Board of Studies
Master of Technology

(Electronics and Communication Engineering)

Revised Regulations, Curriculum and Syllabus
On Regulations 2018

(CBCS)

(with effect from academic year 2021-2022)

Pondicherry University
Pondicherry - 605 014
INDIA

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Master of Technology

(Electronics and Communication Engineering)

Revised Regulation, Curriculum and Syllabus on Regulations 2018

(CBCS)

(offered by Department of Electronics Engineering, Pondicherry University, Pondicherry, with effect from the academic year 2021 - 2022)

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i) Revised CBCS Regulations for M.Tech. (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.

Besides the Choice Based Credit System (CBCS) regulations specified by Pondicherry University in respect of engineering post graduate degree admission, evaluation and awarding degree, the following norms are applicable for this programme.

Name of the Programme	M.Tech. (Electronics and Communication Engineering)
Nature of Programme	Regular, Coming under Engineering Department.
Programme Duration	Two years (Four Semesters). However, one can complete the programme within maximum of eight semesters.
Eligibility Criteria	In addition to University regulations in respect of passing marks at undergraduate level and other criteria, candidates who are holding any one of the following degrees alone shall be considered for this M.Tech Programme: B.E / B.Tech in Electronics/ Electronics and Communication Engineering/ Electronics and Telecommunication Engineering with a minimum of 55% of marks.
Admission Criteria	Based on Pondicherry University's All India Entrance Examination.
Intake	30 Students per year
Teaching and Learning Methods	Lectures, tutorials and seminars are the main methods of course delivery, which would be supplemented by individual practical work, project work, simulation assignment, seminars and industrial visits.
Minimum number of credits to be acquired for successful completion of the programme	74 Credits

Assessment Methods : CBCS is the method of assessment with the following weightage of marks for the various courses of the programme.

For Theory Courses: 40% of marks for internal and 60% for end semester examinations.

The end semester question paper will have Part A (6 × 2 = 12 Marks) consisting of six two mark questions and Part B (4 × 12 = 48 Marks) consisting of six twelve mark descriptive questions of which one of them is compulsory and totally a candidate has to answer four out of six. For the end semester examination (University Semester Examination), the questions will be chosen only from the first four units of every theory subject of the programme to account end semester marks of 60 and internally (cumulatively) to assess a candidate's depth of knowledge in the concerned subject for 40 marks, a minimum of two internal tests (30 marks) shall be conducted. Further, the content of the fifth unit in each subject shall be considered to conduct seminars, tutorials, simulations, assignments, development of hardware models etc. for 10 marks as it is formulated at system level for all subjects of the programme. The question paper setter will be appointed by the Competent Authority of the University. However, the evaluation shall be carried out by both internal and external examiners.

For Practical Courses: 75% of marks for internal and 25 % for end semester examinations.

Non-Class Room Course I:

100% of marks through internal assessment only.

It is optional to undergo internship in established industry or esteemed institution / Seminar/ Workshop / Conference / FDP / Short term course / NPTEL/GIAN/MOOC Course for a period of four weeks (20 working days) either in single or multiple spans by a candidate. Further, a presentation should be given regarding the training or programme underwent during the period with the submission of a report. There shall not be any end semester evaluation. However, the internal evaluation is done by the committee comprising of internal members and one external member from other department of the same institute constituted by Head of the Department for the award of appropriate grade to the candidate based on the performance. The distribution of marks will be decided by the committee. The internship / Seminar/ Workshop / Conference / FDP / Short term course / NPTEL/GIAN/MOOC Course can be completed at any period of the duration of M.Tech. programme to fulfill the partial requirements for the award of M.Tech. degree.

Non-Class Room Course II:

It is mandatory to undergo one course related to the chosen programme for the minimum period of 30 hours either from NPTEL or GIAN or MOOC that is to be completed at any period of the duration of M.Tech. programme to fulfill the partial requirements for the award of M.Tech. degree. Absolute grade shall be awarded to a candidate based on the marks given in the certificate issued by the competent authority (NPTEL or GIAN or MOOC) for the chosen course.

Project - Literature Survey: 100% of marks through internal assessment only.

It is mandatory to undergo a complete literature survey by a candidate on the area of project work in the third semester regularly. There will be two reviews for the candidate on the literature survey carried out. There shall not be any end semester evaluation. However, the internal evaluation is based on the presentation of the candidate with the submission of a report about the literature survey. It will be done by the committee comprising of internal members and one external member from other department of the same institute constituted by Head of the Department for the award of appropriate grade to the candidate based on the performance. The distribution of marks for the literature survey will be decided by the committee.

For Project and Viva Voce: 75% of marks for internal and 25% for end semester examinations.

The Project work shall be evaluated for a maximum of 100 marks. There shall be three assessments during the fourth semester by a review committee. The Head of the Department shall constitute the review committee consisting of supervisor, project coordinator and another faculty member from the Department for the internal assessment (50 marks). The contribution by the respective supervisor of a student for 25 marks shall be accounted for the internal marks of 75. The end semester Project Viva Voce (for 25 marks) shall be conducted by the external member nominated by the competent Authority of the University. The distribution of the marks is shown in the Table given below.

Allocation of Marks for Project and Viva Voce (100 Marks)					
Internal (75 Marks)				**External (25 Marks)**	**Total (100 Marks)**
Review Committee (50 Marks)			Supervisor (25 Marks)		
First Review	Second Review	Third Review			
10 Marks	20 Marks	20 Marks	25 Marks	25 Marks	100 Marks

Publication: Mandatory requirement for the completion of the programme.

It is mandatory to have a minimum of one submitted manuscript / accepted publication in reputed journal during the M.Tech. programme. However, the submitted manuscript / accepted paper is subject to the recommendation of the evaluating committee comprising of internal members from same Department constituted by Head of the Department and one external member (examiner) from other institute nominated by competent Authority of University for the acceptance of the quality of the manuscript /paper of the candidate. The publication can be made at any period of the duration of M.Tech. programme. However, it does not contribute any credits to the programme but mandatory to fulfill the partial requirements for the award of M.Tech. degree. This evaluation process may be carried out along with even end semester examination depending up on the status of the students.

Non Compliance:

Non complaining the requirements of any course(s) by a candidate at any period of the duration of programme shall lead to warrant the implementation of prevailing University CBCS regulations.

Revised Curriculum of M.Tech. (Electronics and Communication Engineering)
(Applicable for CBCS and Non-CBCS)

I Semester

Sl. No.	Course Code	Name of the Course	H/S	L-T-P	Credits
1.	ECENG 510	Communication and Embedded Systems Laboratory - I	H	0-0-4	2
2.	ECENG 511	Advanced Digital Communication	H	3-1-0	4
3.	ECENG 512	Advanced Engineering Mathematics	H	3-1-0	4
4.	ECENG 513	Embedded Systems and VLSI Design	H	3-1-0	4
5.	ECENG 514	High Speed Semiconductor Devices	H	3-1-0	4
6.		Elective I	S	2-1-0	3
7.		Elective II	S	2-1-0	3
				Total Credits for Semester I	**24**

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

II Semester

Sl. No.	Course Code	Name of the Course	H/S	L-T-P	Credits
8.	ECENG 520	Communication and Embedded Systems Laboratory - II	H	0-0-4	2
9.	ECENG 521	Advanced Digital System Design	H	3-1-0	4
10.	ECENG 522	Advanced Digital Signal Processing	H	3-1-0	4
11.	ECENG 523	Advanced Wireless Communications	H	3-1-0	4
12.	ECENG 524	Modern Communication Systems	H	3-1-0	4
13.		Elective III	S	2-1-0	3
14.		Elective IV	S	2-1-0	3
				Total Credits for Semester II	**24**

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

III Semester

Sl. No.	Course Code	Name of the Course	H/S	L-T-P	Credits
15.		Elective V	S	2-1-0	3
16.		Elective VI	S	2-1-0	3
17.		Elective VII	S	2-1-0	3
18.	ECENG 610	Non-Class Room Course I	S	0-2-0	2
19.	ECENG 611	Non-Class Room Course II	S	0-2-0	2
20.	ECENG 612	Project – Literature Survey	H	0-0-1	1
				Total Credits for Semester III	**14**

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

IV Semester

Sl. No.	Course Code	Name of the Course	H/S	L-T-P	Credits
21.	ECENG 620	Project and Viva Voce	H	0-0-12	12
22.	ECENG 621	Publication	-	-	0
				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

Semester I – List of Electives

Sl. No.	Course Code	Name of the Course	L-T-P	Credits
1.	ECENG 530	Advanced Electromagnetics	2-1-0	3
2.	ECENG 531	Advanced Image Processing	2-1-0	3
3.	ECENG 532	Advanced Information Theory and Coding Techniques	2-1-0	3
4.	ECENG 533	Advanced Microcontroller and its Applications	2-1-0	3
5.	ECENG 534	Advanced Optical Communication	2-1-0	3
6.	ECENG 535	Advanced Satellite Communication	2-1-0	3
7.	ECENG 536	Low Power Digital VLSI Design	2-1-0	3
8.	ECENG 537	Micro and Nano Electronic Engineering	2-1-0	3
9.	ECENG 538	Microwave Circuits	2-1-0	3
10.	ECENG 539	Mobile Communication System	2-1-0	3

Semester II - List of Electives

Sl. No.	Course Code	Name of the Course	L-T-P	Credits
1.	ECENG 550	Advanced Radiation Systems	2-1-0	3
2.	ECENG 551	Design of Analog and Mixed VLSI Circuits	2-1-0	3
3.	ECENG 552	Electromagnetic Interference and Compatibility	2-1-0	3
4.	ECENG 553	High Performance Communication Networks	2-1-0	3
5.	ECENG 554	Industrial Electronics	2-1-0	3
6.	ECENG 555	Information and Network Security	2-1-0	3
7.	ECENG 556	Modeling and Simulation of Wireless Communication Systems	2-1-0	3
8.	ECENG 557	Pattern Recognition and Artificial Intelligence	2-1-0	3
9.	ECENG 558	RF Micro-Electromechanical Systems	2-1-0	3

10.	ECENG 559	RF System Design	2-1-0	3

Semester III - List of Electives

Sl. No.	Course Code	Name of the Course	L-T-P	Credits
1.	ECENG 630	Advanced Technologies in Wireless Networks	2-1-0	3
2.	ECENG 631	Bio sensors	2-1-0	3
3.	ECENG 632	Cognitive Radio Technology	2-1-0	3
4.	ECENG 633	Convergence Technologies	2-1-0	3
5.	ECENG 634	Carbon Nanotubes Devices and Applications	2-1-0	3
6.	ECENG 635	Embedded Real Time System	2-1-0	3
7.	ECENG 636	Free space Optical Networks	2-1-0	3
8.	ECENG 637	Green Radio Communication Techniques	2-1-0	3
9.	ECENG 638	Internet of Every Things (IoET)	2-1-0	3
10.	ECENG 639	Multicarrier Wireless Communication	2-1-0	3
11.	ECENG 640	Nano Photonics	2-1-0	3
12.	ECENG 641	Principles of ASIC Design	2-1-0	3
13.	ECENG 642	Soft Computing	2-1-0	3
14.	ECENG 643	Ultra Wideband Communication Systems	2-1-0	3
15.	ECENG 644	Vehicular Ad-hoc Networks (VANET)	2-1-0	3

ii) Syllabus for M.Tech. (Electronics and Communication Engineering):

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
ECENG 510	COMMUNICATION AND EMBEDDED SYSTEMS LABORATORY - I	0	0	4	2	60

Objective : Hands on experience on hardware experiments in order to acquire sufficient knowledge and understand practical nuances of various communication techniques.

LIST OF EXPERIMENTS (Given the list is minimal, however, the course teacher can decide the level of experiments)

1. Microcontroller Based Experiments
    a. Various Logic Operations
    b. Level and Edge Triggering Interrupts
    c. ADC/DAC
    d. Real time digital clock and alarm realization

2. DSP Based Experiments
    a. Wave form generation
    b. Linear and Circular convolution
    c. FIR filter implementation
    d. IIR filter implementation

3. Communication Based Experiments
    a. Design and analysis of GMSK modulator and demodulator
    b. Data transmission, Multiplexing and BER measurement through optical fiber
    c. Characterization of Directional Coupler and Power Divider using microstrip trainer kit
    d. Measurement of radiation pattern of microstrip patch antenna
    e. Study of DPCM and ADPCM using Advanced Digital Modulator trainer kit

4. VLSI Based Experiments
    a. Synthesis of 8-bit adders
    b. Synthesis of 4-bit multiplier
    c. Synthesis of mod-13 counter
    d. Synthesis of FSM

ECENG 510

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
ECENG 511	ADVANCED DIGITAL COMMUNICATION	3	1	0	4	60

Prerequisite: Basics of analog and digital communication systems.

Objective : To make the students to understand the various advanced concepts of digital communication techniques.

Outcome : Students will be able to imply the concepts of advanced digital communication techniques to various applications.

Unit I: Digital Modulation Techniques **12 Hours**

Elements of Digital Communication system - Factors influencing digital modulation techniques; Linear Modulation Techniques: BPSK - QPSK - DPSK; Constant envelope modulation techniques: MSK- GMSK; Linear and constant envelope modulation techniques: M- ary PSK and M- ary QAM.

Unit II: Additive White Gaussian Noise Channel **12 Hours**

Optimum receiver for signals corrupted by AWGN - performance of the optimum receiver for memory less modulation; optimum receiver for CPM signals - optimum receiver for signals with random phase in AWGN channel.

Unit III: Equalization Techniques **12 Hours**

Optimum receiver for channels with ISI and AWGN – Nyquist criterion for zero ISI - linear equalization and its variations - Decision Feedback Equalization - Predictive Decision Feedback Equalization -Turbo equalization.

Unit IV: 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.

Unit V: Instructional Activities **12 Hours**

Simulation: Different digital modulation - AWGN channel - equalization techniques and synchronization using any related platforms

Reference Books:

1. George R. C & Clare D M, "Modern Communications and Spread Spectrum," McGraw Hill Book Company, 1986.
2. John G P, Masoud S, "Digital Communications," 5th Edition, McGraw Hill Book Company, 2014.
3. Kamilo Feher, "Wireless Digital Communications Modulation & Spread Spectrum Applications," PHI, 1995.
4. Bernard S, "Digital Communication fundamentals and applications," 2nd Edition, Pearson education, 2009.
5. Theodire S R, "Wireless Communications," 2nd Edition Pearson Education, 2010.

Hyperlinks:

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

ECENG 511

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
ECENG 512	ADVANCED ENGINEERING MATHEMATICS	3	1	0	4	60

Prerequisite: Basics of Engineering Mathematics

Objective : To make the students to understand various mathematical concepts implied to electronics and communication engineering.

Outcome : The students will be able to apply these mathematical concepts to various applications of electronics and communication engineering.

Unit I: Random Variables **12 Hours**

Random variables: Probability axioms - conditional probability - discrete and continuous random variables, Cumulative Distribution Function (CDF) - Probability Mass Function (PMF) - Probability Density Function (PDF) - Conditional PMF/PDF - Expected value - Variance; Functions of a random variable; Expected value of the derived random variable.

Unit II: Multiple Random Variables **12 Hours**

Multiple random variables: Joint CDF/PMF/PDF - functions of multiple random variables - multiple functions of multiple random variables - independent/uncorrelated random variables - sums of random variables - moment generating function - random sums of random variables.

Unit III: Stochastic Processes **12 Hours**

Classification of stochastic process - stationary process (SSS and WSS) - ergodic process - independent increment process - counting process - narrowband process - normal process - Wiener process - Shot noise process - autocorrelation function.

Unit IV: Finite Difference Time Domain Method **12 Hours**

Wave Equation: Dispersion and Stability ; The FDTD method: Staggered Grids- one space dimension- three space dimensions-integral interpretation of the FDTD method- dispersion analysis in three Dimensions ; Boundary conditions for open regions: The perfectly matched Layer - near to far field transformation.

Unit V: Instructional Activities **12 Hours**

Response of LTI system's - probability distribution and density function - Weiner and Shot noise process- Practical applications of wave scattering in FDTD using related platforms.

Reference Books:

1. Michel K.O, "Applied Probability and Stochastic Processes", John Wiley and Sons, 2008.
2. Paboulis A, Unnikrishna P S, "Probability, Random Variables and Stochastic Processes", 4th Edition, Tata McGraw Hill, 2002.
3. Anders B, Thomas R, Ingelstro P, "Computational Electromagnetics", 2nd Edition, Springer, 2013.
4. Steven K. "Intuitive Probability and Random Processes using MATLAB", Springer, 2006.
5. Sadiku M N O, "Numerical Techniques in Electromagnetics", 2nd Edition, CRC Press, 2000.
6. Sankaran K, "Accurate Domain Truncation Techniques for Time-Domain Conformal Methods", ETH Zurich, 2007.

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.feynmanlectures.caltech.edu/II_toc.html
5. https://www.researchgate.net/publication/282120723_Accurate_domain_truncation_techniques_for_time-domain_conformal_methods

ECENG 512

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
ECENG 513	EMBEDDED SYSTEMS AND VLSI DESIGN	3	1	0	4	60

Prerequisite : Knowledge of digital electronics, microprocessor architecture and assembly language, C programming language

Objective : To make the students to understand the basics of embedded system and also the VLSI design using CMOS.

Outcome : Students will be aware of principles and design issues of various embedded processors and VLSI circuits.

Unit I: Embedded System **12 Hours**

Overview, embedded hardware units - embedded software - embedded System on Chip (SoC) - design process - classification of embedded system - bus - memory devices - component interfacing - networks for embedded systems; Communication interfacings: RS232/UART-RS422/RS485 - IEEE 488 bus.

Unit II: Embedded Processors **12 Hours**

Architecture of the Kernel: Preliminaries - PIC Processor - ARM processor - SHARC processor - design methodologies- specifications - architecture design and system analysis.

Unit III: Digital VLSI Design using CMOS **12 Hours**

Principles of circuit design using pass transistors and transmission gates - combinational logic circuit design - sequential logic circuit design - Flip Flops - synchronous sequential circuits and clocked storage elements.

Unit IV: Layout Analysis **12 Hours**

Resistive and inductive interconnect delays - network delay - layouts - simulation - switch logic networks - gate and network testing - memory cells and arrays - clocking disciplines - power optimization - validation and testing.

Unit V: Instructional Activities **12 Hours**

Study on embedded system design: Telephone PBX - ink jet printer - water tank monitoring system- GPRS - Personal Digital Assistants; Simulation of VLSI Circuits: Basic gates using logic families - CMOS inverter layout.

Reference Books:

1. Marilyn W, "Computers as components: principles of embedded computing system design", 4th Edition, Morgan Kaufmann, 2016.
2. David E S,"An embedded software premier", Addison-Wesley, 1999.
3. Prasad K V K K, "Embedded / real time systems: Concepts, Design and Programming", Dreamtech press, 2003.
4. Kamran E, Douglas A P, Sholeh E, "Essentials of VLSI Circuits and Systems", 1st Edition, PH Learning, 2009.
5. Wayne W, "Modern VLSI Design: IP Based Design", 4th Edition, Prentice Hall, 2008.
6. Jacob R B, "CMOS Circuit Design, Layout and Simulation", 3rd Edition, Wiley-IEEE Press, 2010.
7. Neil W, Kamran E, "Principles of CMOS VL SI Design: A System Perspective", Addison-Wesley Longman Publishing, 1985.
8. Douglas A P, Kamran E, "Basic VLS I Design", 3rd Edition, Pearson College Division, 1995.
9. Sung Mo K, Yosuf L, ChulwooK, "CMOS Digital Integrated Circuits: Analysis and Design", 4th Edition, McGraw-Hill, 2014.
10. John P U, "Introduction to VLSI Circuits and Systems", 1st Edition, Wiley, 2001.

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2. http://mysite.du.edu/~rvoyles/
3. http://courses.cs.washington.edu/courses/cse477/01sp/admin/schedule.html
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5. http://www.onlinevideolecture.com/electrical-engineering/nptel-iit-delhi/embedded-systems
6. http://web.ewu.edu
7. http://ic.sjtu.edu
8. http://nptel.iitm.ac.in

ECENG 513

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

Prerequisite : Fundamental knowledge in Semiconductor Devices and Circuits

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

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

Unit I: Semiconductor Materials **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: Fabrication Techniques **12 Hours**

Crystal Growth and Wafer Preparation- epitaxy - dielectric film deposition and oxidization techniques - masking and lithography techniques (optical, e-beam and other advanced lithography techniques) - diffusion - ion implantation - metallization - bipolar and MOS integration techniques - interface passivation techniques.

Unit III: MOS Devices **12 Hours**

M-S Junction: Structure - operation- characteristics; MOS Diode: Structure - band diagram - operation - C–V characteristics - effects of oxide charges - avalanche injection - high field effects and breakdown; MOSFET: Band diagram - structure - operation - I–V and C–V characteristics (analytical expressions) ; Advanced MOSFET: MOSFET breakdown and punch through – sub-threshold current - scaling down- High k-dielectric materials- SOI MOSFET - buried channel MOSFET - charge coupled devices.

Unit IV: High Speed 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 hetero-junction transistor for high speed applications; Nano devices: Resonant tunneling diode- Resonant tunneling transistor- SET- FinFET - nanowire FET.

Unit V: Instructional Activities **12 Hours**

Simulation study: MOSFET - HBT /HEMT- FinFET – SET using related tools.

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, 2008.
4. J. Singh, "Semiconductor Devices: Basic Principles", John Wiley and Sons, 2007.
5. Waser R, "Nanoelectronics and Information Technology" 2nd Edition, Wiley, 2012.

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/Webcoursecontents/IITKANPUR/HighSpeed_SemiconductorDevices/ ui/Course_home-32.html.

ECENG 514

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
ECENG 520	COMMUNICATION AND EMBEDDED SYSTEMS LABORATORY – II	0	0	4	2	60

Objective : Hands on experience on various simulation tools to design and analyze the various communication techniques.

LIST OF EXPERIMENTS: (Given the list is minimal, however, the course teacher can decide the level of experiments)

1. **Simulation using MATLAB / SCILAB (open source)**
   a. Direct sequence spread spectrum system
   b. Channel coding
   c. Line coding
   d. Filters
   e. Modulation schemes
   f. Security algorithm and authentication protocols

2. **Simulation using VHDL/ Verilog**
   a. Flip Flops
   b. Synchronous/ Asynchronous Counters
   c. Registers
   d. ROM/RAM
   e. PRBS generator

3. **Simulation using PSPICE**
   a. Analog circuits
   b. Digital circuits
   c. Communication circuits

4. **Simulation using NetSim**
   a. Design and configure a simple network model, collect statistics and analyze network performance.
   b. Design and analyse the Spanning tree algorithm.
   c. Performance analysis of WiMAX/ WiFi network.
   d. Performance analysis of convergence networks (WiMAX and LTE networks)

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
ECENG 521	ADVANCED DIGITAL SYSTEM DESIGN	3	1	0	4	60

Prerequisite : Knowledge on digital integrated circuit design, Verilog and FPGA.

Objective : To make the students to understand the design and analysis of the synchronous and asynchronous sequential circuits.

Outcome : The students will be able to design sequential circuits and fault diagnosis algorithms.

Unit I: Sequential Circuit Design **12 Hours**

Analysis of clocked synchronous sequential circuits and modeling- state diagram - state table - state table assignment and reduction - design of iterative circuits - ASM chart and realization using ASM.

Unit II: Asynchronous Sequential Circuit Design **12 Hours**

Analysis of asynchronous sequential circuit: Design of asynchronous sequential circuit - static and dynamic methods - flow table reduction - races - state assignment transition table and problems in transition table - essential hazards - data synchronizers - mixed operating mode asynchronous circuits.

Unit III: Synchronous Design Using Programmable Devices **12 Hours**

Programming logic device families: Designing a synchronous sequential circuit using PLA/PAL - realization of finite state machine using PLD/FPGA.

Unit IV: Fault Diagnosis And Testability Algorithms **12 Hours**

Fault diagnosis method: Path sensitization method - Boolean difference method - D – algorithm - tolerance techniques - compact algorithm - fault in PLA/PAL- test generation - built in self test.

Unit V: Instructional Activities **12 Hours**

Simulation of synchronous/ asynchronous sequential circuits: Logic compilation - two level and multi level logic synthesis - sequential logic synthesis -technology mapping - tools for mapping to PLDs and FPGAs.

Reference books:

1. Charles H R Jr, Larry L K,"Fundamentals of Logic Design", 7th Edition, Global Engineering, 2004.
2. Nripendra N B,"Logic Design Theory" , Prentice Hall of India, 1993.
3. Parag K L, "Fault Tolerant and Fault Testable Hardware Design", 1st Edition, B S Publications, 2002.
4. ParagK.L, "Digital system Design using PLD" ,B S Publications,1990
5. Charles H RJr, "Digital System Design using VHDL", 2nd Edition, CL Engineering, 2007
6. Michael D C, "Modeling, Synthesis, and Rapid Prototyping with the VERILOG HDL", Prentice Hall, 1999.

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2. http://nptel.ac.in/courses/117108040/downloads/Digital%20System%20Design.pdf
3. https://www.doulos.com/knowhow/verilog_designers_guide/
4. https://www.nandland.com/

ECENG 521

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
ECENG 522	ADVANCED DIGITAL SIGNAL PROCESSING	3	1	0	4	60

Prerequisite : Knowledge in Signal and Systems, and Digital Signal Processing

Objective : To make the students to understand the concepts in signal processing mechanisms and power spectrum estimation methods

Outcome : Students will be able to analyze and implement advanced signal processing techniques for various applications.

Unit I:Fundamentals of Signal Processing **12 Hours**

Introduction: Basic elements of Digital Signal Processing System- advantages of digital over analog signal processing; Classification of signals: Deterministic vs random signals - multi channel and multi-dimensional signals; Down Sampling-decimation-up sampling- interpolation.

Unit II: Power spectrum estimation **12Hours**

Estimation of spectra using the DFT from finite duration signals - non– parametric methods for power spectrum estimation: Welch- Bartlett methods; Parametric methods for power spectrum estimation: Yule-Walker method- Burg method for the ARM parameters- sequential estimation methods.

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 square estimation.

Unit IV: Wavelet Transform **12 Hours**

Introduction: Continuous Wavelet Transform - basic properties of wavelet transforms - Discrete Wavelet Transform: 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.

Unit V: Instructional Activities **12 Hours**

EEG/ECG signal analysis for the real time environment; Echo cancellation using adaptive filters; Voice recognition and speech-to-text conversion using related tools.

Reference Books:

1. Proakis J G and Manolkis D G, "Digital Signal Processing: Principles, Algorithms and Applications", 4th Edition, Prentice Hall of India, 2007.
2. Monson H H, "Statistical Digital Signal Processing and Modeling", Wiley, 2002.
3. Cristi R, "Modern Digital Signal Processing", Thomson Brooks/ Cole, 2004.
4. Lokenath D and Firdous A S, "Wavelet Transforms and Their Applications", 2nd Edition, Birkhauser, Springer, 2014.
5. Raghuveer R M, and Ajit S B, "Wavelet Transforms: Introduction to Theory and Applications", Pearson Education, New Delhi, 1998.

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ECENG 522

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
ECENG 523	ADVANCED WIRELESS COMMUNICATIONS	3	1	0	4	60

Prerequisite : Basics of analog, digital and wireless communication.

Objective : To impart the new concepts in advanced wireless communications.

Outcome : Students will able to understand the latest technologies used in advanced wireless communication systems.

Unit I: Introduction **12 Hours**

Introduction about wireless communication - technical challenges of wireless communication- applications; Cellular architecture - frequency reuse - channel assignment - handoff - coverage and capacity improvement; Multiple access: FDMA/CDMA/TDMA/SDMA.

Unit II: Propagation principles **12 Hours**

Propagation principles: Propagation mechanisms - channel modeling methods - radio channels- indoor channels - outdoor channels - fading channels ; Mobile Radio Propagation : Large scale path loss - path loss and propagation models - small scale fading - types of small scale fading- parameters of mobile multipath channels - statistical models for multipath fading channels

Unit III: Modulation and Detection **12 Hours**

Digital modulation: Structure of a wireless communication link - linear and constant envelope modulation techniques for wireless communication - error performance in fading channel; Transmission System; combined fast and slow fading - equalization - different detection techniques used in wireless communication.

Unit IV: MIMO Systems **12 Hours**

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 - performance analysis for space-time trellis codes - comparison of space-time block and trellis codes.

Unit V: Instructional Activities **12 Hours**

Simulation of minimum of (two) modulation and multiple access technique for wireless communication using related tools.

Reference Books:

1. Andreas Molisch F, “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 DaoudYacoub, “Wireless Technology: Protocols, Standards, and Techniques”, CRC Press, 2002.
7. Jafarkhani H, “Space-Time Coding: Theory & Practice”, Cambridge University Press, 2005.

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3. https://videoken.com/search-results
4. http://ee.sharif.edu/~wireless.comm.net/references/Tse, Fundamentals of Wireless Communication.pdf
5. http://ee.sharif.edu/~pr.wireless.comm/references/Goldsmith.pdf

ECENG 523

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
ECENG 524	MODERN COMMUNICATION SYSTEMS	3	1	0	4	60

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

Objective : To impart the new concepts of different communication systems.

Outcome : Students will aware of the principles and techniques used in modern communication systems.

Unit I: Microwave and Satellite Communication Systems **12 Hours**

Microwave communication systems - transmitters - receivers - line of sight propagation; Orbits of satellite - orbital effects on communication system's performance - satellite earth stations - satellite antennas and earth coverage - system noise temperature and G/T ratio - design of downlinks - uplink design - link design for specified C/N - VSAT systems.

Unit II: Optical Communication System **12 Hours**

Prologue: Historical perspective - light sources - photodiodes - fiber losses - signal dispersion - pulse propagation - multichannel propagation - signal propagation - modulation schemes; OFDM for optical communications - MIMO optical communications - Detection Schemes; Coherent optical OFDM detection - optical MIMO detection.

Unit III: Cellular Communication System **12 Hours**

Uniqueness of mobile radio environment - basic cellular system - analog and digital cellular systems - cell coverage - frequency reuse - channel interferences - cell splitting and handoffs - mobile antennas.

Unit IV: Cognitive Radio **12 Hours**

Overview of cognitive radio- cognitive radio network architecture - functions of cognitive radio - spectrum policies and regulations - spectrum sensing - spectrum analysis - spectrum sharing/management and spectrum mobility - applications of cognitive radio.

Unit V: Instructional Activities **12 Hours**

Performance analysis of minimum of four communication systems through simulation using related platforms.

Reference Books:

1. Rappaport T S, "Wireless Communications: Principles and Practice", 2nd Edition, Pearson India, 2010.
2. Keiser G, "Optical Fiber Communication", 3rd Edition, Mc Graw Hill, 2003.
3. Pratt T, Bostian C W and Allnut J E, "Satellite Communications", 2nd Edition, John Willey and Sons, 2003.
4. Grayver E, "Implementing Software Defined Radio", Springer Science & Business Media, 2012.
5. Chen K C and Prasad R, "Cognitive Radio Networks", John Wiley & Sons, 2009.

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5. nptel.ac.in/courses/117102062/

ECENG 524

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
ECENG 530	ADVANCED ELECTROMAGNETICS	2	1	0	3	45

Prerequisite : Basic knowledge of electromagnetic theory.

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

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

Unit I: Electromagnetic Waves **9 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 **9 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 **9 Hours**

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

Unit IV: Integral Equation in Momentum Method **9 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: Instructional Activities **9 Hours**

Simulation study of Green's function - Green's function for Sturm - Green's function in two dimensions - double series method - single series expansion method - Green's function in spectral domain - Green's function for unbounded region.

Reference Books:

1. David J G, "Introduction to Electrodynamics", Cambridge University Press, 4th Edition, 2017.
2. Roger F H, "Time Harmonic Electromagnetic Fields", IEEE Press, Wiley, 2001.
3. John D J, "Classical Electrodynamics", Wiley, 3rd Edition, 2009

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2. http://freevideolectures.com/Course/2340/Electromagnetic-Fields.html
3. http://ocw.mit.edu/OcwWeb/Electrical-Engineering-and-Computer-Science/6-632
4. Electromagnetic-Wave-TheorySpring2003/Course Home/index.html

ECENG 530

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
ECENG 531	ADVANCED IMAGE PROCESSING	2	1	0	3	45

Prerequisite: Fundamentals of signals and systems

Objective : Make the students to understand the concepts used in image processing techniques and its analysis.

Outcome : Students will be able to work with various image processing techniques for real time applications.

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

Image fundamentals: Image acquisition - sampling and quantization - image resolution- basic relationship between pixels - color images - RGB, HSI and other models; Transform based models (DFT, DCT, DWT); Image Enhancement: Spatial and frequency averaging - smoothening and sharpening filters.

Unit II: Segmentation and Denoising **9 Hours**

Image Segmentation: Edge detection - edge linking via Hough transform - thresholding- region based segmentation; Denoising: Maximum likelihood estimation - Bayesian estimators - model selection (MDL principle) - transform based denoising - adaptive wiener filtering - soft shrinkage and hard thresholding.

Unit III: Image Compression **9 Hours**

Image compression: Basics of source coding theory (lossless and lossy) - Vector quantization - codebook design - transform and sub band coding.

Unit IV: Image security and forensic **9 Hours**

Image Security: cryptography and steganography techniques- Chaos based and Non-Chaos based methods; Image Forensics: Key photographic techniques-detection techniques for crime scene analysis.

Unit V: Instructional Activities **9 Hours**

Simulation of preprocessing techniques-implementation of image processing techniques for real time applications-forensic analysis using related tools.

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.
5. Prabat K Andleigh and Kiran Thakrar, "Multimedia Systems and Design", Prentice Hall India, 2007.
6. Tay Vaughan, "Multimedia Making It Work", McGraw Hill, 2011.
7. Parekh R, "Principles of Multimedia",Tata McGraw-Hill, 2006.
8. Robinson and Edward, "Introduction to Crime Scene Photography", Elsevier/Academia Press, 2012.
9. Herbert Blitzer, Karen Stein-Ferguson and Jeffrey Huang, "Understanding Forensic Digital Imaging", 1st edition, Acadamic Press, 2008.

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2. https://www.tutorialspoint.com/dip/
3. https://homepages.inf.ed.ac.uk/rbf/HIPR2/glossary.htm

ECENG 531

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
ECENG 532	ADVANCED INFORMATION THEORY AND CODING TECHNIQUES	2	1	0	3	45

Prerequisite: Knowledge in probability and calculus.

Objective : To understand the concepts of various coding techniques with their applications.

Outcome : Students will be able to incorporate the various coding techniques in the field of wireless communications.

Unit - I : Entropy **9 Hours**

Entropy: Memory less sources - Markov sources - entropy of a discrete random variable - joint conditional and relative entropy - mutual information and conditional mutual information; chain relation for entropy - relative entropy and mutual Information.

Unit - II: Source Coding Theorems & Gaussian Approach **9 Hours**

Loss less source coding: Uniquely decodable codes - instantaneous codes - Kraft's inequality - optimal codes - Huffman code-Shannon's Source Coding Theorem :Arimoto - Blahut algorithm - Fano's inequality ;Shannon's channel coding theorem and its converse; Mutual information and capacity calculation for band limited Gaussian channels - Shannon limit - parallel Gaussian channels - capacity of channels with colored Gaussian noise.

Unit - III: Block Codes **9 Hours**

Linear block codes - error detecting and correcting capability – types of Block Codes – Reed Solomon codes - interleaving and concatenated codes - coding and interleaving applied to the compact disc digital audio system - LDPC codes.

Unit - IV: Convolutional Codes **9 Hours**

Convolutional encoding: Encoder Representation - properties of convolutional codes- convolutional decoding algorithm- Turbo codes - LT codes- Raptor codes – symmetric / asymmetric codes.

Unit- V: Instructional Activities **9 Hours**

Simulation of minimum of five coding techniques using related tools.

References Books:

1. Bernard Sklar, "Digital Communications: Fundamentals and Applications", 2nd Edition, Pearson Edition, New Delhi, 2007.
2. Ortega A, Ramchandran K, "Rate Distortion Theory for Image and Video Compression", IEEE Signal Processing Magazine, November 1998.
3. Thomas Cover M and Joy Thomas A, "Elements of Information Theory", 2nd Edition, John Wiley and Sons, New Delhi, 2006.
4. David MacKay JC, "Information Theory, Inference and Learning Algorithms", 2nd Edition, Cambridge University Press, 2003.
5. McEliece R J, "The Theory of Information & Coding", 2nd Edition, Cambridge University Press, 2002.
6. DeerghaRao K, "Channel Coding Techniques for Wireless Communications", Springer, New Delhi, 2015.

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3. http://www.inference.org.uk/itprnn/book.pdf

ECENG 532

Course Code	Name of the Course	Periods			Credits	Total Hours
ECENG 533	ADVANCED MICROCONTROLLER AND ITS APPLICATIONS	L	T	P	3	45
		2	1	0		

Prerequisite: Knowledge in microprocessor and microcontrollers architecture

Objective : To gain knowledge in advanced topics related to microcontrollers with interfacing methodologies.

Outcome : The students will be able to apply the gained knowledge from basic 8051 microcontrollers to the advanced RISC processors like ARM, for real-time applications.

Unit I: Introduction to 8051 Microcontroller and its architecture **9 Hours**

Introduction to 8051 microcontroller: pin diagram - block diagram - on-chip internal memory (RAM, ROM) - counters - watch dog timer and its applications - instruction set - UART - assembly language programming from simple to interfacing of ADC / DAC - stepper motors - keyboard - sensors - serial data communication.

Unit II: Programming of 8051 in embedded C **9 Hours**

Date types in embedded C - arithmetic and logical operators - control statements and loops in embedded C - functions and arrays in embedded C.

Unit III: PIC 18F Family **9 Hours**

Introduction to PIC 18F: Architecture - programming model - instruction set - simple programming using data transfer - arithmetic and logical instructions - programming on stack - loop instructions and subroutines - programming on timers and counters.

Unit IV: ARM Architectures **9 Hours**

Introduction to ARM: ARM processor fundamentals - ARM instruction set - thumb instruction set - writing and optimizing ARM assembly code - exception and interrupt handling.

Unit V: Instructional Activities **9 Hours**

Interfacing of memory and I/O devices with ARM/ PIC using embedded C programming: Keyboard - servo motor - stepper motor - sensors - ADC/DAC - display devices.

Reference Books:

1. Keneth J Ayala, "The 8051 Microcontroller Architecture, Programming and Applications", 2nd Edition, Delmar Cengage Learning, 1996.
2. Ali Mazidi M, Mazidi J G and McKinlay R D, "The 8051 Microcontroller and Embedded Systems Using Assembly and C", 2nd Edition, Pearson Education, 2009.
3. Raj Kamal, "Microcontroller: Architecture, Programming, Interfacing and System Design", Pearson Education, 2011.
4. Martin B, "PIC Microcontrollers: An Introduction to Microelectronics", 3rd Edition, Newnes: Elsevier, 2011.
5. Martin T, "The Designer's Guide to the Cortex-M Processor Family: A Tutorial Approach", 2nd Edition, Newnes: Elsevier Science and Technology, 2016.
6. Andrew N S, Dominic S and Chris W, "ARM System Developer's Guide-Designing and Optimising System Software", Morgan Kaufmann Publishers :Elsevier, 2004.
7. Ajay V D, "Microcontrollers: Theory and Applications", Tata McGraw-Hill, 2005.

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2. https://www.element14.com/community/roadTests/1501/l/online-course microcontrollers-and-c-programming
3. http://www.kelm.ftn.uns.ac.rs/literatura/mms/pdf/The 8051 Microcontroller Architecture, Programming and Applications. pdf
4. https://onlinecourses.nptel.ac.in/noc18_ec03/preview

ECENG 533

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
ECENG 534	ADVANCED OPTICAL COMMUNICATION	2	1	0	3	45

Prerequisite : Sound knowledge on basic optics, optical communication, various modulation and detection schemes in optical communication.

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

Outcome **:** Students will able to understand the potential of physical layer of optical system and its applications.

Unit I: Introduction **9 Hours**

Prologue: Historical perspective - light sources - modulators, fiber losses - signal dispersion - signal propagation - multi channel propagation - optical solutions- photonic crystal and Photonic Band Gap (PBG); Second order nonlinear optics: Second Harmonic Generation (SHG) - Sum Frequency Generation (SFG) - Difference Frequency Generation (DFG); Third order nonlinear optics: Third Harmonic Generation (THG) - Four Wave Mixing (FWM) - Self Focusing (SF).

Unit II: Modulation schemes **9 Hours**

Noise sources - channel impairments - optical transmission system - advanced modulation formats - multilevel modulation schemes - OFDM for optical communications - MIMO optical communication - polarization multiplexing - constrained (line or modulation) coding - soliton based communication.

Unit III: Detection schemes **9 Hours**

Coherent detection of optical signals - optical coherent detection schemes - optical heterodyne detection - optical homodyne detection - optical intradyne detection - DPSK photonic systems - optical channel equalization - coherent optical OFDM detection - optical MIMO detection.

Unit IV: Optical Channel Estimation **9 Hours**

Optical channel capacity - calculation of information capacity - information capacity of systems with direct detection - capacity of optical OFDM systems - capacity of optical MIMO systems.

Unit V: Instructional Activities **9 Hours**

Simulation of two dimensional photonic crystal, ring resonator and Y-shaped waveguide using 32-bit OPTIFDTD (freeware); Analyze second order nonlinearity and four-wave mixing through simulation using the same FDTD tools.

Reference Books:

1. Keiser G, "Optical Fiber Communication", 4th Edition, McGraw Hill, 2008.
2. Agrawal G P, "Fiber Optics Communication Systems", 4th Edition, Wiley, 2010.
3. Binh L N, "Advanced Digital Optical Communications", 2nd Edition, CRC Press, 2015.
4. William S and Ivan D, "OFDM for Optical Communications", Academic Press: Elsevier, 2010.
5. Ivan P K, Tingye L, and Alan E W, "Optical Fiber Communications VIB: Systems and Networks", 6th Edition, Academic Press: Elsevier, 2013.
6. Milorad C and Ivan B D, "Advanced Optical Communication Systems and Networks", Artech House, 2012.
7. Pierre L, "Fiber - Optic Communications", John Wiley and Sons, 2008.
8. Enrico F, "Optical Communication Theory and Techniques", Springer, 2006.
9. James N D, "Fiber-Optic Communications", Thomson Delmar Learning, 2005.
10. Rogers A J, "Understanding Optical Fiber Communications", Artech House, 2001.
11. Robert W Boyd, "Nonlinear Optics", 3rd edition, Academic Press, 2008.

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3. https://optiwave.com/resources/academia/free-fdtd-download/

ECENG 534

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
ECENG 535	ADVANCED SATELLITE COMMUNICATION	2	1	0	3	45

Prerequisite : Basics of digital and satellite communication.

Objective : To impart the orbital mechanics, space craft sub-systems and satellite link design

Outcome : Students will be able to analyze the advanced technical details behind the satellite link.

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 9 Hours

Link Design: System noise temperature and G/T ratio - C/N design of uplink and downlink - error control for digital satellite link.

Unit IV: VSAT Systems 9 Hours

VSAT Systems: Network architectures - access control protocols - earth station engineering - antennas - link margins - system design procedure.

Unit V: Instructional Activities 9 Hours

Simulation of link budget for two satellite systems - simulation of transponders and antenna system using related tools.

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.

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ECENG 535

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
ECENG 536	LOW POWER DIGITAL VLSI DESIGN	2	1	0	3	45

Prerequisite : Fundamentals of 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 will be able to design low power VLSI circuits.

Unit I: Power Dissipation **9 Hours**

Introduction: Need for low power circuit design - sources of power consumption - design methodology - low power figure of merits - limits and applications of low power VLSI Design.

Unit II: Power Analysis **9 Hours**

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: Energy Recovery Techniques **9 Hours**

Energy recovery techniques: Energy dissipation using the RC model - energy recovery circuit design - power reduction in clock networks - low power bus - delay balancing.

Unit V: Instructional Activities **9 Hours**

Simulation study: Sources of power dissipation in SRAMs - low power SRAM circuit techniques; Sources of power dissipation in DRAMs - low power DRAM circuit techniques using related tools

Reference Books:

1. Kaushik R and Sharat C P, “Low-Power CMOS VLSI Circuit Design”, Wiley Student Edition, 2009.
2. Gary K Y, “Practical Low Power Digital VLSI Design”, Kluwer Academic Publishers, 1998.
3. Bellaouar A and Elmasry M, “Low-Power Digital VLSI Design: Circuits and Systems”, Kluwer Academic Publishers, 1995.
4. Chandrakasan A and Robert W B, “Low-Power CMOS Design”, Wiley-IEEE Press, 1998.
5. Rabaey J M and Massoud P, “Low Power Design Methodologies”, Kluwer Academic Publishers, 1995.
6. Kiat-Seng Y and Kaushik R, “Low-Voltage, Low-Power VLSI Subsystems”, TMH Professional Engineering, 2009.
7. Soudris D, Piguet C and Goutis C, “Designing CMOS Circuits for Low Power”, Kluwer Academic Publishers, 2002.

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1. http://www.nptel.iitm.ac.in/courses/106105034/
2. http://www.eeherald.com/section/design-guide/Low-Power-VLSI-Design.html

ECENG 536

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
ECENG 537	MICRO AND NANO ELECTRONICS ENGINEERING	2	1	0	3	45

Prerequisite : Knowledge in basic sensors, actuators and various fabrication techniques.

Objective : To teach the principles in respect of micro and nano electronics, and MEMS /NEMS.

Outcome : The students will come out with a complete knowledge of micro and nano fabrication concepts, micro and nano sensors. MEMS/NEMS for real- time application.

Unit I: MEMS **9 Hours**

Introduction: Need for miniaturization technology - from perception to realization - overall MEMS market size - MEMS market character – Silicon MEMS - non-Silicon MEMS - MEMS versus traditional precision engineering.

Unit II: Micro Sensors and Actuators **9 Hours**

Sensing and actuation - case studies of real devices; Sensing mechanisms: piezoelectric - piezoresistive - capacitive; Actuation mechanisms: piezoelectric - electrostatic - magnetic and thermal; Physical sensors - opto - fluids - sensors for turbulence measurement and control - micro - actuators for flow control.

Unit III: Nanomaterials and Nanodevices **9 Hours**

Introduction to nanomaterials : properties of nanomaterials - role of size in nanomaterials and nanoparticles - semiconducting nanoparticles; Nanowires - nanoclusters - quantum wells - conductivity - Carbon Nanotube (CNT): structure of CNT and its properties; Nanosensors- structure- applications

Unit IV: Micro and Nano Fabrication Techniques **9 Hours**

Introduction to Lithography: Pattern transfer with different techniques - E beam lithography; Micromachining: Size effect in micromachining - mechanical micromachining; Oxidation - CVD of nanostructures - CVD diamond technology for NEMS and MEMS applications - nano crystals - nanowires - nanolithography - etching techniques.

Unit V: Instructional Activities **9 Hours**

Simulation of minimum of five MEMS/ NEMS using related tools.

Reference Books:

1. Marc J M, "Fundamentals of Microfabrication: The Science of Miniaturization", 2nd Edition, CRC Press, 2002.
2. Groffrey A O, Andre C A and Ludovico C, "Nanochemistry: A chemical approach to nanomaterials", 2nd Edition, RSC Publishing, 2009.
3. Schmidt G, "Nanoparticles: From theory to applications", Wiley, 2006.
4. Jackson M J, "Microfabrication and Nanomanufacturing", CRC Press, 2005.
5. Nadim M and Williams K, "An introduction to Microelectromechanical Systems Engineering", 2nd Edition, Artech House, 2004.
6. Stephen B, Graham E, Michael K and Neil W, "MEMS Mechancial Sensors", Artech House, 2004.
7. Stephen D S, "Microsystem Design", Kluwer Academic Publishers, 2002.
8. Michael J O, "Carbon Nanotubes: Properties and Applications", CRC Press, 2006.
9. Rao C N R and Govindaraj A, "Nanotubes and Nanowires", RCS Publishing, 2005.
10. Kouroush K, Benjamin F, "Nanotechnology enabled sensors", Springer, 2008.
11. Jackson M J, "Micro fabrication and Nanomanufacturing", CRC press, 2005.
12. Cao G and Wang Y, "Nanostructures and Nanomaterials: Synthesis, properties and applications", 2nd Edition, World Scientific, 2011.

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ECENG 537

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
ECENG 538	MICROWAVES CIRCUITS	2	1	0	3	45

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Prerequisite : Knowledge in electromagnetic waves, transmission lines and circuit

Objective : To make the students to have a clear knowledge about different concepts of microwave circuits.

Outcome : Students will be aware of different microwave circuits' and their working principles.

Unit I: Introduction **9 Hours**

Two port network characterization: Scattering matrix representation of microwave components - maximum power transfer theorem; Transmission lines: Need - quarter wave transformer - smith chart.

Unit II: Planar Transmission lines **9 Hours**

Strip line - microstrip line - coplanar waveguide - coplanar strips - slot line - Fin line and characteristics - properties - design parameters and its applications

Unit III: Microstrip Components **9 Hours**

3dB hybrid design - backward directional coupler - hybrid ring and power dividers - MIC filters - Kuroda transformation - K inverter - J inverter - resonator filters - realization using microstrip lines.

Unit IV: Substrate Integrated Waveguide **9 Hours**

Substrate Integrated Waveguide: Substrate integrated waveguide technology - design of SIW - losses in SIW - SIW circuits composed of metallic posts - SIW circuits with dielectric posts.

Unit V: Instructional Activities **9 Hours**

Simulation of (minimum of four) two port networks using various microwave circuits with the help of related tools; Assignments on applications of microwave circuits: space/defense/wireless.

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 S, “Microwave Integrated Circuits”, John Wiley, 1974.
5. Ramesh G, Inder B, Maurizio B, “Microstrip Line and Slot Line”, Artech House, 3rd Edition, 2013.

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5. journal.utem.edu.my/index.php/jtec/article/view/836
6. downloads.hindawi.com/journals/ijap/2013/746920.pdf

ECENG 538

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
ECENG 539	MOBILE COMMUNICATION SYSTEM	2	1	0	3	45

Prerequisite : Fundamentals of analog and digital communication systems.

Objective : To learn the architecture and working principles of mobile communication systems.

Outcome : The students will be able to understand the design principles and techniques of mobile communication systems.

Unit I: Introduction to cellular concepts **9 Hours**

Evolution of mobile radio communication - trends in cellular radio and personal communication; Basics of cellular concepts - types and components of mobile communication - operation of cellular system - handoff - radio channel characterization - multiple access schemes.

Unit II: Mobile standards **9 Hours**

System architecture and working principle: GSM - SCSD - GPRS - EDGE - CDMA digital cellular standard - 3G CDMA 2000 - 3G W-CDMA - IMT-2000 - 4G LTE- 5G.

Unit III: Diversity Schemes **9 Hours**

Realization of independent fading paths - Receiver diversity - selection combing -Threshold combing - maximal - ratio combing - equal - gain combing ; Transmitter Diversity - channel known at transmitter - channel unknown at transmitter - transmit and receive diversity for MIMO systems.

Unit IV: Mobile IP network and transport layer **9 Hours**

Introduction to Mobile IP: Requirements - IP packet delivery- agent discovery- registration, tunneling and encapsulation- optimization- reverse tunneling; Mobile adhoc networks - routing - destination sequence distance vector - dynamic source routing and alternative metrics; Traditional TCP - congestion control- slow start- fast retransmit - fast recovery- implications of mobility; Classical TCP improvements - methods of mobile TCP: Indirect TCP - snooping TCP - mobile TCP - fast retransmit.

Unit V: Instructional Activities **9 Hours**

Simulation study of any (five) mobile communication standards using related tools.

References Books:

1. Mullett, "Introduction to Wireless Telecommunication Systems & Networks", Cengage Learning, 2008.
2. Theodore S. Rappaport, "Wireless Communications Principles & Practice", PHI, 2007.
3. Schiller J, "Mobile Communications", Pearson Education, 2007.
4. Mark J W, Jhuang W, "Wireless Communications & Networking", PHI, 2006.
5. Krzysztof Wesolowski, "Mobile Communication Systems", Wiley, 2002.
6. Ramjee Prasad, Werner Mohr, Walter Konhäuser, "Third Generation Mobile Communication Systems", Artech House universal personal communications series, 2nd Edition, Artech House, 2000.
7. Man Young Rhee, "Mobile Communication Systems and Security", John Wiley & Sons, 2009.
8. John David Parsons, "Mobile Communication Systems", Springer Science & Business Media, 2012.
9. Raj Pandya, "Mobile and Personal Communication Systems and Services", IEEE Series on Digital & Mobile Communication, Volume 13, John Wiley & Sons, 2004.
10. Panagopoulos, Athanasios D, "Handbook of Research on Next Generation Mobile Communication Systems", Advances in Wireless Technologies and Telecommunication, IGI Global, 2015.

Hyperlinks:

1. http://www.techradar.com
2. https://www.digitaltrends.com/mobile/4g-vs-lte
3. http://www.etsi.org/technologies-clusters/technologies/mobile/umts

ECENG 539

Course Code	Name of the Course	Periods			Credits	Total Hours
ECENG 550	ADVANCED RADIATION SYSTEMS	L	T	P	3	45
		2	1	0		

Prerequisite : Electromagnetics and antenna theory.

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

Outcome : Students will be able to design different types of antenna for various applications.

Unit I: Concepts of Radiation and Antenna Fundamentals **9 Hours**

Physical concept of Radiation: Radiation from surface and line current distributions - fundamental parameters of antennas - Friss Transmission Equation - radiation integrals and auxiliary potential functions - Near and Far Field regions - Reciprocity and reaction theorems - radiation hazards and solutions

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 - frequency independent antennas - design and properties of log periodic - Yagi-Uda antennas - loop antennas - 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 - design of rectangular and circular patch - impedance matching of microstrip antennas - broadband - compact and tunable microstrip antennas.

Unit V: Instructional Activities **9 Hours**

Design, simulation and analysis of different antennas for wireless applications using related simulation tools.

Reference Books:

1. Jordan E C and Balmain K G, "Electromagnetic Waves and Radiating Systems", 2nd Edition, Pearson Education, 2015.
2. Balanis C A, "Antenna Theory: Analysis and Design", 4th Edition, John Wiley and Sons, New Jersey, 2016.
3. Kraus J D and Marhefka R J, "Antennas for All Applications", 3rd Edition, Tata McGraw Hill, 2002.
4. Elliot R S, "Antenna Theory and Design", Revised Edition, John Wiley and Sons, India, 2006.
5. Girish Kumar and Ray K P, "Broadband Microstrip Antennas", Artech House, 2003.

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1. http://www.nptel.ac.in/courses/117107035/
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3. http://www.nptel.ac.in/courses/108104099/
4. http://www.nptel.ac.in/courses/108104087/

ECENG 550

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
ECENG 551	DESIGN OF ANALOG AND MIXED VLSI CIRCUITS	2	1	0	3	45

Prerequisite : Basics of semiconductor device operation and VLSI design.

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

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

Unit I: Data Converters **9 Hours**

Data converter fundamentals: Analog versus digital discrete time signals - converting analog signals to data signals- sample and hold characteristics - DAC specifications - ADC specifications - mixed-signal layout issues.

Unit II: Data Converter Architectures **9 Hours**

Data converter architectures: DAC architectures - digital input code - resistors string - R-2R ladder networks - current steering - charge scaling - DACs - cyclic DAC - pipeline DAC - ADC architectures - flash ADC - 2-step flash ADC - pipeline ADC - integrating ADC - successive approximation ADC.

Unit III: SNR in Data Converters **9 Hours**

Data Converter SNR: Improving SNR using averaging (Excluding Jitter & averaging onwards) - decimating filters for ADCs (Excluding Decimating without Averaging onwards) - interpolating filters for DAC - band pass and high pass sync. filters.

Unit IV: Operational Amplifiers and Mixed Signal Circuits **9 Hours**

Differential amplifier- basic differential pair - Gilbert Cell; Op-Amp: Performance parameters - one stage and two stage Op-Amp - design of two stage Op-Amps - gain boosting - common mode feedback - slew rate - offset effects - PSRR- noise - stability and frequency compensation - two stage open loop comparators - high speed comparators - sample and hold circuit- switched capacitor circuits - oscillators - VCO - PLL.

Unit V: Instructional Activities **9 Hours**

Design and simulation of different VLSI Circuits using CAD Tools: Current mirrors - Differential Amplifier - PLL - ADC/DAC

Reference Books:

1. Razavi B, "Design of Analog CMOS Integrated Circuits", Tata McGraw Hill Edition, 2008.
2. Baker R J, "CMOS: Circuit Design, Layout and Simulation", 3rd Edition, John Wiley and Sons, NJ, 2010.
3. Allen P E and Holberg D R, "CMOS Analog Circuit Design", 3rd Edition, Oxford University Press, USA, 2012.
4. Baker R J, "CMOS: Mixed-Signal Circuit Design", John Wiley India Edition, 2009.

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ECENG 551

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
ECENG 552	ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY	2	1	0	3	45

Prerequisite : Electromagnetic theory.

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

Outcome : 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 22/CISPR 11 – IEC-61000 -4-2,3,4,5,6,8,11 -EN; Military Standards: MIL STD461D/ 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: Instructional Activities **9 Hours**

Simulation of minimum of (two) EMI coupling methods and controlling techniques with their performance analysis using related tools.

Reference Books:

1. V. P. Kodali, “Engineering EMC Principles, Measurements and Technologies”, IEEE Press, 2001.
2. Henry W. Ott, “Noise Reduction Techniques in Electronic Systems”, Wiley, 1988.
3. C. R. Paul, “Introduction to Electromagnetic Compatibility”, Wiley, 2006.
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/

ECENG 552

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
ECENG 553	HIGH PERFORMANCE COMMUNICATION NETWORKS	2	1	0	3	45

Prerequisite : Fundamentals of computer networks and wireless networks.

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

Outcome : Students will be able to understand the various topologies, services offered by broadband, WiFi, WiMAX, UWB and LTE networks.

Unit I: Introduction **9 Hours**

Communication Networks: Telephone and computer networks - cable television networks - wireless networks - networking principles - digitalization - network externalities - service integration; Layered architecture: - network bottlenecks - network elements - network mechanisms - traffic characterization and QoS.

Unit II: MANET **9 Hours**

Multihop wireless broadband networks - mesh networks; MANET architecture - classification of routing protocols in MANET -routing metrics; packet scheduling algorithms - power control mechanism.

Unit III: Internet and TCP / IP Networks **9 Hours**

Internet Protocol (IP): Technology trends in IP networks - IP packet communications in mobile communication networks; TCP and UDP - performance of TCP/ IP networks; Circuit switched networks: SONET- DWDM - fiber to the home - DSL; Intelligent Network (IN) scheme - comparison with conventional systems - merits of the IN scheme; CATV and layered network - services over CATV.

Unit IV: Enabling Networks **9 Hours**

WiFi: overview - architecture - PHY an d MAC layer; WiMAX overview - system architecture - frame structure - PMP mode - mesh mode - multihop relay mode; UWB overview - time hopping UWB - direct sequence UWB - multiband UWB; LTE and LTE- A overview - system model - frame structure - comparison with broadband technologies.

Unit V: Instructional Activities **9 Hours**

Simulation study: Wifi network - WiMAX network in mesh mode and multihop relay mode - integration of LTE - A and WiMAX network with single IP network.

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 Mc Graw 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. AmitabhaGhosh and RapeepatRatasuk, "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.
7. Ada Gavrilovska, "Attaining High Performance Communications: A Vertical Approach", CRC Press, 2016.
8. Dimitris N. Chorafas, "High-Performance Networks, Personal Communications and Mobile Computing", Springer, 2016.

Hyperlinks:

1. http:// www.ece.gmu.edu/.../high performance communication networks_1.pdf
2. http://www.amazon.com/dp/1558605746/ref=rdr_ext_tmb

ECENG 553

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
ECENG 554	INDUSTRIAL ELECTRONICS	2	1	0	3	45

Prerequisite : Knowledge in semiconductor devices and circuits with different analysis.

Objective : To familiarize the latest techniques in industrial electronics from fundamentals to applications.

Outcome : The students will be able to design electronic devices for industrial applications

Unit I: Semiconductor Devices **9 Hours**

Semiconductor devices: Diode - application of diode as switch - Zener diode as regulator - Light Emitting Diode - photo diode; Thyristors: Operation and characteristics of SCR; TRIAC - DIAC - UJT - BJT - MOSFET - Insulated Gate Bipolar Junction Transistor (IGBT) - Operational Amplifiers (IC 741) - IC 555 Timer - Operational modes of IC 555- piezoelectric devices-transducers.

Unit II: Phase controlled Rectifiers and Bridges **9 Hours**

Single phase bridge rectifier with R - RL and RLE load - three phase semi converter - three phase full converter - dual converter - harmonic issues in controlled rectifiers; Inverters: Single phase bridge inverter - three phase bridge inverter - 120 and 180 degree mode of operation - voltage and frequency control in inverters.

Unit III: DC-DC converters **9 Hours**

DC - DC conversion - Buck Boost converters - circuit configuration and analysis with different types of loads - Resonant DC – DC converters; Switched Mode Power Supply (SMPS) - Concept of PWM in converters - unity power factor converters - Voltage Source Inverters (VSI) - Current Source Inverters (CSI) - Application of VSI and CSI in induction motor control - Uninterrupted Power Supply (UPS).

Unit IV: Digital Design **9 Hours**

Logic gates and related IC's - combinational and sequential circuits and their IC's - 8086 Microprocessor - 8051 Microcontroller - interfacing of microprocessor and microcontroller with ADC and DAC - display modules - stepper motors and serial ports - application of microprocessors , microcontrollers and DSP in machine drives.

Unit V:Instructional Activities **9 Hours**

Case study in Programmable Logic Controllers (PLC) - PLC programming methodologies - PLC functions - industrial automation using PLC programming.

Reference Books:

1. Kassakian John G, Schlecht Martin F and Verghese George C "Principle of Power Electronics", 1st Edition, Pearson Education Ltd., 2010.
2. Gopal K D, "Power Semiconductor Controlled Drives", Prentice Hall, 1989.
3. Bhattacharya S K, Chatterjee S, "Industrial Electronics and Control", Tata McGraw Hill, 2006.
4. Ned Mohan T, M. Undeland and William, P Robbins; "Power Electronics: Converters, Applications and Design", 3rd Edition, John Wiley and Sons, 2009.
5. Rashid M H, "Power Electronics – Circuits, Devices and Applications", 3rd Edition, Pearson Education, 2004.
6. David Irvin J, "The Industrial Electronics Handbook", CRC Press, 1997.
7. Bose B K, "Modern Power Electronics and AC Drives", Prentice Hall, 2002.
8. Singh M D and Khanchandani K B, "Power Electronics", 2nd Edition, Tata McGraw Hill, 2006.
9. John W W and Ronald A R, "Programmable Logic Controllers Principles & applications", 5th Edition, Prentice Hall India, 2002.
10. Douglas V Hall, "Microprocessor and Interfacing", Revised 2nd Edition, Tata Mc Graw Hill, 2006.
11. Keneth J Ayala, "The 8051 Microcontroller Architecture, Programming and Applications", 2nd Edition, Delmar Cengage Learning, 1996.

Hyperlink:

1. http://cie-wc.edu/Industrial-Electronics-with-PLC-Training-Lab.aspx
2. https://buddhiprakash.weebly.com/uploads/4/5/3/2/45327319/8051microcontroller-ayala.pdf
3. https://www.lbwcc.edu/academics/careertechnical-division/programs/industrial-electronics-technology

ECENG 554

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
ECENG 555	INFORMATION AND NETWORK SECURITY	2	1	0	3	45

Prerequisite : Analog and digital communication

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: Introduction to Cryptography **9 Hours**

Security issues: Security problems in computing - attacks - security services - security mechanism - OSI security architecture - standard setting organizations; Need for cryptographic techniques- substitution - transposition - block ciphers

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

Triple DES with two keys - stream cipher - RC4 - RSA algorithm - elliptical curve cryptography algorithm; MD5 - HASH algorithm - SHA 512 logic - Digital Signatures 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 - security in GSM - security in 3G and 4G.

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: Instructional Activities **9 Hours**

Simulation of minimum of (three) public key and private key cryptography algorithms using related tools.

References Books:

1. Bernard S and Pabitra K R, "Digital Communications: Fundamentals and Applications", 2nd Edition, Pearson Edition, 2009.
2. Stallings W, "Cryptography and Network Security", 4th Edition, Prentice Hall, 2006.
3. Thomas S, Cover M and Joy A T, "Elements of Information Theory", 2nd Edition, John Wiley & Sons, 2006.
4. MacKay J C D, "Information Theory, Inference and Learning Algorithms", 2nd Edition, Cambridge University Press, 2003.
5. McEliece J R, "The Theory of Information and Coding", 2nd Edition, Cambridge University Press, 2002.

Hyperlinks:

1. https://www.cl.cam.ac.uk/teaching/1314/InfoTheory
2. http://gva.noekeon.org/QCandSKD/QCandSKD-introduction.html

ECENG 555

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
ECENG 556	MODELING AND SIMULATION OF WIRELESS COMMUNICATION SYSTEMS	2	1	0	3	45

Prerequisite : Knowledge of MATLAB programming, digital signal processing and digital communication

Objective : To understand the modeling of wireless communication systems through simulation.

Outcome : Students will able to design and analyse the various concept of wireless 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: Sampling - quantizing - reconstruction and interpolation - simulation sampling frequency - complex envelope techniques.

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

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

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

Fundamental Concepts of Monte Carlo Simulation - applications and integration - two Monte Carlo examples; Semi Analytic Techniques System: Level simplifications and sampling rate considerations - overall methodology; Modeling and simulation of nonlinearities: 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 - random process models - simulation methodology; Discrete channel models: Discrete memory less channel models - Markov models for discrete channels with memory- HMMs - Gilbert and Fritchman models - estimation of Markov model parameters.

Unit V: Instructional Activities **9 Hours**

Simulation study of generating PDF for the Gaussian and non-Gaussian distributions - linear and non-linear systems using different techniques with the help of simulation tools

Reference Books:

1. William H T, Samshanmugan K, Rappaport T S and Kosbar K L, "Principles of Communication Systems Simulation with Wireless Applications", Pearson Education, 1st Edition, 2011.
2. Jeruchim M C, Philip B and Samshanmugam K, "Simulation of Communication Systems: Modeling Methodology and Techniques", 2nd Edition, Kluwer Academic Publisher, 2002.
3. Averill M L, "Simulation Modeling and Analysis", 5th Edition, McGraw Hill, 2014.
4. Hayes F J, "Modeling and Analysis of Computer Communication Networks", Springer, Plenum Press, 1984.
5. Banks J, Carson J S, Nelson L B and Nicol D M, "Discrete Event System Simulation", 4th Edition, Pearson Education, 2009.

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2. http://dspace.mit.edu/handle/1721.1/38950
3. http://www.mathworks.in/communications/wireless-wired-channel-modeling.html

ECENG 556

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
ECENG 557	PATTERN RECOGNITION AND ARTIFICIAL INTELLIGENCE	2	1	0	3	45

Prerequisite : Basic concepts of probability theory and random process.

Objective : To help the students to gain in-depth knowledge in pattern recognition and artificial intelligence.

Outcome : Students will be able to apply pattern recognition and artificial intelligence techniques for signal and image processing application.

Unit I: Introduction to Pattern Recognition **9 Hours**

Introduction: Probability- statistical decision making- nonparametric decision making- patterns and features - training and learning in pattern recognition - pattern recognition approach- different types of pattern recognition.

Unit II: Clustering **9 Hours**

Unsupervised learning: Hierarchical clustering- graph theories approach to pattern clustering- fuzzy pattern classifier- application of pattern recognition in medicine.

Unit III: Artificial Intelligence **9 Hours**

Artificial Intelligence: Intelligent agents - perception and language processing - problem solving - searching - heuristic searching - game playing - Logics - logical reasoning.

Unit IV: Expert Systems **9 Hours**

Expert Systems- components- production rules- Backwards vs Forward reasoning- statistical reasoning- certainty factors- measure of belief and disbelief- Meta level knowledge- Introspection.

Unit V: Instructional Activities **9 Hours**

Range images generation- extraction of geometric elements- automatic scene generation- scene recognition- geometrical hashing using related tools.

Reference Books:

1. MacKay D.J.C, "Information Theory, Inference, and Learning Algorithms", Cambridge University Press, 2003.
2. Devi, Susheela V, Murty, Narasimha M, "Pattern Recognition: An Introduction", Universities Press, Hyderabad, 2011.
3. Theodoridis S and Koutroumbas K, "Pattern Recognition", 4th Edition. Academic Press, 2009.
4. Mishra R B, "Artificial Intelligence", PHI, India, 2010.
5. Russell S and Norvig N, "Artificial Intelligence: A Modern Approach", Prentice Hall Series in Artificial Intelligence. 2003.
6. Bishop, C M, "Pattern Recognition and Machine Learning", Springer. 2007.

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1. https://www.tutorialspoint.com/biometrics/pattern_recognition_and_biometrics.htm
2. http://www.cedar.buffalo.edu/~srihari/CSE555/
3. https://www.ibm.com/developerworks/library/cc-beginner-guide-machine-learning-ai-cognitive/index.html

ECENG 557

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
ECENG 558	RF MICRO-ELECTRO MECHANICAL SYSTEMS	2	1	0	3	45

Prerequisite : Knowledge in design of electronic and microwave circuits

Objective : To familiarize the student with the technology and applications of Micro-Electro Mechanical Systems (MEMS).

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

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

Evolution of Micro Electro Mechanical Systems (MEMS): Driving force for MEMS development - MEMS material properties - microelectronics technology for MEMS; The Finite Element Method (FEM): Important mathematical and physical concept in FEM - discretization and other approximation.

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

Fabrication Process: MEMS fabrication technologies - bulk micro machining - surface micro machining - LIGA process; Bonding and packaging of MEMS - MEMS reliability - scaling in MEMS; Recent research direction in MEMS: CMOS- MEMS integration - polymer MEMS - NEMS etc.

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

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

Unit IV: 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: Micro-strip antennas - design parameters.

Unit V: Instructional Activities **9 Hours**

Modeling, simulation and analysis of applications of MEMS switch, sensors and actuators using related platform.

Reference Books:

1. Madou M, "Fundamentals of Micro Fabrication" CRC Press, 3rd Edition, 2011.
2. Senturia, "Micro System Design", Kluwer, 2007.
3. Maluf N , Williams K, "An Introduction to Micro- electromechanical Systems Engineering", Artech House, 2nd Edition, 2004.
4. Varadan V K, Vinoy K J, Jose K A, "RF MEMS and Their Applications" Wiley & Sons, 2003.
5. Rebeiz G, "RF MEMS: Theory, Design, and Technology", Wiley/ IEEE Press, 2004.
6. Robert D C, "Finite Element Modeling for Stress Analysis", John Wiley and Sons, 1995.

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2. http://biomedikal.in/2011/02/lecture-notes-on-mems-technology/
3. http://www.learnerstv.com/Free-engineering-Video-lectures-ltv122-Page1.html

ECENG 558

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
ECENG 559	RF SYSTEM DESIGN	2	1	0	3	45

Prerequisite : Microwave engineering.

Objective : To impart RF system design for different applications.

Outcome : Students will be able to design different types of RF active components, devices and circuits.

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

High Frequency Components: 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 Devices and Circuits **9 Hours**

RF amplifier design- power gain equations - maximum gain design, low noise amplifier design, high power amplifier design- stability considerations; RF oscillator design - one - port and two - port negative resistance oscillators - oscillator design using large - signal measurements; RF Mixer Design: Single ended mixer - double ended mixer.

Unit III: RF feedback systems and Power amplifiers **9 Hours**

Stability of feedback systems: Gain and phase margin - root - locus techniques - time and frequency domain considerations - compensation ; General model - Class A, AB, B, C, D, E and F amplifiers - power amplifier linearization techniques - efficiency boosting techniques - ACPR metric- design considerations.

Unit IV: PLL and Frequency synthesizers **9 Hours**

Linearised model - noise properties - phase detectors - loop filters and charge pumps – integer - N frequency synthesizers - direct digital frequency synthesizers.

Unit V: Instructional Activities **9 Hours**

Simulation of the frequency response of amplifier, oscillator and mixer for different applications using related tools.

Reference Books:

1. Reinhold Ludwig and Pavel Bretchko, “RF Circuit Design”, Pearson Education, 2007.
2. Josn Rogers and Calvin Plett, “Radio Frequency Integrated Circuit Design”, Artech House, 2002.
3. Ferri Losee, “RF systems, Components and Circuits Handbook”, Artech House, 2002.
4. Joseph J. Carr, “Secrets of RF Circuit Design”, Tata McGraw Hill, 2004.
5. Thomas Lee,” The Design of Radio Frequency CMOS Integrated Circuits”, Cambridge University Press, 2nd Edition, Cambridge, 2004.

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ECENG 559

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
ECENG 630	ADVANCED TECHNOLOGIES IN WIRELESS NETWORKS	2	1	0	3	45

Prerequisite : Basics knowledge of computer and wireless networks.

Objective : To learn about the advanced topics in wireless networks with their architectures.

Outcome : Students will able to understand the various technologies in wireless networks.

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

WPAN: System model - protocol stack of IEEE 802.15; Bluetooth: Network architecture - operation - specification; Radio Frequency Identification (RFID): Types and specifications; ZIGBEE and WBAN: section and architecture; WLAN: Network architecture - protocol stack of IEEE 802.11 - physical layer and MAC layer mechanism; WiMAX: BWA - issues and challenges of WiMAX - network architecture - protocol stack of IEEE 802.16 - differences between IEEE 802.11 and IEEE 802.16

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

Issues - design challenges - characteristics and architecture of wireless sensor network - classification - MAC protocols - routing schemes - security - enabling technologies for sensor network.

Unit III: Wireless Internet **9 Hours**

IP for wireless domain - mobile IP - IPv6 advancements - mobility management functions - location management - registration and handoffs; TCP in wireless domain: TCP over wireless - types - mobile transaction - impact of mobility; Wireless security and standards.

Unit IV: Wideband Wireless Technologies **9 Hours**

UWB Radio Communication: Fundamentals of UWB - major issues - operation of UWB systems - comparisons with other technologies - advantages and disadvantages; LTE: System architecture - frame structure – LTE - FDD vs TDD comparison; LTE Advanced: Network architecture - frame structure and its characteristics; 5G networks: Technical challenges- architecture.

Unit V: Instructional Activities **9 Hours**

Simulation of minimum of five wireless networks standards using related tools.

References Books:

1. KavehPahlavan and Prashant Krishnamurthy, "Principle of Wireless Networks - A Unified Approach", Prentice Hall of India, 2006.
2. William Stallings, "Wireless Communication and Networks", 2nd Edition, Prentice Hall, 2005.
3. Clint Smith and Daniel Collins, "3G Wireless Networks", 2nd Edition, Tata McGraw Hill, 2007.
4. Vijay Garg K, "Wireless Communications and Networks", 2nd Edition, Morgan Kaufmann Publishers (Elsevier), 2007.
5. AmitabhaGhosh and RapeepatRatasuk, "Essentials of LTE and LTE-A," Cambridge University Press, 2011.

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2. www.tutorialspoint.com/wimax/
3. http://www.infotech.monash.edu.au/units/archive/2012/s2/fit5083.html
4. http://www.utdallas.edu/~venky/

ECENG 630

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
ECENG 631	BIO SENSORS	2	1	0	3	45

Prerequisite : High speed semiconductor devices and MEMS

Objective : To make the students to understand the usage of different sensors for various biomedical applications.

Outcome : Students will able to analyze different bio sensors and its effective usage for the real time applications.

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

Basic principle of bio sensor- components of bio sensor- classification of biosensors - applications.

Unit II: Semiconductors substrates **9 Hours**

Semiconductor substrates for bio electronics - silicon - diamond - chemical functionalization - covalent attachment of biomolecules to silicon surfaces - DNA modified silicon and diamond surfaces.

Unit III: Immune sensors **9 Hours**

Anti body as bio recognition element: Types of anti-bodies and anti-body fragments; Types of immune sensors - labeled and label-free sensors - immune sensor applications.

Unit IV: Transducers in Biosensors **9 Hours**

Piezoelectric semiconductor - impedimetric - mechanical and molecular electronics based transducers - Chemi - luminescence based bio sensors.

Unit V: Instructional Activities **9 Hours**

Simulation of biosensors for various applications: clinical chemistry-medicine and health care-veterinary - industrial processes - environmental monitoring using related tools.

Reference Books:

1. Itamar W and Eugenii K, "Bio electronics: From Theory to Applications", Wiley VCH, 2005.
2. Chandran K, Kalpana B and Robson B, "Bio sensors and Bio electronics", Elsevier, 2015.
3. Brian R E, "Biosensors an Introduction", 1st Edition, Wiley, 1996.
4. Loic J B and Pierre R C, "Biosensors Principles and Applications", 1st Edition, Marcel Dekker Inc, New York, 1991.
5. Donald G B, "Biosensors Theory and Applications", 1st Edition, Technomic Co. Inc, Lancaster, 1993.

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2. http://biomedikal.in/2011/02/lecture-notes-on-mems-technology/
3. http://www.learnerstv.com/Free-engineering-Video-lectures-ltv122-Page1.html

ECENG 631

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
ECENG 632	COGNITIVE RADIO TECHNOLOGIES	2	1	0	3	45

Prerequisite : Fundamentals in wireless networks

Objective : To understand the requirements in designing software defined radios and cognitive radio with its functionalities.

Outcome : Students will be able to design the wireless network based on cognitive radio technology

Unit I: Introduction **9 Hours**

Fundamentals of communication networks: New challenges - multiple access schemes - cross layer design and optimization; Multicarrier modulation and equalization - ISI; RF spectrum and regulation: Regulatory issues of cognitive access.

Unit II: SDR Architecture **9 Hours**

Software Defined Radio: Evolution - essential functions of the Software Defined Radio - architecture goals - quantifying degrees of programmability - top level component topology - computational properties of functional components - interface topologies among plug and play modules - architecture partitions - merits and demerits of SDR - problems faced by SDR.

Unit III: CR Architecture **9 Hours**

Cognitive radio network architectures: Architectures for spectrum sharing - network optimization - topology aware CRN architectures - Haykin dynamic spectrum architecture.

Unit IV: CR Network Security **9 Hours**

Primary user emulation attacks - security vulnerabilities in IEEE 802.22 - security threats to the radio software.

Unit V: Instructional Activities **9 Hours**

Simulation of CR & SDC network using related tools.

Reference Books:

1. Alexander M. Wyglinski, MaziarNekovee, and Thomas Hou Y, "Cognitive Radio Communications and Networks - Principles and Practice", Elsevier Inc., 2010.
2. Kwang-Cheng Chen and Ramjee Prasad, "Cognitive Radio Networks", John Wiley & Sons Ltd, 2009.
3. Khattab, Ahmed, Perkins, Dmitri, Bayoumi, Magdy, "Cognitive Radio Networks - From Theory to Practice", Springer Series: Analog Circuits and Signal Processing, 2009.
4. Mitola J, "Cognitive Radio: An Integrated Agent Architecture for software defined radio", Doctor of Technology thesis, Royal Inst. Technology, Sweden 2000.
5. Simon Haykin, "Cognitive Radio: Brain –empowered wireless communications", IEEE Journal on selected areas in communications, volume 23, no.2, page no.201-220, Feb 2005.
6. Ian F. Akyildiz, Won – Yeol Lee, Mehmet C. Vuran, ShantidevMohanty, "NeXt generation / dynamic spectrum access / cognitive radio wireless networks: A Survey Elsevier Computer Networks", volume 50, page no.2127-2159, May 2006.
7. Arslan H, "Cognitive Radio, Software Defined Radio and Adaptive Wireless Systems", University of South Florida, USA, Springer, 2007.

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1. http://www.radio-electronics.com/info/rf-technology-design/cognitive-radio-cr/technology-tutorial.php
2. http://www.sciencedirect.com/science/book/9780123747150
3. http://www.xgtechnology.com/innovations/cognitive-radio-networks/

ECENG 632

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
ECENG 633	CONVERGENCE TECHNOLOGIES	2	1	0	3	45

Prerequisite : Basics of wireless networks, elementary concepts in probability, optimization related to communication systems.

Objective : To gain expertise in the convergence technologies in respect of network design and performance measures.

Outcome : Students will be able to enumerate the functions and importance of internetworking/ interoperability of advanced wireless technologies

Unit I: Introduction **9 Hours**

Evolution towards convergence: Next generation network concept - framework for examining next generation and evolving networks - examples of application of framework - enabling mobile network technologies - opportunities and threats to the mobile converging service market.

Unit II: Switching networks and convergence standards **9 Hours**

Switching networks: Packet switched networks - Circuit switched networks; Convergence Standards: VOIP convergence - H.323 protocol - SIP - Media Gateway Control Protocol (MGCP) – MEGACO; Wireless standards: IEEE 802.11 - HYPERLAN - IEEE 802.16 - wireless ATM - wireless convergence - sensor networks - ZigBee and RFID.

Unit III: IP Telephony **9 Hours**

IP Telephony : Network architecture - IP Voice - VoIP call signaling protocols - IP cablecom - media networking - broadband infrastructure - IP TV - cloud computing- interoperability among multicasting/broadcasting systems - QoS.

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 design and analysis 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: Instructional Activities **9 Hours**

Simulation of minimum four convergence technologies for various applications using related tools.

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, KeeChaing 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. 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.
7. C. Siva Ram Murthy and B.S. Manoj, "Ad Hoc Wireless Network: Architectures and Protocols", Pearson Education, 2007.
8. Jerry D. Gibson, "Multimedia Communications: Directions and Innovations", Academic Press, 2000.

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2. www.radio-electronics.com/info/telecommunication_networks/
3. http://www.explainthatstuff.com/how-iptv-works.html
4. http://www.computerweekly.com/feature/Converged-networks-The-VoIP-revolution

ECENG 633

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
ECENG 634	CARBON NANOTUBE DEVICES AND APPLICATIONS	2	1	0	3	45

Prerequisite : Knowledge in high speed semiconductor devices and their characteristics

Objective : To gain knowledge on the use of carbon nanotubes in organic electronic devices

Outcome : Students will be able to understand the carbon nano-tube device modeling and simulation and also the incorporation of functionalized carbon nano-tubes in Field Effect Transistor.

Unit I:Basics of Carbon Nanotubes **9 Hours**

Carbon materials: Allotropes of carbon - structure and band diagram of carbon nanotubes - types of CNTs - electronic properties of CNTs; Band structure of Graphene: Band structure of SWNT from graphene - electron transport properties of SWNTs - scattering in SWNTs - carrier mobility in SWNTs.

Unit II: Synthesis and Integration of SWNT Devices **9 Hours**

CVD synthesis : Method - direct incorporation with device fabrication process - SWNT synthesis on metal electrodes - lowering the synthesis temperature - controlling the SWNT growth - location - orientation - chirality - narrowing diameter distributions - chirality distribution analysis for different CVD processes - selective removal of the metallic nanotubes in FET devices - Integration.

Unit III: Carbon Nanotube Field-Effect Transistors **9 Hours**

Schottky barrier heights of metal S/D contacts - high k-gate dielectric integration - quantum capacitance - chemical doping - hysteresis and device passivation - near ideal; Metal-contacted MOSFETs - SWNT MOSFETs - SWNT band-to-band tunneling FETs.

Unit IV: Carbon Nanotube Device modeling **9 Hours**

SWNT–FET modelling : Compact model for circuit simulation - model of the intrinsic SWNT channel region - full SWNT–FET model - applications of the SWNT–FET compact model - performance modelling for carbon nanotube interconnects - circuit models for SWNTs - circuit models for SWNT bundles - circuit models for MWNTs - carbon nanotube interconnects - applications.

Unit V:Instructional Activities **9 Hours**

Device simulation of SWNT FETs: Assessing the AC response of top gated SWNT FETs; Power measurement using a spectrum analyzer - homodyne detection using SWNT FETs.

References Books:

1. Ali J, Jing K, “Carbon Nanotube Electronics”, Springer Science media, 2010.
2. Michael J, Connell O, “Carbon nanotubes: Properties and Applications and Commercialization” CRC/Taylor & Francis, Second Edition, 2011.
3. Francois L, “The Physics of Carbon Nanotube Devices”, William Andrew Inc., 2009.
4. Saito R, Drbselmus M S, “Physical properties of Carbon Nanotubes”, Imperial College Press, 1998.

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ECENG 634

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
ECENG 635	EMBEDDED REAL TIME SYSTEM	2	1	0	3	45

Prerequisite : Fundamentals in advanced microcontrollers and embedded systems

Objective : To study various SOC, RTOS concept, programming of various communication interfaces for automatic systems

Outcome : Students will be able to understand the SOC concepts and the programming for automatic systems.

Unit I:Introduction to Embedded Automatic Systems **9 Hours**

Embedded Automatic Systems (EAC): Overview - architecture; Components of the system: Processors-memories and interconnects - processor architectures - memory and addressing: SOC memory examples - addressing.

Unit II: SOC **9 Hours**

Introduction to Arduino :Types of Arduino devices - common Arduino shields - Beagle Bone ; Introduction to Raspberry Pi

Unit III: Communication Interfaces and Python Basics **9 Hours**

Communication interfaces: I2C- SPI Bus- UART- RS-232- RS-485- USB- IEEE 139.4 (Firewire) - Infrared (IRDA) - Bluetooth - Wi-Fi - ZigBee – GPRS; Python basics: Introduction - variables - displaying output - reading user input - arithmetic - operations on strings - running commands conditionally - comparing values - logical operators- loops.

Unit IV: RTOS Programming **9 Hours**

Tasks and Task states - semaphores - shared data - message queues - mail boxes and pipes - memory management - interrupt routines - encapsulating semaphore and queues - task management - inter task communication - process input/ output.

Unit V: Instructional Activities **9 Hours**

RFID based attendance management system - embedded video processing - home automation systems using Raspberry Pi/ Arduino /any other SOC.

Reference books:

1. Michael J F and Wayne L. “Computer System Design: System-on-Chip”, John Wiley and Sons, 2011.
2. Hughes M J, “Arduino: A Technical Reference”, 1st Edition, O’REILY, 2016.
3. David E S, “An Embedded software premier”, Pearson Education, 1999.
4. Shibu, “Introduction to Embedded Systems”, 1st Edition, Tata McGraw Hill, 2009.
5. Simon M, “Raspberry Pi Cookbook”, 2nd Edition, O’REILY, 2014.
6. Richardson M and Shawn W, “Make: Getting Started with Raspberry Pi”, 3rd Edition, O’REILY, 2016.
7. Prasad K V K K, “Embedded/ Real-Time Systems”, Dream Tech Press, 2003.
8. Hermann K, “Real–Time systems – Design Principles for Distributed Embedded Applications”, 2nd Edition, Springer, 2011.
9. Derek M, “Top of Form Exploring Beagle Bone: Tools and Techniques for Building with Embedded Linux”, Wiley, 2015.

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2. https://www.arduino.cc/en/Main/Boards

ECENG 635

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
ECENG 636	FREE SPACE OPTICAL NETWORKS	2	1	0	3	45

Prerequisite : Fundamentals of optical communication and networks

Objective : To introduce the concepts of Terabit technology by means of optical wireless communications.

Outcome : Students will be able to design free space optical networks.

Unit I: Introduction **9 Hours**

Propagation of light in unguided media - laser beam characteristics - atmospheric effects on optical signals - coding for atmospheric optical propagation - factors affecting FSO - LOS - LIDAR; Overview of FSO optical transmitters - receivers - subsystems.

Unit II: FSO Transceiver Design and Security **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; FSO inherent security levels and layers.

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

Simple PP 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:Instructional Activities **9 Hours**

Simulation of PP FSO system using ring topology / WDM Mesh FSO network with service protection enabled scenario - performance comparison of FSO networks in ring and mesh topology using related tools.

References Books:

1. Stamatios V. Kartalopoulos, “Free Space Optical Net works 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.
5. In Keun Son, “Design and Optimization of Free Space Optical Networks”, Auburn University, Dissertations, Electrical Engineering and Computer Engineering, 2010.
6. Fang Liu, “Bootstrapping Free-space Optical Networks”, University of Maryland, 2004.
7. HemaniKaushal, Jain V K, SubratKar, “Free Space Optical Communication”, Optical Networks, Springer, 2017

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2. http://ee.stanford.edu/~jmk/research/fsocom.html
3. http://www.rp-photonics.com/free_space_optical_communications.html

ECENG 636

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
ECENG 637	GREEN RADIO COMMUNICATION TECHNIQUES	2	1	0	3	45

Prerequisite : Fundamentals of computer communication and wireless networks.

Objective : To impart the importance of energy conservation, CO_2 emission and inculcate green conceptsfor designing energy efficient next generation wireless networks.

Outcome : Students will be able to design green radio communication networks with energy efficient techniques

Unit I: Introduction **9 Hours**

Fundamental tradeoffs on the design of green radio networks: Insight from Shannon's capacity formula - impact of practical constraints - algorithms for energy harvesting wireless networks: Energy harvesting technologies - PHY and MAC layer optimization for energy harvesting wireless networks – vertical handoff and its types.

Unit II: Green Modulation and Co-operative Techniques **9 Hours**

Modulation and coding schemes with energy optimized techniques for wireless networks; 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 III: Base Station Power Management Techniques **9 Hours**

Base station power management techniques: Opportunistic spectrum and load management - energy saving techniques in cellular wireless base stations - power management for base stations in a smart grid environment.

Unit IV: Wireless Access Techniques **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.

Unit V: Instructional Activities **9 Hours**

Survey about minimum of four green communication networks and carry out simulation of those networks.

Reference Books:

1. EkramHossain, Vijay Bhargava K and Gerhard Fettweis P, "Green Radio Communication Networks", Cambridge University Press, New York, 2012.
2. Richard Yu F, Zhang Xi and Victor Leung C M, "Green Communications and Networking", 1st Edition, CRC press, 2012.
3. Mazin Al Noor, "Green Radio Communication Networks Applying Radio-Over-Fibre Technology for Wireless Access", GRINVerlag, 2012.
4. Mohammad Obaidat S, AlaganAnpalagan and Isaac Woungang, "Handbook of Green Information and Communication Systems", 1st Edition, Academic Press, 2012.
5. Jinsong Wu, SundeepRangan and Honggang Zhang, "Green Communications: Theoretical Fundamentals, Algorithms and Applications", CRC Press, 2016.
6. Ramjee Prasad, Shingo Ohmori and Dina Simunic, "Towards Green ICT", River Publishers, 2010.

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2. http://home.ku.edu.tr/~nwcl/green.html
3. http://mypage.zju.edu.cn/en/honggangzhang/607861.html

ECENG 637

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
ECENG 638	INTERNET OF EVERY THINGS (IoE)	2	1	0	3	45

Prerequisite : Basics of computer communication networks and wireless sensor networks

Objective : To study the architecture and security principles of Internet of Everthings (IoE).

Outcome : Students will be able to design efficient IoE based projects.

Unit I: Introduction **9 Hours**

IoT: Architectural overview - main design principles - standards considerations; M2M and IoT technology fundamentals: devices and gateways - data management - business processes in IoT - everything as a service - M2M and IoT analytics - knowledge management.

Unit II: IoE Sensors **9 Hours**

Sensors for IoE: Wireless sensor structure - energy storage module - power management module - RF Module - sensing module.

Unit III: IoE Security **9 Hours**

Security requirements in IoE architecture - security in enabling technologies - security concerns in IoE applications: Architecture - insufficient authentication/authorization - insecure access control - threats to access control, privacy, and availability - attacks specific to IoE.

Unit IV: IoE Testbed **9 Hours**

ACOEM Eagle - EnOcean Push Button - NEST sensor - Ninja blocks focus on wearable electronics.

Unit V: Instructional Activities **9 Hours**

Simulation of (minimum of any five) IoE applications - home and office infrastructures - security - home appliances and other IoE electronic equipment- interfacing of sensor with sensor node using any embedded target boards (Raspberry Pi / Intel Galileo/ARM Cortex/ Arduino).

Reference Books:

1. Asoke K Talukder and Roopa R Yavagal, "Mobile Computing: Technology, Application and Service Creation", Tata McGraw Hill, 2010.
2. William Stallings, "Data and Computer Communications", 8th Edition, Pearson Education Pte. Ltd., 2009.
3. Adelstein F and Gupta S.K.S, "Fundamentals of Mobile and Pervasive Computing", McGraw Hill, 2009.
4. Barrie Sosinsky, "Cloud Computing Bible", Wiley-India, 2010.
5. Arshdeep Bahga, Vijay Madisetti, "Internet of Things – A hands-on approach", Universities Press, 2015.
6. Manoel Carlos Ramon, "Intel® Galileo and Intel® Galileo Gen 2: API Features and Arduino Projects for Linux Programmers", Apress, 2014.
7. Marco Schwartz, "Internet of Things with the Arduino Yun", Packt Publishing, 2014.

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2. https://www.codeproject.com/Learn/IoT/
3. https://www.edureka.co/blog/iot-tutorial/
4. https://www.bbvaopenmind.com/en/the-internet-of-everything-ioe/

ECENG 638

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
ECENG 639	MULTICARRIER WIRELESS COMMUNICATION	2	1	0	3	45

Prerequisite : Fundamentals of communication systems.

Objective : To impart OFDM transmitter and receiver system.

Outcome : Students will be able to understand the importance of OFDM techniques for wireless systems.

Unit I: OFDM Principles **9 Hours**

System Model: Block diagram of OFDM system - generation of sub carrier using IFFT - guard time - cyclic extensions - windowing - choice of OFDM parameters - signal processing - bandwidth efficiency - peak to average power ratio - peak power problem - PAPR properties of OFDM signals; PAPR reduction techniques: Signal distortion techniques - multiple signaling and probabilistic techniques - coding techniques.

Unit II: 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 III: 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 - Multiuser systems - Maximum likelihood enhanced sphere decoding of MIMO OFDM.

Unit IV: Channel Estimation in OFDM systems **9 Hours**

Pilot Based OFDM channel estimation-example; Comb Type Pilot (CTP) Transmission - example; Channel estimation in time/ frequency domain; Frequency Domain Equalization (FDE).

Unit V: Instructional Activities **9 Hours**

BER Vs E_b/N_0 for OFDM in AWGN channel- OFDM channel estimation using LS, LMMSE, and lower complexity LMMSE methods.

Reference Books:

1. Ramjee P, “OFDM for Wireless Communication Systems”, Artech House, 2004.
2. Hanzo L and Keller T, “OFDM and MC-CDMA: A Primer”, John Wiley & Sons, 2006.
3. Henrik S and Christian L, “Theory and Applications of OFDM and CDMA: Wideband Wireless Communications”, John Wiley & Sons, 2005.
4. Bahai Ahmad R S, Burton R S and Mustafa E, “Multi-Carrier Digital Communications: Theory and Applications of OFDM”, 2nd Edition, Springer, 2004.
5. Rahmatallah Y and Mohan S, “Peak-to-Average Power Ratio Reduction in OFDM System: A Survey and Taxonomy”, IEEE Communication Surveys and Tutorials, vol. 15, no. 5, pp. 1567-1592, 2013.
6. Steven M K, "Fundamentals of Statistical Signal Processing: Estimation Theory ", Volume I, Prentice Hall, 1993.

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ECENG 639

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
ECENG 640	NANO PHOTONICS	2	1	0	3	45

Prerequisite : Solid state physics and Quantum Physics.

Objective : To gain knowledge in photonic crystal and nano photonics.

Outcome : Students will be able to familiarize nano photonic systems with photonic crystal.

Unit I: Basics of Nano photonics **9 Hours**

Photons and electrons - similarities and differences - free space propagation ; Confinement of photons and electrons - propagation through a classically forbidden zone - tunneling - localization under a periodic potential - band gap ; Cooperative effects - nano scale optical interactions - axial and lateral nanoscopic localization ; Nano scale confinement of electronic interactions: Quantum confinement effects - nano scale interaction dynamics - nano scale electronic energy transfer ; Cooperative emissions.

Unit II: Quantum Confined Materials **9 Hours**

Inorganic semiconductors - quantum wells - quantum wires - quantum dots - quantum rings; Manifestation of quantum confinement: Optical properties - nonlinear optical properties - quantum confined stark effect - dielectric confinement effect - super lattices; Core-shell quantum dots and quantum wells - quantum confined structures as lasing media; Organic quantum - confined structures; Plasmonics.

Unit III: Physics of Photonic Crystal **9 Hours**

Basic concepts: TE/TM modes - dispersion relation - theoretical modeling of photonic crystals - features of photonic crystals - methods of fabrication - photonic crystal circuitry - non-linear photonic crystals; 1-D, 2-D and 3-D photonic crystals - multilayer film - physical origin of photonic band gaps - evanescent modes in photonic band gaps - propagation - 2-D Bloch states - localization of light by linear defects - planar localization - surface states; Linear defect and surface defects.

Unit IV: Applications **9 Hours**

1-D, 2-D, 3-D PBGC structure based devices: Delay lines - filters - switching devices - Kerr effect devices - WDM and WDDe-M - supper lenses - prisms - collimators; Meta-materials : Characteristics and structures.

Unit V: Instructional Activities **9 Hours**

Simulation of band gap analysis of photonic crystal - waveguide bends - ring resonator using related tools.

References Books:

1. Bahaa E. A. Saleh and Malvin CarlTeich, “Fundamentals of Photonics”, John Wiley and Sons, NewYork, 1993.
2. Prasad P N, “Nanophotonics”, Wiley Inderscience, 2003.
3. Ohtsu M, Kobayashi K, Kawazoe T and Yatsui T,“Principles of Nanophotonics (Optics and Optoelectronics)”, University of Tokyo, Japan, 2003.
4. Hiroshi Masuhara, Satoshi Kawata, Fumio Tokunaga, “Nano Biophotonics: Science and Technology”, Nanophotonics, Vol.3, Elsevier, 2007
5. Bahaa E. A. Saleh, Malvin Carl Teich, “Fundamentals of Photonics”, 2nd Edition, Wiley, 2007.

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1. https://www.nature.com/articles/nphys3668
2. http://news.mit.edu/2015/quantum-materials-new-paradigm-computing-1106
3. https://www.intechopen.com/books/photonic-crystals-introduction-applications-and-theory
4. http://www.iop.org/resources/topic/archive/photonic/page_65877.html

ECENG 640

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
ECENG 641	PRINCIPLES OF ASIC DESIGN	3	0	0	3	45

Prerequisite : Digital VLSI Design

Objective : To make the students understand the architectural details of programmable ASICs including logic synthesis, floor-planning, placement and routing.

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

Unit I: Introduction to Programmable Devices **9 Hours**

Programmable logic devices: ROM - PLA - PAL - PLD - FPGA - features, programming and applications using complex programmable logic devices; Speed performance and system programmability.

Unit II: Introduction to ASIC **9 Hours**

Design flow - types of ASICs - full custom with ASIC - semi custom ASICs - standard cell based ASIC - gate array based ASIC - channeled – channel less - structured - data path elements - adders - multiplier - cell compilers ; Logical effort : Area and efficiency - paths - multi stage cells - optimum delay.

Unit III: Low Level Design Language **9 Hours**

EDIF: PLA tools - introduction to CFI designs representation; Half gate ASIC: Introduction to synthesis and simulation - two level logic synthesis - high level logic synthesis - VHDL and logic synthesis - types of simulation - boundary scan test - fault simulation - automatic test pattern generation.

Unit IV: 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.

Unit V: Instructional Activities **9 Hours**

Spartan 3E and Vertex Board Analysis - inputs and outputs - clock and power inputs - Xilinx I/O blocks - PLAs and PALs design using ASIC board.

Reference Books:

1. Smith M J S, “Application Specific Integrated Circuits”, Pearson Education, 2009.
2. Farzad N, Faranak N, “From ASICs to SOCs: A practical Approach”, Prentice Hall, 2003.
3. Rajsuman R, “System-on–a–Chip: Design and Test”, Artech House, 2000.
4. Farzad N, “Timing Verification of Application Specific Integrated Circuits”, 1st Edition, Prentice Hall, 1999.

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2. www.utdallas.edu/~zhoud/DesignEntry
3. en.wikipedia.org/wiki/High-level_synthesis

ECENG 641

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
ECENG 642	SOFT COMPUTING	2	1	0	3	45

Prerequisite : Basics of set theory.

Objective : To familiarize the salient approaches in soft computing based on artificial neural networks, fuzzy logic, and genetic algorithms.

Outcome : Students will be able to apply concepts of artificial neural networks, fuzzy logic, and genetic algorithm for real time applications.

Unit I : Neural Network **9 Hours**

Basic concept - mathematical model - properties of neural networks - architectures - different learning methods - common activation functions - application of neural networks; Neuron architecture: Algorithms - McCullo h-Pitts - Back propagation - ADALINE - MADALINE - Discrete Hopfield net - BAM - Maxnet.

Unit II: Fuzzy Sets & Logic **9 Hours**

Fuzzy versus Crisp - fuzzy sets - fuzzy relations - laws of propositional logic - inference - Predicate logic fuzzy logic - quantifiers - inference - defuzzification methods.

Unit III: Genetic Algorithm **9 Hours**

Role of GA - fitness function - selection of initial population - cross over (different types) - mutation - inversion - deletion - constraints handling and applications of travelling salesman and graph coloring.

Unit IV: Hybrid Systems **9 Hours**

Hybrid Systems: GA based BPNN (Weight determination) - Neuro fuzzy systems - Fuzzy BPNN - fuzzy neuron - architecture - learning - Fuzzy logic controlled genetic algorithm.

Unit V:Instructional Activities **9 Hours**

Simulation of PSD - HSA and ACO related to either wireless networking or antenna or image processing using related tools.

Reference Books:

1. S.N. Sivanandam, S.N. Deepa, — "Principles of Soft Computing", 2nd Edition, John Wiley India, 2012.
2. S. Haykin, — "Neural Networks - A Comprehensive Foundation", 2nd Edition, Pearson Education, 2005.
3. T.S. Rajasekaran, G.A. VijaylakshmiPai, — "Neural Networks, Fuzzy Logic & Genetic Algorithms – Synthesis and Applications", Prentice-Hall India, 2003.
4. Sanchez, Takanori, Zadeh, — "Genetic Algorithm and Fuzzy Logic System", World Scientific, 1997.
5. Goldberg David, — "Genetic Algorithms", Pearson Education, 2006.
6. Zimmermann H. J, — "Fuzzy Set Theory & Its Applications", Allied Publishers Ltd, 1991.
7. Stamatios V. Kartolopoulos, - "Understanding neural networks and fuzzy logic: Basic concepts and Applications" Wiley – IEEE press, 1995.

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1. https://www.tutorialspoint.com/biometrics/pattern_recognition_and_biometrics.htm
2. http://www.cedar.buffalo.edu/~srihari/CSE555/
3. https://www.ibm.com/developerworks/library/cc-beginner-guide-machine-learning-ai-cognitive/index.html

ECENG 642

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
ECENG 643	ULTRA WIDEBAND COMMUNICATION SYSTEMS	2	1	0	3	45

Prerequisite : Communication theory and wireless communication.

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

Outcome : Students will be able to design sub-modules of UWB system.

Unit I: UWB Signals and Systems **9 Hours**

Introduction: Comparison of UWB with other wideband communication system - power spectral density - pulse shape - pulse trains - UWB spectrum and spectral masks - multipath and penetration characteristics - spatial and spectral capacities - speed of data transmission - Gaussian waveforms - designing waveforms for specific spectral masks - practical constraints and effects of imperfections - applications of UWB systems.

Unit II: UWB Pulse Generation and Processing **9 Hours**

UWB signal generation: UWB modulation schemes - transmitter and receiver - multiple access techniques - capacity - interference and coexistence of UWB with other systems - Hermite pulses - Orthogonal prolate spheroidal wave functions - wavelet packets in UWB PSM - signal processing: effects of a lossy medium on a UWB transmitted signal - time domain analysis - frequency domain techniques.

Unit III: UWB Channel Modeling **9 Hours**

IEEE proposals for UWB channel models - simplified UWB multipath channel model - path loss model - two-ray UWB propagation model - frequency domain autoregressive model - MIMO for UWB systems - self interference in high data-rate UWB communications - coexistence of UWB with WIMAX and other short range wireless radios.

Unit IV: UWB Antennas and Filters **9 Hours**

Antenna fundamentals - antenna radiation for UWB signals - conventional antennas and impulse antennas for UWB systems - beam forming for UWB signals - UWB filters - prototype - characteristics - filtering techniques - wireless positioning and location - GPS techniques - positioning techniques - time resolution issues - UWB positioning and communications.

Unit V: Instructional Activities **9 Hours**

Simulation of UWB: Pulse generation and processing - channel modeling - antennas using EM - MIMO for UWB systems using related tools.

Reference Books:

1. Ghavami M, Michael L B and Kohno R, "Ultra Wideband Signals and Systems in Communication Engineering", 2nd Edition, John Wiley and Sons, NY, USA, 2007.
2. Reed J H, "An Introduction to Ultra Wideband Communication Systems", Prentice Hall PTR, 2005.
3. Faranak N, "Ultra-Wideband Communications: Fundamentals and Applications", Prentice Hall PTR, 2011.
4. Ranjit G and Peter K, "Ultra Wide Band: Circuits, Transceivers and Systems", Springer, NY, USA, 2008.

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1. https://en.wikipedia.org/wiki/Ultra-wideband
2. https://en.wikipedia.org/wiki/List_of_UWB_channels

ECENG 643

Course Code	Name of the Course	Periods			Credits	Total Hours
		L	T	P		
ECENG 644	VEHICULAR AD-HOC NETWORKS (VANET)	2	1	0	3	45

Prerequisite : Wireless communication and network, and mobile ad-hoc networks

Objective : To introduce the students with the emerging technologies and their standards with applications for vehicular communication systems.

Outcome : Students will able to understand the basic principles, standards, and system architecture of Vehicular Ad-hoc Networks.

Unit I: Introduction **9 Hours**

Basic principles and challenges - past and ongoing VANET activities; Cooperative vehicular safety applications: Introduction - enabling technologies - cooperative system architecture.

Unit II: Vehicular Mobility Models **9 Hours**

Introduction - notation description - random models - flow models - traffic models - behavioral models - trace or survey based models - integration with network simulators - design framework for realistic vehicular mobility models.

Unit III: Routing Protocols **9 Hours**

Routing protocols: Opportunistic packet forwarding - topology based routing - geographic routing; Standards: Protocol stack - DSRC regulations and standard.

Unit IV: Security **9 Hours**

Requirement - challenges - adversaries - VANET supporting properties - message authentication and integrity using Digital Signatures - detection of malicious data and secure position verification.

Unit V: Instructional Activities **9 Hours**

Simulation of vehicle to vehicle communication - vehicle to infrastructure and infrastructure to vehicle communication using related tools

Reference Books:

1. Sommer C, Dressler F, "Vehicular Networking", Cambridge University Press, 2015.
2. Emmelmann M, Bochow B and Kellum C. C, "Vehicular Networking: Automotive Applications and Beyond", Wiley, 2010.
3. Watfa M, "Advances in Vehicular Ad-Hoc Networks: Development and Challenges", Information Science Reference, 2010.
4. Moustafa H, Zhang Y, "Vehicular Networks: Techniques, Standards, and Applications", CRC Press, 2009.
5. Hartenstein H and Laberteaux K. P, "VANET: Vehicular Applications and Inter Networking Technologies", Wiley, 2010.

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1. http://www.irma-international.org/viewtitle/43163/
2. https://en.wikipedia.org/wiki/Vehicular_ad_hoc_network
3. http://comp.ist.utl.pt/~rmr/WSN/CaseStudies2007-no/WSN_Transportation/

ECENG 644

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