Master of Technology

in

Electronics and Communication Engineering

Curriculum and Syllabus

(with effect from the academic year 2014 - 15)

DEPARTMENT OF ELECTRONICS ENGINEERING

SCHOOL OF ENGINEERING AND TECHNOLOGY

PONDICHERRY UNIVERSITY ***(A Central University)***

PUDUCHERRY - 605 014, INDIA

www.pondiuni.edu.in/department/department-electronics-engineering

M.Tech Programme in Electronics and Communication Engineering

The Department of Electronics Engineering under the School of Engineering and Technology, Pondicherry University, Pondicherry has been started in the academic year 2010 – 2011 with Master of Technology (M.Tech) programme in Electronics.

Regulations of the Programme

Besides the regulations specified by Pondicherry University in respect of engineering post graduate degree admission, evaluation and awarding the degree; the following norms are applicable.

Nature of Programme	:	Regular, coming under Engineering Department.
Programme Duration	:	Two years (Four Semesters) - Full Time
Eligibility Criteria	:	In addition to University regulations in respect of passing marks at undergraduate level and other criteria, candidates holding one of the following degrees alone shall be considered for this M.Tech Programme; B.E/B.Tech in Electronics and Communication Engineering, Electronics and Tele Communication Engineering, Electronics Engineering, Information Technology or its equivalent.
Admission Criteria	:	Pondicherry University's All India Entrance Examination or valid GATE score in relevant disciplines.
Intake	:	30 students per year
Teaching and Learning Methods	:	Lectures, tutorials and seminars form the main methods of course delivery, which would be supplemented by individual practical work, project work, simulation, assignments and industrial visits.
Assessment Methods	:	Choice Based Credit System (CBCS) is the method of assessment with 40% for internal and 60% for end semester performance. The end semester question paper will be set by the respective course teacher.
Minimum number of credits to be acquired for successful completion of the programme	:	74 credits.

Curriculum for M.Tech Electronics and Communication Engineering

I Semester

S. No.	Course Code	Course Title	H/S	L-T-P	Credits
1.	EENG 510	Electronic Systems Laboratory	H	0-0-2	2
2.	EENG 511	Probability and Stochastic Processes	H	3-1-0	4
3.	EENG 512	Advanced Digital Communication	H	3-1-0	4
4.	EENG 513	Advanced Digital Signal Processing	H	3-1-0	4
5.	EENG 514	High Speed Semiconductor Devices	H	3-1-0	4
6.	EENG 515	VLSI Design Techniques	H	4-0-0	4
7.		Elective I	S	3-0-0	3
Total Credits for Semester I					**25**

(H – Hard Core Course; S – Soft Core Course)

II Semester

S. No.	Course Code	Course Title	H/S	L-T-P	Credits
8.	EENG 520	Advanced Communication and Embedded Systems Laboratory	H	0-0-2	2
9.	EENG 521	Credit Seminar	H	0-2-0	2
10.	EENG 522	Advanced Electromagnetics	H	3-1-0	4
11.	EENG 523	High Performance Communication Networks	H	3-1-0	4
12.	EENG 524	Fault Tolerance for Digital Logic Circuits	H	3-1-0	4
13.		Elective II	S	3-0-0	3
14.		Elective III	S	3-0-0	3
15.		Elective IV	S	3-0-0	3
Total Credits for Semester II					**25**

(H – Hard Core Course; S – Soft Core Course)

III Semester

S. No.	Course Code	Course Title	H/S	L-T-P	Credits
16.	EENG 610	Project & Viva Voce: Part I	H	0-0-9	9
17.	EENG 611	Directed Study	S	3-0-0	3
Total Credits for Semester III					**12**

(H – Hard Core Course; S – Soft Core Course)

IV Semester

S. No.	Course Code	Course Title	H/S	L-T-P	Credits
18.	EENG 620	Project & Viva Voce: Part II	H	0-0-12	12
Total Credits for Semester IV					**12**

(H – Hard Core Course; S – Soft Core Course)

Total number of credits required to complete
M.Tech in Electronics and Communication Engineering : 74 credits

List of Level I Soft Core Courses

S.No.	Course Code	Name of the Course	L-T-P	Credits
1.	EENG 530	Advanced Optical Communication	3-0-0	3
2.	EENG 531	Computer Communication Networks	3-0-0	3
3.	EENG 532	Embedded Systems	3-0-0	3
4.	EENG 533	Free Space Optical Networks	3-0-0	3
5.	EENG 534	Micro-Electromechanical Systems	3-0-0	3
6.	EENG 535	Quantum Mechanics Its applications to Technology & Advanced Engg. Maths	3-0-0	3
7.	EENG 536	VLSI Systems	3-0-0	3

List of Level II Soft Core Courses

S.No.	Course Code	Name of the Course	L-T-P	Credits
1.	EENG 540	Advanced Image Processing	3-0-0	3
2.	EENG 541	Advanced Radiation Systems	3-0-0	3
3.	EENG 542	Advanced Satellite and Radar Communication	3-0-0	3
4.	EENG 543	Advanced Technologies in Wireless Networks	3-0-0	3
5.	EENG 544	Advanced Wireless Communications	3-0-0	3
6.	EENG 545	CMOS RF Circuit Design	3-0-0	3
7.	EENG 546	Convergence Technologies	3-0-0	3
8.	EENG 547	Design of Analog and Mixed Mode VLSI Circuits	3-0-0	3
9.	EENG 548	Electromagnetic Interference and Compatibility	3-0-0	3
10.	EENG 549	Green Radio Communication Networks	3-0-0	3
11.	EENG 560	Information and Network Security	3-0-0	3
12.	EENG 561	Low Power Digital VLSI Design	3-0-0	3
13.	EENG 562	Modeling and Simulation of Wireless Communication Systems	3-0-0	3

14.	EENG 563	Monolithic Microwave Integrated Circuits	3-0-0	3
15.	EENG 564	OFDM for Wireless Communication	3-0-0	3
16.	EENG 565	Optical Networking	3-0-0	3
17.	EENG 566	Principles of ASIC Design	3-0-0	3
18.	EENG 567	RF Engineering	3-0-0	3
19.	EENG568	RF Transceivers for Wireless Communications	3-0-0	3
20.	EENG 569	Ultra Wideband Communication Systems	3-0-0	3
21.	EENG 580	Wavelet Transform	3-0-0	3

* Directed study course can be chosen from the list of soft core courses (Level I/ Level II) or beyond the list of courses related to the project work. The candidate has to complete two assignments and two seminars or test which will be evaluated by the faculty in-charge. End semester examination will not be conducted for the course.

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
EENG 510	ELECTRONIC SYSTEMS LABORATORY	0	0	2	2	30

LIST OF EXPERIMENTS:

1. 8051 Microcontroller Based Experiments

    a. 32bit Addition/ Subtraction

    b. Logical operations

    c. BCD to Binary conversion and Hexadecimal to Decimal conversion

    d. Level and Edge triggering interrupts

    e. ADC/ DAC

2. DSP 5416 Based Experiments

    a. Sine wave generation

    b. Convolution

    c. FIR filter implementation

    d. IIR filter implementation

3. Communication Based Experiments

    a. Impedance measurement using Gunn diode

    b. Gain measurement of parabolic dish antenna using Klystron oscillator

    c. Characteristics of Directional couplers

    d. Design and analysis of different base band modulation schemes (DPCM, ADPCM)

    e. Design and analysis of different pass band modulation schemes (MSK, QAM)

    f. Analysis of sampling and noise spectral density

    g. Simulation of modulation schemes (FM, FSK, M-PSK, PCM) using MATLAB

    h. Simulation of filters (LPF/HPF/BPF/BSF) using MATLAB

4. Simulation Using VHDL/ Verilog

  a. Synthesis of Gates using VHDL/ Verilog

  b. Synthesis of Half-Adder and Full-Adder using VHDL/ Verilog

  c. Synthesis of Flip Flops using VHDL/ Verilog

  d. Synthesis of Counters using VHDL/ Verilog

  e. Synthesis of Registers using VHDL/ Verilog

  f. Synthesis of Multiplexer using VHDL/ Verilog

  g. Synthesis of PRBS generator using VHDL/ Verilog

5. Simulation Using PSPICE

  a. Simulation of Analog circuits using PSPICE

  b. Simulation of Digital circuits using PSPICE

  c. Simulation of Communication circuits using PSPICE

***** EENG 510*****

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
EENG 511	PROBABILITY AND STOCHASTIC PROCESSES	3	1	0	4	60

Objective : To teach the students for applying probability and stochastic process techniques in design and analysis of communication systems.

Outcome : The students will able to apply the concepts of probability and stochastic process for analyzing the performance of communication systems.

Unit I: Random Variables and their Probability Distributions **12 Hours**

Random Variables: Probability distribution function - probability density function - conditional probability - statistical independence - Bayes formula; Moments of random variables: Expected value and moments - mean and variance of random variable - coefficients of variation - skewness and kurtosis - moments - covariance and correlation coefficient - mean and variance of sum and product of two random variables - conditional mean and variance - application of conditional mean and variance.

Unit II: Discrete Random Variables and their Distributions **12 Hours**

Moment Generation Function: Characteristics function - cumulants - probability generating function - binomial distribution - negative binomial distribution - hypergeometric distribution -multinominal - Poisson distributions - relationship between various discrete type distributions.

Unit III: Continuous Random Variables and their Distributions **12 Hours**

Continuous Distributions: Normal - log normal - multivariate normal - gamma - exponential - chi square - Weibull - Rayleigh distributions - relationship between continuous distributions.

Unit IV: Transformation of Random Variables **12 Hours**

Transformation of Single and Several Random Variables: Function of random variables - sum - differences - product and ratio of two random variables - transformation through characteristic functions.

Unit V: Stochastic Processes **12 Hours**

Introduction: Classification of stochastic process - stationary process (SSS and WSS) - ergodic process - independent increment process - Markov process - counting process - narrowband process - normal process - Wiener Levy process - Poisson - Bernoulli - shot noise process - autocorrelation function.

Reference Books:

1. Michel K. Ochi, "Applied Probability and Stochastic Processes", John Wiley and Sons, 2008.

2. Paboulis A., "Probability, Random Variables and Stochastic Processes", Tata McGraw Hill, 1984.

3. Kishor S. Trivedi, "Probability and Statistics with Reliability Queuing and Computer Science Application", John Wiley and Sons, 2002.

Hyperlinks:

1. http://users.ece.utexas.edu/~gustavo/ee381j.html
2. http://www2.math.uu.se/research/telecom/software.html
3. http://www.ifp.illinois.edu/~hajek/Papers/randomprocesses.html.
4. http://www.rle.mit.edu/rgallager/notes.html.

Beyond the Syllabus Content:

Assignment can be given to simulate and infer the models developed based on probability and stochastic processes.

***** EENG 511*****

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
EENG 512	ADVANCED DIGITAL COMMUNICATION	3	1	0	4	60

Objective : To learn various digital modulations, channel coding, equalization and synchronization techniques of the digital communication systems.

Outcome : Advanced concepts of digital communication techniques will be understood by the students.

Unit I: Introduction **12 Hours**

Elements of Digital Communication System: Communication channels and their characteristics - mathematical models for channels - representation of digitally modulated signals - performance of memoryless modulation methods - signalling schemes with memory - CPFSK - CPM.

Unit II: Optimum Receivers for AWGN Channels **12 Hours**

Waveform and Vector Channel Models: Detection of signals in Gaussian noise - optimum detection and error probability for band limited signalling and power limited signalling - non coherent detection - comparison of digital signalling methods - lattices and constellations based on lattices - detection of signalling schemes with memory - optimum receiver for CPM - performance analysis for wireline and radio communication systems; Introduction to partially coherent, double differentially coherent communication systems.

Unit III: Channel Coding **12 Hours**

Introduction to Linear Block Codes: Convolution coding - Tree, Trellis and state diagrams – systematic - non-recursive and recursive convolutional codes - the inverse of a convolutional encoder and catastrophic codes - decoding of convolutional codes - maximum likelihood decoding - Viterbi algorithm and other decoding algorithms - distance properties - punctured convolutional codes - dual k codes - concatenated codes - MAP and BCJR algorithms - turbo coding and iterative decoding - factor graphs and sum-product algorithms - LDPC codes - trellis coded modulation - performance comparison.

Unit IV: Pulse Shaping and Equalization **12 Hours**

Pulse Shaping: Characterization of band limited channels - ISI - Nyquist criterion - controlled ISI - channels with ISI and AWGN - pulse shaping for optimum transmissions and reception; Equalization: MLSE - linear equalization - decision feedback equalization - ML detectors - iterative equalization - turbo equalization - adaptive linear equalizer - adaptive decision feedback equalization - blind equalization.

Unit V: Synchronization **12 Hours**

Signal Parameter Estimation: Carrier phase estimation - symbol timing estimation - joint estimation of carrier phase and symbol timing - performance characteristics of ML estimators.

Reference Books:

1. John G. Proakis and Masoud Salehi, "Digital communications", 5th Edition, Tata McGraw Hill, 2008.

2. Ian A. Glover and Peter M. Grant, "Digital Communications", 2nd Edition, Pearson Education, 2008.

3. Bernard Sklar, "Digital Communications: Fundamentals and Applications", 2nd Edition, Pearson Education, 2002.

4. Marvin K.Simon, M. Hinedi and William C. Lindsey, "Digital Communication Techniques: Signal Design and Detection", Prentice Hall of India, 2009.

5. John R. Barry, Edward A. Lee, David G. Messerschmitt, "Digital Communication", Kluwer Academic Publishers, 2004.

Hyperlink:

http://nptel.iitm.ac.in/courses/117101051.html

Beyond the Syllabus Content:

1. Develop a digital communication system using MATLAB/ Simulink.

2. Case study on various digital modulation techniques.

***** EENG 512*****

Course Code	Name of the Course	Periods			Credits	Total Hours
EENG 513	ADVANCED DIGITAL SIGNAL PROCESSING	L	T	P	4	60
		3	1	0		

Objective : To help the students to understand and solve complex problems in power spectrum estimations and signal processing.

Outcome : Students will able to analyze and implement advanced signal processing techniques for application levels.

Unit I: Parametric Methods for Power Spectrum Estimation **12 Hours**

Relationship Between Auto Correlation and Model Parameters: The Yule Walker method for the AR model parameters - the Burg method for the AR model parameters - unconstrained least square method for the AR model parameters - sequential estimation methods for the AR model parameters.

Unit II: Non-Parametric Methods for Power Spectrum Estimation **12 Hours**

Estimation of spectra from finite duration observation of signals; Non-Parametric Methods: Bartlett - Welch and Blackman - Tukey method.

Unit III: Adaptive Signal Processing **12 Hours**

FIR Adaptive Filters: Steepest descent adaptive filter - LMS algorithm - convergence of LMS algorithms; Applications: Noise cancellation - channel equalization; Adaptive recursive filters - recursive least squares.

Unit IV: Multirate Signal Processing **12 Hours**

Decimation by a factor D – Interpolation by a factor I – Filter design and implementation for sampling rate conversion; Direct form FIR filter structures – Polyphase filter structure.

Unit V: Discrete Transforms **12 Hours**

Discrete Transforms: Discrete Fourier transform - discrete cosine transform; Wavelet Transform: Introduction - Haar scaling functions and function spaces- nested spaces - Haar wavelet function - orthogonality of $\varphi(t)$ and $\psi(t)$ - normalization of Haar bases at different scales - Daubechies wavelets -support of wavelet system.

Reference Books:

1. John G. Proakis and Dimitris G. Manolkis, “Digital Signal Processing, Principles, Algorithms and Applications”, 3rd Edition, Prentice Hall of India, 2001.

2. Monson H. Hayes, “Statistical Digital Signal Processing and Modeling”, Wiley, 2002.

3. Roberto Crist, “Modern Digital Signal Processing”, Thomson Brooks/ Cole, 2004.

4. Raghuveer. M. Rao and Ajit S.Bopardikar, “Wavelet Transforms: Introduction to Theory and Applications”, Pearson Education, Asia, 2000.

5. K. P Soman, K. I Ramachanadran and N.G Reshmi, “Insights into Wavelets: From Theory to Practice”, 3rd Edition, Prentice Hall of India, 2010.

Hyperlinks:

1. www.aticourses.com/Advanced%20Topics%20in%20Digital%20Signals

2. www.ece.umd.edu/class/enee630.F2012.html

Beyond the Syllabus Content:

1. Assignments on implementation of various techniques in MATLAB for various applications.

2. Case study on surveying the different techniques with a specific application.

***** EENG 513*****

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
EENG 514	HIGH SPEED SEMICONDUCTOR DEVICES	3	1	0	4	60

Objective : The course aims to give exposure on the band diagram, characteristics of hetero-junction devices and fabrication techniques.

Outcome : Students will able to understand the characteristics of semiconductor materials and be aware of the structure of metal semiconductor, MOS and advanced devices and their fabrication techniques.

Unit I: Semiconductor Materials Characteristics **12 Hours**

Review of Crystal Structure: Crystal structure of important semiconductors (Si, GaAs, InP) - electrons in periodic lattices - energy band diagram - carrier concentration and carrier transport phenomenon - electrical - optical - thermal and high field properties of semiconductors.

Unit II: Homojunction Devices **12 Hours**

Homojunction Devices (BJT and FET): Structure - band diagram - operation - I–V and C–V characteristics (analytical expressions) - small signal switching models.

Unit III: MOS Devices **12 Hours**

MOS Diode: Structure - band diagram - operation - C–V characteristics - effects of oxide charges - avalanche injection - high field effects and breakdown; Heterojunction Based MOSFET: Band diagram - structure - operation - I–V and C–V characteristics (analytical expressions) - MOSFET breakdown and punch through - subthreshold current - scaling down; Alternate High k-dielectric Materials: HF–MOSFETs - SOI MOSFET - buried channel MOSFET - charge coupled devices.

Unit IV: Advanced Devices **12 Hours**

HBT and HEMT Devices: AlGaAs/ GaAs, InP and SiGe based HBT and HEMT structure - band diagram - operation - I–V and C–V characteristics (analytical expressions) - small signal switching models - benefits of heterojunction transistor for high speed applications.

Unit V: Fabrication and Characterization Techniques **12 Hours**

Crystal Growth and Wafer Preparation: Epitaxy - diffusion - ion implantation - dielectric film deposition and oxidization techniques - masking and lithography techniques (optical, e-beam and other advanced lithography techniques) - metallization - bipolar and MOS integration techniques - interface passivation techniques; Characterization Techniques: Four probe and hall effect measurement - I–V and C–V for dopant profile characterization and DLTS.

Reference Books:

1. Nandita Das Gupta and Amitava Das Gupta, "Semiconductor Devices: Modeling and Technology", Prentice Hall of India, 2004.

2. M. S. Tyagi, "Introduction to Semiconductor Materials and Devices", John Wiley and Sons, 2008.

3. S. M. Sze, "Physics of Semiconductor Devices", 3rd edition, John Wiley and Sons, 2007

4. J. Singh, "Semiconductor Devices: Basic Principles", John Wiley and Sons, 2007.

Hyperlinks:

1. http://nptel.iitm.ac.in/courses/Webcoursecontents/IITDelhi/Semiconductor%20Devices/index.html

2. http://nptel.iitm.ac.in/video.php/subjectId/117106093

3. http://nptel.iitk.ac.in/courses/Webcourse-contents/IITKANPUR/HighSpeed_SemiconductorDevices/ ui/Course_home-32.html

Beyond the Syllabus Content:

1. Chart preparation on hetero-junction devices mentioning its important features.

2. Assignment on fabrication techniques of heterojunction devices.

***** EENG 514*****

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
EENG 515	VLSI DESIGN TECHNIQUES	4	0	0	4	60

Objective : The course helps the students to understand the design and analysis of digital VLSI chips using CMOS technology.

Outcome : The students will able to understand the design issues at the layout, transistor logic and register-transfer level.

Unit I: MOS Transistor Theory **12 Hours**

NMOS/ PMOS Transistor: Threshold voltage equation - body effect - MOS device design equation - sub threshold region; Channel length modulation - mobility variation - tunneling - punch through; Hot electron effect MOS models - small signal AC characteristics; CMOS inverter - $\beta n/ \beta p$ ratio - noise margin - static load MOS inverters - differential inverter - tristate inverter - BiCMOS inverter.

Unit II: CMOS Process Technology **12 Hours**

Semiconductor Technology Overview: Basic CMOS technology - p well/ n well/ twin tub process; Circuit elements - resistor - capacitor - interconnects - sheet resistance and standard unit capacitance - concepts delay unit time - inverter delays - driving capacitive loads - propagate delays - MOS mask layer - stick diagram - Lambda based design rules and layout - scaling factor.

Unit III: Basics of Digital CMOS Design **12 Hours**

Combinational MOS Logic Circuits: Introduction - CMOS logic circuits - transmission gate; Dynamic Logic Circuits: Introduction - principles of pass transistor circuits; Voltage boot strapping synchronous circuits; Design of Arithmetic Circuits: ripple carry adder - carry look ahead adder - array multiplier - booth multiplier.

Unit IV: CMOS Sequential Logic Design **12 Hours**

Sequential MOS Logic Circuits: Introduction - behavior of bistable elements; SR latches circuit - clocked latch and flip flop circuits - CMOS D latch and triggered flip flop; Design examples of shift register - counter; Domino CMOS structure and design - charge sharing - clocking - clock generation - clock distribution.

Unit V: Verilog Hardware Description Language **12 Hours**

Overview of Digital Design with Verilog HDL: Hierarchical modeling concepts - modules and port definitions - gate level modeling - data flow modeling - behavioral modeling - task and functions - test bench.

Reference Books:

1. Neil Weste and K. Eshragian, "Principles of CMOS VLSI Design: A System Perspective", 2nd Edition, Pearson Education (Asia) Ltd., 2000.

2. Wayne Wolf, "Modern VLSI Design: System on Silicon", 2nd Edition, Pearson Education, 2002.

3. Douglas A Pucknell and Kamran Eshragian, "Basic VLSI Design", PHI, 3rd Edition, 1994.

4. Sung Mo Kang and Yosuf Lederabic Law, "CMOS Digital Integrated Circuits: Analysis and Design", 3rd Edition, McGraw-Hill, 2003.

5. Samir Palnitkar, "Verilog HDL", 2nd Edition, Pearson Education, 2004.

6. John P. Uyemura "Introduction to VLSI Circuits and Systems", John Wiley & Sons, Inc., 2002.

7. J. Bhasker, "A Verilog HDL Primer", 2nd Edition, B. S. Publications, 2001.

Hyperlinks:

1. http://web.ewu.edu
2. http://ic.sjtu.edu
3. http://nptel.iitm.ac.in

Beyond the Syllabus Content:

1. Assignments should insist computer simulations and evaluation of circuit design using Verilog.

2. Group of students can be assigned a project on latest circuit design using SPICE model.

***** EENG 515*****

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
EENG 520	ADVANCED COMMUNICATION AND EMBEDDED SYSTEMS LABORATORY	0	0	2	2	30

LIST OF EXPERIMENTS

1. Advanced microcontroller based system design.
2. Design, implementation and testing of GMSK modulator and demodulator.
3. Multiplexing, BER measurement and data transmission through optical fiber.
4. Analyse the characteristics of Single mode and Multimode fibre using OTDR.
5. Design a directional coupler and study the characteristics using microstrip trainer kit.
6. Design a power divider and study the characteristics using microstrip trainer kit.
7. Design a microstrip resonator and study the characteristics using microstrip trainer kit.
8. To measure the radiation characteristics of microstrip patch antenna.
9. To measure the radiation characteristics of printed dipole antenna.
10. Familiarity with DSP kits (Generation of noise signals).
11. Design and implementation of multirate system.
12. Simulation and performance evaluation of Wi-Fi/ WiMAX/ WSN routing protocols using NS-2/ QUALNET.
13. Design, implementation and testing of modulators used for mobile communication using spectrum analyzer.
14. Implementation of digital circuits using FPGA.
15. Design and implementation of network security algorithm, authentication protocols, firewalls and trusted systems using MATLAB.
16. Measure S/N and C/N using satellite link.

***** EENG 520*****

Course Code	Name of the Course	Periods			Credits	Total Hours
EENG 522	ADVANCED ELECTROMAGNETICS	L	T	P	4	60
		3	1	0		

Objective : This course will develop the skills required to solve problems related to harmonic electromagnetic fields and momentum methods.

Outcome : The students will able to analyze EFIE, MFIE for any type of microwave designs.

Unit I: Electromagnetic Waves **12 Hours**

Maxwell Equations: Integral and differential form - constitutive relations - time dependent wave equations - boundary conditions - polarization - time harmonic fields - pointing theorem - mode concepts - guided waves - TE & TM waves in a rectangular waveguide and circular waveguide - the coaxial transmission line - Smith chart and its applications.

Unit II: Theorems and Concepts **12 Hours**

Source Concept: Duality - uniqueness; Image Theory: Equivalence principle - fields in half space - the induction theorem - reciprocity - Green's function - tensor Green's function - integral equation; Construction of solutions; Radiation fields.

Unit III: Time Varying Harmonic Electromagnetic Fields **12 Hours**

Introduction: Maxwell equations - differential and integral form - constitutive parameters and relations - circuit field relations - boundary conditions - finite conductive media and infinite conductive media - sources along boundary - power and energy - time harmonic electromagnetic fields - Maxwell equations in differential and integral form - power and energy.

Unit IV: Integral Equation in Momentum Method **12 Hours**

Introduction: Integral equation method - electro charge distribution - integral equation - radiation pattern - point matching method - basis function - moment method electric and magnetic field integral equations; Finite diameter wires - Pocklington's integral equation-Hallen's integral equation.

Unit V: Green's Function **12 Hours**

Introduction: Direct construction approach for Green's function - Green's function for Sturm -Liouville differential equation - Green's function for loaded transmission line - Eigen function expression of Green's function - Green's function in two dimensions - double series method - single series expansion method - Green's function in spectral domain - Green's function for probe expectation of TE - modes in rectangular waveguide - Green's function for unbounded region.

Reference Books:

1. David J. Griffiths, "Introduction to Electrodynamics", 3rd Edition, Prentice Hall of India, 1999.

2. Roger. F. Harrington, "Time Harmonic Electromagnetic Fields", IEEE Press, Wiley, 2001.

3. John David Jackson, "Classical Electrodynamics", 3rd Edition, Wiley, 1999.

Hyperlinks:

1. http://nptel.iitm.ac.in/courses/Webcourse-contents/IIT-%20Guwahati/em

2. http://freevideolectures.com/Course/2340/Electromagnetic-Fields.html

3. http://ocw.mit.edu/OcwWeb/Electrical-Engineering-and-Computer-Science/6-632 Electromagnetic-Wave-TheorySpring2003/CourseHome/index.html

Beyond the Syllabus Content:

1. To study the electromagnetic radiating systems by analytical and numerical methods.

2. Introduction to geometric theory of optics and diffraction.

***** EENG 522*****

Course Code	Name of the Course	Periods			Credits	Total Hours
EENG 523	HIGH PERFORMANCE COMMUNICATION NETWORKS	L	T	P	4	60
		3	1	0		

Objective : To learn the architecture and characteristics of high performance networks.

Outcome : Students will able to understand the various topologies, services offered by broadband, TCP/ IP, ATM, WiMAX and UWB networks.

Unit I: Introduction **12 Hours**

Overview of Communication Networks: Telephone networks - computer networks - cable television networks - wireless networks - networking principles - digitalization - network externalities - service integration; Network Services and Layered Architecture: Traffic characterization and QoS - network services - network elements - network mechanisms - layered architecture - network bottlenecks.

Unit II: Broadband Networks **12 Hours**

Introduction: Multihop wireless broadband networks - mesh networks - MANET importance of routing protocols - classification of routing protocols in MANET - routing metrics - packet scheduling algorithms - admission control mechanism.

Unit III: Internet and TCP / IP Networks **12 Hours**

Internet: Internet protocol - technology trends in IP networks - IP packet communications in mobile communication networks; TCP and UDP - Internet success and limitation - performance of TCP/ IP networks; Circuits Switched Networks: SONET - DWDM - fiber to home - DSL - intelligent network (IN) scheme - comparison with conventional systems - merits of the IN scheme - CATV and layered network - services over CATV.

Unit IV: ATM Networks **12 Hours**

Introduction: ATM reference model - addressing - signaling - routing- ATM Adaptation Layer (AAL) - traffic classes - traffic management and quality of service - traffic descriptor - traffic shaping - management and control - traffic and congestion control - network status monitoring and control - user/ network signaling - internetworking with ATM - IP over ATM - multiprotocol over ATM.

Unit V: High Performance Networks **12 Hours**

Introduction: WiMAX overview - competing technologies - overview of the physical layer - PMP mode - mesh mode - multihop relay mode; Introduction: UWB overview - time hopping UWB - direct sequence UWB - multiband UWB; Introduction: LTE and LTE– A overview - system model - specifications - frame structure - comparison with broadband technologies.

Reference Books:

1. Jean Warland and Pravin Varaiya, "High Performance Communication Networks", 2nd Edition, Harcourt and Morgan Kanffman Publishers, London, 2008.

2. Leon Gracia and Widjaja, "Communication Networks", Tata McGraw Hill, 2008.

3. Lumit Kasera and Pankaj Sethi, "ATM Networks: Concepts and Protocols", Tata McGraw Hill, 2007.

4. Jeffrey G. Andrews, Arunabha Ghosh and Rias Muhamed, "Fundamentals of WiMAX Understanding Broadband Wireless Networking", Prentice Hall of India, 2008.

5. Amitabha Ghosh and Rapeepat Ratasuk, "Essentials of LTE and LTE-A", Cambridge University, 2011.

6. David Tung Chong Wong, Peng-Yong Kong, Ying-Chang Liang, Kee Chaing Chua and Jon W. Mark, "Wireless Broadband Networks", John Wiley and Sons, 2009.

Hyperlinks:

1. http:// www.ece.gmu.edu/.../high performance communication networks_1.pdf

2. http://www.cs.cmu.edu/~prs/wirelessS12.html

3. http://www.amazon.com/dp/1558605746/ref=rdr_ext_tmb

Beyond the Syllabus Content:

1. Assignments can be given to explore the interconnection and performance behavior of TCP/ IP or LTE networks through simulation using any network simulation tools.

2. Chart preparation on the layered architectures of high performance communication networks with their important features.

***** EENG 523*****

Course Code	Name of the Course	Periods			Credits	Total Hours
EENG 524	FAULT TOLERANCE FOR DIGITAL LOGIC CIRCUITS	L	T	P	4	60
		3	1	0		

Objective : The course is structured in such a way that each module exposes to various methods of identifying faults in logical circuits.

Outcome : Students will able to design digital systems and state machines with fault tolerance.

Unit I: Design of Synchronous System **12 Hours**

Synchronous System: Erroneous state transition - asynchronous to synchronous conversion - the Go/No Go configuration logical adjacency - top down design of digital systems; Design Examples: Tester control - frame counter - serial adder - reaction timer and an asynchronous receiver.

Unit II: Programmable Logic Devices **12 Hours**

Introduction to Programmable Logic Devices: Read only memory - programmable logic array - programmable array logic - programmable logic sequencer. State Machines: Need for state machine - state machine charts - derivation of SM charts - realization of SM charts - state transition table.

Unit III: Fault Diagnosis in Combinational Circuits **12 Hours**

Hazards in Combinational and Sequential Circuits: Logical fault model - Stuck at open - stuck at short and bridging fault; Fault Diagnosis in Combinational Circuit: Path sensitizing method - boolean difference; Detection of multiple faults; Fault tolerant design and redundancy techniques.

Unit IV: Fault Diagnosis in Sequential Circuits **12 Hours**

Fault Detection Experiments: Homing experiments - distinguishing experiments and synchronizing experiments; Machine Identification: Design of diagnosable machines; Second algorithm for the design of fault detection experiments; Fault detection experiments for machines with no distinguishing sequences.

Unit V: Transformation of Sequential Machines **12 Hours**

Finite State Model: Input/ output transformation - terminal state; Capabilities and Limitations of Finite State Machines: State equivalence and machine minimization - machine equivalence - Isomorphic machines; Simplification of Incompletely Specified Machines: Compatible states - non-uniqueness of reduced machines - merger graph and compatibility graph.

Reference Books:

1. David. J. Comer, “Digital Logic and State Machine Design”, 3rd Edition, Oxford university press, 1994.

2. Zvi Kohavi, “Switching and Finite Automata Theory”, 2nd Edition, Tata McGraw Hill, 2001.

3. Donald A. Neamen, “Electronic Circuit Analysis and Design”, 2nd Edition, Tata McGraw Hill, 2002.

4. Parag K Lala, “Fault Tolerant and Fault Testable Hardware Design”, Prentice Hall of India, 2007.

5. Mishra and Chandrasekaran, “Theory of Computer Science: Automata, Languages and Computation”, 2nd Edition, Prentice Hall of India, 2004.

Hyperlinks:

1. http://www2.cs.uidaho.edu/~krings/CS449

2. http://www.cs.colostate.edu/~malaiya/530/08/1Intro.pdf

3. http://www.ida.liu.se/~TDDB47/lectures/tddb47-dependability-2x3.pdf

Beyond the Syllabus Content:

1. Assignment on implementation of latest fault tolerant techniques.

2. Case studies relevant to the topics discussed in the class.

***** EENG 524*****

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
EENG 530	ADVANCED OPTICAL COMMUNICATION	3	0	0	3	45

Objective : To impart the concepts of multilevel modulation schemes, OFDM and MIMO for optical communication systems.

Outcome : Students will understand the potential of physical layer of optical system with its limitations.

Unit I: Introduction **9 Hours**

Prologue: Historical perspective - light sources - modulators - photodiodes - fiber losses - waveguide theory of fibers - signal dispersion - pulse propagation - multichannel propagation - signal propagation.

Unit II: Noise Sources and Channel Impairments **9 Hours**

Noise Sources: Optical channel noise - BER - SNR - receiver sensitivity; Channel Impairments: Signal impairments - optical transmission link limits.

Unit III: Modulation Schemes **9 Hours**

Modulation Schemes: Multilevel modulation schemes - multi-dimensional hybrid modulation schemes - OFDM for optical communications - MIMO optical communications.

Unit IV: Detection Schemes **9 Hours**

Detection Schemes: Coherent detection of optical signals - optical channel equalization - digital back propagation - synchronization - coherent optical OFDM detection - optical MIMO detection.

Unit V: Optical Channel Capacity and Energy Efficiency **9 Hours**

Optical Channel Capacity: Capacity of continuous channels - channels with memory - coherent detection - optical MIMO/ OFDM systems; Energy Efficiency: Energy efficient optical transmission.

Reference Books:

1. Milorad Cvijetic and Ivan B. Djordjevic, “Advanced Optical Communication Systems and Networks”, Artech House, 2012.

2. Pierre Lecoy, “Fibre-Optic Communications”, John Wiley and Sons, 2010.

3. Enrico Forestieri, “Optical Communication Theory and Techniques”, Springer, 2006.

4. James N. Downing, “Fiber-Optic Communications”, Cengage Learning, 2004.

5. A. J. Rogers, “Understanding Optical Fiber Communications”, Artech House, 2001.

6. Gerd Keiser, “Optical Fiber Communication”, 4th Edition, McGraw Hill, 2010.

7. G. P. Agrawal, “Fiber Optics Communication Systems”, 4th Edition, Wiley, 2010.

8. Leonid G. Kazovsky, Sergio Benedetto and Alan E. Willner, “Optical Fiber Communication Systems”, Artech House,1996.

9. V. S. Bagad, “Optical Communications”, Technical Publications, 2009.

Hyperlinks:

1. http://nptel.iitm.ac.in/courses/117101002.html
2. http://www.optics.arizona.edu/academics/course/opti-632.html

Beyond the Syllabus Content:

Analyze the subsystems of optical system with algorithms like BCJR etc.

***** EENG 530*****

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
EENG 531	COMPUTER COMMUNICATION NETWORKS	3	0	0	3	45

Objective : To gain expertise in network designs and maintenance of individual networks.

Outcome : Students will understand the functionalities of network devices and protocols of computer networks.

Unit I: Introduction to Networks **9 Hours**

Background: Data communication networks - standards - ISO reference model - electrical interface - transmission media - attenuation and distortion sources - signal types - propagation delay - physical layer interface standards - data transmission - asynchronous and synchronous transmission - transmission control circuits and devices.

Unit II: Data Link Control and Protocols **9 Hours**

Flow and Error Control Schemes: Idle and continuous ARQ - link management - protocols application environments character oriented protocols - bit oriented protocols - local area networks - issues - types - protocols and performance.

Unit III: Link Layer Devices and Switching Networks **9 Hours**

Introduction: Interconnection methods - hubs - high speed LANs and MANs - bridges - transparent bridges - source routing bridges - switches - performance issues - wide area networks - characteristics of public data networks - packet switched data networks - circuit switched data networks - integrated services digital networks - private networks.

Unit IV: Internetworking and Transport Protocol **9 Hours**

Introduction: Internetwork architectures - internetworking issues - network layer structure - Internet protocol standards - Internet IP - ISO Internet Protocol - ISO routing protocols - transport protocols - user datagram protocol - transmission control protocol - OSI protocols - service definition - protocol specification.

Unit V: Application Support and Specific Protocols **9 Hours**

Introduction: Session layer - presentation layer – ASN- l5 - data encryption - presentation protocol - association control service element - remote operations service element - commitment concurrency and recovery - reliable transfer service element - TCP/IP application protocols - ISO application protocols - introduction - directory services – examples of OSI environments.

Reference Books:

1. Fred Halsall, “Data Communications, Computer Networks and Open Systems”, Addison Wesley, 1992

2. Fred Halsall, “Computer Networking and the Internet”, 5th Edition, Addison Wesley, 2005.

3. Fred Halsall, “Data Communications and Networking”, 5th Edition, McGraw Hill, 2012.

4. Andrew .S. Tanenbaum, “Computer Networks”, 4th Edition, Prentice Hall of India, New Delhi, 2008.

5. William Stallings, “Data and Computer Communication”, 2nd Edition, Macmillan, New York, 2004.

6. Houston. H. Carr and Charles. A. Snyder, “Data Communications and Network security”, Tata McGraw Hill, New Delhi, 2007.

7. Peterson. L Davie “Computer Networks: A Systems Approach”, Morgan Kauffmann, 2008.

Hyperlinks:

1. http:// www.nptel.iitm.ac.in

2. http://www.ocw.mit.edu

3. http://web.iiit.ac.in/~bezawada/CN.html

Beyond the Syllabus Content:

1. Simulation of routing algorithms.

2. Chart for ISO/ TCP/ IP model.

3. Chart for comparison of all networking protocols.

***** EENG 531*****

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
EENG 532	EMBEDDED SYSTEMS	3	0	0	3	45

Objective : To study the various types of processors, concept of inter-communication and real time operating systems.

Outcome : Students will understand the principles, components and architectures of embedded systems.

Unit I: Introduction to Embedded Processors **9 Hours**

Introduction to Embedded Computing: Issues and challenges in embedded system design - trends - SOC - custom designed chips - configurable designed chips - configurable processors and multicore processors; Embedded Processor Architecture: RISC architecture - 8051 architecture - PIC - ARM and SHARC architecture; VLIW and DSP Processors: General concepts - levels in architecture - functional description - processor organization - memory organization - instruction sets and formats - addressing modes - pipelining - parallelism.

Unit II: Devices and Communication Buses for Devices Network **9 Hours**

I/O Devices: Types and examples of I/O devices - synchronous - iso synchronous and asynchronous communications from serial devices - examples of serial communication devices - RS232/ RS485 - UART - SPI - SCI - parallel port devices - timer and counting devices - serial bus communication protocols using I2C - USB - CAN - advanced serial high speed buses - parallel bus communication protocols using ISA - PCI - PCI/ X and advanced buses - network protocols for internet enabled systems - wireless and mobile system protocols.

Unit III: Programming Concepts and Embedded Programming in C, C++ **9 Hours**

Programming Concepts: Assembly language vs high level language C program elements: macros and functions - use of data types - structure - pointers - function calls - concepts of embedded programming in C++ - objected oriented programming - embedded programming in C++ ; C program compilers - cross compiler - optimization of memory needs.

Unit IV: Inter Process Communication & Synchronization **9 Hours**

Definitions of Process: Tasks and threads - inter process communication - shared data problem - use of semaphore(s) - priority inversion problem and deadlock situations - message queues - mailboxes - pipes - virtual (logical) sockets - remote procedure calls (RPCs).

Unit V: Real Time Operating Systems **9 Hours**

Operating System Services: Goals - structures - kernel - process management - memory management - device management - real time operating system - RTOS task scheduling models - cooperative round robin scheduling - cyclic scheduling with time slicing.

Reference Books:

1. Raj Kamal, "Embedded Systems Architecture, Programming and Design", McGraw-Hill, 2nd Edition, 2008.
2. Wayne Wolf, "Computers as Components: Principles of Embedded Computing System Design", 2nd Edition, Morgan Kaufman Publishers, 2008.
3. Steve Heath, "Embedded Systems Design", 2nd Edition, Newnes, 2003.
4. David E. Simon, "An Embedded Software Primer", 4th Impression, Pearson Education, 2007.
5. Frank Vahid and Tony Givargis, "Embedded Systems Design – A Unified Hardware/ Software Introduction", 2nd Edition, John Wiley, 2006.
6. Arnold S Burger, "Embedded System Design: An Introduction to Processes, Tools and Techniques", CMP books, 2007.
7. Steven F Barrett and Daniel J Pack, "Embedded Systems", Pearson Education, 2008.
8. Dreamtech Software Team, "Programming for Embedded Systems", Wiley Dreamtech, 2002.

Hyperlinks:

1. http://ecee.colorado.edu/~mcclurel/index.html
2. http://mysite.du.edu/~rvoyles/
3. http://www.gtbit.org/news/viewitem.php?id=91
4. http://courses.cs.washington.edu/courses/cse477/01sp/admin/schedule.html
5. http://codesign.cs.tamu.edu/teaching/csce617/labs-projects-s13
6. http://www.onlinevideolecture.com/electrical-engineering/nptel-iit-delhi/embedded-systems/?course_id=519

Beyond the Syllabus Content:

1. Mini project can be given on microcontroller for real time applications.
2. Seminar can be conducted on various topics of advanced embedded systems.

***** EENG 532*****

Course Code	Name of the Course	Periods			Credits	Total Hours
EENG 533	FREE SPACE OPTICAL NETWORKS	L	T	P	3	45
		3	0	0		

Objective : To introduce wireless Gigabit technology by means of optical wireless communications.

Outcome : Students can understand the deployment of free space optics.

Unit I: Introduction **9 Hours**

Introduction: Propagation of light in unguided media - laser beam characteristics - atmospheric effects on optical signals - coding for atmospheric optical propagation - LIDAR.

Unit II: FSO Transceiver Design **9 Hours**

Light Sources: Modulators - photo detectors and receivers - optical amplification - optical signal to noise ratio - acquisition, pointing and tracking - adaptive and active optics - laser safety - node housing and mounting.

Unit III: Point to Point FSO Systems **9 Hours**

Simple PtP Design: Transponder nodes - hybrid FSO and RF - FSO point to multipoint - FSO point to mobile; Ring FSO Systems: Ring topologies and service protection - ring nodes with add drop - concatenated rings - ring to network connectivity.

Unit IV: Mesh FSO Systems **9 Hours**

FSO Nodes for Mesh Topology: Hybrid mesh FSO with RF - hybrid FSO fiber networks; WDM Mesh FSO: DWDM and CWDM optical channels - WDM FSO links - WDM mesh FSO networks - service protection in mesh FSO networks.

Unit V: FSO Network Security and Applications **9 Hours**

Cryptography: Security levels - security layers - FSO inherent security features; FSO Specific Applications: FSO networks for highway assisted communications - mesh FSO in disaster areas - visual light communication.

References Books:

1. Stamatios V. Kartalopoulos, “Free Space Optical Networks for Ultra-Broad Band Services”, IEEE Press, 2011.

2. Arun K. Majumdar and Jennifer C. Ricklin, “Free-Space Laser Communications: Principles and Advances”, Springer, 2008.

3. Olivier Bouchet, Herve Sizun, Christian Boisrobert and Frederique De Fornel, “Free-Space Optics: Propagation and Communication”, John Wiley and Sons, 2010.

4. Heinz Willebrand and Baksheesh S. Ghuman, “Free Space Optics: Enabling Optical Connectivity in Today's Networks”, Sams Publishing, 2002.

Hyperlinks:

1. http://whatis.techtarget.com/definition/free-space-optics-FSO.html
2. http://ee.stanford.edu/~jmk/research/fsocom.html
3. http://www.rp-photonics.com/free_space_optical_communications.html

Beyond the Syllabus Content:

1. FSO versus EM wireless.
2. FSO in Public Network.
3. Optical communication in the mid-wave IR spectral band.
4. Quantum cascade laser based free space optical communication.
5. Free space optics for last mile access by integrating with WiMAX and LTE networks.

***** EENG 533*****

Course Code	Name of the Course	Periods			Credits	Total Hours
EENG 534	MICRO-ELECTROMECHANICAL SYSTEMS	L	T	P	3	45
		3	0	0		

Objective : The course is designed to familiarize the student with the functions and applications of MEMS.

Outcome : Students will able to design different type of MEMS based devices, circuits and subsystems.

Unit I: Introduction to MEMS **9 Hours**

Evolution of Micro Electro Mechanical Systems (MEMS): Market for MEMS - MEMS material properties - microelectronics technology for MEMS; Introduction and Origin of MEMS: Driving force for MEMS development.

Unit II: Micromachining Technology for MEMS **9 Hours**

Fabrication Process: MEMS fabrication technologies - conventional IC fabrication processes - bulk micro machining - surface micro machining - LIGA process - anodic and fusion bonding - packaging techniques for MEMS.

Unit III: Sensor and Actuators **9 Hours**

Sensors: Classifications - principle - design and characterization of thermal - micromachined - mechanical - pressure - flow sensor - bio sensor; Actuation in MEMS Devices: Electrostatic actuation - parallel plate capacitor - cantilever beam based movement; Optical MEMS: Micro mirror.

Unit IV: Accelerometers **9 Hours**

MEMS Accelerometer: Design principle and technology - Temperature drift and damping analysis; Piezo resistive accelerometer - design principle and technology - MEMS capacitive accelerometer - process - gyro sensor.

Unit V: RF MEMS **9 Hours**

Switches: Cantilever MEMS based switch; Inductors and Capacitors: Modeling and design issues of planar inductor and capacitors; RF Filters: Modeling of mechanical filters; Phase Shifters: Classifications and limitations; Micro Machined Antennas: Microstrip antennas - design parameters.

Reference Books:

1. M. Madou, “Fundamentals of Micro Fabrication”, 2nd Edition, CRC Press, 2002.

2. Senturia, “Micro System Design”, Kluwer, 2001.

3. N Maluf, “An Introduction to Micro Electromechanical Systems Engineering”, Artech House, 2000.

4. V. K.Varadan et al, “RF MEMS and Their Applications”, Wiley, 2003.

5. G. Rebeiz, “RF MEMS: Theory, Design, and Technology”, Wiley/ IEEE Press, 2003.

Hyperlinks:

1. http://freevideolectures.com/blog/2010/11/130-nptel-iit-online-courses/#

2. http://biomedikal.in/2011/02/lecture-notes-on-mems-technology/

3. http://www.learnerstv.com/Free-engineering-Video-lectures-ltv122-Page1.html

Beyond the Syllabus Content:

1. Membrane based switch design using microwave material.

2. Modeling of mechanical filters, electrostatic comb drive.

3. Reconfigurable antennas for space, defense and wireless applications.

***** EENG 534*****

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
EENG 535	QUANTUM MECHANICS ITS APPLICATIONS TO TECHNOLOGY & ADVANCED ENGG. MATHS	3	0	0	3	45

Objective : The course is structured to make the students to get exposure on applications of engineering mathematics and quantum mechanics.

Outcome : Students will able to solve application oriented mathematical problems.

UNIT I: Linear Algebra **9 Hours**

Vector Spaces: Linear vector space - linear independence - basis and dimension - linear transformation - matrix representation - diagonalizable matrices - inner product of vectors - Euclidian - frobenius and generalized *p*-norm of vectors and matrices - orthogonal and orthonormal vectors and matrices - Gram-Schmidt orthogonalization procedure - unitary matrices - diagonally dominant matrix - permutation matrix - hermitian and skew - hermitian matrices - symmetric and skew-symmetric matrices - positive definite matrices - properties of special matrices - quadratic forms - reduction of quadratic form to canonical form by orthogonalization method - condition number of a matrix - singular value decomposition.

UNIT II: Ordinary Differential Equations **9 Hours**

Higher order linear ODE's: Homogeneous and inhomogeneous cases - method of variation of parameters - method of undetermined coefficients - Euler-Cauchy equations -power series solution of ODE's - definition of ordinary and singular points of an ODE - series solution of homogeneous ODE about a regular singular point - Frobenius method - Legendre, Bessel, Chebyshev, Hermite and Laguerre differential equations - special functions - generating functions - Rodrigue formula - recurrence relations - orthogonality properties - systems of linear homogeneous differential equations - matrix methods for their solution - fundamental matrix - matrix exponential - planar autonomous systems - classification of critical points - stability - introduction to nonlinear differential equations.

UNIT III: Partial Differential Equations **9 Hours**

Curvilinear Coordinates: Cylindrical polar and spherical polar systems - conversion of coordinates from cartesian to polar and vice-versa (transformation matrices) - expressions for divergence, curl and gradient operators in spherical and cylindrical coordinate systems - classification of PDE’s - Neumann and Dirichlet boundary conditions - method of separation of variables to solve (*a*) Laplace equation, (*b*) Poisson equation, (*c*) Helmholtz equation, (*d*) Wave equation and (*e*) Diffusion equations in spherical polar and cylindrical polar coordinate systems.

UNIT IV: Quantum Mechanics Theory **9 Hours**

Review of Stern - Gerlach Experiment and Inadequacy of Classical Theory: Wave-particle duality - wave packets - Fourier transforms - postulation of time dependent Schrödinger equation in three dimension - time independent Schrödinger equation -physical interpretation of wave function - continuity equation - expectation values.

UNIT V: Applications **9 Hours**

Definition of Bound States and Scattering States: One dimensional potentials - calculation of reflection and transmission coefficients for the following problems - Dirac-Delta potential - potential step - infinite square well - finite square well (or potential well) - potential barrier and quantum tunneling effect - Kronig-Penney model.

Reference Books:

1. R K Jain and S R K Iyengar, "Advanced Engineering Mathematics", 4th Edition, Narosa Publishing, 2010.

2. Amnon Yariv, "An Introduction to Theory and Applications of Quantum Mechanics", Dover Publications, 2012.

3. M C Potter, J Goldberg and E Aboufadel, "Advanced Engineering Mathematics", 3rd Edition, Oxford University Press, 2009.

4. Alan Jeffery, "Advanced Engineering Mathematics", Academic Press (Indian Edition), 2008.

Hyperlinks:

1. www.pbs.org/transistor/science/info/quantum.html
2. www.khanacademy.org/math/linear-algebra

Beyond the Syllabus Content

Simulation of mathematical models for specific applications using MATLAB.

***** EENG 535*****

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
EENG 536	VLSI SYSTEMS	3	0	0	3	45

Objective : The course is structured to give exposure to the students on various VLSI architectures and systems.

Outcome : Students will be able to design an optimized architecture for a specific application.

Unit I: Introduction **9 Hours**

VLSI Architecture: Dedicated and programmable VLSI architectures - instruction sets - addressing modes - enhancement techniques (Parallelism, pipelining, cache, etc.).

Unit II: CISC **9 Hours**

CISC Architecture Concepts: Typical CISC instruction set and its VLSI implementation - RT level optimization through hardware flow charting - design of the execution unit - design of the control part (micro programmed and hardwired); Handling exceptions - instruction boundary interrupts - immediate interrupts and traps.

Unit III: RISC **9 Hours**

RISC Architecture Concepts: Typical RISC instruction set and its VLSI implementation - execution pipeline - benefits and problems of pipelined execution - hazards of various types of pipeline stalling - concepts of scheduling (Static and dynamic) - exceptions in pipelined processors.

Unit IV: VLSI DSP **9 Hours**

DSP Architecture Concepts: Typical DSP instruction set and its VLSI implementation; Dedicated hardware architecture concepts - synthesis - scheduling and resource allocation; Iteration bound - data-flow graph representations - loop bound and iteration bound - algorithms for computing iteration bound - iteration bound of multirate data-flow graphs.

Unit V: Digital System Design **9 Hours**

Combinational Circuit Design: Circuit families - static CMOS; Cascade voltage switch logic - dynamic circuits - pass transistor circuits - differential circuits; Sequencing static circuits - circuit design of latches and flip-flops; Static sequencing element methodology - sequencing dynamic circuits - synchronizers; Data path and array subsystems - addition/ subtraction - comparators - counters - coding - multiplication and division; SRAM - DRAM.

Reference Books:

1. D A Patterson and J L Hennessy, "Computer Architecture: A Quantitative approach", 2nd Edition, Margon Kaufmann, 1996.

2. D A Patterson and J L Hennessy, "Computer Organization and Design: Hardware/ Software Interface", 2nd Edition, Margan Kaufmann, 1998.

3. Avtar Sing and Srinivas S, "DSP: Architecture, Programming and Applications", Thomson Learning, 2004.

Hyperlinks:

1. http://courses.engr.wisc.edu/ece/ece755.html

2. http://www.ul.ie/graduateschool/course/vlsi-systems-meng.html

3. http://web.engr.oregonstate.edu/~sllu/ece474.html

4. http://www.vlsisystemdesign.com.html

Beyond the Syllabus Content:

1. Assignment on implementing pipeline and parallelism structures for simple modules in VLSI tools.

2. Make a chart briefing the complete VLSI system's architecture.

***** EENG 536*****

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
EENG 540	ADVANCED IMAGE PROCESSING	3	0	0	3	45

Prerequisite : Fundamentals of digital signal processing.

Objective : Make the students to understand the new methodology that is discussed for image processing and analysis.

Outcome : Students will able to work with various image processing techniques.

Unit I: Digital Image Fundamentals **9 Hours**

Elements of Digital Image Processing Systems: Elements of visual perception - brightness - contrast - hue - saturation - mach band effect; Image Enhancement: Spatial and frequency averaging - smoothening and sharpening filters - homomorphic filtering; Image Segmentation: Edge detection - edge linking via hough transform - thresholding - region based segmentation - region growing - region splitting and merging - segmentation by morphological watersheds.

Unit II: Image Restoration **9 Hours**

Image Restoration: Degradation model - unconstrained restoration - lagrange multiplier and constrained restoration - inverse filtering - removal of blur caused by uniform linear motion - wiener filtering - geometric transformations - spatial transformations.

Unit III: Image Modeling **9 Hours**

Stochastic Presentation of Images: Stationary continuous and discrete space models - including AR - MRF stationary generalized Gaussian non stationary models - non stationary Gaussian HMM - transform based models (DFT, DCT, Wavelet) - edge and texture models.

Unit IV: Image Denoising **9 Hours**

Introduction: Maximum likelihood estimation - Bayesian estimators - model selection (MDL principle) - transform based denoising - adaptive wiener filtering - soft shrinkage and hard thresholding.

Unit V: Image Compression **9 Hours**

Introduction: Basics of source coding theory (lossless and lossy) - vector quantization – codebook design - transform and subband coding - JPEG 2000 - MPEG 1 and 2 - relationship between compression and denoising.

Reference Books:

1. Rafael C. Gonzalez and Richard E. Woods, "Digital Image Processing", 2nd Edition, Pearson Education, 2004.

2. Anil K. Jain, "Fundamentals of Digital Image Processing", 3rd Edition, Pearson Education, 2002.

3. William K. Pratt, "Digital Image Processing", 2nd Edition, John Wiley, 2002.

4. Milan Sonka et al, "Image Processing, Analysis and Machine Vision", 2nd Edition, Vikas Publishing House, 1999.

Hyperlinks:

1. www.imageprocessingplace.com/DIP-3E/dip3e_main_page.html

2. www.eng.tau.ac.il/~yaro/lectnotes/LI_Images&ImagingDevices_B.pdf

Beyond the Syllabus Content:

1. Students should get familiar with MATLAB image processing toolbox and should able to solve specific engineering problems related to images.

2. Case studies can be done by individuals on topics discussed during class including the ability to understand and apply various image processing techniques.

***** EENG 540*****

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
EENG 541	ADVANCED RADIATION SYSTEMS	3	0	0	3	45

Prerequisite : Electromagnetics and antenna theory.

Objective : To learn the antenna radiation concepts, different types of antenna and its design methodology.

Outcome : Students able to design different types of antenna.

Unit I: Concepts of Radiation **9 Hours**

Physical Concept of Radiation: Radiation from surface and line current distributions - radiation pattern - near and far field regions - reciprocity - directivity and gain - effective aperture - polarization - input impedance - efficiency - Friss transmission equation - radiation integrals and auxiliary potential functions.

Unit II: Aperture and Reflector Antennas **9 Hours**

Huygens's principle - radiation from rectangular and circular apertures - design considerations - Babinets principle - radiation from sectoral - pyramidal - conical and corrugated horns - design concepts of parabolic reflectors and cassegrain antennas.

Unit III: Broadband Antennas **9 Hours**

Principles - design and properties of log periodic - yagi-uda - frequency independent antennas - loop antenna - helical antennas - biconical antennas - broadcast antenna - spiral antenna and slot antennas.

Unit IV: Microstrip Antennas **9 Hours**

Microstrip Antennas: Radiation mechanism - parameters and applications - feeding methods - method of analysis - design of rectangular and circular patch - impedance matching of microstrip antennas.

Unit V: Applications **9 Hours**

Antennas for biomedical applications - smart antennas for mobile communications - antenna for infrared detectors - marine applications - plasma antennas.

Reference Books:

1. Jordan E.C, "Electromagnetic Waves and Radiating Systems", Prentice Hall of India, 2003.

2. Balanis C.A, "Antenna Theory", 2nd Edition, Wiley, 2003.

3. J.D. Krauss, “Antennas”, Tata McGraw Hill, 2006.

4. Elliot, “Antenna Theory and Design”, IEEE press, 2003.

Hyperlinks:

1. http://nptel.iitm.ac.in/syllabus/117107035.html
2. http://freevideolectures.com/blog/2010/11/130-nptel-iit-online-courses/

Beyond the Syllabus Content:

1. To study the antenna radiating systems by analytical and numerical methods.
2. Problems to Review: (a) wave propagation and polarization, (b) plane wave reflection from ground/ earth, (c) bands used for wireless communications, TV, Radio and Wi-Fi (d) student awareness of antennas and wireless communications in their daily life.

***** EENG 541*****

Course Code	Name of the Course	Periods			Credits	Total Hours
EENG 542	ADVANCED SATELLITE AND RADAR COMMUNICATION	L	T	P	3	45
		3	0	0		

Prerequisite : Basics of satellite and digital communication.

Objective : To explore the orbital mechanics, space craft sub-systems, satellite link design, RADAR and applications.

Outcome : Students able to analyze the technical details behind the satellite link and RADAR design.

UNIT I: Introduction and Satellite Access **9 Hours**

Orbits of Satellite: Low - medium - geo-synchronous - angle period - returning period - orbital spacing - delay transponder - earth stations - antennas and earth coverage - altitude and eclipses; Multiple Access: Demand assigned FDMA - spade system - TDMA - satellite switched TDMA - CDMA.

UNIT II: Space Segment and Earth Segment **9 Hours**

Space Segment: Power supply - altitude control - station keeping - thermal control - TT and C subsystem - transponders; Earth Segment: Receive only home TV system - outdoor unit, indoor unit - master antenna TV system - community antenna TV system.

UNIT III: Satellite Link Design and VSAT Systems **9 Hours**

Link Design: System noise temperature and G/T ratio - design of downlinks - uplink design - C/N - error control for digital satellite link; VSAT Systems: Network architectures - access control protocols - earth station engineering - antennas - link margins - system design procedure.

UNIT IV: RADAR System and Concepts **9 Hours**

RADAR: Block diagram - types of RADAR - CW - Doppler - MTI - FMCW - pulsed - tracking RADAR; DSP in RADAR: False alarm and missed detection - RADAR cross section - TR - ATR; Waveform matched filter - matched filtering of moving targets - ambiguity function - pulse burst waveform - COSTAS frequency codes.

UNIT V: Doppler Processing **9 Hours**

Linear FM Pulse Compression: Block diagram - characteristics - reduction of time side lobes - stretch techniques - generation and decoding of FM waveforms; Block Schematic and Characteristics of Passive System: Digital compression - SAW pulse compression.

References Books:

1. Timothy Pratt and Charles W. Bostain, "Satellite Communications", 2nd Edition, Wiley, 2012.

2. D. Roddy, "Satellite Communication", 4th Edition (Reprint), McGraw Hill, 2009.

3. Wilbur L. Pritchard, Hendri G. Suyderhoud and Robert A. Nelson, "Satellite Communication Systems Engineering", Prentice Hall/ Pearson, 2007.

4. Tri T. Ha, "Digital Satellite Communication", 2nd Edition, McGraw Hill, 1990.

5. Brian Ackroyd, "World Satellite Communication and Earth Station Design", BSP Professional Books, 1990.

6. M.I. Skolnik, "Radar Handbook", 2nd Edition, McGraw Hill, 1991.

7. Fred E. Nathanson, "Radar Design Principles – Signal Processing and the Environment", 2nd Edition, PHI, 1999.

8. M. I. Skolnik, "Introduction to Radar Systems", 3rd Edition, TMH, 2001.

9. Peyton Z. Peebles, "Radar Principles", John Wiley, 2004.

10. R. Nitzberg, "Radar Signal Processing and Adaptive Systems", Artech House, 1999.

Hyperlinks:

1. http://advancedengineering.umd.edu/node/2320
2. http://ece564web.groups.et.byu.net
3. http://personal.stevens.edu/~yyao/syllabus-674.html
4. http://staff.um.edu.mt/carl.debono/lectures.html

Beyond the Syllabus Content:

1. Assignment can be given on advanced modulation and multiplexing techniques for satellite systems.

2. Seminars can be given on the topics like GPS, direct broadcast satellite television, design and error control, satellite radio broadcasting, weather forecasting satellites etc.

3. Design an antenna for satellite communication.

***** EENG 542*****

<table>
<tr><th>Course Code</th><th>Name of the Course</th><th colspan="3">Periods</th><th>Credits</th><th>Total Hours</th></tr>
<tr><td rowspan="2">EENG 543</td><td rowspan="2">ADVANCED TECHNOLOGIES IN WIRELESS NETWORKS</td><td>L</td><td>T</td><td>P</td><td rowspan="2">3</td><td rowspan="2">45</td></tr>
<tr><td>3</td><td>0</td><td>0</td></tr>
</table>

Prerequisite : Basics knowledge of computer networks and wireless communication.

Objective : To learn about the architecture, protocol stack, specifications and characteristics of Wi-Fi, WiMAX, WPAN, wireless internet, Ad-hoc and sensor networks.

Outcome : Latest technologies in wireless networks especially the architecture, protocol stack and their network specification will be known by the students.

Unit I: Wireless Area Networks **9 Hours**

WiMAX: BWA - issues and challenges of WiMAX - network architecture - protocol stack of IEEE 802.16 - physical layer, MAC layer schemes - differences between IEEE 802.11 and IEEE 802.16; WLAN: Fundamentals - technical issues - network architecture - protocol stack of IEEE 802.11 - physical layer, MAC layer mechanism; WPAN: Technical issue - system model- protocol stack of IEEE802.15; Bluetooth: Network architecture - operation-protocol stack - specification and application models; Radio Frequency Identification (RFID): Types and specifications.

Unit II: Wireless Internet **9 Hours**

Introduction: Address - mobility - inefficiency of transport layer and application layer protocol, IP for wireless domain; Mobile IP - IPv6 advancements - mobility management - functions - location management - registration and handoffs - wireless security and standards; TCP in Wireless Domain: TCP over wireless - types - traditional - snoop - indirect - mobile - transaction - oriented - impact of mobility.

Unit III: AD-hoc Network **9 Hours**

Ad-hoc Network: Introduction - issues - characteristics - medium access scheme - routing schemes - multicasting - transport layer protocol - pricing scheme - QoS provisioning - self-organization - security - energy management and deployment consideration.

Unit IV: Wireless Sensor Network **9 Hours**

Wireless Sensor Network: Issues - design challenges - characteristics and architecture of wireless sensor network - layered and clustered - data dissemination - data gathering - MAC protocols - routing schemes - security - enabling technologies for sensor network and applications - comparisons with MANET - ZIGBEE standard and architecture -WBAN standard and architecture.

Unit V: Emerging Technologies **9 Hours**

UWB Radio Communication: Fundamentals of UWB - major issues - operation of UWB systems - comparisons with other technologies - advantages and disadvantages; Multimode 802.11 - IEEE 802.11a/b/g - software radio based multimode system - meghadoot architecture - 802.11VoIP phone - IEEE 802.11n; LTE: System architecture – transmission scheme - frame structure - analysis of link and system level performance - LTE FDD vs TDD comparison - LTE advanced- network architecture –frame structure and its characteristics.

Reference Books:

1. C. Siva Ram Murthy and B. S. Manoj, "Ad-hoc Wireless Networks-Architecture and Protocols", 2nd Edition, Pearson education, 2007.
2. Kaveh Pahlavan and Prashant Krishnamurthy, "Principle of Wireless Networks - A Unified Approach", Prentice Hall of India, 2006.
3. William Stallings, "Wireless Communication and Networks", 2nd Edition, Prentice Hall, 2005.
4. Clint Smith and Daniel Collins, "3G Wireless Networks", 2nd Edition, Tata McGraw Hill, 2007.
5. Vijay K.Garg, "Wireless Communications and Networks", 2nd Edition, Morgan Kaufmann Publishers (Elsevier), 2007.
6. Amitabha Ghosh and Rapeepat Ratasuk, "Essentials of LTE and LTE-A," Cambridge University, 2011.
7. Guillaume De La Roche, Andres Alayon Glazunov and Ben Allen, "LTE – Advanced and Next Generation Wireless Networks: Channel Modelling and Propagation", John Wiley and Sons Ltd., 2012.
8. Hossam S. Hassanein, Abd-Elhamid M. Taha, Najah Abu Ali, "LTE, LTE-Advanced, and WiMAX: Towards IMT-Advanced Networks", John Wiley and Sons Ltd., 2012.

Hyperlinks:

1. http://www.ece.rochester.edu/courses/ECE586/lectures.html
2. http://www.bbn.com/technology/networking/wnan
3. http://www.infotech.monash.edu.au/units/archive/2012/s2/fit5083.html
4. http://www.utdallas.edu/~venky/
5. http://www.public.asu.edu/~dshin17/
6. http://www.cs.cmu.edu/~prs/wirelessS12/
7. www.tutorialspoint.com/wimax/
8. http://www.cs.uccs.edu/~racewin/

Beyond the Syllabus Content:

1. Chart preparation on layered architecture of WBAN, WPAN, WLAN, WMAN, and WWAN.
2. Assignment: The students can be asked to give a 20 minute presentation on a topic (For example, Study on IEEE 802.11n and LTE-A networks).
3. Mini- Project: The project will be related to one of the topics covered in the course. The ultimate goal is to initiate some original research on the topic you choose. The latest reference paper may be chosen from IEEE, Elsevier, Springer, IEICE, PIER, Wiley etc.

***** EENG 543*****

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
EENG 544	**ADVANCED WIRELESS COMMUNICATIONS**	**3**	**0**	**0**	**3**	**45**

Prerequisite : Basics of analog and digital communication and elementary knowledge of wireless communication.

Objective : To impart the new concepts in wireless communications.

Outcome : Students will able to understand the principles and technologies used in wireless communication systems.

Unit I: Introduction **9 Hours**

History of Wireless Communications: Vision - technical challenges of wireless communications - current wireless systems - wireless spectrum - applications and requirements of wireless services - types of services - noise and interference limited systems system fundamentals - frequency reuse - channel assignment strategies - handoff strategies - interference and system capacity - improving coverage and capacity in cellular systems.

Unit II: Propagation and Channel Modeling **9 Hours**

Propagation Principles: Propagation mechanisms - deterministic channel descriptions - stochastic channel description - channel modeling methods - radio channels- indoor channels - large & small scale fading - outdoor channels - reference channel model - small scale - path loss and large scale variations, outdoor - indoor channel - modeling principles - empirical propagation, deterministic and hybrid models - vehicular channels - radio channel measurements - vehicular channel characterization and channel models for vehicular communications and new vehicular communication techniques - ray tracing modeling - ray tracing methods.

Unit III: Digital Modulation and Detection **9 Hours**

Introduction: Performance of digital modulation over wireless channels - AWGN channels - alternate Q function representation - fading - Doppler spread- inter symbol interference - diversity- adaptive modulation and coding - transmission system- M-ary modulations – M-QAM -combined fast and slow fading - equalization.

Unit IV: Introduction to MIMO Systems **9 Hours**

Multiple Antennas and Space Time Communications: Narrowband MIMO model - MIMO channel capacity – space time modulation and coding- MIMO fading channels; Types of MIMO Systems: Beam forming – spatial multiplexing - basic space time code design principles- Alamouti scheme - orthogonal and quasi orthogonal space time block codes, space time trellis codes - representation of space - time trellis codes for PSK constellation - performance analysis for space-time trellis codes - comparison of space-time block and trellis codes.

Unit V: Standardized Wireless Systems **9 Hours**

Introduction to CDMA: CDMA IS 95 and CDMA 2000 - forward and reverse channel - power control technique; WCDMA/ UMTS - network structure - physical and logical channels - uplink and downlink – handover; OFDM- system model- frame structure-characteristics.

Reference Books:

1. Andreas F. Molisch, "Wireless Communications", John Wiley and Sons Ltd., 2011.

2. David Tse and Pramod Viswanath, "Fundamentals of Wireless Communication", Cambridge University Press, 2005.

3. Theodore S. Rappaport, "Wireless Communications: Principles and Practice", 2nd Edition, Prentice Hall of India, 2005.

4. Guillaume De La Roche, Andres Alayon Glazunov and Ben Allen, "LTE – Advanced and Next Generation Wireless Networks: Channel Modelling and Propagation", John Wiley and Sons Ltd., 2013.

5. Andrea Goldsmith, "Wireless Communications", Cambridge University Press, 2005.

6. Michel Daoud Yacoub, "Wireless Technology: Protocols, Standards, and Techniques", CRC Press, 2010.

7. H. Jafarkhani, "Space-Time Coding: Theory & Practice", Cambridge University Press, 2005.

Hyperlinks:

1. http://www.nptel.iitm.ac.in

2. http://freevideolectures.com/Course/2329/Wireless-Communication

Beyond the Syllabus Content:

1. Assignment can be given as chart preparation on comparison of FDMA-TDMA-CDMA.

2. Group project can also be given to model all type of communication channels with noise.

***** EENG 544*****

Course Code	Name of the Course	Periods			Credits	Total Hours
EENG 545	CMOS RF CIRCUIT DESIGN	L	T	P	3	45
		3	0	0		

Prerequisite : Analog electronics and VLSI design.

Objective : To educate the students in RF circuit design using CMOS technology.

Outcome : Students will learn the integrated circuit technology and devices. They will learn the differences between standard CMOS devices and CMOS RF circuits and systems.

Unit I: Introduction **9 Hours**

RF Design and Wireless Technology: Design and applications - complexity - choice of technology; Basic Concepts in RF Design: Nonlinearly - time variance - inter symbol interference - random processes and noise - sensitivity - dynamic range - conversion of gains and distortion.

Unit II: Analysis of Circuits at RF Frequencies **9 Hours**

BJT and MOSFET Behavior at RF Frequencies: BJT and MOSFET behavior at RF frequencies - modeling of transistors and SPICE model - noise performance and limitations of devices - integrated parasitic elements at high frequencies and their monolithic implementation.

Unit III: RF Modulation Techniques **9 Hours**

RF Modulation: Analog and digital modulation of RF circuits - comparison of various techniques for power efficiency - coherent and non coherent detection - mobile RF communication - basics of multiple access techniques; Receiver and Transmitter Architectures: Direct conversion and two step transmitters; RF Testing: Heterodyne - homodyne - image reject - direct IF and sub sampled receivers.

Unit IV: Filter and LNA Design **9 Hours**

RF Filter Design: Issues in integrated RF filters - active RF components and modeling - matching and biasing networks - basic blocks in RF systems and their VLSI implementation - low noise amplifier design in various technologies - design of mixers at GHz frequency range - various mixers - working and implementation.

Unit V: Oscillators and PLL **9 Hours**

Oscillators: Basic topologies - VCO - definition of phase noise - noise power and trade off - resonator VCO designs - quadrature and single sideband generators - radio frequency synthesizers - PLL - various RF synthesizer architectures - frequency dividers - power amplifier design - linearization techniques.

Reference Books:

1. B. Razavi, "RF Microelectronics", Prentice Hall of India, 1998.
2. R. Jacob Baker, H.W. Li and D.E. Boyce, "CMOS Circuit Design, Layout and Simulation", Prentice Hall of India, 1998.
3. Thomas H. Lee, "Design of CMOS RF Integrated Circuits", Cambridge University press, 1998.
4. Y. P. Tsividis, "Mixed Analog and Digital Devices and Technology", TMH, 1996.

Hyperlinks:

1. http://www.smdp.iitkgp.ernet.in/PDF/TCAD/TKB.pdf
2. http://www.ssc.pe.titech.ac.jp
3. https://ccnet.stanford.edu/ee314/
4. http://www.ece.ucsb.edu

Beyond the Syllabus Content:

1. Simulations can be given based on CAD tools for the design of various CMOS RF circuits.
2. Assignment can be given on selected topics from referred journals.

***** EENG 545*****

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
EENG 546	CONVERGENCE TECHNOLOGIES	3	0	0	3	45

Prerequisite : Basics of computer networks, elementary concepts in probability, optimization and computer systems.

Objective : To gain expertise in the convergence technologies, networking design and maintenance of individual networks.

Outcome : Student will able to enumerate the internetworking/ interoperability of advanced wireless technologies developed and can identify the functions and importance of the convergence networks.

Unit I: Introduction **9 Hours**

Evolution and Convergence: Next generation network concept - a framework for examining next generation and evolving networks - characteristics of evolving networks- dealing with complexity - examples of application of framework- enabling mobile network technologies- opportunities and threats to the mobile converging service market.

Unit II: IP Telephony and Applications **9 Hours**

IP Protocol Suite Overview: IP protocol - IP addressing and routing – transmission control protocol (TCP) - user datagram protocol (UDP) - domain name service (DNS) - address resolution protocol (ARP) - IP routing- differentiated services (Diff.Serv) - resource reservation protocol (RSVP) - int.services vs diff.services; Internet protocol version 6 (IPv6) - IPv6 address representation - transition from IPv4 to IPv6 - mobile IP for IPv6 - mobile IP for CDMA 2000 - mobile IP for UMTS.

Unit III: Converged Networks with IMS Technology **9 Hours**

IP Multimedia Subsystem (IMS): Call session control function (CSCF) - application server (AS) - breakout gateway control function (BGCF) - multimedia resource function (MRF) - Media gateway control function and media gateway (MGCF and MGW); home subscriber server (HSS); Session Initiation Protocol (SIP): SIP addressing - SIP headers - SIP call establishment - SIP registration - SIP call routing (direct, proxy and redirect) - SIP–PSTN interworking - SIP bridging- conferencing with SIP - SIP event notification - SIP and instant messaging services; IP in radio access network (RAN) - IP ATM interoperating - multiprotocol label switching (MPLS) in UMTS.

Unit IV: Software Methodologies for Converged Networks and Services **9 Hours**

Development of Software Methodologies for ICT: Software processes in the NGN framework - high level analysis and design methods - enterprise and business modeling notation - object and data definition language - dynamic modeling notations - component and interface notations - distributed systems - creating a unified framework.

Unit V: Convergence of Networks **9 Hours**

Introduction: 3GPP/ WLAN interoperability - analytical model for Cellular/ WLAN internetworking - IEEE 802.11u internetworking with external networks- interoperability of WiMAX and LTE - LAN/ WLAN/ WiMAX/ 3G internetworking based on IEEE 802.21- media independent handoff - future Cellular/ WiMAX/ WLAN/ WPAN internetworking.

Reference Books:

1. Hu Hanrahan, "Network Convergence: Services, Applications, Transport, and Operations Support", John Wiley and Sons, 2007.
2. Jeffrey Bannister, Paul Mather and Sebastian Coope, "Convergence Technologies for 3G Networks", John Wiley and Sons, 2008.
3. David Tung Chong Wong, Peng-Yong Kong, Ying-Chang Liang, Kee Chaing Chua and Jon W. Mark , "Wireless Broadband Networks", John Wiley and Sons, 2009.
4. Vijay Garg, "Wireless Network Evolution: 2G to 3G," Prentice Hall of India, 2001.
5. Jyh-Cheng Chen and Tao Zhang, "IP Based Next Generation Wireless Networks - Systems, Architecture and Protocols", John Wiley and Sons,2003.
6. Jeffrey G. Andrews, Arunabha Ghosh and Rias Muhamed, "Fundamentals of WiMAX Understanding Broadband Wireless Networking", Prentice Hall, 2008.
7. Amitabha Ghosh and Rapeepat Ratasuk, "Essentials of LTE and LTE-A", Cambridge University, 2011.
8. Guillaume De La Roche, Andres Alayon Glazunov and Ben Allen, "LTE – Advanced and Next Generation Wireless Networks: Channel Modeling and Propagation", John Wiley and Sons, 2013.

Hyperlinks:

1. www.radio-electronics.com/info/wireless/
2. www.radio-electronics.com/info/telecommunication_networks/
3. www.tutorialspoint.com/wimax/
4. www. iws.collin.edu/...Convergence

Beyond the Syllabus Content:

1. Assignments can be given to explore the interconnection and performance behavior of WiFi/ UMTS or WiMAX/ LTE technologies using any of the network simulation tools.
2. Chart may be developed to compare different models of convergence technologies mentioning its characteristics.

***** EENG 546*****

Course Code	Name of the Course	Periods			Credits	Total Hours
EENG 547	DESIGN OF ANALOG AND MIXED MODE VLSI CIRCUITS	L	T	P	3	45
		3	0	0		

Prerequisite : Basics of semiconductor device operation.

Objective : To study analog integrated circuits features, design and analysis methods of analog and mixed mode VLSI circuits.

Outcome : Students will able to design efficient analog and mixed mode VLSI circuits.

Unit-I: Basic CMOS Circuit Techniques **9 Hours**

MOS Transistor: MOS I/V characteristics - DC and AC small signal parameters from large signal model - voltage current converters - mixed signal VLSI chips.

UNIT-II: Single Stage Amplifiers **9 Hours**

Introduction: Common source amplifier with resistive load - diode load and current source load - source follower - common gate amplifier - cascode amplifier - folded cascode - frequency response of amplifiers.

UNIT-III: Current Mirrors and Differential Amplifiers **9 Hours**

Introduction: Current source/ sink/ mirror - matching - Wilson current source and regulated cascade current source - band gap reference - differential amplifier - Gilbert cell.

UNIT- IV: Operational Amplifiers **9 Hours**

Op-Amp: Design of two stages Op-Amp - gain boosting - DC and AC response - frequency compensation - common mode feedback - slew rate - offset effects - PSRR - noise - comparator.

UNIT- V: Mixed Signal Circuits **9 Hours**

Sense Amplifier: Sample and hold - sampled data circuits - switched capacitor filters - DAC - ADC - RF amplifier - oscillator - PLL - mixer.

Reference Books:

1. Razavi B, “Design of Analog CMOS Integrated Circuits”, Tata McGraw Hill, 2003.

2. Baker, Li and Boyce, “CMOS: Circuit Design, Layout and Simulation”, Prentice Hall of India, 2005.

3. Phillip E. Allen and Douglas R. Holberg, "CMOS Analog Circuit Design", Oxford University Press, 2002.

4. R. Jacob Baker, "CMOS: Mixed-Signal Circuit Design", John Wiley, 2008.

Hyperlink:

http://amesp02.tamu.edu/~sanchez/LV-Dallas-IEEE-Tutorial.PDF

Beyond the Syllabus Content:

1. Assignment can be given based on CAD tools for VLSI system design.

2. Case study may be conducted for mixed signal VLSI circuit design.

***** EENG 547*****

Course Code	Name of the Course	Periods			Credits	Total Hours
EENG 548	ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY	L	T	P	3	45
		3	0	0		

Prerequisite : Electromagnetic theory.

Objective : To expose the students on the fundamentals of electromagnetic interference and compatibility in system design.

Outcome : The students will able to know the EMI environment, coupling principles, specifications, standards and limits, measurements and control techniques and EMC design of PCBs.

Unit I: EMI Environment **9 Hours**

EMI/ EMC Concepts and Definitions: Sources of EMI - conducted and radiated EMI - transient EMI - time domain vs frequency domain EMI - units of measurement parameters.

Unit II: EMI Coupling Principles and Standards **9 Hours**

Principles: Conducted, radiated and transient coupling - common impedance ground coupling - radiated common mode and ground loop coupling - radiated differential mode coupling – near and far field cable to cable coupling - power mains and power supply coupling - units of specifications; Civilian Standards: FCC - CISPR - IEC - EN; Military Standards: MIL STD 461D/ 462.

Unit III: EMI Measurements **9 Hours**

EMI Test Instruments/ Systems: EMI shielded chamber - open area test site - TEM cell - sensors/ Injectors/ Couplers - test beds for ESD and EFT.

Unit IV: EMI Control Techniques **9 Hours**

Techniques: Shielding - filtering - grounding - bonding - isolation transformer - transient suppressors - cable routing - signal control - component selection and mounting.

Unit V: EMC Design of PCBS **9 Hours**

Design: PCB traces cross talk - impedance control - power distribution decoupling - zoning - motherboard designs and propagation delay performance models.

Reference Books:

1. V. P. Kodali, “Engineering EMC Principles, Measurements and Technologies”, IEEE Press, 1996.

2. Henry W. Ott, “Noise Reduction Techniques in Electronic Systems”, Wiley, 1988.

3. C. R. Paul, “Introduction to Electromagnetic Compatibility”, Wiley, 1992.

4. Bernhard Keiser, “Principles of Electromagnetic Compatibility”, 3rd Edition, Artech house, 1986.

Hyperlinks:

1. http://www.nptel.iitm.ac.in/syllabus/syllabus.php?subjectId=117108043

2. http://www.ieee.li/emc/

Beyond the Syllabus Content:

1. Applications to remote sensing of sea, land surfaces and planetary atmospheres.

2. To study the susceptibility test for EMC.

***** EENG 548*****

<table>
<tr><th rowspan="1">Course Code</th><th>Name of the Course</th><th colspan="3">Periods</th><th>Credits</th><th>Total Hours</th></tr>
<tr><td rowspan="2">EENG 549</td><td rowspan="2">GREEN RADIO COMMUNICATION NETWORKS</td><td>L</td><td>T</td><td>P</td><td rowspan="2">3</td><td rowspan="2">45</td></tr>
<tr><td>3</td><td>0</td><td>0</td></tr>
</table>

Prerequisite : Fundamentals of electronics, communication and wireless networks.

Objective : To impart the importance of reducing energy consumption, CO_2 emissions and inculcate green concepts for energy efficient approaches while designing next generation wireless networks.

Outcome : Students can design new green radio architectures and radio techniques to reduce the overall energy consumption.

Unit I: Introduction **9 Hours**

Fundamental Tradeoffs on the Design of Green Radio Networks: Insight from Shannon's capacity formula - impact of practical constraints - latest research and directions; Algorithms for Energy Harvesting Wireless Networks: Energy harvesting technologies - PHY and MAC layer optimization for energy harvesting wireless networks.

Unit II: Green Modulation and Coding **9 Hours**

Modulation: Green modulation and coding schemes in energy constrained wireless networks - energy consumption of uncoded scheme - energy consumption analysis of LT coded modulation.

Unit III: Co-operative Techniques **9 Hours**

Co-operative Techniques for Energy Efficient Wireless Communications: Energy efficiency metrics for wireless networks – co-operative networks - optimizing the energy efficiency performance of co-operative networks - energy efficiency in co-operative base stations.

Unit IV: Base Station Power Management Techniques **9 Hours**

Base Station Power Management Techniques for Green Radio Networks: Opportunistic spectrum and load management for green radio networks - energy saving techniques in cellular wireless base stations - power management for base stations in a smart grid environment.

Unit V: Wireless Access Techniques for Green Radio Networks **9 Hours**

Cross Layer Design: Adaptive packet scheduling for green radio networks - energy efficient relaying for cooperative cellular wireless networks - energy performance in TDD CDMA multihop cellular networks - resource allocation for green communication in relay based cellular networks.

References Books:

1. Ekram Hossain, Vijay K. Bhargava and Gerhard P. Fettweis, “Green Radio Communication Networks”, Cambridge University Press, 2012.

2. F. Richard Yu, Yu, Zhang and Victor C. M. Leung “Green Communications and Networking”, CRC press, 2012.

3. Mazin Al Noor, “Green Radio Communication Networks Applying Radio-Over-Fibre Technology for Wireless Access”, GRIN Verlag, 2012.

4. Mohammad S. Obaidat, Alagan Anpalagan and Isaac Woungang, “Handbook of Green Information and Communication Systems”, Academic Press, 2012.

5. Jinsong Wu, Sundeep Rangan and Honggang Zhang, “Green Communications: Theoretical Fundamentals, Algorithms and Applications”, CRC Press, 2012.

6. Mazin Al Noor, “WiMAX Improvements in Green Radio Communications Utilizing Radio-Over- Fiber”, GRIN Verlag, 2012.

7. Ramjee Prasad and Shingo Ohmori, Dina Simunic, “Towards Green ICT”, River Publishers, 2010.

Hyperlinks:

1. http://www.comsoc.org/webcasts/view/wireless-green-networking

2. http://home.ku.edu.tr/~nwcl/green.html

3. http://mypage.zju.edu.cn/en/honggangzhang/607861.html

Beyond the Syllabus Content:

1. Assignment can be given to compute the amount of energy required for the functioning of various wireless networks.

2. Case studies can be given on mechanical relaying techniques in cellular wireless networks.

***** EENG 549*****

Course Code	Name of the Course	Periods			Credits	Total Hours
EENG 560	INFORMATION AND NETWORK SECURITY	L	T	P	3	45
		3	0	0		

Prerequisite : Computer networks, wireless networks and digital communications.

Objective : To study the various security attacks, data security and network security algorithms and wireless security mechanism.

Outcome : Students will understand the various symmetric and asymmetric cryptographic techniques, authentication mechanism and network security.

Unit I: Security Issues **9 Hours**

Issues: Security problem in computing - attacks - security services - security mechanism - OSI security architecture - standards and standard setting organizations.

Unit II: Data Security and Authentication **9 Hours**

Introduction: Basic encryption and decryption - substitution - transposition - block ciphers - data encryption standard encryption and decryption - differential & linear cryptanalysis - advanced encryption standard encryption and decryption-block cipher modes - triple DES with two keys - stream cipher - RC4 - RSA algorithm – Diffie-Hellmann key exchange algorithm - elliptical curve cryptography algorithm; Message Authentication: HASH functions - MD5 - HASH algorithm - SHA 512 logic - authentication protocols - digital signature standards.

Unit III: Network Security **9 Hours**

Network Security: IP security overview - IP security architecture - authentication header - encapsulating security payload - combining security association - key management - web security considerations - secure socket layer and transport layer security - secure electronic transaction.

Unit IV: System Security **9 Hours**

Intruders and Intrusion Detection: Malicious software - viruses and related threats - virus counter measures - distributed denial of service attack - firewalls design principles - trusted systems.

Unit V: Security for Wireless System **9 Hours**

Wireless Security: Security requirements and standards - security mechanism in IEEE 802.11 - WiMAX security scheme - security in North American cellular system - security in European cellular system.

Reference Books:

1. Charles P. Pleeger, "Security in Computing", Prentice Hall, New Delhi, 2006.

2. Simands, "Network Security", McGraw Hill, New Delhi, 1998.

3. Vijay K. Garg, "Wireless Communications and Networks", 2nd Edition, Morgan Kaufmann Publishers (Elsevier), 2007.

4. William Stallings, "Cryptography and Network Security: Principles and Practice", 6th Edition, Pearson Education, New Delhi, 2013.

5. Behrouz A. Forouzan, "Cryptography and Network Security", Tata McGraw Hill, 2008.

Hyperlinks:

1. http://www.cs.bilkent.edu.tr/~selcuk/teaching/cs519/

2. http://www.vidyarthiplus.com/vp/thread-9976.html

Beyond the Syllabus Content:

1. Seminar on real time network security and current security threats in India.
2. The case study can involve the design and implementation of security protocols and/ or application.

3. Students are expected to employ the theories and techniques learned in the class to design the system.

4. Network simulation environments such as NS-2 or QUALNET, may be used for implementing the projects.

***** EENG 560*****

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
EENG 561	LOW POWER DIGITAL VLSI DESIGN	3	0	0	3	45

Prerequisite : Introduction to CMOS VLSI design.

Objective : To discuss low power design methodologies at various design levels from the circuit level to the system level and also power estimation with optimization techniques.

Outcome : Students can analyze and design low power VLSI circuits using different circuit technologies and design levels.

Unit I: Physics of Power Dissipation **9 Hours**

Introduction: Basic principles - design methodology - limits and applications of low power VLSI Design - low power figure of merits; Physics of power dissipation in CMOS FET devices.

Unit II: Power Analysis **9 Hours**

Simulation Power Analysis: SPICE circuit simulation - discrete transistor modeling and analysis - gate level logic simulation - architecture level analysis - data correlation analysis; Probabilistic Power Analysis: Random logic signals - probabilistic power analysis techniques - signal entropy.

Unit III: Circuit and Logic Level **9 Hours**

Circuit Level: Transistor and gate sizing - equivalent pin ordering - network restructuring and reorganization - special latches and flip flops; Logic Level: Gate reorganization - signal gating - logic encoding - precomputation logic.

Unit IV: Architecture and Energy Recovery Techniques **9 Hours**

Architecture and System: Power and performance management - switching activity reduction -parallel architecture with voltage reduction - flow graph transformation; Energy Recovery Techniques: Energy dissipation using an RC model - energy recovery circuit design.

Unit V: Special and Advanced Techniques **9 Hours**

Special Techniques: Power reduction in clock networks - low power bus - delay balancing; Advanced Techniques: Adiabatic computation - pass transistor logic synthesis - asynchronous circuits.

Reference Books:

1. Kaushik Roy and Sharat C. Prasad, “Low-Power CMOS VLSI Circuit Design”, John Wiley and Sons, 2009.

2. Gary K. Yeap, “Practical Low Power Digital VLSI Design”, Kluwer Academic Publishers, 1998.

3. Abdellatif Bellaouar and Mohamed Elmasry, “Low-Power Digital VLSI Design: Circuits and Systems”, Kluwer Academic Publishers, 1995.

4. Anantha Chandrakasan and Robert W. Brodersen, “Low-Power CMOS Design”, Wiley-IEEE Press, 1998.

5. Jan M. Rabaey and Massoud Pedram, “Low Power Design Methodologies”, Kluwer Academic Publishers, 1995.

Hyperlinks:

1. http://www.nptel.iitm.ac.in/courses/106105034/

2. http://www.eeherald.com/section/design-guide/Low-Power-VLSI-Design.html

Beyond the Syllabus Content:

1. Assignment can be given on the topics MIS structure, long channel and submicron MOSFET, gate induced drain leakage, short circuit and dynamic dissipation, load capacitance etc.

2. Simulation can be given using Monte Carlo concepts to optimize the sub-systems of VLSI.

***** EENG 561*****

Course Code	Name of the Course	Periods			Credits	Total Hours
EENG 562	MODELING AND SIMULATION OF WIRELESS COMMUNICATION SYSTEMS	L	T	P	3	45
		3	0	0		

Prerequisite : Basic knowledge of C programming, signals and systems, digital communication and digital signal processing.

Objective : To learn how to create a successful simulation study based on simulation methodologies and to design and analyze the simulation model of communication systems.

Outcome : Students will able to understand the concept of modeling and simulation of communication systems.

Unit I: Introduction **9 Hours**

Role of Simulation: Examples of complexity - multidisciplinary aspects of simulation - models - deterministic and stochastic simulations; Simulation methodology - aspects of methodology - performance estimation; Fundamental Concepts and Techniques: Sampling - quantizing - reconstruction and interpolation - simulation sampling frequency - low pass simulation models for band pass – low pass complex envelope for bandpass signals - linear bandpass systems - multicarrier signals - nonlinear and time - varying systems.

Unit II: Generating and Processing Random Signals **9 Hours**

Stationary and Ergodic Processes: Uniform random number generators - mapping uniform RVs to an arbitrary PDF - generating uncorrelated Gaussian random numbers - generating correlated Gaussian random numbers - PN sequence generators; Establishing a PDF and a PSD Post Processing: Basic graphical techniques - estimation - coding.

Unit III: Methodology for Simulating a Wireless System **9 Hours**

Monte Carlo Simulation Fundamental Concepts: Applications and integration - two Monte Carlo examples; Semi Analytic Techniques System: Level simplifications and sampling rate considerations - overall methodology; Modeling and Simulation of Nonlinearities: Introduction - modeling and simulation of memory less nonlinearities - modeling and simulation of nonlinearities with memory - techniques for solving nonlinear differential equations.

Unit IV: Modeling and Simulation of Time-Varying Systems **9 Hours**

Introduction: Models for LTV systems - random process models - simulation models for LTV systems; Wired and guided wave - radio channels - multipath fading channels - modeling multipath fading channels; Random process models - simulation methodology; Discrete Channel Models: Discrete memory less channel models - Markov models for discrete channels with memory- example HMMs - Gilbert and Fritchman models - estimation of Markov model parameters.

Unit V: Efficient Simulation Techniques **9 Hours**

Tail Extrapolation: PDF estimators- importance sampling; Case study of a cellular radio system; Cellular radio system - simulation methodology - modeling co-channel interference - two example simulations; A code-division multiple access system - FDM system with a nonlinear satellite transponder - preprocessors for CDMA application.

Reference Books:

1. William H. Tranter, K. Sam Shanmugan, Theodore S. Rappaport and Kurt L. Kosbar "Principles of Communication Systems Simulation with Wireless Applications", Prentice Hall, Upper Saddle River, 2003.
2. M. C. Jeruchim, Philip Balaban and K.Sam shanmugam. "Simulation of Communication Systems", Plenum Press, 2007.
3. M. Law and W. David Kelton , "Simulation Modelling and Analysis", McGraw Hill, 2008.
4. K. Hayes, "Modelling and Analysis of Computer Communication Networks", Plenum Press, 1984.
5. Banks, J. S. Carson, Nelson and D. M. Nicol, "Discrete Event System Simulation", 4th Edition, Prentice Hall of India, 2005.

Hyperlinks:

1. http://ocw.korea.edu/ocw/college-of-engineering/communciation-systems-and-lab/
2. http://dspace.mit.edu/handle/1721.1/38950
3. http://www.mathworks.in/communications/wireless-wired-channel-modeling.html

Beyond the Syllabus Content:

1. Case studies may be given to model wireless systems using MATLAB.
2. Assignment can be given to prepare a review report on modeling and simulation of wireless communication systems.

***** EENG 562*****

Course Code	Name of the Course	Periods			Credits	Total Hours
EENG 563	MONOLITHIC MICROWAVE INTEGRATED CIRCUITS	L	T	P	3	45
		3	0	0		

Prerequisite : Microwave Circuits.

Objective : To study the different technologies of microwave integrated circuits and to analyze the planar transmission line.

Outcome : Students can design and fabricate different lumped elements and nonreciprocal components.

Unit I: Planar Transmission Lines **9 Hours**

Planar Transmission Lines: Strip line - micro strip line - coplanar waveguide - coplanar strips slot line - fin line and characteristics - properties - design parameters and its applications; Technology of MICs: Monolithic and hybrid substrates - thin and thick film technologies - advantages and applications.

Unit II: Microstrip Lines, Analysis and Design **9 Hours**

Introduction: Propagation models - analysis of micro strip line by conformal transformation - quasi static analysis and their characterization - numerical analysis - hybrid mode analysis - losses in microstrips.

Unit III: Planar Passive Components and Filters **9 Hours**

Lumped Elements in MICs: Planar inductors - capacitors - resistors using micro strip lines; Filters: Introduction - low pass to high Pass - band pass - band stop transformations - (Butterworth and Chebyshev responses) filter design.

Unit IV: MIC Components Design **9 Hours**

3dB Hybrid Design: Directional coupler - circulator - power divider - resonator; Realization using Microstrip line components.

Unit V: Applications **9 Hours**

Applications: Space - defense and wireless; Ferrite phase shifters and other components and subsystems.

Reference Books:

1. Hoffman R. K., “Handbook of Microwave Integrated Circuits”, Artech House, 1987.
2. Gupta. K. C and R. Garg, “Microstrip Line and Slot Line”, Artech House, 1996.

3. Ravender Goyal, “Monolithic MIC; Technology & Design”, Artech House, 1989.

4. Gupta K.C. and Amarjit Singh, “Microwave Integrated Circuits”, John Wiley, 1975.

Hyperlinks:

1. http://nptel.iitm.ac.in/syllabus/117105029/

2. http://www.microwaves101.com/encyclopedia/

Beyond the Syllabus Content:

To study the layout design of MMIC components.

***** EENG 563*****

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
EENG 564	OFDM FOR WIRELESS COMMUNICATION	3	0	0	3	45

Prerequisite : Fundamentals of DSP and communication systems.

Objective : To impart OFDM modulation and receiver synchronization techniques.

Outcome : Students able to use OFDM techniques for wireless systems.

Unit I: OFDM Principles **9 Hours**

System Model: Generation of sub carrier using IFFT - guard time - cyclic extensions - windowing - choice of OFDM parameters - signal processing - OFDM bandwidth efficiency.

Unit II: PAPR Reduction Techniques **9 Hours**

Peak to Average Power Ratio (PAPR): Peak power problem - distribution of PAPR - clipping and peak windowing - peak cancellation - PAPR reduction codes - symbol scrambling.

Unit III: OFDM Time and Frequency Domain Synchronization **9 Hours**

System performance with frequency and timing errors; Synchronization algorithms - comparison of frequency acquisition algorithms - BER performance with frequency synchronization.

Unit IV: Adaptive Single and Multiuser OFDM Techniques **9 Hours**

Adaptive Modulation for OFDM: Adaptive OFDM speech system - pre-equalization; Comparison of adaptive techniques - near optimum power and bit allocation in OFDM - multiuser AOFDM.

Unit V: Multiuser OFDM Systems **9 Hours**

Multiuser Systems: Maximum likelihood enhanced sphere decoding of MIMO OFDM - classification of smart antennas; Introduction to Space Time Processing: SDM OFDM system model - optimized hierarchy reduced search algorithm - aided SDM detection.

Reference Books:

1. Ramjee Prasad, "OFDM for Wireless Communication Systems", Artech House, 2004.

2. Richard D. J. Van Nee and Ramjee Prasad, "OFDM for Wireless Multimedia Communication", Artech House, 1999.

3. L. Hanzo, and T. Keller, "OFDM and MC-CDMA: A Primer", John Wiley and Sons, 2006.

4. L. Hanzo, M. Münster, B.J. Choi and T. Keller, “OFDM and MC-CDMA for Broadband Multiuser Communication, WLANs and Broadcasting”, John Wiley and Sons, 2012.

5. Henrik Schulze and Christian Lueders, “Theory and Applications of OFDM and CDMA”, John Wiley and Sons, Ltd, 2005.

Hyperlinks:

1. http://www.nari.ee.ethz.ch/commth/pubs/p/commag06
2. http://www.morganclaypool.com/doi/abs/10.2200/S00255ED1V01Y201002ASE005
3. http://ethesis.nitrkl.ac.in/4380/
4. http://wncg.org/interference-mitigation-in-wireless-ofdm-communication-systems.html

Beyond the Syllabus Content:

1. Computation of implementation complexity of OFDM versus single carrier modulation.
2. Simulation of OFDM systems through MATLAB: Simulation may include single user and multiuser OFDM systems, PAPR reduction techniques, time and frequency domain synchronization, smart antennas and MIMO OFDM systems.

***** EENG 564*****

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
EENG 565	OPTICAL NETWORKING	3	0	0	3	45

Prerequisite : Basics of fiber optic communication.

Objective : To impart the concepts of optical network architectures and design issues.

Outcome : Students able to analyze and design optical links and simple optical networks.

Unit I: Introduction to Optical Networks **9 Hours**

Optical layer; Transparency and all optical networks - optical packet switching - transmission basics - network evolution.

Unit II: Optical Networking Components **9 Hours**

Optical Components: Couplers - isolators - circulators - multiplexers - filters - optical amplifiers - transmitters - detectors - switches - waveguide converters; WDM Network Elements: Optical line terminals - optical line amplifiers - optical add drop multiplexers - optical cross connects.

Unit III: Client Layers of Optical Layer **9 Hours**

Client Layers: SONET/ SDH - optical transport network - ethernet - multiprotocol label switching - resilient packet ring - storage area networks.

Unit IV: WDM Network Design **9 Hours**

Network Design: Cost tradeoffs - LTD and RWA problems - dimensioning wavelength routing networks - statistical and maximum load dimensioning models.

Unit V: Control and Management **9 Hours**

Network Management Functions: Performance and fault management - configuration management - optical safety; Network Survivability: Protection in SONET/ SDH - protection in client layer - need for optical layer protection - optical layer protection schemes.

Reference Books:

1. Rajiv Ramswami, Kumar N Sivarajan and Galen H. Sasaki, "Optical Networks, A Practical Perspective", 3rd Edition, M. Kaufmann Publishers, 2010.

2. Ioannis P. Chochliouros and George A. Heliotis, "Optical Access Networks and Advanced Photonics: Technologies and Deployment Strategies", IGI Global, 2009.

3. Jane M. Simmons, "Optical Network Design and Planning", Springer, 2008

4. Lu Ruan and Ding-Zhu Du, "Optical Networks - Recent Advances (Network Theory and Applications)", Springer, 2001.

5. John R. Vacca, "Optical Networking Best Practices Handbook", John Wiley and Sons, 2006.

6. Vivek Alwayn, "Optical Network Design and Implementation", Cisco Press, 2004.

7. Alberto Bononi, "Optical Networking", Springer, 1999.

Hyperlinks:

1. http://www.cisco.com/en/US/products/hw/optical/
2. http://nextgenerationoptical.com/
3. http://usa.nextgenerationoptical.com/
4. http://www.alcatel-lucent.com/solutions/agile-optical-networking

Beyond the Syllabus Content:

1 Assignments can be given on the topics of photonic packet switching and optical burst switching.

2 Simulations can be given on optical time division multiplexing, synchronization and buffering techniques.

***** EENG 565*****

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
EENG 566	PRINCIPLES OF ASIC DESIGN	3	0	0	3	45

Prerequisite : Digital VLSI design.

Objective : The course focuses on the fundamentals of ASIC and its design methods.

Outcome : The students will able to gain sufficient theoretical knowledge for carrying out FPGA and ASIC design.

Unit I: Introduction **9 Hours**

Preface: Full custom with ASIC - semi custom ASICs - standard cell based ASIC - gate array based ASIC - channeled gate array - channel less gate array - structured gate array - programmable logic device - FPGA design flow.

Unit II: Data Logic Cells and Library Design **9 Hours**

Data Path Elements: Adders - multiplier - arithmetic operator - I/O cell - cell compilers; Logical effort - practicing delay - logical area and logical efficiency logical paths - multi stage cells - optimum delay - optimum no. of stages - library cell design.

Unit III: Low-Level Design and Schematic Entry, Programmable ASICs **9 Hours**

Hierarchical Design: Cell library - names - schematic - icons & symbols - nets; Schematic entry for ASICs - connections - vectored instances and buses - edit in place attributes - net list - screener - back annotation - programmable ASIC logic cell - ASIC I/O cell.

Unit IV: Low Level Design Language, Logic Synthesis **9 Hours**

Introduction to EDIF: PLA tools - introduction to CFI designs representation; Half Gate ASIC: Introduction to synthesis and simulation - two level logic synthesis - high level logic synthesis.

Unit V: Construction Floor Planning and Placement and Routing **9 Hours**

Physical Design: CAD tools - system partitioning - estimating ASIC size - partitioning methods; Floor planning tools - I/O and power planning - clock planning - placement algorithms - iterative placement improvement; Time driven placement methods - physical design flow global routing - local routing - detail routing - special routing - circuit extraction and DRC.

Reference Books:

1. M. J. S .Smith, "Application – Specific Integrated Circuits", Pearson Education, 2003.

2. Jose E. France and Yannis Tsividis, "Design of Analog Digital VLSI Circuits for Telecommunication and Signal Processing", Prentice Hall, 1994.

3. Steve Kilts, "Advanced FPGA Design: Architecture, Implementation, and Optimization," Wiley-Blackwell, 2007.

4. Roger Woods, John McAllister, Ying Yi and Gaye Lightbod, "FPGA-Based Implementation of Signal Processing Systems", Wiley, 2008.

5. Rajsuman R., "System-on-a-Chip Design and Test", Artech House, 2000.

6. Nekoogar F, "Timing Verification of Application-Specific Integrated Circuits (ASICs)", Prentice Hall, 1999.

Hyperlinks:

1. en.wikipedia.org/wiki/Standard_cell

2. www.utdallas.edu/~zhoud/DesignEntry

3. en.wikipedia.org/wiki/High-level_synthesis

4. iroi.seu.edu.cn/books/asics/Book2/CH16/CH16.1.html

Beyond the Syllabus Content:

Seminars/ Assignments can be given on programmable ASIC interconnect: Actel ACT-Xilinx LCA-Xilinx EPLD-Altera MAX 5000 and 7000-Altera MAX 9000-Altera FLEX.

***** EENG 566*****

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
EENG 567	RF ENGINEERING	3	0	0	3	45

Prerequisite : Microwave engineering.

Objective : To impart the modeling of RF system design in the field of communication systems.

Outcome : Students able to design different types of RF/ microwave active components and RF amplifiers.

Unit I: RF Passive Components and Transmission Line Analysis **9 Hours**

High Frequency Resistors: Capacitors and inductors - transmission line analysis - line equation - microstrip line - SWR voltage reflection co-efficient propagation constant - phase constant - phase velocity - Smith chart - parallel RL and RC circuits - ABCD parameters and S parameters.

Unit II: RF Active Components and RF Amplifier Design **9 Hours**

RF Diode: PIN diode - GUNN diode - RF bipolar junction transistor - RF field effect transistor - modeling of diode - transistor and FET; RF Amplifier: Characteristics - power relational and stability considerations - LNA - power amplifiers - differential amplifiers - distributed power amplifiers and broadband amplifiers.

Unit III: RF Circuits Design **9 Hours**

RF Oscillator Design: Fixed frequency oscillator - dielectric resonant oscillator - voltage controlled oscillator - sun element oscillator; RF Mixer Design: Single ended mixer - double ended mixer; RF Filter Resonator and Filter Configuration: Butterworth and Chebyshev filters - design of microstrip filters.

Unit IV: RF IC Design **9 Hours**

Introduction to RFIC: Analog and microwave design versus RFIC design - noise performance estimation - RF technology - receiver with single IF stage metallization - sheet resistance - skin effect -parasitic capacitance and inductance - current handling - metal capacitors - spiral inductors - quality factor - layout in IC - mutual inductance - multilevel - measurement - packaging.

Unit V: RF System Design **9 Hours**

Link Design: Fading design - protected and non protected microwave systems - path calculation - spread spectrum microwave system - compatibility - safety coordinate systems - Datam's and GPS - receiver design - receiver architecture dynamic range - Frequency conversion and filtering; Examples of Practical Receivers: FM broadcast - digital cellular - multimeter wave point to point - Direct conversion GSM receiver; RF MEMS: Concept - implementation and applications.

Reference Books:

1. Reinhold Ludwig and Pavel Bretchko, "RF Circuit Design", Pearson Education, 2007.
2. David Pozar, "Microwave and RF Design of Wireless Systems", John Wiley, 2008.
3. Josn Rogers and Calvin Plett, "Radio Frequency Integrated Circuit Design", Artech House, 2002.
4. Ferri Losee, "RF systems, Components and Circuits Handbook", Artech House, 2002.
5. Joseph J. Carr, "Secrets of RF Circuit Design", Tata McGraw Hill, 2004.
6. Vivek Varadhan, K J. Vinoy and Jose, "RF MEMS and Their Applications", Wiley Eastern Edition, 2003.

Hyperlinks:

1. http://nptel.iitm.ac.in/syllabus/117105029
2. http://www.ece.iisc.ernet.in/~dipanjan/E8_202/E8-202-lecturenotes.html

Beyond the Syllabus Content:

1. Microwave oscillator design.
2. Planar non reciprocal devices.
3. Microwave remote sensing.

***** EENG 567*****

Course Code	Name of the Course	Periods			Credits	Total Hours
EENG 568	RF TRANSCEIVERS FOR WIRELESS COMMUNICATIONS	L	T	P	3	45
		3	0	0		

Prerequisite : Basic knowledge of signal, communication theory and fundamentals of analog and mixed signal circuits.

Objective : To understand techniques for radio architectures and design considerations of multimode and multiband superheterodyne transceiver.

Outcome : Students able to analyze, design, simulate and implement various sub systems of RF transceiver.

Unit I: Fundamentals of System Design **9 Hours**

Fundamentals: Linear and nonlinear systems - transformation - representation and analysis approaches - noise and random process - elements of digital base band system.

Unit II: Radio Architectures and Design Considerations **9 Hours**

Radio Architectures and Design Considerations: Super heterodyne architecture - direct conversion (zero IF) architecture - low IF architecture - bandpass sampling radio architecture.

Unit III: Receiver System Analysis and Design **9 Hours**

Analysis and Design: Sensitivity and noise figure of receiver - intermodulation characteristics - single tone desensitization - adjacent or alternate channel selectivity and blocking characteristics - receiver dynamic range and AGC system - system design and performance evaluation.

Unit IV: Transmitter system analysis and design **9 Hours**

Introduction: Transmission power and spectrum - modulation accuracy - adjacent and alternate channel power - noise emission calculation - important considerations in system design.

Unit V: Applications of System Design **9 Hours**

Applications: Multimode and multiband super heterodyne transceiver - direct conversion transceiver.

Reference Books:

1. Gu Qizheng, “RF System Design of Transceivers for Wireless Communications”, Springer, 2005.

2. Gernot Hueber and Robert Bogdan Staszewski, “Multi-Mode/ Multi-Band RF Transceivers for Wireless Communications: Advanced Techniques, Architectures, and Trends”, Wiley-IEEE Press, 2011.

3. William F. Egan, “Practical RF System Design”, John Wiley and Sons, 2004.

4. Rowan Gilmore and Les Besser “Practical RF Circuit Design for Modern Wireless Systems”, Artech House, 2003.

5. Wolfgang Eberle, “Wireless Transceiver Systems Design”, Springer, 2008.

Hyperlinks:

1. http://www.analog.com/en/rfif-components/rfif-transceivers/products/index.html
2. http://www.maximintegrated.com/products/wireless/
3. http://www.ek.isy.liu.se/courses/tsek38/
4. https://www.sparkfun.com/products/9582

Beyond the Syllabus Content:

1. RF system level specifications from standards and RFIC specifications.

2. Assignments can be given on LTE transceiver design, radio architectures suitable for high levels of integration and common circuit level functions essential to integrated radio architectures.

***** EENG 568*****

<table>
<tr><th>Course Code</th><th>Name of the Course</th><th colspan="3">Periods</th><th>Credits</th><th>Total Hours</th></tr>
<tr><td rowspan="2">EENG 569</td><td rowspan="2">ULTRA WIDEBAND COMMUNICATION SYSTEMS</td><td>L</td><td>T</td><td>P</td><td rowspan="2">3</td><td rowspan="2">45</td></tr>
<tr><td>3</td><td>0</td><td>0</td></tr>
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Prerequisite : Communication theory and wireless communications.

Objective : To impart the concepts of the UWB communication systems.

Outcome : Students able to design sub systems of UWB system.

Unit I: UWB Signals and Systems **9 Hours**
Introduction: UWB definition and features - power spectral density - pulse shape - pulse trains - UWB spectrum and spectral masks - multipath and penetration characteristics - spatial and spectral capacities - practical constraints - pros and cons - applications of UWB systems.

Unit II: UWB Pulse Generation **9 Hours**
UWB Signal Generation: UWB modulation schemes - transmitter and receiver - multiple access techniques - capacity - comparison of UWB with other wideband communication systems - interference and coexistence of UWB with other systems.

Unit III: UWB Signal Processing and Channel Modeling **9 Hours**
Signal Processing: Time domain and frequency domain techniques; Channel Model: Path loss model - two ray UWB propagation model - frequency domain autoregressive model.

Unit IV: UWB Antennas and Filters **9 Hours**
Antenna fundamentals - antenna radiation for UWB signals - conventional antennas and impulse antennas for UWB systems - beamforming for UWB signals - UWB filters - prototype - characteristics - filter techniques.

Unit V: UWB Standards and Advanced Topics **9 Hours**
UWB standardization in wireless personal area networks - MIMO and space time coding for UWB systems - coexistence of UWB with WiMAX and other short range wireless radios.

Reference Books:

1. M. Ghavami, L. B. Michael and R. Kohno, "Ultra Wideband Signals and Systems in Communication Engineering", 2nd Edition, John Wiley and Sons, NY, USA, 2007.

2. Jaffrey, "An Introduction to Ultra Wideband Communication Systems", Prentice Hall, 2005.

3. Faranak Nekoogar, “Ultra-Wideband Communications: Fundamentals and Applications”, Prentice Hall, 2005.

4. Ranjit Gharpurey and Pieter kinget, “Ultra Wide Band: Circuits, Transceivers and Systems”, Springer, 2008.

Hyperlinks:

1. www.uwbforum.org
2. www.pulse-link.net
3. www.ultrawidebandplanet.com

Beyond the Syllabus Content:

Assignments/Seminars/ Simulations can be given on the following topics:

1. Speed of data transmission, Gaussian waveforms and designing waveforms for specific spectral masks.
2. Hermite pulses, orthogonal prolate spheroidal wave functions, wavelet packets in UWB.
3. UWB Error Correction Coding: Super orthogonal convolutional coding (SOC) - turbo super orthogonal convolutional coding (TSOC) – Tomlinson Cercas and Hughes (TCH) coding.
4. Radar UWB array systems - wireless positioning and location - GPS techniques - positioning techniques - time resolution issues - UWB positioning and communications.
5. DS UWB vs. TH UWB vs. MB OFDM
6. UWB proposal - IEEE proposals for UWB channel models - UWB ad-hoc and sensor networks.
7. Self interference in high data rate UWB communications.

***** EENG 569*****

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
EENG 580	WAVELET TRANSFORM	3	0	0	3	45

Prerequisite : Digital signal processing.

Objective : To make the students to understand the mathematical basis of the wavelet transform as a tool in signal and image analysis and applications to time frequency analysis.

Outcome : Students will able to analyze and implement wavelet transforms for various applications.

Unit I: Discrete wavelet transform **9 Hours**

Introduction: Haar scaling functions and function spaces - nested spaces - Haar wavelet function- orthogonality of φ(t) and ψ(t) - normalisation of Haar bases at different scales - Daubechies wavelets - support of wavelet system.

Unit II: Discrete Wavelet Transform Relation to Filter Banks **9 Hours**

Introduction: Signal decomposition - relation with filter banks - frequency response - signal reconstruction - perfect matching filters - vanishing moments of wavelet function and filter properties.

Unit III: Biorthogonal Wavelet **9 Hours**

Introduction: Biorthogonal wavelet system - signal representation - biorthogonal analysis and synthesis.

Unit IV: Designing Wavelets in Frequency Domain **9 Hours**

Properties of Filter Coefficients: Frequency domain characterization - choice of wavelet function coefficients - vanishing moment conditions in Fourier domain - derivation of Daubechies wavelets; Biorthogonal Wavelet Design: Factor multiplication approach.

Unit V: Wavelet Packet Analysis and M-Band Wavelets **9 Hours**

Haar Wavelet Packets: Best basis selection for signal and image compression - M-band wavelets - motivation; Multiresolution Formulation: Derivation of the properties of M-band filter coefficient.

Reference Books:

1. K. P Soman, K. I Ramachandran and N. G Reshmi, "Insights into Wavelets: From Theory to Practice", 3rd Edition, Prentice Hall of India, 2010.

2. C. Sidnay Burrus, Ramesh A, Gopinath and Haitao Guo, "Introduction to Wavelets and Wavelet Transforms – A Primer", Prentice Hall of India, 1998.

3. Martin Vetterli and Jelena Kovacevic, "Wavelets and Subband Coding", Prentice Hall, 1995.

4. Stephane Mallat, "A Wavelet Tour of Signal Processing", 2nd Edition, Academic Press, 1999.

5. Charles K.Chui, "Wavelets: A Tutorial in Theory and Application", 2nd Edition, Academic Press, 2000.

Hyperlinks:

1. www.cse.iitm.ac.in/~vplab/courses/CV_DIP/PDF/Lect-wavelet_filt.pdf.

2. www.disp.ee.ntu.edu.tw/tutorial/WaveletTutorial.pdf

3. www.ai.eecs.umich.edu/people/conway/VLSI/VLSIText/PP-V2/V2.pdf

4. www.inst.eecs.berkeley.edu/~cs250/fa09/lectures/lec01.pdf

Beyond the Syllabus Content:

1. Simulation Study: MATLAB wavelet toolbox, software for filter design, signal analysis, image compression, PDEs, and wavelet transforms on complex geometrical shapes.

2. Case Study: Applications on wavelet transforms - audio and image compression, digital communication and multicarrier modulation, transmultiplexers, text-image compression, medical imaging, scientific visualization and seismic signal analysis.

***** EENG 580*****