School of Electrical Sciences

List of PG Courses

Course Code	Course Title	Credit Structure			
		L	T	P	C
EE 601	Linear Systems Theory	3	0	0	3
EE 602	System Identification and Adaptive Control	3	0	0	3
EE 603	Power and Control Laboratory	0	0	3	2
EE 604	Applied Linear Algebra	3	0	0	3
EE 605	Optimization in Systems and Control	3	0	0	3
EE 606	Nonlinear Control	3	0	0	3
EE 607	AI and Machine Learning	3	0	0	3
EE 608	Optimal and Robust Control	3	0	0	3
EE 610	Power Systems Dynamics & Control	3	0	0	3
EE 611	Modelling and Analysis of Electrical Machines	3	0	0	3
EE 612	Insulation in Power Apparatus and System	3	0	0	3
EE 613	Power Electronic Converters	3	0	0	3
EE 614	Power Electronics Laboratory	0	0	3	2
EE 615	Control of Electrical Drives	3	0	0	3
EE 616	Power Electronics for Renewable Energy Systems	3	0	0	3
EE 617	Wide Area Power System Control	3	0	0	3
EE 618	Smart Grid Technology	3	0	0	3
EE 619	FACTS and HVDC	3	0	0	3
EE 621	Advance Digital Signal Processing	3	0	0	3
EE 622	Electromagnetic Compatibility	3	0	0	3
EE 624	Image Signal Processing	3	0	0	3
EE 627	Wireless Communication	3	0	0	3

EE 628	Random Variables and Stochastic Processes	3	0	0	3
EE 629	Advanced Digital Signal Processing Laboratory	0	0	3	2
EE 630	Introduction to Photonic Integrated Circuits	3	0	0	3
EE 631	Sensors and Actuators: Fabrication and Applications	3	0	0	3
EE 632	Analog Integrated Circuit Design	3	0	0	3
EE 633	VLSI Technology	3	0	0	3
EE 634	Circuits and Systems for Communication	3	0	0	3
EE 635	Digital Integrated Circuit Design	3	0	0	3
EE 637	VLSI CMOS Subsystem Design	3	0	3	4
EE 638	System Design using HDL	3	0	0	3
EE 639	Embedded System Design	3	0	0	3
EE 640	Electrical Discharge Plasma Technology: Basic Concepts & Applications	3	0	0	3
EE 660	VLSI Design Laboratory	0	0	3	2

EE 601 **Linear Systems Theory** **(3-0-0-3)**

Course Contents:

Maths Preliminaries: Vector Spaces, Change of Basis, Similarity Transforms, Introduction: Linearity, Differential equations, Transfer functions, State Space representations, Evolution of State trajectories, Time Invariant and Time Variant Systems, Controller Canonical Form, Transformation to Controller Canonical, State Feedback Design, Discrete-time systems representation, reachability and state feedback design, Observability: Grammian, Lyapunov Equation, Output Energy, Observability matrix Observer canonical form (SO, MO), Unobservable subspace, Luenberger Observer (SO, MO), State Feedback with Leunberger Observers, Minimum order observers, Stabilizability and Detectability, Output feedback and Output Stabilizability, Disturbance Decoupling Problem.

Text Books/References:

1. M. Gopal, Digital Control and State Variable Methods, Tata McGraw-Hill
2. S. Lang, Introduction to Linear Algebra, Springer-Verlag, 2/e, 1997

3. L. A. Zadeh and C. A. Desoer, Linear System Theory: The State Space Approach, Springer-Verlag, 2008
4. C.T. Chen, Linear System Theory and Design, Oxford University Press, 3/e, 1999
5. W. Rugh, Linear System Theory, Prentice Hall, 2/e, 1995
6. W. M. Wonham, Linear Multivariable Control, A Geometric approach, Springer-Verlag, 1985
7. B. Friedland, Control System Design - An Introduction to State-Space Methods, McGraw-Hill

---

EE 602 System Identification and Adaptive Control (3-0-0-3)

Course Contents:

Introduction and overview of Systems Identification, Adaptive Control and Applications. Parameter Estimation: Least Square, Generalized and Recursive Least Square, Estimator properties including error bounds and convergence, MES, ML and MAP estimators, Nonlinear Least Squares. Model Structures and Predictors. Recursive Identification of Linear dynamic systems: RLS, ELS, IV, RML, Stochastic Approximation, Extended Kalman Filter, generalized prediction error framework and its application to ARMA and state models, convergence analysis, Time-varying parameters. Nonlinear System Identification. Adaptive schemes. Adaptive control theory. Applications. Situations when constant Gain feedback is insufficient. Robust control. The adaptive control problem. The model-following problem. MRAS-based on stability theory. Model following when the full state is measurable. Direct MRAS for general linear systems. Prior knowledge in MRAS. MRAS for partially known systems. Use of robust estimation methods in MRAS. The basic idea. Indirect self-tuning regulators. Direct Self-tuning regulators. Linear Quadratic STR. Adaptive Predictive control. Prior knowledge in STR. Linear-in-the-parameters model. Least squares estimation. Experimental conditions. Recursive estimators. Extended least squares. Robust estimation methods (dead zone, projection). Implementation issues. Nonlinear System Identification Techniques.

Text Books/References:

1. K.J. Astrom and B. Wittenmark, Adaptive Control, Pearson
2. L. Ljung, System Identification Theory for the User, Prentice-Hall, 2007
3. K.S. Narendra and A.M. Annaswamy, Stable Adaptive Systems, Prentice-Hall, 1989
4. Miroslav Krsti, Ioannis Kanellakopoulos, and Petar V. Kokotovic, Nonlinear and Adaptive Control Design, Wiley-Interscience, 1995

EE 603 Power and Control Laboratory (0-0-3-2)

Course Contents:

Computer-aided analysis of Power systems, Simulation of FACTS devices, Control of Power electronic converters, Speed control of electrical drives, High-voltage engineering, Solar PV System Characteristics, MPPT Design. DC motor driven closed loop position control system, Position Control System using Synchro, Identification of the model of DC Motor, Compensator Design, Compensator Design for Power System Stabilizer, Position and Speed Control of a DC motor using PD and PID Controller via Ziegler-Nichols tuning method, Discrete-time version of the PID controller, Control of Magnetic Levitation System.

Text Books/References:

1. K. Ogata, Modern Control Engineering,, Pearson Higher Education, 2002
2. I.J. Nagrath, and M. Gopal, Control System Engineering, New Age, 2002
3. P. Kundur, Power System Stability and Control, McGraw Hill Inc, New York, 1995

EE 604 Applied Linear Algebra (3-0-0-3)

Course Contents:

Linear algebraic systems, Linear equations in matrix form, Elementary matrices, Matrix Inversion, Vector Spaces, Span & Linear independence, Basis & dimension, Fundamental Matrix Subspaces, Inner products Inequalities, Inner product space, Orthogonality, Orthogonal basis, QR decomposition, Orthogonal projections, Norms, Vector norms and inequalities, Matrix (Operator) norm and inequalities, Quadratic minimization, Linearity, Linear functions, Linear transformation, Affine transformation & Isometry, Eigenvalues and eigenvectors, Basic properties of Eigenvalue, Eigenvector basis, Invariant subspace, Coupled differential equations, Linear iterative system, Power matrix, Iterative solution to linear system of equation, Computing Eigen values & Eigen vectors, Convergence, Singular value decomposition, Pseudo inverse, Least square, Euclidean norm of a square matrix, Principal component Analysis and Data Compression.

Text Books/References:

1. Strang, Gilbert (2016), Introduction to Linear Algebra (5th ed.), Wellesley-Cambridge Press, ISBN 978-09802327-7-6
2. Hoffman, Kenneth; Kunze, Ray (1971), Linear algebra (2nd ed.), Englewood Cliffs, N.J.: Prentice- Hall, Inc., MR 0276251
3. Meyer, Carl D. (February 15, 2001), Matrix Analysis and Applied Linear Algebra, Society for Industrial and Applied Mathematics (SIAM), ISBN 978-0-89871-454-8 (Free)

4. Olver, Peter J.; Shakiban, Chehrzad (2018), Applied Linear Algebra (2nd ed.), Springer International Publishing, ISBN 978-3-319-91040-6

EE 605 Optimization in Systems and Control (3-0-0-3)

Course Contents:

Concept of space, positive definite matrices, linearity, convex set, convex function Unconstrained optimizations for single and multi-variable problems, Newton step, backtracking line search method Constrained optimization techniques for linear and nonlinear problem, simplex method, active set methods concept of duality, Central path, penalty function, interior point methods Self-Concordant functions and Newton Method Complexity analysis Semidefinite programming, LMI, Evolutionary algorithms, Swarm optimization.

Text Books/References:

1. S. Boyd and L. Vandenberghe, Convex optimization, Cambridge University Press, 2004
2. D. P. Bertsekas, Nonlinear programming, Athena Scientific, 2016
3. D. E. Goldberg, Genetic Algorithms in search, Optimization and Machine Learning, Pearson India, 2002
4. S. Boyd, L. El Ghaoui, E. Feron, V. Balakrishnan, Linear Matrix Inequalities in System and Control Theory, SIAM, 1994

EE 606 Nonlinear Control (3-0-0-3)

Course Contents:

Introduction: state-space representation of dynamical systems, phase-portraits of second order systems, types of equilibrium points: stable/unstable node, stable/unstable focus, saddle; Existence and uniqueness of solutions: Lipschitz continuity, Picard's iteration method, proof of existence and uniqueness theorem, continuous dependence of solutions on initial conditions; Features of nonlinear dynamical systems: multiple disjoint equilibrium points, limit cycles, Bendixson criterion, Poincare-Bendixson criterion; Linearization: linearization around an equilibrium point, validity of linearization: hyperbolic equilibrium points, linearization around a solution; Stability analysis: Lyapunov stability of autonomous systems, Lyapunov theorem of stability, converse theorems of Lyapunov theorem, construction of Lyapunov functions: Krasovskii method and variable gradient method, LaSalle invariance principle, region of attraction, input/output stability of non- autonomous systems, L-stability; Control of nonlinear systems: describing functions method, passivity theorem, small gain theorem, Kalman-Yakubovich-Popov lemma, Aizerman conjecture, circle/Popov criteria, methods of integral quadratic constraints and quadratic differential forms for designing stabilizing linear controllers, multiplier techniques.

Text Books/References:

1. H. K. Khalil, Nonlinear systems, Prentice Hall, 3rd Edn., 2002
2. M. Vidyasagar, Nonlinear systems analysis, 2nd Edn., Society of Industrial and Applied Mathematics, 2002
3. H. Marquez, Nonlinear Control Systems: Analysis and Design, Wiley, 2003
4. A. Isidori, Nonlinear Control Systems, Springer, 3rd Edn., 1995
5. F. Verhulst, Nonlinear Differential Equations and Dynamical Systems, Springer, 1990

EE 607 Artificial Intelligence and Machine Learning (3-0-0-3)

Course Contents:

Concept Learning and General to specific ordering, Concept Learning as search, the inductive learning hypothesis, Decision Tree Learning, Hypothesis space search in decision tree learning. Inferential Statistics: Learn Probability Distribution Functions, Random Variables, Sampling Methods, Central Limit Theorem and more to draw inferences. Linear Regression: Linear regression and predict continuous data values. Supervised Learning: Naive Bayes and Logistic Regression. Unsupervised Learning: Create segments based on similarities using K-Means and Hierarchical clustering. Support Vector Machines: Classification of data points using support vectors. Artificial Neural Networks and Deep Learning: Neural Network representations, appropriate problems for neural network learning, perceptrons, representational power of perceptrons, perceptron training rule, Gradient Descent and Delta rule, Multilayer perceptron and backpropagation algorithm, Recurrent Neural Networks. Layer-by-layer training: Per-layer trained parameters, initialization of further training using contrastive divergence. Genetic Algorithms, Representing Hypotheses, Genetic operators, Population Evolution and schema search, Genetic programming, Models of Evolution and Learning, Parallelizing GAs. Bayesian Learning and Reinforcement Learning. Bayesian Learning: Bayes Theorem and concept of learning, Brute-Force Bayes Concept of Learning, MAP hypothesis and consistent Learners, Maximum Likelihood and Least-squared Error Hypothesis, Bayes Optimal Classifier, GIBBS algorithm, Naïve Bayes classifier, Bayesian Belief Networks, EM algorithm, K Means Algorithm
Introduction to Reinforcement Learning (RL): Understand the basics of RL and its applications in AI. Q-learning: Write Q-learning algorithms to solve complex RL problems.

Text Books/References:

1. Tom M Mitchell, Machine Learning, PHI Learning Pvt. Ltd.-New Delhi, 2015
2. Ethem Alpaydin, Introduction to Machine Learning, The MIT Press, 3rd Edition, 2015

3. R. Duda, P. Hart, and D. Stork. Pattern Classification, 2nd edition, Wiley Interscience, 2001
4. C. M. Bishop. Neural Networks for Pattern Recognition, Oxford University Press, 1995
5. T. Hastie, R. Tibshirani and J. Friedman, Elements of Statistical Learning: Data Mining, Inference and Prediction. Springer-Verlag, 2001

EE 608 **Optimal and Robust Control** **(3-0-0-3)**

Course Contents:

Mathematical preliminaries, Static optimization, Calculus of variations, Solution of general continuous-time optimal control problem, Continuous-time Linear Quadratic Regulator design - Riccati equation, Optimal tracking problem, Free final time problems, Minimum time problem, Constrained input control and Pontryagin's maximum principle, Bang-Bang control, Principle of optimality, Dynamic Programming, Discrete LQR using Dynamic Programming, Continuous control and Hamilton-Bellman-Jacobi Equation.

Text Books/References:

1. D. E. Kirk, Optimal Control Theory: An Introduction, Prentice-Hall, 2004
2. B.D.O. Anderson and J.B. Moore, Optimal Control: Linear Quadratic Methods, Dover Publications, 2014
3. F.L. Lewis, D. Vrabie and V.L. Syrmos, Optimal Control, 3rd edition, Wiley & Sons, 2012

EE 610 **Power Systems Dynamics and Control** **(3-0-0-3)**

Course Contents:

Basic Concepts of dynamical systems and stability. Modelling of power system components for stability studies: generators, transmission lines, excitation and prime mover controllers, flexible AC transmission (FACTS) controllers. Analysis of single-machine and multi-machine systems. Small signal angle instability (low-frequency oscillations): damping and synchronizing torque analysis, eigenvalue analysis, Mitigation using power system stabilizers and supplementary modulation control of FACTS devices. Small signal angle instability (sub-synchronous frequency oscillations): analysis and counter-measures. Transient Instability: Analysis using digital simulation and energy function method. Transient stability controllers. Introduction to Voltage Instability. Analysis of voltage Instability.

Text Books/References:

1. P. Kundur, Power System Stability and Control, McGraw Hill Inc, New York, 1995.
2. P. Sauer & M. A. Pai, Power System Dynamics & Stability, Prentice Hall, 1997.
3. K. R. Padiyar, Power System Dynamics, Stability & Control, Interline Publishers, Bangalore, 1996

EE 611 Modelling and Analysis of Electrical Machines (3-0-0-3)

Course Contents:

Reference Frame Theory – Equations of transformation, commonly used reference frames, variables observed from several frames of reference, transformation between reference frames. Symmetrical Induction Machines – Voltage and torque equations in machine variables, equations of transformation for rotor circuits, voltage and torque equations in arbitrary reference frame variables, commonly used reference frames and analysis of steady-state operation. Permanent-Magnet AC Machines – Voltage and torque equations in machine variables, voltage and torque equations in rotor reference frame variables, analysis of steady-state operation and brushless dc motor. Introduction to design of Electrical Machinery – Machine geometry, stator windings, winding functions, flux linkage and inductances of various windings, lumped parameter magnetic equivalent network, design of radial and axial flux permanent magnet machines, induction motor design, introduction to switched and synchronous reluctance machines, flux reversal and flux switching machines, thermal and stress analysis of machines. Induction Motor and PMAC drives – Volts per Hertz Control, Field oriented control, direct torque control, slip power recovery, voltage source inverter fed PMAC drives, and current regulated inverter fed PMAC drives.

Text Books/References:

1. Analysis of Electric Machinery and Drive Systems, by Paul Krause, Oleg Wasynczuk, Scott Sudhoff and Steven Pekarek, IEEE Press and Wiley Publications
2. The Induction Machine Handbook, by Ion Boldea and Syed A. Nasar, CRC Press, Taylor and Francis Group
3. Brushless Permanent Magnet Motor Design, by Duane C. Hanselman, Magna Physics Publishing
4. Permanent Magnet Motor Technology: Design and Applications, by Jacek F. Gieras, CRC Press, Taylor and Francis Group

---

EE 612 Insulation in Power Apparatus and System (3-0-0-3)

Course Contents:

Introduction to HV engineering course and challenges & opportunities in electric power equipment industry; Insulation engineering: Insulation materials, Stresses on power apparatus insulation & insulation systems of various power apparatus; Fundamentals of Insulation Breakdown: Electrical breakdown in gasses, liquid and solid dielectrics; Stress Control: Principles of stress control, Stress distribution in multiple dielectrics, Stress calculation; Generation of high voltages in laboratory: Generation of High voltage AC by cascading and series resonant system, High DC voltages, Multistage impulse generator circuits, Impulse current generator; Measurement of High Voltages: AC voltage, DC voltage, Impulse voltages; Non-Destructive Insulation Assessment: Schering bridge, Ampere turns bridge, Standard Capacitor, Partial discharge; Testing of Power apparatus: Non-destructive tests to check integrity of insulation of on various power apparatus, Impulse test of transformers.

Text Books/References:

1. Kuffel E., Zaengl W.S. and Kuffel J., High Voltage Engineering Fundamentals, Butterworth- Heineman press, Oxford, 2000
2. M S Naidu & V Kamaraju, High Voltage Engineering, Tata McGraw Hill, 2004
3. Naser E, Fundamentals and Gaseous Ionization and Plasma Electronics, John Wiley & Sons, Inc., New York, 1971
4. A.von Hippel and A. S. Labounsky, Dielectric Materials and Applications, Artech House, Boston, 1995
5. Alston L.L., High Voltage Technology, Oxford University Press, 1968

EE 613 Power Electronic Converters (3-0-0-3)

Course Contents:

Power semiconductor devices, Uncontrolled and controlled AC-DC converters, AC-AC converters, Non- isolated and isolated DC-DC converters, DC-AC converters, Modulation techniques, Harmonic Analysis, Resonant Converters, Multilevel converters, Design aspects of Power electronic converters, Gate drive circuits and Protection.

Text Books/References:

1. N. Mohan, T. M. Undeland, and W. P. Robbins, Power Electronics: Converters, Applications, and Design, John Wiley & Sons, 3rd ed., 2007
2. M. H. Rashid, Power Electronics: Circuits, Devices and Applications, Pearson Education India, 4th ed., 2017
3. R. W. Erickson, D. Maksimovic, Fundamentals of Power Electronics, Kluwer Academic Publishers, 2nd ed., 2001

4. G K Dubey, S R Doradla, A Joshi, and R M K Sinha, Thyristorized Power Controllers, New Age International, 2nd ed., 2012
5. D. G. Holmes and T. A. Lipo, Pulse Width Modulation for Power Converters: Principles and Practice, John Wiley & Sons, 2003

EE 614 Power Electronics Laboratory (0-0-3-2)

Course Contents:

Simulation of power electronic converters: thyristor rectifiers, buck and boost converters, DC-AC converters, PWM gate pulse generation in analog and digital modes, PCB design, Experimental verification of power electronic converters.

Text Books/References:

1. M. H. Rashid, Power Electronics: Circuits, Devices and Applications, Pearson Education India, 4th ed., 2017
2. R. W. Erickson, D. Maksimovic, Fundamentals of Power Electronics, Kluwer Academic Publishers, 2nd ed., 2001

EE 615 Control of Electrical Drives (3-0-0-3)

Course Contents:

Modelling of DC Machines, Phase Controlled DC Motor Drives, Chopper Controlled DC Motor Drives, Modeling of Polyphase Induction Machines, Phase Controlled Motor Drives, Frequency Controlled Induction Motor Drives, Vector Controlled Induction Motor Drives, Permanent Magnet Synchronous and Brushless DC Motor Drive Modeling and Control.

Text Books/References:

1. R. Krishnan, Electric Motor Drives: Modeling, Analysis and Control, Prentice Hall, 2002
2. Mohamed El-Sharkawi, Fundamentals of Electric Drive, CL- Engineering, 1st Edition, 2000

EE 616 Power Electronics for Renewable Energy Systems (3-0-0-3)

Course Contents:

Photovoltaic inverter structures – Inverter structures from H-Bridge Topology (H5, HERIC, FB-ZVR), inverter structure from NPC Topology and Three phase PV inverters, International Regulations for EMC, interconnection of distributed generation, utility interface and anti-islanding requirements. Grid synchronization in single-phase power converters – using Phase-Locked Loop, Phase detection based on In-Quadrature signals, second-order adaptive filter-based PLL, second-order generalized integrator-based PLL. Grid synchronization in three-phase power converters – Synchronous reference frame PLL under unbalanced and distorted grid conditions and decoupled double synchronous reference frame PLL. Islanding detection – Non-detection zone, passive islanding detection methods and active islanding detection methods. Grid converter structures for wind turbine systems – WTS power configurations, single-cell converters, multi-cell (interleaved or cascaded) converters, generator-side control, doubly-fed induction generators and PM synchronous generators for wind turbines. Electric and Plug-In Hybrid EV – Electric, Hybrid Electric and Plug-In Hybrid EV topologies, power electronics for EV and PHEV charging, vehicle-to-grid and vehicle-to-home concepts and power electronics for more electric aircraft.

Text Books/References:

1. Grid Converters for Photovoltaic and Wind Power Systems, by Remus Teodorescu, Marco Liserre and Pedro Rodriguez, IEEE Press and Wiley Publications
2. Power Electronics for Renewable Energy Systems, Transportation and Industrial Applications, by Haitham Abu-Rub, Mariusz Malinowski and Kamal Al-Haddad, IEEE Press and Wiley Publications

---

EE 617 Wide Area Power System Control (3-0-0-3)

Course Contents:

Introduction to Synchrophasor technology: basic architecture and communication requirement; Phasor and frequency estimation; Basic principles for Wide area monitoring and control in real-time; Dynamic modelling of synchronous generator; Transient stability monitoring and control; Small signal monitoring and control; Wide area power system stabilizers; Synchrophasor applications in power system protection and emergency control; Optimal placement of phasor measurement units; State estimation; Real-time monitoring and control of voltage stability.

Text Books/References:

1. A. G. Phadke and J. S. Thorp, Synchronized Phasor Measurements and their Applications, Springer, 2008
2. M. Shadidehpour and Y. Wang, Communication and Control in Electric Power System, Wiley, 2003
3. P. Kundur, Power System Stability and Control, McGraw-Hill, 1995
4. P. M. Anderson and A. A. Fouad, Power System Control and Stability, 2nd Edition, Wiley, 2003
5. Hsiao–Dong Chiang, Direct Methods for Stability Analysis of Electric Power Systems: Theoretical Foundation, BCU Methodologies, and Applications, Wiley, 2011

EE 618 Smart Grid Technology (3-0-0-3)

Course Contents:

Smart grids key characteristics, demand side management, load characteristics, hybrid electric vehicles, energy markets, deregulation, wide area monitoring, protection and control, smart metering, adaptive relaying, power line carrier communication and networking, architectures and standards, renewable energy, distributed generation, smart grids policies.

Text Books/References:

1. Keyhani, Smart Power Grid Renewable Energy Systems, Wiley 2011
2. William H. Kersting, Distribution System Modeling and Analysis, CRC Press, Second Edition, 2004
3. M. A. El-Sharkawi, Electric Energy: An Introduction, CRC Press, 2005

EE 619 FACTS and HVDC (3-0-0-3)

Course Contents:

FACTS: Concept, power flow and stability, basic theory of line compensation, Power Electronic Controllers: Review of PWM voltage source inverters used in FACTS, classifications of FACTS controllers. Static Compensators, Unified Power Flow Controller (UPFC), Stability Analysis: Modeling of FACTS devices, optimization of FACTS, transient and dynamic stability enhancement, Applications: Principle of control of FACTS in HVDC links, coordination of FACTS devices with HVDC links. Advanced FACTS devices, case studies and other applications of FACTS controllers.

Text Books/References:

1. Miller T. J. E., Reactive Power Control in Electric Systems, Wiley-Interscience
2. Hingorani N. G. and Gyugyi L., Understanding FACTS, IEEE Press, Standard Publishers Distributors
3. Padiyar K. R., FACTS Controller in Power Transmission and Distribution, New Age International Private Limited

---

EE 621 **Advance Digital Signal Processing** **(3-0-0-3)**

Course Contents:

Discrete-Time Signals and Systems, Linear Time-Invariant Systems, Representation of sequences by Fourier transforms, The z-Transform, z-Transform properties and ROC, z-Transform Inversion and LTI system, Transform Analysis of Linear Time-Invariant Systems, The Frequency Response of LTI Systems, Minimum-Phase and All-Pass Decomposition, Linear Systems with Generalized Linear Phase, Structures for Discrete-Time System, Block Diagram Representation, Signal Flow Graph Representation, Basic Structures for IIR Systems, Basic Structures for FIR Systems, Finite-Precision Numerical Effects, Sampling of Continuous-Time Signals, Periodic Sampling, Reconstruction of A Bandlimited Signal from Its Samples, Discrete-Time Processing of Continuous-Time Signals, Changing the Sampling Rate Using Discrete-Time Processing, Multirate Signal Processing, Digital Processing of Analog Signals, Oversampling and Noise Shaping In A/D And D/A Conversion, Filter Design Techniques, Design of Discrete-Time IIR Filters from Continuous-Time Filters, Discrete-Time Butterworth, Chebyshev And Elliptic Filters, Frequency Transformations of Lowpass IIR Filters, Design of FIR Filters by Windowing, Optimum Approximations of Fir Filters, The Discrete Fourier Transform, The Discrete Fourier Series (DFS), Properties of the DFS, Sampling the Fourier Transform, Properties of the DFT, Computing Linear Convolution Using the DFT, The Discrete Cosine Transform (DCT), Computation of the Discrete Fourier Transform, Direct Computation of The Discrete Fourier Transform, Decimation-In-Time FFT Algorithms, Decimation-In-Frequency FFT Algorithms, Effects of Finite Register Length, Fourier Analysis of Signals Using the Discrete Fourier Transform, DFT Analysis of Sinusoidal Signals, The Time-Dependent Fourier Transform, Examples of Fourier Analysis of Nonstationary Signals.

Text Books/References:

1. A.V. Oppenheim and Schafer, Discrete Time Signal Processing, Prentice Hall, 2014
2. John G. Proakis and D.G. Manolakis, Digital Signal Processing: Principles, Algorithms and Applications, Prentice Hall, 2014
3. L.R. Rabiner and B. Gold, Theory and Application of Digital Signal Processing, Prentice Hall, 1992
4. J.R. Johnson, Introduction to Digital Signal Processing, Prentice Hall, 1992

EE 622 **Electromagnetic Compatibility** **(3-0-0-3)**

Course Contents:

General introduction and the basic concepts, EMC requirements for electronic systems, Governmental Requirements, Additional Product Requirements, Design Constraints for Products, Advantages of EMC Design, Transmission Lines and Signal Integrity, The Transmission-Line Equations, The Per-Unit-Length Parameters, High-Speed Digital Interconnects and Signal Integrity, Sinusoidal Excitation of the Line and the Phasor Solution, Lumped-Circuit Approximate Models, Non-ideal Behavior of Components, Wires, Printed Circuit Board (PCB), Effect of Component Leads, Resistor, Capacitor, Inductor, Electromechanical Devices, Digital Circuit Devices, Mechanical Switches, Conducted Emissions and Susceptibility, Measurement of Conducted Emissions, Power Supply Filters, Power Supplies, Power Supply and Filter Placement, Conducted Susceptibility, Radiated Emissions and Susceptibility, Simple Emission Models for Wires and PCB Lands, Simple Susceptibility Models for Wires and PCB Lands, Shielding, Shielding Effectiveness, Shielding Effectiveness: Far-Field Sources, Shielding Effectiveness: Near-Field Sources, Low-Frequency, Magnetic Field Shielding, Effect of Apertures, System Design for EMC and ESD, Ground, Printed circuit board , System Configuration and Design, Noise Reduction techniques in electronic systems.

Text Books/References:

1. Clayton R. Paul, Introduction to electromagnetic compatibility, John Wiley and Sons, Inc. 1991
2. Ott. H.W. Noise reduction techniques in Electronic system, 2nd edition, John Wiley Interscience, New York (1988)
3. Laszlo Tihanyi, Electromagnetic Compatibility in Power Electronics, IEEE Press

---

EE 624 **Image Signal Processing** **(3-0-0-3)**

Course Contents:

Imaging Basics: Introduction to Image Processing, Basics of Imaging, Geometric Transformations, Hierarchy of Transformations, Rotational Representation, Homography Computation. Challenges Involving Camera: Basics of Real Aperture Camera, Lens as LSI System, Blur Kernels. Shape from X: Shape from Focus, Generalized Shape from Focus, Depth from Defocus (DFD), and Motion Blur. Image Transforms: Unitary Image Transforms, From 1D to 2D Unitary Transforms, Higher Dimensional Unitary Transforms. 2D Unitary Transforms, 2D Discrete Fourier Transform, 2D Discrete Cosine Transform. Karhunen-Loeve Transform (KLT), Applications of KLT, Singular Value Decomposition. Image Enhancement: Adaptive Thresholding, K-Means Clustering, ISODATA Clustering, Contrast Stretching. Noise Filtering: Non-local Mean Filtering, Impulse Noise Filtering, Noise Filtering in Transform Domain, Illumination Compensation. Image Restoration: Ill-posed Problems, Matrix Conditioning, Matrix Numerical Stability, Inverse Filter for Image Deblurring, Regularization Theory, Minimum Mean Square Error (MMSE) Estimator, Linear MMSE, Spatial Wiener Filter, Wiener filter in Fourier domain, Image Super-resolution, Super-resolution Example.

Text Books/References:

1. Digital Image Processing by Gonzalez and Woods

EE 627 Wireless Communication (3-0-0-3)

Course Contents:

Review of basic linear algebra and probability theory. Overview of cellular standards evolution, wireless propagation and cellular concepts, cellular system capacity, multi-path fading, BER performance in fading channels, diversity, MIMO communications, capacity analysis. Outage capacity for slow fading channels, Ergodic capacity for fast fading channels. Point-to-point communication, Space-time coding, Alamouti Scheme, Coding gain analysis. Spread spectrum communication, CDMA, RAKE receiver, CDMA multi-user detection. 5G MIMO networks, Equalizers, capacity-achieving transceiver design, waveform design, bandwidth efficient modulation for 5G. Channel estimation in 5G, Pilot contamination in massive MIMO. Low complexity channel estimators, Channel hardening and favourable propagation. Impact of spatial channel correlation in massive MIMO. Cell-free massive MIMO, Cloud radio access networks (cRAN) and Open radio access networks (oRANs).

Text Books/References:

1. Wireless Communications, From Fundamentals to Beyond 5G, Andreas F Molisch, 3rd Edition, IEEE Press, 978-1119117209
2. Fundamentals of Wireless Communication, David Tse, P Viswanath, Cambridge University Press. 978-052184527
3. Design and Optimization for 5G Wireless Communications, IEEE Press, 978-1119494553
4. Wireless Communications, Andrea Goldsmith, 978-0521837163

EE 628 Random Variables and Stochastic Processes (3-0-0-3)

Course Contents:

Review of Probability: Distributions, Expectations, Conditioning, Bayes' Theorem, Independence, Random Variables, Bounds: Markov, Chebychev, Chernov. Borel-Cantelli Lemmas. Gaussian Random Variables, Conditioning, Conditional Expectation. Random process and correlation function: Basic concepts. Statistics of stochastic processes. Correlation functions, definition. Properties of The autocorrelation function. Poisson process. Complex process. Definition and properties of cross-correlation function. Correlation coefficient. Correlation function related to a complex random process. Normal process. Stationary random process. Wide-sense stationary process. Random process in the linear system and spectral density: System with stochastic input. Examples: square law detector. Linear time-invariant system. Time Domain analysis of linear system – input/output relationship between correlation functions. Definition of spectral density. Relationship between spectral density and autocorrelation function. Property of spectral density. Cross-spectral density. Existence theorem. Frequency domain analysis of linear systems – input/output relationship between spectral densities. White noise. Hilbert transform of a random process. Wiener-Khinchin theorem. Discrete-time process. Correlation function related to discrete-time random process. Discrete-time linear time-invariant system. Spectral density for the discrete-time process. AR(1) process. Basic application: Random walk and Wiener process. Thermal noise. Shot noise. Modulation, bandlimited process, sampling expansion. Optimum linear system: Systems that maximize signal-to-noise ratio - Matched filter in the presence of white noise and coloured noise. Systems that minimize mean-square error - Smoothing. Orthogonal expansion -Karhunen-Loeve expansion. Ergodicity: Time average. Mean ergodic process, Slutsky's theorem. Discrete-time case. Covariance ergodic process. Distribution ergodic process. Measurement of spectral density, autocorrelation estimate of spectral density, periodogram estimate. Mean square estimation: Estimation using one random variable. Homogeneous linear estimate, non-homogeneous linear estimate, nonlinear estimate. Orthogonality principle. Estimation using multiple random variables. Estimation using a process. Prediction – order 1 Markoff process, prediction using derivative, Prediction using infinite past-continuous case (causal Wiener filter), discrete case, r-step predictor, FIR predictor. Filtering - using a single value, smoothing (non-causal Wiener filter), discrete case. Filtering and prediction - Wiener-Hopf equation, discrete case. Kalman filter, first-order AR case, examples. Markoff process: The continuous-state Markoff process, Chapman-Kolmogorov equation, and Fokker-Planck equation are examples.

Text Books/References:

1. Athanasios Papoulis, (S Unnikrishnan Pillai,) Probability, Random Variables, Stochastic Processes, McGraw-Hill.
2. https://www.probabilitycourse.com/

EE 629 Advanced Digital Signal Processing Laboratory (0-0-3-2)

Course Contents:

Generation of Waveforms (Continuous and Discrete). Verification of Sampling Theorem. Time and Frequency Response of LTI systems (First and second order). Linear Convolution, Circular Convolution and Linear Convolution using Circular Convolution. To find the DFT and IDFT for the given input sequence. Linear convolution using DFT (Overlap-add and Overlap-Save methods). To find the DCT and IDCT for the given input sequence. To find FFT and IFFT for the given input sequence. FIR and IIR filter design using Filter Design Toolbox. FIR Filter (Low-pass, High-pass and Band-pass) design (Window Method). IIR Filter (Low-pass, High-pass and Band-pass) design (Butterworth and Chebychev). Generation of AM, FM & PWM waveforms and their spectrum. Generation of DTMF signals. Study of sampling rate conversion (Decimation, Interpolation, Rational factor). Filtering of noisy signals. Implementation of simple algorithms in audio processing (delay, reverb, flange, etc.). Implementation of simple algorithms in image processing (detection, de-noising, filtering etc.)

Text Books/References:

3. Vinay K. Ingle and John G. Proakis, Digital Signal Processing Using MATLAB, Third Edition
4. A.V. Oppenheim and Schafer, Discrete Time Signal Processing, Prentice Hall, 2014.
5. John G. Proakis and D.G. Manolakis, Digital Signal Processing: Principles, Algorithms And Applications, 4th edition, Prentice Hall, 2007
6. L.R. Rabiner and B. Gold, Theory and Application of Digital Signal Processing, Prentice Hall, 1992
7. The Scientist and Engineer's Guide to Digital Signal Processing, by Steven W. Smith, Ph.D. (http://www.dspguide.com/) Open Source

---

EE 630 Introduction to Photonic Integrated Circuits (3-0-0-3)

Course Contents:

Review of electromagnetic waves, lightwave propagation through waveguides, semiconductor waveguides, passive and active photonic integrated circuit components: waveguide, bend, splitter/combiner, directional coupler, laser, photodiode, etc., design considerations of components and circuits at schematic and layout levels, integrated photonic transceivers: modulators, detectors, non-coherent and coherent systems.

Text Books/References:

1. Lukas Chrostowski, Michael Hochberg, “Silicon Photonics Design: From Devices to Systems,” Cambridge University Press
2. Graham T. Reed, “Silicon Photonics: An Introduction,” John Wiley & Sons Inc
3. Jia-ming Liu, “Photonic Devices,” Cambridge University Press

---

EE 631 Sensors and Actuators: Fabrication and Applications (3-0-0-3)

Course Contents:

Physical Microsensors: Classification of physical sensors- Active and Passive sensors. Sensor Fabrication: Oxidation/Diffusion, Thin Film Deposition Techniques: Chemical Vapor Deposition, Physical Vapor Deposition (Thermal Deposition, E-beam Evaporation, Sputtering, Pulsed Laser Deposition), Basics understanding of Photolithography for pattering layer. Micromachining. Sensor Applications: Various gas sensors: Optical gas sensor, Metal oxide semiconductor gas sensor, Field effect transistor gas sensor, Piezoelectric gas sensor, Polymer gas sensor, Nano-structured based gas sensors. Micro-sensors: Force Sensors, Pressure Sensors, Strain gauges and practical applications. Actuator and its applications: Working principles of Actuators: Piezoelectric and Piezoresistive actuators; microvalve and micropumps with practical applications. Microfluidic device design and pattern transfer techniques (PDMS molding and device bonding techniques). Tutorial: Design, Simulation, Optimization and characterization of various sensors using CoventorWare and COMSOL Multiphysics software.

Text Books/References:

1. Fundamentals of Microfabrication. Marc Madou, CRC Press, 1997.
2. Sensors and Signal Conditioning Wiley-Blackwell, 2008 Jacob Fraden, Handbook of modern sensors, Springer, Stefan Johann Rupitsch.
3. Piezoelectric Sensors and Actuators: Fundamentals and Applications, Springer, 2018 Senturia S. D.
4. Microsystem Design, Kluwer Academic Publisher, 2001 J.D. Plummer, M.D. Deal, P.G. Griffin
5. Silicon VLSI Technology, Pearson Education, 2001 S.M. Sze (Ed)
6. VLSI Technology, 2 Edition, McGraw Hill, 1988

EE 632 Analog Integrated Circuit Design (3-0-0-3)

Course Contents:

Introduction to CMOS analog integrated circuit design. MOS transistor as the basic design unit: device structure, I-V characteristics, second order effects, SPICE models. Basic amplifier topologies: CS, CG, CD, cascode amplifiers. Differential amplifiers: single-ended and differential operation, small signal analysis. Current mirrors: passive and active topologies. Performance parameters of analog circuits: frequency response, noise. Feedback in analog integrated circuits: types of feedback, stability and frequency compensation. Operational amplifiers: topologies, performance parameters. Layout of analog integrated circuits.

Text Books/References:

1. Phillip E. Allen and Douglas R. Holberg, “CMOS Analog Circuit Design,” Oxford University Press
2. Behzad Razavi, “Design Of Analog Cmos Integrated Circuit,” Tata McGraw Hill
3. R. Jacob Baker, Harry W. Li, and David E. Boyce, “CMOS Circuit Design, Layout, and Simulation”, PHI
4. Paul R. Gray, Paul J. Hurst, Stephen H. Lewis, and Robert G. Meyer, “Analysis and Design of Analog Integrated Circuits”, Wiley India

---

EE 633 VLSI Technology (3-0-0-3)

Course Contents:

Introduction: Overview of VLSI. Crystal structure and Single Crystal growth of silicon, Epitaxy, Oxidation, Diffusion, Ion-implantation, Lithography, Dry and Wet Etching, Chemical Vapour Deposition of thin films, Metallization, MOSFET process flow, BJT Process flow, CMOS Technology, BiCMOS Technology, Current trends and challenges.

Text Books/References:

1. S.K. Gandhi, VLSI Fabrication Principles, John Wiley & Sons, 1994
2. S.M. Sze, VLSI Technology, McGraw Hill Education; 2nd edition, 2017
3. M. Madou, Fundamentals of Microfabrication: The Science of Miniaturization, CRC Press; 2nd edition, 2002
4. Stephen D. Senturia, Microsystem Design, Springer, 2005
5. Richard C. Jaeger, Introduction to Microelectronic Fabrication, Pearson, 1988

EE 634 Circuits and Systems for Communication (3-0-0-3)

Course Contents:

Overview of communication systems. Wireless systems: Overview of wireless communication systems, Design considerations-nonlinearity, noise, sensitivity, dynamic range, etc., Review of modulation techniques, Transceivers-Building blocks such as low noise amplifiers, mixers, voltage-controlled oscillators, phase-locked loops, frequency synthesizers, digital synthesis, power amplifiers etc. Broadband systems: Overview of broadband and optical communication systems, Transceivers-Building blocks not covered in wireless systems such as broadband amplifiers, transimpedance amplifiers, clock and data recovery circuits etc. System level integration: Challenges in board level integration, Interconnects and transmission lines, Antennas.

Text Books/References:

1. T. H. Lee, "The Design of CMOS Radio-Frequency Integrated Circuits," Cambridge University Press
2. B. Razavi, "RF Microelectronics," Pearson Education India
3. B. Razavi, "Design of Integrated Circuits for Optical Communications," Wiley India

---

EE 635 Digital Integrated Circuit Design (3-0-0-3)

Course Contents:

Review of MOSFETs: structure, operation, IV characteristics. CMOS inverter: properties, static and dynamic behaviour, power dissipation, optimum sizing. Combinational Circuits: static and dynamic CMOS circuits, complementary CMOS gates, design of CMOS circuit for Boolean expressions, propagation delay, logical effort, path delay optimization, asymmetric and skewed gates, mirror functions, arithmetic circuits. Sequential circuits: types and timing parameters of memory elements, bistable memory elements, design of memory elements. CMOS families: ratioed logic, differential cascode voltage switch logic, pass transistor logic, dynamic logic, etc.

Text Books/References:

1. Jan M. Rabaey, Anantha Chandrakasan, Borivoje Nikolic, “Digital Integrated Circuits: A Design Perspective,” Pearson Education India
2. Neil H E Weste, David Money Harris, and Ayan Banerjee, “CMOS VLSI Design: A Circuits and Systems Perspective,” Pearson Education India
3. Ivan Sutherland, Robert F. Sproull, David Harris, “Logical Effort: Designing Fast CMOS Circuits,” Morgan Kaufmann

---

EE 637 **VLSI CMOS Subsystem Design** **(3-0-4-4)**

Course Contents:

History of VLSI. MOS Transistor Theory: I-V Characteristics, C-V Characteristics, Nonideal I-V Effects (Mobility Degradation, Velocity Saturation, Channel Length Modulation, Threshold Voltage Effects, Leakage Currents, etc.). Transfer Characteristics of Static CMOS Inverter (DC Characteristics, Beta Ratio Effects, Noise Margin). Delay Models: Transient Response, RC Delay Model (Effective Resistance, Gate and Diffusion Capacitance, Equivalent RC Circuits, Transient Response, Elmore Delay), Linear Delay Model (Logical Effort, Parasitic Delay, Delay in a Logic Gate), Logical Effort of Paths (Delay in Multistage Logics, Choosing the Best Number of Stages, Limitations of Logical Effort), Timing Analysis Delay Models (Slope-Based Linear Model, Nonlinear Delay Model). Power Models: Dynamic Power (Activity Factor, Capacitance, Voltage, Frequency), Static Power (Static Power Sources, Power Gating, Multiple Threshold Voltages, Variable Threshold Voltages, Input Vector Control), Energy-Delay Optimization (Minimum Energy, Minimum Energy-Delay Product, Minimum Energy under a Delay Constraint). Combinational Circuit Design: Circuit Families (Static CMOS, Ratioed Circuits, Cascode Voltage Switch Logic, Dynamic Circuits, Pass Transistor Circuits), Subthreshold Circuit Design. Sequential Circuit Design: Sequencing Static Circuits (Sequencing Methods, Maximum Delay Constraints, Minimum Delay Constraints, Time Borrowing, Clock Skew), Circuit Design of Latches and Flip-Flops (Conventional CMOS Latches, Conventional CMOS Flip-Flops, Pulsed Latches, Resettable Latches and Flip-Flops, Enabled Latches and Flip-Flops, Incorporating Logic into Latches). Datapath Subsystems Design: Addition/Subtraction (Single-Bit Addition, CarryPropagate Addition, Subtraction, Multiple-Input Addition, Flagged Prefix Adders), Multiplication (Array Multiplication, Two’s Complement Array Multiplication, Booth Encoding, Fused Multiply and Add, Serial Multiplication), Comparators, Counters, Shift Registers, Code Convertors, Error Detectors and Correctors.

Text Books/References:

1. Neil Weste and David Harris, “CMOS VLSI Design: A Circuits and Systems Perspective”, AddisonWesley Publishing Company, USA, 2010
2. Jan M. Rabaey, “Digital Integrated Circuits: A Design Perspective”, PrenticeHall, Inc., USA
3. SungMo Kang and Yusuf Leblebici, “CMOS Digital Integrated Circuits Analysis & Design”, McGrawHill, Inc., USA, 2002

EE 638 **System Design using HDL** **(3-0-0-3)**

Course Contents:

Review of digital logic design fundamentals. Introduction to hardware description languages. Familiarization of programmable logic devices and gate arrays. Design, simulation, and synthesis of combinational and sequential building blocks of digital systems using hardware description languages and programmable logic devices and gate arrays. Design of floating point arithmetic circuits. State machine techniques for the design of synchronous and asynchronous sequential circuits. Timing analysis of digital systems. Testing of digital systems and design for testability. Case studies of various digital systems for electrical engineering problems.

Text Books/References:

1. Digital Systems Design Using VHDL, Charles H. Roth, Jr and Lizy Kurian John, CENGAGE Learning
2. Fundamentals of Digital Logic with Verilog Design, Stephen D. Brown and Zvonko G Vranesic, Tata McGraw Hill
3. HDL Programming VHDL and Verilog, Nazeih M.Botros, Dreamtech Press
4. VHDL: Programming by Example, Douglas Perry, Tata McGraw Hill

---

EE 639 Embedded System Design (3-0-0-3)

Course Contents:

Review of computer organization and architecture. Microcontrollers: architecture and programming, RISC vs CISC architecture, interrupts, timer/counter, serial communication, pulse width modulation. Embedded system design process. Interfaces: digital and analog interfaces, serial and parallel communication interfaces, memories, drivers, wireless devices, etc. Basics of real-time operating systems. Applications on the Internet of Things, cybersecurity, electric vehicles, robotics, etc.

Text Books/References:

1. A. N. Sloss, D. Symes and C. Wright, “ARM System Developer’s Guide: Design and Optimizing System Software”, Morgan Kaufman Publishers, 2010
2. Alan G. Smith, “Introduction to Arduino: A Piece of Cake”, CreateSpace Independent Publishing Platform, 2011
3. Simon, D.E., “An Embedded Software Primer”, Dorling Kindersley, 2005
4. Michael McRoberts, “Beginning Arduino”, Technology in Action Publications, 2010
5. F. Vahid and T. Givargis, “Embedded System Design: A Unified Hardware/Software Introduction”, Wiley India Pvt. Ltd., 2002
6. W. Wolf, “Computers as Components: Principles of Embedded Computing System Design”, Morgan Kaufman Publishers, 2008
7. Raj Kamal, “Embedded Systems Architecture, Programming and Design”, Tata Mcgraw Hill, 2004

EE 640 Electrical Discharge Plasma Technology: Basic Concepts & Applications (3-0-0-3)

Course Contents:

Introduction to Plasma, Fundamentals of Non-Thermal (NTP)/Atmospheric Pressure Plasma, NTP chemistry and physics, Plasma assisted catalysis in gases and liquid, NTP application in Environment (air pollution & wastewater), Food & agriculture, medicine & biology, Plasma Technology: Challenges and future perspectives, Live Demonstration of experimental analysis using non-thermal plasma assisted techniques.

Text Books/References:

1. Paul K. Chu, Xinpei Lu, “Low-Temperature Plasma Technology”, CRS Press, Taylor & Francis Group, 13: 978-1-4665-0991-7
2. K. H Becker, U Kogelschatz, et al., “Non Equilibrium air plasmas at atmospheric pressure, Institute of Physics”, 0 7503 0962 8
3. Jurgen Meichsner, Martin Schmidt, “Nonthermal plasma chemistry and physics”, CRS Press, Taylor & Francis Group, 13: 978-1-4200-5921-2
4. Xim Tu, J. Christopher Whitehead, et al., “Plasma Catalysis: Fundamentals and Applications”, Springer, 978-3-030-05188-4
5. J. Leon Shohet, “Encyclopedia of Plasma Technology”, CRS Press, Taylor & Francis Group, 13: 978-1-4987-8281-4
6. I Adamovich, S.D. Baalrud, et al., “The 2017 plasma roadmap: Low-temperature plasma science and Technology”, Journal of Physics D: Applied Physics, 50, 2017
7. Annemie Bogaerts, Erik C. Neyts, “Plasma Technology: An emerging Technology for Energy Storage”, ACS Energy Letter, 3, pp. 1013-1027, 2018
8. A. Mizuno, “Recent progress and application of non-thermal plasma”, International journal of Plasma, Environmental Science and Technology, 3(1), pp. 1-7, 2009
9. Dascalescu, “An introduction to ionized gases theory and application”, published by Toyohashi University of Technology, 1993
10. Talebizadeh P., Babaie M., Ristovski Z and Arai M. “The role of non-thermal plasma technique in NOx treatment: A review”, Renewable and sustainable energy reviews, 40, pp. 886-901, 2014

EE 660 VLSI Design Laboratory (0-0-3-2)

Course Contents:

Familiarization of simulation tools for VLSI design and different types of analyses with them – DC operating point analysis, DC sweep analysis, AC analysis, periodic steady-state analysis, noise analysis, etc. Design and simulation of analog integrated circuits: MOS characteristics, single stage and differential amplifiers, and operational amplifiers. Design and simulation of digital integrated circuits: Inverter characteristics, combinational circuits, and sequential circuits. Design and simulation of mixed-signal integrated circuits: comparators and data converters.

Text Books/References:

1. Behzad Razavi, “Design of Analog CMOS Integrated Circuit,” Tata McGraw Hill, ISBN 978-9325983274
2. Jan M. Rabaey, Anantha P. Chandrakasan, and Borivoje Nikolic, “Digital Integrated Circuits,” Englewood Cliffs: Prentice Hall, ISBN 978-9332573925
3. Behzad Razavi, “Principles of Data Conversion System Design,” Wiley-IEEE Press, ISBN 978-0780310933