ELECTRONICS AND COMMUNICATION ENGINEERING

Power and Control

S.No.	Course No.	Course Title	Credits
		Semester I	
1.	HS501 (Core)	Professional and Communication Skills	1-0-2-2
2.	EC521(Core)	Special topics in Power and Control	3-0-0-4
3.	EC522(Core)	Power Electronics and Drives	3-0-0-4
4.	MT612(Core)	PLC and Microcontroller	2-0-4-5
5.	Elective 1	-	3-0-0-4
6.	MT612L	Lab is attached to course MT612(Core)	--
		Semester II	
1.	EC523(Core)	System Design: Power and Control	3-0-2-5
2.	Elective 2	-	3-0-0-4
3.	Elective 3	-	3-0-0-4
4.	EC699a	Thesis	3-0-0-4
5.	EC523L	Lab is attached to course EC523(Core)	--
		Semester III	
1.	EC598a	Graduate Seminar I	2
2.	EC699a	M.Tech. Dissertation	16
		Semester IV	
1.	EC599b	Graduate Seminar II	2
2.	EC699b	M.Tech. Dissertation	16

Electives:

Sl No	Course No	Courses	Credits
1	EC604	Simulation of Modern Power Systems	3-0-0-4
2	EC661	Fuzzy Logic & Neural Networks	3-0-0-4
3	EC511	Advanced Digital Signal processing	3-0-0-4
4	EC422b	Applications of Signal and Image Processing	3-0-0-4
5	EC 513	Advance(d) time frequency analysis	3-0-0-4
6	EC512	Multirate Signal Processing	3-0-0-4

Electives in modular form:

1	EM661	Fuzzy logic and its application	2-0-0-2
2	EM528	Simulation of Power Systems	2-0-1-2

Microwave and Communication Engineering

Semester I			
Sl. No	Course No	Course Title	Credits
1.	HS501(Core)	Professional and Communication Skill (HS501)*	1-0-2-2
2.	EC651(Core)	Advanced Communication Engineering	3-0-0-4
3.	EC533(Core)	Computational Electromagnetics	3-0-0-4
4.	EC638(Core)	RF and Microwave Circuits Design	3-0-2-5
5.	Elective I		3-0-0-4
6.	EC638L	High Frequency Circuits Design (Attached withEC638)	0-0-2-2
Semester II			
1.	EC512	Multirate signal processing (EC512)	3-0-0-4
2.	EC551	Photonics Communication (EC551)	3-0-0-4
3.	Elective 2	-	3-0-0-4
4.	Elective 3	-	3-0-0-4
5.	EC552L	Advanced Communication Lab	0-0-2-2
Semester III			
1.	EC598a	Graduate Seminar 1	2
2.	EC699a	Thesis Credit	16
Semester IV			
1.	EC598b	Graduate Seminar 2	2
2.	EC699b	Thesis Credit	16

Electives

Sl. No	Course No	Course Name	Credits
1.	NS531	Advanced Engineering Mathematics	3-0-0-4
2.	EC616	Industrial Microwave	3-0-0-4
3.	EC535	Advanced Antenna Theory and Design	3-0-0-4
4.	EC615	MMIC and RFIC Design	3-0-0-4
5.	EC635	Nano-Photonics and Plasmonics	3-0-0-4
6.	EC612a	RF and Microwave Active Circuits	3-0-0-4
7.	EC536	Electromagnetic Interference and Compatibility	3-0-0-4
8.	EC534	Advanced Engineering Electromagnetics	3-0-0-4
9.	EC552	Radar Communication	3-0-0-4
10.	EC554	Wireless Mobile Communication	3-0-0-4
11.	EC555	Selected Topics in Wireless Communication	3-0-0-4
12.	EC652	Information Theory and Coding	3-0-0-4
13.	EC556	Detection and Estimation Theory	3-0-0-4
14.	EC636	Wavelet and Filter Banks	3-0-0-4
15.	EC639	Advanced Digital Filter Design	3-0-0-4
16.	EC624	Adaptive Signal Processing	3-0-0-4

Electives in modular form:

1.	EM609d	Biomedical Signal Processing	1-0-0-1
2.	EM666e	RF MEMS Design	2-0-0-2

Micro and Nano-Electronics

Semester I			
S.No.	**Course No.**	**Course Title**	**Credits**
	HS501 (Core)	Professional and Communication Skills	1-0-2-2
1.	EC541(Core)	Physics of Semiconductor Devices	3-0-2-5
2.	EC544(Core)	Digital VLSI Design	3-1-0-4
3.	EC545(Core)	Device Fabrication Technology	3-1-0-4
4.	Elective I	-	3-0-0-4
5.	EC546L	Lab attached to EC541(Core)	--
Semester II			
1.	EC541(Core)	Analog IC Design	3-0-0-4
2.	Elective II	-	3-1-0-4
3.	Elective III	-	3-1-0-4
4.	Elective IV	-	3-1-0-4
5.	EC547L	Lab2 (EDA Tool)	0-0-4-2
Semester III			
1.	EC598a	Graduate Seminar I	2
2.	EC699a	Thesis Credit	16
Semester IV			
1.	EC598b	Graduate Seminar II	2
2.	EC699b	Thesis Credit	16

Elective-I:

Sl No	Course No	Courses	Credits
1.	EC543	CMOS memory Design	3-0-0-4
2.	EC545a	VLSI Device and Modeling	3-0-0-4
3.	EC545b	VLSI Design Automation	3-0-0-4

Elective-II:

Sl No	Course No	Courses	Credits
1.	EC548a	Testing and diagnosis of Digital systems	3-1-0-4
2.	EC548b	Low power VLSI Design	3-1-0-4
3.	EC548	CMOS/RF IC Design	3-1-0-4

Elective-III:

Sl No	Course No	Courses	Credits
1.	EC549a	Advanced micro and Nano Devices/ Nano-electronics	3-1-0-4
2.	EC549b	MEMS/NEMS and Sensors	3-1-0-4

Elective-IV:

Sl No	Course No	Courses	Credits
1.	EC550	Nano Scale Integrated Computing	3-1-0-4

M.Tech. in ECE (Power and Control)

Course Title	**:**	**Special Topics in Power and Control**			
Course Code	**:**	**EC521**	**Course Type**	**:**	**Core 1**
Contact Hours	**:**	**L- 3 T- 0 P- 0**	**Credit**	**:**	**4**
Program/Semester	**:**	**M. Tech./ Sem I**			
Pre-requisites	**:**	**None**			
Evaluation Scheme	**:**	**Quiz I (15%), Mid-Term (30%), Quiz II (15%), End-Term (40%)**			

Course Details:

INTRODUCTION:
Overview of modern power system, renewable energy sources, and restructuring of power system. [4H]

SYSTEM PROTECTION:
Protection concepts unique to various system components: generators, transformers, transmission lines, etc., System-wide protection philosophies/ principles for various modes of system operation, e.g., with and without islanding, Adaptive relaying applied to modern grid operation. [5H]

STATE ESTIMATION: Introduction, Mathematical Formulation, Weighted Least Squares (WLS) Method, Bad Data Detection, Application of State Estimation, Phasor Measurement Unit (PMU) and Wide Area Monitoring Systems (WAMS). [7H]

POWER QUALITY:
Power quality issues in power system, measurement methods. [4H]

STATE VARIABLE ANALYSIS AND DESIGN: Concepts of state variables and state model - state models for linear continuous - time systems - Solution of state equations - Concepts of controllability and observability, Pole placement by State Feedback [5H]

OPTIMAL CONTROL:
Parameter Optimization, Optimal Control Problem, Transfer Function and State variable Approach [5H]

DIGITAL CONTROL:
The z-transform and Inverse z-transform, Pulse Transfer Function, z- and s-domain, Relationship, Stability. State models and Solution of state equations in z-domain [7H]

NON-LINEAR CONTROL:
Common Physical Nonlinearity, Phase plane and describing function methods, stability analysis [5H]

References:

1. A.J. Wood and B.F. WollenBerg, “Power Generation, Operation and control”, John Wiley, 1984.
2. Gopal, M., "*Digital Control and State variable methods*" 4th Edition, Mc Graw Hill, 2016.
3. Kuo, BC, “Sampled data control system” 2nd Edition, Oxford Univ. Press, 2014.
4. Ogata, K., "*State Space Analysis of Control Systems*" 2nd Edition, PHI, 2013.
5. Nagrath, I.J. and Gopal, M., "Control Systems Engineering" 5th Edition, New Age Pub. 2012.
6. C Sankaran, "*Power Quality*", CRC Press, 2002.
7. Volker Quaschning, "*Understanding Renewable Energy Systems*", Earthscan, 2005.
8. Mohammad Shahidehpour, "*Restructured Electrical Power Systems*", Marcel Dekker, 200l

Course Title	**:**	**Power Electronics and Drives**			
Course Code	**:**	**EC522**	**Course Type**	**:**	**Core 2**
Contact Hours	**:**	**L- 3 T- 0 P- 0**	**Credit**	**:**	**4**
Program/Semester	**:**	**M. Tech./Sem I**			
Pre-requisites	**:**	**None**			
Evaluation Scheme	**:**	**Quiz I (10%), Mid-Term (20%), Quiz II (10%), Assignments/ attendance/ Project (20%), End-Term (40%)**			

Course Details:

Introduction:

Basic introduction of power electronics and electric drives, and their industrial application. [6H]

Review of power devices, viz. Thyristor, BJT, MOSFET, IGBT & GTOs. Review of phase controlled/line commutated converters, DC choppers and inverters, Power circuit configurations, voltage control techniques. [8H]

Gate drive requirements and circuits. Principle of unified machine theory, generalized torque equation and modeling of electric machine. Performance evaluation of DC machine and closed loop control of solid state DC drives. [14H]

Three phase induction motor- transformation methods, (stationary, rotor and synchronous frames), three phase synchronous motor representation: Park transformation. Scalar and vector control of induction motor, field oriented control and direct torque control of induction motor, Vector control of synchronous motor, Switched reluctance motor drive and various power circuit configurations and control. [14H]

References:

1. B.K. Bose, "Power Electronics and Motor Drives", Academic Press, 2006.
2. M.H. Rashid, "Power Electronics: Circuits, Devices & Applications", Prentice Hall (I) Pvt. Ltd., 2006.
3. P.C. Krause, "Analysis of Electric Machinery", McGraw Hill, New York, 1987
4. R. Krishnan, "Electric Motor drives - Modelling, Analysis and Control", PHI India Ltd., 2002.

Course Title	**:**	**System Design: Power and Control**			
Course Code	**:**	**EC523**	**Course Type**	**:**	**Core 4**
Contact Hours	**:**	**L- 3 T- 0 P- 2**	**Credit**	**:**	**5**
Program/Semester	**:**	**M. Tech. /Sem II**			
Pre-requisites	**:**	**None**			
Evaluation Scheme	**:**	**Quiz I (15%), Mid-Term (30%), Quiz II (15%), End-Term (40%)**			

Course Details:

INTRODUCTION:
Introduction to power processing, Elements of power electronics, Basic concept of design. [6H]

CONVERTERS IN EQUILIBRIUM:
Principles of steady state converter analysis Steady-state equivalent circuit modelling, losses, and efficiency; Switch realization, discontinuous conduction mode operation. [12H]

CONVERTER DYNAMICS AND CONTROL:
The basic ac modelling approach, State-space averaging.
DESIGN: Design of circuit elements (inductors, transformers, etc.), driver circuits, protection system, filters, controllers. [10H]

COMPENSATOR DESIGN:
Analog and Digital compensator design using frequency response and root locus Methods. [4H]

Identification and Design of Controllers:
Relay-based identification, PID controller, IMC controller design. Pole placement and state observer, dead beat controller. [10H]

References:

1. R.W. Erickson, "*Fundamentals of Power Electronics*", Springer.
2. Gopal, M., "*Digital Control and State variable methods*" IVth Edition, Mc Graw Hill, 2016.
3. Kuo, BC, “Sampled data control system” IInd Edition, Oxford Univ. Press, 2014.
4. Ogata, K., "*State Space Analysis of Control Systems*" IInd Edition, PHI, 2013.

Course Title	:	System Design: Power and Control			
Course Code	:	EC523 L	Course Type	:	Lab
Contact Hours	:	L-0 T-0 P-	Credit	:	
Program/Semester	:	M. Tech. /Sem II			
Pre-requisites	:	None			
Evaluation Scheme	:	Lab Performance (60%), End sem (40%)			

Course Details:

Experiments:

1. Study and use of MATLAB environment and the base program.
2. Use of control system toolbox, power system toolbox, and symbolic math toolbox.
3. Study and use of Simulink including component base applications.
4. DC and AC position control.
5. AC/DC motor control using driver circuit.
6. PWM Controller Design.
7. Study, simulation and implementation of first and second order dynamic systems.
8. Design and hardware implementation of a controller for specific system.
9. Design and simulation of lead-lag compensator.
10. Study, simulation and control of nonlinear system.

References:

1. R.W. Erickson, "*Fundamentals of Power Electronics*", Springer.
2. Gopal, M., "*Digital Control and State variable methods*" IVth Edition, Mc Graw Hill, 2016.
3. Kuo, BC, “Sampled data control system” IInd Edition, Oxford Univ. Press, 2014.
4. Ogata, K., "*State Space Analysis of Control Systems*" IInd Edition, PHI, 2013.

Electives

Course Title	**:**	**Simulation of Modern Power Systems**			
Course Code	**:**	**EC604**	**Course Type**	**:**	**Elective**
Contact Hours	**:**	**L- 2 T- 0 P- 2**	**Credit**	**:**	**4**
Program/Semester	**:**	**M. Tech.**			
Pre-requisites	**:**	**None**			
Evaluation Scheme	**:**	**Quiz I (15%), Mid-Term (30%), Quiz II (15%), End-Term (40%)**			

Course Details:

Introduction: Modern power system overview, operation and control. Different types of Power System Analysis. [4H]

AC Power Flow Analysis: Static and dynamic modelling; Power Flow Equations, Formation of Ybus Matrix, Power Flow Solution Algorithms, Newton-Raphson Load Flow Method, Fast Decoupled Load Flow Method And DC Load Flow Method. [12H]

Analysis of Faulted Power System: Symmetrical and Asymmetrical Faults, Z-matrix formulation and short circuit studies. Analysis of Open Circuit faults. [6H]

Security Analysis: Basic Concepts, Static Security Analysis at Control Centres, Contingency Analysis, Contingency Selection. [6H]

Lab Experiment:

1. Introduction to MATLAB for power system simulations
2. Y Bus formation using MATLAB
3. Load flow analysis using Gauss Seidel Method
4. Load flow analysis using Newton Raphson Method
5. State Estimation using WLS Method
6. Contingency screening using power world simulator
7. Distribution load flow analysis

References:

1. Kothari, DP and Nagrath, "Modern Power System", Mc Graw Hill Education.
2. P. Kundur, "Power System Stability and Control", McGraw Hill Inc, 1995.
3. A.J. Wood and B.F. WollenBerg, "Power Generation, Operation and control", John Wiley, 1984.
4. G.L.Kusic, "Computer Aided Power Systems Analysis", Prentice Hall, 1986.

Course Title	**:**	**Fuzzy Logic & Neural Networks**			
Course Code	**:**	**EC661**	**Course Type**	**:**	**Elective**
Contact Hours	**:**	**L- 3 T- 0 P- 0**	**Credit**	**:**	**4**
Program/Semester	**:**	**M. Tech.**			
Pre-requisites	**:**	**None**			
Evaluation Scheme	**:**	**Quiz I (15%), Mid-Term (30%), Quiz II (15%), End-Term (40%),**			

Course Details:

Classical sets – Fuzzy sets – Membership functions – Fuzzy relations – Knowledge base – Fuzzification– Fuzzy rules – Decision-making logic – Defuzzification. Mamdani and Takagi-Sugeno architectures of Fuzzu inference system. Fuzzy Logic Controllers. [18]

Introduction to Neural Networks – Artificial neuron – Neuron modelling, Multi-layer feed forward network – Learning Techniques and algorithms - Error back-propagation, generalized delta rule. Radial basis function networks. **[18H]**

Adaptive Neuro-Fuzzy Inference System (ANFIS). **[4H]**

Engineering applications of Fuzzy Logic system. **[2H]**

References:

1. T. J. Ross, 'Fuzzy Logic with Engineering Applications', Tata McGraw Hill, 1997.
2. J. M. Zurada, 'Introduction to Artificial Neural Systems', Jaico Publishing home, 2002.
3. Simon Haykin, 'Neural Networks', Pearson Education, 2003
4. John Yen & Reza Langari, 'Fuzzy Logic – Intelligence Control & Information', Pearson Education, New Delhi, 2003.
5. J.S.R. Jang, C.T. Sun, and E. Mizutani,"Neuro-Fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence", Prentice Hall, 1996.

Course Title	**:**	**Advanced Digital Signal processing**			
Course Code	**:**	**EC 511**	**Course Type**	**:**	**Elective**
Contact Hours	**:**	**L- 3 T- 0 P- 0**	**Credit**	**:**	**04**
Program/Semester	**:**	**M.Tech.**			
Pre-requisites	**:**	**Signals and Systems (or equivalent course)**			
Evaluation Scheme	**:**	**Quiz I (10%), Mid-Term (20%), Quiz II (10 %), End-Term (40 %), Assignment (20%)**			

Course Details:

Module1: Overview of Discrete Fourier transform: Properties and applications, FFT: Radix-2, Radix-4, Split radix-FFT algorithms, FFT algorithms in linear filtering and correlation, Discrete Cosine Transform /Discrete Sin Transform: Properties and Applications [10H]

Module2: Design of Digital filters: Design of linear phase FIR filter: window techniques, frequency sampling methods, design of optimum equi-ripple linear phase FIR filters, Design of IIR filters: approximation of derivatives, impulse invariance bilinear transformation, matched Z-transforms, Optimization Methods for IIR and FIR filter Design: Deczky's method for IIR filter design in the frequency domain, Pade approximation method, Least- squares design method in time domain; Frequency sampling method for FIR filter. [14H]

Module3: Introduction to Multi-rate Digital Signal Processing – Sample rate reduction – decimation by integer factors- sampling rate increase – interpolation by integer facto – Design of practical sampling rate converters Filter Specification- filter requirement for individual stages – Determining the number of stages and decimation factors – Sampling rate conversion using poly-phase filter structure – poly-phase implementation of interpolators. [6H]

Module 4: Adaptive Signal Processing – Adaptive filters – Concepts- Adaptive filter as a Noise Canceller – Other configurations of the adaptive filter – Main components of the adaptive filter – Basic Wiener filter theory – The basic LMS adaptive algorithm – Practical limitations of the basic LMS algorithm – Recursive Least Square Algorithm – Limitations – Factorization Algorithm. [6H]

Module 5: Applications of digital signal processing: Speech signal Processing, Bioelectric signal etc. [4H]

Suggested Textbooks:

1. S. K. Mitra, Digital Signal Processing: A Computer Based Approach. Tata McGraw Hill.
2. John G.Proakis, Dimitris G.Manobakis, Digital Signal Processing, Principles, Algorithms and Applications, Third edition, (2000) PHI

References:

1. P.P. Vaidyanathan. Multirate systems and filter banks. Prentice Hall. PTR. 1993.
2. N.J. Fliege. Multirate digital signal processing. John Wiley 1994.
3. Digital Signal Processing Emmanuel C Ifeachor, Barrie W Jrevis, Pearson

Course Title	**:**	**Applications of Signal and Image Processing**			
Course Code	**:**	**EC422b**	**Course Type**	**:**	**Elective**
Contact Hours	**:**	**L- 3 T- 0 P- 0**	**Credit**	**:**	**04**
Program/Semester	**:**	**M.Tech.**			
Pre-requisites	**:**	**NA**			
Evaluation Scheme	**:**	**Quiz I (15%), Mid-Term (30%), Quiz II (15%), End-Term (40%)**			

Course Details:

ECG: Cardiac electrophysiology, relation of electrocardiogram (ECG) components to cardiac events, clinical applications. [6H]

Speech Signals: The source-filter model of speech production, spectrographic analysis of speech. [6H]

Speech Coding: Analysis-synthesis systems, channel vocoders, linear prediction of speech, linear prediction vocoders. [5H]

Imaging Modalities: Survey of major modalities for medical imaging: ultrasound, X-ray, CT, MRI, PET, and SPECT. [5H]

MRI: Physics and signal processing for magnetic resonance imaging. [5H]

Surgical Applications: A survey of surgical applications of medical image processing. Image Segmentation: statistical classification, morphological operators, connected components. [5H]

Application of Signal and Image Processing in power and control systems and mobile robot using physiological signals. [10H]

Suggested Textbooks:

1. Oppenheim, A. V., and R. W. Schafer, with J. R. Buck. Discrete-Time Signal Processing. 2nd ed. Upper Saddle River, NJ: Prentice-Hall, 1999. ISBN: 9780137549207.
2. Karu, Z. Z. Signals and Systems Made Ridiculously Simple. Huntsville, AL: ZiZi Press, 1995. ISBN: 9780964375215.
3. Duda, R., and P. Hart. Pattern Classification and Scene Analysis. New York, NY: John Wiley & Sons, 1973. ISBN: 9780471223610.

References:

1. Clifford, G., F. Azuajae, and P. McSharry. <u>Advanced Methods and Tools for ECG Data Analysis</u>. Norwood, MA: Artech House, 2006. ISBN: 9871580539661.
2. 5. Rabiner, L. R., and R. W. Schafer. Digital Processing of Speech Signals. Upper Saddle River, NJ: Prentice-Hall, 1978. ISBN: 9780132136037.
3. 6. Lim, J. S. Two-Dimensional Signal and Image Processing. Upper Saddle River, NJ: Prentice Hall, 1989. ISBN: 9780139353222.
4. 7. Gonzalez, R., and R. E. Woods. Digital Image Processing. 2nd ed. Upper Saddle River, NJ: Prentice-Hall, 2002. ISBN: 9780201180756.

Course Title	**:**	**Advanced time Frequency analysis**			
Course Code	**:**	**EC513**	**Course Type**	**:**	**Elective**
Contact Hours	**:**	**L- 3 T- 0 P- 0**	**Credit**	**:**	**04**
Program/Semester	**:**	**M.Tech.**			
Pre-requisites	**:**	**NA**			
Evaluation Scheme	**:**	**Quiz I (15%), Mid-Term (30%), Quiz II (15%), End-Term (40%)**			

Course Details:

Basics of Fourier Analysis, The Short-Time Fourier Transform/Spectrogram, Continuous Wavelet Transform/Scalogram, S-tranform. [10H]

Quadratic Time Frequency Transform, Wigner-Ville Distribution (WVD), PWVD, SPWVD, Margenau–Hill (MH), and Rihaczek (RIH) distributions, pseudo-MH (PMH) and pseudo-WV (PWV) [10H]

Empirical Mode decomposition, Improved EMD, and Other non-stationary signal decomposition. [10H]

Non-stationary decomposition based statistical analysis, features extraction. [10H]

Application of Time frequency in biomedical signal processing. [10H]

Suggested Textbooks:

1. S. Mallat, A Wavelet Tour of Signal Processing (3rd edition), Academic Press, 2008, ISBN: 978-0123743701.
2. Leon Cohen, Time-Frequency Analysis, Prentice Hall; 1994, ISBN: 978-0135945322.
3. B. Boashash, Time-Frequency Signal Analysis and Processing: A Comprehensive Reference, Elsevier Science, 2003, ISBN-13: 978-0080443355.
4. R. M. Rao and A. S. Bopardikar, Wavelet Transforms: Introduction to Theory& Applications, Prentice Hall, 1998, ISBN-13: 978-020163463

References:

1. IEEE International Symposium on Time-Frequency and Time-ScaleAnalysis, IEEE Press, NY, 1992. (Publ. TH4788 or ISBN 0-7803-0805-0)

Course Title	**:**	**Fuzzy logic and its application**			
Course Code	**:**	**EM661**	**Course Type**	**:**	**EMF-Elective**
Contact Hours	**:**	**L- 2 T- 0 P- 0**	**Credit**	**:**	**02**
Program/Semester	**:**	**M.Tech.**			
Pre-requisites	**:**	**NA**			
Evaluation Scheme	**:**	**Quiz I (15%), Mid-Term (30%), Quiz II (15%), End-Term (40%)**			

Course Details:

Classical sets – Fuzzy sets – Membership functions – Fuzzy relations – Knowledge base – Fuzzification– Fuzzy rules – Decision-making logic – Defuzzification. Mamdani and Takagi-Sugeno architectures of Fuzzu inference system. Fuzzy Logic Controllers. [16H]

Adaptive Neuro-Fuzzy Inference System (ANFIS). [3H]

Engineering applications of Fuzzy Logic system. [2H]

References:

1. T. J. Ross, 'Fuzzy Logic with Engineering Applications', Tata McGraw Hill, 1997.
2. John Yen & Reza Langari, 'Fuzzy Logic – Intelligence Control & Information', Pearson Education, New Delhi, 2003.
3. J.S.R. Jang, C.T. Sun, and E. Mizutani, "Neuro-Fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence", Prentice Hall, 1996.

Course Title	**:**	**Simulation of Power Systems**			
Course Code	**:**	**EM528**	**Course Type**	**:**	**EMF-Elective**
Contact Hours	**:**	**L- 2 T- 0 P- 0**	**Credit**	**:**	**02**
Program/Semester	**:**	**M.Tech.**			
Pre-requisites	**:**	**NA**			
Evaluation Scheme	**:**	**Quiz I (15%), Mid-Term (30%), Quiz II (15%), End-Term (40%)**			

Course Details:

Introduction: Power system overview and per unit system. [1H]

AC Power Flow Analysis: Static and dynamic modelling; Power Flow Equations, Formation of Ybus Matrix, Power Flow Solution Algorithms, Newton-Raphson Load Flow Method, Fast Decoupled Load Flow Method And DC Load Flow Method. [14H]

Security Analysis: Basic Concepts, Static Security Analysis at Control Centres, Contingency Analysis, Contingency Selection. [6H]

References:

1. Kothari, DP and Nagrath, “Modern Power System”, Mc Graw Hill Education.
2. P. Kundur, “Power System Stability and Control”, McGraw Hill Inc, 1995.

M.Tech. in ECE(Microwave and Communication Engineering)

Course Title	**:**	**Advanced Communication Engineering**			
Course Code	**:**	**EC651**	**Course Type**	**:**	**Core 1**
Contact Hours	**:**	**L- 3 T- 0 P- 0**	**Credit**	**:**	**4**
Program/Semester	**:**	**Mtech / Sem I**			
Pre-requisites	**:**	**Principle of Communication**			
Evaluation Scheme	**:**	**Quiz I (10%), Mid-Term (20%), Quiz II (10%), End-Term (40%), Term Paper/Project/Assignment (20%)**			

Course Details:

Introduction to digital communication system, Complex baseband representation of signals, gram-Schmidt orthogonalization procedure, Mary orthogonal signals**.** **[3L]**

Receiver in additive white Gaussian noise channels: Matched filter and correlator demodulator: Detector: Optimum rule for ML and MAP Detection: Bit-error-rate performance. **[5L]**

Signal Design for Band-Limited Channels: Characterization of band-limited chnnels, Nyquist criterion, Partial response signals, Data detection for controlled ISI, Probability of error in detection of PAM. **[5L]**

Communication Through Band Limited Linear Filter Channels: Optimum receiver for channels with ISI and AWGN. Linear equalization, Decision-feedback equalization, reduced complexity ML detectors.**[10L]**

Digital Communication through Fading Multipath Channels: Characterization of Fading Multipath channels, Effects of signal charactertics on the choice of a channel model, Diversity techniques, Tapped delay line channel model. Rake receiver demodulator. **[10L]**

Spread Spectrum Signals for Digital Communication: Direct sequence spread spectrum signals (DSSS). Frequency hopped spread spectrum signals (FHSS), PN sequences. **[6L]**

Multiuser Communications: Introduction to multiple access techniques, Capacity of multiple access methods, CDMA. **[3L]**

Suggested Textbooks:

1. John G. Proakis, *"Digital Communications*": 4th edition McGraw Hill Book Co.
2. S. Havkin, "Communication Systems", 4th Edition Wiley & Sons Inc.

References:

1. John R. Barry, Edward A. Lee and David G. Messerschmitt, "*Digital Communication*" 3rd edition Springer, 2003.
2. Rodger E. Ziemer and Roger W. Peterson, "*Introduction to Digital Communication"* 2nd edition Prentice Hall, 2000

Course Title	**:**	**Computational Electromagnetics**			
Course Code	**:**	**EC533**	**Course Type**	**:**	**Core 2**
Contact Hours	**:**	**L- 3 T- 0 P- 0**	**Credit**	**:**	**04**
Program/Semester	**:**	**M.Tech. / Sem. I**			
Pre-requisites	**:**	**Electromagnetics fundamentals and working knowledge with one of MATLAB / MATHCAD / Fortran / C**			
Evaluation Scheme	**:**	**Quiz I (10%), Mid-Term (20%), Assignment (15%), End-Term (40%) and Mini Project (15%)**			

Course Details:

Review of Electromagnetic theory, Introduction to Computational Electromagnetics, Difference Approximations based on One-Dimensional Wave Equation, Numerical Dispersion & Group Delay, Stability of Explicit Solution, Implicit Formulation and Stability, Maxwell's Equations in 1, 2, and 3 dimensions, Yee algorithm, Numerical Dispersion, Numerical Stability, **[20H]**

Source Excitation: Total-Field/Scattered-Field Formulation, Waveguide Source Excitations, Analytical Absorbing Boundary Conditions, Perfectly Matched Layer Media, Near Field to Far Field Transformations, Modelling Lumped Elements, Modelling of Antennas, Electromagnetic Crystals, and Metamaterials, Micro-cavity resonators. **[20H]**

Suggested Textbooks:

1. Computational Electromagnetics: The Finite-Difference Time-Domain, A. Taflove and S. C. Hagness, 3rd Edition, Artech House, 2005
2. Electromagnetic Simulation Using The FDTD Method, Dennis M. Sullivan, IEEE Press series On RF and Microwave Technology, 2nd edition, June 2013, Wiley IEEE Press

Course Title	**:**	**RF and Microwave Circuits Design**			
Course Code	**:**	**EC638**	**Course Type**	**:**	**Core 3**
Contact Hours	**:**	**L-3 T- 0 P- 2**	**Credit**	**:**	**05**
Program/Semester	**:**	**M. Tech. / Sem. I**			
Pre-requisites	**:**	**Fundamentals of Electromagnetics**			
Evaluation Scheme	**:**	**Quiz I (15%), Mid-Term (30%), Quiz II (15%), End-Term (40%)**			

Course Details:

Review of Transmission Lines theory:
Waves propagation in transmission line, parameters, concepts of propagation constant, characteristic impedance, reflection coefficient, wave velocities and dispersion, smith chart, impedance transformers, Generator and load mismatches, lossy transmission lines. Network analysis: S (scatter), Z, Y, ABCD, and other multi-port parameters, impedance matching and tuning. . [15H]

Planar transmission lines, circuits and characterization:
Microstrip, strip line, coplanar waveguide and other types of transmission lines, microstrip discontinuities simple printed couplers, filters, power dividers, directional couplers and transmission line resonators and microstrip antennas. [12H]

Ferrimagnetic components: Basic properties, plane wave propagation in ferrite, ferrite isolators, circulators, and phase shifters. [15H]

Suggested Textbooks:

1. Microwave Engineering, David M Pozar, 4th Edition, November 2011, Wiley.

References:

1. Foundations of Microstrip Circuit Design, T. C. Edwards, 1981, Chichester ; New York : John Wiley & Sons.
2. Elements of Electrornagnetics, Mathew N. O. Sadiku, 3rd Edition, 2001, Oxford University Press, New York, NY.

Course Title	**:**	**High Frequency Circuits Design Lab**			
Course Code	**:**	**EC638 L**	**Course Type**	**:**	**Lab**
Contact Hours	**:**	**L-0 T-0 P-3**	**Credit**	**:**	**02**
Program/Semester	**:**	**M.Tech. / Sem. I**			
Pre-requisites	**:**	**Nil**			
Evaluation Scheme	**:**	**Regular Lab Performance (60%), End-Term (40%)**			

Course Details:

Experiments will be based on the theory taught in RF and Microwave Circuit Design course. Each experiment will comprise of design, simulation using high frequency simulators (SERE ADE, ADS, and CST), optimization, fabrication and characterization (using network analyzer) of planar microstrip circuits such as transmission line, matching networks, filters with lumped as well distributed lines, power dividers and couplers.

List of experiments:

1. Calibration of Vector Network Analyzer (VNA) [3H]
2. Design and fabrication of 50 n Microstrip transmission line for known substrate Specifications [3H]
3. Design and fabrication of Matching network for specified load impedance [3H]
4. Design and fabrication of Band-Pass filter for specified center frequency and pass band/stop band attenuation [3H]
5. Design and fabrication of Wilkinson power divider [3H]
6. Design and fabrication of 3-dB Branch line coupler [3H]
7. Design and fabrication of Rat Race Hybrid-Ring coupler [3H]

Suggested Textbooks:

1. Microwave Engineering, David M Pozar, 4th Edition, November 2011, Wiley.

References:

Lab Manual:

1. Foundations of Microstrip Circuit Design, T. C. Edwards, 4 th Edition, February 2016, Wiley-IEEE Press, John Wiley & Sons.
2. Foundations for Microwave Engineering, Robert E. Collin, 2nd Edition, 2007 John Wiley Sons

Course Title	**:**	**Multirate Signal Processing**			
Course Code	**:**	**EC512**	**Course Type**	**:**	**Core 2**
Contact Hours	**:**	**L- 3 T- 0 P- 0**	**Credit**	**:**	**04**
Program/Semester	**:**	**M. Tech. /Sem. I**			
Pre-requisites	**:**	**Nil**			
Evaluation Scheme	**:**	**Quiz I (15%), Mid-Term (30%), Assignment (15%), End-Term and Project (40%)**			

Course Details:

Overview of DSP Discrete time system, Review of Digital filters:
FIR, IIR filter, all pass filter, Design of digital filters: FIR and IIR **[10H]**

Introduction to multirate system:
Sample rate reduction – decimation by integer factors- sampling rate increase – interpolation by integer facto – Design of practical sampling rate converters Filter Specification- filter requirement for individual stages – Determining the number of stages and decimation factors – Sampling rate conversion using poly-phase filter structure – poly-phase implementation of interpolators, Subband coding, Types of subband coding system, Distortion in Subband coding, Nyquist filter, Interpolated filter **[10H]**

Multirate filter Bank:
Uniform Filter bank, DFT Filter bank, Classification filter bank: M-channel Filter bank and two-channel filter bank, Analysis of two-channel filter, aliasing cancellation condition, perfect reconstruction condition, classification of two-channel filter bank, Design of PR filter bank and NPR filter bank, Computationally efficient structure for two-channel filter bank **[10H]**

Multichannel Filter Bank:
Classification of multichannel Filter bank: Tree structure Filter bank, modulated based filter bank, parallel filter bank, Analysis of Tree structure filter bank, Analysis for cosine modulated filter bank, Design of multichannel filter bank Application of multirate signal processing: audio signal **[12H]**

Suggested Textbooks:

1. Multirate systems and filter banks. P.P. Vaidyanathan Prentice Hall. PTR. 1993.
2. Multirate digital signal processing. N.J. Fliege. John Wiley 1994.

References:

1. An Introduction to Wavelets, K. Chui, Academic Press USA.
2. I. Daubechies, Ten Lectures on Wavelets, SIAM, 1990.
3. Lokenath Debnath, Wavelet Transforms and Their Applications, Birkhauser 2002.
4. S. Mallat, A wavelet Tour of Signal Processing, Academi Press USA 2009.

Course Title	**:**	**Photonics Communication**			
Course Code	**:**	**EC551**	**Course Type**	**:**	**Core 5**
Contact Hours	**:**	**L-3 T- 0 P- 0**	**Credit**	**:**	**04**
Program/Semester	**:**	**M. Tech. / Sem. II**			
Pre-requisites	**:**	**Nil**			
Evaluation Scheme	**:**	**Quiz I (10%), Mid-Term (20%), Assignment (15%), End-Term (40%) and Mini Project (15%)**			

Course Details:

Guided Wave Optics: Ray and Wave Optics, Slab Waveguides, Optical Fibers, propagation of light in multimode and single mode fibers, coupling into and out of a fiber, attenuation, group velocity, dispersion, and optical non-linearity. [10H]

Metal Photonics: Electromagnetics of Metals, Dielectric function and dispersion, Surface Plasmon polaritons, Single and multilayer systems, Excitation of surface Plasmon, plasmonic waveguides and resonators, localized surface plasmons, Sub-Wavelength Aperture and Extraordinary Transmission, Nanoantennas. **[**10H]

Photonic Devices: Optical Processes in Semiconductors, PN Junctions, Semiconductor Hetero-structures, Optical sources - LEDs and Lasers, Photo-detectors - pin- detectors, APD, detector responsivity, noise, optical receivers, Optical- Modulators, Amplifiers, Multiplexers/De-Multiplexers and Switches. [08H]

Optical Communication: Fiber optic communication, Analog and Digital transmission system, wavelength division multiplexing (WDM), DWDM, SONET/SDH, Wavelength routed networks, Solition based communication, Optical CDMA. [12H]

Suggested Textbooks:

1. Fiber Optic Communication, G.Keiser, 2nd Edition ,1991 ,McGraw-Hill.
2. Fiber-Optic Communication Systems, G.P.Agrawal, 3rd Edition, Jons & Wiley Sons pub.
3. Integrated Photonics: fundamentals, G. Lifante, January 2003, wiley.

References:

1. Optical Networks: A Practical Perspective, R.Ramaswami and Kumar N Sivarajan, 3r Edition, 2010 Elsevier.

Course Title	**:**	**Advanced Communication Engineering Lab**			
Course Code	**:**	**EC 552 L**	**Course Type**	**:**	**Lab**
Contact Hours	**:**	**L-0 T- 0 P- 3**	**Credit**	**:**	**02**
Program/Semester	**:**	**M. Tech. / Sem II**			
Pre-requisites	**:**	**Nil**			
Evaluation Scheme	**:**	**Lab Sessions (40%), Quiz/Assignment (20%), End-Term (40%)**			

Course Details:

Simulations of communications systems will be performed on MATLAB. In each lab student will learn to simulate the probability of error, outage performance of the wireless communication systems.

List of Simulations:

1. BER performance of binary antipodal and binary orthogonal signalling [3H]

2. BER performance of M-ary antipodal signaling [3H]

3. BER performance of M-ary orthogonal signaling [3H]

4. BER performance of Duo-binary signaling scheme. [3H]

5. Generation and detection of OFDM Signals [3H]

6. Monte Carlo Simulation to estimate the BER performance of and MISO system employing the Alamouti's code. [3H]

7. Generation of PN and Gold sequences and calculation of autocorrelation. [3H]

Suggested Textbooks:

1. J. G. Proakis, Masoud salehi, Modern Communication Systems using MATLAB, 3rd Edition, Cengage Learning, 2013.

ELECTIVES

Course Title	**:**	**Advanced Engineering Mathematics**			
Course Code	**:**	**NS531**	**Course Type**	**:**	**Elective**
Contact Hours	**:**	**L-3 T-1 P-0**	**Credit**	**:**	**04**
Program/Semester	**:**	**M. Tech. /Sem I**			
Pre-requisites	**:**	**None**			
Evaluation Scheme	**:**	**Quiz I (15%), Mid-Term (30%), Quiz II (15%), End-Term (40%)**			

Course Details:

Complex Analysis: Complex numbers, powers and roots of complex numbers. Complex variables: Continuity, and Differentiability, Analytic functions, Cauchy-Riemann equations, Laplace equation, Harmonic functions, Complex logarithmic function, Cauchy's integral theorem, Liouville's Theorem, Taylor series and Laurent series. Zeros, Singularities and its classifications, Residues, Residue theorem and its applications to evaluating real integrals and improper integrals. Conformal mappings, , Schwarz-Christoffel transformation. **[10H]**

Fourier series and transforms: Fourier Integral, Fourier series of periodic functions, Convergence of Fourier series, Differentiation and Integration of Fourier series, Complex form of Fourier series. Fourier Transforms and Properties, Convolution theorems, Inversion theorem, Application in engineering. **[8H]**

Ordinary Differential Equations: Classification of ODEs, Ordinary linear differential equations of first and n-th orders and their solutions, homogeneous and non-homogeneous equations. Operator method. Method of undetermined coefficients and variation of parameters. Power series methods for solutions of ordinary differential equations. Legendre equation and Legendre polynomials, Bessel equations. **[7H]**

Partial Differential Equations: Introduction to PDEs, basic concepts, Linear and quasi-linear first order PDE, Second order PDE and classification of second order semi-linear PDE, Canonical form. Cauchy problems. D' Alemberts formula, Wave equations, Laplace and Poisson equations, Fourier method for IBV problem for wave and heat equation, rectangular region. **[10H]**

Special Functions in Engineering: Introduction to Some Special Functions: Gamma function, Beta function, Bessel function, Henkel Functions, Legendre and Hermite polynomial. Error function, Heaviside's function, Sinusoidal Pulse function, Rectangle function, Gate function, Dirac's Delta function, Signum function, Saw tooth wave function, Triangular wave function, Half wave rectified sinusoidal function, Full rectified sine wave, Square wave function. Applications of special functions in engineering. **[10H]**

Suggested Textbooks:

1. Advanced Engineering Mathematics (8th Edition), by E. Kreyszig, Wiley-India (2007).
2. Advance Engineering Mathematics, by R. K Jain and SRK Iyengar, Narosa Publication.
3. W. E. Boyce and R. DiPrima, Elementary Differential Equations (8th Edition), John Wiley (2005)
4. R. V. Churchill and J. W. Brown, Fourier series and boundary value problems (7th Edition), McGraw-Hill (2006).
5. T.M.Apostol, Calculus , Volume-2 (2nd Edition), Wiley Eastern , 1980

Course Title	**:**	**Industrial Microwave**			
Course Code	**:**	**EC616**	**Course Type**	**:**	**Elective**
Contact Hours	**:**	**L-3 T-0 P-0**	**Credit**	**:**	**04**
Program/Semester	**:**	**M. Tech. /Sem I**			
Pre-requisites	**:**	**None**			
Evaluation Scheme	**:**	**Quiz I (15%), Mid-Term (30%), Quiz II (15%), End-Term (40%)**			

Course Details:

Waveguide Components:

Overview of Attenuators, Phase Shifters, Matched Loads, Detector Mounts, slotted sections, E and H Plane Tees, etc. Signal Generators: Fixed Frequency, Sweep frequency and synthesized frequency oscillators, PLL for high frequency generation **[10H]**

Industrial Microwave:

Noise Sources and Noise meters used in microwave measurements, frequency meters and VSWR meters, Measurement of frequency, attenuation, VSWR and impedance, cavity measurements: Q factor, bandwidth; Dielectric and magnetic properties of materials: Cavity and waveguide methods, Measurement of Power: Calorimetric and Microwave bridges; principles of Time and frequency domain reflectometry, Spectrum Analyzer and Network Analyzer, Measurement of Scattering parameters of passive and active devices **[10H]**

Processes in Industrial Microwave:

Microwave in process control instrumentation, Microwave waste disposal, Microwave in agriculture and medicine, hyperthermia, etc. Microwave Heating, Microwave absorbers, EMC and EMI. **[10H]**

Microwave Communication:

Microwave Radio and its components, Free space propagation model, ground reflection, Earth and its effect on propagation, Clutter theory, Fresnel Zones: First and Second order Fresnel Zones, Signature width of radio, tolerance limits, Practical Link Budget calculations, Atmospheric Attenuation **[10H]**

Suggested Textbooks:

1. Microwave Devices and Circuits, Samuel Y Liao, PEARSON EDUCATION; 3 edition (2007)
2. Microwave Engineering David M Pozar 4ed Wiley 2012

References:

1. T.S. Rappaport, “Wireless Communications,” Pearson Education, 2003.

Course Title	**:**	**Advanced Antenna Theory and Design**			
Course Code	**:**	**EC535**	**Course Type**	**:**	**Elective**
Contact Hours	**:**	**L-3 T-0 P-0**	**Credit**	**:**	**04**
Program/Semester	**:**	**M. Tech. /Sem I**			
Pre-requisites	**:**	**None**			
Evaluation Scheme	**:**	**Quiz I (15%), Mid-Term (30%), Quiz II (15%), End-Term (40%)**			

Course Details:

Theory of electromagnetic radiation; Coordinate system and transformation of field quantities in different coordinate system; Basic concept and definition: Directive gain, side lobe, back lobe, polarization, co-polarization and cross polarization level, beam width, input impedance, bandwidth, efficiency, Self-Impedance: Integral equations and moment methods. [7H]

Various kind of antenna with applications; Formulation of radiation integrals and its application to analysis of wire, loop and helix type antenna; Theory of aperture antenna, including the Fourier transform method and application to slot, waveguide and horn antenna; Design consideration of parabolic reflector antenna, solving Maxwells field equations, and the geometrical theory of diffraction (GTD), based on geometrical optics and asymptotic techniques. [8H]

Microstrip and Planar antennas: Rectangular and circular patch; Feed to microstrip antenna: probe feed, microstrip line feed, aperture feed, electromagnetically fed microstrip patch; Circularly polarized microstrip antenna. [7H]

Theory of linear and phased array: Two element and multi element array, isotropic and non-isotropic array, Binomial and Chebyshev distribution; Planar array, phased array and adaptive antenna; Feed network of microstrip antenna array; Antenna for mobile communication: handset antenna and base station antenna, Beam Forming and Adaptive Arrays: Butler matrix, adaptive algorithms. [9H]

Dielectric Resonator Antennas: Degrees of Freedom, Rectangular, Cylindrical and hemispherical DRAs, empirical formulas for calculation of resonant frequencies, transcendental equations and green’s functions for solutions to various geometries, modes in cavity resonator and radiation modes, wideband techniques. [7H]

Modern topics on Configurability and Filtenna, design issues, active circuits in filtenna design. [5H]

Suggested Textbooks:

1. Antenna Theory: Analysis and Design, Constantine A. Balanis, Wiley, Indian Edition, 2005.
2. Antenna and Wave propagation, J D Kraus, TMH.
3. Antenna and Wave propagation, A. R. Harish and M. Sachidananda, Oxford University Press, 2007.

Reference Books:

1. Field Theory of Guided waves, Robert E Collin, IEEE Press
2. Electromagnetism Theory and Applications, Ashutosh Pramanik, PHI, 2009.
3. Dielectric resonator Antenna Handbook, Aldo Petosa, Artech House, 2007.
4. Research papers from IEEE Antenna and Propagation Society.

Course Title	**:**	**MMIC and RFIC Design**			
Course Code	**:**	**EC615**	**Course Type**	**:**	**Elective**
Contact Hours	**:**	**L-3 T-0 P-0**	**Credit**	**:**	**04**
Program/Semester	**:**	**M. Tech. /Sem I**			
Pre-requisites	**:**	**None**			
Evaluation Scheme	**:**	**Quiz I (15%), Mid-Term (30%), Quiz II (15%), End-Term (40%)**			

Course Details:

MMIC: History of Monolithic Microwave Integrated circuits, Monolithic circuit components Planar Transmission Lines, Lumped and Distributed Passive Elements, GaAs MESFET and Other active devices, Metal semi-conductor functions and their characterization, Physical and Modelling of GaAs MESFET & HEMT. Material and fabrication techniques of GaAs MESFET, Properties of GaAs, Electron beam and X-ray lithography, Plasma assisted deposition, Molecular beam epitaxy & MOCVD. [20H]

RFIC: Amplifier fundamentals in MOS, MOS Transistors and Varactors, Power Compression and Intercept Points, Intermodulation Distortions, Cascading Nonlinear Systems, Bipolar and BiCMOS technologies. SiGe- Heterojunction Bipolar Transistors for RF applications and their noise performance, Trans-receiver building blocks for CMOS, Bipolar and BiCMOS. Low voltage, Low noise, Low power techniques in RF CMOS submicron design receiver Architecture, RF/ Base band filtering and compensation. [20H]

Reference Textbooks:

1. Peter H. Lad brooke, “MMIC Design: GaAs FETs and HEMTs”, January 1989, Artech house Boston & London.
2. G. Gonzalez, “Microwave Transistor Amplifiers”, 2nd Edition, 1997, Prentice-Hall
3. Behzad Razavi, “RF Microelectronics”, Pearson, 2nd Edition, January 2014 .
4. D.M. Pozar, “Microwave Engineering, 3rd Edition”,January 2, 2007 Wiley-India.

Course Title	**:**	**Nano-Photonics and Plasmonics**			
Course Code	**:**	**EC635**	**Course Type**	**:**	**Elective**
Contact Hours	**:**	**L-3 T-0 P-0**	**Credit**	**:**	**04**
Program/Semester	**:**	**M. Tech. /Sem I**			
Pre-requisites	**:**	**Applied Photonics**			
Evaluation Scheme	**:**	**Quiz I (15%), Mid-Term (30%), Quiz II (15%), End-Term (40%)**			

Course Details:

Introduction to Photonics: Electromagnetic waves; light; Maxwell equations; Wave equation; Modes, laser sources, semiconductor quantum wells, photo detectors, quantum dots, nanowires, Dielectric optical waveguides, directional coupler, Machzehnder interferometer, Optical microresonators etc. **[06 H]**

Photonic Crystals: Photonic bandgap (PGB). PBG structures, wave propagation, Construction methods, Applications: wave guides and photonic crystals fibres, optical microcavities, Photonic VLSI. **[08 H]**

Nanophotonics in metals: Electromagnetics of Metals, Electromagnetic Wave Propagation, Dielectric function and dispersion, Surface Plasmon polaritons, Single and multilayer systems, Exaction of surface Plasmon, plasmonic waveguides and resonators, localized surface plasmons, Nanoantennas. Metamaterials and Negative Index at Optical Frequencies,

Transmission through apertures and films: Theory of Diffraction by Sub-Wavelength Aperture, Extraordinary Transmission, Directional Emission via Exit Surface Patterning, Localized Surface Plasmons and Light Transmission Through Single Apertures, Emerging Applications of Extraordinary Transmission, Transmission of Light Through a Film Without Apertures.

[10 H]

Simulation and Design: Optical microresonators, guiding bending and splitting of light through photonic crystals, microcavity based MUX and DEMUX, photonic crystal fiber, plasmonic waveguides and resonators, Nanoantennas, Extraordinary transmission, Bull's eye structures, Metamaterials. **[12 H]**

Suggested Textbooks:

1. Fundamentals and Applications, Stefen A. Maer, Springer 2007.
2. Nanophotonics with Surface Plasmon, Vladimir M. Salaev,Part II, 2006, Photonic Spectra.
3. Photonic crystals:Molding the flow of light, J.D. Joannopoulos, 2nd Edition, 2008 Princeton University Press
4. Integrated Photonics: fundamentals, G. Lifante,Jauary 2003, wiley.

Course Title	:	RF and Microwave Active Circuits			
Course Code	**:**	**EC612**	**Course Type**	**:**	**Elective III**
Contact Hours	**:**	**L-3 T-0 P-0**	**Credit**	**:**	**04**
Program/Semester	**:**	**M. Tech. /Sem I**			
Pre-requisites	**:**	**RF and Microwave Active Design**			
Evaluation Scheme	**:**	**Quiz I (15%), Mid-Term (30%), Quiz II (15%), End-Term (40%)**			

Course Details:

Amplifiers:
Two port power gains, stability criterion, Low noise Amplifier design for maximum gain, constant gain and specific gain, input and output matching networks using lumped element and distributed elements, large signal scattering parameters, design of power amplifier. **[12H]**

RF Diodes:
Schottky diode and detectors, varactor diode, applications of diode in switches and phase shifters, noise and nonlinearity effect in RF active circuits. **[10H]**

Mixers:
General characteristics and applications, single ended diode and FET mixers, image rejection mixer and balanced mixer. **[10H]**

Oscillators:
General classification, transistor oscillators, dielectric resonator oscillators and voltage controlled oscillators, phase noise. **[10H]**

Suggested Textbooks:

1. D.M. Pozar, “Microwave Engineering, 3rd edition”, Wiley-India, 2010.
2. G. Gonzalez, “Microwave Transistor Amplifiers”,2nd Edition, august 1996, Prentice-Hall

Course Title	**:**	**Electromagnetic Interference and Compatibility**			
Course Code	**:**	**EC536**	**Course Type**	**:**	**Elective**
Contact Hours	**:**	**L-3 T-0 P-0**	**Credit**	**:**	**04**
Program/Semester	**:**	**M. Tech. / Sem I**			
Pre-requisites	**:**	**None**			
Evaluation Scheme	**:**	**Quiz I (15%), Mid-Term (30%), Quiz II (15%), End-Term (40%)**			

Course Details:

BASIC CONCEPTS : Introduction and Definition of EMI and EMC with examples, various Parameters, Sources of EMI, EMI coupling modes - CM and DM, ESD Phenomena and effects, Transient phenomena and suppression, Various issues of EMC, EMC Testing categories. [7H]

COUPLING MECHANISM: Electromagnetic field sources and Coupling paths, Coupling via the supply network, Common mode coupling, Differential mode coupling, Impedance coupling, Inductive and Capacitive coupling, Radiative coupling, Ground loop coupling, Cable related emissions and coupling, Transient sources, Automotive transients. [8H]

EMI MITIGATION TECHNIQUES:Working principle of Shielding and Murphy's Law, LF Magnetic shielding, Apertures and shielding effectiveness, Choice of Materials for H, E, and free space fields, Gasketting and sealing, PCB Level shielding, Principle of Grounding, Isolated grounds, Grounding strategies for Large systems, Grounding for mixed signal systems, Filter types and operation, Surge protection devices, Transient protection. [8H]

STANDARD AND REGULATIONS: Need for Standards, Generic/General Standards for Residential and Industrial environment, Basic Standards, Product Standards, National and International EMI Standardizing Organizations; IEC, ANSI, FCC, AS/NZS, CISPR, BSI, CENELEC, ACEC. Electro Magnetic Emission and susceptibility standards and specifications, MIL461E Standards. [10H]

MEASURMENT METHODS AND INSTRUMENTATION:Fundamental considerations, EMI Shielding effectiveness tests, Open field test, TEM cell for immunity test, Shielded chamber , Shielded anechoic chamber, EMI test receivers, Antennas, LISN, Feed through capacitor, current probe, EMC analyzer , Spectrum analyzer, EMI test wave simulators, EMI coupling networks, Line impedance stabilization networks, Feed through capacitors, Current probes, MIL -STD test methods. [10H]

Suggested Textbooks:

1. Clayton R.Paul – Introduction to Electromagnetic compatibility, 2nd Edition, 2006, Wiley & Sons.
2. B. Keiser, Principles of Electromagnetic Compatibility, 3rd Edition, 1987, Artech House.
3. V. P. Kodali, "Engineering EMC Principles, Measurements and Technologies" 1996, IEEE Press, New York.

Course Title	**:**	**Advanced Engineering Electromagnetics**			
Course Code	**:**	**EC534**	**Course Type**	**:**	**Elective I**
Contact Hours	**:**	**L-3 T- 0 P- 0**	**Credit**	**:**	**04**
Program/Semester	**:**	**M. Tech. /Sem I**			
Pre-requisites	**:**	**Nil**			
Evaluation Scheme	**:**	**Presentation (15%), Mid-Term (30%), Term Paper (15%), End-Term (40%)**			

Course Details:

Electromagnetics:

Electrostatic Problems and their solutions, Separation of variables in rectangular, cylindrical and spherical systems, Green's functions, Maxwell's equations, Electromagnetic Waves, Time domain equivalent and its relevance, Propagation of Waves in different medias like Dielectric interface, etc. under normal and oblique incidence plane waves in cylindrical system, Bessel's and Hankel's function, Scattering Problems under different conditions, Wave functions in Planar, Cylindrical and Spherical form. **[20H]**

Transmission Lines:

Telegrapher's equation, Reflection Coefficient, VSWR, impedance matching and techniques, single and double stub matching. Types of transmission lines. **[10]**

Waveguides:

Full wave analysis of different types of waveguides including solutions to TE/TM/HE modes, Parallel Plate waveguide, Rectangular Waveguides, Cylindrical Waveguides, Dielectric Slab waveguide, Cylindrical Dielectric Waveguide, Strip Line analysis, Microstrip Line as Resonator Structure, Quasi TEM modes in Microstrip line, Discontinuities in Microstrip Line, Boxed Microstrip line, Resonant cavities: Rectangular, Cylindrical, Dielectric Resonators. **[12H]**

Suggested Textbooks:

1. Time Harmonic Electromagnetic Fields, Roger F. Harrington, 13 September 2001, IEEE Press Wiley.
2. Electromagnetism Theory and Applications, Ashutosh Pramanik, 2nd Edition, June 2009 PHI.

References:

1. Elements of Electromagnetics, Mathew N. O. Sadiku, 6th Edition, January 2014, Oxford University Press.
2. Electromagnetic Waves and Radiating Systems, Jordan Balman, 2nd Edition, 1968 Prentice-Hall (PHI).
3. Field Theory of Guided Waves, Robert E Collin, 2nd Edition, December 1990, Wiley.
3. IEEE Transactions on Microwave Theory and Techniques Journal.

Course Title	**:**	**Radar Communication**			
Course Code	**:**	**EC552**	**Course Type**	**:**	**Elective II**
Contact Hours	**:**	**L-3 T-0 P-0**	**Credit**	**:**	**04**
Program/Semester	**:**	**M. Tech. /Sem II**			
Pre-requisites	**:**	**RF and Microwave Engineering**			
Evaluation Scheme	**:**	**Quiz I (15%), Mid-Term (30%), Quiz II (15%), End-Term (40%)**			

Course Details:

Introduction to RADAR –

Definition and basic concepts, Block Diagram RADAR equation under different cases - range performance, SNR; Power requirements. Radar Cross Section (RCS) - Different types, detectability of different geometries, Stealth Technology. Theory of detection - Detectability, Clutter Theory, Minimum detectible signal, Effect of weather, Land and Sea Clutter, Detection of Targets. **[15H]**

Types of RADAR–

CW and Frequency modulated Radar, MTI and Pulsed Doppler Radar, Tracking Radar, MSI Radar, LIDAR.
[12H]

Elements of RADAR -

Transmission details, Klystron amplifier, TWT Amplifier, Magnetron Amplifier, Solid State Transmitters, Phase shifters and its application in Transmitters. Receiver Details, Noise Figure, Mixers, Displays, Circulator and Antenna elements, Signal Processing design, Matched filter Receiver, CF AR Receivers. Examples of different types of RADAR in operation (application specific), RFID, propagation of Radar Waves, Round of Earth approximation, Refraction, Diffraction, Attenuation, Synthetic aperture Radar (SAR), Over the Horizon Radar, Air Surveillance Radar, Bistatic Radar, Millimeter waves and future of Radar Technology. **[15H]**

Suggested Textbooks:

1. Merill L Skolnik, "Introduction to RADAR Sy$tems", Tata Mc Graw Hills, 2003.
2. Bassem R. Mazhafa, "Introduction to RADAR analysis", CRC Press, 2000
3. Bassem R. Mazhafa, "RADAR Signal analysis and processing using MATLAB", CRC Press,2008.

Course Title	**:**	**Wireless Mobile Communication**			
Course Code	**:**	**EC554**	**Course Type**	**:**	**Professional Elective**
Contact Hours	**:**	**L-3 T-0 P-0**	**Credit**	**:**	**04**
Program/Semester	**:**	**M. Tech. /Sem I**			
Pre-requisites	**:**	**Fundamentals of Digital Communications**			
Evaluation Scheme	**:**	**Quiz I (15%), Mid-Term (30%), Quiz II (15%), End-Term (40%)**			

Course Details:

Motivation and Introduction, Types of Wireless communication, The modern wireless Communication Systems: generations and standards. **[4H]**

Fundamentals of cellular systems, Operation of cellular system, Concept of frequency reuse, Channel assignment strategies, Hand off strategies, Co-channel and Adjacent channel interference, Trunking and grade of service. Cell splitting, Sectoring**.** **[12H]**

Mobile Radio Signal propagation-path loss and channel models: Large Scale Path Loss, Small Scale Path Loss. [10H]

Modulation techniques for mobile Communication. Equalization and Diversity Techniques. [**10H]**

Coding techniques for mobile Communication. **[5H]**

Current and upcoming wireless systems: 3G, 4G, 802.11a/b/g, 802.16, WiMAX, 802.22. **[5H]**

Suggested Textbooks:

1. T S Rappaport, "Wireless communications", 2e, Prentice-Hall of India, Delhi, 2005.
2. William C. Y. Lee, "Mobile Cellular Telecommunications", 2e, McGraw Hill Inc., 1995.

References:

1. S. Haykin and M. Moher, " Modern Wireless Communications", Prentice Hall, 2005
2. M. Schwartz, "Mobile Wireless Communications", Cambridge University Press, 2005
3. A. Goldsmith , "Wireless Communications Systems", Cambridge university press,2005

Course Title	:	Selected Topics in Wireless Communication			
Course Code	**:**	**EC555**	**Course Type**	**:**	**Professional Elective**
Contact Hours	**:**	**L-3 T-0 P-0**	**Credit**	**:**	**04**
Program/Semester	**:**	**M. Tech. /Sem I**			
Pre-requisites	**:**	**Advanced Communication Engineering**			
Evaluation Scheme	**:**	**Quiz I (15%), Mid-Term (30%), Quiz II (15%), End-Term (40%)**			

Course Details:

Trellis Code Modulation (TCM): TCM principle, Optimum TCM codes, TCM code design for fading channels, Set partitioning. **[6H]**

Space-Time Block Codes: Introduction, Background, A twin- transmitter-based STBC, MAP decoding of STBCs, Channel-coded STBCs. **[8H]**

Space-Time Trellis Codes (STTC): Introduction, the 4-state, 4PSK space-time Trellis encoder and decoder, Other STTCs, Space- time coded transmission over wideband channels. **[8H]**

MIMO Communication: Introduction, Channel Capacity, SVD and Eigen modes of the MIMO channel, MIMO Receivers, Transmit Beamforming, MIMO Diversity-Alamouti's Code. **[10H]**

Orthogonal Frequency Division Multiplexing (OFDM): Introduction to OFDM, Structure of an OFDM signal, Generation of an OFDM signal using IFFT, OFDM signal bandwidth OFDM receiver design, Flash OFDM, MIMO techniques for OFDM, Multi-carrier CDMA (MC-CDMA), OFDM versus MC-CDMA. **[10H]**

Suggested Textbooks:

1. Lajos Hanzo, T. H. Liew, and B. L. Yeap, "Turbo Coding, Turbo Equalisation and Space-Time Coding for Transmission over Fading Channels", Wiley-IEEE Press, 2002.
2. Ramjee Prasad, "OFDM for wireless communications systems", Artech House Publishers, 2004.
3. David Tse and Pramod Viswanath, Fundamental of wireless communication, Cambridge University Press, 2005.

References:

1. Lajos Hanzo, M. Münster, B. J. Choi, and Thomas Keller, "OFDM and MC-CDMA for Broadband Multi-User Communications, WLANs and Broadcasting" Wiley-IEEE Press, 2003.
2. Branka Vucetic, Jinhong Yuan, and Branka Vucetic, "Space-Time Coding" Wiley, 2003.
3. Ahmad R. S. Bahai, Burton R. Saltzberg, and Mustafa Ergen, "Multi-carrier Digital Communications: Theory And Applications Of OFDM", 2e, Springer, 2004.

Course Title	**:**	**Information Theory and Coding**			
Course Code	**:**	**EC652**	**Course Type**	**:**	**Elective II**
Contact Hours	**:**	**L-3 T-0 P-0**	**Credit**	**:**	**04**
Program/Semester	**:**	**M. Tech. /Sem II**			
Pre-requisites	**:**	**Fundamentals of Digital Communications**			
Evaluation Scheme	**:**	**Quiz I (15%), Mid-Term (30%), Quiz II (15%), End-Term (40%)**			

Course Details:

Unit 1:
Review of probability theory, Entropy: marginal entropy, joint entropy, conditional entropy and the chain rule for entropy. Mutual information between ensembles of random variables. [6L]

Unit 2:
Source Coding theorems: prefix, variable and fixed length codes. Channel models and channel capacity. Channel Coding theorem. [9L]

Unit 3:
Linear Block Codes: Generator and parity check matrices, Minimum Distance, Syndrome decoding, Bounds on minimum distance. [8L]

Unit 4:
Cyclic Code: Finite Fields, binary BCH codes, RS Codes. [8L]

Unit 5:
Convolutional Codes: Encoders, Trellis, Viterbi decoding. [9L]

Suggested Textbooks:

1. Elements of Information Theory, Thomas M. Grover, Joy A. Thomas, 12nd Edition, January 2006, Wiley.
2. Digital Communications, John G. Proakis and Masoud Salehi, 5th Edition 2008, McGraw Hill.

References:

1. Error Control Coding, Shu Lin and Daniel Costello, 2nd edition, 2011, Pearson.
2. Modern Coding Theory, Rudiger Urbanke and Thomas Richardson, 1st Edition 2008, Cambridge.

Course Title	**:**	**Detection and Estimation Theory**			
Course Code	**:**	**EC556**	**Course Type**	**:**	**Professional Elective**
Contact Hours	**:**	**L-3 T-0 P-0**	**Credit**	**:**	**04**
Program/Semester	**:**	**M. Tech. /Sem I**			
Pre-requisites	**:**	**Random Signal Theory, Calculus, Linear algebra**			
Evaluation Scheme	**:**	**Quiz I (15%), Mid-Term (30%), Quiz II (15%), End-Term (40%)**			

Course Details:

Stochastic signal, orthogonal representation of signals, random process, Markov process, correlation function, power spectral density, Tchebycheff's inequality. **[10H]**

Detection in presence of noise, correlator, optimum filter, matched filter**.** **[10H]**

Weighted probabilities and hypothesis testing, composite hypothesis, Bayes, Minimax, and Neyman-Pearson criteria, likelihood ratio detection, sequential detection. **[10H]**

Principles of estimation, properties of estimator, Types of estimates and error bounds, Cramer-Rao Bound, Baye's maximum likelihood and least square estimation, parameter estimation, estimation of continuous waveforms, time invariant linear estimation, Wiener-Hopf and Kalman filtering. **[12H]**

Suggested Textbooks:

1. Detection, Estimation and Modulation Theory - Part 1, Harry L. Van Trees, 2004, John Wiley & Sons Inc.,
2. Decision and Estimation Theory, James L. Melsa and David L. Cohn, 1978, McGraw-Hill.

References:

1. Random Signals: Detection, estimation and Data analysis, K. Sam Shanmugan and Arthur M. Breipohl, May 1988, Wiley.
2. Principles of Digital Communication, J. Das, S.K Mullick, P.K Chatterjee, 2^{nd} Edition, 2012, New age International (P) Ltd publisher , New Delhi

Course Title	:	Wavelet and Filter Banks			
Course Code	**:**	**EC636**	**Course Type**	**:**	**Elective**
Contact Hours	**:**	**L-3 T-0 P-0**	**Credit**	**:**	**04**
Program/Semester	**:**	**M. Tech. /Sem I**			
Pre-requisites	**:**	**None**			
Evaluation Scheme	**:**	**Quiz I (15%), Mid-Term (30%), Quiz II (15%), End-Term (40%)**			

Course Details:

Module 1:
Fourier and Inverse Fourier Transforms. The Gabor Transform, Short Time Fourier Transform and the Uncertainty Principle. [6H]

Module 2:
Wavelet Transforms: Continuous and Discrete Wavelet Transform, Basic Properties of Wavelet Transforms, Orthonormal Wavelets, Wavelet Series, and Multiresolution Analysis, Scaling Functions and Orthonormal Wavelet Bases, Constructions of Orthonormal Wavelets, Compactly Supported Wavelets. [9H]

Module 3:
Fundamentals of Multirate Theory: The sampling theorem, Multirate operations: Decimation and Interpolation, multirate identities, Polyphase representation, Digital Filter Banks, DFT Filter Bank-Maximally decimated filter banks, Errors in the QMF bank, Perfect reconstruction (PR) QMF Bank, Design of an alias free QMF Bank. [10H]

Module 4:
M-channel perfect reconstruction filter banks: Uniform band and non-uniform filter bank, tree structured filter bank, Errors created by filter bank system, Polyphase representation, and perfect reconstruction systems. [8H]

Module 5:
Cosine Modulated filter banks: Cosine Modulated pseudo QMF Bank, Alias cancellation, Phase distortion, closed form expression, Polyphase structure, PR System [7H]

Suggested Textbooks:

1. Multirate systems and filter banks, P.P. Vaidyanathan. 2004, Prentice Hall.
2. Multirate digital signal processing. N.J. Fliege. 1994, John Wiley.

References Textbooks:

1. An Introduction to Wavelets, K. Chui, 2016, Academic Press USA.
2. Ten Lectures on Wavelets, I. Daubechies, SIAM,1990, Library of congress cataloguing in pulication data..
3. Wavelet Transforms and Their Applications, Lokenath Debnath, 2nd Edition 2014, Birkhauser.
4. S. Mallat, A wavelet Tour of Signal Processing, S. Mallat , 3rd Edition, 2009, Academic Press USA.

Course Title	**:**	**Digital Signal Compression**			
Course Code	**:**	**EC637**	**Course Type**	**:**	**Elective**
Contact Hours	**:**	**L-3 T-0 P-0**	**Credit**	**:**	**04**
Program/Semester	**:**	**M. Tech. /Sem I**			
Pre-requisites	**:**	**Digital Signal Processing / Signal Processing**			
Evaluation Scheme	**:**	**Quiz I (15%), Mid-Term (30%), Quiz II (15%), End-Term (40%)**			

Course Details:

Module I **[8H]**

Compression Techniques: Loss less compression, Lossy Compression, Measures of performance, Modelling and coding, Mathematical Preliminaries for Lossless compression: A brief introduction to information theory: Entropy, Information Value, Data Redundancy and Models.

Module II **[10H]**

Shannon-Fano Algorithm, Huffman Algorithm, Adaptive Huffman Coding. Arithmetic Coding (Encoding, Decoding, Adaptive Coding), Golomb codes, Rice codes, Tunstall codes, Applications of Hoffman coding: Loss less image compression, Text compression, Audio Compression

Module III **[12H]**

Dictionary Methods: LZ77, LZ78, LZW Algorithms, Wavelet Methods: Discrete Wavelet Transform, JPEG 2000, Image Compression: Discrete Cosine Transform, JPEG.

Module IV **[12H]**

Audio Compression: Digital Audio, WAVE, FLAC, MPEG-1/2 Audio Layers. Video Compression: Motion Compensation, Temporal and Spatial Prediction. MPEG and H.264

Suggested Textbooks:

1. Introduction to Data Compression, Khalid Sayood, 4th Edition 2012, Morgan Kaufmann Publishers Elsevier.
2. Elements of Data Compression, Drozdek, 20 november 2007, Cengage Learning
3. Data Compression: The Complete Reference 4th Edition 2007, David Salomon, Springer
4. Text Compression, Timothy C. Bell, 1st Edition 1990, Prentice Hall

Course Title	**:**	**Advanced Digital Filter Design**			
Course Code	**:**	**EC639**	**Course Type**	**:**	**Elective**
Contact Hours	**:**	**L-3 T-0 P-0**	**Credit**	**:**	**04**
Program/Semester	**:**	**M. Tech. / Sem I**			
Pre-requisites	**:**	**Digital Signal Processing , Matlab**			
Evaluation Scheme	**:**	**Quiz I (15%), Mid-Term (30%), Quiz II (15%), End-Term (40%)**			

Course Details:

Module I: Introduction to DSP **[8H]**

Discrete-time signals, sequence operations, sampling, Digital Signal Processing and its applications, filter and its applications, Discrete Fourier and Z-transforms, system function for linear shift-invariant systems, Fast Fourier Transform (FFT), fast convolution by FFT using the overlap-save or overlap-add methods, FFT algorithms in linear filtering and correlation.

Module II: Introduction of Digital Filters [**10H]**

Design of Infinite Impulse Response (IIR) digital filters by transformation from analog filters: Impulse Invariance, Bilinear Transformation, Matched Z-transforms, Design of LP, HP, BP, SP IIR Filters. Design of Finite Impulse Response (FIR) digital filters by Windowing, Frequency Sampling, Design of optimum Equiripple linear phase FIR filters, Design of LP, HP, BP, SP IIR Filters.

Module III: Advance Design methods of Digital Filters **[10H]**

Optimization Methods for IIR and FIR filter Design: Deczky’s method for IIR filter design in the frequency domain, Pade approximation method, Least- squares design method in time domain, Implementation aspects: Quantization of parameters, Finite word-length, and Filter Structures.

Module IV: Computer Aided Techniques of Filter Design **[10H]**

Computer Aided Design of FIR and IIR digital filters, Design of Digital filters by Criterion Minimization, Computer Added Design of Equiripple FIR Filters, Digital IIR and FIR Filter Design Using MATLAB

Module V: Application of Digital Filters **[4H]**

Application of Digital Filters in Signal and Image processing, Biomedical signal processing, Speech Processing etc.

Suggested Textbooks:

1. S. K. Mitra, Digital Signal Processing: A Computer Based Approach. Tata McGraw Hill. McGraw Hill, 2006.

Reference Textbooks:

1. Digital Signal Processing, Principles, Algorithms and Applications, John G. Proakis, Dimitris G. Manobakis, 3rd Edition, 2000, PHI
2. Digital Signal Processing, Emmanuel C Ifeachor, Barrie W Jrevis, 2002, Prentice Hall Pearson Education.

Course Title	**:**	**Adaptive signal processing**			
Course Code	**:**	**EC624**	**Course Type**	**:**	**Elective**
Contact Hours	**:**	**L- 3 T- 0 P- 0**	**Credit**	**:**	**04**
Program/Semester	**:**	**M.Tech/ Sem II**			
Pre-requisites	**:**	**NA**			
Evaluation Scheme	**:**	**Quiz I (15%), Mid-Term (30%), Quiz II (15%), End-Term (40%)**			

Course Details:

Introduction to Adaptive Filters. Adaptive filter structures, issues and examples. Applications of adaptive filters. [4H]

Discrete time stochastic processes: Re-visiting probability and random variables. Discrete time random processes. Power spectral density - properties. Autocorrelation and covariance structures of discrete time random processes. [5H]

Wiener filter, search methods and the LMS algorithm: Wiener FIR filter (real case). Steepest descent search and the LMS algorithm, Extension of optimal filtering to complex valued input. The Complex LMS algorithm. [5H]

Convergence and Stability Analyses: Convergence analysis of the LMS algorithm. Learning curve and mean square error behavior. Weight error correlation matrix. Dynamics of the steady state mean square error (mse). Misadjustment and stability of excess mse. [5H]

Variants of the LMS Algorithm. The sign-LMS and the normalized LMS algorithm. Block LMS. Review of circular convolution. Overlap and save method, circular correlation. FFT based implementation of the block LMS Algorithm. [5H]

Vector space framework for optimal filtering: Axioms of a vector space, examples, subspace. Linear independence, basis, dimension, direct sum of subspaces. Linear transformation, examples. Range space and null space, rank and nullity of a linear operator. Inner product space, orthogonality, Gram-Schmidt orthogonalization. Orthogonal projection, orthogonal decomposition of subspaces.Vector space of random variables, optimal filtering as an orthogonal projection computation problem. [6H]

The lattice filter and estimator: Forward and backward linear prediction, signal subspace decomposition using forward and backward predictions. Order updating the prediction errors and prediction error variances, basic lattice section. Reflection coefficients, properties, updating predictor coefficients. Lattice filter as a joint process estimator. AR modeling and lattice filters.Gradient adaptive lattice. [7H]

RLS lattice filter: Least square (LS) estimation, pseudo-inverse of a data matrix, optimality of LS estimation. Vector space framework for LS estimation. Time and order updating of an orthogonal projection operator. Order updating prediction errors and prediction error power. Time updating PARCOR coefficients. [7H]

References:

1. "Adaptive Filter Theory" by S. Haykin, Prentice Hall, Englewood Cliffs, NJ, 1991 (end Ed.).
2. "Adaptive Filters Theory and Applications", by B. Farhang-Boroujeny, John Wiley and Sons, 1999.

Course Title	**:**	**Advanced Digital Signal processing**			
Course Code	**:**	**EC 511**	**Course Type**	**:**	**Elective**
Contact Hours	**:**	**L- 3 T- 0 P- 0**	**Credit**	**:**	**04**
Program/Semester	**:**	**M.Tech.**			
Pre-requisites	**:**	**Signals and Systems (or equivalent course)**			
Evaluation Scheme	**:**	**Quiz I (10%), Mid-Term (20%), Quiz II (10%), End-Term (40%), Assignment (20%)**			

Course Details:

Module1: Overview of Discrete Fourier transform: Properties and applications, FFT: Radix-2, Radix-4, Split radix-FFT algorithms, FFT algorithms in linear filtering and correlation, Discrete Cosine Transform /Discrete Sin Transform: Properties and Applications [10H]

Module2: Design of Digital filters: Design of linear phase FIR filter: window techniques, frequency sampling methods, design of optimum equi-ripple linear phase FIR filters, Design of IIR filters: approximation of derivatives, impulse invariance bilinear transformation, matched Z-transforms, Optimization Methods for IIR and FIR filter Design: Deczky's method for IIR filter design in the frequency domain, Pade approximation method, Least- squares design method in time domain; Frequency sampling method for FIR filter. [14H]

Module3: Introduction to Multi-rate Digital Signal Processing – Sample rate reduction – decimation by integer factors- sampling rate increase – interpolation by integer facto – Design of practical sampling rate converters Filter Specification- filter requirement for individual stages – Determining the number of stages and decimation factors – Sampling rate conversion using poly-phase filter structure – poly-phase implementation of interpolators [6H]

Module 4: Adaptive Signal Processing – Adaptive filters – Concepts- Adaptive filter as a Noise Canceller – Other configurations of the adaptive filter – Main components of the adaptive filter – Basic Wiener filter theory – The basic LMS adaptive algorithm – Practical limitations of the basic LMS algorithm – Recursive Least Square Algorithm – Limitations – Factorization Algorithm. [6H]

Module 5: Applications of digital signal processing: Speech signal Processing, Bioelectric signal etc. [4H]

Suggested Textbooks:

1. Digital Signal Processing: A Computer Based Approach. S. K. Mitra, 3rd Edition 2006, Tata McGraw Hill.
2. Digital Signal Processing, Principles, Algorithms and Applications, John G. Proakis, Dimitris G. Manobakis, 3rd Edition, 2000, PHI

References:

1. Multirate systems and filter banks, P.P. Vaidyanathan. 2004, Prentice Hall.
2. Multirate digital signal processing. N.J. Fliege. 1994, John Wiley.
3. Digital Signal Processing, Emmanuel C Ifeachor, Barrie W Jrevis, 2002, Prentice Hall Pearson Education

Course Title	**:**	**Biomedical signal processing**			
Course Code	**:**	**EM609d**	**Course Type**	**:**	**Elective**
Contact Hours	**:**	**L- 3 T- 0 P- 0**	**Credit**	**:**	**01**
Program/Semester	**:**	**M.Tech/ Sem II**			
Pre-requisites	**:**	**NA**			
Evaluation Scheme	**:**	**Quiz I (15%), Mid-Term (30%), Quiz II (15%), End-Term (40%)**			

Course Details:

Introduction of Biomedical Signals (EEG, EMG, ECG, PSG, COP etc..), acquisition of biomedical signals, time domain based technique, frequency domain based technique, time frequency based technique for analysis of biomedical signal, problem, motivation, application and related issues of biomedical signals. [12H]

References:

1. Biomedical signal processing**,** D. Reddy, 2006, McGraw Hill Education.
2. Biomedical Signal Processing and Signal Modeling**,** Eugene N. Bruce, 2007, Wiley India

Course Title	**:**	**RF MEMS Design**			
Course Code	**:**	**EM666e**	**Course Type**	**:**	**Elective**
Contact Hours	**:**	**L- 3 T- 0 P- 0**	**Credit**	**:**	**02**
Program/Semester	**:**	**M.Tech/ Sem II**			
Pre-requisites	**:**	**NA**			
Evaluation Scheme	**:**	**Quiz I (15%), Mid-Term (30%), Quiz II (15%), End-Term (40%)**			

Course Details:

Basics of RF MEMS and related technologies: Applications of RF MEMS components in communications, space and defense applications, Materials and fabrication technologies, Actuation methods in MEMS, Special considerations in RF MEMS design. [7H]

RF MEMS Components: Capacitors, inductors, varactor, RF MEMS series and shunt switches, phase shifter, resonators, transmission lines, cavity resonators, Micro machined tunable filter MEMS antennas MEMS and MEMS based voltage controlled oscillator. [7H]

Simulation, Modelling and Characterization: Simulators, electromagnetic modelling, transient analysis, fabrication, measurement setup, calibration and characterization. [6H]

References:

1. RF MEMS: Theory, Design and Technology, Gabriel M. Rebeiz, 2004, jones & Wiley sons.

M.Tech. in ECE(Micro and Nano-Electronics)

Course Title	**:**	**Physics of Semiconductor Devices**			
Course Code	**:**	**EC 541**	**Course Type**	**:**	**Core 1**
Contact Hours	**:**	**L- 3 T- 0 P- 2**	**Credit**	**:**	**05**
Program/Semester	**:**	**M.Tech / Sem I**			
Pre-requisites	**:**	**None**			
Evaluation Scheme	**:**	**Quiz I (15%), Mid-Term (30%), Quiz II (15%), End-Term (40%)**			

Course Details:

Introduction to Quantum Mechanics
Principle of Quantum Mechanics, Schrodinger's wave equation, application of Schrodinger's wave equation, extension of wave theory to atoms. [5H**]**

Introduction to the Quantum Theory of Solids
Electrical conductions in solids, drift current, density of states function, statistical mechanics. [5H]

The Semiconductor in Equilibrium
Charge carriers in semiconductor, dopant atoms and energy levels, extrinsic semiconductor, statistics of donors and acceptors, charge neutrality, position of Fermi level. [5H]

Carrier Transport Phenomena
Carrier drift, carrier diffusion, Hall-effect, graded impurity distribution. [7H]

Non equilibrium excess carriers
Carriers generation and recombination, characteristics of excess carriers, ambipolar transport, Quasi-Fermi energy level. [7H]

The pn Junction
Basic structures of the PN junction, Zero bias condition, forward bias, reverse bias condition. [7H]

The pn Junction Diode
pn junction current, small signal model of pn junction, generation- recombination current, junction breakdown, charge storage and diode transient. [7H]

Fundamentals of the Metal-Oxide-Semiconductor Field-Effect Transistor
Two terminal MOS structure, basic MOSFET operation, non-ideal effects, MOSFET scaling, threshold voltage modification, radiation and hot electron effects. [7H]

Suggested Textbooks:

1. Physics of Semiconductor Devices, S. M. Sze, 3rd Edition 2006, John & Wiley sons.
2. Semiconductor Physics and Devices, Donald A. Neamen, 3rd Edition, 2007, McGraw Hill.
3. MOS Physics and Technology, E. H. Nicollian and J. R. Brews, 1982 John & Wiley sons.
4. Semiconductor Material and Device Characterization, DK. Schroder, 3rd Edition 2006, John Wiley.
5. Fundamentals of Solid-State Electronic Devices, C. T. Sah, 1991, Allied Publishers and World Scientific.
6. Solid State Electronic Devices, B.G. Streetman and S. Banerjee ,6th Edition, 2006, Prentice Hall India
7. Introduction to Solid State Electronics , E. F. Y. Waug, 2nd Edition 2012, Elsevier science publication company
8. MOSFET Models for VLSI Circuit Simulation,N. D. Arora, 1993, Springer-Verlag.
9. Operation and Modelling of the MOS Transistor, Y. P. Tsividis, 3rd Edition 2010, oxford university press.

Course Title	**:**	**Digital VLSI Design**			
Course Code	**:**	**EC 544**	**Course Type**	**:**	**Core 2**
Contact Hours	**:**	**L- 3 T- 0 P- 0**	**Credit**	**:**	**04**
Program/Semester	**:**	**M.Tech/Sem I**			
Pre-requisites	**:**	**None**			
Evaluation Scheme	**:**	**Quiz I (15%), Mid-Term (30%), Quiz II (15%), End-Term (40%)**			

Course Details:

Introduction to MOSFETs

MOS Transistor theory: Introduction MOS device, fabrication and modelling, body Effect, noise Margin; latch-up. [11H]

MOS Inverter

MOS transistors, MOS transistor Switches, CMOS Logic, circuit and system representations, design equations, static load MOS inverters, transistor Sizing, static and switching characteristics; MOS capacitor; resistivity of **v**arious layers. [11H]

Symbolic and Physical Layout Systems

MOS layers stick/layout diagrams; layout design rules, issues of scaling, scaling factor for device parameters. Combinational MOS logic circuits: Pass Transistors/Transmission gates; designing with transmission gates, primitive logic gates; complex logic circuits. Sequential MOS logic circuits: SR latch, clocked Latch and flip flop circuits, CMOS D latch and edge triggered flip flop. Dynamic logic circuits, basic principle, non-ideal effects, domino CMOS Logic, high performance dynamic CMOS circuits, clocking issues, two phase clocking.

CMOS subsystem design, semiconductor memories, memory chip organization, RAM Cells, dynamic memory cell. [20H]

Suggested Textbooks:

1. CMOS Digital Integrated Circuits: Analysis and Design, S. M. Kang and Y. Leblebici 3rd Edition 2002, MH.
2. Modern VLSI Design: System on Chip, W. Wolf, 3rd Edition2002 , PH/Pearson.
3. Principles of CMOS VLSI Design: A Systems Perspective,N. Weste, K. Eshraghian and M. J. S. Smith, Second Edition (Expanded), AW/Pearson, 2001.
4. VHDL design representation & synthesis, Z. Navabi, McGraw, 2nd Edition 1993 Hill International.
5. Verilog HDL: A Guide to Digital Design and Synthesis, S. Palnitkar, 2nd Edition 2003 Prentice Hall NJ, USA.

Course Title	**:**	**Device Fabrication Technology**			
Course Code	**:**	**EC 545**	**Course Type**	**:**	**Core 3**
Contact Hours	**:**	**L- 3 T- 0 P- 0**	**Credit**	**:**	**04**
Program/Semester	**:**	**M.Tech/Sem I**			
Pre-requisites	**:**	**None**			
Evaluation Scheme	**:**	**Quiz I (10%), Mid-Term (20%), Quiz II (10%), Term paper /Project/Assignment (20%), End-Term (40%)**			

Course Details:

The Science of Miniaturization:

Moore's Laws (1,2,&3) and technology' Roadmap–clean rooms Processing Methods: - Cleaning, oxidation, lithography, etching, CVD, diffusion, ion implantation, metallization, state of the art CMOS architectures photolithography overview ,critical dimension, overall resolution, line-width, lithographic sensitivity and intrinsic resist sensitivity (photochemical quantum efficiency), resist profiles, contrast and experimental determination of lithographic sensitivity, resolution in photolithography, photolithography resolution enhancement technology. [10H]

Nanostructuring by Physical Techniques

Next-generation technologies: state-of-the-art (including principles, capabilities, limits, applications) EUV lithography, phase-shifting photolithography, x-ray lithography, electron beam direct writing system, focused ion beam (FIB) lithography, neutral atomic beam lithography, plasma-aided nanofabrication, soft lithography, nanosphere lithography, nanoimprint, dip-pen nanolithography, key consequences of adopted techniques. [10H]

Nanomanipulation and Processing

Conventional techniques: scanning tunneling microscopy (STM), atomic force microscopy (AFM), near-field scanning optical microscopy (NSOM), advanced techniques: embossing and surface passivation, dimensional subtraction and addition, multistep Processing, of microcontact printing, Molding, implications and applications of the conventional and advanced techniques. [20H]

Nanometer Devices

Material Wave Nanotechnology: Nanofabrication using a de Broglie wave-electron beam holography, atomic beam holography, nanometer lithography using organic positive/negative resists – sub-10 nm lithography using inorganic resist – 40 nm-gate-length metal-oxide-semiconductor field-emitter-transistors-14 nm gate-length electrically variable shallow junction MOSFETs-operation of aluminium-based single-electron transistors at 100 kelvins- room temperature operation of a silicon single-electron transistor. [10H]

Suggested Textbooks:

1. VLSI Technology,S. M. Sze, 2nd Edition 1988, McGraw Hill.
2. VLSI fabrication principles, S. K. Gandhi, John Wiley, 2nd Edition 2008, wiley.
3. ULSI Technology, C. Y. Chang. S. M. Sze, 1996, McGraw Hill companies.
4. Silicon VLSI Technology Fundamentals, Practice and Modeling James D. Plummer Michael, D. Deal Peter B. Griffin, 2009, pearson Educations.
5. Nanostructures & Nanomaterials Synthesis, Properties, and Applications, Guozhong Cao, 2011 World Scientific Publishing Private, Ltd.
6. Nanotechnology and Nanoelectronics-Materials, Devices, Measurement Techniques, W. R. Fahrner, 2006, Springer-Verlag Berlin, Germany.

Course Title	**:**	**Analog Integrated Circuit Design**			
Course Code	**:**	**EC541**	**Course Type**	**:**	**Core 4**
Contact Hours	**:**	**L- 3 T- 0 P- 0**	**Credit**	**:**	**04**
Program/Semester	**:**	**M.Tech/Sem II**			
Pre-requisites	**:**	**None**			
Evaluation Scheme	**:**	**Quiz I (15%), Mid-Term (30%), Quiz II (15%), End-Term (40%)**			

Course Details:

Introduction to Analog Design

Why analog, Why Integrated, Why CMOS, general concepts levels of abstraction, robust analog deign.[7H]

Basics CMOS Device Physics

General considerations- MOSFET as a switch, MOSFET structure, MOS symbols. MOS I/V characteristics: threshold voltage, derivation of I/V characteristics, second order effects. MOS device models- MOS device layouts, MOS device capacitances, MOS small signal models, MOS spice models, nMOS v/s pMOS devices, long channel v/s short channel devices. [7H]

Single Stage Amplifiers

Basic concepts of amplifiers, Common Source Stage- common source with resistive loads, CS stage with diode-connected load, CS stage with current-source load, CS stage with triode load, CS stage with source degeneration, source follower, common gate stage, cascode stage , folded cascade stage, choice of device models. [7H]

Differential Amplifiers

Single ended and differential operation, basic differential pair- qualitative analysis, quantitative analysis, common mode response, differential pair with MOS loads, Gilbert cells. [7H]

Current Sources and Mirrors

Current sources, basic current mirrors, cascade current mirrors, wilson current mirror, large signal and small-signal analysis. [7H]

Frequency Response of Amplifiers:

Miller effect, association of poles with nodes, frequency response of all single stage amplifiers, comparators, charge-pump circuits and multipliers, data converters, analog interconnects, analog testing and layout issues, low voltage and low power circuits. Introduction to RF electronics, basic concepts in RF design. [7H]

Suggested Textbooks:

1. Design of Analog CMOS Integrated Circuits,B. Razavi, McGraw-Hill, 2001.
2. CMOS Circuit Design ,Layout and Simulation, R.Jacob Baker,H.W.Li, and D.E. Boyce, Prentice-Hall of India,1998.
3. Analog VLSI Signal and Information Process, Mohammed Ismail and Terri Faiz, Mc Graw Hill book company 1994.
4. Analysis and design of Analog Integrated circuits,Paul R. Gray and R.G.Meyer,"John Wiley and sons,USA"",(3rd Edition),1993.
5. RF Microelectronics, Prentice-Hall PTR,1998",
6. Journals: (i)IEEE Journal of Solid state Circuits
   (ii)IEEETrans. on Communications,B. Razavi, Prentice-Hall ,1998.

ELECTIVES

Course Title	**:**	**CMOS Memory Design**			
Course Code	**:**	**EC543**	**Course Type**	**:**	**Elective I**
Contact Hours	**:**	**L- 3 T- 0 P- 0**	**Credit**	**:**	**04**
Program/Semester	**:**	**M.Tech/Sem I**			
Pre-requisites	**:**	**CMOS Basics**			
Evaluation Scheme	**:**	**Quiz I (10%), Mid-Term (20%), Quiz II (10%), End-Term (40%), Term Paper/project/Assignment (20%)**			

Course Details:

Introduction to SRAM memory **[10H]**

Overview, volatile memory, non-volatile memory, on-chip memory, on-chip memory types. Review of CMOS circuit design, sensing circuitry basics, write circuitry and other peripheral circuities, refresh, kickback, SRAM (Read and Write operation, 6T, 8T cell implementation etc.).

DRAM Memories **[10H]**

Introduction to DRAM, High speed DRAM architectures, open and folded arrays organizations, bandwidth, latency, and cycle time, power, timing circuits. DRAM Cells read and write operations, issues and challenges related to destructive read operations. Peripheral circuitries, row and column decoders.

FLSAH Memories **[10H]**

Operation of FLASH memories (FLASH array sensing and programming), Charge Pump, PROM, EPROM, EEROM, NAND and NOR flash memories.

Emerging Memories **[10H]**

Emerging devices for memories such as Memristor, and other memories (RRAM, PCRAM, STRAM etc)

Suggested Textbooks:

1. Semiconductor Memories: A Handbook of Design, Manufacture and Application, Betty Prince, 2nd Edition, 1996, Wiley.
2. DRAM Circuit Design: Fundamental and High-Speed Topics, Keeth, Baker, Johnson, and Lin, 2007 ,IEEE Press, Wiley & John sons Publications.
3. CMOS Circuit Design, Layout, and Simulation, Jacob Baker, 3rd Edition, 2010, Wiley-IEEE Press.
4. Semiconductor Memories: Technology, Testing, and Reliability, Ashok K. Sharma, 2013 Wiley IEEE Press.

Course Title	**:**	**VLSI Device and Modeling**			
Course Code	**:**	**EC545a**	**Course Type**	**:**	**Elective I**
Contact Hours	**:**	**L- 3 T- 0 P- 0**	**Credit**	**:**	**04**
Program/Semester	**:**	**M.Tech/Sem I**			
Pre-requisites	**:**	**None**			
Evaluation Scheme	**:**	**Quiz I (15%), Mid-Term (30%), Quiz II (15%), End-Term (40%)**			

Course Details:

Semiconductors, Junctions and MOSFET Overview: Introduction to semiconductors , Conduction, Contact Potential s , P-N Junction, Overview of the MOS Transistor. [3H]

Basic Device Physics: Two terminal MOS structure: Flat -band voltage, Potential balance & charge balance, Effect of Gate- substrate voltage on surface condition, Inversion, Small signal capacitance [3H]

Three Terminal MOS Structure: Contacting the inversion layer, Bod y effect, Regions of inversion, Pinch-off voltage . [5H]

Four Terminal MOS Transistor: Transistor regions of operation, general charge sheet models, regions of inversion in terms of terminal voltage, strong inversion, weak inversion, moderate inversion, interpolation models , effective mobility, temperature effect s, breakdown p-channel MOS FET, enhancement and deletion type, model parameter values , model accuracy etc. Small dimension effects: channel length modulation, barrier lowering, two dimensional charge sharing and threshold voltage, punch- through, carrier velocity saturation, hot carrier effects ,scaling,effects of surf ace and drain series resistance, effects due to thin oxides and high doping. Sub threshold regions. [7H]

CMOS Device Design: Scaling, Threshold voltage, MOSFET channel length;
CMOS Performance Factor s: Basic CMOS circuit elements, parasitic elements ; sensitivity of CMOS delay to device parameter s; performance factor s of advanced CMOS device s. Bipolar Devices , Design & Performance [5H]

Suggested Textbooks:

1. Fundamentals of Modern VLSI Devices by Yuan Taur & Tak H. Ning, 2nd Edition 2013, Cambridge University Press.

Course Title	**:**	**VLSI Design Automation**			
Course Code	**:**	**EC545b**	**Course Type**	**:**	**Elective I**
Contact Hours	**:**	**L- 3 T- 0 P- 0**	**Credit**	**:**	**04**
Program/Semester	**:**	**M.Tech/Sem I**			
Pre-requisites	**:**	**None**			
Evaluation Scheme	**:**	**Quiz I (15%), Mid-Term (30%), Quiz II (15%), End-Term (40%)**			

Course Details:

VLSI CAD basics

VLSI CAD Flow, Chip Layout styles, High-level synthesis, Algorithm Design Approaches for VLSI CAD, models for physical design, Graph theory fundamentals. [10H]

Partitioning and Routing

Partitioning, floorplanning-tutte's approach, Graph-theoretic models of floorplans, Placement-general problem, quality metrics, Gordian, Design Rule Check, Compaction, Clock and Power Routing–Global routing,Channel routing. [5H]

Optimization and Synthesis

Optimization techniques, Logic synthesis and Technology Mapping-Dynamic Programming, Dagon, VLSI and Circuit Design Issues including power and delay analysis. [5H]

New topics in VLSI CAD

Design consideration for Analog and Mixed Signal Design. Emerging topics in the VLSI CAD. [10H]

Suggested Textbooks:

1. VLSI Physical Design Automation: Theory and Practice, S. M. Sait, and H. Youssef, 1999, World Scientific.
2. Introduction to Algorithms, T. H. Cormen, C. E. Leiserson, R. L. Rivest, and C. Stein, 3rd Edition, 2009, MIT Press.
3. Handbook of Algorithms for Physical Design Automation, C. J. Alpert, D. P. Mehta, S. S. Sapatnekar, 2008, Auerbach Publications CRC Press.
4. Practical Problems in VLSI Physical Design Automation, Sung Kyu Lim, 2008, Springer.
5. Algorithm for VLSI Physical Design Automation, Naveed A Sherwani, 3rd Edition, 2007 Kluwer academic publications.

Course Title	**:**	**Testing and diagnosis of Digital systems**			
Course Code	**:**	**EC548a**	**Course Type**	**:**	**Elective II**
Contact Hours	**:**	**L- 3 T- 0 P- 0**	**Credit**	**:**	**04**
Program/Semester	**:**	**M.Tech/Sem II**			
Pre-requisites	**:**	**None**			
Evaluation Scheme	**:**	**Quiz I (15%), Mid-Term (30%), Quiz II (15%), End-Term (40%)**			

Course Details:

Scope of testing and verification in VLSI design process

Fundamental issues in testing and verification of complex chips, embedded cores and SOCs. [10H]

Fundamentals of VLSI testing

Fault models, automatic test pattern generation, design for testability, scan design, test interface and boundary scan, system testing and test for SOCs. Iddq testing, delay fault testing, BIST for testing of logic and memories, test automation. [10H]

Design verification techniques

Design verification techniques based on simulation, analytical and formal approaches, functional verification, timing verification, formal verification, basics of equivalence checking and model checking, hardware emulation. [12H]

Reliability Analysis

Parametric testing, reliability modelling, yield models. [10H]

Suggested Textbooks:

1. Essentials of Electronic Testing for Digital, Memory and Mixed-Signal VLSI Circuits, M. Bushnell and V. D. Agrawal,2000, Kluwer Academic Publishers.
2. Digital Systems Testing and Testable Design, M. Abramovici, M. A. Breuer and A. D. Friedman, 1990, IEEE Press.
3. Introduction to Formal Hardware Verification, T. Krop, 2000. Springer Verlag.
4. System on a Chip Verification Methodology and Techniques, P. Rashinkar, Paterson and L. Singh, 2001, Kluwer Academic Publishers.

Course Title	**:**	**Low Power VLSI Design**			
Course Code	**:**	**EC548b**	**Course Type**	**:**	**Elective II**
Contact Hours	**:**	**L- 3 T- 0 P- 0**	**Credit**	**:**	**04**
Program/Semester	**:**	**M.Tech/Sem II**			
Pre-requisites	**:**	**None**			
Evaluation Scheme	**:**	**Quiz I (15%), Mid-Term (30%), Quiz II (15%), End-Term (40%)**			

Course Details:

Low power Basics:
Need for low power VLSI chips, Sources of power dissipation on Digital Integrated circuits. Emerging Low power approaches. Physics of power dissipation in CMOS devices. [5H]

Device & Technology Impact on Low Power:
Dynamic dissipation in CMOS, Transistor sizing & gate oxide thickness, Impact of technology Scaling, Technology & Device innovation. [5H]

Power estimation Simulation Power analysis:
SPICE circuit simulators, gate level logic simulation, capacitive power estimation, static state power, gate level capacitance estimation, architecture level analysis, data correlation analysis in DSP systems. [5H]

Low Power Design Circuit level:
Power consumption in circuits. Flip Flops & Latches design, high capacitance nodes, low power digital cells library. [5H]

Logic level:
Gate reorganization, signal gating, logic encoding, state machine encoding, pre-computation logic [5H]

Low power Architecture & Systems:
Power & performance management, switching activity reduction, parallel architecture with voltage reduction, flow graph transformation, low power arithmetic components, low power memory design. [5H]

Low power Clock Distribution:
Power dissipation in clock distribution, single driver V/s distributed buffers, Zero skew Vs tolerable skew, chip & package co design of clock network. [5H]

Algorithm & architectural level methodologies:
Introduction, design flow,Algorithmic level analysis & optimization, Architectural level estimation & synthesis. [7H]

Suggested Textbooks:

1. Practical Low Power Digital VLSI Design, Gary K. Yeap, 2012, Springer Science.
2. Low power design methodologies, Rabaey, Pedram, 1997, Kluwer Academic.
3. Low-Power CMOS VLSI Circuit Design, Kaushik Roy, Sharat Prasad 2000, Wiley.

Course Title	**:**	**CMOS RF IC Design**			
Course Code	**:**	**EC548**	**Course Type**	**:**	**Elective II**
Contact Hours	**:**	**L- 3 T- 0 P- 0**	**Credit**	**:**	**04**
Program/Semester	**:**	**M.Tech/Sem II**			
Pre-requisites	**:**	**None**			
Evaluation Scheme	**:**	**Quiz I (15%), Mid-Term (30%), Quiz II (15%), End-Term (40%)**			

Course Details:

Passive Devices for RF circuits

Characteristics of passive components for RF circuits, passive RLC networks. Transmission lines, two-port network modelling, S-parameter model, Smith Chart and its applications. [7H]

Active devices for RF circuits

SiGe MOSFET, GaAs pHEMT, HBT and MESFET, PIN diode, device parameters and their impact on circuit performance. [8H]

RF Amplifiers

RF Amplifier design: single and multi-stage amplifiers, review of analog filter design, low-pass, high-pass, band-pass and band-reject filters, bandwidth estimation methods, voltage references and biasing. [7H]

Low Noise Amplifiers

Low Noise Amplifier design: noise types and their characterization, LNA topologies, power match v/s noise match, linearity and large-signal performance. [10H]

Power Amplifiers

RF Power amplifiers: General properties. Class A, AB and C PAs. Class D, E and F amplifiers, modulation of power amplifiers, analog communication circuits: mixers, phase-locked loops, oscillators and synthesizer, design and performance characterization, transreceiver design [10H]

Suggested Textbooks:

1. The Design of CMOS Radio Frequency Integrated Circuits, Lee Thomas H, 2nd Edition 2004, Cambridge University Press.
2. Design of Analog CMOS integrated circuits, Razavi Behzad, 2002, McGraw Hill
3. VLSI for wireless communication, Bosco Leung, 2nd Edition 2011, Pearson Education

Course Title	**:**	**Advanced Micro and Nano Devices / Nano-electronics**			
Course Code	**:**	**EC549a**	**Course Type**	**:**	**Elective III**
Contact Hours	**:**	**L- 3 T- 0 P- 0**	**Credit**	**:**	**04**
Program/Semester	**:**	**M.Tech/Sem I**			
Pre-requisites	**:**	**None**			
Evaluation Scheme	**:**	**Quiz I (15%), Mid-Term (30%), Quiz II (15%), End-Term (40%)**			

Course Details:

UNIT I FUNDAMENTALS OF NANOELECTRONICS

Fundamentals of logic devices:- Requirements – dynamic properties – threshold gates; physical limits to computations; concepts of logic devices:- classifications – two terminal devices – field effect devices – coulomb blockade devices spintronics quantum cellular automata – quantum computing – DNA computer; performance of information processing systems;- basic binary operations, measure of performance processing capability of biological neurons – performance estimation for the human brain. Ultimate computation:- power dissipation limit – dissipation in reversible computation – the ultimate computer. [10H]

UNIT II SILICON MOSFETs & QUANTUM TRANSPORT DEVICES

Silicon MOSFETS - Novel materials and alternate concepts:- fundamentals of MOSFET Devices- scaling rules – silicon-dioxide based gate dielectrics – metal gates junctions & contacts – advanced MOSFET concepts. Quantum transport devices based on resonant tunneling: - Electron tunneling resonant tunneling diodes – resonant tunneling devices; Single electron devices for logic applications:- Single electron devices applications of single electron devices to logic circuits. [12H]

UNIT III CARBON NANOTUBES

Carbon Nanotube: Fullerenes - types of nanotubes – formation of nanotubes – assemblies – purification of carbon nanotubes – electronic properties – synthesis of carbon nanotubes – carbon nanotube interconnects – carbon nanotube FETs – Nanotube for memory applications – prospects of all carbon nanotube Nano electronics. [13H]

UNIT IV MOLECULAR ELECTRONICS

Electrodes & contacts – functions – molecular electronic devices – first test systems – simulation and circuit design – fabrication; Future applications: MEMS – robots – random access memory – mass storage devices. [10H]

Suggested Textbooks:

1. Nanotechnology: Basic Science and Emerging Technologies, Michael Wilson, Kamali Kannangara, Geoff Smith, Michelle Simmons and Burkhard Raguse, 2002 Chapman & Hall CRC
2. NANO: The Essentials – Understanding Nanoscience and Nanotechnology, T. Pradeep, 2007 TMH.
3. Nanoelectronics and Information Technology: Advanced Electronic Materials and Novel Devices, Rainer Waser ,2003, Wiley-VCH.

Course Title	**:**	**MEMS/ NEMS and Sensors**			
Course Code	**:**	**EC549b**	**Course Type**	**:**	**Elective III**
Contact Hours	**:**	**L- 3 T- 0 P- 0**	**Credit**	**:**	**04**
Program/Semester	**:**	**M.Tech/Sem II**			
Pre-requisites	**:**	**None**			
Evaluation Scheme	**:**	**Quiz I (15%), Mid-Term (30%), Quiz II (15%), End-Term (40%)**			

Course Details:

Introduction

MEMS and NEMS definitions, taxonomy of Nano and Microsystems synthesis and design, classification and considerations, biomimetics, biological analogies, and design, biomimetics fundamentals, biomimetics for NEMS and MEMS, Nano-ICs and nano-computer architectures. [10H]

Modelling Of Micro and Nano Scale Electromechanical Systems

Introduction to modelling, analysis and simulation, basic electro-magnetic with application to MEMS and NEMS, modelling developments of micro-and nano actuators using electromagnetic-Lumped-parameter mathematical models of MEMS, energy conversion in NEMS and MEMS. [10H]

Inorganic and Organic Enabled Sensors

Introduction-types of sensors-Mechanical, optical, spintronics, bioelectronics and biomagnetic sensors-surface modification-surface materials and interactions and its examples. [10H]

Sensor Characteristics and Physical Effects

Introduction to sensors, static Characteristics and dynamic characteristics, Physical effects: Photoelectric-effect, Photoluminescence-effect, Electroluminescence-effect ,Chemiluminescence-effect, Doppler-effect , Hall -effect, thermoelectric-effect, magneto-optical phenomena. [5H]

Future Nanosystems

Nano machines, nano robots, electronics based on CNT, molecular Electronics. Quantum Computation: Future of Meso/Nanoelectronics? -Interfacing with the Brain, towards molecular medicine, Lab-on-BioChips- Guided evolution for challenges and the solutions in NanoManufacturing technology. [7H]

Suggested Textbooks:

1. Micro-Electro Mechanical and Nano-Electro Mechanical Systems, Fundamental of Nano-and Micro-Engineering Sergey Edward Lyshevski, 2nd Edition 2005, CRC Press.
2. Nanomaterials: Synthesis, Properties and Applications Institute of Physics, A. S. Edelstein and Cammarata,2002, Bristol, Philadelphia Institute of Physics.
3. Micro manufacturing and Nanotechnology, N. P. Mahalik, 2006 Springer, Berlin Heidelberg New York.
4. Micro and Nanomanufacturing, Mark J. Jackson, Volume II 2007, Springer.
5. Nanofabrication, Principles, Capabilities and Limits, Zheng Cui, 2nd Edition 2016, Springer.
6. Nanotechnology Enabled Sensors, Kalantar–Zadeh K, 2008, Springer.
7. Future trends in Micro Electronics, Serge Luryi, Jimmy Xu, Alex Zaslavsky, 2007, John Wiley & Sons, Inc. Hoboken, New Jersey.

Course Title	**:**	**Nano Scale Integrated Computing**			
Course Code	**:**	**EC550**	**Course Type**	**:**	**Elective IV**
Contact Hours	**:**	**L- 3 T- 0 P- 0**	**Credit**	**:**	**04**
Program/Semester	**:**	**M.Tech/Sem I**			
Pre-requisites	**:**	**None**			
Evaluation Scheme	**:**	**Quiz I (15%), Mid-Term (30%), Quiz II (15%), End-Term (40%)**			

Course Details:

UNIT - I AN INTRODUCTION TO NANOCOMPUTING

Micro computing era Transistor as a switch, difficulties with transistors at the nanometer scale Nanoscale devices – Molecular devices – Nanotubes – Quantum dots – Wave computing – Quantum computing [8]

UNIT - II QUANTUM COMPUTING

Reversible computations – Quantum computing models – Complexity bounds for quantum computing – Quantum compression – Quantum error correcting codes – Quantum cryptography – Computing with quantum dot cellular automata – Quantum dot cellular automata cell – Ground state computing – Clocking – QCA addition – QCA multiplication – QCA memory – 4-bit processor [8H]

UNIT - III SPIN-WAVE ARCHITECTURES

Spin wave crossbar – Spin wave reconfigurable mesh – Spin wave fully interconnected cluster – Multi-scale Hierarchical architecture – Spin wave based logic devices – Logic functionality – Parallel computing with spin waves – Parallel algorithm design techniques – Parallel routing and broadcasting – On-Spin wave crossbar – On-Spin wave reconfigurable mesh – On-Spin wave fully interconnected cluster [10H]

UNIT - IV MOLECULAR COMPUTING

Switching and memory in molecular bundles – molecular bundle switches – Circuit and architectures in molecular computing – Molecular grafting for silicon computing – Molecular grafting on intrinsic silicon nanowires – Self assembly of CNTs [10H]

UNIT - V COMPUTATIONAL TASKS IN MEDICAL NANOROBOTICS

Medical Nanorobot designs – Microbivores – Clottocytes – Chromallocytes – Common functions requiring onboard computation – Nanorobot control protocols: Operation protocols – Biocompatibility protocols – Theater protocols – Nanoscale image processing: Labeling problem – Convex Hull problem – Nearest neighbor problem [10H]

Suggested Textbooks:

1. Quantum computation and quantum information‖, Nielsen M. A. and Isaac L. Chuang, 2010 Cambridge University Press.
2. Fundamentals of Digital Image Processing‖, Jain A. K., 7th Edition 1989, Prentice-Hall.
3. Semiconductor Material and Device Characterization‖, Schroder D. K., 3rd Edition 2006, New York.
4. Atomic and Molecular wires‖, Zhou C. and New Haven, 1999, Yale University Press.