DEPT OF ECE, NITK SURATHKAL

PhD Course Work

- Eery PhD student has to undergo course work. The courses (generally of the NITK post-graduate (PG) level) are prescribed by the research guide in the relevant area of research.
- The Minimum Course Credit Requirement is 12 (courses carrying 'S'/'N' grades are not be counted).
- The Course work must be completed within the first year of joining the program with a minimum CGPA of 6.0.
- Mandatory Learning Course (MLC): SM900 Research Methodology ((1-1-0)2 credits, S/N grade course).
- Out of 12 credits required, one self-study course (900 level) with a maximum of 4 credits is permitted with recommendation of the DRPC of the department and approval by Dean (A). (DRPC: Doctoral Research Programme Committee).
- The student may also be allowed to enrol pre-approved certified MOOCs towards maximum of 4 credits. Examination to be conducted by the Department for such certified courses to award grades. (MOOC: Massive Open Online Course)
- In the case of Full-time / External registrant sponsored student from industry or other organizations, the minimum of one semester residential requirement may be waived by the DRPC, on case-to-case basis. These students may be allowed to do pre-approved certified MOOCs and also a self-study course, towards 12 credits. Examination will be conducted for such certified courses to award grades by the department. They also need to do a certified Research Methodology course.
- Every PhD student has to qualify the Comprehensive Examination (with 60% marks) and satisfactorily complete the oral examination conducted by the department within one and half years from the date of registration. A maximum of two attempts will be provided to successfully complete the Comprehensive Examination.

List of Courses

EC900 Selected Topics in Advanced VLSI Design (4-0-0)4

Topics from state-of-the-art design methodologies. Architecture, circuit and layout level issues, Timing and Design closure. Deep sub-micron circuit design-logic and layout issues.

Neil Weste and David Harris, "CMOS VLSI Design: A circuits and Systems perspective", 3rd Ed., Addison Wesley, 2004.
RF microelectronics, Behzad Razavi, Prentice Hall, 1998.
William J. Dally, John W. Poulton, "Digital Systems Engineering, "Cambridge University Press 1999.
Yaun Taur and Tak H.Ning, "Fundamentals of modern VLSI devices", Cambridge University Press 1999
Recent publications from IEEE, IEICE and ACM Journals.

EC901 Modeling and Design of High-Speed VLSI Interconnects (4-0-0)4

Detailed study of various problems in modeling and design of high-speed VLSI interconnect at both IC and packaging levels, including device and interconnect modeling, interconnect topology

optimization for delay minimization, wire sizing and device sizing for both delay and performance optimization, and clock network design for high performance systems. Noise issues and reliability

William J. Dally, John W. Poulton, "Digital Systems Engineering, "Cambridge University Press 1999.
Howard Johnson, Martin Graham, "High-Speed Digital Design" A handbook of black magic, "Prentice Hall 1993.
Recent publications from IEEE, IEICE and ACM Journals.

EC902 Integrated Circuits for Communications (4-0-0)4

Analysis and design of electronic circuits for communication systems, with an emphasis on integrated circuits for wireless communication systems. Analysis of distortion in amplifiers with application to radio receiver design. Power amplifier design with application to wireless radio transmitters. Class A, Class B, and Class C power amplifiers. Radio-frequency mixers, oscillators, phase- locked loops, modulators, and demodulators. System integration in single chip/multichip module, system partitioning, high throughput and low latency design requirement for real-time communication, critical path analysis for high-speed VLSI design, design of analog front ends, impedance matching with bonding pads, Si-Ge devices for RF circuits, interface for optical fibres.

The design of CMOS radio-frequency integrated circuits, Thomas H.Lee. Cambridge University Press, 1998.
RF microelectronics, Behzaad Razavi, Prentice Hall, 1998.
Analysis and Design of Integrated Circuits, Paul R Gray, Paul J Hurst, Stephen H. Lewis, Robert G Meyer, Wiley, 2001.
Recent publications from IEEE, IEICE and ACM Journals.

EC903 RF and High-Speed Integrated Circuits (4-0-0)4

Design of RF and high-speed electronic circuits with special attentions to integrated circuits at Both transistor and system levels. Topics include basic RF design concepts, wireless/wireline transceivers, active/passive devices, the physics of noise, amplifiers, low noise amplifiers, mixers, oscillators and phase noise, phase locked loops, frequency synthesizers, clock and data recoveries, and power amplifiers

Thomas H Lee, The Design of CMOS RF IC, Cambridge University Press, 1998.
Razav, RF microelectronics, Prentice Hall, 1998.
Hagen, RF Electronics: Circuits and Applications, Cambridge University Press, 1996.
Gray, Hurst, Lewis, and Meyer, Analysis and Design of Integrated Circuits, Wiley and Sons, 2001.
Van Der Ziel, Noise in Solid-Stage Devices and Circuits, John Wiley and Sons, 1986.
Ott, Noise Reduction Techniques in Electronic Systems, John Wiley and Sons, 1988.
Recent publications from IEEE, IEICE and ACM Journals.

EC904 Advanced Topics in Digital Communications (4-0-0)4

Fading channels, Characterization of Mobile Radio propagation, Signal-time spreading, channel variance, mitigating the degradation effects of fading, fundamentals of statistical detection theory, Baye's theorem, Decision theory, Neyman- Pearson theorem, Multiple hypothesis testing, minimum Baye's risk detection for binary and multiple hypothesis, Orthogonal Frequency Division multiplexing (OFDM), OFDM transmission techniques, synchronization, modulation, demodulation, amplitude limitation of OFDM signals, Space-Time Wireless communications Introduction, Space-Time propagation, Space-Time channel and signal models, spatial diversity, Space-Time OFDM.

J G Proakis, Digital Communications, 4th edition.
H L Van Trees, Detection, Estimation and Modulation Theory, Part I.
T S Rappaport, Wireless Communications " Principles and Practice, 2nd Edition.

EC905 Advanced RF Techniques (4-0-0)4

Planar Transmission Lines-Stripline, microstrip line, suspended stripline and coplanar line; Parallel coupled lines in stripline and microstrip - Analysis, design and characteristics. Microwave Network Analysis - Microwave network representation, Impedance and admittance matrices, Scattering and ABCD parameters, Typical two-port, three port, four port networks. Impedance Matching Techniques - Smith chart, Matching networks using lumped elements, Single and double-stub matching, Quarter wave transformer. Basic Passive Components -Lumped elements in MIC, Discontinuities and resonators in microstrip, Balun, Analysis and design of stripline/microstrip components-Directional couplers, Power divider, Hybrid ring. Basics of MIC, MMIC and MEMS technologies - Substrates used. Fabrication process, and Design techniques. Transistor Amplifiers - Types of amplifiers. S-parameter characterization of transistors; FETs- Equivalent circuit models. Single stage amplifier design-unilateral and bilateral case, Amplifier stability, Constant gain and noise circles, DC bias circuits for amplifiers. Detectors and Mixers - Point contact and Schottky barrier diodes-Characteristics and equivalent circuit, Theory of microwave detection, Detector circuit design. Types of mixers. Mixer theory and characteristics. SSB versus DSB mixers. Single-ended mixer and single-balanced mixer-Design and realization in microstrip. Double balanced and image rejection mixers. Oscillators-Oscillator versus amplifier design, Oscillation conditions. Gunn diode- Modes of operation, Equivalent circuit. Design of Gunn diode oscillator in microstip. FET oscillators. Frequency tuning techniques.

EC906 Selected Topics in Signal Processing (4-0-0)4

Statistical Signal Processing - Autocorrelation and power spectrum, Filtering, Linear estimation, Spectrum estimation, Adaptive filters. Multirate Systems – Multirate operations, Filter banks, PR systems, Tree structured and cosine modulated filter banks. Wavelet analysis – Localization and uncertainty, Orthogonal wavelets, biorthogonal wavelets, Block transforms, frames, approximation and denoising in frames. Sparse signal processing – Sparsity and redundant dictionaries, Matching pursuits.

Sophocles J. Orfanidis, Optimum Signal Processing: An Introduction, McGraw-Hill, 2007.
P.P. Vaidyanathan, Multirate Systems and Filter Banks, Pearson Education India, 2006.
Stephane Mallat, A Wavelet Tour of Signal Processing - The Sparse Way, AP, 2009.
Jelena K., Vivek K Goyal, and Martin Vetterli, Fourier and Wavelet Signal Processing, EPFL Press, 2013.

EC907 Multi-dimensional Signal Processing (4-0-0)4

Speech Fundamentals, Perception and Production, Analysis, Lossless and Perceptually lossless compression, Recognition, Speaker recognition and identification, Image Fundamentals, Transforms, Segmentation, Restoration, Enhancement, Compression standards, Medical Imaging Video analysis, MPEG standard of coding, Segmentation and tracking. Biometrics.

Anil K Jain, Fundamentals of Digital Image Processing, PHI, 2010 R.C.Gonzalez and R.E.Woods, Digital Image Processing, Pearson, 2008.
Douglas O'Shaughnessy, Speech Communication, Human and Machine, IEEE Press, 1999.
L.R. Rabiner and R.W. Schafer, Digital Processing of speech signals, Prentice Hall, 2013 Fundamentals of Medical Imaging, Paul Suetens, Cambridge Press, 2009.

EC908 Selected Topics in Computer Communication Networks (4-0-0)4

Introduction to network resilience problems & solutions, Wireless beyond 3G, Performance modeling of (Wireless) networks & Formal Methods, Network design algorithms and Network design using Network Processors, Wireless Ad- hoc Networks, Security Issues in control, Management, routing and other areas of networks, Distributed control in Wireless network and Middleware, Distributed Mobile Computing, Embedded Systems in Mobile/ Wireless/ Network Systems – Hardware & Software Design/ Development issues, Standardization in Wireless / Mobile Network Systems. Wireless Sensor Networks & Protocol, Queuing Theory in Networking, Network Management

Feng & Leonidas, Wireless Sensor Networks, Elsevier India, 2005.

Kumar D. Manjunath and J. Kuri Communication Networking, An analytical approach, Elsevier, 2004
Subramanian M., Network Management: Principles and Practice, Addson – Wesley, 2000
Burke J., Network Management Concepts and Practice, A Hands- On Approach, Pearson Education, 2000.

EC909 Selected Topics in Radar Signal Processing (4-0-0)4

Elements of a Radar, statistical models of radar cross section (RCS), probability density functions (PDFs) for RCS, RCS Correlation, Swerling models, range and Doppler ambiguities, Radar waveforms, Matched filter for continuous waveforms, Matched filtering for moving targets, ambiguity functions of single pulse and pulse burst of waveforms, The Linear FM (LFM) Waveform, Vector matched filter, Tracking principles, Detection principles, Space time adaptive processing (STAP).

Mark A Richards, Fundamentals of Radar Signal Processing, Tata McGraw Hill, 2005.
Nadav Levanon, Radar Signals, Wiley-IEEE Press, 2004.
L. I Skolnik (ed), Radar Hand Book, McGraw Hill Publication, 1990.

EC910 Selected Topics in Analog and Mixed Signal Integrated Circuits (4-0-0)4

Trade-offs in mixed signal design, Data converters and Switched Capacitor circuits, Calibration and Digital error correction.

R. Jakob Beker, CMOS: Mixed Signal Circuit Design, 2nd Ed., Wiley-IEEE, 2009.
Behzad Razavi, Principles of Data Conversion System Design, Chand & Company Ltd (IEEE Press), 2000.
Gabriele Manganaro, Advanced Data Converters, Cambridge Univ. Press, 2012.
Mingliang (Michael) Liu, Demystifying Switched capacitor Circuits, Elsevier, 2006.
Analog Devices Inc. (edited by Walt Kester), The Data Conversion Handbook, Newnes, 2005.

EC911 Mathematical Methods for Signal Processing and Communication Engg (4-0-0)4

Selected Topics in Vector spaces: Vectors, Vector norms, vector algebra, subspaces, basis vectors, Gramm-Schmidt orthonormalization. Matrices, matrix rank, matrix norms, determinant, inverse, condition number. Hermitian and symmetric matrices, positive definite matrices unitary matrices, projection matrices and other special matrices. LDU decomposition, QR decomposition, Eigenvalue decomposition, singular value decomposition. Solving linear system of equations using matrices. Least-Squares approach, total least squares approach. Numerical issues. Perturbation theory of matrices. Differentiation of scalar functions of vectors and matrices. Matrix functions of scalar variables, Kronecker product of matrices.
Analysis: Review of real and complex number systems, topology of metric spaces. Continuity and differentiability. Construction of the Lebesgue measure, measurable functions, limit theorems. Lebesgue integration. Different notions of convergence and convergence theorems. Product measures and Fubini's theorem. Signed measure and the Radon- Nikodym theorem, change of variables.
Optimization Techniques: Need for unconstrained methods in solving constrained problems. Necessary conditions of unconstrained optimization, structure of methods, quadratic models. Methods of line search, Armijo-Goldstein and Wolfe conditions for partial line search. Global convergence theorem, steepest descent method. Linear and Quadratic Programming. Duality in optimization.
Stochastic Models: Review of Random variables, Stochastic processes, Markov chains, stationary distribution of Markov chains, Poisson and birth and death processes.

Todd K Moon, Striling, "Mathematical Methods and Algorithms for Signal Processing, Prentice Hall, 2000.
Stephen Boyd, Lieven Vandenberghe, Convex Optimization, Cambridge University Press Ross S.M, Introduction to Probability Models, Academic Press and Hardcourt Asia, 2000.
Rudin, W., Principles of Mathematical Analysis, McGraw-Hill, 1986.

EC912 Advanced Coding Techniques for Wireless and Storage Systems (4-0-0)4

Need for error control codes in wireless and storage systems application, Alternate decoding algorithms for Reed-Solomon codes, Derivations of Welsch-Berlekamp Key equation and methods of solving, Guruswami-Sudan decoding algorithm and soft RS decoding, VLSI architecture for RS and BCH codes, Construction of LDPC codes, Tanner graphs, Hard decision decoding, Iterative decoding, EXIT charts for LDPC codes, Correction of erasures, Irregular LDPC construction, Construction and decoding of Repeat-Accumulate codes, Quasi-Cyclic LDPC, Construction of LDPC codes based on finite fields and finite geometries, Error floors and trapping sets, Fountain codes, VLSI architecture for binary LDPC codes, Turbo code encoders, Turbo decoding algorithms: MAP, BCJR, SOVA; Error floor and weight distribution, EXIT chart analysis, Hardware architecture for Turbo codes, Polar Codes: Channel polarization (N=2, and N > 2 channels), Theorems for Polar coding theory, Design rules for Polar codes, Systematic encoding of Polar codes, List decoding and LLR-based successive cancellation decoding of Polar codes, Hardware realization and throughput analysis, Applications.

Todd K. Moon, "Error Correction Coding: Mathematical Methods and Algorithms", Second Edition, John Wiley & Sons, 2020.
William Ryan, and Shu Lin, "Channel Codes: Classical and Modern", Cambridge University Press, 2009.
Shu Lin, and Juane Li, "Fundamentals of Classical and Modern Error-Correcting Codes", Cambridge University Press, Nov 2021.
Xinmiao Zhang, "VLSI Architectures for Modern Error-Correcting Codes", CRC Press, 2016.

EC913 Machine Learning for Signal Processing (4-0-0)4

Introduction to real world signals - text, speech, image, video. Feature extraction and dimensionality reduction – principal components, linear discriminants. Decision theory for pattern recognition, ML and MAP methods, Bias-variance tradeoff, model assessment, cross-validation, estimating generalization error. Generative modelling and density estimation - Gaussian and mixture Gaussian models, kernel density estimators, hidden Markov models. Expectation Maximization.
Linear regression and kernel methods. Regularization methods. Discriminative modelling - support vector machines, decision trees and random forest classifiers, bagging and boosting. Neural networks: gradient descent optimization and back propagation, regularization in neural networks, dropout. normalization methods. Introduction to deep learning - feedforward, convolutional and recurrent networks, practical considerations in deep learning. Introduction to graphical models - directed and undirected graphs, belief propagation.

Deep Learning: Methods and Applications, Li Deng, Microsoft Technical Report.
Automatic Speech Recognition - Deep learning approach - D. Yu, L. Deng, Springer, 2014.
Machine Learning for Audio, Image and Video Analysis, F. Camastra, Vinciarelli, Springer, 2007.

EC914 Algorithms for Satellite Image Processing (4-0-0)4

Introduction: Digital image formation, digital image display mechanism, image histograms, look up table data. Physics of Remote Sensing: Sources of Energy, Active and Passive Radiation, electromagnetic Radiation - Reflectance, Transmission, Absorption, Thermal Emissions, Interaction with Atmosphere, Atmospheric windows, Spectral reflectance of Earth's surface features, **Platforms and Sensors:** Various types of platforms, different types of aircraft, manned and unmanned spacecrafts used for data acquisition - characteristics of different types of platforms airborne and spaceborne, IRS Satellite Sensors, LANDSAT, SPOT, IKONOS, Quickbird, Geoeye, Kompsat, Worldview II & III etc. **Data Acquisition Systems**: Optical, Thermal and Microwave; Resolutions - spatial, spectral, radiometric and temporal, signal to noise ratio, **Satellite Image Enhancement:** Pre-processing– Atmospheric, Radiometric, Geometric Corrections – Basic Principles of Visual Interpretation, Ground Truth, Orthorectification, Spatial Domain enchantment: Linear and non-linear
Contrast enhancement techniques, density slicing, pseudo colour images, convolution filtering, spectral enhancement techniques, data dehazy, data fusion techniques, advance methods.
Satellite Image Segmentation- Thresholding, Mean-shift, Watershed, Edge detection, Clustering, Minimum description length(MDL); Spectral indices- Vegetation indices, water related indices, indices

related to cloud properties, deep learning methods, **Classification Techniques**: Supervised Classification, Training set - Statistical computation, understanding feature space & scatter plots, signature purity & separability, Signature Baye's decision rule, nonparametric & parametric classification techniques, minimum distance rule, Parallelepiped algorithm, maximum like-hood method, unsupervised and hybrid classification techniques, classification analysis - confusion matrix, error analysis & kappa coefficient, Analysis of Multi-Temporal series and change detection; **Advanced classification techniques:** Learning methods, Object, Texture, Object based Fuzzy, Machine and Deep learning classification techniques, Google Earth Engine platform for satellite data processing

John R Jensen, Introductory Digital Image Processing, Prentice Hall, New Jersey, 2004.
Robert G Reeves, Manual of Remote Sensing Vol. I & II, American Society of Photogrammetry, Falls Church, USA, 1983.
Florence Tupin, Jordi Inglada and Jean-Marie Nicolas, Remote Sensing Imagery, ISTE and Wiley, 2014.
Nello Cristiani and John Shawe Taylor., An Introduction to Support Vector Machines, Cambridge University Press, 2000.
Machine Learning for Audio, Image and Video Analysis, F. Camastra, Vinciarelli, Springer, 2007.