M. Tech Degree (Full Time) Programme

in

ELECTRONICS & COMMUNICATION ENGINEERING
(Specialisation: WIRELESS TECHNOLOGY)

SCHEME OF EXAMINATION & SYLLABUS

SCHOOL OF ENGINEERING
COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY
COCHIN– 682 022

JULY – 2018

M. Tech Degree (Full Time) Programme in ELECTRONICS & COMMUNICATION ENGINEERING (Specialisation: WIRELESS TECHNOLOGY)

SEMESTER I						
Sl No.	**Course Code**	**Course Name**	**Hours/Week**			**Credits**
			L	**T**	**P**	
1	18-453-0101	Digital Communication	3	1	0	4
2	18-453-0102	Antenna Systems	3	1	0	4
3	18-453-01**	Elective I	3	1	0	3
4	18-453-01**	Elective II	3	1	0	3
5	18-453-0109	Antenna Lab	0	0	3	1
6	18-453-0110	Digital Communication Lab	0	0	3	1
7	18-453-0111	Core Common: Research Methodology & IPR	2	1	0	2
Total			14	5	6	**18**

SEMESTER II						
Sl No.	**Course Code**	**Course Name**	**Hours/Week**			**Credits**
			L	**T**	**P**	
1	18-453-0201	Electromagnetic Interference & Compatibility	3	1	0	4
2	18-453-0202	Wireless Communications	3	1	0	4
3	18-453-02**	Elective III	3	1	0	3
4	18-453-02**	Elective IV	3	1	0	3
5	18-453-0209	Wireless Communication Lab	0	0	3	1
6	18-453-0210	Seminar	0	0	3	1
7	18-453-0211	Mini Project	0	0	3	2
Total			12	4	9	**18**

SEMESTER III						
Sl No.	**Course Code**	**Course Name**	**Hours/Week**			**Credits**
			L	**T**	**P**	
1	18-453-03**	Elective V	3	1	0	3
2	18-453-03**	Elective VI	3	1	0	3
3	18-453-0307	Dissertation Phase – I	0	0	20	12

Total			6	2	20	**18**

SEMESTER IV						
Sl No.	**Course Code**	**Course Name**	**Hours/Week**			**Credits**
			L	**T**	**P**	
1	18-453-0401	Dissertation Phase – II	0	0	30	18
Total			0	0	30	**18**

***Electives must be selected from the following list for the corresponding semester*

Total credits for the M.Tech programme = **72**

ELECTIVES I & II (Semester I)	
18-453-0103	Advanced Digital Signal Processing
18-453-0104	Advanced Information Theory
18-453-0105	Communication Network
18-453-0106	Microwave Integrated Circuits
18-453-0107	Detection and Estimation of Signals
18-453-0108	Embedded Cyber Physical System

ELECTIVES III & IV (Semester II)	
18-453-0203	OFDM & MIMO Wireless Communication
18-453-0204	Software Defined Radio
18-453-0205	Multimedia Compression Techniques
18-453-0206	Wireless Sensor Networks
18-453-0207	VLSI for Wireless Communication
18-453-0208	Optical Networks

ELECTIVES V & VI (Semester III)	
18-453-0301	Cooperative Communication
18-453-0302	Analytical and Computational Techniques in Electromagnetics
18-453-0303	Optical & Satellite Communication
18-453-0304	Interconnection Networks for High Performance Computing
18-453-0305	Advanced Techniques for Wireless Reception
18-453-0306	Internet of Things

M. Tech Degree (Full Time) Programme in ELECTRONICS & COMMUNICATION ENGINEERING (Specialisation: WIRELESS TECHNOLOGY)

SEMESTER – I

18-453-0101 Digital Communication

Course Outcome: ***On completion of this course the student will be able to:***

1. ***Understand the theoretical and practical aspects of digital communication Systems.***
2. ***Analysis the performance of digital communication system***
3. ***Model various communication channels***
4. ***Realize the signal space concept and Construct the same for a modulation scheme***
5. ***Evaluate and mitigate the ISI of bandwidth constraint channel***
6. ***Explore issues related to wireless channel modelling***

Module I: Elements of a digital communication system – Signal & Vector space concept. Gram Schmidt method -Representation of digitally modulated signals – Performance of memory less modulation methods – signaling schemes with memory – CPFSK – CPM .

Module II: Communication through band limited linear filter channels: Optimum Receiver for Signals Corrupted by AWGN, Performance of the Optimum Receiver for Memory-less Modulation, Optimum Receiver for CPM Signals Optimum receiver for channels with ISI and AWGN, Linear equalization

Module III: Coding Techniques: Introduction to linear block codes, **Convolution coding** –Tree, Trellis and State diagrams — Decoding of convolutional codes - maximum likelihood decoding, Viterbi algorithm

Module IV: Digital Communication through fading multi-path channels: Characterization of fading multi-path channels, the effect of signal characteristics on the choice of a channel model, frequency-Nonselective, slowly fading channel, diversity techniques for fading multi-path channels, Digital signal over a frequency-selective, slowly fading channel. Channel Capacity of fading Channel, Water filling algorithm.

Reference Books:

1. Robert. Gallager “Principles of Digital communication”, Cambridge University Press, 2008.
2. John G. Proakis, “Digital Communications**”**," 5th edition, McGraw Hill, 2006.
3. Stephen G. Wilson, “Digital Modulation and Coding**”**, Pearson Education (Asia) Pte. Ltd, 2003.

18-453-0102 Antenna Systems

Course outcome: ***On completion of this course the student will be able to:***

1. Analysis of practical antennas.
2. Study antenna for various application
3. Understand the concept of smart antenna
4. Carryout CEM for antenna
5. Calculation of Antenna parameters
6. Design of general antenna arrays and array design method

Module 1: System Applications for Antennas- Receiving Properties of Antennas, Antenna Noise and Radiometry, Antennas in Communication Systems, Antennas in Radar Systems. Microwave Radio Communication - Frequency Modulated Microwave Radio System, Microwave Repeater Station, Line of Sight Path Characteristics, Microwave System Gain, and Satellite System Link Models, Satellite system Parameters, Link Equations, and Link Budget

Module 2: Low Profile Antennas and Personal Communication Antennas - Antennas for Compact Devices, Multiband/Broadband Handset Antennas. Fundamental Limits on Antenna Size- Electrically small antennas, Antenna Miniaturization and Fractal Antennas Human Body Effects on Antenna Performance, Radiation Hazards

Module 3: Terminal and Base Station Antennas for Wireless Applications - Satellite Terminal Antennas, Base Station Antennas, Mobile Terminal Antennas, Smart Antennas, Antenna Beamforming, Adaptive and Spatial Filtering Antennas

Module 4: CEM for Antennas: The Method of Moments - Integral Equations, Source Modeling, Weighted Residuals, Formulation and Computational Considerations, Calculation of Antenna Characteristics- The Wire Antenna

References:

1. W.L. Stutzman & G.A Thiele “Antenna Theory & Design”, 3rd edition, John Wiley & Sons, Inc. 2013
2. Balanis C A, “Antenna Theory, Analysis and Design”, 3rd edition, John Wiley & Sons, Inc. 2012.
3. Wayne Tomasi, “Advanced Electronic Communications Systems,” 6th edition, PHI, 2010.

18-453-0109 Antenna Lab
Course outcome:

On completion of this course the student will be able to:

1. Understand the measurement of practical antennas parameters.
2. Use software microwave simulation tool
3. Familiarize the microwave equipment
4. Carryout CEM for antenna
5. Do calculation of link power budget
6. Design and characterise patch microwave circuit

1. Radiation pattern of dipole antennas and antenna arrays using MATLAB.
2. Modelling of microwave networks and antennas using RF & Antenna tool box in MATLAB.
3. Simulation of printed antennas for wireless applications using HFSS /CST.
4. Fabrication of printed antennas for wireless applications.
5. Familiarisation and calibration of Vector Network Analyzer.
6. Measurement of antenna parameters using Vector Network Analyzer and Anechoic chamber.
7. Familiarizing and calibration of Spectrum Analyzer.
8. Field strength & Antenna Gain Measurement with Spectrum Analyzer.
9. Electromagnetic Simulation using ADS.
10. End-to-End RF Transceiver Measurement.

18-453-0110 Digital Communication Lab

Course Outcomes*: On completion of this lab course the students will be able to:*

1. Understand implement basic block of Digital communication system .
2. Design and implement different modulation and demodulation techniques.
3Analyze digital modulation techniques by using MATLAB tools.
4. Identify and describe different techniques in modern digital communications, in particular in source coding using MAT Lab tools.
5. Perform channel coding.

1. Simulation of digital modulation systems and its performance analysis under various channel conditions
   a) AWGN b) Band limited channel and Fading channel.
2. Study of ISI and equalizer.
3. Implementation of Viterbi algorithm.
4. Optimum power allocation in a multi carrier communication
5. Implementation of Rake receiver and its performance.

18-453-0111 Core Common: Research Methodology & IPR

Course Outcomes:

On completion of this course the student will be able to:

1. *Demonstrate knowledge of research processes (reading, evaluating, and developing)*
2. *Perform literature reviews using print and online databases*
3. *Summarize and discuss important issues and trends within the actual research area.*
4. *Write a scientific article within a limited topic but with a quality such that the article could be accepted for presentation in a conference or workshop*
5. *Create a scientifically sound and reasonable and well documented plan for a Masters thesis project of excellent quality.*
6. *Understand the basics of the four primary forms of intellectual property rights.*
7. *Compare and contrast the different forms of intellectual property protection in terms of their key differences and similarities.*

Module I

Meaning of research problem, Sources of research problem, Criteria and Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches to investigation of solutions for research problem - data collection, analysis, interpretation. Necessary instrumentation.

Module II

Effective literature review approaches, Plagiarism, Research ethics.Effective technical writing. How to write a good report and a paper?Developing a Research Proposal, Format of research proposal, Presentation and assessment by a review committee.

Module III

Nature of Intellectual Property: Patents, Industrial Designs, Trademark and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development.International Scenario: International cooperation on Intellectual Property. Procedure for grant of patents, Patenting under Patent Cooperation Treaty (PCT).

Module IV

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indication of goods,.

New Developments in IPR: Administration of Patent System. IPR of Biological Systems, Computer Software etc. Traditional knowledge: Indigenous, medicinal and bioprospecting knowledge, Need for protection. Case Studies.

References:

1. Stuart Melville and Wayne Goddard, Research methodology: An introduction for Science & Engineering students, Juta & Co Ltd, 1996.
2. Ranjit Kumar, Research Methodology: A Step by Step Guide for beginners, 2nd Edition, Pearson, 2005.
3. Gopalakrishnan N S, and Agitha T G, Principles of Intellectual Property, 2nd Edition, Eastern Book Company, 2015.
4. Bansal K and Bansal P, Fundamentals of Intellectual Property for Engineers, BS Publications, 2013.
5. Deborah E. Bouchoux, Intellectual Property: The Law of Trademarks, Copyrights, Patents, and Trade Secrets, 4th Edition, Cengage Learning, 2012.
6. Markel, Mike, Technical Communication. 11th Edition, Mac Millan, 2015.

SEMESTER – II

18-453-0201 Electromagnetic Interference & Compatibility

COURSE OUTCOMES: ***At the end of this course, the student should be able to:***

1. Identify Standards.
2 Compare EMI test methods,
3. Apply EMI mitigation techniques,
4. Learn about the precautions and shielding used in electronic gadgets.
5. Calculate EMI of a system
6. EMC Design of PCBs

Module I Introduction to EMC, Aspects of EMC, decibels and common EMC units. EMC requirements for Electronic systems: Governmental requirements, Product requirements. FCC and CISPR classifications. Antennas, elemental dipole antennas, characterization of antennas, Directivity and gain, effective aperture, Antenna Factor. Broad band Measurement Antennas.

Module II Non Ideal behavior of components; Wires, resistance and internal inductance of wires, external inductance and capacitance of parallel wires, Per unit length parameters of Resistors, Capacitors, and Inductors, Ferrites and common-mode chokes. Conducted Emission, The Line Impedance Stabilization Network (LISN).

Module III Spectra of digital circuit waveforms, spectral bounds for Trapezoidal waveforms, Spectrum analyzers. Radiated Emissions and Susceptibility: Simple emission models for wires and PCB lands, Differential-mode versus common-mode currents, differential-mode current model, common-mode current model. Simple susceptibility models for wires and PCB lands. Power supply and filter placement.

Module IV Common and differential mode current gain, power supply filters. Electro static Discharge (ESD), origin of ESD and effects of ESD. Shielding, shielding effectiveness –far-field sources, shielding effectiveness –near-field sources. EMI measurement: Open Area Test sites, Anechoic chamber, TEM Cell, GTEM Cell

References:

1. Clayton R. Paul, *Introduction to Electromagnetic compatibility*, John Wiley and Sons Inc,1992, ISBN-10: 0471549274, ISBN-13: 978-0471549277

2. V. Prasad Kodali, *Engineering Electromagnetic Compatibility Principles, Measuments, technologies and Computer Models* IEEE PRESS, ISBN 0-7803-4743-9

3. Henry W Ott, *Electromagnetic Compatibility Engineering*, John Wiley and Sons,1/e,2009, ISBN-13: 978-0470189306, ISBN-10: 0470189304

4. Archambeault Bruce R, Ramihi Omar M, Brench, *EMI/EMC Computational Modeling Handbook*, Springer publications/e,2001

18-453-0202 Wireless Communications

Course outcome: ***On completion of this course the student will be able to:***

1. Understand the various wireless communication systems. 2. Apply various channel models 3. Design & analyse equalizers 4. Identifies the issues in fading scenario 5. Apply the concept of Software defend radio 6. Solve communication issues in the Frequency and power constraint of the system

Module I Introduction to Wireless Communication. Challenges Technical and others, Different types of Mobile radio systems, Classification. Cellular Concept: Frequency reuse, channel assignment strategies, handoff strategies; Practical Handoff Consideration, Interference and system capacity, trunking and grade of service, improving coverage and capacity in cellular systems. Methods to improve coverage and capacity of cellular systems FDMA, TDMA, CDMA, SDMA, OFDMA introduction. Influence of mobile communication to the layer model.

Module II Mobile Radio Propagation: Propagation Basics, Mobile Radio Propagation Effects, Frequency dependence, Free space propagation model, Propagation mechanisms-Reflection, Diffraction and Scattering. Multipath propagation, Propagation Models, Outdoor propagation models, Indoor propagation models, Small-Scale Multipath Propagation, impulse response model of a multi-path channel, small scale multi-path measurements, parameters of mobile multi-path channels, types of small scale fading, Rayleigh and Ricean distributions, statistical models for multi-path fading channels. Practical link budget design using path loss models, Doppler Shift, Delay spread, Intersymbol Interference, Coherence Bandwidth, Types of Small-Scale Fading.

Module III Methods to improve receiver signal quality: Equalization, Diversity, and Channel coding, Fundamentals of Equalization, Working of an Adaptive Equalizer; Concepts of Diversity, Types of Diversity-Polarization Diversity, Frequency Diversity, Space Diversity, Time Diversity, Multipath diversity, RAKE Receiver . Software Defined Radio (SDR). Basics, Classification, Characteristics and benefits of a Software Radio, Practical SDR architecture, Design Principles of Software Radio. Applications of SDR.

Module IV Multiuser Systems; Future Wireless Networks, IP based cellular communication networks. Evolution of cellular networks into software controlled networks. The mobile big data, Cloud based Big Database and Data center techniques; Ad-Hoc/Mesh Networks- Design Issues.

Reference Books:

1. Theodore S. Rappaport, “Wireless Communications: Principles and Practice”, 2nd edition, Prentice Hall of India, 2005.

2. Kamilo Feher, "Wireless Digital Communications: Modulation and Spread Spectrum Techniques”, Prentice Hall of India, 2004.

3. S Haykin and M Moher, “Modern Wireless Communication”, Pearson Education, 2005.

18-453-0209 Wireless Communication Lab

Course outcome: ***Students able to***

1) analyze and implement the wireless communication systems.
2) Implement MAC protocol
3) Find Performances measure of routing protocol.
4) Implement Space time codes
5) Outage capacity of MIMO
6) Implement adaptive modulation schemes

1. Medium access protocol development (CSMA, ALOHA).
2. Channel modeling
3. Wireless Sensor network protocol
4. Routing protocols
5. Signal detection techniques.
6. LTE/WiMAX Based 4G Wireless.
7. MIMO/OFDM Wireless Systems.

18-453-0210 SEMINAR

Cousre outcome: ***Upon successful completion of the seminar, the student should be able to***

1. ***Get good exposure in the current topics in the specific stream.***
2. ***Improve the writing and presentation skills.***
3. ***Explore domains of interest so as to pursue the course project.***

Students shall individually prepare and submit a seminar report on a topic of current relevance related to the field of wireless technology. The reference shall include standard journals, conference proceedings, reputed magazines and textbooks, technical reports and URLs. The references shall be incorporated in the report following IEEE standards reflecting the state-of-the-art in the topic selected. Each student shall present a seminar for about 45 minutes duration on the selected topic. The report and presentation shall be evaluated by a team of internal experts comprising of 3 teachers based on style of presentation, technical content, adequacy of references, depth of knowledge and overall quality of the seminar report.

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18-453-0211 MINI PROJECT

Course outcome: ***Students able to***

1) Build and test the mini project successfully
2) Improve the communication and management skills
3) Study and enhance software/ hardware skills.
4) Demonstrate and build the project successfully by hardware requirements, coding, emulating and testing.
5) To report and present the findings of the study conducted in the preferred domain
6) Identify the requirements for the real world problems.

Each batch comprising of 1 to 2 students shall design, develop and realize a complete electronic product. Basic elements of product design must be considered each student shall submit a project report at the end of the semester. The project report should contain the design and engineering documentation including the test results. Innovative design concepts, reliability considerations and aesthetics / ergonomic aspects taken care of in the project shall be given due weight.

SEMESTER – III

18-453-0307 DISSERTATION PHASE – I

Course Outcome: ***Upon successful completion of the project phase 1, the student should be able to***

1. ***Identify the topic, objectives and methodology to carry out the project.***
2. ***Finalize the project plan for their course project.***

Each student shall identify a project related to wireless technology with the help of a guide / faculty. The project work has to be carried out within the department itself. There is a project guide allotted to each student by the head of the division / course coordinator. Normally a faculty member shall not supervise more than five individual M.Tech candidates. However the department may evolve a transparent policy for the distribution of M.Tech.in the department. Teachers entrusted with the guidance of the project work shall help the student in identifying, analyzing the problem of the project work. The project work shall be reviewed and evaluated periodically by the project guide during 3rd semester and be continued in the 4th semester. Under special cases, student can carry out a project in a reputed R&D institution with the permission of course coordinator/ HOD.

At the end of the semester, each student shall submit a project report comprising of the following.

1. Literature Review.
2. Application and feasibility of the project.
3. Objectives.
4. Detailed documentation including circuit diagrams and algorithms / circuits.
5. Project implementation action plan.

The project must be evaluated by a team comprising of 2 internal examiners including the project guide, coordinator /HOD

SEMESTER – IV

18-453-0401 DISSERTATION PHASE – II

Course Outcome: ***Upon successful completion of the this phase, the student should be able to***

1. ***Get a good exposure to a domain of interest.***
2. ***Get a good domain and experience to pursue future research activities.***

The project work started in the third semester shall be reviewed and evaluated periodically in the 4th semester by the guide. At the end of the semester, each student shall submit a project report comprising of the following.

Literature Review

1. Objectives
2. Detailed documentation including circuit diagrams and algorithms / circuits
3. Conclusion
4. Future scope

The thesis will be examined by an oral examination committee. The committee shall consist of the thesis supervisor (project guide), one faculty member from the department (course coordinator or faculty appointed by HOD/ HOD). The final evaluation of the project shall include the following.

1. Presentation of the work
2. Oral examination
3. Demonstration of the project against objectives
4. Quality and content of the project report

18-453-0103 Advanced Digital Signal Processing

Course outcome: ***On completion of this course the student will be able to:***

1. ***Understand the broad perspective on DSP systems.***
2. ***Explore the transform domain techniques for signal processing***
3. ***Understand ST analysis and Define and Describe Wavelet theory***
4. ***Carryout wavelet decomposition of signal***
5. ***Understand fundamentals of adaptive filters***
6. ***Design of multirate systems***

Module I : Wavelets & Applications: Fourier and Sampling Theory - Generalized Fourier theory, Fourier transform, Short-time(windowed) Fourier transform, Time-frequency analysis, Wavelets - The basic functions, Specifications, Admissibility conditions, Continuous wavelet transform (CWT), Discrete wavelet transform (DWT).

Module II: The multiresolution analysis (MRA) of L2(R) - Wavelet decomposition and reconstruction of functions in L2(R). Fast wavelet transform algorithms - Relation to filter banks, Wavelet packets. Wavelet Transform Applications: Image processing - Compression, Denoising, Edge detection and Object detection. Audio - Perceptual coding of digital audio. Wavelet applications in Channel coding.

Module III : Adaptive Filters: FIR adaptive filters -adaptive filter based on steepest descent method-Normalized LMS. Applications. Adaptive channel equalization etc.

Module IV : Multi-rate Digital Signal Processing**:** Mathematical description of sampling rate conversion - Interpolation and Decimation, Decimation by an integer factor - Filter implementation for sampling rate conversion, Sub band coding.

References:

1. Monson H.Hayes, “Statistical Digital Signal Processing and Modeling,” Wiley India, 2008.

2. John G. Proakis and Dimitris G.Manolakis, “Digital Signal Processing,” Fourth Edition, Prentice Hall of India, New Delhi, 2007.

3. John G. Proakis et.al., “Algorithms for Statistical Signal Processing,” Pearson Education, 2002.

4. Dimitris G.Manolakis et.al., “Statistical and Adaptive Signal Processing,” McGraw Hill, Newyork, 2000.

18-453-0104 Advanced Information Theory

Course outcome: ***On completion of this course the student will be able to:***

1. ***Know the most important basics in information theory***
2. ***Know lossless data compression of discrete sources***
3. ***Know the data transmission capacity over discrete channels***
4. ***Identifies the capacity of network channel***
5. ***Know convex optimization***
6. ***Implement data compression algorithms***

Module I: Introduction to Information theory- Uncertainty and information – average mutual information, Average self-information, Average conditional self-information, Measures of information-Information content of a message-Average information content of symbols in long independent sequences – Average information content of symbols in long dependent sequences Information measure for continuous random variables.

Module II: Communication channels, Discrete communication channel-Rate of information transmission over a discrete channel-capacity of a discrete memory less channel-continuous channel – Shannon – Hartley theorem and its implications. Channel models- channel capacity –BSC ,BEC-cascade channels-symmetric channel –asymmetric channel and their capacities-Information capacity theorem ,Shannon limit , channel capacity for MIMO system (case study).

ModlueIII: Source Coding :Purpose of coding, Uniquely decipherable codes ,Shannon's I and II fundamental theorem- Source coding theorem –Huffman coding – Shannon fano-Elias coding, Arithmetic coding –Lempel-Ziv algorithm- Rate distortion function-optimum quantizer design.

Module IV: Channel Coding: Linear block codes and cyclic codes-Galois fields, Vector spaces and matrices, Noisy channel coding theorem. Decoding of linear block codes , error detection and error correction capability perfect codes, Hamming codes. Low density parity check (LDPC) Turbo codes-Turbo decoding- Space Time Codes. Network information theory.

Reference Books:

1. Cover and Thomas, "Elements of Information theory," Wiley Eastern Limited, 2008.

2. Ranjan Bose, "Information Theory Coding and Cryptography," Tata McGraw Hill Education Private Ltd, New Delhi, 2010.

18-453-0105 Communication Network

Course outcome: ***On completion of this course the student will be able to:***

1. ***Understand the layered network architecture.***
2. ***Explore the Local Area Networks, and Wide Area Networking issues***
3. ***Understand routing and flow control.***
4. ***Identifies the issues in common resource sharing in a multi-access scenario***
5. ***Understand QoS in Network***
6. ***Issues of communication network management***

Module I: Overview of networking principles, networking technologies Analysis of packet multiplexed stream traffic; Introduction to Deterministic Network Calculus and packet scheduling algorithms and their analysis. Circuit multiplexing. Blocking probability calculations. Application to a simple analysis of cellular network. Window flow/congestion control algorithms, analysis of the TCP protocol.

Module II: Stochastic analysis of packet multiplexed stream traffic. Overview of queuing models, Little's theorem, M/G/1 queue formulae, development of equivalent bandwidth of a stream source. M/M/1, M/M/m, M/M/m/m, M/M/∞, M/G/1 queuing models – Networks of Transmission lines - Time reversibility (Burke's theorem) – Network of Queues (Jackson's theorem).

Module III: Introduction to multiple access channels. Description and analysis of the Aloha, Ethernet, and CSMA/CA protocols. Brief overview of ad hoc networks and issues in sensor networks. Packet Switching and Architecture of routers and packet switches. Queuing issues in packets switches, input and output queuing, virtual-output-queuing, maximum and maximal matching algorithms, stable matching algorithms.

Module IV: Switching architectures. Algorithms for packet processing in switches and routers. Overview of routing issues and principles. Introduction to optimal routing. Bellman-Ford and Dijkstra's shortest path routing algorithms. Brief overview of QoS routing and aggregate routing. Network Management.

References

1. A Kumar, D Manjunath and J Kuri, Communication Networking: An Analytical Approach, Morgan Kaufman Publishers, 2004.

2. D Bertsekas and R Gallager. "Data Networks", Prentice Hall (India), Second Edition. 1998

3. Peterson and B Davie, "Computer Networks: A Systems Approach" Morgan Kaufman Publishers, Third Edition.

18-453-0106 Microwave Integrated Circuits

Course outcome: ***On completion of this course the student will be able to:***

1. ***Understand the planar microwave wave structure.***
2. ***Study various MIC components***
3. ***Design & analyse microwave strip elements like filters***
4. ***Identifies the issues in fabrication of MMIC***
5. ***Recognise the principle of active microwave components***
6. ***Frequency and power constraint of microwave components.***

Module I: Introduction, Types of MICs and their technology, Propagating models, Analysis of MIC by conformal transformation, Numerical method, Hybrid mode analysis, Losses in micro strip, Introduction to slot line and coplanar waveguide. Introduction to coupled microstrip, Even and odd mode analysis, Branch line couplers, Design and fabrication of lumped elements for MICs, Comparison with distributed circuits. Scattering Parameters Impedance matrix, Admittance matrix Passive reciprocal loss-less two port junctions General two-port network Power gain/loss, Signal flow graph, Transducer power gain/loss ABCD parameters

Module II: Ferromagnetic substrates and inserts, Micro strip circulators, Phase shifters, Microwave transistors, Parametric diodes and amplifiers, PIN diodes, Transferred electron devices, Avalanche, IMPATT, BARITT diodes. Amplifier power gain Stability circles, Constant-gain circles Noise figure, Noise figure in cascaded network Constant noise figure circles LNA design

Module III: MICROSTRIP CIRCUIT DESIGN AND APPLICATIONS: Introduction, Impedance transformers, Filters, High power circuits, Low power circuits, MICs in Satellite and Radar.

Module IV: MMIC TECHNOLOGY: Fabrication process of MMIC, Hubrid MMICs, Dielectric substances, Thick film and thin film technology and materials, Testing methods, Encapsulation and mounting of devices.

Reference Book:

1. Gupta K.C and Amarjit Singh, “Microwave Integrated Circuits”, John Wiley, New York, 1975.
2. Hoffman R.K."Handbook of Microwave integrated circuits", Artech House, Bostan, 1987

18-453-0107 Detection and Estimation of Signals

Course Outcome: ***On completion of this course the student will be able to:***

1. ***Understand the signal detection and its parameter estimation***
2. ***Do hypothesis testing***
3. ***Design & analyse linear detection***
4. ***Estimation of random signal parameters***
5. ***Solve problems involving estimation of different signals***
6. ***Implement Kalman filtering***

Module I: Review of Gaussian variables and processes; problem formulation and objective of signal detection and signal parameter estimation in discrete-time domain. **Statistical Decision Theory:** Bayesian, mini-max, and Neyman-Pearson decision rules, likelihood ratio, receiver operating characteristics, composite hypothesis testing, locally optimum tests, detector comparison techniques, asymptotic relative efficiency.

Module II; Detection of Deterministic Signals: Matched filter detector and its performance; generalized matched filter; detection of sinusoid with unknown amplitude, phase, and frequency and arrival time, linear model. Detection of Random Signals: Estimator-correlator, linear model, general Gaussian detection, detection of Gaussian random signal with unknown parameters, weak signal detection.

Module III; Nonparametric Detection: Detection in the absence of complete statistical description of observations, sign detector, robustness of detectors. Estimation of Signal Parameters: Minimum variance unbiased estimation, Fisher information matrix, Cramer-Rao bound, sufficient statistics, minimum statistics, complete statistics; linear models; best linear unbiased estimation; maximum likelihood estimation, invariance principle; estimation efficiency; Bayesian estimation: philosophy, nuisance parameters, risk functions, minimum mean square error estimation, maximum a posteriori estimation.

Module IV : Signal Estimation in Discrete-Time: Linear Bayesian estimation, Weiner filtering, dynamical signal model, discrete Kalman filtering

References:.

1. H. L. Van Trees, "Detection, Estimation and Modulation Theory: Part I, II, and III", John Wiley, NY, 1968.
2. H. V. Poor, "An Introduction to Signal Detection and Estimation", Springer, 2/e, 1998.
3. S. M. Kay, "Fundamentals of Statistical Signal Processing: Estimation Theory", PHI, 1993.
4. S. M. Kay, "Fundamentals of Statistical Signal Processing: Detection Theory", PHI, 1998.

18-453-0108 Embedded Cyber Physical System

Course outcome: ***On completion of this course the student will be able to:***

1. Understand the basics of models, analysis tools, and control for embedded systems operating in real time.

2. Students learn how to combine physical processes with computation.

3. Realize models of computation, control, analysis and verification, interfacing with the physical world, mapping to platforms

4. Explore distributed embedded systems.

5. Study Finite state machine

6. Recognize Research trends in cyber physical systems

Module I Modeling of Dynamic Behaviors: Continuous, Newtonian Mechanics -Actor Models , Properties of Systems, Feedback Control , Discrete Discrete Finite-State Machines, Behaviors and Traces, Hybrid Classes of Hybrid Composition of State Machines, Concurrent Composition Hierarchical State Structure of Models. Synchronous - Reactive Models - Dataflow Models of Computation. Timed Models of Computation.

Module II Design of Embedded Systems- Memory Architectures interfacing with the physical world: sensor/actuator modeling and calibration. Program Design and Analysis

Module III Mapping to embedded platforms: real-time operating systems, execution time analysis, scheduling, concurrency, Multitasking, Scheduling.

Module IV Distributed embedded systems: Protocol design, predictable networking, security, Analysis and Verification - analysis of embedded systems, methods for desired and undesired behaviors and checking - an implementation.

References:.

1. A. Lee and s. A. Seshia Introduction to embedded systems - a cyber-physical systems approach second edition, mit press, 2017.
2. Wayne Wolf, “Computers as Components: Principles of Embedded Computing system Design,” 2nd Edition, Morgan Kaufmann Publishers, 2008.
3. Raj Kamal, “Embedded Systems-Architecture, Programming and Design,” The McGraw Hill Companies, 2nd Edition, 2008.
4. Allan C. Shaw, “Real time systems & Software,” John Wiley & Sons, India Reprint, 2001.
5. Richard Zurawski, “Embedded Systems Handbook,” Industrial Information Technology series, Taylor and Francis group, the academic division of T&F Informa plc.

18-453-0203 OFDM & MIMO Wireless Communication

Course outcome: ***On completion of this course the student will be able to:***

1. ***Understand the OFDM communication system.***
2. ***Apply resource allocation in OFDM***
3. ***Reduce PAPR reduction methods***
4. ***Identifies the use of space dimension to increase capacity***
5. ***Find the degree of freedom of space communication***
6. ***Apply simultaneous use of space time freedom to solve network issues.***

Module I OFDM Basics: Multi-carrier transmission- Data Transmission using Multiple Carriers-Multicarrier Modulation with Overlapping Sub channels OFDM modulation & demodulation, BER; coded-OFDM; Orthogonal frequency-division multiple-access (OFDMA). OFDM Synchronization: Effect/estimation of symbol-time offset (STO); Effect/estimation of carrier-frequency offset (CFO); Effect/compensation of sampling-clock offset (SCO).

Module II Peak-to-Average Power Ratio Reduction (PAPRR): Distribution of OFDM-signal amplitude; PAPR & oversampling; Frequency and Timing Offset Issues -Mitigation methods

Module III Introduction to MIMO, MIMO Channel Capacity, SVD and Eigen modes of the MIMO Channel MIMO Spatial Multiplexing - MIMO Diversity Gain: Beam forming Antennas Diversity: Receive-antenna diversity; Transmit-antenna diversity.

Module IV Space-Time Modulation and Coding: ML detection, rank and determinant criteria, space-time trellis and block codes - Detection for Spatially Multiplexed MIMO Systems - MIMO - OFDM, Massive MIMO

References

1 Li Wang, Ming Jiang, Lajos L. Hanzo, Yosef Akhtman. “MIMO-OFDM for LTE, WiFi and WiMAX” Weily 2011

2. Ezio Biglieri Robert Calderbank Anthony Constantinides Andrea Goldsmith Arogyaswami Paulraj H. Vincent MIMO Wireless Communications Cambridge University Press (2007)

3. Yong Soo Cho, Jaekwon Kim, Won Young Yang, Chung G. Kang “MIMO-OFDM Wireless Communications with MATLAB “John Wiley & Sons (2010)

4 Ramjee Prasad “OFDM for Wireless Communications Systems” , Artech House Publishers (2004

18-453-0204 Software Defined Radio

Course outcome: ***On completion of this course the student will be able to:***

1. Understand the SDR communication system.

2. under the terminology used in industrial data-sheets

3. Reduce PAPR reduction methods

4. Select appropriate commercial solutions for a practical transceiver design.

5. Understanding the interplay of analog and digital signal processing for power as well as spectrum efficient transmission and reception of signal leads to an optimized,

6. Implement hardware, and software domain for flexibility and configurability

Module I Basic SDR – Software and Hardware Architecture of an SDR – Spectrum Management – Managing unlicensed spectrum – Noise Aggregation. distortion parameters-Sources and metrics of distortion in a transceiver,Nonlinear distortion

Module II SDR As Platform For Cognitive Radio: Introduction – Hardware and Software architecture – SDR development process and Design – Application software – Component development – Waveform development – cognitive waveform development Linearization Techniques for nonlinear distortion in SDR, Predistortion Techniques for nonlinear distortion in SDR.

Module III Cognitive Radio Technology **: I**ntroduction – Radio flexibility and capability – Aware – Adaptive – Comparison of Radio capabilities and Properties – Available Technologies – IEEE 802 Cognitive Radio related activities – Application.

Module IV CR Technical Challenges Design Challenges associated with CR – Hardware requirements – Hidden primary user problem – detecting spread spectrum primary users – sensing duration and frequency – security SPECTRUM SENSING Overview – Classification - Matched filter – waveform based sensing – cyclostationary based sensing – Energy detector based sensing – Radio Identifier – Cooperative sensing- other sensing methods

REFERENCES

1. Huseyin Arslan , *"Cognitive Radio, Software Defined Radio and Adaptive wireless system,* Springer, 1 edition ,September 24, 2007

2. Bruce A Fette, *"Cognitive Radio Technology"*, Academic Press, 2009.

3. Mitola, J. and J. Maguire, G. Q., *"Cognitive radio: making software radios more personal,"* IEEE Personal Commun. Mag., vol. 6, no. 4, pp. 13–18, Aug. 1999.

4. Tevfik Y¨ucek and H¨useyin Arslan, *"A Survey of Spectrum Sensing Algorithms for Cognitive Radio Applications"* , IEEE Communications Surveys & Tutorials, Vol. 11, No.1, First Quarter 2009, Pp 116-130

5. Patrick Roblin, "Nonlinear RF circuits and nonlinear vector network analyzers: interactive measurement and design techniques", Cambridge University Press, 2011.

6. F. M. Ghannouchi, O. Hammi and M. Helaoui, "Behavioral modeling and predistortion of wideband wireless transmitters", John Wiley & Sons, 2015

18-453-0205 Multimedia Compression Techniques

Course outcome: ***On completion of this course the student will be able to:***

1. ***Understand the multimedia***
2. ***Identify Constraint of multimedia in a wireless network***
3. ***Know the importance of media compression***
4. ***Identifies the use of redundancy of human system for multimedia transmission***
5. ***Know various multimedia standards***
6. ***Implement data compression algorithms***

Module I: Introduction to Multimedia – components of multimedia- Graphics and Image Data Representations -Fundamental Concepts in Video – analog and digital video. Basics of Digital Audio – Storage requirements for multimedia applications -Need for data compression. Audio Compression: Digital audio- audio compression techniques

ModuleII: Data Compression: Huffman coding, Arithmetic coding – Adaptive methods – Adaptive Huffman Coding — Adaptive Arithmetic Coding – Dictionary Methods– LZW algorithm.

Module III: Image Transforms – orthogonal transforms- DCT, JPEG , progressive image Differential lossless compression –DPCM. Wavelet based compression- Filter banks, DWT, Multiresolution decomposition, EZW Coders, JPEG 2000 standard (case study)

Module IV: Video Compression: Video signal components - Video compression techniques - Motion Compensation video compression standards (H.264).

References:

1. Mark S.Drew and Ze-Nian Li, “Fundamentals of Multimedia,” PHI, 1st Edition, 2008.

2. David Salomon, “Data Compression – The Complete Reference,” Springer Verlag New York Inc.,3rd Edition, 2008.

18-453-0206 Wireless Sensor Networks

Course outcome: ***On completion of this course the student will be able to:***

1. ***Know the issues of sensor network***
2. ***Methods for energy conservation/ mitigation***
3. ***Know important sensor protocols***
4. ***Know the application of sensor network***
5. ***Exposure to IoT concept***
6. ***Know the distributed processing***

Module I Mobile ad hoc networking; imperatives, challenges and characteristics - Applications, Deployment & Configuration, Localization - Coverage and connectivity, Topology control, Connected dominating sets.

Module II Wireless Communications,- Link quality, shadowing and fading effects, Medium Access, - Scheduling sleep cycles, random access MAC, S MAC Energy efficient communication in ad hoc networks. Power save protocols.

Module III Data Gathering - Tree construction algorithms and analysis - Asymptotic capacity - Lifetime optimization formulations, Routing and Querying, Routing approaches. Proactive and reactive protocols. Clustering and hierarchical routing. Multipath routing. Security aware routing. Maximum life time routing.

Module IV Collaborative Signal Processing and Distributed Computation:- Detection, estimation, classification problems, Characterization of network traffic. QOS classification. Self similar processes. Statistical analysis of non – real time traffic and real – time services. Security issues- Attacks and countermeasures. Intrusion detection. Security considerations in ad hoc sensor networks.

Reference books:

1. Holger Karl & Andreas Willig, " Protocols And Architectures for Wireless Sensor Networks" , John Wiley, 2005.
2. Feng Zhao & Leonidas J. Guibas, “Wireless Sensor Networks- An Information Processing Approach", Elsevier, 2007.
3. Kazem Sohraby, Daniel Minoli, & Taieb Znati, “Wireless Sensor Networks- Technology, Protocols, And Applications”, John Wiley, 2007.
4. Anna Hac, “Wireless Sensor Network Designs”, John Wiley, 2003.

18-453-0207 VLSI for Wireless Communication

Course Outcomes: : ***On completion of this course the student will be able to:***

1. Understand the basic components and devices and their design.

2. Study about the different types of mixers.

3. Design phase detectors and oscillators.

4. Design and implementation of FIR and IIR filters in subsystems.

Implement CDMA in Multitier Wireless System

Module I: COMPONENTS AND DEVICES Integrated inductors, resistors, MOSFET and BJT AMPLIFIER DESIGN: Low Noise Amplifier Design - Wideband LNA - Design Narrowband LNA - Impedance Matching - Automatic Gain Control Amplifiers – Power Amplifiers

Module II : MIXERS Balancing Mixer - Qualitative Description of the Gilbert Mixer - Conversion Gain – Distortion - Low Frequency Case: Analysis of Gilbert Mixer – Distortion - High-Frequency Case – Noise - A Complete Active Mixer. Switching Mixer - Distortion in Unbalanced Switching Mixer - Conversion Gain in Unbalanced Switching Mixer - Noise in Unbalanced Switching Mixer - A Practical Unbalanced Switching Mixer. Sampling Mixer - Conversion Gain in Single Ended Sampling Mixer - Distortion in Single Ended Sampling Mixer - Intrinsic Noise in Single Ended Sampling Mixer - Extrinsic Noise in Single Ended Sampling Mixer.

Module III FREQUENCY SYNTHESIZERS Phase Locked Loops - Voltage Controlled Oscillators - Phase Detector – Analog Phase Detectors – Digital Phase Detectors - Frequency Dividers - LC Oscillators - Ring Oscillators - Phase Noise - A Complete Synthesizer Design Example (DECT Application).

Module IV Data converters in communications, adaptive Filters, equalizers and transceivers IMPLEMENTATIONS VLSI architecture for Multitier Wireless System

REFERENCES:

1. B.Razavi ,"RF Microelectronics" , Prentice-Hall ,1998.
2. Bosco H Leung "VLSI for Wireless Communication", Pearson Education, 2002.
3. Thomas H.Lee, "The Design of CMOS Radio –Frequency Integrated Circuits', Cambridge University Press ,2003.
4. Emad N Farag and Mohamed I Elmasry, "Mixed Signal VLSI Wireless Design - Circuits and Systems", Kluwer Academic Publishers, 2000.
5. Behzad Razavi, "Design of Analog CMOS Integrated Circuits" McGraw-Hill, 1999. 6. J. Crols and M. Steyaert, "CMOS Wireless Transceiver Design," Boston, Kluwer Academic Pub., 1997.

18-453-0208 Optical Networks

Course outcome: ***On completion of this course the student will be able to:***

1. ***Know the concept of optical networking***
2. ***Study optical networking components***
3. ***Understand optical packet switching***
4. ***Evaluate the performance of different routing protocols***
5. ***Explore methods for improving the network reliability***
6. ***Understand different optical network architecture***

Module I: Optical Networking-Introduction and Challenges: Advantages of optical network, overview and architecture, WDM optical networks, all optical networks, Challenges of optical WDM network. **Optical Networking Components/Building Blocks:** Optical transmitters, semiconductor laser diode, tunable and fixed laser, laser characteristics, photodectors, tunable and fixed optical filters, channel equalizers, optical amplifiers and its characteristics, semiconductor laser amplifier, Raman amplifier, doped fiber amplifier, various switching elements, OADM, OXC, CLOS architecture, MEMS, wavelength convertors.

Module II Single and Multi-hop Networks: Introduction to single and multi-hop networks, Characteristics of single and multi-hop networks,. Optical packet switching basics, header and packet format, contention resolution in OPS networks **Optical Access Network:** Introduction to access network, PON, EPON and WDN

Module III Optical Metro Networks: Introduction to metro network, overview of traffic grooming in SONET ring, traffic grooming in WDM ring **Routing and wavelength assignment:** Problem formulation, routing sub-problem: fixed routing, fixed alternate routing, adaptive routing, fault tolerant routing, wavelength assignment sub-problem, algorithms: simulated annealing, flow deviation algorithm.

Module IV

Optical Multicasting and traffic grooming: Introduction to multicasting, Multicast-capable switch architecture, unicast, broadcast and multicast traffic, multicast tree protection, traffic grooming overview, static and dynamic traffic grooming. Network survivability - Optical Burst Switching - burst switching protocols-wavelength channel scheduling.

References:

1. C. Siva Ram Murthy and Mohan Gurusamy, “WDM Optical Networks: Concepts, Design and Algorithms”, Prentice Hall of India, 2002.

2. Rajiv Ramaswami and Kumar N. Sivarajan, “ Optical Networks: A Practical Perspective, Second edition, Morgan Kaufmann Publishers, 2002.

18-453-0301 Cooperative Communication

Course outcome: ***On completion of this course the student will be able to:***

1. ***Know the additional freedom of cooperation in wireless scenario***
2. ***Know capacity limit of cooperative channel***
3. ***Know the diversity of cooperative channel***
4. ***Identifies the capacity bound in cooperative scenario***
5. ***Know optimization of resource in cooperative scenario***
6. ***Know massive mimo concept***

Module I: Introduction to Cooperative Communications Systems, Cooperation in Wireless Network, Cooperative Diversity , Capacity theorems for the relay channel, spatial diversity in wireless networks, Cooperative strategies and capacity theorems for relay networks, Capacity bounds for cooperative diversity.

Module II: Cooperative Demodulation , Modulation and demodulation for cooperative diversity in wireless systems, performance of cooperative demodulation with decode-and-forward relays, OFDM Cooperative Space-Time Diversity System, Symbol error probabilities for general cooperative links

Module III: Cooperative Space-Time Coding, Space-Time Codes for High Data Rate Wireless Communication, Distributed space-time-coded protocols, Fading relay channels: performance limits and space-time signal design, Space-time diversity enhancements using collaborative communications.

Module IV: Channel access issue Cooperative Multiple Access Communication, Relay channel and protocol , Relay selection, Energy efficiency

References

1. Yan Zhang, Hsiao-Hwa Chen, Mohsen Guizan Cooperative Wireless Communications Auer Bach Publications 2009
2. K.J.R. Liu, A.K. Sadek, W. Su, A. Kwasinski, Cooperative Communications and Networking, Cambridge University Press, 2008.
3. S. Haykin and K.J.R. Liu, Eds., Handbook on Array Processing and Sensor Networks, IEEE-Wiley, 2009.
4. K.J.R. Liu and B. Wang, Cognitive Radio Networking and Security: A Game Theoretical View, Cambridge University Press, 2010.
5. H. V. Zhao, W.S. Lin, and K.J.R. Liu, Behavior Dynamics in Media-Sharing Social Networks, Cambridge University Press, 2011.

18-453-0302 Analytical and Computational Techniques In Electromagnetics

Course outcome: ***On completion of this course the student will be able to:***

1. ***Exposure to the research in the area of RF anf Microwaves Engineering***
2. ***Apply finite element method to microwave structure***
3. ***Apply FEM to solve integral equation***
4. ***Identifies the constrains of computational method***
5. ***Exposure to FDTD***
6. ***Know 3D FDTD***

Module I Introduction: Elements of Computational Methods, Basis Functions, Sub-domain Basis Functions, Entire-domain Basis Functions, Convergence and Discretization Error Convergence Test, Order of Convergence, Disctretization Error and Extrapolation, Discretization of Operators, Discretization Error in FDM, FDTD, and FEM, Stability of Numerical Solutions, Stability of FDTD Solution, Stability of Matrix Solution, Accuracy of Numerical Solutions, Modeling Errors, Truncation Error, Round-off Error, Validation, Spurious Solutions, Formulations for the Computational Methods

Module II Method of Moments: Basis Functions**,** Sub-domain Basis Functions, Entire-domain Basis Functions, Point Matching and Galerkin's Methods, Eigen value Analysis using MoM**.** Solution of Integral Equations using MoM**,** Static Charge Distribution on a Wire, Analysis of Stripline, Analysis of Wire Dipole Antenna**,** Scattering from a Conducting Cylinder of Infinite Length, Greens functions.

Module III Finite Difference Time Domain Analysis: FDTD Analysis in One-Dimension: Pulse Propagation in a Transmission Line, Spatial Step Δx and Numerical Dispersion, Time Step Δt and Stability of the Solution, Source or Excitation of the Grid, Absorbing Boundary Conditions, Applications of One-Dimensional FDTD Analysis, Reflection at an Interface, Determination of Propagation Constant, Design of Material Absorber, Exponential Time-stepping Algorithm in the Lossy Region, FDTD Analysis in Two-Dimensions, Unit Cell, Numerical Dispersion in Two-Dimensions, Time Step Δt for Two-Dimensional Propagation, Absorbing Boundary Conditions for Propagation in Two, Dimensions, Perfectly Matched Layer ABC's FDTD Analysis in Three-Dimension, Yee Cell, Numerical Dispersion in Three-Dimension, Time Step Δt for Three-Dimensional Propagation, Absorbing Boundary Conditions and PML for Three-Dimensions Implementation of Boundary Conditions in FDTD, Perfect Electric and Magnetic Wall Boundary Conditions, Interface Conditions

Module IV : Finite Element Method: Basic Steps in Finite Element Analysis**,** Discretization or Meshing of the Geometry**,** Derivation of the Element Matrix**,** Assembly of Element Matrices**,** Solution of System Matrix**,** Post-processing**,** FEM Analysis in One-dimension**,** Treatment of Boundary and Interface

Conditions**,** Accuracy and Numerical Dispersion**,** FEM Analysis in Two-dimension, Element Matrix for Rectangular Elements**,** Element Matrix for Triangular Elements**,** Assembly of Element Matrices and System Equations**,** Capacitance of a Parallel Plate Capacitor**,** Cut-off Frequency of Modes in a Rectangular Waveguide**,** FEM Analysis of Open Boundary Problems

References:

1. Ramesh Garg, Analytical and Computational Methods in Electromagnetics, Artech House, 2008, ISBN-10: 1596933852

2. Matthew N. O. Sadiku, Numerical Techniques in Electromagnetics, CRC press, 2/e, 2000.

3. David B. Davidson, Computational Electromagnetics for RF and Microwave Engineering, Cambridge university press,2/e,2010

4. Allen Teflove, Susan C Hagness, Computational Electrodynamics: The Finite Difference Time Domain Method., Artech House publications,3/e,2005

5. R.F. Harrington, Field Computation by Moment Method., Wiley,1993

6. John L. Volakis, and Kubilay Sertel, Frequency Domain Hybrid Finite Element Methods forElectromagnetics, Morgan & Claypool Publishers ,2006

7. Balanis.C.A. Advanced Engineering Electromagnetics,Wiley Publications, 1989, ISBN-10: 0471621943

18-453-0303 Optical & Satellite Communication

Course outcome: ***On completion of this course the student will be able to:***

1. Design and use of modern optical communication systems with emphasis on components and network architecture

2. Identify the various optical fiber modes, configurations and various signal degradation factors associated with optical fiber.

3. Know the important optical the various sources and optical detectors and their use in the optical communication system

4. Analyze the performance of satellite communications systems

5. Know analog and digital technologies are used for satellite communications networks

6. Know the topologies and applications of those networks.

Module-I: Satellite System Technology Satellite orbits, Satellite constellation and ISL, orbital parameters, look angle determination, launching procedures. Spacecraft subsystems - Attitude and orbit control, power, TT & C, Communication and antennas. Earth station engineering - Transmitter and receiver, antenna. Link Design: Digital satellite link analysis and design for FSS and BSS - link budget and Eb/No calculations. Performance impairments - Noise, interference, propagation effects and frequency considerations.

Module-II: Access Techniques FDMA concept- Inter modulation and back off - SPADE system. TDMA concept - Frame and burst structure - Frame acquisition and synchronization - Satellite Switched TDMA system. CDMA concepts - DS and FH System acquisition and Tracking.

Module-III: Digital Transmission Systems Point-to-point Links, coding and error considerations, Noise effects on system performance. Analog Systems:-Carrier-to-Noise Ratio, Multichannel Transmission Techniques.

Module-IV: Optical amplifiers and Integrated Optical devices Optical amplifiers, Amplifier Noise, System Applications, Wavelength Converters. Integrated Optical devices.Optical Networks:- Basic Networks, SONET/SDH, Broadcast-and-Select WDM Networks, Wavelength-Routed Networks, Ultrahigh Capacity Networks.

Text Books:

1. Tri T. Ha, Digital Satellite Communication Systems Engineering, McGraw Hill, 1990.

2. Wilbur L. Pritchard, Henri G. Suyderhoud, and Robert A. Nelson, Satellite Communication System Engineering, 2nd Edn., Pearson Education, New delhi 2006.

3. G. Keiser, Optical Fibre Communications, Mc-Graw-Hill 3rd edition 2006

4 J.M.Senior, Optical Fibre Communications Principles and Practice, PHI 3rd edition 2008

18-453-0304 Interconnection Networks for High Performance Computing

Course Outcome: ***On completion of the course students are able to***

1. Examines the architecture, design methodology, and trade-offs of interconnection networks that are used in high-performance computing systems
Study multi-core systems
3. Evaluate future technologies for implementing the interconnection network.
4. Address router issues
5. Carryout Performance measures of networking
6. Understand various router architecture

Module I: Introduction to Interconnection Networks Need for Interconnection Networks, Uses of Interconnection Networks – Processor-Memory Interconnect, I/O Interconnect, Packet Switching Fabric. Network Basics: Topology – Routing – Flow Control – Router Architecture – Performance of Interconnection Networks.

Module II: Network Topology Topology Basics: Channels and Nodes – Direct and Indirect Networks – Paths – Symmetry. Traffic Patterns, Performance: Throughput and Maximum Channel Load – Latency – Path Diversity.Structure of Butterfly Networks and Torus Networks.

Module III: Routing and Flow ControlTaxonomy of Routing Algorithms, Routing Relation, Routing Mechanics: Table based Routing – Algorithmic Routing. Different types of routingFlow Control Basics, Buffered Flow Control: Packet-Buffer flow control, Flit Buffer flow control. Deadlock and Livelock.

Module IV: Router Architecture Basic Router Architecture: Block Diagram - Router Pipeline. Router Datapath Components: Input Buffer Organization – Switches – Output Organization.Arbitration and Allocation.

References:

1. W. J. Dally and B. Towles "Principles and Practices of Interconnection Networks", Morgan Kauffman Publishers.
2. J. Duato, S. Yalamanchili and L. Ni, Morgan "Interconnection Networks: An Engineering Approach", Kauffman Publishers, 2002.
3. N.E Jerger and L.-S Peh**,** "On-Chip Networks", Morgan Claypool Publishers, 2009**.**
4. Timothy M. Pinkston and Jose Duato, "Computer Architecture: A Quantitative Approach" 5th ed., Morgan Kaufmann, 2012.

18-453-0305 Advanced Techniques for Wireless Reception

On completion of this course the student will be able to:

1. ***Know the techniques used for wireless signal reception***
2. ***Use Methods for multi user detection***
3. ***Understand space time MUD***
4. ***Carryout interference mitigation in wireless communication***
5. ***Use methods for multi user interference cancellation***
6. ***Use nonlinear methods for signal detection***

Module I: Blind Multiuser Detection:Wireless signaling environment, Basic receiver signal processing for wireless reception- matched filter/raked receiver, equalization and MUD. Linear receiver for synchronous CDMA- decorrelating and MMSE detectors. Blind MUD, direct and subspace methods.

Module II Group Blind MUD:Linear group blind MUD for synchronous CDMA, Non-linear group blind multiuser detectors for CDMA-slowest descent search. Group blind multiuser detection in multipath channels- Linear group blind detectors.

Module III: Space-Time MUD:Adaptive array processing in TDMA systems-Linear MMSE combining, sub-space based training algorithm and extension to dispersive channels. Optimal space time MUD. Linear space time MUD Linear MUD via iterative interference cancellation, single user space-time detection and combined single user/multiuser linear detection.

Module IV: Narrow band Interference Suppression**:** Linear predictive techniques-linear predictive methods. Non-linear predictive techniques-ACM filter, Adaptive non-linear predictor Signal Processing for Wireless Reception Bayesian signal processing- Bayesian framework, batch processing Versus adaptive processing, Monte-Carlo methods.

References:

1. X.Wang and H.V.Poor," Wireless Communication Systems," Pearson,2004

2. Iti Saha Misra,"Wireless Communications and Networks,"Tata McGraw Hill,2009.

3. . Kamilo Feher, "Wireless Digital Communications: Modulation and Spread Spectrum Techniques", Prentice Hall of India, 2004

18-453-0306 Internet of Things

Course outcome: ***On successful completion of the course, the student will:***

1. Understand the concepts of Internet of Things

2. Analyze basic protocols in wireless sensor network

3. Design IoT applications in different domain and be able to analyze their performance

4. Implement basic IoT applications on embedded platform

5. Understand State of the Art – IoT Architecture.

6. Know Real World IoT Design Constraints, Industrial Automation and Commercial Building Automation in IoT.

Module I: Introduction to IoT Defining IoT, Characteristics of IoT, Physical design of IoT, Logical design of IoT, Functional blocks of IoT, Communication models & APIs : IoT & M2M Machine to Machine, Difference between IoT and M2M, Software define Network

Module II: Network & Communication aspects Wireless medium access issues, IoT Communication Protocols MAC protocol survey, Survey routing protocols, Sensor deployment & Node discovery, Data aggregation & dissemination.

Module III: Challenges in IoT Design challenges, Development challenges, Security challenges, Other challenges. Implications for Society, specific applications of IoT Home automation, Industry applications, Surveillance applications, Other IoT applications.

Module IV: Developing IoTs, Introduction to different IoT tools, Developing applications through IoT tools, Developing sensor based application through embedded system platform, Implementing IoT

REFERENCES:

1. Vijay Madisetti And Arshdeep Bahga, "Internet Of Things (A Hands-On-Approach)", 1st edition, VPT, 2014.

2. Francis Dacosta, "Rethinking The Internet Of Things: A Scalable Approach To Connecting Everything", 1st Edition, Apress Publications, 2013

3 W Stallings . Foundations of modern networking : sdn, nfv, qoe, iot and cloud1 Edition Pearson Education.