SCHEME AND SYLLABI

FOR

M. Tech. DEGREE PROGRAMME

IN

ADVANCED COMMUNICATION & INFORMATION SYSTEMS

(2013 ADMISSION ONWARDS)
**SCHEME AND SYLLABI FOR M. Tech. DEGREE**

**PROGRAMME IN**

**ADVANCED COMMUNICATION & INFORMATION SYSTEMS**

**SEMESTER – II**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Course No.</th>
<th>Subject</th>
<th>Hrs / Week</th>
<th>Evaluation Scheme (Marks)</th>
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<th>Elective – I (MEC CI 205)</th>
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<tr>
<td>MECC 205 – 1$^*$ Multicarrier Communication Systems</td>
<td>MECCI 206 – 1$^*$ MIMO Communication Systems</td>
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<tr>
<td>MECC 205 – 2$^{**}$ Principles of Secure Communication</td>
<td>MECCI 206 - 2 Spread Spectrum and CDMA Systems</td>
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<td>MECC 205 – 3 Speech Technology</td>
<td>MECCI 206 – 3$^*$ Optimization Techniques</td>
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<td>MECC 205 – 4$^*$ Mobile Computing</td>
<td>MECCI 206 – 4 RADAR Communication Systems</td>
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</table>

L – Lecture, T – Tutorial, P – Practical
TA – Teacher’s Assessment (Assignments, attendance, group discussion, quiz, tutorials, seminars, etc.)
CT – Class Test (Minimum of two tests to be conducted by the Institute)
ESE – End Semester Examination to be conducted by the University

**Electives:** New Electives may be added by the department according to the needs of emerging fields of technology. The name of the elective and its syllabus should be submitted to the University before the course is offered.

* Common with MECEC  ** Common with MECCE, $ Common with MECCE and MECEC , # Common with MECCE, MECEC and MECAE
Module I

**Fundamentals of Multirate Digital Signal Processing**: Basic sampling rate alteration devices - Sampling rate reduction by an integer factor: Down sampler - Time and frequency domain characterization of downsampler – Anti-aliasing filter and decimation system – Sampling rate increase by an integer factor: Upsampler – Time and frequency domain characterization of upsampler – Anti-imaging filter and interpolation system – Gain of anti-imaging filter – Changing the sampling rate by rational factors – Transposition theorem-Multirate identities - Direct and Transposed FIR structures for interpolation and decimation filters – The Polyphase decomposition - Polyphase implementation of decimation and interpolation filters – Commutator models - Multistage implementation of sampling rate conversion – Filter requirements for multistage designs – Overall and individual filter requirements

Module II


Module III


Module IV
Multiresolution formulation of Wavelet systems and Wavelet applications:
Scaling function and wavelet function – dilation equation – Filter banks and the DWT - Analysis – from fine scale to coarse scale – Analysis tree – Synthesis – from coarse scale to fine scale – Synthesis tree – Wavelet packets – Wavelet packet algorithms – Application of wavelet theory in signal denoising, image and video compression – Application to communication – OFDM multicarrier communication, Wavelet packet based MCCS

References:

Module I

Characterization of Communication signals and systems: Elements of digital communication systems, performance, communication channels and their characteristics, mathematical models for communications channels, Representation of band pass and low pass signals, Signal space representation of waveforms: vector space concepts, signal space concepts, Gram-Schmidt procedure, Bounds on tail probability, limit theorems for sum of random variables, complex random variables, random process

Module II

Digital modulation schemes: Representation of digitally modulated signals, memoryless modulation methods: PAM, PSK, QAM, Multidimensional signalling; orthogonal signalling, FSK, biorthogonal signalling, signalling schemes with memory: CPFSK, CPM, Power spectrum of digitally modulated signals: PSD of digitally modulated signal with memory, PSD of CPFSK and CPM

Module III

Optimum receivers for AWGN Channels: Waveform and vector channel models: optimal detection for a general vector channel, MAP and ML, receiver, decision regions, error probability, sufficient statistics. Waveform and vector AWGN channels, optimal detection for the vector AWGN channel, Implementation of optimum receiver for AWGN channels: The correlation receiver, The matched filter receiver.

Module IV

Communication through Band Limited Channels: Characterization of band limited channels, Signal design for band limited channels. Design of band limited signals for no ISI-The Nyquist criterion, Design of band limited signal with controlled ISI-Partial response signaling, Optimum receiver with ISI & AWGN: optimum maximum likelihood receiver, A discrete time model for a channel with ISI. Maximum-Likelihood Sequence Estimation (MLSE) for a discrete time white noise filter model detectors, turbo equalization, adaptive equalization, equalizer, decision feedback equalizer, recursive least squares algorithms, blind equalization.
References:

2. Bruce Carlson, Crilly&Rutledge, Communication systems, McGraw Hill
Module I

Overview of wireless communication; path loss and shadowing: Radio wave propagation, Transmit and receive signal models, Free space path loss, ray tracing, Simplified path loss model, Empirical path loss model: okumura model - hata model - walfisch model - piecewise linear model- indoor propagation models, shadow fading, combined path loss and shadowing, Cell coverage area

Module II

Capacity of wireless channel: Capacity of flat fading channel, Capacity of frequency selective fading channels

Diversity: Receiver diversity: system model - selection combining - threshold combining - maximal ratio combining - equal gain combing, Transmitter diversity: channel known at transmitter - Alamouti scheme

Module III

Channel coding: Linear block codes: Cyclic codes - Block Coding and Interleaving for Fading Channels, Convolution codes: Trellis diagram - maximum likelihood decoding - Viterbi Algorithm - Convolution Coding and Interleaving for Fading Channels, Concatenated codes, Turbo codes, Low density parity check codes.

Module IV

Multiple Antenna and Space time communication: Narrow band MIMO Model, Parallel decomposition of MIMO, MIMO channel capacity: static and fading channel, MIMO diversity gain, Diversity/Multiplexing trade off, Spacetime modulation and coding, Frequency selective MIMO channels.

Equalization: Equalizer noise enhancement, equalizer types, folded spectrum and ISI-free transmission, linear equalizer.

Multi carrier modulation: Data transmission using multiple carriers, Multi carrier modulation with overlapping sub channels, Mitigation of subcarrier fading

References
1. Andrea Goldsmith, "Wireless Communications", Stanford University
2. ShuLin, Costello Jr. “Error control coding”, Pearson Education
Module I

Neural Networks: Supervised Learning Neural Networks – Perceptrons-Multilayer
perceptrons-Backpropagation- Radial Basis Function Networks – Unsupervised
Learning Neural Networks – Competitive Learning Networks – Kohonen Self-
Organizing Networks – Learning Vector Quantization – Hebbian Learning

Module II

Fuzzy Set Theory: Fuzzy Sets – Basic Definition and Terminology – Set-
theoretic Operations – Member Function Formulation and Parameterization –
Fuzzy Rules and Fuzzy Reasoning – Extension Principle and Fuzzy Relations –
Fuzzy If- Then Rules – Fuzzy Reasoning – Fuzzy Inference Systems – Mamdani
Fuzzy Models – Sugeno Fuzzy Models – Tsukamoto Fuzzy Models – Input Space
Partitioning and Fuzzy Modeling

Module III

Optimization: Derivative-based Optimization – Descent Methods – The Method
of Steepest Descent – Classical Newton’s Method – Step Size Determination –
Derivative-free Optimization – Genetic Algorithms – Simulated Annealing –
Random Search – Downhill Simplex Search.

Module IV

– Hybrid Learning Algorithm – Learning Methods that Cross-fertilize ANFIS and
RBFN – Coactive Neuro Fuzzy Modeling – Framework Neuron Functions for
Adaptive Networks – Neuro Fuzzy Spectrum.

Reference:

1. Satheeshkumar “Neural Networks: A class room approach”, Tata McGraw

2. Timothy J. Ross, “Fuzzy Logic with Engineering Applications”, McGraw-


Module I

Review of wireless channel characteristics – Multi carrier and OFDM system fundamentals – OFDM system model - Comparison with single carrier - Channel capacity and OFDM – FFT implementation – Power spectrum – Impairments of wireless channels to OFDM signals – Comparison with other multicarrier modulation scheme: MC CDMA

Module II


Module III

Channel Estimation in OFDM systems – Differential and Coherent detection; Pilot symbol aided estimation - Block type and Comb type pilot arrangement; Decision directed channel estimation – MMSE estimation using time and frequency domain correlation; MIMO channel estimation- basic concepts; Concepts of Time and Frequency domain equalization.

Module IV

Clipping in Multi carrier systems – Power amplifier non linearity – Error probability analysis – Performance in AWGN – PAPR properties of OFDM signals – PAPR reduction techniques with signal distortion; Techniques for distortion less PAPR reduction – Selective mapping and Optimization techniques.

References:

Module I


Module II

**Basic encryption techniques** - Concept of cryptanalysis, Shannon’s theory. Perfect secrecy, Block ciphers, Cryptographic algorithms, Features of DES, Stream ciphers, Pseudo random sequence generators, linear complexity. Non-linear combination of LFSRs, Boolean functions

Module III

**Private key and Public key cryptosystems** - One way functions - Discrete log problem – Factorization problem - RSA encryption - Diffie Hellmann key exchange. Message authentication and hash functions - Digital signatures - Secret sharing - features of visual cryptography - other applications of cryptography

Module IV

**Elliptic curves** - Basic theory - Weirstrass equation - Group law - Point at Infinity
Elliptic curves over finite fields - Discrete logarithm problem on EC - Elliptic curve cryptography - Diffie Hellmann key exchange over EC - Elgamal encryption over EC - ECDSA

References:

5. Evangelos Kranakis, “Primality and Cryptography”, John Wiley & Sons
Module I

Speech Production and Categorization of Speech Sounds: Introduction to speech signal processing, overview of speech signal processing applications, human speech production mechanism, acoustic theory of speech production, nature of speech signal, spectrographic analysis of speech, categorization of speech sounds, coarticulation, prosody.

Module II

Speech Analysis and Synthesis: Time and frequency domain analysis, Review of DSP techniques-z-transform, Discrete Fourier transform, short-time analysis of speech, linear prediction analysis, cepstral analysis, Contrasting linear prediction analysis and cepstral analysis, vector quantization(VQ) methods.

Module III

Speech Recognition: Speech recognition, Bayes rule, segmental feature extraction, mel frequency cepstral coefficient(MFCC), dynamic time – warping(DTW), Gaussian mixture models (GMM), hidden Markov model(HMM), approaches for speech, speaker and language recognition.

Module IV

Speech Coding, Speech Synthesis and Enhancement: Speech coding, quality measures, speech redundancies, time-domain waveform coding, Linear predictive coding, LPC residual coding, principles of speech synthesis, fundamentals of speech enhancement

References

Module I

**Introduction to Mobile Computing and Media access control**: Mobile Computing (MC): Introduction to MC, novel applications, limitations, and architecture. **GSM**: Mobile services, System architecture, Radio interface, Protocols, Localization and calling, Handover, Security, and New data services. Motivation for a specialized MAC (Hidden and exposed terminals, Near and far terminals), SDMA, FDMA, TDMA, CDMA.

**Module II:**

**Mobile Network Layer and Transport Layer**: Mobile IP (Goals, assumptions, entities and terminology, IP packet delivery, agent advertisement and discovery, registration, tunneling and encapsulation, optimizations), Dynamic Host Configuration Protocol (DHCP). Traditional TCP, Indirect TCP, Snooping TCP, Mobile TCP, Fast retransmit/fast recovery, Transmission /time-out freezing, Selective retransmission, Transaction oriented TCP.

**Module III**

**Database Issues**: Hoarding techniques, caching invalidation mechanisms, client server computing with adaptation, power-aware and context-aware computing, transactional models, query processing, recovery, and quality of service issues.

**Module IV**

**Data Dissemination**: Communications asymmetry, classification of new data delivery mechanisms, push-based mechanisms, pull-based mechanisms, hybrid mechanisms, selective tuning (indexing) techniques

**References:**


Module I

**Information Theoretic aspects of MIMO** : Review of SISO fading communication channels, MIMO channel models, Classical i.i.d. and extended channels, Frequency selective and correlated channel models, Capacity of MIMO channels, Ergodic and outage capacity, Capacity bounds and Influence of channel properties on the capacity.

Module II

**MIMO Diversity and Spatial Multiplexing** : Sources and types of diversity, analysis under Rayleigh fading, Diversity and channel knowledge. Alamouti space time code, MIMO spatial multiplexing. Space time receivers. ML, ZF, MMSE and Sphere decoding, BLAST receivers and Diversity multiplexing trade-off.

Module III

**Space Time Block Codes** : Space time block codes on real and complex orthogonal designs, Code design criteria for quasi-static channels (Rank, determinant and Euclidean distance), Orthogonal designs, Generalized orthogonal designs, Quasi-orthogonal designs and Performance analysis.

Module IV

**Space Time Trellis Codes** : Representation of STTC, shift register, generator matrix, state-transition diagram, trellis diagram, Code construction, Delay diversity as a special case of STTC and Performance analysis.

References:

Module I

**Fundamentals of Spread Spectrum:** Introduction to spread spectrum communication, direct sequence spread spectrum, frequency-hop spread spectrum system. Spreading sequences- maximal-length sequences, gold codes, Walsh orthogonal codes- properties and generation of sequences. Synchronization and Tracking: delay lock and tau-dither loops, coarse synchronization principles of serial search and match filter techniques

Module II

**Performance Analysis of SS system:** Performance of spread spectrum system in jamming environments- Barrage noise jamming, partial band jamming, pulsed noise jamming and single tone jamming. Error probability of DS-CDMA system under AWGN and fading channels, RAKE receiver

Module III

**Capacity, Coverage and multiuser detection:** Basics of spread spectrum multiple access in cellular environments, reverse Link power control, multiple cell pilot tracking, soft and hard handoffs, cell coverage issues with hard and soft handoff, spread spectrum multiple access outage, outage with imperfect power control, Erlang capacity of forward and reverse links. Multi-user Detection -MF detector, decorrelating detector, MMSE detector. Interference Cancellation: successive, Parallel Interference Cancellation, performance analysis of multiuser detectors and interference cancellers.

Module IV

**CDMA Systems:** General aspects of CDMA cellular systems, IS-95 standard, Downlink and uplink, Evolution to Third Generation systems, WCDMA and CDMA-2000 standards, Principles of Multicarrier communication, MCCDMA and MC-DS-CDMA

References :

Module I

Unconstrained optimization: Necessary and sufficient conditions for local minima, one dimensional search methods, gradient methods - steepest descent, Inverse Hessian, Newton’s method, conjugate direction method, conjugate gradient algorithm, quasi Newton methods

Module II

Linear Programming: Convex polyhedra, standard form of linear programming, Basic solutions, Simplex algorithm, Matrix form of the simplex algorithm, Duality, non simplex methods : Khachiyan method, Karmarkar’s method

Module III

Nonlinear Constrained Optimization: Equality constraints – Lagrange multipliers, inequality constraints – Kuhn-Tucker conditions, Convex optimization, Geometric programming, Projected gradient methods, Penalty methods

Module IV

Introduction to Graph Theory and Combinatorial Optimization: Routing-traveling salesman; Assignment – satisfiability, constraint satisfiability, graph coloring; Subsets- set covering, partitioning; Scheduling; Shortest path and Critical path algorithms

References

4. Jonathan L Grosss, Jay Yellen, Chapmann and Hall, “Graph theory and its application”, 2e,CRC pub,
5. Alan Tucker, “Applied Combinatorics”, John wiley and Sons
Module I
Radar Block Diagrams and operations: Radar frequencies, Pulse operations, Pulse repetitions, Frequency, Radar range equations, Minimum detectable signal, Receiver noise, Signal to noise ratio, Integration of radar pulses, Radar cross section, Propagation losses.


Module II
Detection of Radar Signals: Matched filter receiver, Correlation Detection, Likelihood function, Detection Characteristics, Inverse probability, Optimum Design Criteria, Binary Integrators, Delay line Integrators

Module III
Target Parameter Estimation: Statistical Estimation of Parameters, Maximum Likelihood estimation, Theoretical accuracy of range and Doppler velocity measurements, Uncertainty relation, Angular Accuracy, Ambiguity function and radar transmitted Waveform design, Pulse compression Radar.

Module IV
Radar Applications: Direction finders, Instrument landing systems, Ground controlled approach, Radar beacons, Biostatic Radar, Detection and tracking of extraterrestrial objects, Ionized media, Earth satellites and Space vehicles, Airborne weather avoidance Radar, Electronics War fare (ECM & ECCM)

References:
1. Modeling and Simulation of Radio Channels - Multipath Fading Channels- Jake’s Model
2. Frequency non-selective and frequency selective fading channels realization.
3. OFDM system simulation, BER performance in fading channels
4. Channel estimation in OFDM
5. Synchronization in OFDM
6. Source Coding: Hamming code, Huffman coding
7. Arithmetic Coding
8. Channel Coding- Linear Block Code
9. Convolutional codes, Viterbi decoding
10. Cyclic codes
11. Ethernet and Token Ring simulation and Evaluation
12. Scheduling and Queuing Disciplines in Packet Switched Networks: FIFO, Fair Queuing, RED
13. TCP Performance analysis with and without RED.
14. Modelling of Wireless Networks : Physical layer and MAC layer
15. Simple Sensor Networks Simulation and Evaluation
16. Mobile Adhoc Network Simulation and Evaluation

**Tools:** Numerical Computing Environments – GNU Octave or MATLAB, Simulink, LabVIEW or any other equivalent tool and specialized tools like OPNET/NS-2 etc. Suitable Hardware Tools like USRP (Universal Software Radio Peripheral) to supplement the simulation tools.
Minimum 10 experiments from the above list should be completed.

*** Topics could be added in concurrence with the syllabus of elective subjects offered

**References:**

Each student shall present a seminar on any topic of interest related to the core/elective courses offered in the 1st semester of the M. Tech. Programme. He / She shall select the topic based on the references from international journals of repute, preferably IEEE journals. They should get the paper approved by the Programme Co-ordinator / Faculty member in charge of the seminar and shall present it in the class. Every student shall participate in the seminar. The students should undertake a detailed study on the topic and submit a report at the end of the semester. Marks will be awarded based on the topic, presentation, participation in the seminar and the report submitted.

**Goals:** This course is designed to improve written and oral presentation skills and to develop confidence in making public presentations, to provide feedback on the quality and appropriateness of the work experience, and to promote discussions on design problems or new developments.