M.TECH – COMMUNICATION ENGINEERING AND SIGNAL PROCESSING

Department of Electronics and Communication Engineering

Communication Engineering and Signal processing applications have been rapidly growing and evolving over the past few years. Ubiquitous communication is becoming a necessity for the society. The proposed M.Tech. Program is designed to offer not only in-depth theoretical knowledge in the areas of Communication Engineering, Signal Processing, and Wireless Networks, but also system modeling and integration aspects emphasizing overall system behavioral studies in a laboratory. Such courses are unique and fall in-line with the requirements from the industries. At the end of the programme the student would acquire the ability to identify pressing research issues and research directions in Communications, Signal Processing, and Wireless Networks.

CURRICULUM

First Semester

Course Code	Type	Course	L	T	P	Cr
16MA602	FC	Mathematical Methods for Communication Systems	3	0	1	4
16CE601	FC	Signal Processing	3	0	1	4
16CE602	SC	Coding Theory	3	0	0	3
16CE603	SC	Digital Communication	3	0	0	3
16CE604	SC	RF Circuits and Systems	3	0	0	3
16HU601	HU	Cultural Education*				P/F
					Credits	17

***Non-credit course**

Second Semester

Course Code	Type	Course	L	T	P	Cr
16CE605	FC	Estimation and Detection Theory	3	0	0	3
16CE606	SC	Stochastic Signal Processing	3	0	1	4
16CE607	SC	Wireless Communication Theory	3	0	1	4
16CE608	SC	Modeling and Simulation of Communication Systems	2	0	2	4
	E	Elective I	3	0	0	3
16CE611	SC	Communication Systems Lab	0	0	2	2
16CE797	P	Research Methodology	0	0	2	2
16EN600	HU	Technical Writing*				P/F
					Credits	22

***Non-credit course**

Third Semester

Course Code	Type	Course	L	T	P	Cr
	E	Elective II	3	0	0	3
	E	Elective III	3	0	0	3
16CE798	P	Dissertation				8
16CE612	SC	Live in lab/open lab	0	0	1	1
				Credits		15

Fourth Semester

Course Code	Type	Course	L	T	P	Cr
16CE799	P	Dissertation				12
				Credits		12
					Total Credits	**66**

List of Courses

Foundation Core

Course Code	Course	L	T	P	Cr
16MA602	Mathematical Methods For Communication Systems	3	0	1	4
16CE601	Signal Processing	3	0	1	4
16CE605	Estimation and Detection Theory	3	0	0	3

Subject Core

Course Code	Course	L	T	P	Cr
16CE602	Coding Theory	3	0	0	3
16CE603	Digital Communication	3	0	0	3
16CE604	RF Circuits and Systems	3	0	0	3
16CE606	Stochastic Signal Processing	3	0	1	4
16CE607	Wireless Communication Theory	3	0	1	4
16CE608	Modeling and Simulation of Communication Systems	2	0	2	4
16CE611	Communication Systems Lab	0	0	2	2
16CE612	Live in lab/open lab	0	0	1	1

Electives

Course Code	Course	L	T	P	Cr
16CE701	Millimeter Wave Communication Systems	3	0	0	3
16CE702	Multi User Detection	3	0	0	3
16CE703	Multicarrier Communications	3	0	0	3
16CE704	Optical Wireless Communications	3	0	0	3
16CE705	Microwave Integrated Circuits	3	0	0	3
16CE706	Security for Wireless Communications	3	0	0	3
16CE707	Software Defined Radio	3	0	0	3
16CE708	Wireless Networks and Protocols	3	0	0	3
16CE709	Radar Systems	3	0	0	3
16CE710	RF Transceiver System Design	3	0	0	3
16CE711	Satellite Communication System Design	3	0	0	3
16CE712	Multirate Signal Processing for Communication Systems	3	0	0	3
16CE713	Array Signal Processing	3	0	0	3
16CE714	Image Analysis and Pattern Recognition	3	0	0	3
16CE715	Image and Video Processing	3	0	0	3
16CE716	Machine Learning	3	0	0	3
16CE717	Speech and Audio Processing	3	0	0	3
16CE718	Multimedia Processing and Coding	3	0	0	3

16CE719	Hyper Spectral Image Processing and Analysis	3	0	0	3
16CE720	Signal Processing for Machine Fault Diagnosis	3	0	0	3
16CE721	Convex Optimization	3	0	0	3

Project Work

Course Code	Course	L	T	P	Cr
16CE797	Research Methodology	0	0	2	2
16CE798	Dissertation				08
16CE799	Dissertation				12

16MA602 MATHEMATICAL METHODS FOR COMMUNICATION SYSTEMS 3-0-1-4

Objectives:

- To bridge the gap between introductory signal processing and communication classes and the mathematics
- To provide a unified applied treatment of fundamental mathematics, seasoned with demonstrations using standard tools
- To develop contemporary techniques for applications in the diverse areas like communications, system identification, information theory, artificial intelligence, pattern recognition, image analysis and data acquisition

Keywords:
Vector Spaces, Matrix Decompositions, Optimization, Random Process

Contents:
Matrices and vectors-inverse and transpose-vector spaces-subspaces – linear independence – basis and dimension – orthogonal vectors and subspaces – matrix decompositions – QR decomposition - Singular value decomposition – Eigen values – Eigen vectors – Diagonalization of matrix- Introduction to Optimization - linear optimization – unconstrained optimization – constrained optimization – nonlinear optimization. Introduction to Probability concepts- Two dimensional jointly distributed random variables- stochastic random variables- convergence and limit theorems- multi variant probability distribution covariance and regression models. Bayesian methods of estimation - Random process - power spectrum - discrete time process - spectrum estimation - Markov chains introduction.

Outcome:

- The approach of how to think about practical problems by investigating from different perspectives and to understand that there is usually more than one way to approach a problem
- Develop competency in application of mathematical methods in problems arising in communication and signal processing

TEXT BOOKS / REFERENCES:

1. Gilbert Strang, *Linear Algebra and its Applications*, Fourth Edition, Cambridge University Press. 2009.
2. Todd K. Moon and Wynn C. Sterling, *Mathematical Methods and Algorithms for Signal Processing*, PHI, 2000.
3. C. Bender and S. Orszag, *Advanced Mathematical Methods for Scientists and Engineers*, Springer, 1998.
4. Papoulis. A and S.U. Pillai, *Probability Random Variables and Stochastic Processes*, Fourth Edition, Mc Graw Hill, 2002.

16CE601 SIGNAL PROCESSING 3-0-1-4

Objectives:

- To bring the students coming with different backgrounds to a common minimum level of understanding of signal processing, systems, time, frequency and time-frequency transformation techniques

- To Provide required input to learn Stochastic Signal Processing

Keywords:
Transform processing, Filters, Multi-rate signal processing, Wavelet transform

Contents:
Review of signal processing and digital filters - Introduction to Transforms: DFT- DCT- KL Transforms– Walsh Transforms- Properties of DFT – FFT- Introduction to multi-rate digital signal processing – the effect of up-sampling and down sampling of the signal – applications of multi-rate signal processing – sub-band coding-Significance of joint time-frequency domains-Short Time Fourier Transform (STFT),Continuous wavelet transforms (CWT) – DWT – Time-frequency tiling - Scaling and Wavelet Functions – Filter Banks- Selected applications of signal processing with case studies (Ex: signal coding, feature extraction, introduction to synthesis and signal enhancement etc)

Outcome:
- To make the students confident in programming and experiment with various signal processing algorithms
- To make them do a term work on a selected application of signal processing. Students are encouraged to take the term work based on research papers on topics not discussed in class but related to topics discussed in class

TEXT BOOKS / REFERENCES:

1. John G Proakis and Dimitris.G.Manolakis, *Digital Signal Processing, Principles, Algorithms, Applications*, Fifth Edition, Prentice Hall India Incorporation, 2003.
2. N. Ahmed and K. R. Rao, *Orthogonal Transforms for Digital Signal Processing*, Springer,1975.
3. Soman K. P. and Ramachandran K. I, *Insight into Wavelets from Theory to Practice*,Prentice Hall, 2004.
4. Raghuveer M Rao and Ajit S Bopardikar, *Wavelet Transforms*, Addison Wesley, 1998.

16CE602 CODING THEORY 3-0-0-3

Objectives:
- To enable the students to understand the properties, encoding and decoding techniques of various error control codes
- To introduce the state-of-the-art error control codes

Keywords:
Minimum distance, Block codes, Interleaver, Performance analysis, Tanner graphs

Contents:
Computations using Galois field arithmetic – Review of Linear Block codes– BCH codes: Code construction– Decoding of BCH codes - Interleaved codes - Cyclic Product codes - Reed Solomon codes: Encoding and Decoding - Trellises for Linear Block Codes - Optimum decoding of Convolutional codes: Soft Output Viterbi algorithm (SOVA), BCJR algorithm - single level and multilevel concatenated codes-Turbo codes: Design and properties of Turbo

codes, Iterative decoding of Turbo codes - LDPC codes: Construction of LDPC codes, Bit flipping, Sum product and Min sum decoding algorithms - Polar codes: Properties– Encoding and Decoding of polar codes.

Outcome:

- Ability to select codes, implementation of encoding and decoding algorithms and analysis of the performance of codes for various applications

TEXT BOOKS / REFERENCES:

1. Shu Lin and Daniel J.Costello, *Error Control Coding – Fundamentals and Applications*, Second Edition, Prentice-Hall, 2004.
2. Tom Richardson and Rudiger Urbanke, *Modern Coding Theory*, Cambridge University Press, 2008.
3. Richard E. Blahut, *Algebraic Codes for Data Transmission*, Cambridge University Press, 2003.
4. Richard B. Wells, *Applied Coding and Information Theory for Engineer*, Pearson Education, LPE, First Indian Reprint, 2004.
5. W.C. Huffman and V. Pless, *Fundamentals of Error-Correcting Code*, Cambridge, 2003.

16CE603 DIGITAL COMMUNICATION 3-0-0-3

Objectives:

- To understand the design of spectrally and power efficient modulation techniques in existing and evolving communication systems
- To analyze error performance of a digital communication system in presence of noise and other interferences
- To understand the implementation issues with respect to carrier and symbol synchronization

Keywords:

Digital modulation techniques, Orthogonal signals, Bit error rate, Outage probability, Carrier and Symbol Synchronization

Contents:

Review of digital communication systems, modulation techniques– Advanced Digital Modulation and Detection-Baseband and Pass band modulation techniques, Phase Shift Keying (MPSK) – Quadrature Amplitude Modulation (MQAM), GSK- GMSK- Continuous-Phase FSK (CPFSK)-Decision Regions and the Maximum Likelihood Decision Criterion - Performance of Digital Modulation over Wireless Channels-AWGN Channels Signal-to-Noise Power Ratio and Bit/Symbol Energy, Error Probability for BPSK and QPSK - Error Probability for MPSK- Error Probability for MPAM and MQAM - Error Probability for FSK and CPFSK, fading outage probability. Carrier and Symbol Synchronization - Signal Parameter Estimation, Carrier Phase Estimation, Symbol timing Estimation.

Outcome:

- Ability to design power efficient and spectral efficient modulation and demodulation techniques accounting for various issues
- Helps in rapid prototyping of communication system addressing real-time issues like phase offset and symbol synchronization

TEXT BOOKS / REFERENCES:

1. John Proakis and Masoud Salehi, *Digital Communications*, Fifth Edition, McGraw-Hill Publications, 2007.
2. Simon S Haykins, *Digital Communication Systems*, Wiley Publication, 2013.
3 Robert G. Gallager, *Principles of Digital Communication*, Second Edition, Cambridge University Press, 2012.
4. Andrea Goldsmith, *Wireless Communications*, Cambridge University Press, 2006

16CE604 RF CIRCUITS AND SYSTEMS 3-0-0-3

Objectives:

- To motivate and create expertise in the design aspect of radio frequency circuits and systems for wireless communication industry with minimal emphasis on electro magnetics
- To study and understand the RF front-end systems, motivate for exploring the research and project opportunities
- To create manpower in the area of advanced wireless communications systems in strategic applications

Keywords:
Chip resisters, Coaxial, Stripline, Quarter-wave, Scattering parameter, Smith chart, RF Filter, Antenna, Active RF circuits, GPS, DTH, DBS

Contents:

RF behavior of passive components – Transmission line equation – Lossless transmission line model – Microstrip and Stripline transmission lines – Terminated lossless Transmission lines – Special Termination conditions – Sourced and loaded Transmission lines – Smith chart representation and calculations – Scattering parameters – Practical measurements – Network Analyser –RF Filter design – Filter realization – Implementation – Examples of microstrip filter design – Impedance matching networks - Microstrip matching networks – RF noise characterization – Signal to noise ratio – Noise figure - RF Amplifier Design – Classes of operation and efficiency – Power gains – Stability circles – Constant gain – examples of low noise amplifier design –system aspects of power amplifiers, mixers and local oscillators - Microstrip antenna radiation principles – Types of patch antennas – Examples of antenna design using electromagnetic simulation tools – Radio receiver and transmitter architectures, comparison of tuned, direct conversion and heterodyne receivers – Functional descriptions of Global Positioning Systems (GPS) - Direct broadcasting satellite systems (DBS) - Radio Frequency Identification (RFID) - Typical Radio Frequency Front-ends for various applications.

Outcome:

- Understanding the basic design principles of radio frequency components and systems leading to the design of wireless communication systems
- Enable expertise in the area of RF front-end design for strategic applications
- Motivating to pursue research and development activities in the RF systems area

TEXT BOOKS / REFERENCES:

1. Ludwig R and Bogdanov G, *RF Circuit Design, Theory and Applications*, Second Edition, Pearson Education Inc, 2013.
2. Pozar D M, *Microwave Engineering*, Third Edition, John Wiley and Sons Pvt Ltd, 2007.
3. Cheng D K, *Field and Wave Electromagnetics*, Second Edition, Pearson Education Inc, 2008.
4. Behzad Razavi, *RF Microelectronics*, Pearson, 2014.

16CE605 ESTIMATION AND DETECTION THEORY 3-0-0-3

Objectives:

- To introduce the properties and performance of optimal estimators for signal parameters
- To introduce statistical techniques for detection of deterministic and random signals

Keywords:
MVUE, MMSE, Suboptimal estimators, Baye's risk, Binary hypothesis, Multiple hypothesis

Contents:

Fundamentals of Estimation Theory Cramer-Rao Lower Bound– Linear Modeling– Estimation Techniques - Least Squares Estimation– Recursive Least Squares Estimation– Best Linear Unbiased Estimation, Likelihood and Maximum Likelihood Estimation - Bayesian Philosophy– Maximum a Posteriori Estimation –Fundamentals of Detection Theory - Hypothesis Testing -Baye's Detection, MAP Detection, ML Detection, Minimum Probability of Error Criterion– Min-Max Criterion, Neyman-Pearson Criterion - Detection of Signals in White Gaussian Noise (WGN) - Detection of signals with Random Parameters.

Outcome:

- Ability in finding optimal estimators for signal parameters in various applications
- Ability in detecting deterministic and random signals in various applications

TEXT BOOKS / REFERENCES:

1. Steven M. Kay, *Statistical Signal Processing: Vol. 1: Estimation Theory, Vol. 2: Detection Theory*, Prentice Hall Inc., 1998.
2. Harry L. Van Trees, *Detection, Estimation and Modulation Theory, Part 1 and 2*, John Wiley and Sons Inc. 1968.
3. Monson H. Hayes, *Statistical Digital Signal Processing and Modeling*, John Wiley and Sons Inc., 1996.
4. H.Vincent Poor, *An Introduction to Signal Detection and Estimation*, Second Edition, Springer, 1994.

16CE606 STOCHASTIC SIGNAL PROCESSING 3-0-1-4

Objectives:

- To extend the understanding of signal processing to statistical signal processing and stochastic modeling of signals
- Learn a few applications on its use

- Experiment these algorithms in lab and deepen the understanding of the algorithms

Keywords:
Stochastic modeling of signals, Gaussian mixture models, Signal enhancement, Hidden Markov models

Contents:
Introduction to statistical signal processing – Random variables-random process-statistical parameters-stationary- white noise- power spectrum–filtering random process- Linear signal models- parametric and non parametric models - Optimum linear filters – Least squares filtering and prediction- Adaptive filters-Principles of adaptive filters - Least squares adaptive filters - Wiener filters - Dynamic adaptive filtering-Kalman filters - noise suppression- Particle filtering - Theory and applications of Statistical modeling of signals – Case studies (Eg: signal representations – coding and synthesis of signals - dynamic time warping – Introduction to Gaussian mixture models and hidden Markov models - feature extraction – environmental robustness – signal enhancement)– recent advances in statistical modeling of signals.

Outcome:
- To help the students understand statistical algorithms used in signal processing and modeling
- Experiment the algorithms for the development of practical systems
- Experimental verification of selected topic within the purview of the course, but not part of the regular experiments

TEXT BOOKS / REFERENCES:

1. Dimitris G Manolakis, Vinay K Ingle and Stephen M Kogon, *Statistical and Adaptive Signal Processing*, McGraw-Hill, Singapore, 2000.
2. Monson H. Hayes, *Statistical Digital Signal Processing and Modeling,* John Wiley and Sons Inc., 1996.
3. Don H Johnson, *Statistical Signal Processing*, Lecture Notes, Rice University, 2013.
4. Joseph Mariani (Ed), *Language and Speech Processing*, Wiley, 2009
5. Xuedong Huang, Alex Acero and Xiao-Wuen Hon, *Spoken Language Processing – A Guide to Theory, Algorithm, and System Development*, Prentice Hall, 2001.

16CE607 WIRELESS COMMUNICATION THEORY 3-0-1-4

Objectives:
- To understand the wireless communication channel model
- To understand multiple access technique used in cellular communication for optimal resource utilization is discussed

Keywords:
Fading channel, AWGN, Multiple Access, Diversity, Multiplexing, Multicarrier

Contents:
Wireless Channel Models- Path loss and Shadowing models– Statistical fading models– Narrow band and wideband fading models– Rayleigh fading channels– Ricean model; Mobile radio channel –large scale fading– small scale fading– power budget of mobile links, Doppler spread and coherent time– delay spread and coherent bandwidth–, flat

fading and frequency selective fading; Interference and Capacity calculation of wireless channels- Capacity of flat and frequency selective fading channels. Multiple Access and Diversity Techniques- frequency division multiple access (FDMA) - time division multiple access (TDMA) - code division multiple access (CDMA) - space division multiple access (SDMA); Diversity and multiplexing gains, Time diversity– frequency diversity and space diversity– Multiuser techniques; Introduction to OFDM (multicarrier system) and MIMO based radio system– performance in respect of BER– capacity of OFDM and MIMO. Principle of cellular system design with a case study on 2G, wireless/mobile communication standards of 3G and 4G.

Outcome:

- Ability to design communication systems comprehending channel impairments
- Ability to identify challenges in evolving communication technology and design systems conforming to industry standards

TEXT BOOKS / REFERENCES:

1. Andrea Goldsmith, *Wireless Communications*, Cambridge University Press, 2006.
2. T.S. Rappaport, *Wireless Communication Principles and Practice*, PHI, 2002.
3. Simon Haykin and Michael Moher, *Modern Wireless Communications*, Pearson Education, 2007.
4. G.L Stuber, *Principles of Mobile Communications*, Second Edition, Kluwer Academic Publishers, 2001.
5. David Tse and Pramod Vishwanath, *Fundamentals of Wireless Communication*, Cambridge University Press, July 2005.

16CE608 MODELING AND SIMULATION OF COMMUNICATION SYSTEMS 2-0-2-4

Objectives:

- To comprehend system aspects of modern communication systems through modeling and simulation
- To analyze and predict the behavior of broadband and high data rate intractable communication systems

Keywords:

Power efficiency, Spectral efficiency, System behavior predictions, Baseband simulation, Channel models

Contents:

Introduction, evolution of communication systems in terms spectral efficiency– challenges in design and optimization– overview of deterministic and stochastic simulations– tractable and intractable systems– role of simulations for link budgeting– implementation and behavior predictions —simulation methodology—basic steps and aspects of simulation—simulation errors due to sampling and quantization– choice of simulation sampling frequency—baseband representation of linear and non-linear band pass signals and systems– time varying systems—modeling of system building blocks such as filters, linear and nonlinear amplifiers with internal noise, modeling oscillator phase noise —simulation of random process and noise sources—post processing of data and waveforms– generation of eye-diagrams– spectrum and scatter-plots—BER simulations using monte carlo techniques—introduction to simulation of nonlinear and time varying systems—models of waveform channels– guided and unguided channels, radio channels, multi-path– and fading channel—introduction to discrete channel

models—case studies of simulation of M-PSK systems with amplitude and phase noise– simulation of power amplifier nonlinearity for CDMA- simulation of OFDM systems.

Outcome:

- Enable students to be industry ready Engineers and Researchers
- Enable students to do calculations and tradeoffs of various subsystem parameters
- Enable students to do modeling and simulations of complex intractable systems with non-linearities

TEXT BOOKS / REFERENCES:

1. W. H. Tranter, K. S. Shanmugan, T. S. Rappaport and K. L. Kosbar, *Principles of Communication Systems Simulation with Wireless Applications*, Prentice Hall, 2003.
2. G. Rubino and B. Tuffin, *Rare Event Simulation Using Monte Carlo Methods*, John Wiley and Sons, 2009.
3. M. Schiff, *Introduction to Communication Systems Simulation*, Artech House, 2006.
4. C. B. Rorabaugh, *Simulating Wireless Communication Systems: Practical Models in C*, Prentice Hall, 2004.

16CE611 COMMUNICATION SYSTEMS LAB 0-0-2-2

1. EM tools based simulations (Microstripline design, Rectangular microstrip antenna design and Planar Filter design).
2. Horn and Dish antenna based experiments (X Band).
3. GNU radio and USRP based experiments.
4. 1D and 2D filter design using Xilinx/Vivado system generator.

16CE612 OPEN LABORATORY / LIVE-IN LAB 0-0-1-1

Objectives:

- To introduce an opportunity for the students to carryout independent research culminated to a practical setup or demonstration of a conceived idea
- To engage and utilize the existing facilities / tools in full form in order to extract its full potentials
- To design, develop and realize new experiments for the program, including practical manuals
- To introduce the students to provide technical solutions for real world problems and develop proto-type systems through Live-In labs

Contents:

Selection of lab /tool / domain. Evaluation of proposed concept and its requirements / Timeline. Final evaluation of the proposal and demonstration of the proposed system. Evaluation of the manual / report / accuracy and importance. Review on Patentability / Publication potentials on the system. Evaluation components (Campus specific): Review team to evaluate (one time) the authenticity of the project / Lab experiment options/ utilization of existing lab tools / manual preparation / demonstration of hardware/software.

Outcome:

- Enable the students' potentials to realize a proto-type system
- New experiments utilizing the full potential of the lab facilities for future students
- Improve the confidence and understanding for students and teachers of the concepts in practical aspects
- Drastic improvements will be visible in the approach of major projects
- Students will be engaged fully in laboratories and other establishments

16CE797 RESEARCH METHODOLOGY 0-0-2-2

Objectives:

- To learn and practice the literature survey aspects of projects and prepare the scope and goals for the proposed project
- To learn, practice and improve the research presentation skills and with latest tools
- To learn and understand the research publication ethics and tools
- To learn, practice and use document preparation tools – LaTeX

Keywords:
Plagiarism, Seminar, LaTeX, Journal, Ethics, Scopus, Science Citation, Web of science, Thomson Reuters, H-index

Contents:
Logical thinking, approach towards analytical probing – defining problems – perceptive views of conclusions (refer the following document or website). Selection of project domain – allocation of project supervisor/ Mentor. Publication ethics– Tools and evaluation. Basic components of a research paper – procedures and processes. Journal types– Scopus– web of science– Thomson Reuters– Science Citation Index, H-index– Google citations. Selection of tentative project area and process of literature survey – Literature survey components and procedures. Presentation of selected project proposal – Oral presentation. Preparation of a report on the selected project proposal in LaTeX format. Evaluation components (Campus specific): Attending special invited lectures– practical orientation in searching and collecting literature through library– online tools– presenting a seminar on selected project proposal– and submitting project report prepared using LaTeX.

Outcome:

- Enable the student potentials to organize, coordinate and focus the research aptitude with confidence
- Improve the awareness on indexing, quality evaluation and author index of publications
- Improve the presentation skills through seminars
- Expertise in LaTeX tool for report preparation

TEXT BOOKS/REFERENCES:
www.csus.edu/indiv/d/**dowden**b/4/**logical-reasoning**.pdf

16EN600 TECHNICAL WRITING P/F

(Non-credit Course)

Technical terms – Definitions – extended definitions – grammar checks – error detection – punctuation – spelling and number rules – tone and style – pre-writing techniques – Online

and offline library resources – citing references – plagiarism – Graphical representation – documentation styles – instruction manuals – information brochures – research papers – proposals – reports (dissertation, project reports etc.)

TEXTBOOKS/REFERENCES:

1. H.L. Hirsch, *Essential Communication Strategies for Scientists, Engineers and Technology Professionals*, Second Edition, New York: IEEE Press, 2002.
2. P.V. Anderson, *Technical Communication: A Reader-Centered Approach*, Sixth Edition, Cengage Learning India Pvt. Ltd., New Delhi, 2008, (Reprint 2010).
3. W.Jr. Strunk and E.B.White, *The Elements of Style*, New York. Alliyan & Bacon, 1999.

16CE701 MILLIMETER WAVE COMMUNICATION SYSTEMS 3-0-0-3

Objectives:

- To understand the channel behavior in mm wave communication systems
- To develop mathematical theory and engineering practice of wireless communication in higher frequency of mm wave
- To understand diversity and interpretation of capacity calculations
- To learn the transceiver architecture in mm wave communication range
- To understand beam steering and beam forming techniques in multi antenna array

Keywords:
Millimeter wave, 60GHz, MIMO, Diversity

Contents:
Millimeter Wave (MMW) characteristics - 60 GHz MMW Case Study and Technical Challenges - Channel performance at 60 GHz - ITU Indoor Path Loss Model - Log Distance Path Loss Model - Link Budget- Development of MMW standards - Coexistence With Wireless Backhaul. Modulation Schemes for MMW communications- PSK - OFDM. MMW Transceiver architecture- MMW Antennas- Path Loss and Antenna Directivity - Antenna Beam width - Beam steering Antenna- Need for MIMO – Channel Capacity of SISO and MIMO Systems - Water-filling algorithm- Spatial Diversity of Antenna Arrays - Multiple Antennas - Multiple Transceivers - Noise Coupling in a MIMO System - Potential Benefits of Advanced Diversity for MMW- Spatial And Temporal Diversity - Spatial and Frequency Diversity - Dynamic Spatial, Frequency and Modulation Allocation - Advanced Beam steering and Beam forming -The Need for Beam steering/Beam forming.

Outcome:

- Improve the confidence in mathematical modeling and understanding of different mm wave channel models
- The ability to apply knowledge of design processes in higher frequency band of mm wave
- The ability to understand and design of mm Wave transceiver
- The ability to generate innovative design to fulfill new requirements particularly in the field of wireless communications at higher frequency in mm wave

TEXT BOOKS / REFERENCES:

1. Kao- Cheng Huang and Zhoacheng Wang, *Millimeter Wave Communication Systems*, Wiley IEEE Press, 2011.

2. Theodore S. Rappaport, Robert W. Heath Jr, Robert C. Daniels and James N. Murdock, *Millimeter Wave Wireless Communication*, Prentice Hall, 2014.
3. John S. Seybold, *Introduction to RF Propagation*, John Wiley and Sons, 2005.
4. Chia-Chin Chong, Kiyoshi Hamaguchi, Peter F. M. Smulders and Su-Khiong, *Millimeter-Wave* Wireless *Communication Systems*: *Theory and Applications*, Hindawi Publishing Corporation, 2007.

16CE702 MULTI USER DETECTION 3-0-0-3

Objectives:

- To understand different access technology
- To develop mathematical theory and engineering practice of wireless communications for different access schemes and multiuser scenario
- To learn analysis and design of multi-user techniques for communication
- To understand optimum detection principle in multiple user environment

Keywords:
Multiple Access, CDMA, Multiuser Detection, Single user, MMSE

Contents:
Introduction - multiple access communications – Code division multiple access (CDMA) channel- Basic synchronous CDMA - asynchronous CDMA- Discrete Time synchronous model, Discrete Time asynchronous model- Single User Matched filter – matched filter in the CDMA channel– probability of error for synchronous users– probability of error for asynchronous users- asymptotic multi user efficiency and related measures - Optimum multiuser detection- synchronous two user– K user multiuser detection– asynchronous two user, K user multiuser detection - Multiuser Performance Measures– Multi-user Efficiency (MUE)-Asymptotic Multiuser Efficiency (AME) - near-far resistance (NFR) - Principles of optimal multiuser detection definitions of optimality, probability of error determination– ML detection - Principles of linear multiuser detection: conventional– decorrelator– MMSE detection - Adaptive multiuser detection– Blind Multiuser detection - Principles of nonlinear multiuser detection: successive cancellation– multistage detection– decision feedback.

Outcome:

- The ability to apply the knowledge of design of access techniques in communications
- The ability to apply knowledge of design processes in multiuser detection scenario
- The ability to generate innovative designs to fulfill new needs, particularly in the fields of mobile/wireless communication systems
- The ability to identify the necessary networks for different applications

TEXT BOOKS / REFERENCES:
1. Sergio Verdu, *Multiuser Detection*, Cambridge University Press, 1998.
2. Andrew J. Viterbi, *CDMA Systems: Principles of Spread Spectrum Communication*, Addison Wesley, 1995.
3. Henk Wymeersch, *Iterative Receiver Design*, Cambridge University Press, 2007.
4. J. G. Proakis, *Digital Communications*, Fifth Edition, McGraw Hill, 2007.

16CE703 MULTICARRIER COMMUNICATIONS 3-0-0-3

Objectives:

- To develop mathematical theory and engineering practice of digital communications over fading channels
- To learn multi channel/carrier techniques for fading wireless channels and mobile radios
- To learn analysis and design of multi-channel techniques for communication
- To understand the synchronization issues in multicarrier environment
- To understand the challenges in the design of such multicarrier systems

Keywords:
Multicarrier communications, OFDM, MIMO, Synchronizations, PAPR

Contents:
Introduction- High Rate Wireless Applications - Single-Carrier vs. Multi-Carrier Transmission - Introduction to OFDM - Basic Principle of OFDM - Modeling of OFDM for Time-Varying Random Channel- Appropriate Channel Model for OFDM Systems - Impairments of Wireless Channels to OFDM Signals - Application to Millimeter-Wave Radio Channels -Coded OFDM - Multiple Access Extensions of OFDM– Multiband OFDM- MIMO OFDM -Performance Optimization - Channel Partitioning - Synchronization - Timing Offset Estimation - Frequency Offset Estimation -Synchronization in Cellular Systems-Channel Estimation - Pilot Structure - Training Symbol-Based Channel Estimation - DFT-Based Channel Estimation - Decision-Directed Channel Estimation -PAPR Reduction- Inter-Cell Interference Mitigation Techniques

Outcome:
- The ability to apply knowledge of design processes in multicarrier systems
- To generate innovative designs to fulfill new needs, particularly in the fields of broadband networks and mobile/wireless communication systems
- The ability to analyze the performance of multicarrier system in wireless cellular systems

TEXT BOOKS / REFERENCES:

1. Ye (Geoffrey) Li and Gordon L. Stuber, *Orthogonal Frequency Division Multiplexing for Wireless Communications*, Springer, 2006.
2. Ramjee Prasad, *OFDM for Wireless Communications Systems*, Artech House, 2004
3. Bahai, Saltzberg and Ergen, *Multi-Carrier Digital Communications, Theory and Applications of OFDM*, Second Edition, Springer, 2004.
4. Henrik Schulze and Christian Lueders, *Theory and Applications of OFDM and CDMA Wideband Wireless Communications*, John Wiley and Sons, 2005.

16CE704 OPTICAL WIRELESS COMMUNICATIONS 3-0-0-3

Objective:
- To understand the concepts of optical wireless communications and its unexplored applications
- To understand the basic components and design of transceiver
- To understand the optical wireless channel model and link characteristics

Keywords:
Optical Wireless Communications, Infrared, Visible Light Communications, Optical Channel Characteristics

Contents:

Introduction: A Brief History of OWC, Fundamental principles of OWC- Spectrum of interest, characteristics of THz spectrum and channel- Technology Overview- Application areas, System/link Configurations- Safety and regulations- Comparative study with RF- Challenges in OWC- basic components.Optical Sources- Detectors and channel characterization: Light Sources- Light-Emitting Diode, The Laser, Photo detectors - Photo detection Techniques, Photo detection Noise- Characterization of OWC: Characterization of transmitter (emitter)- types of optical modulation- Optical Channel Model and characterization- Noise sources- atmospheric effect, SNR analysis, BER performance.
OWC transmitter & receiver design: Transmitter Design Considerations, Transmitter design issue, driver design- Automatic Power Control- Receiver Design Considerations- Photo detection in Reverse-biased Diodes- Choosing the Photo detector- Front end amplifier- Receiver Noise Consideration- Bit Error Rate and Sensitivity- Bandwidth- Signal Amplification Techniques; Terrestrial free space optics communication, Emerging visible light communications- Research challenges.

Outcome:

- Students will able to understand the basic components of optical wireless communication
- They will able to analyze and understand the optical wireless channel and able to analyze the performance measures
- The students will able to design optoelectronics transceivers for optical wireless communication

TEXT BOOKS / REFERENCES:

1. Z Ghassemblooy, W Popoola and S Rajbhandari, *Optical Wireless Communications: Sysetm and Channel Modelling with MATLAB*, CRC Press, 2012.
2. Rober Ramirez-Iniquez, Sevia M, Idrus, and Ziran Sun, *Optical Communications: IR for Wireless Connectivity*, CRC Press, 2008.
3.Devi Chadha, *Terrestrial Optical Wireless Communication*, McGraw Hill Professional, 2013.
4. Olivier Bouchet, *Wireless Optical Telecommunications*, John Wiley and Sons, 2013.

16CE705 MICROWAVE INTEGRATED CIRCUITS 3-0-0-3

Objectives:

- To understand the principle of microwave components and circuits in integrated form
- To study the design principles of various components used in microwave IC design
- To study the concepts of high frequency integrated systems used for wireless systems

Keywords:
Nonlinearity, Low Noise Amplifier, Mixers, Oscillators, Phase locked loop, Transceiver

Contents:
Basic concept of wave propagation, Transmission lines, Planar circuits and analytical methods – Microwave passive and active diodes – Bipolar transistors – GaAs MESFETs – High Electron Mobility Transistors – Materials used for IC and fabrication flow – Amplifiers – Oscillators – Mixers – Digital modulators and phase shifters – Microwave radio systems – Broadcast systems – Device and circuit measurement systems – Dielectric and magnetic materials – CAD for microwave Integrated Circuits – Circuit simulation – Device modeling for circuit simulation – Parameter extraction

Outcome:

- Able to design basic components of microwave systems in a given tool
- Able to design a microwave system for a given application
- Able to understand the necessary requirements for microwave integrated circuits

TEXT BOOKS / REFERENCES:

1. Yoshihiro Konishi, *Microwave Integrated Circuits*, Marcel Dekker Inc, 1991.
2. Davis W. Alan and Van Nostrand Reinhold, *Microwave Semiconductor Circuit Design*, 1984.
3. Gonzalez G, *Microwave Transistor Amplifier: Analysis and Design*, Prentice Hall, 1984.

16CE706 SECURITY FOR WIRELESS COMMUNICATIONS 3-0-0-3

Objectives:

- To introduce the key concepts and analytical models of physical layer security in both single-user and multi-user communication systems
- To apply signal processing techniques to design physical layer security enhancements

Keywords:

MIMO, OFDMA, LDPC, Security key, Wireless Networks

Contents:

Fundamentals of Physical Layer Security - Information-Theoretic Secrecy Metrics – Secret Communication Over Noisy Channels - Wiretap Channel Model - Coding Mechanisms for Secret Communication - Coding for Wiretap Channels –Polar and LDPC Codes for the Gaussian Wiretap Channel - Coding for Security - Asymptotic Analysis - Key Generation From Wireless Channels- Information Theoretic Models for Key Generation - Basic Approaches for Key Generation - A Joint Source-Channel Key Agreement Protocol - Key Agreement techniques - Secrecy With Feedback - Achieving Secrecy through Discussion and Jamming. MIMO Signal Processing Algorithms for Enhanced Physical Layer Security - Secrecy Performance Metrics -Physical Layer Security in OFDMA Networks -Power Allocation Law for Secrecy - Multiple Eavesdroppers - Resource Allocation for Physical Layer Security in OFDMA Networks- Application of Cooperative Transmissions to Secrecy Communications. Game Theory for Physical Layer Security on Interference Channels. Non-Cooperative Games in Strategic Form -Cooperative Solutions - Stochastic Geometry Approaches to Secrecy in Large Wireless Networks.

Outcome:

- Develop skills to use the tools from game theory and graph theory to analyze and design wireless networks with physical layer security considerations
- Able to explore issues and solutions in providing physical layer security in practical wireless systems

TEXT BOOKS / REFERENCES:

1. Xiangyun Zhou, Lingyang Song and Yan Zhang, *Physical Layer Security in Wireless Communications*, CRC Press, 2013.
2. Lidong Chen and Guang Gong, *Communication System Security*, Chapman and Hall/CRC, 2012.

16CE707 SOFTWARE DEFINED RADIO 3-0-0-3

Objectives:

- To understand software radio design and implement Multirate DSP, RF front-ends, direct digital synthesis of modulated waveforms, A/D and D/A conversion
- To appreciate performance improvement with the help of smart antennas and other adaptive array algorithms

Keywords:
Direct Digital Synthesis, Antennas, Resolution, A/D Converters, FPGA, ASICS

Contents:
Introduction to software-defined radio - Review of telecommunication concepts and systems - Analog and Digital Communication System - Front-end RF system - Link Budgets, noise, C/N and S/N ratios - Digital filtering - Signal recovery - Baseband and Band pass Sampling - Complete SDR systems - Future trends in SDR. Multirate signal processing - Sample Rate conversion principles - Efficient Structures for Decimation and Interpolation Filters – Polyphase filters – Digital Filters Banks– Arbitrary sampling rate conversion – CIC Filter - Analog to Digital and Digital to Analog converters for SDR. Hardware and Software Architecture for SDR: Universal Software Radio Peripheral, bladeRF, RTL-SDR, HackRF, WebSDR

Outcome:

- Ability to use programmable DSP to implement software radio for wireless systems and sub-systems
- Ability to appreciate the design flexibility in software defined radios by using software tools
- To take up some case studies under SDR Forum

TEXT BOOKS / REFERENCES:

1. Jeffrey H Reed, *Software Radio: A Modern Approach to Radio Engineering*, Prentice Hall PTR, 2002.
2. Johnson, C.R. and W.A. Sethares, *Telecommunication Breakdown: Concepts of Communication Transmitted via Software-Defined Radio*, Pearson Prentice Hall, 2004.
3. Tony J. Rouphael, *RF and Digital Signal Processing for Software-Defined Radio: A Multi-Standard Multi-Mode Approach*, Elsevier Inc., 2009.
4. Walter Tuttlebee, *Software Defined Radio: Origins, Drivers and International Perspectives*, John Wiley and Sons Ltd, 2002.

16CE708 WIRELESS NETWORKS AND PROTOCOLS 3-0-0-3

Objectives:

- Aims at providing insight and knowledge about architectures and protocols for mobile and wireless communication. Topics ranging from physical layer to application layer in the mobile and wireless networking fields are covered
- To understand the concept of wireless networks and protocol
- To develop mathematical theory and engineering practice in wireless networks such as WLAN
- To learn the existing standards of WLAN and associated technologies
- To understand and compare the performance of networking environment in wired and wireless networks

Keywords:
WLAN, 802.11, Protocols, MAC Layer, AdHoc Netowrks, ZigBee

Contents:
Introduction to Wireless Networks and Protocols: Wireless networks, History, Standards and market issues, Evolution and trends on wireless networking (Wireless local area network – WLAN); Wireless Networks Concepts and Systems: WLAN - Project IEEE 802.11, Architecture- components- and protocols, Mobility concepts and management; Physical and MAC Layer Characteristics and Protocols: Physical layer characteristics and technologies, MAC Layer Protocol such as DCF - PCF; Routing in Wireless Networks (Ad Hoc Networks and WSNs) - Transport Layer protocols and Security: Routing and Transport layer protocols in WLANs- Security and Privacy. Wireless Technology and Standards: Bluetooth, ZigBee etc.; Quality of service: Characterization and model.

Outcome:
- Ability to apply knowledge of design processes in WLAN
- To generate innovative designs to fulfill new needs, particularly in the fields of broadband networks and WLAN
- Ability to design protocols at different layers in WLAN
- Ability to develop authentication and security algorithm necessary in WLAN

TEXT BOOKS / REFERENCES:

1. Yi-Bing Lin and Imrich Chlamtac, *Wireless and Mobile Network Architectures*, Wiley, 2001.
2. C. Siva Murthy and B. Manoj, *Ad-hoc Wireless Networks, Architectures and Protocols*, Prentice Hall, 2004.
3. Chai K Toh, *Ad Hoc Mobile Wireless Networks: Protocols and Systems*, Prentice Hall, 2002.
4. Subir Kumar Sarkar, T.G. Basavaraju and C. Puttamadappa, *Ad Hoc Mobile Wireless Networks: Principles, Protocols and Applications*, Auerbach Publications, Taylor and Francis Group, 2007.

16CE709 RADAR SYSTEMS 3-0-0-3

Objectives:
- Understanding the components of a radar system and their relationship to overall system performance
- Understanding basic detection theory as applied to radar
- Understanding the concepts of the matched filter, ambiguity functions and other aspects of waveform and signal processor design

Keywords:
Radar range equations, SNR, Matched filter, Doppler radars, SAR

Contents:
Radar range equation, Radar Cross Section-Examples of simple radar systems-analysis of SNR model for system noise-radar detection in the presence of noise-matched filter detection-target effects on detection-parametric description of antennas. Pulsed Radars-fundamentals of range measurements-range ambiguity. Doppler radar-velocity measurements. FM-CW radars-Doppler ambiguity. SAR-signal processing-pulse compression-azimuth signal processing-

imaging-design example and system implementation issues-ambiguity functions-theorems-polarimetric radars-interferometric radars.

Outcome:

- Ability to understand the system perspective of Radar Technology

TEXT BOOKS / REFERENCES:

1. Skolnik M, *Introduction to Radar Systems*, Tata-Mcgraw Hill, 2003.
2. David K. Barton, *Modern Radar System Analysi*s, Artech House, Inc., NY 1988.
3. Brookner E, *Aspects of Modern Radar*, Artech House, Inc., NY 1988.

16CE710 RF TRANSCEIVER SYSTEM DESIGN 3-0-0-3

Objectives:

- Be familiar with RF transceiver system design for wireless communications
- Be exposed to design methods of receivers and transmitters used in communication systems

Keywords:

CMOS RF Design, S-Parameters, PLL, Frequency Synthesizers, RF Mixers

Contents:

Introduction to MOSFET Physics, Noise: Thermal, shot, flicker, popcorn noise, Two port Noise theory, Noise Figure, THD, IP2, IP3, Sensitivity, Phase noise – Specification distribution over a communication link, Homodyne Receiver, Heterodyne Receiver, Image reject, Low IF Receiver Architectures Direct up conversion Transmitter, Two step up conversion Transmitter S-parameters with Smith chart - Passive IC components, Impedance matching networks - Common Gate - Common Source Amplifiers - OC Time constants in bandwidth estimation and enhancement - High frequency amplifier design - Power match and Noise match - Single ended and Differential LNAs - Terminated with Resistors and Source Degeneration LNAs. -Stability of feedback systems: Gain and phase margin - Root-locus techniques - Time and Frequency domain considerations – Compensation - General model – Class A, AB, B, C, D, E and F amplifiers - Power amplifier Linearization Techniques - Efficiency boosting techniques, ACPR metric, Design considerations - Linearised Model - Noise properties - Phase detectors - Loop filters and Charge pumps-Integer-N frequency synthesizers - Direct Digital Frequency synthesizers - Mixer characteristics - Non-linear based mixers - Quadratic mixers - Multiplier based mixers - Single balanced and double balanced mixers - sub sampling mixers - Oscillators describing Functions - Colpitts oscillators – Resonators - Tuned Oscillators - Negative resistance oscillators - Phase noise.

Outcome:

- Ability to design RF transceiver systems
- Ability to use the systematic design methods of receivers and transmitters

TEXT BOOKS / REFERENCES:

1. QizhengGu, *RF System Design of Transceiver for Wireless Communications,* Springer Science and Business Media, 2005.
2. Thomas H Lee, *The Design of CMOS Radio-Frequency Integrated Circuits*, Cambridge University Press, 2012.

3. David M Pozar, *Microwave and RF Design of Wireless Systems,* John Wiley and Sons, 2001.
4. B.Razavi, *RF Microelectronics*, Pearson Education, 1997.
5. Devendra.K. Misra, *Radio Frequency and Microwave Communication Circuits – Analysis and Design,* John Wiley and Sons, Newyork, 2004.

16CE711 SATELLITE COMMUNICATION SYSTEM DESIGN 3-0-0-3

Objective:

- To understand the concepts of space missions, orbits and spacecraft systems
- To study the mechanism of guidance, controls, navigation systems and sensor technology
- To study the power communication and data handling systems, concept of small satellite requirements and design

Keywords:
Spacecraft, Orbit, Launch vehicle, Navigation, EMI, EMC, Telemetry

Contents:
Space Mission Design: Introduction: Elements of a Space Mission: The mission, the spacecraft, trajectories and orbits, launch vehicles, mission operations systems, Overview of Orbit and Constellation Design: The orbit design process - Earth coverage - Simple delta-V budgets - Selecting orbits and constellations - Common Examples - The physical environment of space and spacecraft system design. Sensors and Mechanisms, Guidance and Control: Mechanisms and Optics – kinematics - bearings and lubrication - motors and drives; mechanisms – wheels - materials. Optical mountings, alignment, and stray-light controlSensors- Guidance - Navigation and Control Systems - Optical sensor technology; ADCS sensor technology; GNC systems. Power communication and Data handling systems: Power Systems - EMC and Interfacing Power Systems - Power generation – storage - regulation and monitoring. Harnesses and connectors - EMC, shielding and grounding - monitoring and protection - TT&C - RF Systems and On-Board Data Handling, Tracking – telemetry - & command systems; RF link - OBCs. Small Satellite Designs: Micro/Nano-Satellite Design Principles: Organization - the KISS principle – capabilities - technology road-map - Space Mission Design Exercise

Outcome:

- Able to understand the Space Environment & its Effects
- Able to understand Spacecraft Platform Systems, design, satellite manufacture & Testing
- Able to understand Applications of Small, Low-Cost Satellites, space mission analysis & design

TEXT BOOKS / REFERENCES:

1. Maral and Bousquet, *Satellite Communications Systems,* Third Edition, Wiley ISBN 0-471-97166-9: 1998.
2. Jerry Jon Sellers, *Understanding Space - An Introduction to Astronautics,* McGraw Hill ISBN 0-07-057027-2: 1994.
3. Fortesque and Stark (eds), *Spacecraft Systems Engineering,* John Wiley and Sons ISBN 0-471-93451-8: 1992.
4. W.J. Larson (eds), *Space Mission Analysis & Design,* Second Edition, Kluwer Academic Publishers ISBN 0-7923-19982.

16CE712 MULTIRATE SIGNAL PROCESSING FOR COMMUNICATION SYSTEMS 3-0-0-3

Objectives:

- To understand the signal processing algorithms, filter design methods, and signal processing techniques
- To provide the design engineers with the tools necessary for efficient implementation of digital transceivers
- To focus on the multirate systems arising in the communications, especially wireless and software defined radios

Keywords:
Multirate systems, Resampling, Polyphase architectures, Digital up-conversion, Digital Down-conversion, CIC filters

Contents:

Fundamentals of Multirate Signal Processing – Nyquist and Square root Nyquist Filter– Systems using resampling filter. Quadrature Mirror Filters (QMF): Theory and Application - Wavelet for multirate signal processing. Polyphase FIR filter – Resampling Filter - Half-band Filters – Dyadic filter – Arbitrary Sampling Rate Conversion. Recursive polyphase filter – Cascade Integrator Comb Filter (CIC) - Cascade and multiple stage filters – Application in communication systems – Conventional Digital down converters (DDC), Aliasing DDC, Timing recovery in digital demodulation, Carrier recovery and phase recovery.

Outcome:

- Ability to design a resampling architecture for digital RF front end systems
- Ability to design efficient filter implementations for baseband transceivers
- Ability to design multirate systems for carrier, phase and timing recovery for communication receivers

TEXT BOOKS / REFERENCES:

1. Fredric J Harris, *Multirate Signal Processing for Communication Systems*, Pearson Education, 2004.
2. Behrouz Farhang-Boroujeny, *Signal Processing Techniques for Software Radios*, Lulu Publishing House, 2008.
3. Vaidyanathan P P, *Multirate Systems and Filter Banks*, Prentice Hall Inc., 1993.
4. N. J. Fliege, *Multirate Digital Signal Processing - Multirate Systems, Filter Banks and Wavelets*, John Wiley, 1994.
5. Omid S. Jahromi, *Multirate Statistical Signal Processing*, Springer, 2007.

16CE713 ARRAY SIGNAL PROCESSING 3-0-0-3

Objectives:

- To familiarize with spatial signals
- To introduce the concept behind sensor arrays
- To familiarize with spatial frequency
- To introduce different methods for direction of arrival estimation

Keywords:
Spatial frequency, Sensor arrays, Planar array, Random array, Aliasing

Contents:
Spatial Signals: Signals in space and time-spatial frequency-direction Vs. frequency-wave fields-far fields and near fields signals-Sensor Arrays: spatial sampling-Nyquist criterion-sensor arrays-uniform linear arrays-planar and random arrays-array transfer (steering) vector-array steering vector for ULA-broadband arrays-Spatial frequency: aliasing in spatial frequency domain-

Outcome:
- Gain knowledge about the efficient use of different signal processing and optimization techniques in adaptive arrays
- Equip students to design and develop more efficient practical systems to meet the future requirements using adaptive arrays.spatila frequencytransform-spatial spectrm-spatial domain filtering-beam forming-spatially white signal-Direction of arrival estimation: non parametric methds-beam forming and capon methods-resolution of beam forming methods-subspace methods-MUSIC-minimum Norm and ESPRIP techniques-spatial smoothing

TEXT BOOKS / REFERENCES:

1. Don H Johnson and Dan E. Dudgeon, *Array Signal Processing: Concepts &Techniques*, Prentice Hall, 1993.
2. Petre Stoica and Randolph L. Moses, *Spectral Analysis of Signals*, Prentice Hall, 2005
3. Bass J, McPheeters C, Finnigan J and Rodriguez E. *Array Signal Processing* [Connexions Web site]. February 8, 2005.
4. Available at:http://cnx.rice.edu/content/col10255/1.

16CE714 IMAGE ANALYSIS AND PATTERN RECOGNITION 3-0-0-3

Objectives:
- To understand image formation in a camera, have good concept on early vision
- To have deep understanding of middle level vision such as image classification and object detection
- To have in-depth concept about parametric and non parametric classification techniques

Keywords:
Computer vision, Low level and High level processing, Naïve Baye's theorem, Discriminant functions, Clustering

Contents:
Image formation- photometric image formation-geometric image formation-camera models camera projection models-orthographic-affine perspective and projective models-projective geometry-transformation to 2D to 3D- Early Vision: Linear Filters and Convolution, Shift Invariant Linear Systems, Discrete Convolution, Edge effects in Discrete Convolutions, Spatial Frequency and Fourier Transforms, Smoothing and Re-sampling Filters. Local Image features, textures. Middle Level Vision: Segmentation by clustering, Image classification, Object detection and Object recognition. Statistical decision making-Introduction, Baye's theorem, multiple features, conditionally independent features, decision boundaries, unequal costs of error, estimation of error rates, the leaving-one-out technique, characteristic curves,

estimating the composition of population Nonparametric Decision making: Introduction, histograms, adaptive decision boundaries, adaptive discriminate functions, minimum squared error discriminate functions, choosing a decision making technique. Clustering-Introduction, hierarchical clustering, partitioned clustering.

Outcome:

- Ability to implement image processing techniques
- Ability to validate Image processing algorithms
- Ability to draw inference from case studies

TEXT BOOKS / REFERENCES:

1. Forsyth and Ponce, C*omputer Vision –A Modern Approach*, Prentice Hall, 2003.
2. Marco Treibler, *An Introduction to Object Recognition Selected Algorithms for a Wide Variety of Application*, Springer, 2010.
3. Earl Gose, Richard Johnsonbaugh and Steve Jost, *Pattern Recognition and Image Analysis*, Prentice Hall India Private Limited, 2003.
4. Christopher M Bishop, *Pattern Recognition and Machine Learning*, Springer, 2006.

16CE715 IMAGE AND VIDEO PROCESSING 3-0-0-3

Objectives:

- To help the students deepen their understanding of image processing algorithms, two dimensional transforms and video processing concepts
- To strengthen the research skills of students in image and video processing

Keywords:

2D Transforms, Image Filtering, image Compression, Video processing

Contents:

Two dimensional signals and systems-Sampling in two dimensions-Two dimensional discrete transforms– DCT –DWT- Application to images -2D Hadamard Transform, Walsh Transform, KLT, Application to images- Z Transform and its properties, Application to images-Image Acquisition-Filtering in Spatial and Frequency domain- Color Image Processing – Image Segmentation - Image Compression-3D signals and Systems-3D sampling and reconstruction-Digital Video Processing-Digital Video Compression

Outcome:

- Make the students confident in programming and experiment with the various image and video processing algorithms
- Do a term work on a selected application of image/video processing, with minimum support from the faculty. Objective is to support the students to be placed in core companies

TEXT BOOKS / REFERENCES:

1. Rafael C. Gonzalez, *Digital Image Processing*, Third Edition, PHI Private Limited, New Delhi, 2008.
2. John W. Wood, *Multidimensional Signal, Image, Video Processing and Coding*, Elsevier, 2006.
3. A K Jain, *Fundamentals of Image Processing*, Prentice Hall, 2001.
4. Wiliam K Pratt, *Digital Image Processing*, Third Edition, Prentice Hall, 2007.

16CE716 MACHINE LEARNING 3-0-0-3

Objectives:

- To strengthen the expertise of the students in machine learning algorithms

Keywords:
GMM, HMM, SVM, Neural networks, Auto encoders, Restricted Boltzman machine

Contents:
Introduction to mixture models and EM, K-means clustering, mixture of Gaussians– maximum likelihood and EM for Gaussian mixtures, Bayesian neural networks. Introduction to linear algebra- theory of optimization-unconstrained optimization– sufficient condition for optimality-optimization with constraints-introduction to Lagrangian multipliers-Kuhn Tucker conditions-Lagrangian function for optimization with equality and inequality constraints-Lagrangian duality-Support vector machines-SVM formulation with two variables-Lagrangian dual– L1 SVM with soft margin (linear Kernel) –, L2 norm linear SVM– Non-linear SVM and Kernel trick- SVM formulation of non-linear Kernels with soft margin (L1 norm, and L2 norm) –Introduction to support vector regression– one class SVM – Neural networks-network training–local quadratic approximation-use of gradient information – gradient descent optimization; error back propagation – The Jacobian matrix – Hessian matrix and diagonal approximation - Regularization in neural networks – mixture density neural networks - convolutional networks – Introduction to deep learning neural networks – Theoretical advantages of deep architectures - Neural networks for deep architectures – Deep generative architectures – Convolution neural networks – Auto encoders – Restricted Boltzmann machines – Variants of RBMs and auto encoders.

Outcome:

- Training the students on the state-of-the-art machine learning algorithms
- Prepare them to apply these algorithms for their further study/research

TEXT BOOKS / REFERENCES:

1. Christopher Bishop, *Pattern Recognition and Machine Learning*, Springer, 2006.
2. Bernard Scholkopf and Alexander J Smola, *Learning with Kernel*, MIT Press, London, England, 2002.
3. K. P. Soman, R. Loganathan, and V. Ajay, *Machine Learning with SVM and Kernel Methods*, PHI Learning Private Ltd., New Delhi.2011.
4. Yoshua Bengio, *Learning Deep Architectures for AI, Foundations and Trends in Machine Learning*, Vol. 2, Now Publishers Inc.

16CE717 SPEECH AND AUDIO PROCESSING 3-0-0-3

Objectives:

- To help the students deepen their understanding of signal processing algorithms for speech and audio processing
- To strengthen the research skills of students in speech processing

Keywords:
Speech signal analysis, Speech recognition, Speaker recognition, Language modeling, Feature extraction

Contents:
Speech analysis-source filter modeling - speech sounds - lip radiation - linear prediction - lattice filters - Levinson-Durbin recursion, Feature extraction for speech processing-short term Fourier transform-wavelets - cepstrum, sinusoidal and harmonic representations –mel frequency cepstral coefficients (MFCC) - perceptual linear prediction (PLP) –mel filter bank energies– use of temporal patterns (TRAPS) in speech processing– Principles of speech coding–main characteristics of a speech coder - key components of a speech coder - from predictive coding to CELP - Improved CELP coders–wide band speech coding, audio-visual speech coding – Speech synthesis–Linguistic processing – acoustic processing - training models automatically – text pre-processing – grapheme to phoneme conversion – rule based and decision tree approaches – syntactic prosodic analysis – prosodic analysis - speech signal modeling – Principles of speech recognition-Hidden Markov models (HMM) for acoustic modeling - observation probability and model parameters - HMM as probabilistic automata Viterbi algorithm – Language models – n-gram language modeling and difficulties with the evaluation of higher order n-grams and solutions – spoken language identification approaches – acoustic– phonetic – LVCSR based – Introduction to speaker recognition– DET– EER– Cost function – weighted error rate and HTER

Outcome:
- Enables to develop a speech/speaker recognition system
- Enables to analyze the speech signal in both time and frequency domain

TEXT BOOKS / REFERENCES:

1. Joseph Mariani (Ed), *Language and Speech Processing*, John Wiley and Sons, 2009.
2. Lawrence R Rabiner and Ronald W Schafer, *Digital Processing of Speech Signals*, Pearson Education, 2003.
3. Thomas F. Quatieri Cloth, *Discrete-Time Speech Signal Processing: Principles and Practice*, Prentice Hall Inc, 2008.
4. B. Gold and N. Morgan, *Speech and Audio Signal Processing: Processing and Perception of Speech and Music*, Wiley, 2000.
5. Xuedong Huang, Alex Acero and Hsiao-Wuen Hon, *Spoken Language Processing, A Guide to Theory, Algorithm and System Development*, Prentice Hall Inc, New Jersey, USA, 2000.

16CE718 MULTIMEDIA PROCESSING AND CODING 3-0-0-3

Objectives:
- To understand Video signals, color signal concepts, multimedia services, video compression techniques and standards
- To understand Error control in video streaming

Keywords:
Multimedia, JPEG200, QAM, Video signals, Video streaming, Multimedia networking

Contents:
Overview of multimedia processing and coding: overview of multimedia services and applications – video coding fundamentals – Lossless compression and Lossy compression– Transform coding – Motion compensated predictive coding. Multimedia coding standards:

JPEG2000 – H.26X MPEG-I/4/7– AVC – Scalable video coding. Multimedia Networking: End-to-End QOS for video delivery – Wireless Video – Error control in Video streaming– Cross layer Video adaptation.

Outcome:

- Writing code for color image format conversion
- To analyze composite Video signals
- To analyze Waveform video coding
- Implementing error control codes in video streams

TEXTBOOKS /REFERENCES:

1. Yao Wang Joern Osterman and Ya-Qin Zhang, *Video Processing and Communications*, Prentice Hall, 2001.
2. MihaelaVBan der schaar and Philip chou, *Multimedia over IP and Wireless Networks: Compression, Networking, and Systems*, Academic Press, 2000.
3. Mohammed Ghanbari, *Standard Codecs: Image Communication to Advanced Video Coding*, IEEE UK, 2003.
4. Special Issues on *Advances in Video Coding and Delivery*, Proceedings of IEEE, January 2005.

16CE719 HYPERSPECTRAL IMAGE PROCESSING AND ANALYSIS 3-0-0-3

Objectives:

- To face the challenges of HIS in various fields such as Geology, defense, Agriculture
- To enable the students with concepts, methodologies and applications of hyper spectral imaging Technology

Keywords:

Hyperspectral imagery, Remote sensing, Spectrometry

Contents:

Examination of popular multispectral sensors - bandwidths and comparison with spectral signatures of typical surface features, development of hyper spectral remote sensing, AVIRIS-CASI - DIAS, Hyperion, Proba-1 etc., reflectance spectrometry– field and lab spectra radiometers, pre-processing of hyper spectral imagery: atmospheric calibration/correction– spectral correlation and data redundancy – dimensionality reduction and feature selection– end member extraction – PPI – N-FINDR - hyper spectral band ratios and vegetation indices– classification methods: spectral angle mapper, spectral information divergence – constrained energy minimization – spectral feature fitting– band depth analysis – support vector machines– applications of hyper spectral remote sensing: vegetation biophysical and biochemical parameters – soil properties – mineral identification– water quality assessment– material identification and mapping– anomaly detection– reference spectral libraries- USGS- and ASTER spectral libraries

Outcome:

- Opportunities for the employment in the remote sensing areas
- Enable the students to acquire skills in advance techniques of hyper spectral image processing

TEXT BOOKS / REFERENCES:

1. Marcus Borengasser, William S. Hungate, and Russell Watkins, *Hyper Spectral Remote Sensing: Principles and Applications*, CRC Press.
2. Hans F. Grahn and Paul Geladi, *Techniques and Applications of Hyperspectral Image Analysis*, Wiley and Sons Ltd.
3. Margaret Kalacska and G. Arturo Sanchez-Azofeifa *Hyperspectral Remote Sensing of Tropical and Subtropical Forests*., CRC Press.
4. Chein-I Chang, *Hyperspectral Data Exploitation: Theory and Applications*, Wiley and Sons Ltd.

16CE720 SIGNAL PROCESSING FOR MACHINE FAULT DIAGNOSIS 3-0-0-3

Objectives:

- To introduce the students to maintenance techniques, sensors, signal processing techniques and machine learning approaches used for machine fault diagnosis

Keywords:
FMECA, Signal conditioning, Cepstrum analysis, Electrical machinery faults, Fault diagnosis, GMM, SVM, Neural networks

Contents:
Introduction, principles of maintenance, failure modes effects and criticality analysis (FMECA), sensors, sensor placement– wireless sensor networks– smart sensors– data acquisition systems. Digital signal processing: Introduction, classification of signals– signal analysis– frequency domain signal analysis– fundamentals of Fast Fourier Transform (FFT)- signal conditioning – cepstrum analysis. Feature extraction and classification– dimensionality reduction techniques – fusion and integration technologies. The fault diagnosis framework– fault diagnosis requirements and performance metrics. Electrical machinery faults: Faults in electric motor – fault detection in electric motor. Applications of thermography in condition monitoring. Other methods in condition monitoring: Eddy current testing, ultrasonic testing– radiography – acoustic emission. Data driven fault diagnosis: Introduction to machine learning– Gaussian mixture model (GMM) - support vector machine (SVM) - neural networks. Physical model based fault diagnosis– case studies in diagnosis– Introduction to fault prognosis– prognosis algorithm approaches. Logistics: Support of the system in operation, product-support architecture, knowledge base and methods for condition based maintenance (CBM) – product support without CBM - product support with CBM, maintenance schedule strategies.

Outcome:

- Able to understand the importance of condition based maintenance and condition monitoring for industries
- Able to learn the signal processing techniques and machine learning approaches for effective fault diagnosis of machines
- To enable students to develop and plan for effective maintenance systems

TEXT BOOKS / REFERENCES:

1. Mohanty, Amiya Ranjan, *Machinery Condition Monitoring: Principles and Practices*. CRC Press, ISBN 9781466593046, 2014.
2. George Vachtsevanos, Frank L. Lewis, Michael Roemer, Andrew Hess and Biqing Wu, *Intelligent Fault Diagnosis and Prognosis for Engineering Systems*, ISBN: 978-0-471-72999-0, Wiley 2006.

3. Vasile Palade, Cosmin Danut Bocaniala and Lakhmi Jain, *Computational Intelligence in Fault Diagnosis*, ISBN: 978-1-84628-343-7, Springer, 2006.
4. Steven X. Ding, *Model-based Diagnosis Techniques: Design Schemes, Algorithms, and Tools*, ISBN: 978-1-4471-4798-5, Springer-Verlag, 2008.
5. Rolf Isermann, *Fault-Diagnosis Applications*, ISBN:978-3-642-12766-3 Springer-Verlag, 2011.

16CE721 CONVEX OPTIMIZATION 3-0-0-3

Objectives:

- To efficiently solve mathematical optimization problems which arise in a variety of applications
- To discover many applications in areas such as, estimation and signal processing, communications and networks, electronic circuit design, data analysis and modeling, statistics, automatic control systems and finance
- It is aimed to be for a more leisurely pace, more applications, more detailed treatment of theory, and perhaps a short student project

Keywords:
Linear Programming, Quadratic Programming, Semi definite programming, Interior Point methods, KKT conditions

Contents:
Introduction - linear algebra fundamentals - Solving linear equations with factored matrices - Block elimination and Schur complements - Convex sets - Convex functions - examples - Classes of Convex Problems - Linear optimization problems - Quadratic optimization problems - Geometric programming - Vector optimization -Reformulating a Problem in Convex Form - Lagrange Duality Theory and KKT Optimality Conditions - Interior-point methods- Primal and Dual Decompositions-Applications

Outcome:

- Develop a working knowledge of convex optimization, i.e., to develop the skills and background needed to recognize, formulate, and solve convex optimization problems
- Design sophisticated algorithms based on Convex Optimization for applications in communication and signal processing

TEXT BOOKS/REFERENCES:

1. Stephen Boyd and LievenVandenberghe, *Convex Optimization*, Cambridge University Press, 2004.
2. Daniel Palomar, *Convex Optimization in Signal Processing and Communications*, Cambridge University Press, 2009.
3. Dimitri P Bertsekas, *Convex Optimization Theory*, Athena Scientific, 2009.