antenna beam width, polarization, advanced beam steering and beam forming, mm wave design consideration, On-chip and In package mm wave antennas, Techniques to improve gain of on-chip antennas, Implementation for mm wave in adaptive antenna arrays, Device to Device communications over 5G systems, Design techniques of 5G mobile.

References
K.C. Huang, Z. Wang, "Millimeter Wave Communication Systems", Wiley-IEEE Press, March 2011.
Robert W. Heath, Robert C. Daniel, James N. T.S. Rappaport, Murdock, "Millimeter Wave Wireless Communications", PH, 2014.
Xiang, W.Zheng, K. Shen, X.S, "5G Mobile Communications", Springer, 2016.

EC477 IMAGING, INFORMATICS AND COMPUTATIONAL PHYSICS (3-1-0) 4

Course Outcomes:
CO1: Appreciate and understand the physics of imaging in various domains of endeavors.
CO2: Apply the theory and practice to solve problems in the domain.
CO3: Apply the imaging techniques to problems of diverse engineering domains.
CO4: Develp numerical techniques and algorithms using computing technology to solve concrete engineering problems.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	-	-	-	-	-	-	-	-	-	-	2	2	2
CO2	-	3	-	-	-	-	-	-	-	-	-	-	2	3
CO3	1	2	3	-	2	2	1	1	-	-	1	1	2	2
CO4	-	-	-	3	3	2		1	2	1	1	-	2	3

Course Contents
Physics of imaging, material structure, Imaging methods and modalities, computational aspects, theoretical and applied; modalities in medical imaging, geophysics, applied physics, biology, astronomy, remote sensing and optics; methods and applications in nuclear medical imaging physics and radiology, image guided radiotherapy; computational photography, inverse problems and reconstruction, image informatics; use of optimization, compressed sensing and pattern recognition and machine learning theory; applications of deep learning and artificial intelligence.

References
Kedar Khare, Fourier Optics and Computational Imaging, Wiley, 2015.
H. K. Huang, PACS and Imaging Informatics: Basic Principles and Applications 2nd Edition, Wiley-Blackwell, 2010.
E. Russell Ritenour and William Hendee, Medical Imaging Physics, Wiley 2002.
B. H Brown, R. H Smallwood, D. C. Barber, P.V Lawford, D.R Hose, Medical Physics and Biomedical Engineering, CRC Press 1998
S Webb, The Physics of Medical Imaging, Institute of Physics, 1988.
Paul Suetens, Fundamentals of Medical Imaging, Cambridge University Press, 2009.
Thayalan K, The Physics of Radiology and Imaging, Jaypee Brothers 2014.
Tetsuo Asano, Geometry, Morphology and Computational Imaging, Springer 2002.

EC478 COMPLEX ANALYSIS AND APPLICATIONS (3-1-0) 4

Course Outcomes:
CO1: Appreciate the necessity of the complex analysis.
CO2: Apply the complex analysis theory to solve peoblems.
CO3: Use computing tools to apply to solve the problems in the domain.
CO4: Identify and apply the techniques to solve complex engineering problems.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	-	1	-	-	-	-	-	-	-	-	1	2	2
CO2	-	3	-	3	2	1	1	-	-	1	-	1	2	2
CO3	-	-	-	-	1	3	-	2	1	-	1	1	2	2
CO4	-	-	2	1	3	3	1	2	1	1	1	1	2	2

Course Contents
Complex numbers: algebra, representation, polar forms, complex exponential, powers and roots, topological representation, Riemann sphere and stereographic representation. Analytic functions: limits and continuity, analyticity, CR equations, harmonic functions, elementary functions: polynomials, rational functions, exponential, hyperbolic functions, complex integration: contour integrals, Cauchy's integral theorem, bounds for analytic functions, Series representation for analytic functions: Taylor series, power series, Laurent series, singularities, Residue theory: improper integrals, Conformal mapping, Entire and meromorphic functions, applications of harmonic functions, Fourier series and Laplace transform. Applications in Circuit Simulators, Electromagnetism (timeharmonic fields). Electrostatics (solutions to Laplace's equation), and in various other fields of engineering, natural and applied sciences.

References
S Ponnusamy, H Silverman, Complex variables with applications, Birkhauser, 2006.
JH Mathews, RW Howell, Complex analysisfor mathematics and engineering, Jones and Bartlett, 2001.
Edward B. Saff, Arthur David Snider, Fundamentals of Complex Analysis with Applications to Engineering, Science, and Mathematics, Pearson Education 2003
Kozo Sato, Complex Analysis for Practical Engineering, Springer, 2015.
Cohen, Harold Complex Analysis with Applications in Science and Engineering, Springer, 2007.
JW Brown, RV Churchill, Complex variables with applications, 8thed, McGraw Hill 2009.

EC479 COMPUTATIONAL INVERSE PROBLEMS AND APPLICATIONS (3-1-0) 4

Course Outcomes:
CO1: Understand inverse problems in various fields.
CO2: Apply the theory to solve ill-posed problems.
CO3: Use computing tools to apply to solve the inverse problems numerically.
CO4: Apply the theory and techniques to solve concrete engineering problems.
Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	-	-	2	-	-	-	-	-	-	-	1	2	2
CO2	3	2	3	2	-	-	-	-	-	-	-	1	2	2
CO3	-	2	2	1	3	-	-	1	2	1	-	1	2	2
CO4	-	2	-	-	3	2	1	1	2	2	2	1	2	2

Course Contents
Inverse Problems and Interpretation, Examples of inverse problems, III posed problems and numerical solutions. Classical Regularization Methods, Statistical Inversion Theory, nonstationary Inverse Problems, Regression, regularization, and iterative schemes for smooth optimization, numerical optimization, Bayesian approach to inverse problems, Inverse problems in imaging modalities and radar, applications in remote sensing, geoscience, biomedical.

References

Heinz Engl, Michael Hanke, and Andreas Neubauer, Regularization of Inverse Problems, Dordrecht, 2nd ed, 1996.
Curtis R.Vogel, Computational Methods for Inverse Problems, SIAM, 2002.
Per Christian Hansen, Discrete Inverse Problems: Insight and Algorithms, SIAM, 2010.
Jennifer Mueller and SamuliSiltanen, Linear and Nonlinear Inverse Problems with Practical Applications, SIAM, 2012.
Jorge Nocedal and Stephen J. Wright, NumericalOptimization, Springer-Verlag, 1999.

EC480 REMOTE SENSING: PRINCIPLES, TECHNIQUES AND APPLICATIONS (3-1-0) 4

Course Outcomes:
CO1: Able to understand concepts of physics of remote sensing, platforms and sensors, data acquisition systems and image processing algorithms for remote sensing applications.
CO2: Able to understand and apply concepts of pre-processing and post processing methods for multi-sensor satellite imagery data.
CO3: Able to implement concepts and advance methods for object segmentation and classification for multi-sensor satellite imagery data.
CO4: Able to implement advance methods for object detection, classification and change detection from multi-sensor satellite imagery data with real applicationsns.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	-	-	-	-	-	-	-	-	-	3	1
CO2	3	3	2	2	-	-	-	-	-	-	-	-	3	2
CO3	3	3	2	2	2	-	-	-	-	-	-	-	3	3
CO4	3	2	3	2	2	2	2	-	-	-	-	-	3	3

Course Contents
History and Introduction, electromagnetic radiation, basic laws, Radiometry, Interaction of EMR with matter, RS in visible and IR domain: Radiance to reflectance, atmospheric and topographic correction, Radio remote sensing, RS image acquisition, Different types of sensors, resolution concepts, Resolution concepts, Spectral reflectance curves, Spectral reflectance curves, Spectral indices, Thermal infrared remote sensing, Passive microwave radiometry, Active microwave remote sensing: Imaging radar, Platforms used for RS data acquisition and characteristics, Hyperspectral Remote Sensing, Information Extraction from the Image Data, Lidar, Common remote sensing datasets and data portals, mathematical techniques and algorithms for processing the RS data, acquisition and analysis, estimation, detection, recognition, classification techniques, Applications of RS for land use and land cover monitoring, water resources management, agricultural, environmental, forestry, geology applications, and etc.
References

Iain H. Woodhouse, Introduction to Microwave Remote Sensing, CRC Press 2005.
W. G. Rees, Physical Principles of Remote Sensing, Cambridge University Press, 2012.
Hamlyn G. Jones and Robin A. Vaughan, Remote Sensing of Vegetation: Principles, Techniques, and Applications, Oxford University Press, 2010.
J. Richards, Remote Sensing with Imaging Radar, Springer 2020.
Pinliang Dong and Qi Chen, LiDAR Remote Sensing and Applications, CRC Press, 2017.
Marcus Borengasser, William S. Hungate, Russell Watkins: Hyperspectral Remote Sensing Principles and Applications, 1 Ed, CRC Press, 2007.

EC481 ADVANCE DEEP LEARNING AND APPLICATIONS (3-1-0) 4

Course Outcomes:
CO1: Able to understand the mathematical formulation of different types of existing deep learning models.
CO2: Apply deep learning models for simple regression applications.
CO3: Develop advance deep learning models with real-world applications.
CO4: Design, develop and evaluate advance deep learning models for various real-world applications.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	-	-	-	-	-	-	-	-	-	1	1
CO2	3	3	2	-	2	-	-	-	-	-	-	-	1	1
CO3	3	3	2	2	2	-	-	-	-	-	-	-	2	2
CO4	3	2	2	2	2	2	2	-	-	-	-	-	2	2

Course Contents

Review of CNNs for classification and segmentation tasks, Advance concepts-depth-wise separable convolution, Atrous convolution, Group Convolution, Gated Atrous Pyramid Pooling, Attention and Self-attentions. Deep CNN Models for Regression, classification and Segmentations task: ResNet Models, Variants of UNet, BiSeNet V2. Advance CNNs for Object Detection and Text Classification, Graph Neural Networks. Vision Transformer and its Applications: object segmentation, detection and classification.

References

Ian Goodfellow, Yoshua Bengio, and Aaron Courville, Deep Learning, MIT Press, 2016.
Mahmoud Hassaballah and Ali Ismail Awad, Deep Learning in Computer Vision: Principles and Applications, CRC Press, 2020.
Rowel Atienza, Advanced deep learning with Keras, Packt, October 2018.
Wang, Zhao, &Pourpanah, F.Recent, Advances in deep learning. Int.J.Mach. Learn. & Cyber. 11,747-750 (2020).
Alexey Dosovitskiy, et al., An Image is Worth 16x16 Words: Transformers for Image Recognition at Scale
Chen, Xiangning, Cho-Jui Hsieh, and Boqing Gong. "When vision transformers outperform resnets without pre-training or strong data augmentations." arXiv preprint arXiv:2106.01548 (2021).

EC280 MINI PROJECTS IN ELECTRICAL CIRCUITS & SYSTEMS (0-0-3) 2

Course Outcomes:

CO1: Understanding the problem statement and identifying the electrical components needed for the design.
CO2: Applying the knowledge of electrical circuits from previous courses for the circuit design.
CO3: Implementation of the proposed electrical circuit in circuit simulators.
CO4: Evaluate the designed electrical circuit by comparing with published data and effectively communicate the developed project information in the form of reports and presentations.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	-	2	3	2	3	3	3	2	3	3
CO2	3	3	3	3	3	1	2	2	3	3	3	2	2	3
CO3	2	3	3	2	3		1	2	3	3	3	3	2	2
CO4	1	2	1	2	2	1	1	3	3	3	3	3	2	1

EC281 MINI PROJECTS IN DIGITAL SYSTEM DESIGN (0-0-3) 2

Course Outcomes:

CO1: Understand the features of the code development environment and the FPGA kit.
CO2: Verify the timing and functional performance of a digital system.
CO3: Design a complete digital system in HDL.
CO4: Implement on FPGA board and demonstrate the performance.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	-	-	-	-	3	-	-	-	1	-	-	2	2	-
CO2	1	2	-	-	3	-	-	-	1	-	-	2	2	-
CO3	3	3	3	3	3	-	-	-	2	2	-	2	2	2
CO4	3	3	2	2	3	-	-	-	2	2	-	2	2	2

EC380 MINI PROJECTS IN COMMUNICATION SYSTEMS AND NETWORKS (0-0-3) 2

<u>Course Outcomes</u>:

CO1: Identify real-world design problems and suggest possible solutions.
CO2: Apply the technical knowledge gained from Communication Systems and Networks courses to execute the mini project work.
CO3: Learn project management skills and implement the proposed project.
CO4: Evaluate the solution and communicate technical project information by preparing research project reports and oral presentation of the mini project carried out.

<u>Course Articulation Matrix</u>

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	-	2	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	1	-	3	3	3	3	3	3	3
CO3	-	-	3	2	3	-	-	3	3	3	3	3	2	2
CO4	1	-	-	2	2	-	1	3	3	3	3	3	1	1

EC381 MINI PROJECTS IN MICROPROCESSOR & EMBEDDED SYSTEM (0-0-3) 2

<u>Course Outcomes</u>:

CO1: Identify real-world Design problems and suggest possible solutions.
CO2: Apply the technical knowledge gained from Microprocessor and Embedded system courses to execute the project work.
CO3: Learn project management skills and implement the proposed project.
CO4: Evaluate the solution and communicate technical project information by preparing research reports and oral presentations.

<u>Course Articulation Matrix</u>

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	-	2	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	1	-	3	3	3	3	3	3	3
CO3	-	-	3	2	3	-	-	3	3	3	3	3	2	2
CO4	1	-	-	2	2	-	1	3	3	3	3	3	1	1

EC382 MINI PROJECTS IN ANALOG SYSTEM DESIGN (0-0-3) 2

<u>Course Outcomes</u>:

CO1: Identify Analog system design problems and formulate possible solutions.
CO2: Apply the knowledge of Analog circuit design gained from various courses to execute the design project work.
CO3: Implementation of the analog circuit in circuit simulators.
CO4: Evaluate the solution by comparing with experimental data and communicate the work done through proper documentation.

<u>Course Articulation Matrix</u>

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	-	2	2	2	2	2	2	3	3	3
CO2	3	3	3	3	2	1	1	3	3	2	3	3	3	3
CO3	2	3	2	2	3	-	-	3	3	3	3	3	3	3
CO4	1	2	1	1	2	-	1	3	3	3	2	3	2	1

EC383 MINI PROJECTS IN VLSI DESIGN (0-0-3) 2

Course Outcomes:

CO1: Identify VLSI Design problems and suggest possible solutions.
CO2: Apply the technical knowledge gained from VLSI domain courses to execute the project work.
CO3: Learn project management skills and implement the proposed project.
CO4: Evaluate the solution and communicate technical project information by preparing research reports and oral presentations.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	-	2	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	1	-	3	3	3	3	3	3	3
CO3	-	-	3	2	3	-	-	3	3	3	3	3	2	2
CO4	1	-	-	2	2	-	1	3	3	3	3	3	1	1

EC384 MINI PROJECTS IN RF DESIGN (0-0-3) 2

Course Outcomes:

CO1: Understanding the problem statement and identifying the RF components needed for the design.
CO2: Applying the knowledge of electronics circuits from previous courses for the RF circuit design.
CO3: Implementation of the proposed RF circuit in Advanced simulators.
CO4: Evaluate the designed RF circuit by comparing with published data and effectively communicate the developed project information in the form of reports and presentations.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	-	2	3	2	3	3	3	2	3	3
CO2	3	3	3	3	3	1	2	2	3	3	3	2	2	3
CO3	2	3	3	2	3	-	1	2	3	3	3	3	2	2
CO4	1	2	1	2	2	1	1	3	3	3	3	3	2	1

EC385 MINI PROJECTS IN DIGITAL SIGNAL PROCESSING (0-0-3) 2

Course Outcomes:

CO1: To understand and implement the concepts learnt in digital signal processing theory.
CO2: To Apply, analyse and solve problems based the theoretical understanding of the concepts of digital filtering, fast Fourier transform and other digital processing techniques.
CO3: To simulate the various digital signal processing-based problems chosen by the tam of members.
CO4: To design a small project based on software and hardware so as to accomplished the designated task in the mini project.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	2	1	0	0	3	2	0	0	3	2
CO2	3	3	3	3	2	1	0	0	3	3	0	0	2	1
CO3	3	3	3	3	3	1	0	0	3	3	0	0	2	1
CO4	3	3	3	3	3	1	1	1	3	3	0	0	1	1

EC386 MINI PROJECT IN IMAGE PROCESSING (0-0-3) 2

Course Outcomes:
CO1: Able to read and understand literature about a practical image processing problem.
CO2: Design and develop image processing algorithms in practice.
CO3: Evaluate and compare the results with other implementations.
CO4: Effectively document, present, demonstrate the work and work in a team.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	1	-	-	-	-	-	2	-	1	1	2	2
CO2	2	3	3	-	2	-	-	-	2	-	1	1	3	2
CO3	2	1	3	3	2	-	-	-	2	-	1	1	3	2
CO4	2	1	1	3	2	-	-	-	2	2	1	1	3	2

EC387 MINI PROJECT IN AI AND MACHINE LEARNING (0-0-3) 2

Course Outcomes:
CO1: Identify relevant problem to solve using AI and ML.
CO2: Apply AI and ML techniques to design and solve the problem.
CO3: Implement, manage, test and validate the project as an individual and as a team.
CO4: Prepare project reports, demonstrate the project, and present the project.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	-	2	-	-	1	-	-	-	-	2	2	1
CO2	-	-	3	-	-	-	-	-	-	-	-	-	2	2
CO3	-	-	-	2	3	-	-	3	3	-	3	-	-	2
CO4	-	-	-	-	-	3	-	-	-	3	-	-	-	1

EC388 MINI PROJECT IN PHOTONICS (0-0-3) 2

Course Outcomes:
CO1: Identify real-time problems in the area of photonics and suggest possible solutions.
CO2: Apply the technical knowledge gained from previous courses for project development.
CO3: Show an ability to communicate technical information by means of written reports and oral presentation.
CO4: Improve project management skills in development of project.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	_	2	3	3	_	_	1	3	3	3
CO2	3	3	3	2	2	_	_	_	_	_	_	3	3	3
CO3	_	_	_	_	_	_	_	3	3	_	3	3	_	2
CO4	_	_	_	_	_	_	_	3	3	3	_	3	_	1

The contents of these mini projects will be defined by the instructor.

EC390 SEMINAR (0-0-2) 1

EC490 PRACTICAL TRAINING (0-0-3) 2

EC498 MAJOR PROJECT 6

Course Outcomes:

CO1: Identify engineering problems and suggest possible solutions.
CO2: Apply the technical knowledge gained from previous courses to execute the project work.
CO3: Learn project management skills and implement the proposed project.
CO4: Evaluate the solution and communicate technical project information by preparing research reports and oral presentations.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	-	2	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	1	-	3	3	3	3	3	3	3
CO3	-	-	3	2	3	-	-	3	3	3	3	3	2	2
CO4	1	-	-	2	2	-	1	3	3	3	3	3	1	1

EC497 CORNERSTONE/CAPSTONE PROJECT 4

Course Outcomes:

CO1: Understand some foundation concepts and applications covered by different engineering disciplines.
CO2: Design and implement the project by working collaboratively in a team setting.
CO3: Explore possible innovative engineering solutions via experiential learning and self-initiated, blended learning processes.
CO4: Present and demonstrate their projects orally and in writing.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	-	2	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	1	-	3	3	3	3	3	3	3
CO3	-	-	3	2	3	-	-	3	3	3	3	3	2	2
CO4	1	-	-	2	2	-	1	3	3	3	3	3	1	1

For details refer to clause 3.2 under Regulations specific to Undergraduate Programmes.

UC401 LIBERAL ARTS COURSES/CO-CURRICULAR/EXTRACURRICULAR ACTIVITIES 10

For details refer to clause 3.2 (f) under Institute Regulations specific to Undergraduate Programmes.

COURSES FOR MINOR STREAM

EC391M ANALOG ELECTRONIC CIRCUITS (3-0-0) 3

Course Outcomes:

CO1: Understand the ideal opamp characteristics, concept of negative feedback in opamp circuits, frequency response of amplifiers and the concept of analog to digital interface.
CO2: Analyze the effects of negative/positive feedback on simple discrete transistor amplifier circuits.
CO3: Design a few linear and non-linear analog systems using opamps by building appropriate feed-back network around the opamps.
CO4: Evaluate the effects of non-idealities of opamps on the performance of circuits.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	-	-	-	-	-	-	-	-	-	-	-	-
CO2	3	2	-	-	-	-	-	-	-	-	-	-	-	-
CO3	3	2	-	-	-	-	-	-	-	-	-	-	-	-
CO4	3	2	-	-	-	-	-	-	-	-	-	-	-	-

Course Contents

Introduction to operational amplifiers: The difference amplifier and the ideal operational amplifier models, concept of negative feedback and virtual short, Analysis of simple operational amplifier circuits, Frequency response of amplifiers, Bode plots. Feedback: Feedback topologies and analysis for discrete transistor amplifiers, stabillity of feedback circuits using Barkhausen criteria. Linear applications of operational amplifiers: Instrumentation and Isolation amplifiers, Current and voltage sources, Non-linear applications of operational amplifiers: Comparators, clippers and clampers, Precision rectifiers, Waveform Generation: Sinusoidal feedback oscillators, Relaxation oscillators, square-triangle oscillators. Practical perational amplifiers: Non-idealities and their on circuit performance. Analog and Digital interface circuits: Relays, S/H circuits, Opto-couplers, A/D, D/A Converters.

References

Ramakant A. Gayakwad, Op-Amps and Linear Integrated Circuits, Pearson, 2015
Sergio Franco, Design with OPAMPS and Linear Integrated circuits, Tata McGraw Hill, 2002.
Ron Mancini, Op Amp for Everyone, Texas Instruments, 2002
Phillip E. Allen and Douglas R. Holberg, CMOS Analog Circuit Design, Oxford University Press, 2003.

EC392M DIGITAL ELECTRONICS (3-0-0) 3

Course Outcomes:

CO1: Understand Boolean Algebra and arithmetic operation using binary number system.
CO2: Analysis and Design of combinational circuits using specified/ available MSI devices given a set of specifications.
CO3: Understand and appreciate the features of digital logic families.
CO4: Analysis and Design of sequential circuits using specified/ available MSI devices given a set of specifications.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	-	-	-	-	-	-	-	-	-	-	-
CO2	3	2	3	-	-	-	-	-	-	-	-	-	-	-
CO3	3	2	1	-	-	-	-	-	-	-	-	-	-	-
CO4	3	2	3	-	-	-	-	-	-	-	-	-	-	-

Course Contents

Introduction to Boolean Algebra and Switching Functions, Boolean Minimization, Finite State Machines, Design of synchronous FSMs, FSM Minimization, Bipolar Logic Families – TTL, MOS logic families (NMOS and CMOS), and their electrical behaviour. Memory Elements, Timing circuits, Elementary combinational and sequential digital circuits: adders, comparators, shift registers, counters. Logic Implementation using Programmable Devices (ROM, PLA, FPGA).

References

Morris. M. Mano, Michael D. Ciletti, Digital Design, Fourth Edition, Prentice-Hall India. 2008.
Charles. H. Roth, Jr., Fundamentals of Logic Design, Fifth Edition, Thomson Brooks/Cole, 2005.
J.F.Wakerly, Digital Design Principles and Practices, PH, 1999.
D.D. Givone, Digital Principles and Design, TMH, 2002

EC393M SIGNALS AND SYSTEMS (3-0-0) 3

Course Outcomes:
CO1: To understand basis of signals classifications, it's inherent properties and mapping of signals with variety of practical scenarios or with laboratory test signals.
CO2: To gain understanding of basic signals/operations such as sampling, impulse concept, impulse response and step response of an LTI system, Convolution etc.
CO3: To understand representation of continuos-time as well as discrete-time signals and systems in time and frequency domain using appropriate mathematical models and relevance to various use cases.
CO4: Analyzing practical linear and nonlinear systems such as amplifier, rectifier, filters and evaluating their performance using appropriate methodologies in time and frequency domain. Using these techniques in a variety of signal and Image processing applications and to design these systems.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	-	-	-	-	-	-	-	1	-	-
CO2	3	2	1	2	-	-	-	-	-	-	-	1	-	-
CO3	3	2	2	2	3	3	2	3	-	-	-	3	-	-
CO4	2	1	2	3	1	2	2	3	-	-	-	3	-	-

Course Contents
Sinusoids –complex exponentials and phasor, Spectrum representation – spectrum of sum of sinusoids, Periodic signals, Fourier series representation, synthesis. Sampling and aliasing – sampling of sinusoidal signals, aliasing, sampling theorem, reconstruction. Discrete time FIR systems – moving average filter, general FIR filter, impulse filter, implementation of FIR filters, LTI systems, convolution, frequency response of FIR systems. Z Transform: Definition and properties, ROC, inverse Z transform, transfer function, poles and zeros, application of Z transforms to discrete-time systems. Discrete time IIR systems – Impulse response, step response, representation of LTI systems, frequency response of IIR systems. Applications of DSP – Sinusoidal synthesis, Image denoising,
References
Mc Chellan, R.W. Schafer & Yoder, *Signal Processing First*, Pearson 2003.

EC394M COMMUNICATION SYSTEMS (3-0-0) 3

Course Outcomes:
CO1: Understand the fundamentals Analog and Digital communication systems.
CO2: Analyze various noise issues in the receiver, threshold effect, and capture effect.
CO3: Application of various modulation technique in the modern communication system.
CO4: Design and modeling of basic communication systems.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	-	-	-	-	-	-	-	-	-	2	-	-
CO2	3	2	2	2	2	-	-	-	-	-	-	2	-	-
CO3	3	2	2	2	2	-	-	-	-	-	-	2	-	-
CO4	3	3	3	3	2	-	-	-	-	-	-	2	-	-

Course Contents
Amplitude Modulation, Time & Frequency domain description, Modulation techniques, Switching modulator, Demodulation techniques, Envelope detector, Coherent detection, Costas Receiver, The Superheterodyne Receiver, Quadrature Carrier Multiplexing, Single side band and vestigial sideband modulation, Frequency Translation,

Frequency Division Multiplexing. Angle Modulation, Basic definitions, Frequency Modulation, Narrow Band FM, Wide Band FM, Transmission bandwidth of FM Signals, Generation of FM Signals, Demodulation of FM Signals, FM Stereo Multiplexing, Phase–Locked Loops and their application in FM demodulation. Theme example: FM stereo broadcast. Noise in Analog Modulation, Introduction, Receiver Model, Noise in DSB-SC receivers, Noise in AM receivers, Threshold effect, Noise in FM receivers, Capture effect, FM threshold effect, FM threshold reduction, Pre-emphasis and Deemphasis in FM. Digital Representation of analog signals, The Sampling process, Pulse Amplitude Modulation, Time Division Multiplexing, Pulse-Position Modulation, Generation of PPM Waves, Detection of PPM Waves, Quantization Process, Quantization Noise, Pulse Code Modulation: Sampling, Quantization, Encoding, Regeneration, Decoding, Filtering, Multiplexing, Application to Vocoders.

References

M. F. Mesiya, "Contemporary Communication Systems", McGrawHill, 2013.
Steven W. Ellingson, "Radio Systems Engineering", Cambridge University Press, 2016.
Taub and Schilling, "Principles of Communication systems", Second Edition, Tata McGrawHill, 2006 Proakis and Salehi, "Fundamentals of Communication Systems", Second Edition, Pearson International, 2014.
Simon Haykin, "Communication Systems", Fourth Edition, Wiley, 2000.

EC395M DATA COMMUNICATION AND NETWORKS (3-0-0) 3

Course Outcomes:

CO1: Understand basic concepts of Data communication, networking and switching technologies.
CO2: Identify the different types of network devices and their functions within a network.
CO3: Study different components of computer networks, various protocols, modern technologies and their applications.
CO4: Ability to calculate the data communication traffic and trucking efficiency.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	1	1	-	-	-	-	-	1	2	-	-	-
CO2	3	3	1	1	-	-	-	-	-	1	2	-	-	-
CO3	3	3	1	1	-	-	-	-	-	1	2	-	-	-
CO4	3	3	2	1	-	-	-	-	-	1	2	-	-	-

Course Contents

Data encoding and transmission concepts, Digital data transmission, NRZ encoding, Multilevel binary encoding, Biphase encoding, Scrambling techniques, Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK), Phase Shift Keying (PSK), Performance of digital and analog modulation schemes, Quadrature Amplitude Modulation (QAM), Pulse Code Modulation, Non-linear encoding, Delta modulation, Asynchronous transmission, Synchronous transmission, Ethernet link layer frame example. Switching techniques, Multiplexing and Multiple Access techniques, Packet Switched Networks. OSI and TCP/IP Models, Internet protocols and addressing, networking devices, data links and transmission, LANs and Network of LANS, Wireless Networks and Mobile IP, Routing and internetworking, transport and end to end protocols, congestion control techniques, Application Layer and network management, Network Security. Packet Queues and delays, Little's theorem, Birth and death process, Queuing disciplines, M/M/1 Queues, Burkes and Jackson theorems. Traffic models, ISDN, ATM Networks, Quality of service and resource allocation, VPNs and MPLS, Cellular Telephone and Optical networks, VOIP and Multimedia networking. Mobile Adhoc Networks and Wireless Sensor Networks.

References

Nader F. Mir, Computer and Communication Networks, Pearson Education, 2007
Garcia and Widjaja, Communication Networks, McGraw Hill, 2006
J.F. Hayes, Modelling and analysis of Computer Comm. Networks, Plenum, 1984.
Jean Walrand & Pravin Varaiya, High Performance Communication Networks, Morgan Kaufmann Publishers, 2002
Taub and Schilling, "Principles of Communication systems", Second Edition, Tata McGrawHill, 2006 Proakis and Salehi, "Fundamentals of Communication Systems", Second Edition, Pearson International, 2014.
Simon Haykin, "Communication Systems", Fourth Edition, Wiley, 2000.

EC500M MACHINE LEARNING FOR ELECTRONICS AND COMMUNICATION ENGINEERING (3-1-0) 4

Course Outcome:

CO1: Able to understand basics of machine learning algorithms.
CO2: Able to mathematically formulate regression and classification tasks.
CO3: Design machine learning systems for different domains of Electronics and Communication Engineering.
CO4: Design advanced and real time machine learning systems for Electronics and Communication applications.

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	-	-	2	-	-	-	-	-	-	-	-	-
CO2	3	2	-	-	2	-	-	-	-	-	-	-	-	-
CO3	3	2	1	2	2	-	-	-	-	-	-	-	-	-
CO4	3	2	2	2	2	-	-	-	-	-	-	-	-	-

Course Contents
Machine learning for 5G and 6G Wireless Networks, Medical Signal and Image Processing, Satellite Image Processing and Remote Sensing, Radar Signal Processing, Tactical and Surveillance Applications, Speech and Audio Processing, VLSI, Device modelling, electronic manufacturing, Computer vision and other applications.

References
Josh Patterson and Adam Gibson, "Deep Learning: A Practitioner's Approach", O'Reilly, 2017
Ian Goodfellow, Y. Bengio and A. Courvelle, "Deep Learning", MIT Press, 2016
Li Deng and Dong Yu, "Deep Learning: Methods and Applications", 2013
Machine Learning for Audio, Image and Video Analysis", F. Camastra, Vinciarelli, Springer, 2007
Jeremy Watt and Reza Borhani, Machine Learning Foundation, Algorithms and Applications
Fa-long Luo, MAchine learning for future Wireless Communications, 2020 edition, Wiley

COURSES FOR HONORS STREAM
(For more details, please refer to PG curriculum)

EC702 ANALOG INTEGRATED CIRCUIT DESIGN (4-0-0) 4

Course Contents

MOSFET - Review of current equation, regions of operation, small signal model. Current mirrors, Single-ended amplifiers, Differential amplifiers, Two-stage amplifiers – analysis, frequency response, stability, compensation; Band gap references, Constant–Gm biasing; Types of Noise, Introduction to switched capacitor circuits, switched capacitor amplifiers, noise analysis, Distortion, current and voltage references, Oscillators and PLL.

References

Behzad Razavi, Design of Analog CMOS Integrated Circuits McGraw-Hill International Edition 2016
Behzad Razavi, Fundamentals of Microelectronics, Second edition, Wiley, 2013
Sedra and Smith, Microelectronics Circuits, Oxford Univ. Press, 2004
David A. Johns and Ken Martin, Analog Integrated Circuit Design, John Wiley, 2002
Phillip E. Allen and Douglas R. Holberg, CMOS Analog Circuit Design, Oxford University Press, 2003.
NPTEL Video Lectures

EC703 VLSI DATA CONVERTERS (4-0-0) 4

Course Contents

Sample and Hold Circuits: Basic S/H circuit, effect of charge injection, compensating for charge injection, bias dependency, bias independent S/H. D/A Converter – General considerations, Static non-idealities and Dynamic nonidealities; Current-steering DAC – Binary weighted DAC, Thermometer DAC, Design issues, Effect of Mismatches. A/D converter – General considerations, static and dynamic non-idealities. Flash ADC – Basic architecture, Design issues, Comparator and Latch, Effect of non-idealities, Interpolative and Folding architectures. Successive Approximation ADC; Pipeline ADC. Over sampling ADC – Noise shaping, Sigma-Delta modulator.

References

Behzad Razavi, Design of Analog CMOS Integrated Circuits McGraw-Hill International Edition 2016
David A. Johns and Ken Martin, Analog Integrated Circuit Design, John Wiley, 2002
Phillip E. Allen and Douglas R. Holberg, CMOS Analog Circuit Design, Oxford University Press, 2003.
Behzad Razavi, Principles of Data Conversion System Design, Wiley-IEEE Press, 1995
Rudy J. van de Plassche, CMOS Integrated Analog-to-Digital and Digital-to-Analog Converters, Springer, 2003
NPTEL Video Lectures

EC704 VLSI DESIGN AUTOMATION (4-0-0) 4

Course Contents

Introduction to VLSI design automation: VLSI design methodologies, use of VLSI EDA tools, Algorithmic Graph Theory, computational Complexity; Partitioning, Simulated Annealing. Floor planning and placement, Routing, High Level Synthesis, operation scheduling, Static Timing Analysis, Topological vs logical timing analysis, False paths, Arrival time, Required arrival Time, Slacks. Advanced VLSI Design Automation: Physical Synthesis, Optical Proximity correction, Interconnect issues.

References

Naveed Sherwani, Algorithms for VLSI Physical Design Automation, 3rd ed., Kluwer Academic Pub., 1999
Majid Sarrafzadeh and C. K. Wong, An Introduction to VLSI Physical Design, McGraw Hill, 1996.
Sabih H. Gerez, Algorithms for VLSI Design Automation, John Wiley, 1998
Sung Kyu Lim, Practical Problems in VLSI Physical Design Automation, Springer, 2008
Sadiq M. Sait & Habib Youssef, VLSI Physical Design Automation: Theory and Practice, WS Publishing, 1999
NPTEL Video Lectures

EC733 OPTICAL NETWORKS AND SWITCHING (4-0-0) 4

Course Contents

Introduction to basic optical communications and devices. Optical multiplexing techniques. Optical Networks: Conventional optical networks, Multiple access optical networks, Optical amplification in all optical networks. All-optical subscriber access networks. Design issues. Optical switching: Motivation, Spatial light modulator, Relational and non-relational switching devices, Fundamental limits on optical switching elements, Switching architectures, Free-space optical switching. Wavelength routed networks and other special topics. Soliton based networks, Optical networks management issues.

References

Rajiv Ramaswami, Kumar Sivarajan, Galen Sasaki, Morgan Optical Networks: A Practical Perspective, Kauffman Publishers, ELSEVIER, 2010.
Hussein T. Mouftah, Jaafar M. H. Elmirghani, Photonic Switching Technology: Systems and Networks, Wiley, 1999.
Ray T. Chen, Joseph C. WDM and Photonic Switching Devices for Network Applications, Volume 4653, Chon SPIE, 2002 - Technology & Engineering
Martin Maier, Optical Switching Networks, Cambridge University Press, 2008.
A. Selvarajan, Subrat Kar, T. Srinivas, Optical Fibre Communication: principles and systems, TMH, 2002.

EC734 SIGNAL DETECTION AND ESTIMATION (4-0-0) 4

Course Contents

Hypothesis Testing, Neyman Pearson Lemma, UMP test, Decision Theoretic framework, Multiple-Decision Problem. Parameter Estimation - Unbiasedness, Consistency, asymptotic normality, sufficient statistics, minimax estimation, decision theoretic framework, Rao-Blackwell theorem, Cramer – Rao inequality. Estimation: Minimum mean square linear estimation, Wiener filter, Kalman filter, Levinson – Durbin and innovation algorithms.

References

H. L. Van Trees Detection, Estimation and Modulation Theory, Part I, John Wiley, 1968.
Srinath, Rajasekaran and Viswanathan, Introduction to Statistical Signal Processing with applications, PHI, 1995.
Steven M. Kay, Fundaments of Statistical Signal Processing, Vol. I:Estimation Theory, Vol. II: Detection Theory, Prentice Hall International, 1993
Papoulis A., Probability Random Variables and Stochastic Processes, McGraw Hill, 2002
H. Stark and J. W Woods, Probability and Random Processes with applications to signal processing, Pearson Education, 2002.

EC761 INFORMATION PROCESSING AND COMPRESSION (4-0-0) 4

Course Contents

Introduction to Information theory, Entropy and Inference. Mathematical preliminaries for Lossless compression, Shannon's Source Coding Theorem Huffman coding, Arithmetic Coding, LZW coding. Mathematical preliminaries for lossy compression, quantization and the Lloyd-Max Algorithm, rate-distortion theory, Scalar and vector quantization, Transform coding, Subband coding.

References

Khalid Sayood, Introduction to Data Compression, Morgan Kaufman, 5th Ed. 2018.
David McKay, Information Theory, Inference and Learning Algorithms, Cambridge University Press, 2003.
David Solomon, Handbook of Data Compression, Springer, 2010.

EC762 PATTERN RECOGNITION AND MACHINE LEARNING (4-0-0) 4

Course Contents

Statistical foundations, Different Paradigms of Pattern Recognition, Probability estimation, Proximity measures, Feature extraction, Different approaches to Feature selection, Nearest Neighbor Classifier and variants, Bayes classification.
Linear models, regression, logistic regression, neural networks, objective function and learning, back propagation. Kernel based methods, support vector machines. Dimensionality reduction, principal component analysis, reconstruction, discriminant analysis. Clustering, K-means algorithm, distance measure, objective function, initialization. Anomaly detection, recommender systems. Scaling of algorithms.

References

R. O. Duda, P. E. Hart and D. G. Stork Pattern Classification, Wiley Publications, 2001.
D. McKay, Information Theory, Inference, and Learning Algorithms, Cambridge University Press 2003.
C. M. Bishop, Pattern Recognition and Machine Learning, Springer, 2006.

EC763 OPTIMIZATION (4-0-0) 4

Course Contents

Convex sets and Convex functions, Level sets and Gradients. Unconstrained Optimization: Search methods, Gradients Methods, Newton Method, Conjugate Direction Methods, Quasi-Newton Methods. Linear Programming: Standard Form Linear Programs, Simplex method, Duality and Non Simplex Methods. Nonlinear Constrained Optimization: Problems with equality constraints, Problems with Inequality Constraints, Convex Optimization Problems. Algorithms for Constrained Optimization: Projected Gradient Methods and Penalty Methods.

References

Lieven Vandenberghe and Stephen P. Boyd, Convex Optimization, Cambridge University Press, 2004.
Dimitris Bertsekas, John N. Tsitsiklis, Introduction to Linear Optimization, Athena Scientific Series, 1997.
Aharon Ben-Tal and Arkadi Nemirovski, Lectures on Modern Convex Optimization: Analysis, Algorithms, and Engineering Applications, SIAM, 2001.

EC792 HIGH PERFORMANCE COMPUTING ARCHITECTURES (4-0-0) 4

Course Contents

Instruction Level Parallelism: Pipelining, Hazards, Instruction Level Parallelism, Branch prediction, Static and Dynamic Scheduling, Speculation, Limits of ILP. Multicore Memory Hierarchy: Cache trade-offs, Basic and Advanced optimizations, Virtual Memory, DRAM optimizations. Multiprocessors: Symmetric and Distributed architectures, Cache coherence protocols - Snoopy and Directory based, ISA support for Synchronization, Memory Consistency Models. Interconnection Networks: Architectures, Topologies, Performance, Routing, Flow control, Future of NoCs.

References

J. Hennessy and D. Patterson, Computer Architecture-A Quantitative Approach 6th Ed., Morgan Koufmann, 2017
John Paul Shen and Mikko H. Lipasti, Modern Processor Design: Fundamentals of Superscalar Processors, Tata McGraw Hill, 2013
David A. Patterson and John L. Hennessy, Computer Organization and Design RISC-V Edition: The Hardware Software Interface, Morgan Kaufman, 2017.
Behrooz Parhami, Computer Arithmetic Algorithms and Hardware Design, Oxford, 2000.
NPTEL Video Lectures & other MOOC Courses

EC801 LOGIC SYNTHESIS TECHNIQUES (4-0-0) 4

Course Contents

Introduction to Computer aided synthesis and optimization. Hardware Modeling. Advanced Boolean Algebra and Applications, Shannon co-factors, satisfiability and cover, Binary Decision Diagrams, Representing Boolean functions, ROBDD, ITE operator, Variable ordering- choice of variables, application of BDD to synthesize Boolean functions, Two-level combinational logic optimization, Multi-level combinational optimization. Sequential logic optimization. Cell Library Binding. Algorithms for Technology mapping – Structural and Boolean matching, Simulation & Static Timing analysis - Event driven simulation – zero delay, unit delay and nominal delay simulation, Timing analysis at the logic level, Delay models, Delay graph, static sensitization, State of the art and future trends.

References

Giovanni De Micheli: "Synthesis and Optimization of Digital Circuits", McGraw Hill, 1994.
Sunil P. Khatri · Kanupriya Gulati, Editors, "Advanced Techniques in Logic Synthesis, Optimizations and Applications", Springer publications, 2011.
S. Hassoun and T. Sasao, (Editors), Logic Synthesis and Verification, Kluwer Academic publishers, 2002
Srinivas Devadas, Abhijith Ghosh and Kurt Keutzer: "Logic Synthesis", Kluwer Academic, 1998.
G. D. Hachtel and F. Somenzi, "Logic Synthesis and Verification Algorithms", Kluwer Academic Publishers, 1996.
NPTEL Video Lectures & other MOOC Courses

EC803 MICROELECTRONIC DEVICES (4-0-0) 4

Course Contents

Review of basic device physics, Electronic structure of semiconductors, Diodes, MOS capacitor. Transistor theory. Scaling - Moore's law on technology scaling, MOS device scaling theory, Short channel effects, sub threshold leakage, Punch through, DIBL, High field mobility, Velocity saturation and overshoot. Reliability. Various definitions of channel length, Performance metric of digital technology, Transistor design trade-offs, Technology case studies, Silicon on Insulator (SOI) devices, Partially depleted and fully depleted SOI, Floating body effects, SOI for low power, Interconnects in sub-micron technology, Foundry technology, International Technology Roadmap for Semiconductors.

References

J. A. del Alamo Integrated Microelectronic Devices: Physics and Modeling, Pearson, 2017
Yaun Taur, Tak H. Ning, Fundamentals of modern VLSI devices, Cambridge university press, 1998.
B. G. Streetman & S. Banerjee, Solid State Electronic Devices, Prentice Hall, 1999.
M. K. Achuthan and K. N. Bhat, Fundamentals of Semiconductor Devices, McGraw Hill, 2006
Nandita Dasgupta, Amitava Dasgupta, Semiconductor Devices: Modelling And Technology, Phi, 2009
A. K. Dutta, Semiconductor Devices and Circuits, Oxford Univ. Press, 2008.
ITRS Road map - http://public.itrs.net/
NPTEL Video Lectures

EC804 DIGITAL VLSI TESTING & TESTABILITY (4-0-0) 4

Course Contents

Overview of testing and verification, Defects and their modeling as faults at gate level and transistor level. Functional V/s. Structural approach to testing. Complexity of testing problem. Controllability and observability. Generating test for a signal stuck-at-fault in combinational logic. Algebraic algorithms. Test optimization and fault coverage. Logic Level Simulation – Delay Models, Event driven simulation, general fault simulation (serial, parallel, deductive and concurrent). Testing of sequential circuits. Observability through the addition of DFT hardware, Adhoc and structured approaches to DFT – various kinds of scan design. Fault models for PLAs, bridging and delay faults and their tests. Memory testing, testing with random patterns. LFSRs and their use in random test generation and response compression (including MISRs), Built-in self-test.

References

M. Abramovici, M. A. Breuer, and A. D. Friedman, Digital Systems Testing and Testable Design, IEEE Press, 1994.
M. L. Bushnel and V. D. Agarwal, Essentials of Testing for Digital, Memory and Mixed – Signal VLSI Circuits, Kluwer Academic Publishers, 2000.
Ajai Jain, Learning Module for the course - VLSI Testing and Testability, IIT, Kanpur, 2001.
NPTEL Video Lectures

EC808 CMOS RF INTEGRATED CIRCUITS (4-0-0) 4

Course Contents

Basic concepts in RF Design – harmonics, gain compression, desensitization, blocking, cross modulation, intermodulation, inter symbol interference, noise figure, Friis formula, sensitivity and dynamic range; Receiver architectures – heterodyne receivers, homodyne receivers, image-reject receivers, digital-IF receivers and subsampling receivers; Transmitter architectures – direct-conversion transmitters, two-step transmitters; Low noise amplifier (LNA) – general considerations, input matching, CMOS LNAs; Down conversion mixers – general considerations, spur-chart, CMOS mixers; Oscillators – Basic topologies, VCO, phase noise, CMOS LC oscillators; PLLs – Basic concepts, phase noise in PLLs, different architectures.

References

Behzad Razavi, RF Microelectronics, Prentice Hall PTR, 1997
Thomas H. Lee, The design of CMOS radio-frequency integrated circuit, Cambridge University Press, 2006
Chris Bowick, RF Circuit Design, Newnes, 2007
NPTEL Video Lectures

EC832 MIMO COMMUNICATION SYSTEMS (4-0-0) 4

Course Contents

Overview of MIMO communications: Introduction to MIMO, Introduction to Spatial Diversity and Spatial Multiplexing, MIMO capacity formula, MIMO System Model. Application of MIMO Capacity, Phenomenology of multipath channels, Power law propagation, Impulse response of a multipath channel, Intrinsic multipath channel parameters, Classes of multipath channels, Statistics of small-scale fading, MIMO channels in LOS geometry, Antenna spacing and scattering angle. Alamouti Coding and Space-time Coding: Maximal ratio receive combining (MRRC), Maximum likelihood decoding in MRRC and Alamouti receivers, Performance results, Space-time coding. Spatial Multiplexing: Overview of spatial multiplexing, BLAST architecture, Broadband MIMO, Narrowband and Broadband MIMO channel estimation

References

Jerry R. Hampton, "Introduction to MIMO Communications", Cambridge University Press, 2014.
Bliss and S. Govindasamy, "Adaptive Wireless Communications: MIMO Channels and Networks", Cambridge University Press, 2013.
Simon Haykin, Michael Moher, "Modern Wireless Communications", First Edition, Pearson, 2004.
Andrea Goldsmith, "Wireless Communication", Cambridge University Press 2005.
Jafarkhani, "Space-Time Coding: Theory and Practice", Cambridge University Press, 2005.

EC834 ERROR CONTROL CODING (4-0-0) 4

Course Contents

Coding for reliable digital transmission and storage. Groups, Rings, Vector Spaces, Galois Fields, Polynomial rings, Channel models, Linear Block codes, Cyclic codes, BCH codes, Reed Solomon Codes, Berlekamp-Massey and Euclid decoding algorithm, Applications of Reed-Solomon codes, Convolutional codes, Decoding algorithms for Convolutional codes, Viterbi, Trellis coded modulation, Turbo Codes, LDPC codes.

References

Shu Lin and Daniel J. Costello Jr., Error Control Coding: Fundamentals and Applications, Prentice Hall, 2003.
S. B Wicker, Error Control Systems for Digital Communication and Storage, Prentice Hall International, 1995.
Blahut R.E., Algebraic codes for Data transmission, Cambridge University Press, 2003.

EC836 RADAR SIGNAL PROCESSING AND APPLICATIONS (4-0-0) 4

Course Contents

Radar and its composite environment, Review of Radar range performance computations, Detection Processes, Sequential and adaptive processes, Atmospheric effects, Sea and land Back scatter, Signal Processing concepts and waveform designs MTI & CW radars, phase coding techniques, FM pulse compression waveforms, Mateorogical radar and system performance analysis.

References

R.J Sullivan, Radar Foundations for imaging and Advanced Concepts, PMI, 2004.
F.E Nathanson, Radar Design Principles, Signal Processing and the Environment, PMI, 2004.
J.C. Toomay, Principles of radar, PMI, 2004.

EC839 NANO-PHOTONICS (4-0-0) 4

Course Contents

Fundamentals, Maxwell's equations, light-matter interaction, dispersion, EM properties of nanostructures, etc. Photonic crystals and photonic crystal fibers, Photonic and plasmonic nanocircuits, Metal optics Manipulating light with plasmonic nanostructures, Plasmonic nano-sensors, Near-field optics, Metamaterials: artificial magnetism and negative refractive index, Metamaterials: superlens and hyperlens, Transformation optics and cloaking, Metasurfaces, Nanolasers, Tunable and active plasmonic materials, Refractory plasmonics, Plasmonics for energy conversion, data storage and biomed applications, Silicon photonics, Diamond photonics, Graphene photonics, Intro to quantum photonics.

References

W. Cai and V. Shalaev, Optical Metamaterials: Fundamentals and Applications, Springer, 2009.
Surface plasmons on smooth and rough surfaces and on gratings," Raether (Springer-Verlag, New York, 1986)
Principles of Nano-Optics," Lukas Novotny and Bert Hecht, Cambridge, 2006.
S. Maier, Plasmonics: Fundamentals and Applications, Springer (2007). Photonic Crystals: Molding the Flow of Light" J. D. Joannopoulos, R. D. Meade, J. N. Winn (Princeton University Press, 1995).

EC840 MILLIMETER WAVE COMMUNICATIONS (4-0-0) 4

Course Contents

Millimeter wave characteristics, Radio wave propagation for mm wave, emerging applications of millimeter wave communications. Millimeter wave generation and amplification, Analog mm wave components, Consumption factor theory, Modulation for millimeter wave communications, Millimeter wave link budget, Transceiver architecture, Millimeter wave calibration, Millimeter wave design considerations. Massive MIMO Communications, Noise coupling in MIMO system, Dynamic spatial, frequency and modulation allocation. Antenna beam width, polarization, advanced beam steering and beam forming, mm wave design consideration, Implementation for mm wave in adaptive antenna arrays, Device to Device communications over 5G systems.

References

K.C. Huang, Z. Wang, "Millimeter Wave Communication Systems", Wiley-IEEE Press, March 2011.
Robert W. Heath, Robert C. Daniel, James N. Theodore S. Rappaport, Murdock, "Millimeter Wave Wireless Communication", Prentice Hall, 2014.
Jonathan Wells, "Multi-Gigabit Microwave and Millimeter-Wave Wireless Communications", Artech House, 2010.
Xiang, W; Zheng, K; Shen, X.S; "5G Mobile Communications: Springer, 2016.

EC841 CRYPTOGRAPHY (4-0-0) 4

Course Contents

Elementary Number Theory, Finite series, Arithmetic and Algebraic Algorithms, Secrete key and Public key Cryptography, Pseudo Random bit generators, Block and Stream Ciphers, Hash functions and Message digests, Public key encryption, Authentication, Digital Signatures, Zero Knowledge Interactive Protocols, Elliptic curve cryptosystems, formal verification, Crypt analysis, Hard Problems.

References

Koblitz N., A Course on Number Theory and Cryptography, Springer Verlag, 1986.
Menezes A. et. all, Handbook of Applied Cryptography, CRC Press, 1996.

EC864 SPEECH AND AUDIO PROCESSING (4-0-0) 4

Course Contents

Speech Production–human speech production mechanism, digital models for speech production, Speech perception, Speech Analysis–Time and frequency domain analysis of speech, Linear prediction, Speech compression, Audio processing–characteristics of audio signals, sampling, Audio compression techniques, Standards for audio compression in multimedia applications, MPEG audio encoding and decoding, audio databases and applications. Speech synthesis–text to speech synthesis, letter to sound rules, syntactic analysis, timing and pitch segmental analysis. Speech recognition.

References

Douglas O'Shaugnessy, Speech Communication–Human and Machine, IEEE Press, 2000
L R Rabiner, Digital Processing of Speech Signals, Pearson,1978.
T.F Quatieri , Discrete-time speech signal processing: Principles and Practise Pearson,2002.
Zi Nian Li, Fundamentals of Multimedia, Pearson Education, 2003.

EC866 DEEP LEARNING AND APPLICATIONS (3-0-2) 4

Course Contents

Linear Regression , Logistic regression, Basic neuron structure, Perceptron, error functions, optimization – gradient descent, Multilayer perceptron, transfer function, nonlinearities, learning, backpropagation, function approximations, overfitting, underfitting, Deep networks, challenges, regularization techniques – Norm penalties, early stopping, drop outs, dataset augmentation, bagging and ensemble methods, Convolutional Networks – Convolution, pooling, variants, transfer learning, Sequence Modeling – Recurrent neural networks, Bidirectional RNNs, architectures, LSTM, Application examples – Computer Vision, Speech recognition, NLP.

References

Simon S. Haykin, Neural Networks and Learning Machines, 3rd Ed, Pearson, 2009.
José C. Principe, Neil R. Euliano, W. Curt Lefebvre, Neural and Adaptive Systems: Fundamentals through Simulations, John Wiley and Sons, 2000.
Ian Goodfellow, Yoshua Bengio, Aaron Courville, Deep Learning, MIT Press, 2016.

EC872 NONLINEAR DYNAMICS, CHAOS AND FRACTALS (4-0-0) 4

Course Contents

Review of linear systems; discrete and continuous, difference and differential equation modeling and solution, dynamics of linear and nonlinear systems, maps and flows, phase-plane analysis, bifurcations, limit cycles, attractors, chaotic behavior, strange attractors, chaotic systems and their analysis, fractals, Mandlebrot and Julia sets, iterated function systems, fractal dimension, stable and unstable manifolds, multifractals, applications.

References

Steven H. Strogatz, Nonlinear Dynamics And Chaos: With Applications To Physics, Biology, Chemistry, And Engineering, Addison-Wesley, 1994.
MW Hirsch, S. Smale, RL Devaney, Differential equations, dynamical systems, and an introduction to chaos, Academic Press. 2012.
Drazin, P. G. Nonlinear systems. Cambridge, UK: Cambridge University Press, 1992.
Peitgen, H-O., H. Jurgens, and D. Saupe. Chaos and Fractals: New Frontiers of Science, Springer, 2004.
M. Barnsley, Fractals everywhere, Academic Press, 1993.

EC873 COMPUTATIONAL IMAGING AND PHYSICS (4-0-0) 4

Course Contents

Imaging methods and modalities, computational aspects of analysis, theoretical and applied; modalities in medical imaging, geophysics, applied physics, biology, astronomy, remote sensing and optics; methods and applications in nuclear medical imaging physics and radiology, image guided radiotherapy; computational photography, inverse problems and reconstruction, modeling, analysis; use of optimization, compressed sensing and pattern recognition and machine learning theory; applications of deep learning and artificial intelligence.

References

Kedar Khare, Fourier Optics and Computational Imaging, Wiley, 2015.
B.H Brown, R.H Smallwood, D.C. Barber, P.V Lawford, D.R Hose, Medical Physics and Biomedical Engineering, CRC Press 1998.
S Webb, The Physics of Medical Imaging, Institute of Physics, 1988.
Paul Suetens, Fundamentals of Medical Imaging, Cambridge University Press, 2009.
Thayalan K, The Physics Of Radiology And Imaging, Jaypee Brothers 2014.
Tetsuo Asano, Geometry, Morphology, and Computational Imaging, Springer 2002.

EC875 PROBABILISTIC MODELS IN MACHINE LEARNING (4-0-0) 4

Course Contents

Probabilistic graphical models, belief networks, decision making, Bayesian linear models, linear Gaussian state space models, Expectation Maximization, Markov models, Bayesian networks, Markov random fields, Markov networks, variational inference, latent variable models, Markov chain Monte Carlo, Kalman Filtering, Particle Filters, Dynamic Bayesian Networks.

References

David Barber, Bayesian Reasoning and Machine Learning, 1st Ed, Cambridge University Press, 2012.
Jerome H, Friedman, Robert T'ibshirani, Trevor Hastie, The Elements of Statistical Learning; Data Mining, Inference, and Prediction, Springer, 2nd Ed, 2009.
Kevin P. Murphy, Machine Learning; A Probabilistic Perspective, MIT, 2012.
Zoubin Ghahramani, Probabilistic Modelling, Machine Learning and the Information Revolution, MIT Tutorial 2012.

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