MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent unit of MAHE, Manipal)

B Tech Curriculum – 2022

Department of Electronics and Communication Engineering

ECE XXXX BASIC ELECTRONICS [3 0 0 3]

Total Number of contact hours: 36

Course Learning Outcomes:

At the end of the course, the student will be able to:

CLO1	Describe the characteristics of various electronic devices and analyze simple circuit applications using them.
CLO2	Analyze rectifier circuits, voltage regulator and Amplifier.
CLO3	Discuss Op-Amp and its basic applications using suitable circuits.
CLO4	Simplify Boolean expressions and implement simple digital circuits using logic gates.
CLO5	Describe the principles of analog and digital communication

Diode, Zener diode, Applications. Special purpose diodes. MOSFET structure and operations, V-I Characteristics, Large-Signal Model, Amplifier Biasing Techniques, Configurations. Working principle. Operational Amplifier: Block diagram and characteristics, Inverting and Non-Inverting amplifier, OPAMP Applications. Number system: Decimal, binary, octal and Hexa-decimal number systems. One's and two's complements. Weighted and non-weighted codes, Self-complimenting codes, Error detecting and correcting codes. Combinational Circuits, Sequential Circuits. Electronic Communication: modulation techniques, Principle of Sampling and Digitization, Basic Pulse and Digital modulation systems.

***Self-directed Learning:**

Principle of Cellular mobile communication and GSM architecture

References:

1. Robert L. Boylestad, "Louis Nashelsky- Electronic Devices & Circuit Theory", 11th Edition, PHI, 2012.
2. Behzad Razavi, "Fundamental of Microelectronics", Wiley, 2013.
3. Morris Mano- Digital design, "Prentice Hall of India", Third Edition., 2013.
4. George Kennedy, Bernad Davis- "Electronic Communication Systems", 4th edition, TMH, 2004.
5. *Raj Pandya, "Mobile and Personal Communication Services and Systems", Wiley-IEEE Press, 1999.

III Semester

MAT XXXX MATHS-III (LINEAR ALGEBRA, AND FOURIER SERIES AND TRANSFORMS) [3 0 0 3]

Total Number of contact hours: 36
Course Learning Outcomes:
At the end of the course, the student will be able to:

CLO1	Find the independent solutions of the system of linear equations.
CLO2	Apply concept of orthonormal basis and orthonormal projections in practical situations.
CLO3	Apply suitable matrix decomposition methods for dimension reduction process.
CLO4	Formalize the semantics of programming languages and the specification of programs.
CLO5	Acquire the knowledge of Fourier series expansions and apply them in engineering domain.

Systems of Linear Equations, Matrices, Solving Systems of Linear Equations, Vector Spaces, Linear Independence, Basis and Rank, Linear Mappings, Affine Spaces. Norms, Inner Products, Lengths and Distances, Angles and Orthogonality, Orthonormal Basis, Orthogonal Complement, Inner Product of Functions, Orthogonal Projections, Rotations. Determinant and Trace, Eigenvalues and Eigenvectors, Cholesky Decomposition, Eigen decomposition and Diagonalization, Singular Value Decomposition, Matrix approximation, Periodic function, Fourier Series expansion. even and odd functions, functions with arbitrary periods, Half range expansions, Fourier transform, basic properties, Parseval's identity and applications.

***Self-directed Learning:**
Singular Value Decomposition, Fourier cosine and sine transform application to Heat and Wave equation.

Text Books:

1. Marc Peter Deisenroth, A. Aldo Faisal, Cheng Soon Ong, "Mathematics for Machine Learning", Cambridge University Press, 2020.
2. Grewal B.S. – "Higher Engineering Mathematics", Khanna Publishers, 43rd edition, 2015

References:

1. Stephen H. Friedberg Lawrence E Spence, *Arnold J Insel*, Elementary Linear Algebra: "A Matrix Approach Introduction to Linear Algebra", Second Edition, 2019.
2. David Lay, Steven Lay, Judi McDonald, "Linear Algebra and Its Applications, Pearson", 2019.
3. Gilbert Strang, "Introduction to Linear Algebra", Fifth Edition, Wellesley-Cambridge Press, 2016
4. Mordechai Ben-Ari, "Mathematical Logic for Computer Science", Third Edition, Springer, 2012
5. Narayanan, Ramaniah and Manicavachagom Pillay, "Advanced Engineering Mathematics", Vol 2 and 3, Vishwanthan Publishers Pvt Ltd. 1998

*Erwin Kreyszig, Advanced Engineering Mathematics, 5th edn., Wiley Eastern, 1985.

ECE XXXX ANALOG ELECTRONIC CIRCUITS [4 0 0 4]

Total Number of contact hours: 48

Course Learning Outcomes:

At the end of the course, the student will be able to:

CLO1	Apply the basic principles of MOSFET and analyze various biasing techniques.
CLO2	Analyze and design MOSFET based amplifiers using appropriate small signal model
CLO3	Discuss the frequency response of MOSFET based amplifiers
CLO4	Describe the concept of feedback, analyze different types of negative feedback amplifiers and design different types of Oscillators.
CLO5	Design and analyze power amplifiers and compare different types.

Structure, operation, I-V Characteristics of MOSFET; Large-Signal and Small-Signal Model, PMOS Transistor; MOSFET Biasing, Analysis and Design of Common-Source, Common-Gate Amplifier and Source Follower; Current mirror and active load; Differential Amplifier; Frequency Response of MOS amplifiers, High-Frequency Model of MOSFET, Frequency Response of CS, CG, CD, Cascode and differential amplifier Stage; Concepts of Feedback; Oscillators; Power Amplifiers.

***Self-directed Learning:**

Analyse different types of Power Amplifiers.

References:

1. *Behzad Razavi, "Fundamental of Microelectronics", Wiley, 2013.
2. A. S. Sedra, K. C. Smith, "Microelectronic circuits", Oxford University Press, 2011.
3. R. L. Boylestad, L. Nashelsky, "Electronic Devices and Circuit Theory", 2009.
4. J. Millman, C. C. Halkias, Chetan. D. Parekh, "Integrated Electronics", McGraw Hill.2010

https://youtu.be/huDZjQcEBMg.

ECE-XXXX **NETWORK ANALYSIS** **[3 0 0 3]**

Total Number of contact hours: 36

Course Learning Outcomes:

At the end of the course, the student will be able to:

CLO1	Apply network theorems for loop and nodal analysis of various networks.
CLO2	Evaluate the initial and final conditions in passive circuits and apply them to obtain the response of RL, RC, and RLC circuits to DC excitation.
CLO3	Apply Laplace transform for analysis of passive networks.
CLO4	Evaluate the response of RC circuits for step, pulse, square and ramp input
CLO5	Analyse Two-Port Networks using two port parameters and Network Functions.

Network equations; Mesh and nodal analysis; Network theorem- Superposition, Reciprocity, Thevenin's, Norton's theorems, Maximum power transfer theorem; Initial and final conditions in RL, RC and RLC Circuits for DC Excitations. General and Particular solution of the first order and second order circuits. Applications of Laplace transform in finding solution or RC, RL, and RLC networks, Response of RC circuits for step, pulse, square, and ramp input; Two port network- Open circuit impedance parameters, short circuit admittance parameters, transmission parameters, hybrid parameters

Self-directed Learning:

Two-port Interconnections

References:

1. M. E. Van Valkenberg, "Network analysis", Prentice Hall of India, 2000.
2. Ravish R Singh, "Network analysis and Synthesis", McGraw Hill, 2013.
3. William H. Hayt, Jack E. Kemmerly, Steven M Durbin, "Engineering Circuit Analysis", 8th edition, Tata McGraw Hill India, 2013.
4. Millman, H. Taub, "Pulse, digital and switching waveforms", 3rd Edition, *McGraw* Hill, 2017.
5. Joseph Edminister, "Electric Circuits", Schaum's Series, McGraw Hill, 2018.

* https://nptel.ac.in/courses/108102042

https://nptel.ac.in/courses/108102042

ECE XXXX SIGNALS AND SYSTEMS [3 0 0 3]

Total Number of contact hours: 36

Course Learning Outcomes:

At the end of the course, the student will be able to:

CLO1	Classify signals and describe them mathematically
CLO2	Describe Fourier representation of signals and appreciate their practical importance
CLO3	Discuss system properties and analyze linear time invariant (LTI) systems in time and frequency domain.
CLO4	Illustrate the use of Laplace and Z-transform to analyze the LTI systems.
CLO5	Understand sampling of continuous time signals.

Continuous time (CT) and discrete time (DT) signals, Representation and classification of Signals, Elementary signals, time domain operations on signals, correlation between signals; Continuous time and discrete time systems, system properties. LTI system, impulse response, response of LTI system, Convolution, differential/difference equation and block diagram representation; Fourier analysis of signals and systems, LTI systems in frequency domain, Parseval relation, ESD, PSD; LTI system analysis using Laplace transform, transfer function, poles/zeroes, stability; Z-transform, application in LTI system analysis; sampling and re-construction.

***Self-directed Learning:**

Generation of signals and Fourier analysis

References:

1. Simon Haykin, Barry Van Veen, “Signals and Systems”, John Wiley & Sons, NewDelhi,2008
2. A. V. Oppenheim, A. S. Willsky, A. Nawab, “Signals and Systems”, PHI. Pearson Education, New Delhi, 2015.
3. H. Hsu, R. Ranjan “Signals and Systems”, Schaums outline, Tata McGraw Hill, New Delhi, 2006.
4. Michael J. Roberts, “Fundamentals of Signals and Systems”, First Edition, Tata McGraw Hill Publishing Company Limited, 2007.
5. Rodger E. Ziemer, William H. Tranter D. Ronald Fannin, “Signals and Systems”, Fourth Edition, Pearson Education, 2004.
   *Signal Processing tool box in MATLAB

ECE XXXX DIGITAL SYSTEM DESIGN [3 0 0 3]

Total Number of contact hours: 36

Course Learning Outcomes:

At the end of the course, the student will be able to:

CLO1	Design and realize combinational circuits using various MSI components and logic optimization techniques.
CLO2	Discuss different classes of flip-flops, counters and shift registers.
CLO3	Analyze and design asynchronous and synchronous sequential circuits.
CLO4	Discuss the design flow, architecture of FPGAs, PLDs and implement digital circuits.
CLO5	Design combinational and sequential circuits using Verilog HDL in different modeling styles.

Logic Design Fundamentals, Review of logic minimization techniques, Design of combinational blocks and circuits, Flip-flops, counters, shift registers, analysis and design of synchronous and asynchronous sequential circuits. Digital System implementation using PROM, PLAs and PALs, FPGA, Introduction to HDL, language constructs and conventions**,** operators. Data flow, behavioral and structural Verilog coding, subprograms, UDP, test benches.

***Self-directed Learning:**

Simulation of combinational and sequential circuits and their test-benches using Verilog HDL

References:

1. Donald D.Givone, "Digital Principles and Design", Tata McGraw Hill, 2002.
2. William I. Fletcher, "An Engineering approach to Digital Design", Prentice Hall of India, 2009.
3. Zvi Kohavi, Niraj K Jha, "Switching and Finite Automata Theory", Cambridge, Third edition, 2010.
4. Samir Palnitkar, "Verilog HDL: A Guide to Digital Design and Synthesis," Prentice Hall PTR, 2003.
5. Charles Roth, Lizy Kurian John, Byeong Kil Lee, "Digital System Design Using Verilog", 1st Edition, 2016.

*https://edaplayground.com/

ECE XXXX ELECTROMAGNETIC WAVES [3 0 0 3]

Total Number of contact hours: 36

Course Learning Outcomes:

At the end of the course, the student will be able to:

CLO 1	Describe the governing laws of electrostatics and magneto statics
CLO1	Describe solution of electromagnetic wave equation in simple lossless and lossy geometrical structures
CLO2	Estimate transmission and reflection coefficients for normal and oblique incidence of TEM waves
CLO3	Analyze signal propagation in transmission lines using relevant theory and Smith Chart
CLO5	Analyze guided wave propagation through simple waveguide structures

Review of Electrostatics and Magneto statics: Coordinate system and vectors, Curl and Divergence, Divergence theorem and Stokes theorem in the context of electromagnetics. Uniform Plane Waves: Maxwell's equations, Electromagnetic wave propagation. Transmission Lines: parameters, Transmission line equations and solutions Standing Wave Ratio, power and impedance measurement, Stub impedance matching, Smith Chart and its applications in transmission line calculations, applications of transmission lines. Waveguides: Rectangular waveguides – TE, TM modes, power transmission. Introduction to Cylindrical waveguides

*Self-Directed Learning

Planar dielectric waveguides

References:

1. *Jr. Hayt and Buck, "Engineering Electromagnetics", 7th Edition, McGraw Hill, 2012.
2. Ryder J. D, "Networks, Lines, and Fields", 2nd Edition, PHI, 2015.
3. Shevgaonkar R. K, "Electromagnetic Waves", 2nd Edition, Tata McGraw Hill, 2019.
4. Plonus M. A, "Applied Electromagnetics", McGraw Hill, 1988
5. Edminister J. A, "Electromagnetics", 2nd Edition, Schaum's Outline Series, Tata McGraw Hill, 2006.

ECE XXXX DIGITAL SYSTEM DESIGN LAB [0 0 3 1]

Total Number of contact hours: 30
Course Learning Outcomes:
At the end of the course, the student will be able to:

CLO1	Measure voltage levels and noise margin for TTL ICs.
CLO2	Design and test combinational circuits using ICs and logic gates
CLO3	Design basic latches using logic gates.
CLO4	Design and test ripple, synchronous counters and shift registers
CLO5	Design and test synchronous sequential circuits using flip flops and logic gates.

TTL IC specifications & Implementation of Boolean functions; Code Conversion Circuits Arithmetic circuits; Magnitude comparator & Parity checker/ generator. Multiplexers & De-multiplexers. Encoders & Decoders. Study of Flip-flops. Counters; Shift Registers; Sequential circuits

References:

1. Donald D.Givone, “Digital Principles and Design”, Tata McGraw Hill, 2002.
2. Morris Mano, “Digital design”, Prentice Hall of India, Third Edition, 2016.
3. William I. Fletcher, “An Engineering approach to Digital Design”, Prentice Hall of India, 2009.
4. Zvi Kohavi, “Switching and Finite Automata Theory”, Tata Mc Graw Hill, second edition, 2008.
5. C.H.Roth, “Fundamentals of Logic Design”, Thomson, 2000.

ECE-XXXX ELECTRONIC CIRCUITS LAB [0 0 3 1]

Total Number of contact hours: 30

Course Learning Outcomes:

At the end of the course, the student will be able to:

CLO1	Simulate and verify the KCL, KVL and network theorems for the given circuits
CLO2	Verify the diode rectification circuits
CLO3	Analyze the I/O characteristics of MOSFET and OPAMP
CLO4	Design, simulate and analyze the performances of the OPAMP and MOSFET amplifiers and oscillators
CLO5	Design, simulate and analyze the performance of the OPAMP's linear and non-linear applications

To apply various network theorems on the given circuits and analyze, to verify the diode rectifier circuits, to investigate the I/O characteristics of MOSFET and OPAMP, design and verify the OPAMP and MOSFET amplifiers and oscillators, to design and analyze OP-AMP based linear and non-linear circuits.

References:

1. Lab manual.
2. William H. Hayt, Jack E. Kemmerly, Steven M Durbin, "Engineering Circuit Analysis", 8th edition, Tata McGraw Hill India, 2013.
3. Behzad Razavi, "Fundamental of Microelectronics", Wiley, 2013.
4. R. L. Boylestad, L. Nashelsky, "Electronic Devices and Circuit Theory", 2009.

IV SEMESTER

MAT XXXX MATHS - IV (PROBABILITY AND OPTIMIZATION) [2 1 0 3]

Total Number of contact hours: 36

Course Learning Outcomes:

At the end of the course, the student will be able to:

CLO1	Understand the probability aspects and apply in engineering models
CLO2	Discuss random variables and their applications
CLO3	Quantify the uncertainty in the data using aspects of probability.
CLO4	Apply the concept of vector gradient and gradient descent in physical phenomenon.
CLO5	Apply and analyze the optimistic solutions for the machine learning problems.

Construction of a Probability Space, Discrete and Continuous Probabilities, Sum Rule, Product Rule, and Bayes' Theorem, Summary Statistics and Independence, Distributions: Binomial, Poisson, uniform, normal, Chi-square and exponential distributions. Two and higher dimensional random variables, covariance, correlation coefficient. Moment generating function, functions of one dimensional and two dimensional random variables. Static probabilities: review and prerequisites generating functions, difference equations. Dynamic probability: definition and description with examples. Markov chains, transition probabilities. Differentiation of Univariate Functions, Partial Differentiation and Gradients, Gradients of Vector-Valued Functions, Gradients of Matrices, Useful Identities for Computing Gradients, Backpropagation and Automatic Differentiation, Higher-Order Derivatives, Linearization and Multivariate Taylor Series. Basic solution, Convex sets and function, Simplex Method, Optimization Using Gradient Descent, Constrained Optimization and Lagrange Multipliers.

***Self-directed Learning:**

Markov chains, Transition probabilities.

Text Books:

1. Marc Peter Deisenroth, A. Aldo Faisal, Cheng Soon Ong, "Mathematics for Machine Learning", Cambridge University Press, 2020.
2. P L Meyer, "Introductory Probability and Statistical Applications", Addison Wiley, 2000.
3. Medhi. J. "Stochastic Processes", Wiley Eastern, 2022.

References:

1. Murray R. Spiegel, Vector Analysis Theory and Problems, Schaum's Outline Series, 2019.
2. Hamdy A. Taha, "Operations Research: An Introduction", 8^{th} Edn., Pearson Education (2008).
3. Sheldon M. Ross, "Introduction to Probability Models", Eleventh Edition Elsevier, 2014.
4. E. S. Page, L. B. Wilson, "An Introduction to Computational Combinatorics", Cambridge University Press, 1979.
5. Bhat U R, "Elements of Applied Stochastic Processes", John Wiley, 2022.

*https://youtu.be/CgP-3HctGe4

ECE XXXX **VLSI DESIGN** **[4 0 0 4]**

Total Number of contact hours: 48

Course Learning Outcomes:

At the end of the course, the student will be able to:

CLO1	Describe the basic operation of MOS transistors.
CLO2	Design combinational and sequential logic circuits using MOS devices
CLO3	Design the layout and discuss the MOS fabrication process
CLO4	Describe various issues involved in subsystem design.
CLO5	Analyze the delay models and the circuit performance

MOS Transistor, CMOS logic, Inverter, Power: Dynamic Power, Static Power, Fabrication of MOS transistor, Latch-up in CMOS, Stick Diagrams, Layout Design Rules, Static CMOS, Ratioed Circuits, Dynamic Circuits, Pass Transistor Logic, Transmission Gates, with examples, Domino, Dual Rail Domino, CPL, Cascode Voltage Switch Logic, Bi-CMOS inverter circuits. Static latches and Registers, Dynamic latches and Registers, Sense Amplifier Based Register, clocking strategies, Subsystem design, Sheet resistance and delay models.

***Self-directed Learning:**

Simulation of MOSFET based logic circuits using LTSPICE

References:

1. Jan M Rabaey, "Digital Integrated Circuits", Prentice Hall India, 2003.
2. Weste. N and Eshraghian K, "Principles of CMOS VLSI Design", 2nd Edition, Addison Wesley Publication, 1993.
3. Sung Mo Kang and Yusuf leblebici, "CMOS digital Integrated circuits design and analysis", 3rd edition, Tata Mcgraw Hill, 2003.
4. Pucknell D. A. and Eshraghian K., "Basic VLSI Design", PHI publication, 2009.
5. Amar Mukherjee, "Introduction to NMOS & CMOS VLSI systems Design", Prentice Hall, 1986.

*https://www.analog.com/en/design-center/design-tools-and-calculators/ltspice-simulator.html

ECE-XXXX DIGITAL SIGNAL PROCESSING [3 0 0 3]

Total Number of contact hours: 36

Course Learning Outcomes:

At the end of the course, the student will be able to:

CLO1	Discuss discrete Fourier transform (DFT).
CLO2	Describe FFT algorithms.
CLO3	Analyze various block diagram representations of IIR and FIR filter realizations.
CLO4	Design IIR and FIR filters
CLO5	Analyze the basics of power spectrum estimation.

Discrete Fourier transform(DFT), properties, linear filtering; efficient computation of DFT, FFT algorithm, Goertzel algorithm; Implementation of Discrete time filters, Structures for IIR and FIR filters; Classical design of IIR filters by impulse invariance, bilinear transformation and matched Z - transform, characteristics and design of commonly used filters - Butterworth, Chebyshev and elliptic filters. Spectral transformation, direct design of IIR filters; design of linear phase FIR filters using window functions, frequency sampling design; Power spectrum estimation, non-parametric methods of PSD estimation.

***Self-directed Learning:**

Parametric methods of PSD estimation: AR, ARMA and MA modeling

References:

1. *Proakis J. G, Manolakis D. G. Mimitris D., "Introduction to Digital Signal Processing" Prentice Hall, India, 2007.
2. Oppenheim A.V, Schafer R. W, "Discrete Time Signal Processing", Pearson Education, 2004.
3. Ifeachar, Jervis, "Digital Signal Processing - A Practical approach", Pearson Education, Asia, 2003.
4. Rabiner L. R, Gold D. J, "Theory and applications of digital signal processing", Prentice Hall, India, 1998.
5. Sanjit Mitra K, "Digital Signal Processing - A computer based approach", TMH, 2007

*https://www.youtube.com/watch?v=xZ4zfE11X7U

ECE -XXXX ANALOG INTEGRATED CIRCUITS [3 0 0 3]

Total Number of contact hours :36

Course Learning Outcomes:

At the end of the course, the student will be able to:

CLO1	Develop circuits using Op-Amps for linear applications.
CLO2	Develop circuits using Op-Amps for non-linear applications
CLO3	Design filters for different applications using Op-Amps.
CLO4	Analyze and describe the operation and applications of special ICs
CLO5	Analyze the operation of data converters

Operational Amplifier. Linear applications of operational amplifier, instrumentation amplifier and bridge amplifier**.** Active filters: Design and analysis. Non-linear applications of operational amplifier: Precision half wave and full wave rectifiers, Voltage regulators, peak detector, sample and hold circuit, log and antilog amplifiers, analog multipliers and dividers, comparators, window detector, Schmitt trigger, square wave, triangular wave generators and pulse generators. Specialized ICs: 555 IC, functional diagram of 555 IC, a stable multi-vibrator, positive and negative edge triggered mono-stable multi-vibrator, working of Phase looked loop IC 565 and its applications. Data Converters.

***Self-directed Learning:**

Working of Phase looked loop IC 565 and its applications.

References:

1. Franco S, "Design with Op amps & Analog Integrated Circuits" McGraw Hill, 4th edition, 2015.
2. *Ramakant A. Gayakwad, “Op-Amps and Linear Integrated Circuits”, Prentice Hall of India, 2000.
3. Choudhury Roy D, Shail B. Jain, “Linear Integrated Circuits”, Wiley Eastern, 2003.
4. Stanley William D, “Operational Amplifiers with Linear Integrated Circuits”, Prentice Hall, 2004
5. Sedra A S and Smith K C, “Micoelectronics circuits- Theory and applications”, Oxford publishers, 7th Edition, 2017.

*NPTEL Link: Mod-11 Lec-31 Phase locked loop basics

ECE XXXX MICROWAVE ENGINEERING [3 0 0 3]

Total Number of contact hours: 36

Course Learning Outcomes:

At the end of the course, the student will be able to:

CLO1	Describe the basic principle and operations of microwave hybrid circuits and devices.
CLO2	Analyze various microwave sources and solid-state devices.
CLO3	Describe the principles of basic parameters of antennas and develop the expressions for linear wire antennas.
CLO4	Design and analyze various types of antenna arrays
CLO5	Design and Analyze micro-strip, millimeter wave, and Fractal antennas.

Waveguide tees, Magic tees, Hybrid rings, Corners, Bends, and Twists. S- Matrix. Directional couplers – Two hole directional couplers, S-matrix of a directional coupler, Circulators, and isolators Klystrons, Tunnel Diode, Gunn Diode, Read Diode, IMPATT Diode, BARITT Diode, TRAPATT Diode, Varactor Diode, Types of Antennas (Isotropic, Omnidirectional and directional antennas) radiation mechanism, current distribution. Basic antenna parameters: Radiation pattern, power density and radiation intensity, directivity, gain, efficiency, HPBW, return loss, Vector Potential A and F, Solution of vector Potential wave equations, Far-Field Radiation Infinitesimal dipole, small dipole, and half wave dipole, two element array, Broadside and end-fire arrays, Design of micro-strip antenna, millimeter wave 5G antenna, Fractal antennas.

***Self-directed Learning:**

Introduction to Millimeter Wave Technology and Antennas
Millimeter Wave Propagation and systems

References:

1. Balanis, C. A. “Antenna theory: analysis and design” John wiley & sons, 2015.
2. Liao, Samuel Y. “Microwave devices and circuits”, Pearson Education India (3rd Edition), 1989.
3. J.D Kraus “Antennas”, Second Edition, TMH Publication 1989
4. G. S. N. Raju. “Antennas and Wave Propagation” Pearson Education, 2006
5. K.D. Prasad. “Antennas & Wave Propagation” Satya Prakashan,Tech India Publications, New Delhi, 2001.

*Link: https://onlinecourses.nptel.ac.in/noc21_ee76/preview

ECE XXXX MODERN CONTROL THEORY [3 0 0 3]

Total Number of contact hours: 36

Course Learning Outcomes:

At the end of the course, the student will be able to:

CLO1	Model electrical and mechanical systems and deduce equations
CLO2	Analyse the performance of linear time-invariant systems
CLO3	Determine the absolute and relative stability of linear systems from their frequency response
CLO4	Design and realize Controllers and Compensators to achieve the given specifications
CLO5	Discuss state space models and solution of state equation for a continuous time systems

Block diagrams and signal flow graphs: Transfer function. System modeling: Modeling of electrical and mechanical systems (translational & rotational), system equations, and its electrical equivalent (analogous) networks. Time domain analysis: Stability, Routh-Hurwitz criterion, time response of continuous data systems, type and order of systems, steady state error for linear systems. Frequency domain analysis: second order prototype system, Bode diagram, gain and phase margins, Nyquist stability criterion. Compensators and Controllers: Feedback and feed forward controllers, proportional, integral, PI, PD and PID controllers, lead, lag and lead-lag compensators. State space representation, State Transition Matrix, Controllability and Observability.

***Self-directed Learning:**

Simulation to test the stability of a system in time domain (Root Locus)

Simulation to test the stability of a system in frequency domain (Bode Plot)

References:

1. B.C.Kuo and F.Golnaraghi, "Automatic Control Systems", 10th edition, McGraw Hill, 2018
2. Nagrath and Gopal, "Control System Engineering", 6th edition, New Age International Publishers,2018
3. K.Ogata, "Modern control engineering", 5th edition, Pearson 2015
4. Norman.S.Nise, "Control Systems Engineering", 8th edition Wiley 2019
5. * Dr.Shailendra Jain, "Modeling and Simulation using MATLAB & Simulink", 2nd Edition, Wiley, 2011.

*LabVIEW -Control design toolbox
Mat Lab- Control system toolbox

ECE XXXX VLSI LAB [0 0 3 1]

Total Number of contact hours: 30
Course Learning Outcomes:
At the end of the course, the student will be able to:

CLO1	Familiarize different EDA tools and FPGA Kit
CLO2	Model and simulate digital circuits using different modeling styles in Verilog HDL.
CLO3	Implement digital circuits using Xilinx FPGA Kit.
CLO4	Draw and simulate the layouts of digital circuits using layout editor.
CLO5	Simulate MOS circuits using EDA Tool.

Introduction to VIVADO tools, logic simulation of combinational and sequential circuits, logic synthesis of circuits, Technology mapping, Implementation of circuits in FPGA Kit, drawing logical circuits using layout tool, Simulation of various MOSFET based inverter circuits using EDA Tools, Implement of MOS transistor-based switch logic and gate logic circuits.

References:

1. Lab Manual.
2. User manual for Xilinx FPGA Kit.
3. Sung Mo Kang and Yusuf leblebici, "CMOS digital Integrated circuits design and analysis", 3rd edition, Tata Mcgraw Hill, 2003.
4. Pucknell D. A. and Eshraghian K., "Basic VLSI Design", PHI publication, 2009.
5. edaplayground.com

ECE XXXX ELECTRONIC SYSTEM DESIGN LAB [0 0 6 2]

Total Number of contact hours: 60

Course Learning Outcomes:

At the end of the course, the student will be able to:

CLO1	Design and test linear and nonlinear application circuits using OPAMP ICs.
CLO2	Design and verify the regulation characteristic using IC regulators.
CLO3	Design and test multivibrator circuits using IC 555.
CLO4	Design a PCB using EDA tools
CLO5	Simulate digital filters using LabVIEW software and System design using NI MyDAQ

Design and test Mathematical operations of OPAMP, Precision rectifier using OPAMP, Non-linear applications of OPMP. Design and verify the regulation characteristics using IC regulators. Design astable and mono-stable multi-vibrators using IC 555. Design and simulate Active filters using OPAMP. Digital filter design using LabVIEW. Experiments based on PCB design using EDA tool.

***Self-directed Learning:**

Mini-project based on Software/Hardware tools.

References:

1. Lab Manual
2. https://easyeda.com/
3. Ramakant A. Gayakwad, "Op-Amps and Linear Integrated Circuits", Prentice Hall of India, 2000
4. LabVIEW user manual.

V SEMESTER

HUM XXXX ENGINEERING ECONOMICS & FINANCIAL MANAGEMENT [3 0 0 3]

Total contact periods: 36
Course Learning Outcomes:
At the end of this course the students will be able to:

CLO 1	Apply the appropriate engineering economics analysis method(s) for problem solving
CLO 2	Compute the depreciation of an asset using standard depreciation techniques
CLO 3	Describe and apply the basic techniques of financial statement analysis
CLO 4	Apply all mathematical approach models covered in solving engineering economics problems
CLO 5	Analyze the responsibility of an engineer on risk and safety

Time Value of money: Time Value of Money, Interest Factors for Discrete Compounding, Nominal & Effective Interest Rates, Present and future worth of Single, Uniform, and Gradient cash flow. Related problems and case studies. Economic Analysis of Alternatives: Bases for Comparison of Alternatives, Present worth amount, Capitalized Equivalent Amount, Annual Equivalent Amount, Future Worth Amount, Capital Recovery with Return, Rate of Return Method, Incremental Approach for Economic Analysis of Alternatives, Replacement analysis. Break Even Analysis for Single Product and Multi Product Firms, Break Even Analysis for Evaluation of Investment Alternatives. Minimum Cost Analysis. Depreciation: Physical & Functional Depreciation, Methods of Depreciation - Straight Line, Declining Balance, Double-Declining balance method, Case Study. Financial Statement Analysis: Balance Sheet and Profit & Loss Statement, Meaning & Contents. Ratio Analysis, Financial Ratios such as Liquidity Ratios, Leverage Ratios, Turn over Ratios, and Profitability Ratios, Drawbacks of Financial Statement Analysis. Project Risk: Safety and Risk, Assessment of Risk and Safety, Case study, Risk Benefit Analysis and Reducing Risk

References:

1. Chan S. Park, *Contemporary Engineering Economics*, 4th Edition, Pearson Prentice Hall, 2007.
2. Thuesen G. J, *Engineering Economics*, Prentice Hall of India, New Delhi, 2005.
3. Blank Leland T. and Tarquin Anthony J., *Engineering Economy*, McGraw Hill, Delhi, 2002.
4. Prasanna Chandra, *Fundamentals of Financial Management*, Tata McGraw Hill, Delhi, 2006.

ECE-XXXX ANALOG AND DIGITAL COMMUNICATION [4 0 0 4]

Total Number of contact hours: 48

Course Learning Outcomes:

At the end of the course, the student will be able to:

CLO1	Describe Random Process, Random Variables and Distributions in the context of Communication Systems.
CLO2	Discuss the fundamentals of detection and estimation theory
CLO3	Evaluate the performance of various analog and digital modulation schemes
CLO4	Describe the fundamental theorems of Information theory and source coding
CLO5	Apply channel coding techniques for information storage and transmission

Random Process, Random Variables and Distributions used in Communication Systems. Analog Modulation Schemes: Analytical concepts and the concept of Noise. Detection and Estimation theory, practical studies and Design challenges. PCM, DPCM, DM, ADM, Baseband data transmission. Digital Modulation schemes, ASK, FSK, BPSK, QPSK, DPSK, probability of error design. Introduction to Information Theory, Entropy, Source coding: Shannon Fano Encoding and Huffman Coding. Entropy Mutual Information capacity of a DMC, Shannon's theorem on channel capacity and Binary symmetric channel. Elementary channel coding techniques.

***Self-directed Learning:**

Fundamentals of Fourier Series, Transforms and Modulation Properties.

References:

1. * John G Proakis and Masoud-Salehi."Digital Communications" , 5th Edition 2008.
2. Herbet Taub and Schilling, "Principles of Communication systems" ,2001
3. Simon Haykin, "Analog and Digital Communication Systems" 2nd Edition, 2006
4. Simon Haykin, "Digital Communication",2nd Edition., 2008

ECE XXXX **MICROPROCESSORS** **[3 0 0 3]**

Total Number of contact hours: 36

Course Learning Outcomes:

At the end of the course, the student will be able to:

CLO1	Describe ARM7 architecture and Programmer's model.
CLO2	Discuss ARM assembler directives and instruction sets.
CLO3	Compose assembly program for the ARM processor.
CLO4	Demonstrate ARM processor interface with peripheral devices and programming
CLO5	Discuss the performance improvement techniques in ARM and distinguish hardware modes with exceptions

Overview of computing systems: ALU, registers, control unit, memory unit. The ARM architecture and features. The ARM7TDMI programmer's model. Assembler rules and directives. ARM instruction set and programming: Addressing modes. Instruction types and format, conditional execution, Instruction set. Endianness; Constants and literal pools. Loops and Branches, Subroutine and stacks; passing parameters to subroutine. Assembly programming. Memory mapped peripherals: The LPC2148, Architecture and features, Hardware interfacing: display devices, actuators, data converters, programming. Performance improvement techniques. ARM Thumb model, Thumb instructions, Exception handling, interrupts, and Error conditions.

***Self-directed Learning:**

Embedded C program for ARM7 Microprocessor

References:

1. Andrew N Sloss, "ARM System developer's guide, designing and optimizing system software", Elsevier, 2004
2. William Hohl , "ARM assembly language fundamentals and techniques" , CRC press, 2009
3. Steve Furber," ARM System on chip Architecture", Pearson Education, 2000
4. J. R. Gibson "ARM Assembly Language-an Introduction" Dept. of Electrical Engineering and Electronics, The University of Liver-pool, 2007.
5. Raghunandan G.H, "Microcontroller (ARM) and Embedded Systems", Cengage Learning India Pvt. Ltd., 2020.

* https://www.keil.com/download/

*https://www.youtube.com/watch?v=j-lfh3OrXlw

ECE XXXX COMMUNICATION NETWORKS [3 0 0 3]

Total Number of contact hours: 36

Course Learning Outcomes

At the end of the course, the student will be able to:

CLO1	Discuss the various communication network models and functions of Physical Layer.
CLO2	Describe and analyze the performance of DLL Protocols.
CLO3	Evaluate the performance of Network layer Protocols.
CLO4	Describe the various Transport Layer Protocols.
CLO5	Discuss the functioning of various Application Layer Protocols.

Types of CNs, Network Hardware, Software, ISO: OSI, TCP/IP, ATM Reference Models. Physical Layer: Media, Line coding, channel capacity, Multiplexing, Multiple Access, switching. Design issues of DLL, Error Control, Flow Control, MAC: Random Access, Controlled Access, IEEE 802.3, 802.5, FDDI. Design issues of Network Layer, Shortest Path Routing, Distance Vector, Link State, Hierarchical Routing, Congestion Control, QoS, IP Addressing, NAT, ARP, RARP, Unicast Routing Protocols. TCP, UDP. Application Layer protocols. Mobile IP and TCP.

***Self-directed Learning:**

Intra Domain Routing Protocols, Inter Domain Routing Protocols (BGP), Application Layer Services (HTTP, FTP, Email, DNS).

References:

1. Fourouzan B. A., "Data Communications and Networking",5th Edition Mc Graw Hill, 2013
2. Garcia A.L and Widjaja I., "Communication Networks", McGraw Hill, 2006
3. Stallings W., "Data and Computer Communication" (7e), Prentice Hall. 2004
4. Mir N.F., "Computer and Communication Networks", Pearson Education, 2007
5. Jean Walrand & Pravin Varaiya, "High Performance Communication Networks", 2nd Edition, Morgan Kauffman, 2000

*https://nptel.ac.in/courses/106105183

ECE XXXX DIGITAL COMPUTER ARCHITECTURE [3 0 0 3]

Total Number of contact hours: 36

Course Learning Outcomes:

At the end of the course, the student will be able to:

CLO1	Describe general and specific computer architectures and analyse instruction formats
CLO2	Design processing unit and control unit
CLO3	Discuss memory hierarchy and cache mapping techniques
CLO4	Describe basic input and output techniques
CLO5	Discuss performance enhancement techniques

Computer Architecture and Organization. Processor Design. Quantitative principles of computer design, Design of arithmetic and logic unit (ALU), Registers, Multiplication algorithms for signed and unsigned data, Division Algorithms. Memory and I/O Organization. Cache memory organization, Mapping techniques, Accessing I/O devices, I/O interfacing, Direct memory access, Virtual memory system. Functional Organization. Register transfer language for computer's internal operation, Micro-programmed and hardwired control unit design, Instruction pipelining and instruction-level parallelism (ILP), Data dependences and Hazards, Flynn's classification for parallelism, Thread level parallelism.
DSP Architecture and addressing modes.

***Self-directed Learning:**

Processor Architectures: VLIW, MIMO, SIMO.

References:

1. David A. Patterson and John L. Hennessy, "Computer Organization and Design –The Hardware / Software Interface", 4th Edition, Morgan Kaufmann, Elsevier, 2009.
2. *John L. Hennessy and David A. Patterson, "Computer Architecture – A Quantitative Approach", 5th Edition, Morgan Kaufmann, Elsevier, 2011.
3. William Stallings, "Computer Organization and Architecture", Ninth edition, Pearson Education, 2013.
4. M.Raffiquzzaman & Chandra, "Modern Computer Architecture, Galgotia publications", New Delhi, 1990.
5. Kuo S. M. and Gan W. S., "Digital Signal Processors-Architectures, Implementations and Applications", Pearson Education, 2005.

ECE XXXX VLSI TESTING AND TESTABILITY [3 0 0 3]

Total Number of contact hours: 36
Course Learning Outcomes:
At the end of the course, the student will be able to:

CLO1	Describe the different types of testing, testing process and its significance.
CLO2	Discuss and analyze different types of faults and prepare models for the same.
CLO3	Derive test vectors for finding stuck at faults in combinational circuit and sequential circuit using various types of structural, algebraic algorithms and state table verification method.
CLO4	Discuss the testability measures and compare various design for Testability techniques
CLO5	Describe the techniques to generate the random patterns and discuss the fundamental of PLA testing.

Introduction to testing and testability: Need for testing, digital and analog testing; Physical Faults and their modeling; Fault models; Testing of combinational circuits: Various types of faults. Functional v/s structural approach to testing; Testability Techniques: scan-path testing, Boundary scan; Testing of sequential circuits: Test pattern generation for sequential circuits;
Signatures and self-test: Testing with random patterns. LFSRs, random test generation and response compression, Built-in self-test (BIST), PLA Testing.

***Self-directed Learning:**
Testability techniques, Scan chain and Boundary scan

References:

1. *M. L. Bushnell and V. D. Agrawal, "Essentials of testing for digital, memory and mixed-signal VLSI circuits", Boston: Kluwer Academic Publishers, 2000.
2. M. Abramovici, M. A. Breuer, and A.D. Friedman, "Digital Systems Testing and Testable Design", Piscataway, New Jersey: IEEE Press, 1994.
3. Miczo, "Digital Logic Testing and simulation". New York: Harper & Row, 1986.
4. P.K. Lala, "Fault Tolerant & Fault Testable hardware Design", BS Publications, 1998
5. Stanley L. Hurst, “VLSI Testing: digital and mixed analogue digital techniques” Pub:Inspec/IEE, 1999.

ECE XXXX SATELLITE COMMUNICATION [3 0 0 3]

Total Number of contact hours: 36

Course Learning Outcomes

At the end of the course, the student will be able to:

CLO1	Explain fundamentals of satellite communication systems.
CLO2	Describe the satellite orbits with the definitions of parameters associated with it.
CLO3	Describe the electronic hardware systems associated with the satellite subsystem and earth station
CLO4	Compute the satellite link parameters under various propagation conditions with the illustration of multiple access techniques
CLO5	Describe the various applications of satellite with the focus on national satellite system.

Overview of satellite communication systems, Satellite Orbits: Kepler's Laws, Definitions of terms for earth-orbiting satellites, Orbital effects on satellite's performance, Launching Procedures**.** Satellite subsystem. Earth Station: Types, Design considerations, Satellite tracking. Satellite Link Design Fundamentals: Equivalent isotropic radiated power, Transmission losses. Multiple access techniques: FDMA, TDMA, CDMA, SDMA assignment methods, compression – encryption, coding schemes. Satellite Applications**:** Communication satellites**,** Remote sensing satellites. Navigation satellites- GPS system, NAVIC, GAGAN.

***Self-directed Learning:**

Position determination using GNSS

References:

1. Dennis M Roddy, "Satellite communications", 4th edition, McGraw Hill, 2006.
2. Timothy Pratt and Jeremy E. Allnutt, "Satellite communications", 3rd edition, Wiley 2019
3. Tri T ha, "Digital satellite communications", 2nd edition, McGraw Hill Education, 2008
4. M.Richharia, "Satellite communication systems-Design Principles‖", Macmillan 2003
5. Anil K. Maini, Varsha Agrawal, "Satellite communications", Wiley India Pvt. Ltd., 2015

*https://www.youtube.com/watch?v=50U2T6Tmr1E&list=PLLy_2iUCG87A55NPtEwWoWPiKs0-9NNT1&index=3

ECE XXXX DIGITAL SIGNAL PROCESSING LAB [0 0 3 1]

Total Number of contact hours: 30
Course Learning Outcomes:
At the end of the course, the student will be able to:

CLO1	Use MATLAB and Code Composer Studio to analyze signals and systems in time and transfer domain.
CLO2	Design and simulate analog and digital filters using standard filter design techniques.
CLO3	Evaluate and compare the performance of different filters.
CLO4	Apply the concepts of DSP to process speech and image signals using MATLAB.
CLO5	Implement different types of filters using DSP processors.

Time domain and frequency domain analysis of signals and systems. Analysis in *z*-domain. Filter design. Applications to speech and image signal processing. Simulation experiments using Code Composer Studio. Filter implementation using DSP Kits.

References:

1. Lab manual
2. Ifeachar, Jervis, "Digital Signal Processing - A Practical approach", Pearson Education, Asia, 2003.
3. Code Composer Studio user guides

ECE XXXX MICROPROCESSOR LAB [0 0 6 2]

Total Number of contact hours: 60

Course Learning Outcomes:

At the end of the course, the student will be able to:

CLO1	Write ARM7 assembly language program and simulate using Keil IDE
CLO2	Write ARM7 assembly language programs to interface display devices, switches, keypads, motors, data converters.
CLO3	Write ARM7 assembly language programs for on chip features.
CLO4	Compose embedded C programs to interface ARM7 processor with external devices and on-chip features.
CLO5	Develop and demonstrate project on Microcontrollers

Assembly Programming for arithmetic, logical and data transfer operations, Assembly as well as C Programming for interfacing I/O devices like Switches, Keypad, display devices, Data converters, and Motor controllers. Assembly as well as C Programming for on chip features of ARM processor: hardware interrupts, timers, PWMs, ADC, DAC and serial communication protocols.

*Self directed learning

Develop and demonstrate projects using Microcontrollers.

References:

5. Lab Manual
6. William Hohl , “ARM assembly language fundamentals and techniques” , CRC press, 2009
3. https://www.nxp.com/docs/en/user-guide/UM10139.pdf
4. http://arantxa.ii.uam.es/~gdrivera/sed/docs/ARMBook.pdf

VI- SEMESTER

HUM XXXX ESSENTIALS OF MANAGEMENT [3 0 0 3]

Total contact periods: 36

Course Learning Outcomes:

At the end of this course the students will be able to:

CLO 1	Analyze the roles of managers, principles of management, managerial skills, and strategies required to run a business successfully with social and ethical responsibilities
CLO 2	Develop an organizational structure and plan for manpower in a given business organization
CLO 3	Apply leadership and motivational theories in the organizational contexts
CLO 4	Suggest proper techniques of controlling for the given process
CLO 5	Prepare a business plan by identifying business opportunities, conduct market analysis and prepare feasibility reports

Introduction to Business, Industrial Business, Classification of Industries and Job Opportunities (referring the industries visiting our campus). Functions of Managers/Management and time spent on various managerial functions by managers at various levels, two characteristics of managerial functions, Efficiency and Effectiveness. Principles of Management by Henri Fayol. Three types of managerial responsibilities. Planning: Strategic, Tactical and Operational. Nature and characteristics, Types, qualitative and quantitative objectives, Stakeholders and their interests, Fiscal and Social Responsibilities. Strategic Planning: Planning Tools – SWOT, TOWS, Business Portfolio Analysis and Porter's model; Process. Principles of Organizing; Span of Control. Departmentalization: Types of Departmentalization. Staffing HRM and HRD. Leading**:** Meaning, differences between – leading and managing, leader and manager. Maslow's Need Hierarchy, Herzberg's 2 – factor theory and McGregor X and Y theory. Motivational techniques. Leadership. Controlling Management Control Techniques. Entrepreneurship. International Management Practices. Professional Ethics and Global Issues**.**

References:

1. Harold Koontz and Heinz Weihrich, "Essentials Of Management", 4th Edition, Mc Graw Hill, New Delhi, 2012.
2. Peter Drucker, "Management: Tasks, Responsibilities and Practices", Harper and Row, New York, 1993.
3. Peter Drucker, "The Practice of Management", Harper and Row, New York, 2004.
4. Vasant Desai, "Dynamics of Entrepreneurial Development and Management", Himalaya Publishing House, 2007.
5. Poornima M Charantimath, "Entrepreneurship Development", Pearson Education, 2006.
6. S S Khanka, "Entrepreneurship Development", S Chand & Co., 2007.

ECE XXXX WIRELESS COMMUNICATION [3 0 0 3]

Total Number of contact hours: 36
Course Learning Outcomes:
At the end of the course, the student will be able to:

CLO1	Discuss various path loss models of wireless communication channels
CLO2	Discuss mathematical models of time varying wireless communication channels
CLO3	Estimate information carrying capacity of wireless channels
CLO4	Evaluate the performance of different digital modulation schemes in wireless communication scenario
CLO5	Analyze equalization and diversity techniques

Path Loss and Shadowing, Empirical Path Loss Models, Combined Path Loss and Shadowing, Outage Probability under Path Loss and Shadowing, Cell Coverage area. Time-Varying Channel Impulse Response, Classification of Fading models, Narrowband Fading, Wideband Fading Models, Capacity in AWGN, capacity of flat fading channel, capacity of frequency selective fading, Outage Probability, Average Probability of Error, Combined Outage and Average Error Probability; Doppler Spread, Inter symbol Interference, Adaptive equalization, Linear and Non-Linear equalization, Zero forcing and LMS Algorithms, Diversity combining techniques, Transmitter.

*Self -Directed Learning:
Diversity Techniques.

References:

1. Andrea Goldsmith, "Wireless Communications", Cambridge University Press, 2005
2. David Tse, Pramod Viswanath "Fundamentals of Wireless Communication", Cambridge University Press, 2005
3. Aditya Jagannatham, "Principles of Modern Wireless Communication Systems Theory and Practice", McGraw Hill, 2016
4. *Andreas F. Molisch, "Wireless Communications" IEEE Press, 2010.
5. Simon Haykin, Michael Moher "Modern Wireless Communications", Pearson, 2011.

ECE XXXX SYSTEM-ON-CHIP DESIGN [3 0 0 3]

Total Number of contact hours: 36

Course Learning Outcomes:

At the end of the program, the students will be able to:

CLO1	Explain the need, benefits, and features of System-on-Chip.
CLO2	Discuss the SoC Physical Design flow.
CLO3	Describe SoC implementation, Intellectual property, and interconnects.
CLO4	Analyse the techniques involved in SoC verification, testing, and packaging.
CLO5	Describe the evolution of SOC to state of the art – NoC.

Basics of SoC, Constituents of SoC - Life cycle, Design flow, Physical Design, Logic Synthesis, Floor Planning, Placement, Routing, Physical Design Constraints, Clock Tree Synthesis, Timing analysis, power routing, Interconnects, Switch Interconnects, Layered Architecture, Network Interface, IP-based design, IP evaluation on FPGA prototypes, SOC verification, testing, Standardization-SoC Test Automation, SoC packaging. Network on Chip, architectures, Reconfigurable NoC, NoC interconnects and 3D-NoC.

*Self Directed Learning

Modern NoC Architectures

References:

1. Michael J.Flynn, Wayne Luk, , "Computer system Design: System-on-Chip", Wiley-India, 2012.
2. Veena S. Chakravarthi- "A Practical Approach to VLSI System on Chip (SoC) Design", Springer Nature Switzerland AG, 2020
3. Sudeep Pasricha, Nikil Dutt, "On Chip Communication Architectures: System on Chip", Morgan Kaufmann Publishers, 2008.
4. W.H.Wolf,, "Computers as Components: Principles of Embedded Computing System Design", Elsevier, 2008.

   * NPTEL-IIT Madras https://youtube.com/playlist?list=PL3p-ZpXPqK6vvxeTp1k4kDMJj74WIetyC

ECE XXX **RF CIRCUIT DESIGN** **[3 0 0 3]**

Total Number of contact hours: 36

Course Learning Outcomes:

At the end of the course, the student will be able to:

CLO1	Discuss the basic architecture of transmission line.
CLO2	Design and analyze the High frequency amplifier.
CLO3	Design and analyze the Low Noise Amplifier
CLO4	Design and analyze the Power amplifier and PLL
CLO5	Discuss the GSM ,CDMA, UMTS radio architectures

RF systems – basic architectures, Parallel RLC tank, Quality factor, Series RLC networks, matching, Distributed Systems, Transmission lines High Frequency, Amplifier Design, Bandwidth estimation using open-circuit time constants, Bandwidth estimation using short-circuit time constants. LNA Design Multiplier based mixers, Subsampling mixers, RF Power amplifiers: Class A, AB, B, C amplifiers, Class D,E, F amplifiers Voltage controlled oscillators and Phase locked loop Radio architectures

*Self -Directed Learning:

Analysis /simulation of RF modules like Low Noise amplifier or gilbert cell and its application

References:

1. Thomas H. Lee, "The Design of CMOS Radio-Frequency Integrated Circuits" by Cambridge University Press, 2004
2. Behzad Razavi, "RF Microelectronics",.Prentice Hall, 1997.
3. Frank Ellinger, "Radio frequency integrated circuits and technologies" by. Springer Science & Business Media, 2008.
4. Jörg Eberspächer, Christian Bettstetter, Hans-Joerg Vögel, Christian Hartmann "GSM – Architecture, Protocols and Services",Wiley Telecom, 2009

*Simulation using Cadence software/ LT simulator

ECE XXXX INFORMATION THEORY AND CODING [3 0 0 3]

Total Number of contact hours: 36
Course Learning Outcomes:
At the end of the course, the student will be able to:

CLO1	Recall the mathematical requirement to study the information theory and coding and compute the entropy of discrete memoryless sources.
CLO2	Describe Markov source, its adjunct and compute entropy
CLO3	Design instantaneous and uniquely decodable codes, Kraft's Inequality, Compact codes and adaptive Huffman codes
CLO4	Describe Mutual information, noiseless and deterministic channels.
CLO5	Describe channel capacity, error probability and Shannon's Second theorem

Information, Entropy of discrete memoryless source and memory sources, Instantaneous and uniquely decodable codes, Kraft's inequality, compact codes, Shannon's theorem code efficiency & redundancy, Information channels, Joint Entropy and Conditional Entropy, Relative Entropy and Mutual Information and its properties, cascaded channel, channel capacity Chain Rules, Data-Processing Inequality, Fano's Inequality, Error probability and decision rules, reliable messages and unreliable channels, An example of coding to correct errors, Differential entropy Shannon's second theorem for BSC.

*__Self-directed learning__

Channel Coding: Properties and design of Linear block codes

References:

1. Thomas M. Cover, Joy A. Thomas, "Elements of Information Theory", John Wiley and sons, INC, 1991.
2. Norman Abramson, "Information Theory and Coding", McGraw Hill, 1963.
3. Haykin S, "Digital Communications", Wiley, 2008.
4. Khalid Sayood, "Introduction to Data Compression", 3rd Edition, MK Publishers, 2012.
   *An Introduction to Coding Theory - Introduction - YouTube. Video lectures

ECE XXXX COMMUNICATION NETWORKS LAB [0 0 3 1]

Total Number of contact hours: 30

Course Learning Outcomes:

At the end of the course, the student will be able to:

CLO1	Simulate Wired & Wireless network Topologies.
CLO2	Configure and test various Data Link Layer protocols.
CLO3	Simulate and verify functions of various Network Layer protocols.
CLO4	Simulate MANETs and WSNs and analyze their performance.
CLO5	Demonstrate IoT based Applications.

To simulate a three point-to-point network with duplex links between them. To simulate the transmission of ping message over a network topology and find the number of packets dropped due to congestion. To Simulate and compare the performance of network with topologies such as Star, Ring and Mesh. Wired and Wireless LANs: Mobile Ad-hoc network (MANET), Infrastructure Basic Service Set (IBSS) network with multiple traffic and analyze the performance of the network. Cluster based WSN, Wi-Max network and analyze the performance with multiple traffics. Implementation of ALOHA Protocols for packet communication between a number of nodes connected to a common bus. CSMA, CSMA/CD, Token Bus, Token Ring. To provide reliable data transfer between two nodes over an unreliable network using the stop-and-wait protocol with and without BER. Perform error control at DLL using Bit stuffing, Checksum and Character count. CRC, Hamming Coding. Routing Algorithms.

***Self-Directed Learning:**

Mobile Ad hoc Networks (MANETs), Wireless Sensor Networks (WSNs)

References:

1. Fourouzan B. A.,"Data Communications and Networking", 5th Edition Mc Graw Hill, 2013
2. Garcia A.L and Widjaja I., "Communication Networks", McGraw Hill, 2006
3. Stallings W.,"Data and Computer Communication" (7e), Prentice Hall. 2004
4. Mir N.F., "Computer and Communication Networks", Pearson Education, 2007
5. Jean Walrand & Pravin Varaiya, "High Performance Communication Networks", 2nd Edition, Morgan Kauffman, 2000

   * https://archive.nptel.ac.in/courses/106/105/106105160/

ECE XXXX COMMUNICATION SYSTEMS LAB [0 0 3 1]

Total Number of contact hours: 30
Course Learning Outcomes:
At the end of the course, the student will be able to:

CLO1	Design, simulate and test Patch Antennas.
CLO2	Design, simulate and test Multiband antennas and understand the hardware design for microstrip passive components.
CLO3	Design and characterize the radiation pattern of microstrip antennas.
CLO4	Compose codes for digital modulation techniques.
CLO5	Design and analyze the performance of MIMO antennas

Design and Analysis of Micro strip single band and multi band patch antenna-using HFSS. To study and Characterize the Radiation pattern for Micro strip antenna. Design and Analysis of Array and 5G MIMO antennas using HFSS. To study the performance characteristics of Microwave Components. Implementation of BPSK, QPSK and BFSK using MATLAB/LabVIEW and find the error performance using USRP 2901. Design of a simple 2×2 MIMO spatial multiplexing scheme and evaluate the performance over a Rayleigh/Rician fading channel using MATLAB. Design a Space Time Block Code (Alamouti- STBC) using MATLAB/LabVIEW. Diversity and Combining Techniques 1×1, 2×2 using MRC.

***Self-Directed Learning:**
Millimeter Wave components and devices

References:

1. John J Prokis and Dimitris G. Manolakis "Digital Signal Processing Principles, Algorithms, and Applications" Prentice-Hall International, Inc., 2015.
2. J Proakis and M. Salehi "Contemporary communication systems using MATLAB", 3rd Edition Cengage Learning, 2013.
3. Ed Doering -Reports on Communication Systems Projects with LabVIEW. https://www.rose-hulman.edu/~doering/
4. KC Raveendranathan, "Communication systems modelling simulation using MATLAB and SIMULINK" by 1St edition, Taylor and Francis Group, 2015.
5. Balanis, C. A. "Antenna theory: analysis and design" John wiley & sons, 2015.
6. J.D Kraus "Antennas", Second Edition, TMH Publication 1989

*Link: https://onlinecourses.nptel.ac.in/noc21_ee76/preview

PROGRAM ELECTIVES (Minor)

1. *COMPUTATIONAL INTELLIGENCE*

ECE XXXX MACHINE LEARNING [3 0 0 3]

Total Number of contact hours: 36
Course learning outcomes:
At the end of the course, the student will be able to:

CLO1	Understand basics of machine learning algorithms.
CLO2	Analyze dimensionality reduction techniques for feature selection.
CLO3	Explain artificial neural network (ANN) and its initialization, training & validations.
CLO4	Describe the various parametric, nonparametric, and graphical methods of classifiers.
CLO5	Describe evaluation measures for classifier performances.

Machine learning basics, Naïve Bayesian Model. Non-Parametric Techniques: Density Estimation, Parzen Windows, k- Nearest-Neighbor Estimation, K- nearest neighbor classification, Radial Basis Function Network, Learning Vector Quantization, Clustering, K-Means clustering, Competitive learning, , Support vector machines, , feature selection methods – Filter based techniques and wrapper methods, Principal Component Analysis, Applications of PCA, PCA ,Independent component analysis, Voting, Error correcting output codes, Bagging, Boosting

*Self directed learning**:**
Self-Organizing Maps, Recurrent Neural Network, Hopfield Neural Network, Adaptive Resonance Theory, Statistical Hypothesis testing- t-test, ANOVA.

References:

1. Alpaydin E, “Introduction to Machine Learning”, (2e), MIT Press. 2010.
2. Duda R.O, Hart P.E. and Stork D.G., “Pattern Classification”, (2e), Wiley, 2001
3. Harrington P., “Machine Learning in Action, Manning” Publications, 2012.
4. Bishop C. M., “Pattern Recognition and Machine Learning”, Springer, 2007.
5. Jensen R. and Shen Q. “Computational Intelligence and Feature Selection”: Rough and Fuzzy Approaches, Vol. 8, IEEE Press Series on Computational Intelligence, John Wiley and Sons, 2008

   * https://nptel.ac.in/courses/106106139

ECE XXXX COMPUTER VISION [3 0 0 3]

Total Number of contact hours: 36

Course learning outcomes:

At the end of the course, the student will be able to:

CLO1	Describe image formation using a pinhole camera and explain preprocessing techniques.
CLO2	Analyze different local image features such as SIFT, HOG, and texture.
CLO3	Contrast different image segmentation methods based on clustering, model fitting and probabilistic modelling.
CLO4	Explain the geometry of two views and discuss the least square estimation method for camera calibration with radial distortion.
CLO5	Evaluate various techniques for building classifiers with examples of their use in vision applications.

Image formation, linear filters and convolution, edge detection, image features, texture analysis and synthesis, Segmentation using clustering, Segmentation and fitting using probabilistic methods, Homogenous coordinates, Epipolar geometry, least-square parameter estimation, Feature selection, Bayes Classifier, Multi-layer perceptron, Support Vector Machine.

*Self directed learning:

Simulation of Image Segmentation

References:

1. David A. Forsyth and Jean Ponce, "Computer Vision": A Modern Approach, Pearson Education, 2003
2. Richard Szeliski, "Computer Vision: Algorithms and Applications", Springer, 2010
3. Richard Hartley and Andrew Zisserman, "Multiple View Geometry in Computer Vision", 2nd Edition, Cambridge University Press, 2004
4. Linda Shapiro and George Stockman, "Computer Vision", Pearson Education, 2001.

*Image processing tool box in MATLAB

2. *EMBEDDED SYSTEM*

ECE XXXX EMBEDDED SYSTEM DESIGN [3 0 0 3]

Total Number of contact hours: 36
Course learning outcomes:
At the end of the course, the student will be able to:

CLO1	Describe embedded system design tools and methodologies
CLO2	Discuss the standard software and hardware Building Blocks of Embedded System
CLO3	Develop programming skills for embedded systems
CLO4	Design computational models for Embedded systems
CLO5	Describe life cycle of embedded system design and testing.

Embedded systems overview, Embedded Software: Interrupts, interrupt latency, shared data problems. que scheduling, Real time operating system architecture, Introduction to real time operating system; Embedded hardware: standard peripherals; Communication; protocols; Designing embedded system using FSM models. Hardware and software co-design; Embedded C programming. Embedded development life cycle (EDLC).

*Self directed learning

Design and simulate an embedded system using Circuit simulation software.

References:

1. Frank Vahid & Tony Givargis, "Embedded system design", Wiley Publication, 2002.
2. David E Simon, "An Embedded software primer", Addison Wesley, 1999.
3. Shibu K. V, "Introduction to embedded systems", Mc Graw Hill Publication, 2013.
4. Raj Kamal, "Embedded Systems", 2nd edition, Tata McGraw Hill, 2003.

   *https://electrosome.com/getting-started-with-proteus-beginners-tutorial/

ECE XXXX INTERNET OF THINGS [3 0 0 3]

Total Number of contact hours: 36

Course learning outcomes:

At the end of the course, the student will be able to:

CLO1	Describe IoT trend settings, realization, and demonstration.
CLO2	Discuss the key wireless technologies evolved to support the requirements of IoT systems.
CLO3	Describe reference architecture and protocols for IoT echo systems.
CLO4	Elaborate trends and transitions in cloud landscape to cope with advancements in IoT.
CLO5	Describe various analytical approaches, frameworks, algorithms, platforms, engines, and methods for squeezing out value-adding IoT data.

Demystifying the IoT Paradigm; IoT Protocols and Technologies; Concept of Device-to-Device/Machine-to-Machine Integration, Device-to-Cloud Integration, Realization of IoT Ecosystem Using Wireless Technologies; Infrastructure and Service Discovery Protocols for the IoT Ecosystem; Next-Generation Clouds for IoT Applications and Analytics; Cloud Computing; Emerging Field of IoT Data Analytics; Software Defined Networking (SDN)

***Self-Directed Learning:**

Introduction to Arduino Programming: Integration of Sensors and Actuators with Arduino
Introduction to Python programming, Raspberry Pi, Implementation of IoT with Raspberry Pi.

References:

1. Raj P. and Raman A. C., The Internet of Things: Enabling Technologies, Platforms and Use Cases, CRC Press, 2017
2. Bagha A. and Medisetti V, "Internet of Things": A Hands on Approach, University Press, 2015.
3. Holler J., Tsiatsis V., Mulligan C., Karnouskos S., Avesand S., and Boyle D., From "Machine to Machine to the Internet of Things": "Introduction to a New Age of Intelligence", Academic Press, 2014
4. Vahid F, Givargis T., "Embedded Systems Design": "A Unified Hardware/Software Introduction", Wiley Publications, 2000
5. Axelson J, "Parallel Port Complete", Penram Publications, 1996.

*https://onlinecourses.nptel.ac.in/noc21_cs63/unit?unit=41&lesson=48

3. *SIGNAL PROCESSING*

ECE XXXX ADVANCED DIGITAL SIGNAL PROCESSING [3 0 0 3]

Total Number of contact hours: 36

Course Learning Outcomes:

At the end of the course, the student will be able to:

CLO 1	Discuss decimation and interpolation operations and describe interpolated FIR and poly phase filter implementations.
CLO 2	Analyse DFT filter bank and QMF bank.
CLO 3	Describe concepts of multi resolution analysis and analyse filter bank for STFT and wavelet transform.
CLO 4	Develop LMS and RLS algorithms and discuss their important applications.
CLO 5	Analyse cepstrum of signals and describe homomorphic system for convolution and its applications.

Multi-rate systems; decimation and interpolation (integer and fractional); poly phase filter structure; quadrature mirror filter bank (QMF); short-time Fourier transform and discrete-time wavelet transform; principle of adaptive filters; least mean square (LMS) algorithm; recursive least square (RLS) algorithms; application of adaptive filters; homomorphic system; complex cepstrum; homomorphic systems for convolution and de-convolution; examples of homomorphic signal processing.

*Self directed learning
Multirate signal processing

References:

1. Vaidyanathan P. P, Multirate Systems and Filter Banks, Prentice Hall, India, 1993.
2. Gadre V M, Abhyankar A S, Multiresolution and Multirate Signal Processing: Introduction, Principles and Applications, McGraw Hill, 2017.
3. Orfanidis S. J, Optimum Signal Processing, McGraw Hill , NJ, 2007.
4. Oppenheim A.V and Schafer R.W., Digital Signal Processing, PHI Learning, 2008.

   * https://www.youtube.com/playlist?list=PLyqSpQzTE6M_h5UgZWpybzBVDGmHGhQQb – NPTEL NOC - IITM

ECE XXXX DIGITAL SPEECH PROCESSING [3 0 0 3]

Total Number of contact hours: 36

Course Learning Outcomes:

At the end of the course, the student will be able to:

CLO1	Understand the human speech production system, different speech sounds and describe digital models.
CLO2	Analyze various time domain and spectral features of speech.
CLO3	Compute pitch period and formants of voiced speech signal using LPC parameters.
CLO4	Describe the speech signal processing applications in speech coding and speech synthesis.
CLO5	Describe the speech processing application in speech enhancement and speech recognition.

Fundamentals of speech: Anatomy and physiology of speech production system, phonetics, types of speech sounds. Time domain analysis of speech: Time dependent processing of speech, pitch period estimation using auto correlation function. Short-time Fourier analysis of speech: Short time Fourier transform analysis, formant evaluation using log spectrum and power spectral density estimates, spectrograms. Homomorphic processing of speech: Cepstral analysis of speech. Linear predictive coding of speech: Linear models of speech, Basic principles of LPC. Speech Processing Applications: Speech coding, Speech recognition systems.

*Self-directed learning:

Automatic speech recognition (ASR), Speech Synthesis.

References:

1. Rabiner L.R and Schaffer R.W, “Digital Processing of Speech Signals”, Prentice Hall, NJ, 2007.
2. Thomas F. Quatieri, “Discrete.time Speech Signal Processing—Principles and Practice”, Pearson Education, Inc., 2004.
3. Douglas O' Shaughnessy, “Speech Communications. Human and Machine Reading”, Addison Wesley, 1987.
4. Dr. Shaila D. Apte, “Speech and Audio Processing”, Wiley India, 2012.
5. *Lawrence Rabiner, Biing-Hwang Juang, B. Yegnanarayana, “Fundamentals of Speech Recognition”, Pearson, 2011 (Fifth Impression).

4. *COMMUNICATION SYSTEMS*

ECE XXXX MACHINE LEARNING FOR COMMUNICATION SYSTEMS [3 0 0 3]

Total Number of contact hours: 36
Course Learning Outcomes:
At the end of the course, the student will be able to:

CLO1	Discuss techniques used in machine learning
CLO2	Design deep and CNN architectures for various applications
CLO3	Use machine learning algorithms for communication system applications
CLO4	Identify challenges in evolving machine learning concepts conforming to industry standards
CLO5	Discuss and develop Reinforcement learning based application

Linking machine learning and communication systems. Overview of supervised, unsupervised and reinforcement learning. Communication Systems: use of machine learning in OSI layer. Connection between signal processing, adaptive filtering and machine learning. Self-organizing wireless networks, Cognitive radio and machine learning. Neural networks, network training, use of gradient information, gradient descent optimization; error back propagation, Bayesian neural networks, Support vector machines. ML and DL for communication system.

***Self-directed Learning:**
Classification of learning

References:

1. Christopher Bishop, “Pattern Recognition and Machine Learning”, First Edition, Springer, 2016.
2. Krishna Kant Singh, Akansha Singh, Korhan Cengiz, Dac-Nhuong Le, “Machine Learning and Cognitive Computing for Mobile Communications and Wireless Networks”, Wiley, 2020.
3. Yoshua Bengio, “Learning Deep Architectures for AI,Foundations and Trends in Machine Learning”, First Edition, Now Publishers Inc, 2009.

*https://www.youtube.com/watch?v=EWmCkVfPnJ8&list=PLJ5C_6qdAvBGaabKHmVbtryZW9KpICiHC&index=2

ECE XXXX B5G COMMUNICATION SYSTEMS [3 0 0 3]

Total Number of contact hours: 36

Course Learning Outcomes:

At the end of the program, the students will be able to

CLO1	Discuss challenges of deploying B5G network and technology.
CLO2	Describe various type of antenna technology for next generation communication systems.
CLO3	Discuss multiband millimetre-wave technology for 5G and beyond .
CLO4	Analyze and characterize multiband millimetre-wave technology for B5G
CLO5	Describe 6G networks deployment, challenges and benefits.

Challenges in next generation mobile technologies. High Altitude Stratospheric Platform Station Systems, Human Bond Communications, CONASENS, Introduction to propagation model for 5G. Antennas and propagation for 5G and beyond, Antennas Technology for future Generation communication system: state-of-the-art and open challenges Massive MIMO antenna technology, State-of-the-art phased arrays. 5G and beyond antenna challenges, Multiband millimetre-wave technology for 5G: Concept and topology, Megatrends toward 6G, 6G Services, Requirements, Candidate Technologies: Terahertz Technologies, Novel Antenna Technologies, Evolution of Duplex Technology, Evolution of Network Topology, Spectrum Sharing, Comprehensive AI, Split Computing, High-Precision Network. 6G Timeline.

***Self-directed Learning:**

Topologies for 6G services

References:

1. Ramjee Prasad, "5G: 2020 and Beyond", River Publishers, 2019.
2. Qammer H. Abbasi, Syeda F. Jilani, Akram Alomainy and Muhammed A.Imran, "Antennas and propagation for 5G and beyond", IET, 2020.
3. Hai Tang, Ning Yang, Zhi Zhang, Zhongda Du, Jia Shen, "5G NR and Enhancements": From R15 to R16", Elsevier, 2021.
4. *Samsung 6G white paper "6G:The Next Hyper Connected Experience for All" Samsung Research, 2021.
5. Christopher Cox, "An Introduction to 5G: The New Radio, 5G Network and Beyond", Wiley, 2020.

ECE XXXX PHOTONIC COMMUNICATION SYSTEM [3 0 0 3]

Total Number of contact hours: 36

Course Learning Outcomes:

At the end of the course, the student will be able to:

CLO1	Analyse propagation of light in optical fibers taking into account dispersion and other loss mechanisms
CLO2	Understand and analyse the construction and operating principles of high speed optoelectronic and photonic devices
CLO3	Utilize various optical signal processing techniques in photonic communication systems
CLO4	Demonstrate knowledge of TDM, WDM, SONET/SDH, optical crosstalk and optical access networks
CLO5	Design and analyze the performance of a simple Photonic communication system

Light propagation in multimode and single mode fibers, optical impairments, Optoelectronic Devices, Semiconductor Detectors, Photonic Devices and circuits, Light wave Systems, Optical Signal Processing, Optical Networks Photonic Communication System Design

***Self-directed Learning:**

Optical Networks

References:

1. B. E. A. Saleh and M. C. Teich , "Fundamentals of Photonics", Wiley-India, 2007
2. *J. M. Senior , "Optical Fiber Communication-principles and practice", Prentice hall of India, 3rd Edition, 2009.
3. Gerd Keiser, Optical Fiber Communications, TMH publication, 5th edition, 2017.
4. Govind P. Agrawal - Fiber-optic communication systems - Wiley et Sons , 4th edition,2010
5. R. Ramaswami and K. Sivarajan, Optical Networks: A Practical Perspective, Morgan Kaufmann, 2nd Edition, Elsevier, 2001.

ECE XXXX SATELLITE BASED WIRELESS COMMUNICATION

[3 0 0 3]

Total Number of contact hours: 36

Course Learning Outcomes:

At the end of the course, the students will be able to:

CLO1	Demonstrate and understand orbital and functional principles of satellite Communication, Satellite sub system and Earth station system.
CLO2	Discuss the ideas of link design and polarization techniques used for wireless satellite communication.
CLO3	Understand and design the concepts of Diversity combining techniques in MEO satellites.
CLO4	Design and simulate the concepts of free space optical communication and ATP.
CLO5	Implement beamforming techniques used for Satellite Communication using SDR.

Orbital Mechanics and Sub systems, Satellite link Design: Uplink and Downlink Design, Design of Satellite Links for Specified Carrier-to-Noise plus Interference Ratio, Noise figure and Noise temperature. Attenuation Noise, Tropospheric Multipath and Scintillation Effects. Interference Analysis, Interference to and from Adjacent Satellite Systems, Terrestrial Interference, Cross-polarization Interference, Intermodulation Interference. Diversity Combining and Handover techniques in 5G using MEO. Free Space Optical Communication for Inter Satellites: design issues. Acquisition Tracking Pointing of an optical beam. Beamforming in FSO inter satellite.

*Self Directed Learning:

Modulation formats for 5G wireless systems.

References:

1. Tri T. Ha ,"Digital Satellite Communications", 2/e, McGraw-Hill, 1990.
2. T. Pratt, C.W. Bostian, "Satellite Communications", John Willey and Sons, 2011.
3. *Shree Krishna Sharma, Symeon Chatzinotas and Pantelis-Daniel Arapoglou, "Satellite Communications in the 5G Era" IET Telecommunications series- 79, 2018.
4. Terrestrial-"Satellite Communication Networks": Transceivers Design and Resource Allocation, Springer International Publishing AG 2017, Linling Kuang, Chunxiao Jiang Yi Qian, Jianhua Lu. 2017

5. *VLSI DESIGN*

ECE XXXX LOW POWER VLSI DESIGN [3 0 0 3]

Total Number of contact hours: 36

Course Learning Outcomes:

At the end of this course, the student will be able to:

CLO1	Describe the need, device technology impact and probabilistic power analysis technique on Low power design.
CLO2	Analyze the different circuit level power reduction technique in CMOS circuits
CLO3	Describe the issues involved in logic level power reduction techniques.
CLO4	Describe the power reduction technique using low power architecture and systems.
CLO5	Identify the origin of power dissipation in clock structure and techniques for low power clock distribution along with system level power reduction techniques.

Basics of low power VLSI design, sources of power dissipation in digital integrated circuits, Power dissipation in CMOS circuits. Dynamic and static power dissipation. Probabilistic power analysis. Equivalent Pin Ordering, Network Restructuring and Reorganization. Logic encoding, state machine encoding, reduction of power in address and data buses. Power and performance management, parallel architecture with voltage reduction, low power memory design. Low power clock distribution.

*Self-Directed Learning:

Battery-Aware Systems, OS level and software level power reduction techniques.

References:

1. *Gary K. Yeap, “Practical Low Power Digital VLSI Design”, KAP, 2002.
2. Christian Piguet, “Low Power CMOS Circuits – Technology, Logic Design and CAD Tools”, CRC Press, 2006.
3. Jan M. Rabaey, Massoud Pedram, “Low power design methodologies”, Kluwer Academic, 1997.
4. Kaushik Roy, Sharat Prasad, “Low Power CMOS VLSI Circuit Design”, Wiley, 2000.
5. Kiat Seng Yeo, Samir S. Rofail, Wang-Ling Goh, “CMOS/BiCMOS ULSI: Low Voltage, Low Power”, Pearson, 2002.

ECE XXXX MOS DEVICE MODELLING [3 0 0 3]

Total Number of contact hours: 36

Course Learning Outcomes:

At the end of the program, the student will be able to:

CLO1	Describe the spice models and its various models
CLO2	Describe the circuit simulation techniques
CLO3	Identify the noise sources in MOSFET and its effect on MOS device working.
CLO4	Describe the various aspect of BSIM4 mosfet model.
CLO5	Use SPICE device simulators for various circuits

Introduction to SPICE modelling, SPICE modelling of passive elements and active devices. MOSFET model parameters; Circuit simulation techniques: DC analysis, AC analysis, Transient analysis; noise model: Noise sources in MOSFET; BSIM4 MOSFET model: BSIM3 model, issues in BSIM3, Layout-Dependent Parasitics. Data Acquisition and model parameter measurements, Other Models; Introduction to SPICE tools: Introduction to Device simulators, models supported.

***Self-Directed Learning:**

Introduction to SPICE tools- CMOS VLSI Design

References:

1. Tar Fjeldly, Trond Ytterdal and Michael S. Shur "Introduction to Device Modeling and Circuit Simulation" Wiley-Blackwell, 1997.
2. Giuseppe Massabrio and Paolo Antognetti "Semiconductor Device Modeling with Spice" Tata McHill, 2010.
3. William Liu, "MOSFET Models for SPICE Simulation: Including BSIM3v3 and BSIM4", Wiley-IEEE Press, 2001.
4. Nandita Das Gupta and Amitava Das Gupta, "Semiconductor Devices. Modeling and Technology", PHI, New Delhi, 2004.
5. M.K.Achuthan and K.N. Bhat, "Fundamentals of Semiconductor Devices", Tata McGraw.Hill, New Delhi, 2011.

*Introduction to SPICE tools- CMOS Digital VLSI Design By Prof. Sudeb Dasgupta ,IIT Roorkee

ECE XXXX DIGITAL DESIGN VERIFICATION [3 0 0 3]

Total Number of contact hours: 36

Course Learning Outcomes:

At the end of the course, the student will be able to:

CLO1	Describe the concept of digital verification.
CLO2	Describe the concept of different verification approaches.
CLO3	Apply System Verilog for Design and Verification
CLO4	Discuss concept of verification planning and test-bench architecture
CLO5	Apply System Verilog for advanced functional verification and formal verification technique

Introduction to verification, Developing Verification strategies, Applying Verification strategies, RTL ports and interfaces, Modelling hardware interfaces with concurrency constructs, simulating test benches using Fork-join, stimulus synchronization using conventional synchronization constructs like Mailboxes, Semaphores, regions and events. Basics of UVM verification, System Verilog, Advanced Functional Verification, Basics of Formal Verification.

***Self-directed Learning:**

Verification of combinational and sequential logic circuits using System Verilog

References:

1. Padmanabhan T.R. and Sundari B.B.T., "Design Through Verilog HDL", John Wiley &Sons, 2004.
2. Palnitkar S., Verilog® HDL. A Guideto Digital Designand Synthesis IEEE 1361-2001 Compliant (2e), Prentice Hall,2003
3. Bhaskar J., "A VerilogHDL" Primer, BS Publications, 2005.
4. Brown S..and Vranesic Z., "Fundamentals of Digital Logic with VerilogDesign (5e)", Tata McGraw Hill, 2005.
5. Ciletti M.D., "Advanced Digital Design with the Verilog HDL", PHI, 2005.

* https://edaplayground.com/

ECE XXXX ANALOG IC DESIGN [3 0 0 3]

Total Number of contact hours: 36

Course learning outcomes:

At the end of the course, the student will be able to:

CLO1	Design single stage integrated CMOS amplifiers.
CLO2	Apply different types of current mirrors in integrated circuits.
CLO3	Design CMOS operational amplifier for given specifications.
CLO4	Investigate stability and frequency compensation techniques of CMOS amplifiers.
CLO5	Analyze integrated voltage references and voltage regulators.

Integrated circuit design philosophy, Recent trends and challenges in IC design, SPICE coding, Analyze and design of Basic current mirrors, Single stage amplifiers, Analysis and Design of Integrated two stage CMOS amplifier, Stability and frequency compensation, Temperature independent biasing, PTAT voltage, CTAT voltage device, beta multiplier, Band-gap reference, Linear voltage regulator specifications, performance parameters, LDOs.

*** Self-Directed Learning: -**

Examples of Current sink and sources

References:

1. Behzad Razavi, "Design of Analog CMOS Integrated Circuits", McGraw-Hill, 2001.
2. R. Jacob Baker, "CMOS Circuit Design, Layout and Simulation", Wiley India, 2010.
3. Allen and Holberg, "CMOS Analog Circuit Design", 2nd Edition, Oxford Press, 2002
4. Sedra ans Smith, "Microelectronic Circuits", Oxford Press, 2005.
5. Gabriel A. Rincon-Mora, "Analog IC Design with Low-Dropout Regulators", McGraw-Hill Education, 2009.

* http://www.satishkashyap.com/2013/06/video-lectures-and-lecture-notes-on.html

OTHER ELECTIVES

ECE XXXX DATA STRUCTURES AND ALGORITHMS [3 0 0 3]

Total Number of contact hours: 36

Course Learning Outcomes:

At the end of the course, the students will be able to:

CLO1	Describe fundamentals of data structures and their applications.
CLO2	Implement and analyze the Linear Data Structures: Stack, Queues, Lists
CLO3	Implement and analyze the Non-Linear Data Structures: Trees, Graphs
CLO4	Implement and analyze the searching and sorting algorithms
CLO5	Assess appropriate data structure during program development.

Data Structures – Introduction to Data Structures, abstract data types, Time and space complexity Linear list – singly linked, circular linked list, Double linked list, Applications of linked lists. Stacks-Operations, array and linked representations of stacks, stack applications, recursion implementation. Queues-operations, array and linked representations, applications of queues. Trees - tree representation, properties of trees, Binary tree representation, binary tree properties, binary tree traversals, binary tree implementation, applications of trees, Graph- Representation of Graph, types of graph, Matrix Representation of Graphs, Elementary Graph operations, Spanning Trees, Shortest path, Minimal spanning tree. Searching and Sorting – Sorting- selection sort, bubble sort, insertion sort, quick sort, merge sort, shell sort, radix sort, Searching-linear and binary search methods, comparison of sorting and searching methods.

*Self-Directed Learning:

Implementation of data structure and algorithms using compilers

References:

1. Ellis Horowitz;Sartaj Sahni;Dinesh Mehta, “Fundamentals of Data Structures in C++”, 2nd edition, Universities Press (India) Limited, 2013.
2. Mark A. Weiss, “Data Structures and Algorithm Analysis in C++”, 3rd Edition, Pearson Education India, 2007.
3. Lipschutz, “Data Structures with C++”, Schaum outline series, 2006
4. Michael T. Goodrich, Roberto Tamassia, David Mount, “Data Structures and Algorithms in C++”, John Wiley & Sons, 2011.
5. *https://www.javatpoint.com/cpp-installation

ECE XXXX DATA ANALYTICS AND VISUALIZATION [3 0 0 3]

Total Number of contact hours: **36**

Course Learning Outcomes:

At the end of the course, the student will be able to:

CLO1	Describe the data analytics methods and data representation
CLO2	Appreciate the tools used for the statistical analysis of data
CLO3	Discuss the visual representation of data
CLO4	Classify the visualization systems of data
CLO5	Simulate the various data representation and visualization techniques.

Data analytics methods and representation, Data Gathering and Preparation: Data Formats, Parsing and Transformation, Scalability and Real-time Issues; Data Cleaning. Exploratory Analysis, Descriptive and comparative statistics, Hypothesis testing, Statistical Inference. Association rule mining, FP Growth, Partitioning, measures of pattern interestingness. Clustering: Visualization: Visual Representation of Data, Gestalt Principles, Information Overloads. Classification of Visualization Systems, Interaction and Visualization Techniques, Visualization of One, Two and Multi-Dimensional Data, Text and Text Documents; Visualization of Groups: Trees, Graphs, Clusters, Networks, Software, Metaphorical Visualization.

* Self-Directed Learning:

Visualization of Volumetric Data.

References:

1. 1.Glenn J. Myatt, Wayne P. Johnson, Making Sense of Data I: A Practical Guide to Exploratory “Data Analysis and Data Mining”, 2nd Edition, John Wiley & Sons Publication, 2014.
2. *Glenn J. Myatt, Wayne P. Johnson, Making Sense of Data II: A Practical Guide to Data Visualization, Advanced Data Mining Methods, and Applications, John Wiley & Sons Publication, 2009.
3. E. Tufte. The Visual Display of Quantitative Information, (2e), Graphics Press, 2007.
4. Jules J., Berman D., Principles of Big Data: Preparing, Sharing, and Analyzing Complex Information, (2e), 2013.
5. Matthew Ward and Georges Grinstein, Interactive Data Visualization: Foundations, Techniques, and Applications, (2e), A K Peters/CRC Press, 2015.

ECE XXXX ERROR CONTROL CODING [3 0 0 3]

Total number of lecture hours: 36

Course Learning Objectives

At the end of this course, student will be able to:

CLO1	Apply concepts of groups, fields, Galois Field, vector spaces, matrices in error control coding
CLO2	Implement and analyze the Linear block Codes, Hamming Codes
CLO3	Implement and analyze the Cyclic Code, Cyclic Shortened Code
CLO4	Design multiple error correcting BCH code and RS code.
CLO5	Analyze Convolution Codes, turbo codes and LDPC codes. Decode the received code using Viterbi decoding algorithm.

Prime Number theory, Fields, Galois field arithmetic, vector spaces, Matrices. Linear block codes, Cyclic codes: shortened cyclic codes, burst error correcting cyclic codes, Fire codes, and interleaved codes. Multiple error correcting codes: BCH codes, Non binary BCH codes: RS codes. Convolution codes: Trellis, Tree, & state diagram, Viterbi algorithm. Recent developments: Turbo codes and LDPC codes.

*Self-Directed learning

Applications of Turbo codes and LDPC codes

References:

1. S. Lin and D. J. Costello Jr, “Error control coding Fundamentals and Applications” Prentice Hall, 1983.
2. McWilliams & Sloane, “Theory of Error Correcting Codes”, North Holland Publishing Co, 2006.
3. W. W. Peterson and E. J. Weldon “Error Correcting Codes”, 2nd edition, John Wiley, 1972.
4. E. R. Berlekamp, “Algebraic Coding Theory”, Aegean Park Press, 1984.
5. Blahut, R. E., “Theory and Practice of Error Control Codes”, Addison-Wesley Pub. Co., 1983.

* https://archive.nptel.ac.in/courses/117/106/108106137/

ECE XXXX NUMBER THEORY AND CRYPTOGRAHY [3 0 0 3]

Total number of lecture hours: 36

Course Learning Outcomes:

At the end of this course, the student will be able to:

CLO1	Apply number theory, Euclidean algorithm and Chinese remainder theorem and perform various computations required in cryptographic techniques.
CLO2	Apply different classical algorithms to encrypt and decrypt data.
CLO3	Encrypt and decrypt the data using standard algorithms.
CLO4	Apply public key cryptosystems for encryption and decryption.
CLO5	Apply elliptic curve cryptosystems to Diffie Hellman, ElGamal, Digital signature schemes.

Prime Numbers theories & Algorithm, Congruence, Fields & Galois field arithmetic, Discrete Logarithms. Classical cryptosystems: Symmetric Cryptography, Substitution Cipher, Affine Cipher, Hill cipher. Stream Ciphers Vs Block ciphers, Encryption and Decryption with Stream Ciphers, SP networks. Encryption standard: DES, AES. Asymmetric key cipher: Knapsack problem, Merkle - Hellman, RSA, Rabin, Elgamal, & Diffie Hellman Key exchange. Elliptic Curve Cryptosystems and its Elgamal,& Diffie Hellman. Message integrity and message authentication: Hash function, Whirlpool algorithms, digital signatures and authentication protocols. RSA Signature Scheme, Elgamal Digital Signature Scheme, Elliptic Curve Digital Signature Algorithm (ECDSA).

*Self Directed Leraning

Role of digital signatures in cryptography. Recent developments in Elliptic curve cryptosystem.

References:

1. Neal Koblitz, "A course in Number Theory and Cryptography", 2nd Edition, Springer,1994
2. Behrouz A. Forouzan, D. Mukhopadhyay, "Cryptography and Network Security", 2nd edition, Tata Mc Graw Hill, 2007.
2. William Stallings, "Cryptography and Network Security", 4th edition, Pearson Education, 2005.
4. Henry Beker, Fred Piper, "Cipher systems: the protection of communications" Northwood Books, 1982.

* https://csrc.nist.gov/Topics/Security-and-Privacy/cryptography/digital-signatures
* P. Barreto, B. Lynn and M. Scott, "Efficient implementation of pairing-based cryptosystems", Journal of Cryptology, 17 (2004), 321–334.

ECE XXXX ELECTRONIC INSTRUMENTAION [3 0 0 3]

Total Number of contact hours: 36

Course Learning Outcomes:

At the end of the course, the student will be able to:

CLO1	Discuss and analyze different types of transducers.
CLO2	Describe electronic measurement systems.
CLO3	Illustrate measurement of different physical parameters.
CLO4	Discuss signal conditioning and amplification systems.
CLO5	Analyze working of biomedical instruments.

Transducers, Generalized measurement system, functional description of measuring systems. Generalized performance characteristics. Static and dynamic characteristics, Errors and their classification, statistical analysis., Temperature and pressure measurement, Level and thickness measurement, Flow measurement, applications, and Biomedical instruments for measurement of ECG, EEG, EMG, and EGG.

*Self-directed topic:

Study of biomedical instruments.

References:

1. DVS Murthy, "Transducers & Instrumentation", PHI, New Delhi, 1999.
2. A.K. Sawhney, "Electrical & Electronic Measurements and Instrumentation", Dhanpat Rai& Co, New Delhi, 2002.
   3. Doeblin E.O., "Measurement Systems. Application and Design", 4th edition, McGraw-Hill, New York, 1996.
3. Khandpur, "Hand book of Biomedical Instrumentation", McGraw Hill, 2003.
   ***** NPTEL: Electrical Measurement and Electronic Instruments

ECE XXXX PCB AND SYSTEM DESIGN [3 0 0 3]

Total Number of contact hours: 36

Course Learning Outcomes:

At the end of the course, the student will be able to:

CLO1	Design an electronic system as per the given specifications.
CLO2	Construct various sensing, actuating and signal conditioning circuits.
CLO3	Describe power management ,packaging and soldering techniques
CLO4	Discuss PCB production techniques and modern PCB design
CLO5	Troubleshooting and quality testing of various Electronics systems

Electronic system design, Systems approach to Engineering, electronic system design flow, design stages, reverse engineering, and redesign methodology, Signal acquisition and conditioning and assessment of electronic systems Printed circuit board and production techniques, Electronic design automation(EDA) tools for PCB designing, soldering techniques, Tin lead phase diagram, Mechanical operations, PCB technology, multilayer boards, Modern PCB Design, soldering techniques, packages for semiconductor devices ad ICs, reliability issues in ICs, SMD components, SMD family, component packaging, assembling, pad dimensions, microsystem packaging,

* Self-Directed Learning:
Simulation of PCB using EDA tools

References:

1. Kevin N.Otto and Kristin L.Wood, "Product Design techniques in Reverse Engineering and New product Development", Pearson Education, 2001.
2. Walter C. Bosshart, "Printed circuit Board Design and technology", McGraw-Hill Education – Europe. 2002.
3. Neil storey,"Electronics System approach" Pearson Education, 2011
4. Rudolf Strauss, "Surface Mount Technology", Butterworth-Heinemann Ltd, Oxford, 1994.
5. Douglas Brooks, "Signal Integrity Issues and Printed Circuit Board Design", Prentice Hall, 2003.

*F. Giudice, G. Rosa, Antonino Risitano, Product Design for the environment - A life cycle approach, Taylor & Francis 2006, ISBN: 08493272.

* NPTEL Course on "An introduction to Electronic Systems Packaging ,IISC Bangalore by Professor G.V.Mahesh.

ECE XXXX FLEXIBLE ELECTRONICS [3 0 0 3]

Total Number of contact hours: **36**
Course Learning Outcomes:
At the end of the course, the student will be able to:

CLO1	Understand the trends and technologies of flexible electronics and its road map.
CLO2	Identify the materials and understand its basic properties for flexible electronics application
CLO3	Describe the various thin film deposition methods .
CLO4	Provide the insight of various flexible device structures and its characteristics
CLO5	Discuss the development of flexible sensors for consumer, healthcare, agriculture and environmental applications.

Introduction to Flexible Electronics: Background and history, trends, emerging technologies; Basic of disordered materials: Basic concepts, atomic and electronic structure, electronic properties; Materials for Flexible Electronics; Processing technology for flexible electronics: gravure printing, photolithography, low-temperature process integration; Flexible devices: Thin Film Transistors; Optoelectronic devices; Flexible Electronics Applications: Displays, memory devices, lab-on-a-chip, and flexible solar panels. Flexible devices and sensors for healthcare, environmental and agriculture applications.

***Self-Directed Learning -**

Gravure printing, inkjet printing, roll-to-roll processing, micro contact printing.
CVD, PECVD, PVD, etching, photolithography.

References:

1. William S. Wong, Alberto Salleo, "Flexible Electronics": "Materials and Applications", 2011, 1st Edition, Springer, New York.
2. Guozhen Shen, Zhiyong Fan, "Flexible Electronics: From Materials to Devices", 2015, 1st Edition, World Scientific Publishing Co, Singapore
3. Richard Zallen, "The Physics of Amorphous Solids", Wiley-Interscience Publication, 1983.
4. Sanjiv Sambandan, "CIRCUIT DESIGN Techniques for Non-Crystalline Semiconductors", CRC Press Taylor & Francis Group, 2013.
5. Edward Sazonov, Michael R. Newman, "Wearable Sensors: Fundamentals, Implementation and Applications", 2014, 1st Edition, Academic Press, Cambridge

* Advanced Textile Printing Technology, IIT Delhi, Prof. Kushal Sen, https://nptel.ac.in/courses/116102052.

* VLSI Technology, IIT Madras Dr. Nandita Dasgupta, https://nptel.ac.in/courses/117106093.

ECE XXXX MICROWAVE INTEGRATED CIRCUITS [3 0 0 3]

Total Number of contact hours: 36

Course Learning Outcomes:

At the end of the course, the student will be able to:

CLO1	Describe the fabrication process of MMICs
CLO2	Design and analyze the Planar Transmission line
CLO3	Design and analyze the Lumped elements using micro-strip
CLO4	Design and analyze filters, Resonators, Amplifiers using micro-strip
CLO5	Appreciate the MIC measurements and its Applications

Introduction to Monolithic Microwave Integrated Circuits (MMICs), planar transmission lines for MICs. Method of Conformal transformation for micro-strip analysis Coupled micro-strips. Slot Line Approximate analysis and field distribution, Fin lines & Coplanar Lines. Introduction, Analysis of Fin lines by Transverse Resonance Method, Lumped Elements for MICs: Use of Lumped Elements, Resonators and narrow band filters, Filter design, Power gain equations, Amplifier Gain Stability, Noise, DC Biasing, Oscillator Design MIC Measurement, Testing and Applications: MIC measurement system, measurement techniques, S parameter measurement, noise measurement, MIC applications.

***Self-directed Learning:**

Filter synthesis, Kuroda's Identity

References:

1. K. C. Gupta ,"Microwave Integrated circuit", 1975
2. Samuel Y. Liao , "Microwave Devices & Circuits 3/e", 2003
3. "Microstrip lines and Slot lines", K.C. Gupta, R. Garg.,I.,Bahl, P. Bhartia, Artech House, Boston, 1996.
4. Stripline-like "Transmission lines for Microwave Integrated circuits", B. Bhat, S. K. Koul, Wiley Eastern Ltd., New Delhi. 1990
5. Microwave Integrated Circuits, By Ivan Kneppo, J. Fabian, P. Bezousek, 1994
6. SDL link: https://archive.nptel.ac.in/courses/117/105/117105138/

ECE XXXX MOTION AND GOMETRY BASED METHODS IN COMPUTER VISION [3 0 0 3]

Total Number of contact hours: 36
Course Learning Outcomes:
At the end of the course, the student will be able to:

CLO1	Explain the geometric primitives, 2D/3D transformations and image feature descriptors
CLO2	Discuss various approaches for registration of 2D/3D images and range images
CLO3	Describe methods to generate an inference about the motion of an object from a sequence of images
CLO4	Evaluate local and global methods for binocular fusion and reconstruction
CLO5	Describe methods to estimate the scene structure and the apparent motion of the cameras relative to the points (structure from motion)

Geometric primitives, 2D/3D transformations, image features, MATLAB programming, Image registration (2D/3D) of rigid and deformable objects, range image registration, Tracking by detection, tracking using optical flow and KLT, tracking linear dynamical models with Kalman filters, Epipolar geometry, binocular reconstruction, local and global methods for binocular fusion, Structure from motion: Internally calibrated perspective cameras, Uncalibrated weak perspective cameras, Uncalibrated perspective cameras.

*Self Directed Learning

MATLAB programming for stereovision and structure from motion

References:

1. David A. Forsyth and Jean Ponce, “Computer Vision: A Modern Approach”, Pearson Education, 2003.
2. Richard Szeliski, “Computer Vision: Algorithms and Applications”, Springer, 2010.
3. Richard Hartley and Andrew Zisserman, “Multiple View Geometry in Computer Vision”, 2nd Edition, Cambridge University Press, 2004.
4. Rafael C. Gonzalez and Richard E. Woods, “Digital Image Processing”, 4th edition, Pearson Education, 2018.

   * https://in.mathworks.com/discovery/stereo-vision.html
   * https://in.mathworks.com/help/vision/ug/structure-from-motion.html

ECE XXXX EMBEDDED OPERATING SYSTEMS AND RTOS [3 0 0 3]

Total Number of contact hours: 36

Course Learning Outcomes

At the end of the course, the student will be able to:

CLO1	Describe the elements of operating systems and services
CLO2	Discuss embedded operating systems and real time operating systems
CLO3	Appreciate the different types of scheduling with real time operating systems
CLO4	Compose high level language program using RTOS for a standard Microprocessor
CLO5	Analyze different kernel objects and inter-process communication.

Embedded systems, Advanced processors and controllers; ARM cortex M-processor architecture. The Cortex Microcontroller Software Interface Standard (CMSIS). Operating systems concept, Process, Thread. Developing with RTOS, RTX – Real-time executive. Programming, UART. Scheduling options in RTX, RTX program. Uniprocessor scheduling. Inter process communication. Task synchronization, Classical synchronization problem, kernel objects. Free RTOS, Heap memory management, Task management, Queue management, Interrupt & Resource management, Event groups & Task notifications. Deadlock.

*Self Directed Learning

RTX programming on LPC 1768 (*RTX Manual). Simulation using Free RTOS

References:

1. William Stallings , "Operating systems", PHI, 2001.
2. Valvano J.W., "Embedded Systems": "Real-Time Operating Systems for ARM Cortex-M Microcontrollers", Volume3, (4e), Self Published in 2017.
3. Qing Li , "Real time concepts for Embedded Systems", CMP Books, Elsevier, 2003.
4. Wang K.C., "Embedded and Real-Time Operating Systems", Springer, 2017.
5. *Barry R., "Mastering the Free RTOS Real Time Kernel – A Hands on Tutorial Guide, Real Time Engineers LTD., 2016

ECE XXXX WIRELESS CELLULAR AND LTE 4G BROADBAND [3 0 0 3]

Total Number of contact hours: 36
Course Learning Outcomes:
At the end of the course, the student will be able to:

CLO1	Discuss the design issues involved in Wireless Fundamental and analyze LTE Features
CLO2	Design and analyze Multicarrier modulation, OFDMA in LTE
CLO3	Design and analyze Multiple antenna Reception and Transmission in LTE
CLO4	Design and analyze Downlink, Uplink, Physical layer Procedures in LTE
CLO5	Analyze MIMO and Diversity Multiplexing

Key Enablers for LTE features, Wireless Fundamentals, Multicarrier Modulation, OFDMA and SC-FDMA, Multiple Antenna Transmission and Reception, Overview and Channel Structure of LTE, Downlink Transport Channel Processing, Uplink Channel Transport Processing, Radio Resource Management and Mobility Management, MIMO Techniques.

References:

1. Amithabha Ghosh and Rapeepat Ratausk , "Essentials of LTE and LTE-A", Cambridge University Press.
2. Lin DU and Swamy, "Wireless Communication Systems" Cambridge University Press, 2010.
3. Chokhalingam and B. S. Rajan, "Large MIMO systems", Cambridge University Press, 2014.
4. B. Kumbhani and R. S. Kshetrimayum, "MIMO Wireless Communications over Generalized Fading Channels", CRC Press, 2017
5 .T. L. Marzetta, E. G. Larsson, H. Yang and H. Q. Ngo, "Fundamentals of Massive MIMO", Cambridge University Press, 2016.

ECE XXXX POWER ELECTRONICS [3 0 0 3]

Total Number of contact hours: 36

Course Learning Outcomes:

At the end of the course, the student will be able to:

CLO1	Discuss the characteristics of semiconductor devices for power electronics applications and chose suitable switch for a given application.
CLO2	Analyze power electronics components and circuits.
CLO3	Describe various power converter modules used to build power electronics system with the help of circuits, waveforms and expressions.
CLO4	Select and design appropriate power converter modules/systems to meet the requirements of industrial applications.
CLO5	Design, testing and debug power electronics circuits.
CLO6	Identify applications of power electronics in power systems and motor drives and choose converter types of a given application.

Power Electronics Devices, controlled rectifiers, single phase and three phase converters for different loads, dual converters and cyclo converters. DC-DC switched mode converters: Buck, Boost, Buck-Boost, Cuk, Flyback, forward. DC-AC switched mode inverters: Half bridge and full bridge single phase inverters, three phase inverters with 120^o and 180^o conduction.

*Self Directed Learning

Switched mode power supplies, power conditioners, UPS.

References:

1. Hart D.W., Introduction to Power Electronics, McGraw Hill, 2010.
2. Rashid M.H., Power Electronics Circuits, Devices and Applications, Prentice Hall of India, New Delhi, 2004.
3. Mohan N., Power Electronics Converters, Applications and Design, John Wiley and Sons. INC, 1995.
4. Singh M. D., Power Electronics, Tata McGraw Hill, 2007.

* http://www.digimat.in/nptel/courses/video/108108036/L40.html

* https://archive.nptel.ac.in/courses/108/102/108102145

ECE XXXX TIME FREQUENCY AND WAVELET TRANSFORMS [3 0 0 3]

Total Number of contact hours: 36
Course Learning Outcomes:
At the end of the course, the student will be able to:

CLO1	Define and explain Short-time Fourier Transform (STFT), Multi-resolution analysis and continuous-time wavelet transform (CWT).
CLO2	Relate wavelet transform with Fourier transform.
CLO3	Define discrete wavelet transform (DWT), describe the orthogonality principle and analyze filter bank concept.
CLO4	Describe the bi-orthogonality concept in wavelets.
CLO5	Analyze and apply 1-D and 2-D wavelet transforms for signal processing applications.

Time frequency analysis and wavelet transforms, STFT. Continuous wavelet transforms and their properties. Discrete wavelet transforms and their properties. DWT and its relation to filter banks, Multi-rate sampling fundamentals, Haar filter bank. Designing orthogonal and bi-orthogonal wavelet systems.

*Self Directed Learning
Two-dimensional wavelet system.

References:

1. Addison P. S, The Illustrated Wavelet Transform Handbook, Institute of Physics Publishing, 2002.
2. Rao R.M., Bopardikar A.S., Wavelet Transforms- Introduction to Theory and Applications, Pearson Education, 2008.
3. *Soman K. P. and Ramachandran K. I., Insight into Wavelets from Theory to Practice, Prentice Hall of India, 2005.
4. Narasimhan S. V., Basumallick N., S. Veena, Introduction to Wavelet Transform: A Signal Processing Approach, Narosa Publishing House, 2012.
5. Vaidyanathan P. P., Multirate Systems and Filter Banks, Pearson, 2012.

ECE XXXX VLSI PROCESS TECHNOLOGY [3 0 0 3]

Total Number of contact hours: 36

Course Learning Outcomes:

At the end of the course, the student will be able to:

CLO1	Explain the properties of materials and crystal growth techniques employed in IC fabrication.
CLO2	Explain the oxidation and lithographic process.
CLO3	Describe the processes used for doping the substrate.
CLO4	Explain deposition and epitaxial growth process.
CLO5	Discuss the fabrication processes of components and devices.

Material properties and Crystal Growth, Silicon Oxidation, dry and wet oxidation, Deal-Grove Model, Oxide thickness characterization. Photolithography: Optical Lithography. Etching: Wet chemical etching of Silicon and Silicon dioxide, Dry etching, Etch mechanism. Diffusion, Diffusion mechanism. Ion Implantation. Film deposition: Epitaxial growth techniques. Metallization. Fabrication processes of components and devices: resistor, capacitor, Inductor, BJT, and MOSFET.

*Self Directed Learning

Chemical Vapor Deposition (CVD) and Molecular Beam Epitaxy

References:

1. May G. S. and Sze S. M, Fundamentals of Semiconductor Fabrication, Wiley India Pvt. Ltd. 2011.
2. Gandhi S. K., VLSI Fabrication Principles, John Wiley and Sons, 2009.
3. Ruska W. S, Microelectronic Processing, McGraw Hill, 1997.
4. Zant P. V., Microchip Fabrication, McGraw Hill, 2013.
5. Campbell S., The Science and Engineering of Microelectronic Fabrication, Oxford Press, Cambridge, 2013.
   https://nptel.ac.in/courses/117106093

ECE XXXX WIRELESS SENSOR NETWORKS [3 0 0 3]

Total Number of contact hours: 36

Course Learning Outcomes:

At the end of the course, the student will be able to:

CLO1	Understand the Characteristics of Ad hoc networks and Wireless Sensor Networks.
CLO2	Discuss distributed computing and network protocol design principles in Wireless Sensor Networks.
CLO3	Illustrate Network level protocols for MAC, Routing, Time Synchronization, Aggregation, and Distributed tracking.
CLO4	Analyze Energy management techniques for sensor node lifetime longevity.
CLO5	Use simulation tools to develop energy efficient routing protocols.

Ad hoc Networks: Cellular vs Ad hoc Wireless Networks, Applications, Design issues: MAC schemes, Routing, Multicasting, Transport layer Protocols, Pricing schemes, QoS, Energy management. Wireless Sensor Networks: Ad hoc Networks vs Sensor Networks, Unique constraints and challenges, Advantages, Applications, Design issues, Architecture, Data Dissemination and Gathering, Enabling Technologies, Designing MAC Protocols, S-MAC, IEEE 802.15.4, Routing Protocols: Design Issues, Classification, QoS and Energy Management, Networks Layer Solutions, System Power Management Schemes, Sensor Networks Platforms and Tools: Programming, Sensor Node Hardware and Software.

Self-Directed Topics:

UAV Networks, Underwater Sensor Networks.

References:

1. C Siva Ram Murthy, B.S Manoj "Ad Hoc Wireless Networks" Pearson Education 2008.
2. Holger Karl, Andreas Willig " Protocols and Architectures for Wireless Sensor Networks" John Wiley, 2005
3. Feng Zhao,Leonidas J.Guibas,"Wireless Sensor Networks-An Information Processing Approach"Elsevier 2007.
4. Kazem Sohraby, Daniel Minoli, Taieb Znati "Wireless Sensor Networks- Technology, Protocols, and Applications" John Wiley, 2007.
5. Anna Hac "Wireless Sensor Network Designs" John Wiley 2003.

* https://archive.nptel.ac.in/courses/106/105/106105160/

ECE XXXX MODERN COMPUTER ORGANIZATION AND ARCHITECTURE [3 0 0 3]

Total Number of contact hours: 36

Course Learning Outcomes:

At the end of the course, the student will be able to:

CLO1	Discuss the key technologies and components employed in modern processor and computer architectures
CLO2	To understand the architecture and design principles underlying modern computer systems
CLO3	Discuss the implementation of the high-level services in a computer operating system provides Hardware-Software interface
CLO4	Analyze the internal behavior of processors with the execution of code specific to x86 and ARM processors
CLO5	Discuss the principal virtualization techniques and commercial tools to implement them

Computer architecture Interrupts, Modern computer system specifications; Network Interface, Device drivers, Input/output System (BIOS) and Unified Extensible Firmware Interface (UEFI) firmware's, Multiprocessing**;** Physical and virtual memory concepts, Memory management unit, Performance enhancing techniques, Multithreading; Handling interrupts and exceptions, Real-time computing systems, Digital signal processor, GPU processing; AMD x86 architecture and instruction set, RISC-V architecture and features; Processor virtualization and Cloud computing.

***Self-Directed Learning**

Virtualization Tools

References:

1. Jim Ledin, "Modern Computer Architecture and Organization-Learn x86, ARM, and RISC-V architectures and the design of smartphones, PCs, and cloud servers", 2020.
2. David A. Patterson and John L. Hennessy, "Computer Organization and Design –The Hardware / Software Interface", 4th Edition, Morgan Kaufmann, Elsevier, 2009.
3. John L. Hennessy and David A. Patterson, "Computer Architecture – A Quantitative Approach", 5th Edition, Morgan Kaufmann, Elsevier, 2011.

* https://github.com/PacktPublishing/Modern-Computer-Architecture-and-Organization

ECE XXXX BIO-MEMS AND MICROSENSORS [3 0 0 3]

Total Number of contact hours: 36

Course Learning Outcomes:

At the end of the course, the student will be able to:

CLO1	Describe various micromachining techniques
CLO2	Discuss the MEMS transduction and actuation techniques
CLO3	Appreciate basic Bio-mems fabrication techniques
CLO4	Discuss Microfluidic System, Devices and Components for Bio-MEMS
CLO5	Discuss sensing technologies for Bio-mems applications

Historical Background of MEMS, MEMS Transduction and Actuation Techniques, Micro sensing for MEMS, Basic Bio-MEMS Fabrication Technologies, UV Lithography of Ultra thick SU-8 for Microfabrication of High-Aspect-Ratio Microstructures and Applications in Microfluidic and optical components, Microfluidic Devices and Components for Bio-MEMS: Micro pump Applications in Bio-MEMS, Micro mixers, Sensing Technologies for Bio-MEMS Applications, Culture-Based Biochip for Rapid Detection of Environmental Mycobacteria, MEMS for Drug Delivery, Microchip Capillary Polymerase Chain Reaction and microsystem approach for PCR.

*Self Directed Learning

Microfluidics & Bio sensing devices for real time applications.

References:

1. 1RF MEMS and Their Applications, Vijay K. Varadan, K.J. Vinoy and K.A. Jose, Wiley, 2003 Edition.
2. Bio-MEMS-Technologies and Applications, Edited by Wanjun Wang and Steven A. Soper, CRC Press, 2007.
3. 3.Richard P.Buck,William E.Hatfieldc , “Biosensors Technology” Marcel dekker USA, 1990.
4. Stephen D. Senturia, "Microsystem Design" by, Kluwer Academic Publishers, 2001.
5. Marc Madou, “Fundamentals of Microfabrication” by, CRC Press, 1997.
6. Gregory Kovacs, “Micromachined Transducers Sourcebook” WCB McGraw-Hill, Boston, 1998.

*https://www.youtube.com/watch?v=BAJPvN2WBIA Lecture series 03 from Professor Suman Chakraborthy IIT Kharagpur

ECE XXXX SPINTRONIC VLSI [3 0 0 3]

Total Number of contact hours: 36

Course Learning Outcomes:

At the end of the course, the student will be able to:

CLO1	Explain the properties and Quantum Mechanics of spin.
CLO2	Describe spin dependent tunneling and transport.
CLO3	Explain the magnetic materials and magnetoresistance effect.
CLO4	Describe spintronic devices and spin transistor.
CLO5	Analyze the use of spintronic devices in logic computation.

The advent of spintronics, Quantum Mechanics of Spin: Pauli Spin Matrices. Spin-orbit interaction, spin polarized drift/diffusion, Spin-orbit interaction in a solid: Rashba Interaction, Spin Relaxation. Spin transfer torque (STT), anomalous Hall effect, Spin Hall effect (SHE), spin orbit torque (SOT). Spin valve, Magnetic tunnel junction (MTJ). Silicon based spin electronic devices: toward a spin transistor. Spintronic computing: Hybrid spintronics, Inmemory computing using spintronic devices.

*Self Directed Learning

All spin logic, Ferroelectric tunnel junctio (FTJ), Domain wall (DW) in magnetic nanowire

References:

1. J. M. D. Coey, "Magnetism and Magnetic Materials", Cambridge University Press, 2010.
2. S. Bandyopadhyay, M. Cahay, "Introduction to Spintronics", CRC Press, 2008.
3. S. Maekawa, "Concepts in Spin Electronics", Oxford University Press, 2006.
4. D. D. Awschalom, R. A. Buhrman, J. M. Daughton, S.V. Molnar, and M.L. Roukes, "Spin Electronics", Kluwer Academic Publishers, 2004.
5. Suri Manan, "Applications of Emerging Memory Technology", Springer Series in Advanced Microelectronics, 2020.

   *https://nanohub.org/wiki/Spin
   https://nanohub.org/publications/375/1
   http://gdr-rest.polytechnique.fr/node/94

ECE XXXX HARDWARE FOR MACHINE LEARNING [3 0 0 3]

Total Number of contact hours: 36

Course Learning Outcomes:

At the end of the course, the student will be able to:

CLO1	Discuss the basic machine learning algorithms and learning methods with examples and data structures used.
CLO2	Describe the requirements and characteristics of deep learning algorithms with respect to their hardware implementation.
CLO3	Analyze architectural implementation for applications with deep learning in an embedded resource constrained environment.
CLO4	Compare and evaluate the system architectures and parallel-processing techniques exploiting deep learning for real-time applications.
CLO5	Design and use various evaluation platforms to implement Machine/Deep learning algorithms.

Latest Machine Learning innovations and projects, Classical ML algorithms, feature extraction, Supervised, Unsupervised, Reinforcement Learning: Q-learning, Performance metrics and verification. Deep Neural networks, (CNN), Recurrent Neural Network (RNN), Generative Adversarial Networks (GAN), Model compression, Pruning, Dropout, Drop Connect, Distillation, Weight-sharing, Numerical compression, Encoding, Zero-skipping, Activation function approximation, Model and Data-flow optimization. Hardware software co-design, Optimizing Memory, Quantization Inference Engine, Fast Implementation of Deep Learning Kernels, Data flows, Sparsity. Study of Evaluation platforms like AWS Cloud, Xilinx ZYNQ, Vitis AI, Zynq FPGA, Intel OpenVINO DLDT, NVDIA Jetson Nano, TPU, Case study: Tesla- Full-Self-Driving Computer.

*Self-Directed Learning

TPU: Google, Coral and Domain Specific Accelerators

References:

1. Shigeyuki Takano, “Thinking Machines: Machine Learning and Its Hardware Implementation”, Academic Press, Elsevier, 2021
2. Albert Chun Chen Liu and Oscar Ming Kin Law, “Artificial Intelligence Hardware Design: Challenges and Solutions”, IEEE Press Wiley, 2021, First edition
3. Ethem Alpaydin, "Introduction to Machine Learning", MIT press, 2004.
4. T. Mitchell, “Machine Learning”, McGraw-Hill, 1997.
5. Duda, Richard O., Hart, Peter E., Stork, David G.” Pattern Classification” John Wiley (2nd Edition), 2004

   *https://cloud.google.com/tpu/docs/tpus

   *https://viso.ai/edge-ai/google-coral/

ECE XXXX BIOINSPIRED AND EVOLVABLE SYSTEMS [3 0 0 3]

Total Number of contact hours: 36

Course Learning Outcomes:
At the end of the course, the student will be able to:

CLO1	Explain the strengths, weaknesses and appropriateness of evolutionary algorithms.
CLO2	Describe the fundamental concepts of neural, Immune and DNA computing.
CLO3	Discuss the need and flow for reconfigurable hardware evolutionary algorithms implementation.
CLO4	Explain the intrinsic characteristics and implementation of evolvable hardware.
CLO5	Discuss the evolvable systems like cellular automata and some of their applications.

Introduction to Soft, Quantum, DNA Computing, Genetic algorithms, PSO, ACO, Spiking Neural Networks, Self-Organizing Maps, Deep Learning: CNN, Immune System, Random Forest, Adleman's experiment, Universal DNA Computers. Reconfigurable Hardware: FPGAs, Evolutionary hardware Design and Application: Implementation of evolutionary clustering. Evolvable Hardware: Cartesian Genetic Programming, Redundancy and Neutrality, Fitness Landscape Analysis, Chromosome to Fitness Value, Platforms for Circuit Evolution, Evolutionary Circuit Design: Static and Dynamic Fitness Function, Communication between Evolvable Component and Environment, Applications: Filters in Image Processing, smoothing. Evolvable and Non-Uniform Cellular Automaton, General Evolvable Computational Machine, Computation of Evolvable Machines, Changing Fitness Function, The Turing Machine, Church-Turing Thesis, Site Machine.

***Self-Directed Learning**
Cellular Automaton

References:

1. Lukas Sekanina, “Evolvable Components: From Theory to Hardware Implementations”, Springer-Verlag Berlin Heidelberg New York, 2004,
2. David W. Corne, Peter J. Bentley, “Creative Evolutionary Systems”, Academic Publishers, 2002.
3. Albert Chun Chen Liu and Oscar Ming Kin Law, “Artificial Intelligence Hardware Design: Challenges and Solutions”, IEEE Press Wiley, 2021, First edition
4. Floreano D. and Mattiussi C., "Bio-Inspired Artificial Intelligence: Theories, Methods, and Technologies", MIT Press, Cambridge, MA, 2008.
5. Leandro Nunes de Castro, " Fundamentals of Natural Computing, Basic Concepts, Algorithms and Applications", Chapman & Hall/ CRC, Taylor and Francis Group, 2007

   * Xuewei Li, Jinpei Wu, Xueyan Li –‘Theory of Practical Cellular Automaton’ Springer Singapore, 2018 (First edition).
   https://mathworld.wolfram.com/CellularAutomaton.html

ECE XXXX NATURE INSPIRED ALGORITHMS, TOOLS AND APPLICATIONS [3 0 0 3]

Total Number of contact hours: 36

Course Learning Outcomes:

At the end of the course, the student will be able to:

CLO1	Understand the strengths, weaknesses and appropriateness of nature-inspired algorithms.
CLO2	Understand fundamental concepts of NP-hardness and computational complexity.
CLO3	Prove algorithm convergence rates using probabilistic arguments, perform appropriate analyses of the outputs of stochastic algorithms.
CLO4	Apply nature-inspired algorithms to optimization, design and learning problems.
CLO5	Understand the motivation, methodology and the way to propose new Nature Inspired Algorithms.

Biomimetics, Individuals, Entities and agents - Parallelism and Distributivity Interactivity, Adaptation Feedback-Self-Organization-Complexity, Chaos and Fractals, Evolutionary computing**,** Hill Climbing and Simulated Annealing, Genetic Clustering. Swarm intelligence- PSO, ACO, Artificial Bee Colony, Grey Wolf Optimization, Colliding Bodies Optimization, Swarm Robotics, Immune system inspired computing**,** Random Forest, Spiking Neural Networks, Self-Organizing Maps, Perceptron, Deep Learning, DNA Computing, Adleman's experiment, Universal DNA Computers.

***Self-Directed Learning**

DNA Computing

References:

1. Leandro Nunes de Castro, " Fundamentals of Natural Computing, Basic Concepts, Algorithms and Applications", Chapman & Hall/ CRC, Taylor and Francis Group, 2007
2. Floreano D. and Mattiussi C., "Bio-Inspired Artificial Intelligence: Theories, Methods, and Technologies", MIT Press, Cambridge, MA, 2008.
3. Albert Y. Zomaya, "Handbook of Nature-Inspired and Innovative Computing", Springer, 2006.
4. Marco Dorrigo, Thomas Stutzle," Ant Colony Optimization", PHI,2005
5. *Martyn Amos- Natural Computing Series- 'Theoretical and Experimental DNA Computation' [1 ed.]- Springer 2005.
   https://computer.howstuffworks.com/dna-computer.htm

ECE XXXX NANODEVICES & NANO SENSORS [3 0 0 3]

Total Number of contact hours: 36
Course Learning Outcomes:
At the end of the course, the student will be able to:

CLO1	Describe the basic principles of quantum devices and circuit implementation.
CLO2	Discuss the principles of tunneling devices and implementation of circuits using it.
CLO3	Explain the sensor characteristic and its physical effects.
CLO4	Appreciate the various Nano-sensor applications
CLO5	Describe the various lithographic techniques for nanoscale fabrications.

Quantum Electronic devices – Quantum Dot array – Quantum computer- Bit and Qubit. Carbon Nanotube based logic gates; tunneling devices- Tunneling Diode – Resonant Tunneling Diode – Basics Logic Circuits – Single Electron Transistor (SET); sensor characteristics and physical effects**:** Active and Passive sensors – Static characteristic - Accuracy, offset and linearity – Dynamic characteristics; Nano sensors applications- Biosensors, conducting Polymer based sensor, DNA Biosensors, optical sensors. Biochips. NEMS. Nano tweezers; Nanolithography-Basics of lithography, optical, micro, ion beam lithography, lithographic tools, nanoimprint, lithography.

***Self-Directed Learning:**
Nanolithography- Basics of lithography, optical, micro, ion beam lithography, lithographic tools, wet chemical etching.

References:

1. K. Goser, P. Glosekotter and J. Dienstuhl, "Nanoelectronics and Nanosystems-From Transistors to Molecular Quantum Devices" , Springer, 2004.
2. .Ramon Pallas-Areny, John G. Webster, "Sensors and signal conditioning" John Wiley & Sons, 2001.
3. W.R.Fahrner, "Nanotechnology and Nanoelectronics – Materials, Devices and Measurement Techniques" Springer, 2006 13
4. H. Meixner , Sensors: Micro & Nanosensors, Sensor Market trends (Part 1&2) by
5. M Feldman, "Nanolithography:The Art of Fabricating Nanoelectronic and Nanophotonic Devices and Systems", Woodhead Publishing Series in Electronic and Optical Materials 2014.

   * VLSI Technology, IIT Madras Dr. Nandita Dasgupta,
   https://nptel.ac.in/courses/117106093.

ECE XXXX NEUROMORPHIC VLSI CIRCUITS [3 0 0 3]

Total number of lecture hours: 36

Course Learning Outcomes

At the end of this course, the student will be able to:

CLO1	Describe the biological neurons and its various models and circuits
CLO2	Analyze MOS basic for neuromorphic systems, static circuits and dynamic circuits
CLO3	Explain the basic of Current-Mode and Signal-Aggregation Circuits for neuromorphic systems.
CLO4	Analyze Analog and Digital neuromorphic systems
CLO5	Describe the various architecture and performance characteristics of demonstrated chips

Introduction; Signaling and operation of Biological neurons, neuron models; device physics and sub-threshold circuits; Static and dynamic circuits: current mirror, trans conductance amplifiers, multipliers, power-law circuits, resistive networks, Follower-Integrator, Differentiators; Current-Mode and Signal-Aggregation Circuits: Trans linear Principle, Floating-Gate MOS Circuits, Bump Circuit, Current Multipliers; Analog and digital neuromorphic designs: Non-volatile memristive semiconductor devices; Electronic synapse design; Architecture and performance characteristics of demonstrated chips employing Analog neuromorphic VLSI, Digital neuromorphic VLSI, Electronic synapses and other neuromorphic systems.

***Self-Directed Learning:**

Static and dynamic circuits: current mirror, transconductance amplifiers, multipliers, power-law circuits, resistive networks, Follower-Integrator, Differentiators, Second-Order Sections, linear and nonlinear filters, adaptive circuits -

References:

1. C. A. Mead , "Analog VLSI and Neural Systems", *1990.*
2. Shih-Chii Liu, Jörg Kramer, Giacomo Indiveri, Tobias Delbrück, Rodney Douglas, “Analog VLSI: circuits and principles”, MIT press, 2002.
3. Carver Mead, “Analog VLSI and neural systems”, Addison-Wesley, 1989, ISBN0201059924
4. Eric Kandel, James Schwartz, Thomas Jessell, Steven Siegelbaum, A.J. Hudspeth, “Principles of neural science”, McGraw Hill 2012, ISBN 0071390111
5. Leslie S. Smith and Alister Hamilton , "Neuromorphic systems", *World Science*, 1998.

   * Analog IC Design, IIT Madras, Prof. S. Aniruddhan, NPTEL, https://nptel.ac.in/courses/108106105.

ECE XXXX ANTENNA FOR 5G AND BEYOND NETWORKS [3 0 0 3]

Total Number of contact hours: 36

Course Learning Outcomes:

At the end of the course, the student will be able to:

CLO1	Discuss the fundamentals of antenna design parameters.
CLO2	Design and analyze the rectangular and circular patch antenna.
CLO3	Design and analyze UWB antenna and SWB antenna
CLO4	Design and analyze 5G antenna
CLO5	Design and analyze Millimeter Wave MIMO Antennas

Fundamental of Antenna: Antenna Introduction, Basic Parameters of Antenna, Impedance matching, Antenna measurements. Micro-strip Antenna Design: Introduction, Basic Characteristics, Rectangular and circular Patch antenna design. Wideband Antenna Design: UWB antenna design and applications, SWB antenna design and applications, Notching in Wideband antennas, Different notching structure design. Antennas for 5G: Key features of 5G antennas, Massive MIMO antenna technology: Antenna array topology, Single user (SU)-MIMO and multiple user (MU)-MIMO, Beamforming antennas in 5G massive MIMO, State-of-the-art phased arrays, 5G antenna challenges: Active and passive antenna systems. Millimeter Wave MIMO Antennas: Introduction, mm Wave MIMO Antennas, Compact mm Wave MIMO Antenna Design, Prototype and MIMO Antenna Performance.

***Self-directed Learning:**

Modeling of 5G antenna

References:

1. Balanis, Constantine A. “Antenna theory: analysis and design’. John wiley & sons, 2015.
2. James, James R., Peter S. Hall, and Colin Wood. Microstrip antenna: theory and design. Vol. 12. Iet, 1986.
3. R. ITU-R, "Characteristics of ultra-wideband technology," ITU-R, vol. SM.1755-0, 2006
4. Kumar, Sumit, et al. "Fifth generation antennas: A comprehensive review of design and performance enhancement techniques." IEEE Access 8 (2020): 163568-163593.
5. Sherine Mohamed Abd El-Kader, Hanan Hussein : “Fundamental and Supportive Technologies for 5G Mobile Networks’, IGI Global,2020
   * https://www.youtube.com/watch?v=p3wU5xwyCV8

ECE XXXX CMOS MIXED SIGNAL VLSI DESIGN [3 0 0 3]

Total Number of contact hours: 36

Course Learning Outcomes:

At the end of the course, the student will be able to:

CLO1	Explain the basic building blocks and circuits used in CMOS mixed-signal design (MSD)
CLO2	Analyze and design the filters, switched-capacitor (SC) and comparators.
CLO3	Design digital to analog converters and analog to digital converters for given Specifications.
CLO4	Discuss the various aspects of Phased Lock Loop circuits and applications
CLO5	Discuss mixed-signal layout issues.

Introduction to Mixed-Signal Design (MSD):Basic building blocks: data converters, continuous-time and sampled-data filters; Filters: Sample and hold (S/H) circuits, MOS switches, OTA-C approach; Switched Capacitor Circuits: Introduction to Switched Capacitor circuits- basic building blocks, Operation and Analysis; Comparators: Comparator specifications – input offset and noise, hysteresis, OPAMP as a comparator, errors and charge injections, types; Data Converters: Fundamentals, DAC and ADC specifications, DAC architectures ,ADC Architectures, Phased Lock Loop (PLL): Basic PLL topology, Dynamics of simple PLL, Mixed Signal Layout Issues: Power-supply and grounding issues, fully-differential design, ESD protection, sensor interfaces, VLSI interconnects.

* **Self-Directed Learning:** -
Phased Lock Loop (PLL)

REFERENCES:

1. R.Jacob Baker, "CMOS Mixed Signal Circuit Design, Wiley India, 2nd Edition, 2016.
2. Behzad Razavi ,Design of Analog CMOS Integrated Circuits , McGraw Hill Education; Second edition,2017.
3. Rudy van de Plassche, CMOS Integrated Analog-to-Digital and Digital-to-Analog Converters, Springer, 2003.
4. P. V. Anand Mohan, Current-mode VLSI Analog Filters: Design and Applications, Birkhäuser; 3rd edition,2012.
5. T Deliyanis, Y Sun and J K Fidler, Continuous-Time Active Filter Design, CRC Press, 1999.

* Lecture notes by S. Aniruddhan , IIT Madras, https://www.ee.iitm.ac.in/~ani/2013/ee5390/lectures.html

ECE XXXX SWITCHING THEORY FOR LOGIC SYNTHESIS [3 0 0 3]

Total Number of contact hours: 36

Course Learning Outcomes:

At the end of the course, the student will be able to:

CLO1	Describe the mathematical foundation of logic functions.
CLO2	Explain the optimization techniques for two level logic networks.
CLO3	Explain the optimization techniques for sequential networks.
CLO4	Describe the optimization of multi-valued input two-valued output functions
CLO5	Describe the technology mapping of logic function and design using EXOR function

Introduction to Boolean algebra, logic functions and their Representations; Optimization of and-or two-level logic networks: N-Dimensional Cube, Karnaugh Map, Prime Implicate, Quine-McCuskey Method; optimization of sequential networks: Sequential circuit optimization technique; Multi-valued input two-valued output function: Tautology, Equivalence, Generation of Prime Implicates, Sharp Operation. Heuristic optimization of two-level networks; Technology mapping: Decomposition, Pattern Matching; Logic design using exors: Classification of AND-EXOR Expressions, Simplification of ESOPs, Fault Detection and Boolean difference.

***Self-Directed Learning :**

Sequential circuit optimization – State diagram reduction using equivalence method and implicant chart table technique.

References:

1. Tsutomu Sasao, “Switching Theory for Logic Synthesis”, Springer Publication, 1999.
2. Soha Hassoun , Tsutomu Sasao, “Logic Synthesis and Verification”, Springer Publication, 2002.
3. Giovanni De Michelli , “Synthesis and Optimisation of Digital Circuits”, Tata-McGraw Hill, New Delhi,2008.
4. Gary D. Hachtel, Fabio Somenzi , “Logic Synthesis and Verification Algorithm”, Kluwer Academic Publication, Boston,2002.
5. D.D. Gajski, N.D. Dutt, A.C. Wu and A.Y. Yin, “High-level synthesis: introduction to chip and system design”, Kluwer Academic Publishers.

* Switching Theory and Logic Design-A. Anand Kumar, PHI, 2nd Edition.

ECE XXXX OBJECT ORIENTED PROGRAMMING USING C++ [3 0 0 3]

Total Number of contact hours: 36

Course learning outcomes:

At the end of the course, the student will be able to:

CLO1	Comprehend principles of object-oriented programming; different programming methods; Non-modular, Modular and object-oriented programming.
CLO2	Comprehend classes and objects including abstraction, encapsulation, overloading, friend function, constructor, destructors, and dynamic memory allocation.
CLO3	Comprehend inheritance and polymorphism conceptually and be able to create C++ classes using them.
CLO4	Describe the concepts of IO systems, file handling and streams.
CLO5	Discuss the concepts of exception handling in C++.

Overview of C++, Classes & Objects, defining member functions, data hiding, constructors, destructors, parameterized constructors, static data members, functions, friend functions, passing objects as arguments, Inheritance: constructors, destructors and inheritance, passing parameters to base class constructors, granting access, virtual base classes. Virtual functions, polymorphism: I/O system basics, file I/O: Exception handling.

*** Self-Directed Learning:** -

Analytic representation of complex systems and their attributes : NPTEL course : Object-Oriented Analysis and Design, IIT Kharagpur

References:

1. Schildt H., "The Complete Reference C++", Tata McGraw Hill, 2003.
2. Lafore R., "Object-Oriented Programming in C++", Pearson Education, Reprint 2011.
3. Lippmann S.B., Lajore J., "C++ Primer", Pearson Education, 2005.
4. Deitel P.J., Deitel H.M., "C++ for Programmers", Pearson Education, 2009.
5. Sourav Sahay, "Object oriented programming with C++", Oxford University press, 2006.

* https://nptel.ac.in/courses/106105153

ECE XXXX RADAR AND NAVIGATION SYSTEMS [3 0 0 3]

Total Number of contact hours: 36

Course Learning Outcomes

At the end of the course, the student will be able to:

CLO1	Demonstrate an understanding of the factors affecting the radar performance using Radar Range Equation
CLO2	Analyze the principle of FM-CW radar and apply it in FM-CW Altimeter
CLO3	Differentiate between a MTI Radar and a Pulse Doppler Radar based on their working principle
CLO4	Describe the basic principle of operation of navigation and guidance
CLO5	Understand the principle of operation of a global navigation satellite system

Maximum Unambiguous Range, Simple form of Radar Equation, Radar Block Diagram and Operation, Radar Frequencies and Applications, Prediction of Range Performance, Minimum Detectable Signal, Receiver Noise, Modified Radar Range Equation. Radar Equation: SNR, Envelope Detector, Transmitter Power, PRF and Range Ambiguities, System Losses (qualitative treatment), Tracking Radar, Angular resolution, Mono pulse Technique; CW and Frequency Modulated Radar, Bandwidth Requirements, Applications of CW radar. FM-CW Radar: FM-CW Radar, Range and Doppler Measurement, Block Diagram and Characteristics (Approaching/ Receding Targets), FM-CW, Multiple Frequency CW Radar, MTI and Pulse Doppler Radar, Navigation Approaches, Global Positioning System (GPS), GLONASS, Satellite based navigation system.

*** Self-Directed Learning:**

Tracking Radar, Angular resolution, Mono pulse Technique

References:

1. Merrill I. Skolnik, “Introduction to Radar Systems”, 3rd Edition Tata McGraw-Hill, 2001.
2. Mark A. Richards, James A. Scheer, William A.Holm, “Principles of Modern Radar: Basic Principles, SciTech Publishing Inc, 2013.
3. Hofmann-Wellenhof, B., Lichtenegger, H., Verlag Wien, Collins, J “Global Positioning System Theory and Practice” Springer 2001.
   *https://onlinecourses.nptel.ac.in/noc21_ee108/preview

ECE XXXX OPTICAL WIRELESS COMMUNICATION [3 0 0 3]

Total Number of contact hours: 36

Course Learning Outcomes:

At the end of the course, the student will be able to:

CLO1	Understand the operation of various essential optical components
CLO2	Explain optical signal propagation in atmospheric channel and factors affecting it
CLO3	Analyze the performance of simple FSO communication system
CLO4	Understand the VLC system and Hybrid-FSO WDM system
CLO5	Design link budget for the simple FSO communication link

Introduction to Optical Wireless Communication, Optical Devices, Factors affecting optical signal propagation in atmosphere, Atmospheric Turbulence Models, Modulation Techniques, FSO Link Performance under the Effect of Atmospheric Turbulence, Atmospheric Turbulence Mitigation Techniques, Visible Light Communications, Hybrid Fiber and FSO Wavelength multiplexing FSO system.

***Self-Directed Learning:**

Atmospheric Turbulence Models (Log-Normal Turbulence Model)

References:

1. *Z. Ghassemlooy, W. Popoola, S. Rajbhandari, "Optical Wireless Communications: System and Channel Modelling with MATLAB", CRC Press, 2012
2. L. C. Andrews and R. L. Phillips, Laser Beam Propagation through Random Media, 2nd ed. Bellingham, Washington: SPIE Press- "The International Society for Optical Engineering", 2005.
3. O. J. Bandele, P. N. Desai, M. S. Woolfson, A. J. Phillips, "Saturation in Cascaded Optical Amplifier Free-Space Optical Communication Systems", IET Optoelectronics, vol. 10, no. 3 pp. 71-79, 2016
4. A. M. Mbah, J. G. Walker, A. J. Phillips, "Outage probability of WDM free-space optical systems affected by turbulence-accentuated interchannel crosstalk", IET Optoelectronics, vol. 11, no. 3 pp. 91-97, 2016

ECE XXXX 5G FUNDAMENTALS & ARCHITECTURES [3 0 0 3]

Total contact periods: **36**

Course Learning Outcomes:

At the end of the program, the students will be able to:

CLO1	Describe LTE- Basic and Advance
CLO2	Describe 5G Fundamentals, Use Cases, Network Architecture
CLO3	Compare 5G Base Station Architecture & Antenna Architecture
CLO4	Understand Network Interfaces, Protocol Stacks & Call Management
CLO5	Discuss MIMO & Beamforming in 5G, 3GPP Standards

Introduction to 4G/LTE, Introduction to 5G networks, Use Cases, Network Architecture, Understanding of Base Station Architecture & Antenna Architecture, Different types & configurations of Antennas, Various interfaces of different Network elements, 5G protocol stack for Layer 1, 2 & 3. Call Processing & Handovers, MIMO techniques, Beamforming in 5G - Types, Analog, Digital, Hybrid. 3GPP standards & roadmap, Hands On training.

***Self-directed Learning:**

Overview of 5G communication technology

Propagation Characteristics of 5G Channel models

References:

1. Chris J, "5G New Radio in Bullets", Paper back, 1st Edition, 2019.
2. Nokia 5G Core eBook - Innovate, execute and pivot to new opportunities
3. Nokia 5G white papers 5G white papers - 5G Massive MIMO Innovations
4. Boosting Spectral, Energy and Site Efficiency
5. 5G Indoor network strategies for small medium enterprises and residences
6. https://onestore.nokia.com/asset/200999?_ga=2.11956852.1970943933.1650955329-1776165991.1650955328
7. 6G Flag ships https://www.oulu.fi/6gflagship/6g-white-paper-localization-sensing
8. https://www.nokia.com/networks/5g/mobile/5g-resources/
9. https://onestore.nokia.com/asset/210692?_ga=2.255171144.1970943933.1650955329-1776165991.1650955328

   *Link: https://onlinecourses.nptel.ac.in/noc22_ee56/preview

ECE xxxx EMBEDDED PROGRAMMING [3 0 0 3]

Total Number of contact hours: 36 hours

Course Learning Outcomes

At the end of the course, the student will be able to:

CLO1	Describe the concepts of embedded programming
CLO2	Discuss the Embedded debugging and development tools.
CLO3	Differentiate the software and hardware architectures
CLO4	Appreciate the embedded operating systems.
CLO5	Program effectively using embedded C.

Basics of Embedded Systems, Embedded Programming Concepts: Role of Infinite loop – Compiling, Linking and locating, Efficient compilation examples – downloading and debugging – Emulator and simulator processors – External peripherals – Memory testing – Flash Memory Operating System: Embedded operating systems – Real time characteristics – Selection process – Flashing the LED – serial ports – code efficiency – Code size – Reducing memory usage – Impact of object oriented programming. Hardware Fundamentals: Buses – DMA – interrupts – Built-ins on the microprocessor – Conventions used on schematics – Microprocessor Architectures – Software Architectures – RTOS Architectures. RTOS Tasks and Task states – System V IPC mechanisms – Memory management – Interrupt routines – Encapsulating semaphore and queues – Hard Real-time scheduling – Power saving. Embedded Software Development Tools– Linkers / Locators for Embedded Software – Debugging techniques – Instruction set simulators Laboratory tools – Practical example – Source code. Case study on Portable computing platforms.

*Self Directed Learning

Embedded C programming

References:

1. Michael Barr, Anthony Massa “Programming Embedded Systems with C and GNU Development Tools”, O’reilly Media , Second edition, Oct, 2006.
2. David E. Simon, “An Embedded Software Primer”, Pearson Education, 2003
3. *Michael Barr, “Programming Embedded Systems in C and C++”, O’Reilly, 2003.
4. Wang K.C., “Embedded and Real-Time Operating Systems”, Springer, 2017.

ECE xxxx SPREAD SPECTRUM COMMUNICATION [3 0 0 3]

Total contact periods: 36 hours

Course Learning Outcomes:

At the end of the program the student will be able to:

CLO1	Describe the principle of spread spectrum and its significance.
CLO2	Analyze and compare direct sequence and frequency hopping techniques.
CLO3	Design PN sequence generators and discuss the properties of PN sequences
CLO4	Analyze and evaluate the performance of direct sequence and frequency hop modulation schemes.
CLO5	Analyze code tracking and synchronization methods.
CLO6	Discuss CDMA and analyze its role in multipath rejection.

Digital modulation and spectral efficiency, direct sequence and frequency hopping spread spectrum principles. PN sequences; Direct sequence spread spectrum system; DS/QPSK system and other advanced schemes; Frequency hopping spread spectrum system. Code acquisition and synchronization. Applications:

References

1. Peterson R. L. and Ziemer R. E., "*Introduction to Spread Spectrum Communication*", PHI, 1995.
2. George R. and Cooper C. D., "*Modern Communications and Spread Spectrum*", McGraw Hill, 2nd Ed, 1986.
3. R. C. Dixon, "*Spread Spectrum Communication*", IEEE press, John Wiley and Sons, 1976.
4. Sklar B, "*Digital Communication Fundamentals and Applications*", Pearson Education, 2001.

ECE xxxx SEMICONDUCTOR DEVICE MODELLING [3 0 0 3]

Total contact periods: **36**
Course Learning Outcomes:
At the end of the program the students will be able to:

CLO1	Describe the basic energy band structure of semiconductors.
CLO2	Analyze the basic of device models and various charge transport model.
CLO3	Describe the PN junction diode and its modelling characteristics.
CLO4	Describe the MOSFET operation and its various second orders parameters for modelling.
CLO5	Classify the different SPICE models and BSIM model.

Energy Bands in Semiconductors. Device modeling basic and charge transport-Basic equations for device analysis, Mobility of carriers, Effect of electric field, temperature, doping and high electric field, Charge transport in SC, drift current, Hall effect, diffusion current, Current density equation, Einstein's relation, PN junction-PN junction under thermal equilibrium, PN junction under applied bias, Static current- voltage characteristics of PN junction, Transient analysis, Injection and transport model. MOSFET structure and operation, short channel effects on MOSFET performance parameters. Second order effects in MOSFET, Effect of Gate voltage on carrier mobility, Effect of Drain voltage on carrier mobility, Channel length modulation, Breakdown and punch through, Subthreshold current, Short channel effects. SPICE, HSPICE, PSPICE, Level 1, Level 2, Level 3, BSIM models-M MOSFET MODELING

References:

1. Nandita DasGupta and Amitava DasGupta, "Semiconductor Devices. Modeling and Technology", PHI, New Delhi, 2004.
2. M.K.Achuthan and K.N. Bhat, "Fundamentals of Semiconductor Devices", Tata McGraw.Hill, New Delhi, 2011.
3. B. G. Streetman and S. Banerjee, "Solid State Electronic Devices", PHI, New Delhi, 2011.
4. Tar Fjeldly, Trond Ytterdal and Michael S. Shur " Introduction to Device Modeling and Circuit Simulation" Wiley-Blackwell, 1997.
5. Giuseppe Massabrio and Paolo Antognetti "Semiconductor Device Modeling with Spice" Tata McHill, 2010.

OPEN ELECTIVES

ECE XXXX CONSUMER ELECTRONICS [3 0 0 3]

Total Number of contact hours: 36

Course Learning Outcomes:

At the end of this course, the student will be able to:

CLO1	Discuss the principles of operation of various audio systems.
CLO2	Describe the working principles of television systems.
CLO3	Analyze the working principles of telecommunication systems.
CLO4	Explain the working of different office electronic gadgets.
CLO5	Discuss the working of different home appliances.

Microphones, headphones and hearing aids, loudspeakers, loudspeaker systems, optical recording and reproduction systems – CDs, DVDs, Blue ray technology, iPods, MP4 players and accessories, home audio systems. Elements of TV communication system, scanning, composite video signal, need for synchronizing and blanking pulses, picture tubes, construction and working of camera tubes, block diagram of TV receiver, LCD, LED and plasma TV fundamentals, block diagram and principles of working of cable TV and DTH. Basics of telephone system, caller ID telephone, intercoms, cordless telephones, cellular mobile systems. Automatic teller machines, facsimile machines, digital diaries, safety and security systems. Digital camera system, microwave ovens, washing machines, air conditioners and refrigerators.

***Self-directed Learning:**

Introduction to Electronics Gadgets

References:

1. S. P. Bali, "Consumer Electronics", Pearson Education, 2005.
2. R. R. Gulati, "Monochrome and Color Television", New Age International Publisher, 2001.
3. A. M. Dhake, "TV and Video Engineering", Tata McGraw-Hill Education, 2001.
4. *Introduction to Electronics Gadgets: https://nptel.ac.in/courses/117102059

ECE XXXX ELECTRONIC PRODUCT DESIGN & PACKAGING [3 0 0 3]

Total number of contact hours: 36
Course Learning Outcomes:
At the end of the course, the student will be able to::

CLO1	Explain the industrial product design steps.
CLO2	Describe the thermal effect on product design.
CLO3	Explain various packaging techniques in product design process.
CLO4	Describe EMI in electronic systems.
CLO5	Discuss noise reduction techniques in electronic products.

Industrial design, product life cycle and reliability, Thermal management, heat transfer methods, heat sink selection, cooling methods in electronic systems, packaging techniques, microelectronics, and packaging technologies, - IC packaging, printed circuit boards, Reliability prediction, and measurement, Noise in electronic systems and EMI, PCB design and layout: system assembly considerations. Sources of EMI, shielding of signal lines, ground loops, noise emission characteristic of SMPS and other power electronic equipment, reduction techniques, reflections, and cross-talk in digital circuits.

* **Self-Directed Learning:** -
Advanced electronic packaging over multilayer PCB

References:

1. Flurshiem C. H. "Industrial design and Engineering", Springer Verilog, 2007.
2. P. Horowitz and W Hill, "The art of electronics", Cambridge, 1995.
3. H. W. Ott, "Noise Reduction Techniques in Electronic Systems", Wiley, 1989.
4. W.C. Bosshart, "Printed Circuit Boards: Design and Technology", Tata *McGraw* Hill, 2000.
5. G.L. Ginsberg, "Printed Circuit Design", McGraw Hill, 1991.
6. https://www.digimat.in/nptel/courses/video/108108031/L01.html Lecture series on electronic systems packaging

ECE XXXX INTRODUCTION TO COMMUNICATION SYSTEMS [3 0 0 3]

Total Number of contact hours: 36
Course Learning Outcomes:
At the end of the course, the student will be able to:

CLO1	Discuss the basic communication system and describe the working of different wireless technologies
CLO2	Describe the principles of optical fiber communication
CLO3	Explain satellite communication system
CLO4	Explain cellular mobile communication systems
CLO5	Describe principles of radar systems

Model of communication systems and types of electronic communication. Telephone system, signaling tones, DTMF. Optical fibers, numerical aperture. Attenuation and dispersion, optical sources and detectors. Principles of satellite orbits and positioning, Earth station technology, multiple access techniques, Application of satellites. Free space optical communications: ATP using FSO and RF. Wireless Communications: Frequency reuse, cell splitting, sectoring, macro cell and micro cell, Architecture of GSM systems. Fundamentals of RADAR systems: Pulse radar, duplexer, MTI Radar. Wireless LAN, PAN, bluetooth, ZigBee, RFID and NFC.

***Self-directed Learning:**
Simulation of basic communication system using MATLAB- Simulink

References:

1. Frenzel L.E.Jr., “Principles of Electronic Communication Systems”, 4th Ed. Mc Graw Hill Education, 2016.
2. Pratt T., “Satellite Communication Systems”, John Wiley and Sons, 2006.
3. Stallings W., “Wireless Communication and Networks”, Pearson Education, 2006.
4. Keiser G., “Optical Fiber Communication”, McGraw Hill, 1991.
5. Kennedy G. and Davis B., “Electronic Communication Systems", Tata McGraw Hill, 1999.

*Self-Learning part: https://www.youtube.com/watch?v=F3slBe2r8vA&list=PLq-Gm0yRYwTgX2FkPVcY6io003-tZd8Ru

ECE XXXX MEMS TECHNOLOGY [3 0 0 3]

Total Number of contact hours: 36
Course Learning Outcomes:
At the end of the course, the student will be able to:

CLO1	Discuss the need for and importance of MEMS
CLO2	Describe the basic processing steps and processing modules for MEMS design.
CLO3	Discuss the design process of variety of micro sensors and actuators.
CLO4	Design and analyze microfluidics drug delivery systems.
CLO5	Analyze coupled domain aspects of Bio-MEMS

Historical background of MEMS. Introduction to Micromachining, Bulk micromachining, surface micromachining, wafer Bonding, LIGA. Transduction and actuation techniques. Micro sensing for MEMS, MEMS Microstructures, Pressure measurement. Basic Bio-MEMS fabrication technologies. Review of RF-based Communication systems, MEMS switches, and Phase shifters**.** Microfluidic devices and components for Bio-MEMS, sensing technologies for Bio-MEMS, chemical and biomedical microsystems, Introduction to MEMS simulation tool, Need of simulation tool, Case studies on MEMS/Biomes microstructure and their applications.

*** Self-directed learning:**
Simulation of various MEMS devices using COMSOL Multiphysics

References:

1. Liu C., Foundations of MEMS, Prentice Hall, 2011.
2. Bao M., Analysis and Design Principles of MEMS Devices, Elsevier Science, 2005.
3. Senturia S.D., Microsystem Design, Springer, 2001.
4. WangW., SoperS.A., Bio-MEMS-Technologies and Applications, CRC Press, 2007.
5. Rebeiz G.M., RF MEMS: Theory, Design, and Technology, John Wiley &Sons, 2003.

*COMSOL (Installed in the Lab)

ECE XXXX INTRODUCTION TO NANOSCIENCE & NANOTECHNOLOGY [3 0 0 3]

Total Number of contact hours: 36

Course Learning Outcomes:

At the end of the course, the student will be able to:

CLO1	Explain the crystal structure and lattice systems
CLO2	Describe the Nanostructures and its transport mechanisms
CLO3	Explain the semiconductor length scales of nanomaterials.
CLO4	Discuss various carbon nanostructures and its properties
CLO5	Describe the various characterization techniques for Nanomaterials and its applications

Crystal structure of common materials – cubic lattice systems, Surface to volume ratio, wave mechanics, Classification of Nano structures, Low dimensional structures, Quantum wells, wires and dots, Semiconductors- length scales –De-Broglie wavelength and exaction Bohr radius – Exaction Bohr radius and binding energies- confinement regimes. Quantum confinement. Carbon Nanostructures – Preparation –Properties and applications; Characterization – SEM, TEM, STM, AFM, RAMAN, XRD, FTIR. Electronic devices, sensors.

***Self-directed Learning:**

References:

1. V. V. Mitin, V.A. Kochelap and M.A. Stroscio , "Introduction to Nanoelectronics: Science, Nanotechnology, Engineering and applications", Cambridge University Press; 1st edition (6 December 2007)
2. M.Kuno, "Introduction to Nanoscience & Technology: a workbook"., CreateSpace Independent Publishing Platform, 2014.
3. Donald A Neamen, "Semiconductor physics and devices Basic principles", McGraw -Hill, 2012
4. C N R Rao, A. Muller, A.K. Cheetham, The Chemistry of Nanomaterials : Synthesis properties and applications , Wiley VCH Verlag Gmbh & Co., Weinheim 2004
5. Kenneth J Klabunde (Eds), Nanoscale Materials Science, JOHN WILEY & SONS INC, 2001
6. G. Cao, Nanostructures and Nanomaterials: Synthesis, properties and applications, Imperial College press 2004.

* https://nptel.ac.in/courses/118104008

Nanostructures and Nanomaterials: Characterization and Properties, IIT Kanpur, Dr. Kantesh Balani, Dr. Anandh Subramaniam

ECE-XXXX BASICS OF BUILDING AUTOMATION SYSTEMS [3 0 0 3]

Total Number of contact hours: 36

Course Learning Outcomes:

At the end of the course, the student will be able to:

CLO1	Explain the concept of intelligent building and BAS.
CLO2	Select the hardware and design of HVAC in building automation system.
CLO3	Discuss the concept of energy management system.
CLO4	Design and implement the safety system
CLO5	Design and integrate the different systems in BAS.

Concept and application of Automation and Management System; Design issues related. HVAC system, Sensors & Transducers. Valves and Actuators, Various Controllers, Energy Management System, Energy Meters, Types, Meter Networking, Monitoring Energy Parameters, Analysis of Power Quality, Energy Conservation, Importance of Energy Saving. Security Systems: Introduction, Access Control – Concept, Generic Model, Components, Types, Features, Card Technologies, Protocols, Controllers, Biometrics, CCTV Cameras, CCD Camera Basics, Traditional CCTV System, Video Recording, Drawbacks, Digital Video, TCP/IP Networking Fundamentals, System Network Load Calculations, Network Design. Integration of Building Management System, Safety System, Security Systems & Video Management.

***Self-directed Learning:**

Energy Management system

References:

1. Shengwei "Wang, Intelligent Buildings and Building Automation", 2009.
2. Reinhold A. Carlson Robert A. Di Giandomenico, "Understanding Building Automation Systems Direct Digital Control, Energy Management, Life Safety, Security Access Control, Lighting,Building,1st edition, R.S. Means Company Ltd, 1991
3. National Joint Apprenticeship & Training Committee, "Building Automation System Integration With Open Protocols: System Integration With Open Protocols". 2009.
4. John I. Levenhagen and Donald H. Spethmann, "HVAC Controls and Systems, Mechanical Engineering", 1992.
5. James E.Brumbaugh, "HVAC fundamentals", Kindle edition, 2007.

*Business Opportunities in the field-Research papers/conference papers

ECE XXXX INTELLIGENT INSTRUMENTATION SYSTEM [3 0 0 3]

Total Number of contact hours: 36

Course Learning Outcomes:

At the end of the course, the student will be able to:

CLO1	Discuss signal conditioning and automation
CLO2	Describe PLC and develop PLC programming for different processes
CLO3	Develop codes for virtual instrumentation and measurement
CLO4	Design and develop intelligent controllers
CLO5	Apply instrumentation system to solve simple problems.

Transducer review; Automation system; Direct Digital Control's Structure and Software. SCADA sensors, Remote terminal units, sensors and actuators; PLC; Virtual instrumentation; LabVIEW; Introduction to intelligent controllers.

***Self-directed Learning:**

Controller design using LabVIEW

References:

1. Krishna Kant, "Computer Based Industrial Control", PHI , 2011
2. Curtis D. Johnson, "Process Control Instrumentation", Pearson Education ,2014
3. D. Patranabis , "Principle of Industrial Instrumentation "MH publications , 2017
4. Patrick H. Garrett, "High performance Instrumentation and Automation", CRC Press, Taylor & Francis Group,2005
5. D. Patranabis , "Sensors and Transducers" -By, PHI Learning Private Limited, 2004.

*https://www.ni.com/en-in/support/downloads/software-products/download.labview.html#460283

ECE XXXX COMPUTATIONAL INTELLIGENCE AND ENVIRONMENTAL SUSTAINABILITY [3 0 0 3]

Total Number of contact hours: 36

Course Learning Outcomes:

At the end of the course, the student will be able to:

CLO1	Explain the various Computational Intelligence Paradigms
CLO2	Discuss the role of Computational Intelligence in Environmental sustainability
CLO3	Describe spatial data representation using QGIS
CLO4	Appreciate Computational Intelligence in time series prediction
CLO5	Discuss implementation of various Computational Intelligence Paradigms

Introduction to Computational Intelligence, Historical views of Computational Intelligence, Evolutionary Computation Concepts, Paradigms and Implementations, Environmental issues and sustainable development, Nexus between technology and sustainable development, Computational Intelligence and GIS, QGIS spatial-and temporal data analysis, Application of Computational Intelligence in Environmental sustainability.

*** Self-directed learning:**

Simulation of various case studies on application of CI in environmental sustainability.

References:

1. A Konar, "An Introduction to Computational Intelligence. In: Computational Intelligence". Springer, Berlin, Heidelberg, 2005
2. Russell C. Eberhart and Dr. Yuhui Shi, "Computational Intelligence", Concepts to Implementation, by Morgan Kaufmann Publishers, An imprint of Elsevier by Elsevier Inc,2007.
3. F. Giudice, G. Rosa, Antonino Risitano, "Product Design for the environment - A life cycle approach", Taylor & Francis 2006, ISBN: 0849327229.
4. Allen D.T and Shonnard D.R, "Sustainable engineering, Concepts, Design and case studies", Pearson publication, 1st edition,2011.
5. Qihao Weng , "An introduction to Contemporary Remote sensing", McGraw-Hill Publication, 2012.

*Research papers on applications of CI in environmental sustainability and simulation using open source tools like Python/MATLAB/Weka .

ECE XXXX APPLICATIONS OF SIGNAL PROCESSING [3 0 0 3]

Total Number of contact hours: 36

Course Learning Outcomes:

At the end of the course, the student will be able to:

CLO1	Understand basics of signals and their classifications.
CLO2	Describe time and frequency domain representation of signals.
CLO3	Explain speech signal and its various applications.
CLO4	Explain image and its various applications.
CLO5	Describe the applications of signal processing in automation, robotics and real-time applications.

Basics of multimodal signals, Types of signals in real time applications, Image perception, Image representation, Image and video processing. Basics of sound Speech and processing, time and frequency domain analysis of speech. An overview of pen computing and processing, applications of gesture recognition. Speech controlled devices for home automation, concepts of real time applications such as Surveillance video processing, face recognition, face tracking.

*Self-directed learning:

Case studies with different domain such as aviation, automation like driver less vehicles, gesture controlled Robots, handwritten data analysis, recommendation systems for digital marketing.

References:

1. R.C. Gonzalez and R.E. Woods, Digital Image Processing, (4e), Pearson Education Inc., 2017.
2. A.K. Jain, Fundamentals of Digital Image Processing, Prentice Hall, 1989, Fourth Indian
3. Rabiner L.R and Schaffer R.W, Digital Processing of Speech Signals, Prentice Hall, NJ, 2007.
4. Thomas F. Quatieri, Discrete. Time Speech Signal Processing—Principles and Practice, Pearson Education, Inc., 2004.

*Introduction to Pen Point (the operating system of the Go computer). Article is from 1992, but the system is way cool

ECE XXXX INTRODUCTION TO BIOSENSORS [3 0 0 3]

Total Number of contact hours: 36
Course Learning Outcomes:
At the end of the course, the student will be able to:

CLO1	Describe the basic principles of bio-sensing and amplification techniques.
CLO2	Explain the working phenomenon of different transduction principles applied in biosensors
CLO3	Describe the basics of the hardware and software requirements for the Electronic Interfaces of Sensor.
CLO4	Describe the steps involved in microfabrication for biosensors.
CLO5	Discuss the material and scale based biosensors.

Biosensor classification, Main elements in biosensors, Bio-recognition Elements in a Biosensor, Principles of Bio-recognition. Biomolecules in biosensors; Detection in biosensors – Electrochemical transducer, Enzyme-based electrochemical biosensors, Iron-Selective Field-Effect Transistor (ISFET), Immunologically Sensitive Field Effect Transistor (IMFET);Data-acquisition systems: Resistors, Diodes, Transistors, Temperature sensors, Wheatstone Bridge, Op-amp, Hardware and Software of Data Acquisition System (DAS); Fabrication: Microfabrication process, Self-assembled Monolayers, Micromachining, Micro fabricated structures for biosensors. Type of biosensors: Nanomaterial based biosensors, Conducting Polymer-based Biosensors, protein based biosensors, DNA based biosensor, Quantum Dot based sensor.

***Self-directed Learning:**
Basic of Sensor fabrication and characterization, electrochemical transducer, optical and Quantum dots, DNA detections.

References:

1. B. D. Malhotra and C.M. Pandey, “Biosensors: Fundamentals and Applications”, Smithers Rapra Publications, 2017.
2. Jeong-Yeol Yoon,"Introduction to Biosensors: From Electric Circuits to Immunosensors " Springer Publications, 2013.
3. Jon Cooper, “Biosensors A Practical Approach”, Oxford University press,2003.
4. Manoj Kumar Ram, Venkat R, Bhethanabolta, “Sensors for chemical and biological Applications”, CRC Press,2017.
5. C.S Kumar, “Nano materials for biosensors”, Wiley – VCH, 1st Edition, 2007.

* Optical Sensors, IIT Roorkee,Prof. Sachin Kumar Srivastava- https://nptel.ac.in/courses/115107122.

* Nanobiotechnology, IIT Roorkee,Dr. R. P. Singh , Dr. Naveen kr. Navani- https://nptel.ac.in/courses/118107015

ECE XXXX MACHINE LEARNING IN VLSI COMPUTER AIDED DESIGN [3 0 0 3]

Total Number of contact hours: 36

Course Learning Outcomes:

At the end of the course, the student will be able to:

CLO1	Describe Preliminary Taxonomy for Machine learning in VLSI CAD and design flow.
CLO2	Explain the concepts of Machine learning for system design and optimization
CLO3	Discuss the steps of high-level synthesis (HLS) and the algorithms pertaining to scheduling.
CLO4	Describe the concepts of Machine learning from limited data in VLSI CAD.

A Preliminary Taxonomy for Machine learning in VLSI CAD, Machine learning taxonomy, VLSI CAD Design flow, Logic synthesis. Graph Theory Introduction to Graph Theory, Control, and data flow graph (CDFG). Graph optimization problems and algorithms, Reduced ordered binary decision diagram (ROBDD), IF THEN ELSE (ITE) algorithm. Machine Learning for system design and optimization- Two level combinational logic synthesis and optimization- Exact and heuristic method. Sequential circuit optimization. Machine learning for system design and optimization algorithms –A synthesis parameter autotuning system for optimizing High performance processors (SynTunSys). High level synthesis (HLS) algorithms. Machine learning from limited data in VLSI CAD, Iterative feature search, Fast Statistical analysis using machine learning. Case Study on Machine learning in VLSI.

***Self-Directed Learning**:

Case Study on Machine learning in VLSI Algorithms.

References:

1. Ibrahim (Abe) N Alfadel, Duane S Boning, Xin Li: Machine learning in VLSI Computer Aided design, Springer, 2019.
2. Giovanni De Michelli ,: Synthesis and Optimisation of Digital Circuits, Tata-McGraw Hill, New Delhi,2008.
3. Gary D. Hachtel, Fabio Somenzi , Logic Synthesis and Verification Algorithm, Kluwer Academic Publication, Boston,2002.
4. M.J.S.Smith , Application Specific ICs, Addison Wesley,2002.

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