# SCHEME OF COURSES FOR ME (Wireless Communications)

## First Semester

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Course No.</th>
<th>Course Name</th>
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<th>Cr</th>
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<tbody>
<tr>
<td>1.</td>
<td>PEC101</td>
<td>Discrete Time Signal Processing</td>
<td>3</td>
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<td>2.</td>
<td>PWC101</td>
<td>Random Variables and Stochastic Processes</td>
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<td>3.</td>
<td>PWC102</td>
<td>Information and Coding Theory</td>
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<td>4.</td>
<td>PEC104</td>
<td>Antenna Systems</td>
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## Second Semester

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<tr>
<td>1.</td>
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<td>Space Time Wireless Communication</td>
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<td>Advanced Wireless Communication Systems</td>
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## Third Semester

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**Total Credits:** 63.0

Approved by 76th meeting of the Senate held on 11.02.2012
List of Electives

Elective–I

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<tr>
<th>S. No.</th>
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<tr>
<td>1.</td>
<td>PEC211</td>
<td>Passive Optical Networks</td>
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Elective–II

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Electives–III

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<tr>
<td>1.</td>
<td>PWC331</td>
<td>Wireless Sensor networks</td>
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<td>Space-Time Coding for Wireless Communication</td>
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<td>PWC334</td>
<td>Spread Spectrum Communication</td>
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PEC101 DISCRETE TIME SIGNAL PROCESSING

Prerequisite(s): None


Multirate Signal Processing: Introduction, Concepts of multirate signal processing, Decimation and Interpolation by Integer factors, Sampling rate conversion by rational factors, efficient polyphase structures, design of phase shifters, Implementation of sampling rate conversion, Multistage Implementation, Applications of multirate signal processing, Digital filter banks, Two Channel and M-Channel filter bank, Wavelets.

Estimation and Prediction: Random signal, Correlation function and Power spectra, Innovations Representation, Linear prediction, forward and backward linear prediction, Levinson-Durbin Algorithm, Schur algorithm.

Adaptive Filters: Concept of Adaptive filters, Basic Wiener filter Theory, LMS adaptive algorithm, Recursive Least Square algorithm, Applications of adaptive filters.


DSP Processors: Architecture and instruction set of TMS320C54X DSP Chips, some example programs.

Laboratory Work
Calculation of Z, Fourier transform, Design of FIR and IIR filters, Multirate signal processing, realization of prediction, Adaptive Filters. Some example programs using TMS320C5402.

Recommended Books

Approved by 76th meeting of the Senate held on 11.02.2012
Introduction to Probability: Definitions, fields, sample space and events; Probability on finite sample spaces, Joint and conditional probabilities, independence, total probability; Bayes’ rule and applications

Random variables: Definition of random variables, continuous and discrete random variables, cumulative distribution function (cdf) for discrete and continuous random variables; probability density functions (pdf) and properties, Jointly distributed random variables, conditional and joint density and distribution functions, independence; Bayes’ rule for continuous and mixed random variables

Some special distributions: Uniform, Gaussian and Rayleigh distributions; Binomial, and Poisson distributions; Multivariate Gaussian distribution, Vector-space representation of random variables, linear independence, inner product, Schwarz Inequality

Sequence of random variables and convergence: Almost sure (a.s.) convergence and strong law of large numbers; convergence in mean square sense with examples from parameter estimation; convergence in distribution Central limit theorem and its significance

Stochastic process: Random process: discrete and continuous time processes, examples Probabilistic structure of a random process; mean, autocorrelation and auto-covariance functions Stationarity: strict-sense stationary (SSS) and wide-sense stationary (WSS) processes Autocorrelation function of a real WSS process and its properties, cross correlation function Ergodicity and its importance Spectral representation of a real WSS process: power spectral density, properties of power spectral density ; cross-power spectral density and properties; auto-correlation function and power spectral density of a WSS random sequence Linear time-invariant system with a WSS process as an input: stationarity of the output, auto-correlation and power-spectral density of the output; examples with white-noise as input; linear shift-invariant discrete-time system with a WSS sequence as input Spectral factorization theorem Examples of random processes: white noise process and white noise sequence; Gaussian process; Poisson process, Markov Process
Recommended Books

**PWC102 - INFORMATION AND CODING THEORY**

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**Information Theory and Entropy:** Introduction to Information theory and coding, Definition of information measure and entropy, Extension of an information source, Markov Source, Adjoint of an information source, Joint and Conditional Information measures, Properties of Joint and conditional information measures and a Markov source, Asymptotic properties of entropy and problem solving in entropy

**Source Coding:** Instantaneous codes and its properties, Kraft Mcmillan equality and Compact codes, Shannon’s first theorem, Coding strategies and introduction to Huffman Coding, Huffman coding and proof of its optimality, Competitive Optimality of the Shannon Code, Non-Binary Huffman coding, Adaptive Huffman coding, Lampel-Ziv coding, Shannon-Fano-Elias Coding, Arithmetic Coding

**Information Channel and Mutual Entropy:** Introduction to information channel, Equivocation and Mutual Information, Properties of different information channels, Reduction of information channels, Properties of Mutual information, Introduction to channel capacity, Calculation of channel capacities for different information channels, Shannon’s second theorem, Error free communication over noisy channel.

**Rate Distortion Theory:** Introduction, Definition and properties of rate distortion functions, Calculation of rate distortion functions, Computational approach for calculation of rate distortion functions.

**Channel Coding:** Parity Check codes, Repetitive codes, Hamming codes, Coding gain and their distance properties, Coding and decoding of information using Linear Block Codes and , Cyclic codes, Reed Solomon codes, Convolution codes, Viterbi Algorithm, Implementation of Viterbi decoder, Turbo codes

**Recommended Books**

Prerequisite(s): None

Review of Radiation Principles: Review of vector algebra, Basic Antenna Concepts and parameters, Potential functions and the Electromagnetic field, Alternating current element, Power Radiated by a current element, Applications to short antennas, Assumed current distributions, Radiation from a quarter-wave monopole or half wave dipole, Near and far fields.

Thin Linear Antennas and Arrays: Short Electric dipole, Thin linear antenna, Radiation resistance of antennas, Radiation resistance at a point which is not a current maximum, Fields of a thin linear antenna with a uniform travelling wave, Array parameters, Half-power beamwidth Mathematics of linear array, Antenna element spacing without grating lobes, Linear broadside array with non uniform distributions, Gain of regularly spaced planar arrays with $d = \lambda/2$, Tchebyscheff Array antennas, Reduction of sidelobes by tapering, Circular array, Phase and amplitude errors.

Secondary Sources and Aperture Antennas: Magnetic currents, Duality, Images of electric and magnetic currents, electric and magnetic currents as sheet sources, Impressed and induced current sources, Induction and equivalence theorems, field of a secondary or Huygens source, Radiation from open end of a coaxial line, Radiation through an aperture in conducting screen, slot antenna.


Applications and Numerical Techniques: Different types of antennas for applications in communication systems. Antennas for space communication, Numerical techniques in antenna design.

Adaptive Array Concept: Motivation of using Adaptive Arrays, Adaptive Array problem statement, Signal Environment, Array Element Spacing considerations, Array
Performance, concept of optimum Array Processing, Recursive Methods for Adaptive Error Processing.

**Laboratory Work**
Practicals related to Antenna Techniques using Software and Hardware.

**Recommended Books**
PEC105 ADVANCED COMMUNICATION SYSTEMS

L T P Cr
3 1 2 4.5

Prerequisite(s): None

Introduction: Introduction to analog and digital communication systems, baseband, bandpass and equivalent lowpass signal representations, concept of pre-envelope and Hilbert transform, representation of bandpass stochastic processes, concept of sampling and reconstruction of signal, introduction to oversampling, sigma-delta A/D converter, PCM, DPCM and ADPCM systems, memoryless modulation methods, linear modulation with memory, nonlinear modulation methods with memory, power spectra of CPFSK and CPM signals, Comparison of QPSK, MSK and GMSK.

Optimum Receivers for AWGN Channels: Correlation demodulator, Matched filter demodulator, optimum detector, maximum likelihood sequence detector, A symbol by symbol MAP detector for signals, Probability of error calculations for,"binary modulation, M-ary orthogonal signals, biorthogonal signals, simplex signals, M-ary binary coded signals, M-ary PAM, M-ary PSK, DPSK, QAM,” optimum demodulation and detection of CPM, optimum receiver design for signals with random phases, comparison of coherent and non-coherent receivers.

Carrier and Symbol Synchronization: Likelihood function, carrier recovery and symbol synchronization in signal demodulation, ML carrier phase estimation, PLL, decision directed loops and non-decision directed loops, ML timing estimation, non-decision directed timing estimation, joint estimation of carrier phase and symbol timing.

Signal Design for Band Limited Channels: Characterization of band limited channels, design of band limited signals for no ISI, Design of band limited signals with controlled ISI, data detection for controlled ISI, signal design for channels with distortion, probability of error for detection of PAM with zero ISI and with partial response signals, modulation codes for spectrum shaping.

Communication through Band Limited Linear Filter Channels: ML receiver for channels with ISI and AWGN, discrete time model for channel with ISI, Viterbi algorithm for discrete time white noise filter model, Performance of MLSE for channels with ISI, linear equalization – peak distortion criterion, MSE criterion and its performance, fractionally spaced equalizers, decision feedback equalization – coefficient optimization, performance characteristics.


Selected Areas in Communication: Introduction to MIMO, CDMA, MC-CDMA, OFDM, BLAST and Ultra-wideband systems, Modern Coding Techniques – block coding, convolution coding, Turbo coding, STBC, STTC, soft-decoding, hard-
decoding and Viterbi decoder.

**Laboratory Work**
Practicals based upon hardware using communication kits and simulation with the help of simulation packages.

**Recommended Books**
PWC201 SPACETIME WIRELESS COMMUNICATION

Prerequisite(s): PEC104 Antenna Systems
PEC202 Advanced Wireless Communications


ST Propagation: Wireless channel, path loss, fading, scattering model in macrocells, channel as a ST random field, scattering functions, polarization and field diverse channels, antenna array topology, degenerate channels, reciprocity and its implications.

ST Channel and Signal Models: SISO channel, SIMO channel, MISO channel and MIMO channel, physical scattering model for ST channel, Extended channel models, Statistical properties of $H$, channel measurements and test channels, sampled signal model, ST multiuser and ST interference channel, ST channel estimation.

Capacity of ST Channels: Capacity of frequency flat faded deterministic MIMO channels, channel unknown to transmitter, channel known to transmitter, capacity of random MIMO channels, Influence of Ricean fading, fading correlation XPD and degeneration on MIMO capacity, capacity of frequency selective MIMO channels.

Spatial Diversity: Diversity gain, receive antenna diversity, transmit antenna diversity, diversity order and channel variability, diversity performance in extended channels, combined space and path diversity, Indirect transmit diversity.

Capacity Limits of MIMO Systems: Mutual information and Shannon capacity, Single-user MIMO, Multi-user MIMO, Multi-cell MIMO, MIMO for ad hoc networks.

ST Coding without Channel Knowledge at Transmitter: coding and interleaving architecture, ST coding for flat added channels, ST coding for frequency selective channels.

Precoding Design: Transmit channel side information, Information-theoretic foundation for exploiting CSIT, A transmitter structure, Precoding design criteria, Linear precoder designs, Precoder performance results and discussion, Applications in practical systems.

ST Receivers: Receivers SISO, SIMO, MIMO, Iterative MIMO receivers, Reception of uncoded signals, Factor graphs and iterative processing, MIMO receivers for uncoded signals, MIMO receivers for coded signals, Some iterative receivers.

Exploiting Channel Knowledge at Transmitter: Linear pre-filtering, optimal pre-filtering at maximum rate, optimal pre-filtering for error rate minimization, selection at transmitter, exploiting imperfect channel knowledge.

MIMO-Multiuser: MIMO MAC, MIMO BC, outage performance of MIMO-MU.

Approved by 76th meeting of the Senate held on 11.02.2012
ST Co-Channel Interference Mitigation: CCI characteristics, Signal models, CCI mitigation on receive SIMO, CCI mitigating on receivers for MIMO, CCI mitigation on transmit for MISO, joint encoding and decoding.

Recommended Books
PWC202 ADVANCED WIRELESS NETWORKS

L T P Cr
3 0 0 3.0

Prerequisite(s): None


Approved by 76th meeting of the Senate held on 11.02.2012


**Recommended Books**


Capacity of Wireless Channels: Capacity in AWGN, Capacity of Flat-Fading Channels, Channel and System Model, Channel Distribution Information (CDI) Known, Channel Side Information at Receiver, Channel Side Information at Transmitter and Receiver, Capacity with Receiver Diversity, Capacity Comparisons, Capacity of Frequency-Selective Fading Channels.


Diversity: Receiver Diversity, System Model, Combining techniques Transmitter Diversity, Channel Known and unknown at Transmitter, Moment Generating Functions in Diversity Analysis for MRC, EGC, SC, Non-coherent and Differentially Coherent Modulation.

Coding for Wireless Channels: Code Design, Hard Decision Decoding (HDD), Probability of Error for HDD and SDD in AWGN, Code Characterization, ML Decoding, State Diagrams and Transfer Functions, Error Probability for Convolutional Codes, Concatenated Codes, Turbo Codes, Low Density Parity
Check Codes, Coded Modulation, Coding and Interleaving for Fading Channels, Protection Codes, Joint Source and Channel Coding.

**Adaptive Modulation and Coding:** Adaptive Transmission System, Adaptive Techniques, Variable Rate Techniques, Variable-Power, Error Probability, Coding, Hybrid Techniques and Rate techniques, Variable-Power MQAM, Adaptive Rate and Power Schemes, Channel Inversion with Fixed Rate, Discrete Rate Adaptation, General M-ary Modulations, Continuous and Discrete Rate Adaptation, Adaptive Techniques in Combined Fast and Slow Fading.

**Multicarrier Modulation:** Data Transmission using Multiple Carriers, Overlapping Sub channels, Mitigation of Sub carrier Fading, Discrete Implementation of Multi-carrier, Cyclic Prefix, OFDM, Matrix Representation of OFDM, Vector Coding, PAR, Frequency and Timing Offset, Multi-user Channels, Multiple Access, Downlink Channel Capacity, Uplink Channel Capacity, Capacity in AWGN, Fading, and with Multiple Antennas.

**Recommended Books**
Text coding: Lossless JPEG, UNIX compress, and the GIF format, Burrows-Wheeler compression, Gunzip, Winzip etc.

Speech Compression: Speech Production model, Objectives and requirements of speech coding, Quantizers for speech signal, Differential PCM and adaptive prediction, Linear predictive coding (LPC) of speech, Computational aspects of LPC parameters, Cholesky decomposition, Lattice formulation of LPC parameters, Linear predictive synthesizers, LPC Vocoder, Code excited linear predictive coding, Voice excited linear predictive coding.

Image Compression: Introduction, Lossless and Lossy image compression, Discrete Cosine Transform (DCT), DCT Quantization and limitations, Theory of wavelets, Discrete wavelet transforms (DWT), DWT on images and its encoding, Embedded Zero Tree wavelet encoding, Digital watermarking, Introduction to Curvelets.


Recommended Books

PEC211 PASSIVE OPTICAL NETWORKS

Prerequisite(s): None


Components for Future Access Networks: Tuneable Optical Network Unit, Fast-Tunable Laser at the Optical Line Terminal, Arrayed Waveguide Gratings, Reflective Receivers and Modulators, Colourless ONT.


Economic Models: WDM/TDM PON, Long Reach PONs, Long Term Dynamic WDM/TDM-PON Cost Comparison.

Recommended Books


Microwave circuit design Filters Filter design theory, RF distributed filter design, Singly and Doubly Terminated Networks, Lowpass Filter Prototype, Maximally Flat (Butterworth) Lowpass Approximation, Chebyshev Lowpass Approximation, Element Extraction, Butterworth and Chebyshev Filters, Impedance and Admittance Inverters, Filter Transformations.


Recommended Books:


Wireless Physical Layer Technologies: ISM Spectrum, Frequency Hopping Spread Spectrum (FHSS), Direct Sequence Spread Spectrum (DSSS), Orthogonal Frequency Division Multiplexing (OFDM)

Wireless Local and Personal Area Networks: Ad Hoc Mode, Infrastructure Mode, Bridging, Repeater, Mesh Wireless Networks, Local Area Networking Standards, IEEE 802.11, Real-World Wireless Data Rates, Personal Area Network (PAN) 802.15, Bluetooth 802.15.1, Infrared (IR), Ultra wide Band 802.15.3, ZIGBEE 802.15.4

Wide Area Wireless Technologies: Cell Phone Technologies, Analog, TDMA, CDMA, CDMA2000, GSM, GPS, 802.16 Air Interface Standards, 802.20 Standards.


Recommended Books

Prerequisite(s): None

Introduction: Fractional operations and the fractional Fourier transform, Applications of the fractional Fourier transform, Signals, Systems, Representations and transformations, Operators, The Fourier transform, Some important operators, Uncertainty relations, Time-frequency and space-frequency representations, The Wigner distribution and the ambiguity function, Linear canonical transforms.

The Fractional Fourier Transform: Fractional operations, Definitions of the fractional Fourier transform, Eigenvalues and Eigenfunctions, Transforms of some common functions, Properties, Rotations and projections in the time-frequency plane, Fractional Fourier domains, Chirp bases and chirp transforms, Relationships with the Wigner distribution and the ambiguity function Two-dimensional fractional Fourier transforms, Applications of the fractional Fourier transform.

The Discrete Fractional Fourier Transform: Discrete Hermite-Gaussian functions, The discrete fractional Fourier transform, Definition in hyperdifference form, Higher-order discrete analogs, Discrete computation of the fractional Fourier transform.

The Fractional Fourier Transform in Optics: General fractional Fourier transform relations in free space, Fractional Fourier transformation in quadratic graded-index media, Hermite-Gaussian expansion approach, First-order optical systems, Fourier optical systems, Locations of fractional Fourier transform planes, Wavefield reconstruction, phase retrieval, and phase-space tomography, Applications of the transform to wave and beam propagation.

Applications to Signal Processing: Optimal Wiener filtering in fractional Fourier domains, Multi-stage, multi-channel, and generalized filtering configurations, Applications of fractional Fourier domain filtering, Convolution and filtering in fractional Fourier domains, Repeated filtering in the ordinary time and frequency domains, Multiplexing in fractional Fourier domains, Fractional correlation, Controllable shift-invariance, Performance measures for fractional correlation, Fractional joint-transform correlators, Adaptive windowed fractional Fourier transforms, Applications with different orders in the two dimensions

Other fractional Transforms: Fractional sine and Cosine transforms, fractional Hartley Transforms, fractional Wavelet Transforms and their applications in one and two dimensional Signal processing.

Recommended Books
2. IEEE and Elsevier Papers.

Approved by 76th meeting of the Senate held on 11.02.2012
PVL203 VLSI SIGNAL PROCESSING

Prerequisite(s): None

Introduction: Introduction to DSP Systems, Terminating and Non-Terminating, Representation of DSP programs, Data Flow graphs (DFGs), Single rate and multi rate DFGs, Iteration bound, Loop, Loop Bound, Iteration rate, Critical loop, Critical path, Area-Speed-Power trade-offs, Precedence constraints, Acyclic Precedence graph, Longest Path Matrix (LPM) and Minimum Cycle Mean (MCM) Algorithms, Pipelining and parallel processing of DSP Systems, Low Power Consumption.

Algorithmic Transformations: Retiming, Cut-set retiming, Feed-Forward and Feed-Backward, Clock period minimization, register minimization, Unfolding, Sample period reduction, Parallel processing, Bit-serial, Digit-serial and Parallel Architectures of DSP Systems, Folding, Folding order, Folding Factor, Folding Bi-quad filters, Retiming for folding, Register Minimization technique, Forward Backward Register Allocation technique.

Systolic Architecture Design and Fast Convolution: Systolic architecture design methodology, Projection vector, Processor Space vector, Scheduling vector, Hardware Utilization efficiency, Edge mapping, Design examples of systolic architectures, Cook-Toom Algorithm and Modified Cook-Toom Algorithm, Wnograd Algorithm and Modified Winograd Algorithm, Iterated Convolution, Cyclic Convolution.


Recommended Books:

Approved by 76th meeting of the Senate held on 11.02.2012
Prerequisite(s): PEC103 Information and Communication Theory


**Recommended Books**


Approved by 76th meeting of the Senate held on 11.02.2012
PEC216 ADVANCED COMPUTER NETWORKS and PROTOCOLS

L T P Cr
3 0 0 3.0

Prerequisite(s): None


Recommended Books
PWC321 NEXT GENERATION WIRELESS SYSTEMS AND NETWORKS  
L T P Cr  
3 1 2 4.5

Prerequisite(s): PEC105 Advanced Communication Systems  
PEC202 Advanced Wireless Communications


3G Mobile Cellular Technologies: CDMA2000, WCDMA, TD-SCDMA.


Laboratory Work
Matlab related simulation experiments.

Approved by 76th meeting of the Senate held on 11.02.2012
**Recommended Books**


Approved by 76th meeting of the Senate held on 11.02.2012
PEC322 VIDEO AND IMAGE PROCESSING

Prerequisite(s): None

**Introduction:** Digital image representation, fundamental steps in image processing, elements of digital image processing systems digitization.

**Digital Image fundamentals:** A Simple Image Model, Sampling and Quantization, Relationship between Pixel, Image Formats, Image Transforms.

**Image Enhancement:** Histogram processing, image subtraction, image averaging, smoothing filters, sharpening filters, enhancement in frequency and spatial domain, low pass filtering, high pass filtering.

**Image Compression:** Fundamentals, Image Compression Models, Elements of Information Theory, Error-Free Compression, Lossy Compression, Recent Image Compression Standards.

**Video Fundamentals and Compression:** Introduction to Digital Video, Spatial and Temporal Redundancy, Entropy Coding, Motion Estimation, I, B, P Pictures, Generic Inter-Frame Video Codec, Recent Video Compression Standards.

**Recent Trends in Image and Video Coding:** Video Surveillance, Video Coding for Broadcasting Applications, Content based Video Databases.

**Recommended Books**
Introduction: Codes and ensembles, MAP and ML decoding, APP processing, Channel Coding Theorem, Linear Codes and complexity, Hamming codes, Gallager’s parity check codes, Decoding complexity of linear codes, Convolutional codes and its complexity, Iterative coding and decoding, Extending, Puncturing and shortening of codes

Factor Graphs: Distributive law, Graphical representation of factorization, Recursive determination of marginals, Marginalization via message passing, Decoding via message passing, Limitations of cycle-free codes, Message passing on codes with cycles.

Binary Erasure Channel: Channel model, Transmission via linear codes, Tanner graphs, Low density parity check (LDPC) codes, Message passing decoder, Computation graph and tree ensemble, Convergence to tree channel, Density evolution, Monotonicity, Gallager’s lower bound on density, Sparse distribution, Maxwell decoder

Turbo Codes: Structure and encoding, decoding of turbo codes, Density evolution, Stability condition, Exit charts, MAP performance, High performance turbo codes, Sliding window turbo codes, Turbo coded modulation, Set partitioning, Multi level codes.

Recommended Books

PWC323 WIRELESS BROADBAND NETWORKS

Prerequisite(s): PEC202 Advanced Wireless Communications


Approved by 76th meeting of the Senate held on 11.02.2012
**Wireless Broadband Networking with WiMAX:** WiMAX Overview, Competing Technologies, Overview of the Physical Layer, PMP Mode, Mesh Mode, Multihop Relay Mode.

**Wireless Local Area Networks:** Network Architectures, Physical Layer of IEEE 802.11n, Medium Access Control, Mobility Resource Management; Quality of Service, Applications.

**Wireless Personal Area Networks:** Network Architecture, Physical Layer, Medium Access Control, Mobility Resource Management, Routing, Quality of Service, Applications.

**Convergence of Networks:** GPP/WLAN Interworking, IEEE 802.11u Interworking with External Networks, LAN/WLAN/WiMax/3G Interworking Based on IEEE 802.21 Media-Independent Handoff, Future Cellular/WiMax/WLAN/WPAN Interworking, Analytical Model for Cellular/WLAN Interworking.

**Recommended Books**

PEC217 MICROSTRIP ANTENNAS

Prerequisite(s): PEC104 Antenna Systems


Microstrip Antenna Arrays: Array theory, Array calculations and analysis, array architectures, corporate array design, Resonant series fed array design, series fed traveling wave array design.


Coplanar lines and wave guides: Introduction of Coplanar Waveguide and Coplanar Strips, Quasi-Static Analysis, Design Considerations Losses, Effect of Tolerances, Comparison With Microstrip Line and Slotline, Transitions, Discontinuities in Coplanar Waveguide, Coplanar Line Circuits.


Microstrip circuit design: impedance transformers, filters, isolators and phase shifters.

Laboratory
Circuit are designed by IE3D and HFSS ANSOFT software.

Recommended Books
PVL343 SENSOR TECHNOLOGY AND MEMS

Prerequisite(s): None

Introduction to MEMS: Overview of CMOS process in IC fabrication, MEMS system-level design methodology, Equivalent circuit representation of MEMS, Signal-conditioning circuits and Sensor Noise calculation.

Principles of Physical and Chemical Sensors: Sensor classification, Sensing mechanism of Mechanical, Electrical, Thermal, Magnetic, Optical, Chemical and Biological Sensors.


Sensor Modeling: Numerical modeling techniques, Model equations, different effects on modeling (mechanical, electrical, thermal, magnetic, optical, chemical and biological) and examples of modeling.


Sensor Applications: Pressure Sensors with embedded electronics, accelerometer with transducer, gyroscope, RF MEMS Switch with electronics, Process engineering, medical diagnostic and patient monitoring, environmental monitoring.

Future Aspects of MEMS: RF MEMS, Optical MEMS, NEMS, MOEMS,

Recommended Books

PEC327 - Photonic Integrated Devices and Circuits

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**Introduction to Optical Fiber Communication:** Nature of light; optical communication; optical fibres; propagation of light in optical fibres; transmission characteristics of optical fibres; fabrication of optical fibres.

**Planar Optical Waveguides and Passive Devices:** Waveguide classification, step-index waveguides, graded-index waveguides, 3D waveguides, coupled mode theory, grating in waveguide structure, bent waveguides, directional coupler, Bragg reflectors, waveguide filters, multiplexers, demultiplexers.

**Semiconductor Light Sources and Amplifiers:** Spontaneous and stimulated emission, emission from semiconductors, semiconductor injection lasers, single frequency lasers, injection laser characteristics, LEDs - Introduction, LED power efficiency, LED structures, LED characteristics and Organic LEDs, Optical amplifiers, Semiconductor optical amplifier.

**Optical Modulators:** Electro-optic modulator, Acousto-optic modulator, Electro-absorption modulator, Interferometric modulator, micro-electro-mechanical modulator.

**Optical Detectors:** Optical detection principle, quantum efficiency and responsivity, semiconductor photodiodes with/without internal gain, silicon-germanium detector.

**Optical MEMS and NEMS:** Micro-electro-mechanical and nano-electro-mechanical systems, MEMS integrated tunable photonic devices-filters, lasers, hollow waveguides; NEMS tunable devices.

**Silicon Photonics:** Importance and need of silicon photonics, Silicon-on-insulator (SOI) technology, silicon modulators, non-linear silicon photonics, lasers on silicon.

**Nanophotonics:** Photonic crystals, slow light, slow light using photonic crystals, slot waveguide, diffraction limit on photonic device size, plasmonics, plasmonic waveguides, nano-lasers.

**Recommended Books**

Introduction: The vision of Ambient Intelligence, Application examples, Types of applications, Challenges for WSNs, Why are sensor networks different?, Enabling technologies.

ARCHITECTURES

Single Node Architecture: Hardware components, Energy consumption of sensor nodes, Operating systems and execution environments, Some examples of sensor nodes, Conclusion.

Network Architecture: Sensor network scenarios, Optimization goals and figures of merit, Design principles for WSNs, Service interfaces of WSNs, Gateway concepts, Conclusion.

COMMUNICATION PROTOCOLS

Physical Layer: Introduction, Wireless channel and communication fundamentals, Physical layer and transceiver design considerations in WSNs.

MAC Protocols: Fundamentals of (wireless) MAC protocols, Low duty cycle protocols and wakeup concepts, Contention-based protocols, Schedule-based protocols, The IEEE 802.15.4 MAC protocol, How about IEEE 802.11 and Bluetooth.


Naming and Addressing: Fundamentals, Address and name management in wireless sensor networks, Assignment of MAC addresses, Distributed assignment of locally unique addresses, Content-based and geographic addressing.

Time Synchronization: Introduction to the time synchronization problem, Protocols based on sender/receiver synchronization, Protocols based on receiver/receiver synchronization,


Topology Control: Motivation and basic ideas, Flat network topologies, Hierarchical networks by dominating sets, Hierarchical networks by clustering, Combining hierarchical topologies and power control, Adaptive node activity.

Data-Centric and Content-based Networking: Introduction, Data-centric routing, Data aggregation, Data-centric storage, Conclusions.

Transport Layer and Quality of Service: The transport layer and QoS in wireless sensor networks, Coverage and deployment, Reliable data transport, Block delivery, Congestion control and rate control.


Laboratory Work
Experiments related to wireless sensor networks.

Recommended Books
PEC332 ADAPTIVE SIGNAL PROCESSING

Prerequisite(s): PEC101 Discrete Time Signal Processing, PEC103 Information and Communication Theory

Signals and Systems: System theory, stochastic processes Gauss Markov model, Representation of stochastic processes, likelihood and sufficiency, Hypothesis testing, decision criteria, multiple measurements.


System Modeling and Identification: System identification based on FIR (MA), All Pole (AR), Pole Zero (ARMA) system models, Least square linear prediction filter, FIR least squares inverse filter, predictive de convolution, Matrix formulation for least squares estimation: Cholesky decomposition, LDU decomposition, QRD decomposition, Grahm - Schmidt orthogonalization, Givens rotation, Householder reflection, SVD.

Adaptive Filtering: Least square method for tapped-delay line structures. Least Mean Squares (LMS) and Recursive Least Squares (RLS) algorithms and their convergence performance, IIR adaptive filtering and Transform domain adaptive filtering, introduction of different types of LMS, RLS and Kalman filters and their relationship with each other.


Nonstationary Signal Analysis: Time frequency analysis, Cohen class distribution, Wigner-Ville Distribution, Wavelet Analysis.

Applications: Noise and echo cancellation, Parameters estimation in Radar systems, Dynamic target tracking, Application to pattern classification and system identification, channel identification and equalization, Generalized inverses, regularization of ill-posed problems. Interpolation and approximation by least squares and minimax error criteria, Optimization techniques for linear and nonlinear problems, Model order selection, MUSIC, ESPRIT algorithms, Signal Analysis with Higher order Spectra, array processing, Beam forming, time-delay estimation, successive and parallel interference cancellers.
**Laboratory Work**
Practicals based upon hardware using communication kits and simulation with the help of simulation packages.

**Recommended Books**
Prerequisite(s): PEC104 Antenna Systems
PEC202 Advanced Wireless Communications,

MIMO Information Theory: Entropy and Mutual Information, Capacity of the MIMO Channel, Channel Capacity for Informed Transmitters, Ergodic Channel Capacity The Ratio Between IT and UT Channel Capacities, Outage Capacity.


Space-Time Block Codes: Alamouti Space-Time Code with Multiple Receive Antennas, Space-Time Block Codes (STBC), STBC for Real Signal Constellations, STBC for Complex Signal Constellations, Decoding of STBC, Performance of STBC, Effect of Imperfect Channel Estimation and Antenna Correlation on Performance.

Space-Time Trellis Codes: Encoder Structure for STTC, Generator Description, Optimal STTC Based on the Rank, Determinant and Trace Criterion, Performance Comparison for Codes Based on Different Design Criteria, The Effect of Imperfect Channel Estimation on Code Performance, Design of Space-Time Trellis Codes on Fast Fading Channels, Construction of Recursive STTC, Space-Time Turbo Trellis Codes, Comparison of ST TurboTC and STTC, Effect of Memory Order and Interleaver Size, Decoder EXIT Charts Effect of Interleaver Type.


Differential Space-Time Block Codes: Differential Encoding, Differential Decoding, Differential STBC with Real Signal Constellations for one, two, Three and Four Transmit Antennas, Differential STBC with Complex Signal Constellations for Three and Four Transmit Antennas, Unitary Space-Time Modulation, Unitary Group Codes.

Space-Time Coding For Informed Transmitters: Information Theoretical Considerations, STBC with Linear Precoding, Quantized Feedback and Diversity, Linear Precoding for Known Fading Statistics, OSTBC with One-Bit Feedback for nt = 2.


Laboratory Work
Matlab related simulation experiments.

Recommended Books
PWC333 WIRELESS COMMUNICATION PROTOCOLS

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Prerequisite(s): None


MOBILE IP AND WIRELESS ACCESS PROTOCOL: Mobile IP Operation of mobile IP, Co-located address, Registration, Tunneling, WAP Architecture, overview, WML scripts, WAP service, WAP session protocol, wireless transaction, Wireless datagram protocol.

BLUE TOOTH: Overview, Radio specification, Base band specification, Links manager specification, Logical link control and adaptation protocol. Introduction to WLL Technology.

Mobile Network Layer

Wireless Application Protocol
WAP(1.0) Introduction – Main Objectives – Integration of WAP components – Stack arrangement with WAP – WAP network – Protocol stack of WAP - WAP client architecture - WAP network architecture
WAP (2.0): Advantages – Main architectural components of WAP 2.0 – WAP Programming model – Uses of WAP 2.0 additional services.

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Recommended Books

3. Wireless Communication of Networks - William Stallings PHI
Prerequisite(s): PEC-101 Discrete Time Signal Processing

An Introduction to DSP Processors: Advantages of DSP, characteristics of DSP systems, classes of DSP applications, DSP processor embodiment and alternatives, Fixed Vs Floating point processors, fixed point and Floating point Data Paths.

DSP Architecture: An introduction to Harvard Architecture, Differentiation between Von-Neumann and Harvard Architecture, Quantization and finite word length effects, Bus Structure, Central Processing Unit, ALU, Accumulators, Barrel Shifters, MAC unit, compare, select, and store unit (CSSU), data addressing and program memory addressing.

Memory Architecture: Memory structures, features for reducing memory access required, wait states, external memory interfaces, memory mapping, data memory, program memory and I/O memory, memory mapped registers.

Addressing: Various addressing modes - implied addressing, immediate data addressing, memory direct addressing, register direct and indirect addressing, and short addressing modes.

Instruction Set: Instruction types, various types registers, orthogonality, assembly language and application development.

Execution Control and Pipelining: Hardware looping, interrupts, stacks, pipelining and performance, pipelining depth, interlocking, branching effects, interrupt effects, instruction pipelining.

Peripherals: Serial ports, timers, parallel ports, bit I/O port, host ports, communication ports, on-chip A/D and D/A converters, external interrupts, on chip debugging facilities, power consumption and management.

Processors: Architecture and instruction set of TMS320C3X, TMS320C5X, TMS320C6X, ADSP 21XX DSP Chips, some example programs.


Laboratory Work
Introduction to code composer studio, Using CCS write program to compute factorial, dot product of two arrays, Generate Sine, Square and Ramp wave of varying frequency and amplitude, Design various FIR and IIR filters, Interfacing of LED, LCD, Audio and Video Devices with the DSP processor.

Recommended Books

Approved by 76th meeting of the Senate held on 11.02.2012
PWC334 - SPREAD SPECTRUM COMMUNICATIONS

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**Introduction:** Radio channel characteristics, Channel Modeling, Channel Statics, ISI and ICI, Discrete Multipath Channel Models, Diversity, Multi Carrier Transmission OFDM, Advantages and drawbacks of OFDM, Applications and standards of OFDM, Spread Spectrum Techniques, Multicarrier Spread Spectrum, MC-CDMA, MC-DS-CDMA

**Hybrid Multiple Access Schemes:** Multi carrier FDMA, OFDMA, OFDMA with code division multiplexing, distributed DFT, localized DFT, multi carrier TDMA, Pseudo random PPM Ultra Wide Band systems, Comparison of Hybrid multiple access schemes, Multi carrier modulation and demodulation, synchronization, channel estimation, channel coding and decoding, signal constellation, mapping demapping and equalization, Adaptive techniques in multi carrier transmission, RF issues

**Applications:** 3GPP LTE systems, Requirements on LTE, Radio Access Network Architecture, Radio protocol Architecture, Downlink and Uplink Transmission Scheme, WiMax, System Architecture, WiMax Profiles, Hyper Man and 802.16x, Future mobile communication concepts, VSF-OFCDM access schemes, Wireless LAN, interaction channel for DVB-T: DVB-RCT

**Additional Techniques for Capacity and Flexibility Enhancement:** MIMO, BLAST architecture, Space-time coding, diversity techniques for multi carrier transmission, spatial pre-coding for multi carrier transmission, software defined radio.

**Laboratory Work**
Matlab related simulation experiments.

**Recommended Books**

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