CURRICULUM

M. TECH. in VLSI DESIGN

(July 2019 admission onwards)

APPROVED BY

BOARD OF STUDIES (BOS)

8th MEETING, February 20, 2019

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

Dr B R AMBEDKAR NATIONAL INSTITUTE OF TECHNOLOGY,

Jalandhar

VISION

To become a globally recognized department of higher learning that will provide inter-disciplinary knowledge, human values and professional ethics among the youth, so as to serve as a valuable resource for industry and society.

MISSION

"Educate to Excel in Social Transformation"

To serve the nation and the world by graduating proficient, knowledgeable engineers in the field of Electronics, Communication and related areas through constant interaction with research organizations and Industries.

Program Educational Objectives

PEO 1. Postgraduates shall be able to integrate foundation in engineering and in-depth knowledge so as to use it for contemporary problem solving in various aspects of VLSI Design

PEO 2. Postgraduates would be competent, creative, and highly valued professionals in industry, academia, or government

PEO 3. Postgraduates would be flexible and adaptable in the workplace, possess the capacity to embrace new opportunities of emerging technologies, and embrace leadership and teamwork opportunities

PEO 4. Postgraduates would act with global, ethical, societal, ecological, and commercial awareness expected of practicing engineering professionals

Program Outcomes

1. An ability to independently carry out research /investigation and development work to solve practical problems.
2. An ability to write and present a substantial technical report/document.
3. Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.
4. Post Graduates will show the understanding of technical communication and the impact of engineering solutions on the society and also will be aware of contemporary issues.

M. Tech. (VLSI Design)
(Applicable from 2019 batch)

First Semester

Sr. No.	Course Code	Course Title	L	T	P	Credits	Contact Hours
1.	EC-505	Solid State Devices	3	0	0	3	3
2.	EC-507	Digital Logic Design	3	0	0	3	3
3.	EC-509	Analog VLSI Circuits	3	0	0	3	3
4.	EC-519	Advanced Signal and Image Processing	3	0	0	3	3
5.	EC-5XX	Elective-I	3	0	0	3	3
6.	EC-551	VLSI CAD Lab-I	0	0	3	2	3
7.	EC-559	Advanced Signal and Image Processing Lab	0	0	3	2	3
		Total	**15**	**0**	**6**	**19**	**21**

Second Semester

Sr. No.	Course Code	Course Title	L	T	P	Credits	Contact Hours
1.	EC-502	Embedded Systems Design	3	0	0	3	3
2.	EC-508	Digital Integrated Circuits	3	0	0	3	3
3.	EC-510	Integrated Circuit Fabrication	3	0	0	3	3
4.	EC-5XX	Elective-II	3	0	0	3	3
5.	EC-5XX	Elective-III	3	0	0	3	3
6.	EC-552 b	Embedded Systems Design Lab	0	0	3	2	3
7.	EC-554	VLSI CAD Lab-II	0	0	3	2	3
		Total	**15**	**0**	**6**	**19**	**21**

Third Semester

Sr. No.	Course Code	Course Title	L	T	P	Credits	Contact Hours
1.	EC-511	RF Circuit Design	3	0	0	3	3
2.	EC-5XX	Elective-IV	3	0	0	3	3
3.	EC-515	Seminar/ Independent Study	1	0	0	3	1
4.	EC-600	Project Phase-I	0	0	12	6	12
		Total	**7**	**0**	**12**	**15**	**19**

Fourth Semester

Sr. No.	Course Code	Course Title	L	T	P	Credits	Contact Hours
1.	EC-600	Project Phase-II	0	0	24	12	24
		Total	**0**	**0**	**24**	**12**	**24**

Grand Total of Credits= 65

List of Electives

Sr. No.	Course Code	Course Title	L	T	P
1.	EC-521	Biomedical Electronics	3	0	0
2.	EC-522	Sensors and Transducers	3	0	0
3.	EC-523	Wavelet Transforms for Signal and Image Processing	3	0	0
4.	EC-524	Machine Learning	3	0	0
5.	EC-525	Advanced Optical Communication Systems	3	0	0
6.	EC-526	OFDM for Wireless Communications	3	0	0
7.	EC-527	Photonics Networks and Switching	3	0	0
8.	EC-528	Probability and Stochastic Processes	3	0	0
9.	EC-529	Signal Detection and Estimation Theory	3	0	0
10.	EC-530	Cardiovascular variability and its Interpretation	3	0	0
11.	EC-531	Medical Image Processing	3	0	0
12.	EC-532	Satellite Communication	3	0	0
13.	EC-533	Wireless Sensor Networks	3	0	0
14.	EC-534	Cognitive Radios	3	0	0
15.	EC-535	Wireless Networking Planning and Optimization	3	0	0
16.	EC-536	Computer Vision	3	0	0
17.	EC-537	Nature Inspired Computing	3	0	0
18.	EC-538	Cloud Computing	3	0	0
19.	EC-539	Adaptive Signal Processing	3	0	0
20.	EC-540	Advanced Embedded Processors	3	0	0
21.	EC-561	Game Theory	3	0	0
22.	EC-562	Image Processing	3	0	0
23.	EC-563	VLSI Technology and Process Modeling	3	0	0
24.	EC-564	Reconfigurable Computing	3	0	0
25.	EC-565	Semiconductor Device Modeling	3	0	0
26.	EC-566	Integrated Circuit Technology	3	0	0
27.	EC-567	Neural Networks and Fuzzy Systems	3	0	0
28.	EC-568	Digital Signal Processors	3	0	0

29.	EC-569	Sensor Technologies and MEMS.	3	0	0
30.	EC-570	Cluster and Grid Computing	3	0	0
31.	EC-571	GPU Computing	3	0	0
32.	EC-572	Advanced Computer Networks	3	0	0
33.	EC-573	Evolutionary Algorithms for Engineering Design	3	0	0
34.	EC-574	Advanced Computer Architecture	3	0	0
35.	EC-575	Solid State Circuits	3	0	0
36.	EC-576	Digital Voice and Picture Communication	3	0	0
37.	EC-577	Fluctuation Phenomena in Microelectronics	3	0	0
38.	EC-578	Quantum Computing	3	0	0
39.	EC-579	Testing and Fault Tolerance	3	0	0
40.	EC-580	Process Characterization and Device Modeling	3	0	0
41.	EC-581	Memory Design and Testing	3	0	0
42.	EC-582	Hardware Description Languages	3	0	0
43.	EC-583	System on Chip	3	0	0
44.	EC-584	RF Measurements and Design	3	0	0
45.	EC-585	Data structure and Algorithm Analysis	3	0	0
46.	EC-586	Computational Technique	3	0	0
47.	EC-587	Low Power VLSI Design	3	0	0
48.	EC-588	Real Time Systems and Software	3	0	0
49.	EC-589	Algorithm for VLSI Design Automation	3	0	0
50.	EC-590	Process, Devices & Circuit Simulation	3	0	0
51.	EC-591	Nano Technology	3	0	0
52.	EC-592	Hardware-Software Co-design	3	0	0
53.	EC-593	Cryptology and Crypto chip Design	3	0	0
54.	EC-594	Advanced Computational Methods	3	0	0
55.	EC-595	High Speed Digital System Design	3	0	0
56.	EC-597	ASIC Design and FPGA	3	0	0
57.	EC/ME-635	Thermal Management of Electronics System	3	0	0
58.	EC-637	Autism and Assisted Technologies	3	0	0
59.	EC-639	Nanoelectronics	3	0	0

Detailed course contents of 1st semester

EC-505	Solid State Devices	[3 0 0 3]

Course Objectives

The purpose of this course is to explain the semiconductor device physics, provide detailed analysis of PN junctions, BJT, MOSFET (various versions). This helps in custom design approach for VLSI. It introduces materials (e.g. GaAs) in contrast to Silicon and their significance in the dynamics of semiconductor physics; and special MOS devices including imagers and memories and their applications.

Course Contents

Basic semiconductor physics: Carrier concentrations, Thermal Equilibrium and wave particle duality, Intrinsic semiconductors, Extrinsic semiconductor, Carrier transport, Random motion, Drift and diffusion, Excess carriers, Injection level, Lifetime, Direct and indirect semiconductors. **(10)**

PN junction: Device structure, Equilibrium representation, DC forward and reverse characteristics, Small-signal equivalent circuit, Switching characteristics, Metal-semiconductor junction. Non-ideal effects. **(10)**

Junction Transistors: BJT, Device structures, Transistor action and amplification, Common emitter DC characteristics, Small-signal Equivalent circuit, Ebers-Moll model, Gummel-Poon model, Switching, Other important effects, HBT. **(6)**

Field Effect Transistors: JFET, MESFET, MOSFET, HEMT: MOS, C-V characteristics, threshold voltage, body effect, Device structures and fabrication, Common source DC characteristics Small-signal equivalent circuit, Scaling and important effects. **(10)**

Special purpose MOS devices including memories and imagers, Other semiconductor devices. **(4)**

Course Outcomes

CO1: Explain the semiconductor device physics, detailed analysis of PN junctions, BJT, MOSFET (various versions). This helps in custom design approach for VLSI.

CO2: Understand the concepts of Hetro-junctions are also introduced. Other materials i.e. GaAs and related compounds are discussed for their significance, where Silicon fails.

CO3: Devices' application part is also conveyed in imagers and memories.

Recommended Books

1. R.S. Muller and T.I. Kamins, "Device Electronics for Integrated Circuits" Wiley, 2002.
2. BG Streetman and SK Banerjee, "Solid State Electronic Devices" PHI, 6th edition 2006.
3. R. F. Pierret, "Semiconductor Device Fundamentals" Addison Wesley, 1996.
4. S M Sze, "Physics of Semiconductor Devices" Wiley, 2nd edition, 1981.
5. S S Islam, "Semiconductor Physics & Devices, Oxford University Press, 2006.

EC-507	Digital Logic Design	[3 0 0 3]

Course Objectives

The objective of this course is to explain the system level digital design concepts, MSI, LSI logic and memory devices. It enables students to analyze synchronous and asynchronous Finite State Machines; understand and deal with complex design issues viz. clock distribution, hazards, Metastability etc. The students will learn how to design complex digital systems.

Course Contents

Synchronous FSM Design: Review of digital concepts**,** MSI and LSI circuits and their applications, Synchronous state machine design and analysis-models, latches and flip-flops, setup and hold times, tristate logic and buses, Mealy and Moore FSM design, design of iterative circuits, timing analysis of FSMs, FSM optimization, pipelining. **(12)**

Dealing with asynchronous inputs: Synchronizers and metastability, Asynchronous machines analysis and design- models for asynchronous FSMs, detection and elimination of timing defects in asynchronous FSMs- cycles, races and hazards. **(10)**

Clock Distribution: Clock skew, low-skew clock buffers, clock jitter, PLL, Delay-Locked Loops, Clock distribution networks-Timing Analysis of synchronous and source synchronous bus interfaces. **(9)**

Memory Devices: ROM, Programmable Logic Devices (PLDs) and Programmable Gate Arrays architecture, designing with PLDs, Designing with FPGAs and CPLDs. **(9)**

Course Outcomes

CO1: Explain the system level digital design concepts.

CO2: Understand the fundamental knowledge of state machine design, their timing analysis and issues involved in their efficient design.

CO3: Analyze the problems related to system level signal distribution e.g. clock signal distribution on chip and ways to mitigate their unwanted effects.

CO4: Building on the knowledge gained in logic design, the course introduces Programmable devices architecture and system level design using them.

Recommended Books

1. Richard F Tinder, "Engineering Digital Design" 2nd edition, Academic Press, 2000.
2. John F Wakerly, "Digital Design-principles and practices" 3rd edition, Pearson Education Asia, 1999.
3. David J Comer, "Digital Logic and State Machine Design" 3rd edition, Oxford University Press.
4. William I Fletcher, "An Engineering Approach to Digital Design" PHI,1980.
5. Marcovitz, "Logic Design" 2nd Edition, Tata McGraw Hill.
6. Mark Balch, "Complete Digital Design" Tata McGraw Hill.

EC-509	Analog VLSI Circuits	[3 0 0 3]

Course Objectives

The course aims at developing an understanding of semiconductor physics and operation of MOS devices. It provides the students with the knowledge of basic analog circuits like single ended amplifiers, differential amplifiers, current mirrors, and active loads and their analysis, ability to design analog circuits like filters and A/D converters and also, the in-depth analysis of phase locked loops (PLLs) and issues faced in the design of PLLs.

Course Contents

Introduction: Analog MOS circuits, single stage amplifiers, differential amplifiers, passive and active current mirrors, frequency and transient responses, noise, feedback, operational amplifiers, stability and frequency compensation, analog switches, switched-capacitor circuits, oscillators. **(11)**

Filters & A/D Converters: Sampled Data Analog Filters, Over Sampled A/D Converters and Analog Integrated Sensors: First-order and Second SC Circuits-Bilinear Transformation – Cascade Design-Switched-Capacitor Ladder Filter-Synthesis of Switched-Current Filter – Nyquist rate A/D Converters-Modulators for Over sampled A/D Conversion **(11)**

Operational Amplifier: Differential and Common mode circuits, Op Amp CMRR requirements, Need for single and multistage amplifiers, Effect of loading in differential stage. Performance Analysis: dc gain, frequency response, noise, mismatch, slew rate of cascade and two stage OP Amps, Fully Differential Op Amps-common-mode feedback, loop stability **(10)**

Phase Locked Loops: Problem of lock acquisition, phase Detector. Basic PLL and its dynamics, Charge-pump PLL, Non-ideal effects in PLL: PFD/CL non idealities, Jitter, Delay Locked Loop, Amplifications. **(8)**

Course Outcomes

CO1: Analog VLSI subject deals with analysis and design of analog CMOS Integrated Circuits.

CO2: Demonstration an understanding of MOS basic physics and operation of MOS devices.

CO3: An ability to analyze basic amplifier stages, differential amplifier stage, current mirrors, and active loads. Students should be able to make choices among these building blocks.

CO4: Analyze various single-stage and two-stage opamp circuits to determine gain (differential and common-mode), frequency response, and output resistance, short-circuit transconductance, input common-mode range, and output signal range.

Recommended Books

1. Neil H. E. Weste & Kamran Eshraghian, "Principles of CMOS VLSI Design" 2nd edition, Pearson education Asia, 2000.
2. Wayne Wolf, "Modern VLSI Design" Pearson Education, 4th Indian Reprint 2005. R.S. Muller and T.I. Kamins, "Device Electronics for Integrated Circuits" Wiley, 1986.
3. DA. and Eshrachian K, "Basic VLSI design-systems & circuits", PHI, 1988.
4. B Razavi, "Design of Analog CMOS Integrated Circuits", Mc Graw Hill, 2000.

EC-519	Advanced Signal and Image Processing	[3 0 0 3]

Course Objectives

The objective of this course is to provide in-depth knowledge of the basics of prevailing signal and image processing techniques and their deficiencies. This course focuses on the analysis of various signal models and their processing techniques and enables students to design adaptive digital filters. This course leads to understanding of techniques for image acquisition and processing and classification such as medical image classification etc.

Course Contents

Adaptive Filters: Adaptive signal processing-FIR adaptive filters – steepest descent adaptive filter – LMS algorithm – convergence of LMS algorithms – Application: noise cancellation – channel equalization – adaptive recursive filters – recursive least squares. **(6)**

Multirate Signal Processing: Multirate signal processing- Decimation by a factor D – Interpolation by a factor I – Filter Design and implementation for sampling rate conversion: Direct form FIR filter structures – Polyphase filter structure. **(7)**

Image Processing Fundamentals: Introduction Image Processing-Introduction to Medical imaging, Medical Image Formation, Image Enhancement, Major modalities for medical imaging: ultrasound, X-ray, CT, MRI, PET, and SPECT. **(6)**

Feature Extraction: Feature Extraction and Selection-Introduction to Medical Image Features, Image Representation, Texture and shape features in Biomedical Images, Characterizing the Texture, Texture Segmentation, Feature Selection, Examples of the Use of Features in Biomedical Applications. **(8)**

Image Segmentation: Image segmentation- Introduction to image segmentation, need of image segmentation, Various methods of image segmentation, Parametric and Non-Parametric Clustering, Region-Based Segmentation, Deformable models**.** **(7)**

Image Classification: Image classification-Introduction to image classification, Methods of image classification like SVM, neural and fuzzy network, Genetic algorithms (GA). Need and designing of Computer aided diagnosis system, Content-Based Medical Image Retrieval, Examples for Medical CBIR Systems. **(6)**

Course Outcome

CO1: The outcome of this course is to provide in-depth treatment on methods and techniques in discrete-time signal transforms, digital filter design, optimal filtering, power spectrum estimation, multi-rate digital signal processing and models of speech signal.

CO2: The various coding techniques to provide a complete model, Wavelet transform and its applications in image processing.

CO3: Understand the various DSP architectures, which are very important in the areas of signal processing, control and communications.

Recommended Books

1. John G.Proakis, Dimitris G.Manobakis, "Digital Signal Processing, Principles, Algorithms and Applications" 3rd edition, PHI, 2000.
2. Monson H.Hayes, "Statistical Digital Signal Processing and Modelling" Wiley, 2002.
3. Emmanuel C. Ifeachor and Barrie W. Jervis, "Digital Signal Processing: A Practical Approach" Pearson Education, 2008.
4. Robert J. Schilling and Sandra L. Harris, "Fundamentals of Digital Signal Processing" Cengage Learning, 2005.

EC-551	VLSI CAD Lab-I	[0 0 3 2]

Understanding the features, capabilities and usage of following **VLSI CAD Tools**
Xilinx Ise-suite ,PlanAhead Tool, Chipscope Pro Analyser
Mentor Graphics -Modelsim, and HDL Designer,calibre
Cadence-RC compiler, SoC Encounter.
Synopsys-Design Compiler, Prime TIme
FPGA Kit- Spartan -3e and Virtex II Pro.

With an objective to

Write our idea in HDL language (verilog/VHDL) and verifying using Simulator tool mentioned above.
Change RTL code to gate level netlist using rc compiler or design compiler
Placement of standard cell to silicon area to form layout using SoC Encounter .
Finally change the layout in GDS-II format
This GDS-II information is send to Fabrication vendor for the manufacturing of Silicon Chip.

Experiments

Two bit counter design using FSM, Parallel to Serial Converter, VHDL Calculator using FSM to perform simple calculations like addition, multiplication and subtraction, A simplified HDL UART, VHDL implementation of I2C Bus, Design of hardware multiplier using sequential circuit components, ALU Design which should be able to add, subtract, NOR and NAND the numbers.

In addition to the lab experimentation, the students will have to carry out additional project work (independently or in group) related to the laboratory contents.

Course Outcomes:

CO1: Understanding of the features, capabilities and usage of VLSI CAD Tools for digital design automation.
CO2: Ability to write, simulate and synthesize HDL codes for various circuits/systems.
CO3: Ability to implement digital design on FPGA kits and verification on hardware

EC-559	**Advanced Signal and Image Processing Lab**	**[0 0 3 2]**

Design of an FIR low-pass filter with specific cut off frequency, Design of an FIR band-pass filter with specific cut off band frequencies, Design of an IIR band-pass filter with specific cut off band frequencies, Acquisition of images, image enhancement, image segmentation, image feature extraction. Classification of images.

In addition to the lab experimentation, the students will have to carry out additional project work (independently or in group) related to the laboratory contents.

Course Outcomes:

CO1: Understanding and capability to design system model for data series
CO2: Familiarization with the design of various FIR filters
CO3: Knowledge of design of IIR filters with specific cut-off band frequencies
CO4: Knowledge of various signal processing concepts like speech signal recording and noise reduction, study of wavelets, etc.

Detailed course contents of 2nd semester

EC-502	**Embedded System Design**	**[3 0 0 3]**

Course Objectives

The aim of this course to provide in-depth knowledge of fundamentals of embedded systems - hardware/firmware and strategies to select embedded processors. The students will gain knowledge of architecture and programming of 16- and 64- bit processors and 16-bit microcontroller. This course introduces RISC/ System-on-chip machines and RTOS and provide the students the ability to interface the processor/ microcontroller with peripheral devices.

Course Contents

Introduction: Introduction to Embedded system, Fundamentals of embedded system hardware and firmware design, Processor in the System, Introduction to RISC/CISC, Embedded processor selection, Definition and Classification – Overview of Processors. **(5)**

Embedded Processors: Hardware characteristics & salient features of 16 bit – 64-bit processors, Review of internal architecture & programming model of 16-bit processor; its algorithmic consideration for constructing machine codes, hardware requirements and considerations, device I/O types, Interrupts. **(10)**

Microcontrollers: Overview of 8,16,32 bit microcontrollers, Review of 8-bit microcontroller architecture, I/O Ports, Timers, Interrupts, Programming, Introduction to PIC and ARM Processor families, Thumb set-Exceptions Handing, Interrupts, Operating System, RTOS, Processes and Threads, Scheduling, Memory Management, Introduction to open source and miniature computing system. **(16)**

Communication and Interfacing: Synchronous and asynchronous communications from serial devices - USART, Programmable Peripheral Interfaces, Programmable Interrupt Controller, Programmable Timer, Interfacing, Parallel Port Devices, Microcontroller connections to RS-232, its intra-inter process communication and synchronization of processes using on-chip timers/counters, interrupt sources, serial communication, Interfacing applications, Embedded processor based Real time applications. **(9)**

Course Outcomes

CO1: Understand the basics of an embedded systems and real time systems.
CO2: Explain the characteristics, design and implementation of embedded systems and real time systems.
CO3: Discuss the Hardware characteristics & salient features of 16 bit to 64 bit processors.
CO4: Introduction to microcontroller and its programming.
CO5: To understand applied computing principles in emerging technologies and applications for embedded systems.

Recommended Books

1. Douglas V. Hall, "Microprocessor & Interfacing: Programming & Hardware" Tata McGraw Hill, 1992.
2. Muhammad Ali Mazidi, Janice Gillispie Mazidi and Rolin D. McKinlay, "The 8051 Micro controllers & Embedded Systems Using Assembly and C" 2nd Indian reprint, Pearson education, 2005.
3. Brey, "Intel Microprocessors, The 8056/8055, 80186/80188, 8028, /80386, 80486, Pentium & Pentium Pro, Pentium II, III, IV: Architecture, Programming and Interfacing" 8th edition, PHI, 2008.
4. Han-Way Huang and Leo Chartrand, "PIC Microcontroller: An Introduction to Software &

Hardware Interfacing" Thomson Delmar Learning, 2004.
5. Steve Furber, "ARM System-on-Chip Architecture" 2nd Edition, Pearson Education Limited, 2000.
6. William Hohl, "ARM Assembly Language: Fundamentals and Techniques" CRC Press, 2009.
7. Tammy Noergaard, "Embedded Systems Architecture: A Comprehensive Guide for Engineers and Programmers (Embedded Technology)" Elsevier, Newnes.

EC-508	Digital Integrated Circuits	[3 0 0 3]

Course Objectives

This course focuses on analysis and design of modern digital circuits. It provides the students with the knowledge of issues in Digital IC Design, MOS transistor theory and manufacturing of MOS devices; and enables them to analyze and design combinational and sequential circuits using various static and dynamic CMOS techniques. It also provides them with an understanding of scalability of CMOS devices and associated design rules and their application to the layouts of circuits; and knowledge of creating layouts for CMOS circuits and techniques for optimizing the circuit performance.

Course Contents

Introduction: Issues in Digital IC Design. Quality Metrics of a Digital Design. MOS Transistor. Manufacturing CMOS Integrated circuits. Design Rules. Layouts. : **(7)**

MOS Inverter: Introduction, Resistive-load inverter, inverter with enhancement and depletion MOSFET load. **(2)**

The CMOS inverter: Static CMOS inverter, static and dynamic behaviour practice of CMOS inverter. Components of energy and Power, switching, Technology scaling and its impact on the inverter metrics**. (10)**

CMOS Combinational logic circuit Design: Static CMOS Design, Complementary CMOS, Ratioed Logic, Pass Transistor Logic, Dynamic CMOS Design: Dynamic Logic Design Considerations. Speed and Power Dissipation of Dynamic logic, Signal integrity issues, Cascading Dynamic gates**. (11)**

CMOS Sequential Logic Circuit Design: Introduction. Static Latches and Registers. Dynamic Latches and Registers. Pulse based Registers. Sense Amplifier Based registers. Latch vs. Registers-based pipelines structures, Interconnect and Timing Issues. **(10)**

Course Outcomes

CO1: This course focuses on analysis and design of modern digital circuits. CMOS digital circuits will be introduced and analyzed.

CO2: Analysis and design of CMOS based combinational and sequential digital integrated circuits are covered.

CO3: Provides exposure to the complex, non-digital behavior of the devices and circuits with which digital systems are implemented.

CO4: Emphasis is given on the circuit design, optimization, and layouts.

Recommended Books

1. Rabaey J.M, Chandrakasan A, Nikolic B, "Digital Integrated Circuits-A Design Perspective" 2nd edition, PHI, 2005.
2. S M Kang and Y Lebici, "CMOS Digital Integrated Circuits-analysis and design" 4th edition, McGraw Hill, 2019.
3. David A Hodges, Horace G Jackson and Resve A Saleh, "Analysis and Design of Digital Integrated Circuits in Deep Submicron Technology" TMH, 2005.
4. Neil. H. E.Weste, David Harris, Ayan Banerjee, " CMOS VLSI Design: A circuit and Systems Perspective" , (2/e),PHI.2005
5. John F Wakerly, "Digital Design-principles and practices" 3rd edition, Prentice Hall, 1999.

EC-510	Integrated Circuit Fabrication	[3 0 0 3]

Course Objectives

This course focuses on familiarizing the students with the technologies for IC manufacturing and providing in-depth knowledge of processing steps involved in the manufacturing process of ICs. It also provides an understanding the concepts of thin-film and thick-film technology and knowledge of process modeling and its application in manufacturing MEMS.

Course Contents

Environment for IC Fabrication: Clean room technology, Wafer cleaning process, Basic I.C. **(10)**

Processing steps and Crystal Growth

Oxidation, Lithography, Diffusion, Ion implantation, Rapid Thermal Annealing, Etching, Epitaxy, Film Deposition and Metallization. **(15)**

Thin Film and Thick film technology

Hybrid circuits, circuit elements-diodes, resistors, inductors, contacts and interconnection, Self aligned silicides, Shallow junction formation, Standard bipolar NMOS and CMOS process sequences, Testing, Bonding, Packaging, Novel structures in bipolar and MOS: VMOS etc. Introduction to process modeling, SUPREM, Introduction to MEMS-LIGA, Bulk Micromachining, Surface micromachining. **(15)**

Course Outcomes

CO1: To give an inside and feel of silicon foundry, this course is must for VLSI design engineers in particular and for ECE students in general.

CO2: The level of integration which leads to higher packaging density of components and devices on a chip in studied.

CO3: Latest techniques and processes adopted for fabrication are discussed.

CO4: This course covers extraction of Si from Silica (Sand) up to packaged Integrated Circuit.

CO5: The concepts used are extended for realization of micro electrical mechanical system (MEMS).

Recommended Books

1. S K Gandhi, "VLSI Fabrication Principles: Silicon and Gallium Arsenide", 2nd edition, Wiley, 1994.
2. G S May, S M Sze, "Fundamental of Semiconductor fabrication" Wiley, 2003.
3. Stephen A. Campbell "The Science and Engineering of Microelectronic Fabrication" 2nd Edtion, Oxford University Press, 2001.
4. Benjamin Eynon, Banqiu Wu, "Photomask Fabrication Technology" 1st edtion,Mcgraw-Hill, 2005.
5. Jose Pineda de Gyvez, Dhiraj Pradhan, "Integrated Circuit Manufacturability: The Art of Process and Design Integration", IEEE press, 1999.

EC-552 b	Embedded Systems Design Lab	[0 0 3 2]

Programming exercises using embedded processors, Interfacing of LEDs, Switches, Relays, LCD, 7 Segment Display, ADC, DAC, Stepper Motor etc, ZigBee, RFID, GSM, Sensors.

In addition to the lab experimentation, the students will have to carry out additional project work (independently or in group) related to the laboratory contents.

Course Outcomes

CO1: Knowledge of concepts used in programming using embedded processors.
CO2: Understanding of interfacing of different electrical devices with the processor kit like Stepper Motor, Switches, Relays etc.
CO3: Familiarization with interfacing of communication modules like ZigBee, RFID, GSM, Sensors etc with the processor kit.
CO4: Knowledge of interfacing of LEDs, LCD, 7 Segment Display, ADC, DAC, etc with the processor kit.

EC-554	VLSI CAD Lab-II	[0 0 3 2]

Study of VLSI CAD Tools-Working Environment, Introduction to Linux, Cadence Virtuoso ADE with Spectre simulator/Mentor graphics Design Architect with Eldo simulator.

Circuit design and simulation:

Applying MOS I-V equations and small-signal models to MOS circuits.
Analysing switching characteristics and power consumption of the inverter.
Analysing and Designing complex CMOS gates for speed.
Designing and characterization (Transient and DC Analysis) of various digital blocks.
Physical design (Layout) of Analog and Digital cells (DRC, LVS, RCX, Post –layout simulation ,export GDSII and LEF file)

In addition to the lab experimentation, the students will have to carry out additional project work (independently or in group) related to the laboratory contents.

Course Outcomes

CO1: Familiarization with VLSI CAD Tools for analog circuits.
CO2: Ability to design VLSI Circuit and their characterization.
CO3: Ability to generate physical design (layout) and carry out analysis of various circuit extraction parameters.

Detailed course contents of 3rd semester

EC-511	RF Circuit Design	[3 0 0 3]

Course Objectives

This course focuses on active and passive microwave components, and various types of transmission lines used in RF communication; and their modelling. It provides an introduction to RF specific diodes and transistors and analysis of their operation in microwave frequencies; enables students to understand concepts like impedance matching, line matching, scattering parameters and design and analysis of planar circuits used in modern RF circuits like filters, amplifiers, oscillators, mixers etc.

Course Contents

Introduction: Importance of Radiofrequency Design, RF Behavior of Passive Components, Chip Components and Circuit Board Considerations, General Transmission Line Equation, Microstrip Transmission Lines **(6)**

Single-and Multiport Networks: Interconnecting Networks, Network Properties and Applications, Scattering Parameters. **(4)**

RF Filter: Basic Resonator and Filter Configurations, Special Filter Realizations, Filter Implementation, Coupled Filter. **(6)**

Active RF Components and Modeling: Semiconductor Basics, RF Diodes, Bipolar-Junction Transistor, RF Field Effect Transistors, High Electron Mobility Transistors, Diode Models, Transistor Models **(6)**

Matching and Biasing Networks: Impedance Matching Using Discrete Components, Microstrip Line Matching Networks, Amplifier Classes of Operation and Biasing Networks. **(6)**

RF Transistor Amplifier: Characteristics of Amplifiers, Amplifier Power Relations, Stability Considerations, Constant Gain, Noise Figure Circles, Constant VSWR Circles, Broadband, High Power, and Multistage Amplifiers. **(7)**

Oscillators and Mixers: Basic Oscillator Model, High Frequency Oscillator Configuration, Basic Characteristics of Mixers. **(5)**

Course Outcomes

CO1: Understand the circuit behavior from low frequency to high frequency circuits. It gives fundamental knowledge of microwave frequency design and analysis.

CO2: It concentrates on the planer circuits which are enormously used in modern RF circuits and also describes multiport and scattering parameter. Prototype and planer RF filter design and analysis considered here.

CO3: Also it covers Active and Passive RF component analysis and Design such as RF amplifier and their stability consideration, Oscillators modeling and mixer characteristics, which are very advantageous at RF frequencies.

Recommended Books

1. Reinhold Ludwig, Pavel Bretchko, "RF Circuit Design" 1st Indian Reprint, Pearson Education Asia, 2001.
2. B Razavi, "Design of Analog CMOS Integrated Circuits" Mc Graw Hill, 2000.
3. Behzad Razavi, "RF Microelectronics", Pearson Education, 2nd edition, 1997.
4. Reinhold Ludwig,Gene Bdgdanov,"RF Circuit Design: Theory & Applications " 2nd edtion, 2008.
5. Peter b. Kenington, "High Linearity RF Amplifier Design", Artech House Microwave Library,Kindle Edition, 2000.
6. Jeremy Everard, "Fundamentals of RF Circuit Design With Low Noise Oscillators", John Wiley & Sons Ltd, 2001.

Detailed course contents of Electives

EC-521	Biomedical Electronics	[3 0 0 3]

Course Objectives

This course incorporates knowledge from various fields of engineering, physics and physiology to develop deeper understanding of the human physiology. The concept is related to various biomedical signal and image applications like ECG, EEG, ESR GSR monitoring and basics behind imaging modalities.

Course Contents

Physiology & Human Nervous System: Cell, Bioelectricity, Sodium Potassium pump, Action and Resting potentials, Bioelectric Signals, Nervous System, Peripheral Nervous System, Autonomic Nervous System, SNS, PNS. **(10)**

Electro-Physiological Measurements: Basic components of biomedical electronics system, Electrodes: Micro, Needle and Surface electrodes, Electrical activity of heart, Generation and Recording of ECG signals, ECG Waves and Time Intervals, Heart Rhythms, Heart beat morphologies, Noise and artifacts, Respiratory system, EEG, EEG Rhythms and waveforms, Recording**.** **(10)**

Non-Electrical Parameter Measurement: Blood pressure measurement, Cardiac output, Heart Sounds, Respiratory rate, Gas volume, Flow rate, ph value, ESR, GSR, Plethysmography**.** **(10)**

Assistive Restorative and Medical Imaging Equipments: Phonocardiography, Vectrocardiography, Defibrillators, Pacemakers, X-Ray, Ultrasonography, Computer Tomography, MRI**.** **(10)**

Recommended Books

1. Joseph J. Carr and John M. Brown, "Introduction to Biomedical Equipment Technology" 4th edition, Pearson Education India, 2001.
2. Leslie Cromwell, Fred J, Weibell and Erich A. Pfeiffer, "Biomedical Instrumentation and Measurements" Prentice Hall of India Pvt. Ltd, New Delhi.
3. John G. Webster (Ed.), "Medical Instrumentation Application & Design" 3rd Edition, Wiley India.
4. Khandpur R S, "Handbook on Biomedical Instrumentation" TMH, 13th Reprint, New Delhi.
5. Barbara Christe, "Introduction to Biomedical Instrumentation: The Technology of Patient Care" Cambridge University Press 2009.

EC-522	Sensors and Transducers	[3 0 0 3]

Course Objectives

To introduce the student to the different types of sensors, signal conditioning circuits, and actuators. The student also should be familiar with the basic techniques of designing the required signal conditioning for a particular sensor. To gain knowledge about the measuring instruments and the methods of measurement and the use of different transducers. To get the basic idea of measurements and the errors associated with measurement. To differentiate between the types of transducers available. To gain information about the function of various measuring instruments and using them.

Course Contents

Measurements: Science of Measurements and Instrumentation of Transducers, Units and Standards, Calibration Methods, Static Calibration, Classification of Errors, Error Analysis, Statistical Methods, Odds and Uncertainty, Classification of Transducers, Selection of transducers, Characteristics of Transducers, Static Characteristics, Accuracy, Precision, Resolution, Sensitivity, Linearity, Threshold Resolution, Hysteresis and Dead Space, Dynamic Characteristics, Mathematical model of Transducer, Zero, II Order Transducers and I. Response to Impulse, Step, Ramp and Sinusoidal Inputs**.** **(16)**

Transducers: Variable Resistance Transducers, Principle of Operation, Construction Details, Characteristics and Application of Resistance potentiometer, Strain Gauge, Resistance Thermometer, Thermistor, Hot-Wire Anemometer, Piezoresistive Sensor, Humidity Sensor, Variable Inductance and Variable Capacitance Transducers, Induction Potentiometer, Variable Reluctance Transducers, EI Picks Up, LVDT, Capacitive Transducer, Types-Capacitor Microphone, Frequency Response**.** **(15)**

Advanced Transducers and Smart Sensors: Other Transducers like Piezoelectric Transducer, Magnetostrictive, IC Sensor, Digital Transducers, Smart Sensor, Fiber Transducer. **(9)**

Recommended Books

1. D Patranabis, “Sensors and Transducers” PHI, 2nd ed, 2004.
2. E. A. Doebelin “Measurement Systems: Application and Design” Mc Graw Hill, New York, 2003.
3. H. K. P. Neubert “Instrument Transducers” Oxford University Press, London and Calcutta, 1963.
4. Ian Robertson Sinclair, “Sensors and Transducers” Newnes, Third Edition, 2001.
5. M. J. Usher, “Sensors and Transducers” Scholium Intl, December 1985.
6. Keith Brindley, “Sensors & Transducers” CRC Press; 1 edition, September 30, 1988.
7. Harry N. Norton, “Handbook of Transducers” Prentice Hall, 1989.
8. Nakara, “Instrumentation: Measurement and Analysis” McGraw-Hill Education – Europe, 1985.

EC-523	**Wavelet Transforms for Signal and Image Processing**	[3 0 0 3]

Course Objectives

The purpose of this course is to introduce and teach students the fundamentals of wavelet transform and its applications related to signal and image processing. To learn and apply different types of wavelets for multi-resolution analysis. The student will be able to incorporate these concepts into fields of signal processing, communications and sensing.

Course Contents

Introduction: Basics of Functional Analysis, Stationary and Non-stationary Processes, Transform, Fourier Transform, Spectral Theory, Short Time Fourier Transform, Wavelets over FT and STFT, Wavelets Applications**.** **(15)**

Wavelet Transform: Continuous Wavelet Transform, Types of wavelets, Time-Frequency Resolution, Discrete Wavelet Transform DWT, Sub-band Coding, Multi-resolution Analysis, Wavelet Coefficients Estimation, Inverse DWT, Applications of DWT and IDWT in Signal and Image Processing. **(15)**

Un-decimated Wavelet Transform: Algorithme `a Trous, Estimation of Wavelet Coefficients, Inverse Un-decimated Wavelet Transform, Applications, Matched Wavelets**.** **(10)**

Recommended Books

1. James S. Walker, "A Primer on Wavelets and Their Scientific Applications, Second Edition (Studies in Advanced Mathematics)" Chapman & Hall/CRC, CRC Press, 2008.
2. Lokenath Debnath, "Wavelet Transforms & Time-Frequency Signal Analysis**"** Birkhauser Boston, 2001.
3. Stephane Mallat, "A Wavelet Tour of Signal Processing, Third Edition: The Sparse Way" Elsevier, Academic Press, 2008.
4. Albert Boggess, Francis J. Narcowich, "A First Course in Wavelets with Fourier Analysis" John Wiley & Sons, 2009.

EC-524	Machine Learning	[3 0 0 3]

Course Objectives

Machine learning uses interdisciplinary techniques such as statistics, linear algebra, optimization, and computer science to create automated systems that can sift through large volumes of data at high speed to make predictions or decisions without human intervention. Machine learning as a field is now incredibly pervasive, with applications spanning from business intelligence to security, from healthcare to structural monitoring of aging bridges, and from weather forecasting to stock-market, etc. The major course objectives are:

- Familiarization with a broad cross-section of models and algorithms for machine learning
- Familiarization with the available platforms for designing and building machine learning applications
- Apply machine learning techniques for research or industry applications

Course Contents

Introduction: What is Machine Learning? Why use Machine Learning? **(2)**
Type of Machine Learning Systems: Supervised Learning: k-Nearest Neighbours, Linear Regression, Logistic Regression, Support Vector Machines, Neural Networks, etc. **(12)**
Unsupervised Learning: Clustering (k-means, Hierarchical Cluster Analysis, Expectation Maximization), Dimensionality Reduction (Principal Component Analysis) etc. **(10)**
Semi supervised Learning, **Reinforcement Learning** **(1)**
Batch and Online Learning, Instance-based and Model-based Learning **(1)**
Some Machine Learning Platforms: TensorFlow, Matlab, Scikit-Learn, etc. **(6)**
Machine Learning Applications **(8)**

Recommended Books

1. EthemAlpaydin, "Introduction to Machine Learning", MIT Press, 2nd edition (2004).
2. Tom Mitchell, "Machine Learning", McGraw-Hill, 1st edition (1997).
3. Richard O. Duda, Peter E. Hart & David G. Stork, "Pattern Classification", Wiley & Sons, 2nd edition (2001).
4. Richard S. Sutton and Andrew G. Barto, "Reinforcement learning: An introduction", MIT Press, 2nd Edition (1998).
5. NelloChristanini, John Shawe-Tayer, "An Introduction to Support Vector Machines", Cambridge University Press, 1st edition (2000).

EC-525	Advanced Optical Communication Systems	[3 0 0 3]

Course Objectives

The purpose of this course is to introduce and teach the students the fundamentals of fiber optic communication systems. To make the students familiar with different optical modules used in fiber optic communication like optical transmitters, optical receivers, optical filters etc. The student will be able to model and simulate different optical networks by using the different topologies. At the end of this course students will be introduced with the MEMS.

Course Contents

Overview of fiber optic communication systems: Evolution, nature of light, advantages and applications. Optics Review: Ray theory, lenses, imaging, numerical aperture, diffraction**.** **(5)**

Light wave fundamentals and optical fibers: Introduction to electromagnetic waves, wave equations, group velocity, dispersion, polarization, resonant cavities, total internal reflection. Integrated optic waveguides: dielectric-slab waveguide, modes, coupling, dispersion, integration. Optic fibers: step-index fibers, graded-index fibers, modes and fields in fibers, pulse broadening and information rate, fiber fabrication and characterization. Optical sources and amplifiers: PN junction, LEDs, laser principles, laser diodes, tunable laser diodes, VCSELs, modulation, optical amplifiers. **(12)**

Optical receivers: Photomultipliers, photodiodes, APDs, responsivity, quantum efficiency, noise, heterodyne detection, preamplifiers**.** **(6)**

WDM concepts and components: WDM principles, N_N couplers, star couplers, add/drop multiplexers, fiber grating filters, tunable sources, and tunable filters. **(7)**

Modeling and Simulation of Optical Networks: Difference between networking and transmission. Bandwidth management, internet growth, topology, OSI reference model. Protocols: PDH, SDH. Shared access networks. Static and dynamic allocation. Ethernet, optical Ethernet. All optical-switching: advantages, MEMS introduction, optical MEMS devices for optical switching. Local Area Networks: FDDI. Reflective star networks. **(10)**

Recommended Books

1. J.C. Palais, "Fiber Optic Communications" 5th edition, Pearson Prentice Hall, 2005.
2. Gerd Keiser, "Optical Fiber Communications" 3rd edition, McGraw-Hill, 2000.
3. G. P. Agrawal, "Fiber-Optic Communication Systems" 3rd edition, John Wiley & Sons, 2002.
4. Robert H. Kingston, "Optical Sources, Detectors, and Systems" Academic Press, 1995.
5. R Ramaswami and K.N.Sivarajan, "Optical Networks: A practical perspective" 3rd edition, Morgan Kaufman, 2010.

EC-526	OFDM for Wireless Communications	[3 0 0 3]

Course Objectives

This course provides the review of channel fading and the concept of orthogonal signals. The course focuses on two key wireless technologies, OFDM, and it contains details on the applications of these technologies to new wireless systems such as WiMax and UMTS LTE. The student will be able to analyze the performance of OFDM systems with estimation and equalization.

Course Contents

Introduction: Review of channel fading fundamentals. Concept of Orthogonality and Orthogonal signals. Single Carrier and Multi Carrier communication system, Evolution/ History, Detailed study of Block diagram of OFDM system**.** **(9)**

Performance over channels: Performance of OFDM system over AWGN and Rayleigh fading channel, Error Probability. **(8)**

Clipping and Synchronization issues: Clipping in OFDM systems, PAPR problem, Timing and Frequency offset in OFDM, Synchronization issues of Transmitter and Receiver**.** **(8)**

Estimation and Equalization concept: Channel estimation for OFDM systems, Equalization in OFDM systems. Performance analysis with Estimation and Equalization **(8)**

Applications of OFDM: Applications of OFDM in Wi-Max, LTE, Cognitive Radio etc**.** **(7)**

Recommended Books

1. Ramjee Prasad, "OFDM for Wireless Communications Systems" Artech House, 2004.
2. Ye Geoffrey Li and Gordon L. Stuber, "Orthogonal Frequency Division Multiplexing for Wireless Communications (Signals and Communication Technology)" 1st edition, Springer, 2010.
3. Ahmad R. S. Bahai, Burton R. Saltzberg and Mustafa Ergen, "Multi-carrier Digital Communications: Theory and Applications of OFDM" 2nd edition, Springer, 2004.
4. Yong Soo Cho, Jaekwon Kim, Won Young Yang and Chung G. Kang, "MIMO-OFDM Wireless Communications with MATLAB" Wiley, 2010.
5. Juha Heiskala and John Terry, "OFDM Wireless LANs: A Theoretical and Practical Guide" SAMS publication, 2001.

EC-527	Photonics Networks and Switching	[3 0 0 3]

Course Objectives

This course will give students knowledge about the principles of operations of photonic networks. This course covers the principle methods used to multiplex data at the optical level and various topologies used to connect the photonic networks. The objective of this course is to make the students familiar with optical switching and its fundamental limits.

Course Contents

Optical multiplexing techniques: Wavelength division multiplexing, Optical frequency division multiplexing, time division multiplexing, code division multiplexing, Need of Optical Networks, Conventional optical networks, SONET / SDH, FDDI, IEEE 802.3, DQDB, FCS, HIPPI etc. Multiple access optical networks, Topologies, Single channel networks, Multichannel networks, FTFR, FTTR, TTFR and TTTR, Single hop networks, Multihop networks, Multi access protocols for WDM networks issues and some designs, Switched optical networks. Optical amplification in all-optical networks. Design issues of subscriber access networks**.** **(22)**

Optical switching: Motivation, Example of an optical switch using 2x2 coupler, Spatial light modulator, Relational and non-relational switching devices. Fundamental limits on optical switching elements, Switching Architectures, Free-space optical Switching. Wavelength routed networks and other special topics. Soliton based networks, Issues of Optical Networks management**.** **(18)**

Recommended Books

1. Ramaswami and kumar, "Optical Networks: A practical perspective" 3rd edition, Elsevier, 2010.
2. Wedzinga, Gosse, "Photonic Slot Routing in Optical Transport Networks" Kluwer Academic publisher, 2003.
3. Achyut K. Dutta, Niloy K. Dutta, Masahiko Fujiwara, "WDM Technologies: Optical Networks (Optics and Photonics Series)" Academic Press, 2002.
4. Andrew R, Pirich and Ray T. Chen, Photonic Integrated Systems" Society of Photo Optical, 2003.
5. Hussein T. Mouftah and Jaafar M. H. Elmirghani, "Photonic Switching Technology Systems and Networks" IEEE Press, 1999.

EC-528	Probability and Stochastic Processes	[3 0 0 3]

Course Objectives

This course provides the review of probability and statistics**.** The objective of this course to make the students familiar with Ito Stochastic Calculus. This course will provide the introduction of different Differential Equations. The main objective of this course is to provide students with the foundations of probabilistic and statistical analysis mostly used in varied applications in engineering and science and Modeling of them with Stochastic Differential Equations

Course Contents

Probability and Statistics: Random Variables and Distributions, Random Number Generators, Moments, Convergence of Random Sequences, Basic Ideas About Stochastic Processes. Discrete and continuous state and discrete and continuous time stochastic processes. Markov chains and accompanying theory, Diffusion Processes, Wiener Process and White Noise, Statistical Tests And Estimation**.** **(10)**

Probability and Stochastic Processes: Aspects of Measure and Probability Theory, Integration and Expectations, Stochastic Processes, Diffusion and Wiener Processes**.** **(6)**

Ito Stochastic Calculus: Introduction, The Ito Stochastic Integral, The Ito Formula Vector valued Ito Integrals, Other Stochastic Integrals, The Stratonovich integral. **(6)**

Stochastic Differential Equations: Introduction, Linear Stochastic Differential Equations, Reducible Stochastic Differential Equations, Some Explicitly Solvable Equations, The Existence & Uniqueness of Strong Solutions, Strong Solutions as Diffusion Processes, Diffusion Processes as Weak Solutions, Vector Stochastic Differential Equations, Stratonovich Stochastic Differential Equations. **(12)**

Modelling with Stochastic Differential Equations: Ito versus Stratonovich, Diffusion Limits of Markov Chains, Stochastic Stability, Parametric Estimation, Optimal Stochastic Control, Filtering (e.g. Kalman filtering). **(6)**

Recommended Books

1. Sheldon M. Ross, " Introduction to Probability Models" 10th edition, Academic Press, 2010
2. Hwei Hsu, "Probability, Random Variables, and Random Processes" 2nd edition, Schaum's Outline Series, 2011
3. Saeed Ghahramani, "Fundamentals of Probability, with Stochastic Processes" Prentice Hall, 2004
4. Richard M. Feldman, "Applied Probability and Stochastic Processes" 2nd edition, Springer, 2010.
5. Roy D. Yates and David Goodman, "Probability and Stochastic Processes: A Friendly Introduction for Electrical and Computer Engineers" 2nd edtion, Wiley, 2004.

EC-529	Signal Detection and Estimation Theory	[3 0 0 3]

Course Objectives

The objective of this course is to introduce students to the fundamental concepts of detection and estimation theory. The capability of identifying the engineering problems that can be put into the framework of statistical signal processing. The concept is related to various application areas such as communications, automatic control, radar/sonar, speech/image processing and medical signal processing.

Course Contents

Background: Review of Gaussian variables and processes; problem formulation and objective of signal detection and signal parameter estimation in discrete-time domain. **(5)**

Statistical Decision Theory: Bayesian, minimax, and Neyman-Pearson decision rules, likelihood ratio, receiver operating characteristics, composite hypothesis testing, locally optimum tests, detector comparison techniques, asymptotic relative efficiency. **(7)**

Detection of Deterministic Signals: Matched filter detector and its performance; generalized matched filter; detection of sinusoid with unknown amplitude, phase, frequency and arrival time, linear model. **(6)**

Detection of Random Signals: Estimator-correlator, linear model, general Gaussian detection, detection of Gaussian random signal with unknown parameters, weak signal detection. **(6)**

Nonparametric Detection: Detection in the absence of complete statistical description of observations, sign detector, Wilcoxon detector, detectors based on quantized observations, robustness of detectors. **(6)**

Estimation of Signal Parameters: Minimum variance unbiased estimation, Fisher information matrix, Cramer-Rao bound, sufficient statistics, minimum statistics, complete statistics; linear models; best linear unbiased estimation; maximum likelihood estimation, invariance principle; estimation efficiency; Bayesian estimation: philosophy, nuisance parameters, risk functions, minimum mean square error estimation, maximum a posteriori estimation. **(10)**

Recommended Books

1. H. L. Van Trees, "Detection, Estimation and Modulation Theory: Part I" John Wiley, NY, 2001.
2. H. V. Poor, "An Introduction to Signal Detection and Estimation" 2nd edition, Springer, 1998.
3. S. M. Kay, "Fundamentals of Statistical Signal Processing: Estimation Theory" PHI, 1993.
4. S. M. Kay, "Fundamentals of Statistical Signal Processing: Detection Theory" PHI, 1998.
5. Mourad Barkat, "Signal Detection and estimation" 2nd edition, ARTECH house publishing, 2005.

EC-530	**Cardiovascular variability and its Interpretation**	**[3 0 0 3]**

Course Objectives

The main objective of this course is to provide basic and state of art knowledge of signal processing techniques for processing the physiological variability signals towards healthcare and diagnostic application. The prime goal is to promote the ethos of synergy for multidisciplinary research between medical and signal processing techniques.

Course Contents

Introduction to Biomedical Signals: Examples and acquisition of Biomedical signals - ECG, EEG, EMG etc - Tasks in Biomedical Signal Processing - Computer Aided Diagnosis origin of bi potentials. **(5)**

Review of linear systems: Fourier Transform and Time Frequency Analysis (Wavelet) of biomedical signals- Processing of Random & Stochastic signals - spectral estimation – Properties and effects of noise in biomedical instruments - Filtering in biomedical instruments. **(7)**

Concurrent, coupled and correlated processes: Illustration with case studies - Adaptive and optimal filtering -Modelling of Biomedical signals - Detection of biomedical signals in noise - removal of artifacts of one signal embedded in another -Maternal-Fetal ECG - Muscle-contraction interference. Event detection - case studies with ECG & EEG - Independent component Analysis - Cocktail party problem applied to EEG signals - Classification of biomedical signals. **(9)**

Cardio vascular applications: Basic ECG - Electrical Activity of the heart- ECG data acquisition – ECG parameters & their estimation - Use of multiscale analysis for ECG parameters estimation - Noise & Artifacts- ECG Signal Processing: Baseline Wandering, Power line interference, Muscle noise filtering – QRS detection - Arrhythmia analysis - Data Compression: Lossless & Lossy- Heart Rate Variability – Time Domain measures - Heart Rhythm representation - Spectral analysis of heart rate variability - interaction with other physiological signals. **(10)**

Neurological Applications: The electroencephalogram - EEG rhythms & waveform - categorization of EEG activity - recording techniques - EEG applications- Epilepsy, sleep disorders, brain computer interface. Modelling EEG- linear, stochastic models - Non linear modelling of EEG - artifacts in EEG & their characteristics and processing - Model based spectral analysis - EEG segmentation - Joint Time-Frequency analysis - correlation analysis of EEG channels - coherence analysis of EEG channels**.** **(9)**

Recommended Books

1. Kim E. Barrett, Susan M. Barman, Heddwen Brooks, Scott Boitano, “Genong’s Review of Human Physiology” McGraw Hills 2005.
2. Rangaraj M. Rangayyan, “Biomedical signal analysis-A case study approach” IEEE Press Engineering in Medicine and Biology Society, 2002.
3. O.P.Sharma, “ECG with brief discussions of cardiac arrhythmias” Lotus Publishers 2008.
4. D.C.Reddy, “Biomedical Signal Processing,” Tata McGraw Hills 2009.
5. Joseph Alpert, “Cardiology for the Primary Care Physician” McGraw Hills 1998.

EC-531	Medical Image Processing	[3 0 0 3]

Course Objectives

The objective of this course is to provide students with an overview of the computational and mathematical methods in medical image processing. The course covers the main sources of medical imaging data (CT, MRI, PET, and ultrasound). Also study many of the current methods used to enhance and extract useful information from medical images. A variety of radiological diagnostic scenarios will be used as examples to motivate the methods.

Course Contents

Introduction: Fundamentals of Biomedical Image Processing-Introduction to Medical imaging, Medical Image Formation, Image Enhancement, Visual Feature Extraction, Survey of major modalities for medical imaging: ultrasound, X-ray, CT, MRI, PET, and SPECT. Basic Principle, working and applications of X rays MRI, PERT, CT & ultrasound. Statistics related to biomedical image**.** **(9)**

Image Registration: Image Registration-Introduction to image registration, Transformation Model, Registration Basis, Optimization and validation, Application of image registration**.** **(7)**

Feature Extraction: Feature Extraction and Selection-Introduction to Medical Image Features, Image Representation, Texture and shape features in Biomedical Images, Characterizing the Texture, Texture Segmentation, Feature Selection, Examples of the Use of Features in Biomedical Applications. **(8)**

Image Segmentation: Image segmentation- Introduction to image segmentation, need of image segmentation, Various methods of image segmentation, Parametric and Non-Parametric Clustering, Region-Based Segmentation, Deformable models**.** **(7)**

Image Classification: Image classification-Introduction to image classification, Methods of image classification like SVM, neural and fuzzy network, Genetic algorithms (GA). Need and designing of Computer aided diagnosis system, Content-Based Medical Image Retrieval, Examples for Medical CBIR Systems. **(9)**

Recommended Books

1. Thomas Deserno, "Biomedical Image Processing" Springer, 2011.
2. John L. Semmlow, "Bio Signal and Biomedical Image Processing MALAB based Application", CRC Press, 2004.
3. Bernd Jahne, "Digital image processing" Springer, 2005.
4. Thomas Deserno, "Biomedical Image Processing" Springer, 2011.
5. J.L.Prince and Jonathan Links, "Medical imaging signals and systems" Pearson Education, 2006.
6. Sonka, Hlavac, Boyle "Digital image processing and computer vision" Cenage Learning , 2008.

EC-532	Satellite Communication	[3 0 0 3]

Course Objectives

This course presents the fundamentals of satellite communications link design and provides an overview of practical considerations. Be able to calculate an accurate link budget for a satellite communications link. Existing systems are described and analyzed, including direct broadcast satellites, VSAT links, and Earth-orbiting and deep space spacecraft. Topics include satellite orbits, link analysis, antenna and payload design, interference and propagation effects, modulation techniques, coding, multiple access, & Earth station design.

Course Contents

Introduction: Origin and brief history of satellite communications, an overview of satellite system engineering, satellite frequency bands for communication. Orbital Theory: Orbital mechanics, launching techniques, Earth looks angle determination. Azimuth & elevation calculations. Earth Station & Spacecraft Systems: Earth station components**.** **(8)**

Antennas used for satellite communication: antenna types, gains, antenna pointing loss, G/T ratio and its measurement, High power amplifier, Low noise amplifiers, Up and down converters, Monitoring and control. Spacecraft system: Attitude control subsystem, orbit control subsystem, telemetry, tracking and command (TT&C), communications subsystems, transponders, spacecraft antennas. **(8)**

Satellite Link Design: Basic transmission theory, Basic link analysis, noise figure and noise temperature of receiver, C/N ratio, Satellite link budget analysis: Uplink, downlink and overall link performance with non-regenerative and regenerative repeaters. Satellite link design: downlink design & uplink design considerations and issues. Propagation delay over satellite links, Rain effects. **(8)**

Modulation Techniques in Satellite Communications: Digital data transmission: BPSK, QPSK & QAM, coherent FSK and Non-coherent FSK modulation schemes and their performance, SNR Calculations, G/T measurement**.** **(6)**

Multiple Access Techniques in Satellite Communications: Pre-assigned FDMA, Demand-Assigned FDMA, Bandwidth-limited and Power-limited TWT amplifier operation, FDMA downlink analysis. TDMA : Reference Burst; Preamble and Post-amble, Carrier recovery, Network synchronization, unique word detection, Traffic Date, Frame Efficiency and Channel capacity, pre-assigned TDMA, Demand assigned TDMA.CDMA : Direct-Sequence spread spectrum – code signal c(t) – autocorrelation function for c(t) – Acquisition and tracking – Spectrum spreading and dispreading – CDMA throughput. Satellite Systems: Satellite broadcast networks, Broadband satellite networks, GPS system. **(10)**

Recommended Books

1. Tri T. Ha, "Digital Satellite Communications" Mc-Graw Hill Publications, 1990.
2. Timothy Pratt, Charles W. Bostian, "Satellite Communications" John Wiley & Sons, 2002.
3. Dennis Roddy, "Satellite Communications" 3rd edition, Mc. Graw-Hill International Ed. 2001.
4. Gerard Maral,Michel Bousquet, "Satellite Communications Systems: Systems, Techniques and Technology" John Wiley & Sons, 2009.
5. Bruce R. Elbert, "Introduction to Satellite Communication (Artech House Space Applications)" Artech House Inc., 2008.

EC-533	Wireless Sensor Networks	[3 0 0 3]

Course Objectives

The main objectives of this course are to: obtain a broad understanding of the technologies and applications for the emerging and exciting domain of wireless sensor networks, get in-depth hands-on experience in designing and developing a real operational embedded network system, and design and develop foundational systems software, sensor-actuator-controller algorithms and network protocols.

Course Contents

Introduction: Introduction to Sensor Networks, unique constraints and challenges, Advantage of Sensor Networks, Applications of Sensor Networks, Mobile Ad-hoc networks (MANETs) and Wireless Sensor Networks, Enabling technologies for Wireless Sensor Networks **(5)**

Sensor Node Hardware and Network Architecture: Single-node architecture, Hardware components & design constraints, Operating systems and execution environments, introduction to TinyOS and nesC, Network architecture, Optimization goals and figures of merit, Design principles for WSNs, Service interfaces of WSNs, Gateway concepts **(6)**

Deployment and Configuration: Localization and positioning, challenging issues of localization, Coverage and connectivity, Single-hop and multi-hop localization, self- configuring localization systems, node discovery protocols, sensor management **(6)**

Network Protocols: Issues in designing of MAC protocol for WSNs. Classification of MAC Protocols, S-MAC Protocol, & B-MAC protocol. IEEE 802.15.4 standard and Zig-Bee, Dissemination protocol for large sensor network **(5)**

Routing protocols: Issues in designing routing protocols, Classification of routing protocols, Energy-efficient routing, Unicast, Broadcast and multicast, Geographic routing **(6)**

Data Storage and Manipulation: Data centric and content based routing, storage and retrieval in network, compression technologies for WSN, Data aggregation technique **(6)**

Applications: Detecting unauthorized activity using a sensor network, WSN for Habitat Monitoring, Security challenges in WSN, preservation and efficiency **(6)**

Recommended Books

1. Holger Kerl, Andreas Willig, "Protocols and Architectures for Wireless Sensor Network", Wiley-Interscience, 2007
2. Waltenegus Dargie, Christian Poellabauer, "Fundamentals of Wireless Sensor Networks: Theory and Practice", Wiley, 2010
3. C.S. Raghavendra, Krishna M. Sivalingam, Taieb Znati (Eds), "Wireless Sensor Networks", Springer, 2006.
4. Feng Zhao, Leonidas Guibas, "Wireless Sensor Networks", Morgan Kaufmann, 2004
5. Kazem Sohraby, Daniel Minoli, Taieb Znati, "Wireless Sensor Networks: Technology, Protocols, and Applications", Wiley-Interscience, 2007
6. Bhaskar Krishnamachari, "Networking Wireless Sensors", Cambridge University Press, 2011.
7. Nitaigour P. Mahalik, "Sensor Networks and Configuration: Fundamentals, Standards, Platforms, and Applications", Springer, 2010.

EC-534	Cognitive Radios	[3 0 0 3]

Course Objectives

This course will provide the introduction of the basic principles of Software Defined Radios (SDR) and Cognitive Radio (CR). The student will be able to analyze the performance of CR networks using OFDM, diversity and channel aggregation techniques. The objective of this course is to make the student able to design various signaling protocols by considering IEEE standards.

Course Contents

Introduction: Spectrum trading and Management policies, spectrum scarcity problem, low spectrum utilization scenarios, spectrum efficiency improvement methods, issues. **(6)**

Software Defined Radios: Brief history of SDR, hardware and software architecture of SDR, implementation in 3G and beyond, SDR to Cognitive Radio (CR), Cognition and CR, Cognitive cycle, CR types, Protocol stack for CR**.** **(7)**

CR Air Interface: Spectrum sensing, sharing, management and mobility. Spectrum access technique, new opportunities, underlay and overlay access systems, opportunistic spectrum access and dynamic spectrum access, priority access**.** **(8)**

Enabling Techniques for Cognitive Radio: Adaptive modulation, Role of OFDMA, smart broadband antennas, spectrum, time and spatial awareness, transceiver, interference avoidance, spectrum sensing techniques, beam forming, channel aggregation **(8)**

Standardization and Implementation: Review of ITU and IEEE standards, Protocol development and cross layer issues, distributed signalling protocols, spectrum trading and models, Products under test. **(6)**

Associated Application Areas: Interoperability, Heterogeneity with CR, Green communication, disaster recovery **(5)**

Recommended Books

1. Ekram Hossian, Dustin Niyato, Zhu Han, "Dynamic Spectrum access and Management in Cognitive Radio Networks", Cambridge University Press, 2009.
2. Bruce A. Fette, "Cognitive Radio Technology", Newnes Publications, 2009
3. Linda E. Doyle, "Essentials of Cognitive Radio", Cambridge University Press, 2009.
4. Kwang-Cheng Chen and Ramjee Prasad, "Cognitive Radio Networks", John Wiley and Sons, 2009.
5. Hüseyin Arslan (Ed.), "Cognitive Radio, Software Defined Radio, and Adaptive Wireless Systems", Springer, 2007.
6. Alexander M. Wyglinski, Maziar Nekovee and Thomas Hou (Eds.), "Cognitive Radio Communications and Networks: Principles and Practice", Academic Press, 2009.

EC-535	**Wireless Networking Planning and Optimization**	**[3 0 0 3]**

Course Objectives

This course will provide the introduction of the basic principles of Software Defined Radios (SDR) and Cognitive Radio (CR). The student will be able to analyze the performance of CR networks using OFDM, diversity and channel aggregation techniques. The objective of this course is to make the student able to design various signaling protocols by considering IEEE standards.

Course Contents

Mobile Network Evolution: First generation systems, second generation mobile networks, Third Generation Mobile Networks **(6)**

Second Generation (2G) Network Planning and Optimization: Scope of Radio Network Planning, Radio Network Planning Process, Radio Network Pre-Planning, Radio Network Detailed Planning, Radio Network Optimization, 2G Transmission and Core Network Planning and Optimization **(10)**

2.5 Generation Network Planning and Optimization: GPRS Network Planning and Optimisation, EDGE Network Planning and Optimisation **(6)**

Third Generation (3G) Network Planning and Optimization: Scope, Radio Interface Protocol Architecture, Multipath Propagation, WCDMA Radio Network Optimization, 3G Transmission and Core Network Planning and Optimization **(10)**

4G Network Planning **(4)**

Indoor Radio Planning **(4)**

Recommended Books

1. Ajay R Mishra, Fundamentals of Cellular Network Planning and Optimisation: 2G/2.5G/3G... Evolution to 4G, First Edition, Wiley Interscience, 2004.
2. Morten Tolstrup, Indoor Radio Planning: A Practical Guide for GSM, DCS, UMTS and HSPA, Wiley, 2008.
3. Ajay R Mishra (Editor), Advanced Cellular Network Planning and Optimisation: 2G/2.5G/3G. Evolution to 4G, First Edition, Wiley, 2007.

EC-536	Computer Vision	[3 0 0 3]

Course Objectives

This course aims to introduce the concepts of vision and its incorporation in computer systems, recognition process and inverse graphics; how to use the basic principles and operations for image processing. The students will understand the concept of edge detection for analysis of different shapes and ultimately develop the skills in the design and implementation of computer vision applications

Course Contents

Introduction: The Nature of vision, the process of recognition, tackling the recognition problem, object location, scene analysis, vision as inverse graphics. **(7)**

Low Level Vision: Image and imaging operations, gray scale vs. color, image processing operations, some basic operations on gray scale images, basic operation on binary images, noise suppression by image accumulation, convolutions and points spread functions, sequential vs. parallel operations. **(9)**

Edge Detection: Basic theory of edge detection, Binary shape analysis, Connectedness in binary images, object labeling and counting, size filtering, Skeltons and thinning**.** **(7)**

Intermediate Level Vision: Line detection, Application of the Hough transform to line detection, The Foot-of-Normal method, Final Line fitting, Circle Detection, Hough based scheme for circular object detection. **(8)**

3-D Vision and Motion: Introduction, Three dimensional visions- the variety of methods, Projection schemes for three dimensional vision, Shape from shading, Photometric stereo. Real time pattern recognition system, Process of inspection, High Performance Computing for vision applications. (**9)**

Recommended Books

1. E. R. Davies, "Machine Vision - Theory, Algorithms, Practicalities", Morgan Kaufmann, 2005.
2. J. R. Parker, "Algorithms for Image Processing and Computer Vision", Wiley, 2010.
3. Robert Laganière, "OpenCV 2 Computer Vision Application Programming Cookbook", Packt Publishing, 2011
4. Gary Bradski, "Learning OpenCV: Computer Vision with the OpenCV Library", O'Reilly Media, 2008.
5. Carsten Steger, Markus Ulrich, Christian Wiedemann, "Machine Vision Algorithms and Applications", Wiley-VCH, 2008.
6. Alexander Hornberg, "Handbook of Machine Vision", Wiley-VCH, 2006.

EC-537	Nature Inspired Computing	[3 0 0 3]

Course Objectives

The course objective is to give the student an introduction to various algorithms in the area of natural computing and show how they have proven to be very powerful in solving various kinds of problems. The students will be able to apply various computational techniques inspired by nature. The aim is to develop skills for solving complex optimization problems and for modeling and simulating complex systems.

Course Contents

Introduction: Unconstrained Optimization, Gradient based methods, constrained optimization **(5)**

Nature Inspired Metaheuristics

Genetic Algorithms: Introduction, Basic Procedure, parameters, implementation, Case Studies **(5)**

Ant Algorithms: Behaviour of Ants, Ant Colony Optimization, Double Bridge Problem, Virtual Ant Algorithm, Some Case Studies. **(6)**

Bee Algorithms: Behaviour of Honey Bee, Bee Algorithms, Honey Bee Algorithm, Virtual Bee Algorithm, Artificial Bee Colony Algorithm, Some Case Studies. **(7)**

Swarm Optimization: Swarm Intelligence, Particle Swarm Optimization, gbest and lbest models, PSO parameters, Some Case Studies. **(6)**

Simulated Annealing (SA): Annealing and Probability, Choice of parameters, SA algorithm, Some Case Studies **(5)**

Immune Algorithms: Overview, Clonal Selection Algorithm, Artificial Immune Algorithm, Some Case Studies. **(6)**

Recommended Books

1. Xin-She Yang, Nature-Inspired Metaheuristic Algorithms, Luniver Press, 2008.
2. Jason Brownlee, "Clever Algorithms: Nature-Inspired Programming Recipes", lulu.com, 2011
3. Marco Dorigo, "Ant Colony Optimization", Bradford Books, 2004.
4. Russell C. Eberhart, "Swarm Intelligence", Morgan Kaufmann, 2001
5. Dipankar Das Gupta, "Artificial Immune Systems and Their Applications", Springer, 1998.

EC-538	Cloud Computing	[3 0 0 3]

Course Objectives

The objective of this course is to impart fundamental concepts in the area of cloud computing and to impart knowledge in applications of cloud computing. This course will provide the introduction about infrastructure as a service, platform as a service and software as a service.

Course Contents

Cloud Computing: Definition, Characteristics, Comparison with Traditional Technologies, Benefits to the IT world, Service model (IaaS, PaaS and SaaS), Pricing models, Cloud Management, Management of Resources, Issues with Cloud Vendors, Cloud Deployment Models, Understanding a Private Cloud, Comparing Private, Public and Hybrid Models. Going for a Public or a Private Cloud or a Hybrid Deployment Model? Checkpoints, Understanding Private Cloud Offering from popular vendors like Amazon, Microsoft, IBM etc. **(10)**

Infrastructure as a Service (IaaS): Difference between Internet Service Providers (ISP) and IaaS, Evolution of IaaS from ISP. Exploring IAAS offerings from: Amazon, Rackspace, GoGrid. **(6)**

Platform as a Service (PaaS): Introduction to PaaS, Categories of Environment: Integrated lifecycle platform, Anchored lifecycle platform, Enabling technologies as a platform. Introduction to Google Apps Engine, Other Google Infrastructure Services and Development Stack, Microsoft Azure: Windows Azure, Microsoft .NET Services, Microsoft SQL Services. **(8)**

Software as a Service (SaaS): Origin of SaaS, SaaS Market, Features of SaaS, Economies of SaaS, Categories of SaaS, Packaged software, Collaborative software, Enabling and management tools. Building a SaaS Application. **(6)**

Other Issues related with the Cloud: Security, Trust Issues, Data Centre Issues, Energy Considerations, Cloud Laws and Cloud Regulations, Myths related with the Cloud, Differences between Grid and Cloud Computing, Virtualisation and Cloud, Characteristics of Virtualisation, Hypervisors and their types, Hardware abstraction, Issues with Virtualisation, Provisioning Softwares, Hardware provisioning and Storage, Security Issues with Virtualisation, Costs with the Cloud, NIST Standard Cloud Architecture, Cloud Computing in India, Data Archiving, Metadata Sorting, Resource Provisioning and Other Issues, Possible Solutions to Problems. **(10)**

Recommended Books

1. Judith Hurwitz, "Cloud Computing For Dummies", For Dummies, 2009.
2. Barrie Sosinsky, "Cloud Computing Bible", Wiley, 2011.
3. John Rhoton, "Cloud Computing Explained: Implementation Handbook for Enterprises", Recursive Press, 2009.
4. George Reese, "Cloud Application Architectures: Building Applications and Infrastructure in the Cloud", O'Reilly Media, 2009.
5. Rajkumar Buyya, James Broberg, Andrzej M. Goscinski (Eds.), "Cloud Computing: Principles and Paradigms", Wiley, 2011.

EC-539	Adaptive Signal processing	[3 0 0 3]

Course Objectives

The objective of this subject is to provide introduction to the concepts, key issues and motivating examples for adaptive filters; Discrete time linear systems and filters; Random variables and random processes, covariance matrices; Z transforms of stationary random processes.Optimum discrete time Wiener filter; Principle of orthogonality and canonical forms; Constrained optimisation; Method of steepest descent - convergence issues; Least squares and recursive least squares. Linear Prediction - Forward and backward linear prediction; Levinson Durbin; Lattice filters.

Course Contents

Discrete Random Processes: Random variables, Random processes, filtered random processes, ensemble averages, correlation, covariance, power spectrum, cross power spectrum, ergodicity, time averages, biased and unbiased estimators, consistent estimators. **(12)**

Linear Prediction & Wiener Filtering: Direct form linear prediction filtering, normal equations for linear prediction filtering, levinson algorithm, linear prediction lattice filtering, Wiener smoothing and prediction filters, application of wiener smoothing to noise cancellation, application of wiener prediction filters, constrained linear MMSE filtering, minimum variance beam forming. **(12)**

Least Mean Squares Adaptive Filters & Orthogonal Adaptive Filters: LMS adaptive algorithm, properties of LMS adaptive filter, normalized forms, finite precision effects, adaptive beamforming, frequency domain adaptive filters, adaptive lattice filters. **(8)**

Least Squares adaptive Filters & Other adaptive filtering techniques: Godard algorithm, lattice, neural networks and multi-layer perceptrons, adaptive IIR filtering, constant modulus algorithm **(8)**

Recommended Books

1. S. Haykin, "Adaptive filter theory" Prentice-Hall, 4th edition, 2001.
2. Ali H. Sayed, "Fundamentals of Adaptive Filtering" John Wiley , 2003.
3. D.Manolakis, V.Ingle,S.Kogan, "Statistical and Adaptive Signal Processing : Spectral Estimation, Signal Modeling, Adaptive Filtering and Array Processing" McGraw Hill, 1999.
4. J. Triechler, C. Johnson, M. Larimore, "Theory and Design of Adaptive Filters" Prentice-Hall, 1995.
5. P.Diniz, "Adaptive Filtering : Algorithms and Practical Implementation" Kluwer 1997.

EC-540	**Advanced Embedded Processor**	**[3 0 0 3]**

Course Objectives

The purpose of this course is to introduce few embedded systems and differences between embedded systems and general purpose systems. To introduce different peripheral interfaces to embedded systems. To apply knowledge gained in software-hardware integration in team-based projects. Understanding of various real time software

Course Contents

Study of advanced microcontroller system designs with an emphasis on multi-tasking, Embedded system evolution trends , RISC versus CISC, Multimedia and DSP, Single-processor & Multi-Processor Architectures, Introduction to ARM architecture, Programming model, Instruction set, Onchip device peripherals, Embedded / RTOS concepts, Multiprocess and task, Task states and TCB, Interrupt handling and latency, Interprocess communication, OS service, Overview of RTOS RTLinux, VxWorks, MicroC/OS. **(40)**

Recommended Books

1. David. E. Simon, "An Embedded Software Primer", Pearson Education, 2001.
2. Muhammad Shafique, Jörg Henkel, "Hardware/Software Architectures for Low-Power Embedded Multimedia Systems" Springer, 2011.
3. Steve Furber, "ARM System-on-Chip Architecture (2nd Edition)" Pearson Education Limited, 2000.
4. Maurice Herlihy, NirShavit, "The Art of Multiprocessor Programming" Elsevier, Morgan Kauphann Publishers, 2008.
5. Rajkamal, "Embedded system Architecture programming and Design" Mc Graw hill, Second edition, 2009.

EC-561	Game Theory	[3 0 0 3]

Course Objectives

By the end of this course the things will be learnt are: Grasp, or recognize, real situations where game theory can be enlightening, Abstract a real situation into game theoretic formalism, Manipulate the formalism via game theory to reveal insights, and explain your insights in terms of the real situation.

Course Contents

Introduction to Game theory: What is Game theory? Where did games theory come from? Why isGame theory relevent to wireless communication and networking? Proper use of game theory? Introduction to example: Power control, Routing, Trust management. **(10)**

Decision Making and Utility Theory: Preference relationships, Existence of ordinal utility representation: Finite X, Countable X,Uncountable X, Uniqueness of utility Functions, The von Neumann- Morgenstern Axioms. **(10)**

Strategic From Games: Defination of strategic Form games, dominated Strategies and iterative deletion of dominated Strategies , mixed Strategies . Nash Equilibrium: Dealing with mixed Strategies , decision of Nash Equilibrium. Exiestence of Nash Equilibria. **(12)**

Role of pricing: Application of game theory, Pricing of Network Resources, Flow control. Case studies for engineering and management applications. **(8)**

Recommended Books

1. Allen B. MacKenzia and Luiz A. Dasilva , "Game theory for wireless Engineers" A publication in the Morgan and claypool Publisers, 2006.
2. Shaun P. Hargreaves- Heap and Yanis Varoufakis , " Game Theory A critical Introduction" Taylor and Francis group Publication ,2004.
3. Edward C. Rosenthal, "Game Theory The Fascinating math behind decision Making" Marie Butler Knight Publisher 2011.
4. William Poundstone, "Game theory in everyday Life" Published by Basic books, 2008.

EC-562	Image Processing	[3 0 0 3]

Course Objectives

The primary goal of this course is to lay a solid foundation for students to study advanced image analysis topics such as computer vision systems, biomedical image analysis.This course provides an introduction to basic concepts, methodologies and algorithms of digital image processing focusing on the following two major problems concerned with digital images: (1) image enhancement and restoration for easier interpretation of images, and (2) image analysis and object recognition. Some advanced image processing techniques (e.g., wavelet and multi-resolution processing) will also be studied in this course.

Course Contents

Digital Image Fundamentals: Digital Image Processing: Definition, Fundamental Steps in Digital Image Processing, Components of an Image Processing System, Elements of visual perception – Image sampling and Quantization, Basic relationship between pixels – Basic geometric transformations - Introduction to Fourier Transform and DFT – Properties of 2D Fourier Transform – FFT – Separable Image Transforms -Walsh – Hadamard – Discrete Cosine Transform, Haar. **(12)**

Image Enhancement Techniques: Spatial Domain methods: Basic grey level transformation, Histogram Equalization, Image Subtraction, Image averaging, Spatial filtering: Smoothing, sharpening filters – Laplacian filters, Frequency domain filters: Smoothing – Sharpening filters, Homomorphic filtering. **(9)**

Image Restoration: Model of Image Degradation/restoration process, Noise models, Inverse filtering, Least mean square filtering, Blind image restoration, Singular value decomposition. **(8)**

Image Compression and Segmentation: Lossless compression: Variable length coding, LZW coding, Bit plane coding, Predictive coding-DPCM, Lossy Compression: Transform coding, Wavelet coding, Basics of Image compression standards: JPEG, MPEG, Edge detection, Thresholding, Region Based segmentation. **(11)**

Recommended Books

1. R. C. Gonzalez and R. E. Woods, “Digital Image Processing”, Pearson Education, 2002.
2. G. A. Baxes, “Digital Image Processing” John Wiley, 1994 (Int. Ed.).
3. R.J. Schalkoff, “Digital Image Processing and Computer Vision” John Wiley, 1989.
4. Sid Ahmed, “Image Processing” McGraw -Hill, 1994.
5. William K Pratt, “Digital Image Processing” John Willey, 2001.
6. Millman Sonka, Vaclav hlavac, Roger Boyle, “Image Processing Analysis and Machine Vision” Broos/colic, Thompson Learning, 1999.
7. A. K. Jain, “Fundamentals of Digital Image processing” PHI, 2002.
8. Chanda Dutta Magundar, ”Digital Image Processing and Applications” Prentice Hall of India, 2000.

EC-563	VLSI Technology and Process Modelling	[3 0 0 3]

Course Objectives

This course follows a top to bottom approach , starting with a complete process flow for both CMOS and advanced bipolar technologies. The idea is to introduce at an early stage to the complexities and challenges associated with VLSI chip fabrication. Discussions on the unit steps will follow in greater detail in the context of the complete CMOS and bipolar process flow. This course aims at gaining a better understanding of both the constituent processes and the global picture of VLSI manufacturing.

Course Contents

Environment for VLSI Technology: Clean room and safety requirements, Wafer cleaning process and wet chemical etching techniques. **(3)**

Impurity incorporation: Solid state diffusion modelling and technology, Ion implantation modelling, technology and damage annealing, Characterization of impurity profiles. **(5)**

Oxidation: Kinetics of Silicon dioxide growth both for thick, thin and ultrathin films, Oxidation technology in VLSI, characterization of oxide films, high K and low k dielectrics for ULSI. **(5)**

Lithography: Photolithography, E-beam lithography and newer lithography techniques for VLSI, Mask generation. **(4)**

Chemical vapour deposition techniques: CVD techniques for deposition of polysilicon Silicon dioxide, Silicon nitride and metal films, epitaxial growth of Silicon, modelling and techniques. **(6)**

Metal film deposition: Evaporation, sputtering techniques, Failure mechanisms in metal interconnects, multi level and metallization schemes. Bonding, encapsulation, isolation techniques; junction, oxide, V groove, trench, SOI, SOS, Modern processing techniques. **(8)**

Plasma and Rapid thermal processing: Plasma etching and RIE techniques, RIBE, LPCVD, PECVD, laser enhanced CVD, EB, IB and X-ray lithography, Pattern generation techniques, Bipolar IC processing, MOS/CMOS processing; Modern trends in IC processing, Process modelling of unit processes, Introduction to process simulators. **(9)**

Recommended Books

1. S M Sze, G S May, "Fundamentals of semiconductor fabrication" Wiley, 1st Ed. 2004.
2. S. Wolf, "The Submicron MOSFET, volume 3 of Silicon Processing for the VLSI Era" Lattice Press, 1995.
3. Carver Mead and Lynn Conway, "Introduction to VLSI Systems", BS Publications, Indian Reprint,1st edition, 2003.
4. Neil H. E. Weste & Kamran Eshraghian, "Principles of CMOS VLSI Design", Pearson education asia, 2nd edition, 2004.
5. Wayne Wolf, "Modern VLSI Design" Pearson Education, 4th Indian Reprint, 2005.
6. S K Gandhi "VLSI fabrication Principles" John Wiley Inc., New York,2nd edition 1983.
7. James D. Plummer, M. D. Deal, P. B. Griffin "Silicon VLSI Technology, Fundamentals, Practice and modelling", Prentice Hall, 1st edition July 2000.

EC-564	Reconfigurable Computing	[3 0 0 3]

Course Objectives

This course is designed to offer an introduction in the theory and engineering design principles of the modern Reconfigurable Computing Systems (RCS). The emphasis is in understanding of the concepts of architecture reconfigurability, programmable logic devices and optimization of the RCS architecture to the task algorithm and data structure.

Course Contents

Device architectures: FPGA architectures, Logic, Array , Interconnect, Extending logic, configuration SRAM, Antifuse, Flash, Case Study**:** **(10)**

CAD for FPGAs: Overview, LUT mapping, timing analysis, placement and routing. **(8)**

Reconfigurable Computing Architectures: Reconfigurable devices-from fine-grained to coarse-grained devices, RPF integration into traditional computing system, Reconfiguration architectures, Single contex, Multi Contex, Parallel Reconfigurable, Pipeline Reconfigurable. **(13)**

Reconfigurable Management: Configuration Grouping, Configuration Caching, Configuration Scheduling, Software-based Relocation and Defragmentation, Context Switching. Reducing Configuration Transfer Time. **(11)**

Recommended Books

1. Scott Hauck and Andre DeHon "Reconfigurable Computing" Morgan Kaufmann, imprint of Elsevier Publisher, 2008.
2. Uwe Meyer-Baese, "Digital Signal Processing using Field Programmable Gate Arrays" Springer 2001.
3. Oppenheim, Schafer and Buck, "Discrete-Time Signal Processing" 2nd edition, Prentice Hall, 1999.
4. Svetlana P. Kartashev , Steven I. Kartashev, "Designing and Programming Modern Computer Systems, vol. II, Supercomputing Systems : Reconfigurable Architectures", prentice-Hall, 1989.
5. Maya Gokhale, Paul S. Graham, "Reconfigurable Computing: Accelerating Computation with Field-Programmable Gate Arrays", illustrated Edition, Springer Birkhauser, 2005.

EC-565	Semiconductor Device Modelling	[3 0 0 3]

Course Objectives

The purpose of this course is to extend knowledge on bipolar devices to include the influence of recombination .To investigate the physical mechanisms underlying the delays and speed limitations of the devices and to extract equivalent circuit models for the devices. The student will be able to explain qualitatively the mechanisms of electronic conduction in bipolar devices, and calculate relevant quantities from given data.

Course Contents

Physics and Properties of Semiconductors: P-N Junction, Bipolar transistor, State-of-the-Art Bipolar Transistor Technology, Metal-Semiconductor Contacts, Metal-Oxide-Silicon System, MOS Field-Effect Transistor, State-of-the-Art MOS Technology. Compact models for MOSFET and their implementation on SPICE. Level 1, 2 and 3, MOS model parameters in SPICE. **(22)**

UDSM Transistor Design Issues: Short channel and ultra shot channel effects; Effect t_{ox}, effect of high k and low k dielectrics on the gate leakage and Source- drain leakage; tunneling effects; different gate structures in UDSM-impact and reliability challenges in UDSM**.** **(18)**

Recommended Books

1. R.S. Muller and T.I. Kamins, "Device Electronics for Integrated Circuits" Wiley,
2. R. F. Pierret, Addison, "Semiconductor Device Fundamentals" Wesley, 1996.
3. S M Sze, "Physics of Semiconductor Devices", Wiley, 2nd edition.
4. S M sze,G S May, "Fundamentals of semiconductor fabrication" Wiley.
5. Y.P. Tsividis, "The MOS transistor", McGraw-Hill, International edition, 1988.

EC-566	Integrated Circuit Technology	[3 0 0 3]

Course Objectives

The purpose of this course is to familiarize the students with the basic principles of modern Integrated Circuits Technology. This course discusses the fabrication of CMOS Integrated circuits, basic CMOS technologies and various failure issues.

Course Contents

Introduction to IC components: Circuit and System Representation - behavioral, structural and physical representations, Analysis and design of basic logic circuits. **(10)**

Circuit Characterization: Resistance estimation, Capacitance estimation, Switching characteristics, Analytic delay models, Scaling of MOS transistor dimensions. **(10)**

Fabrication of CMOS Integrated Circuits: Overview of silicon semiconductor technology, Basic CMOS Technology- Basic n–well CMOS process, P-well process, Twin-Tub process, Silicon-on-Insulator process, CMOS process enhancements-Interconnects and circuit elements, Latch-up-Physical origin, Triggering, Prevention techniques, Technology-related CAD issues Spacing and dimension checks, Circuit extraction. **(15)**

Reliability: Failure, yield and reliability of ICs. **(5)**

Recommended Books

1. R.S. Muller and T.I. Kamins, "Device Electronics for Integrated Circuits" Wiley, 1986.
2. DA. And Eshrachian K, "Basic VLSI design systems & circuits" PHI, 1988.
3. Geigar BR, Allen PE & Strader ME, "VLSI design techniques for Analog & Digital circuit" Mc Graw Hill, 1990.
4. Carver Mead and Lynn Conway, "Introduction to VLSI Systems" BS Publications, Indian Reprint 2003.
5. Neil H. E. Weste & Kamran Eshraghian, "Principles of CMOS VLSI Design" 2nd edition, Pearson education Asia.

EC-567	Neural Networks and Fuzzy Systems	[3 0 0 3]

Course Objectives

The principal objective of this subject is to introduce students to neural networks and fuzzy theory from an engineering perspective. In the identification and control of dynamic systems, neural networks and fuzzy systems can be implemented as model-free estimators and/or controllers. This subject is helpful to explore the functional components of neural network classifiers or controllers, and the functional components of fuzzy logic classifiers or controllers. This course will also discuss to develop and implement a basic trainable neural network or a fuzzy logic system for VLSI, computing application or biomedical application.

Course Contents

Neural Networks: Neurons and neural networks, basic models of artificial neural networks: simple layer perception, feed forward multilayer perceptron, Hopfield networks, competitive learning networks, applications of neural networks for matrix algebra problems, adaptive filtering and adaptive pattern recognition, dynamic system identification, dynamic system modelling using recurrent neural networks, approximation/optimization problems, VLSI implementation of neural networks. **(20)**

Fuzzy Systems: Basic concepts of Fuzzy logic, Fuzzy vs. Crisp set, Linguistic variables, membership functions, operations of Fuzzy sets, Fuzzy if-then rules, Variables inference techniques, defuzzification techniques, basic Fuzzy interference algorithm, application of fuzzy logic, Fuzzy system design implementation, useful tools supporting design. Type-2 fuzzy logic systems. **(20)**

Recommended Books

1. Simon Haykin, "Neural Networks and Learning Machines", PHI, 2009.
2. Laurene V Fausett, "Fundamentals of Neural Networks: Architectures, Algorithms And Applications", Prentice Hall, 1993
3. Sandaya Samarasinghe, "Neural Networks for Applied Sciences and Engineering: From Fundamentals to Complex Pattern Recognition", Auerbach Publications, 2006.
4. George J. Klir, "Fuzzy Sets and Fuzzy Logic: Theory and Applications", PHI, 1995
5. John Yen, Reza Langari, "Fuzzy Logic: Intelligence, Control, and Information", PHI, 1998.
6. Oscar Castillo, Patricia Melin, "Type-2 Fuzzy Logic: Theory and Applications", Springer, 2010.

EC-568	Digital Signal Processors	[3 0 0 3]

Course Objectives

The course objective is to study fundamentals of digital signal processing, various issues involved in DSP processor designing, to make students familiar with popular processors used by industry specially Texas Instruments processors architecture, to use Code Composer Studio for developing applications for Texas Instruments embedded processors and most important to study application of the DSP processors in spectral analysis, FIR/IIR filter, linear-predictive coding, etc

Course Contents

Review of Digital Signal Processing fundamentals. Issues involved in DSP processor design - speed, cost, accuracy, pipelining, parallelism, quantization error, etc. Key DSP hardware elements - Multiplier, ALU, Shifter, Address Generator, etc. Popular processors family architecture from Texas Instruments, Rapid Design and Prototyping of DSP Systems, Code Composer Studio. Applications using DSP Processor - spectral analysis, FIR/IIR filter, linear-predictive coding, etc. **(40)**

Recommended Books

1. Kuo, Digital Signal Processors: Architectures, Implementations, and Applications, Prentice Hall, 2004.
2. Kuo, Real-Time Digital Signal Processing: Implementations and Applications, Wiley, 2006
3. Nasser Kehtarnavaz, Real-Time Digital Signal Processing: Based on the TMS320C6000, Newnes, 2004
4. Rulph Chassaing, DSP Applications Using C and the TMS320C6x DSK, Wiley Interscience, 2002
5. Application Notes and Product Brochures from Texas Instruments (www.ti.com).
6. Rulph Chassaing, DSP Applications Using C and the TMS320C6x DSK, Wiley-Interscience, 2002.
7. Sen M. Kuo and Woon-Seng S. Gan, Digital Signal Processors: Architectures, Implementations, and Applications, Prentice Hall, 2004.
8. Andy Bateman, Iain Paterson-Stephens, The DSP Handbook: Algorithms, Applications and Design Techniques, Prentice Hall, 2002.

EC-569	Sensor Technologies and MEMS	[3 0 0 3]

Course Objectives

Objective of this course is to teach students the principles of working of all types of sensors and transducers which form the components of all instrumentation systems. Students shall have a detailed understanding of characteristics of the sensors and transducers and various processes employed to fabricate those devices. The student shall be able to incorporate these concepts to find applications for the given sensors. This course shall introduce the student to the existing designs, principles and applications and shall enable them to be able to contribute to the ongoing innovations in the field of sensor design, fabrication and applications with the help of case studies.

Course Contents

Introduction: Basics of Micro technology, lithography, etching techniques, principle of bulk surface micromachining: subtractive processes, additive processes (evaporation, sputtering, epitaxial growth).Devices and processes, Multi user MEMS process (MUMPs), SUMMiT :design rules, applications, microhinges and development actuators, CMOS MEMS, clean room lab techniques, microoptoelectromechanical systems (MOEMS), Bio MEMS and biomaterials. **(18)**

Sensors types and classification: Mechanical, acoustic, electromagnetic, thermal, chemical, radiation and biosensors. Microsensors. Sensors based on surface-acoustic wave devices. Micromachining techniques MEMS for automative, communication and signal processing applications, Modeling and simulation of microsensors and actuators. Sensors and smart structures. Micro-opto-electro-mechanical sensors and system. **(12)**

Application case study : MEMS Scanner and Retinal Scanning Display (RSD), Grating Light Valve (GLV), Digital Micromirror Devices (DMD), Optical switching, capacitive micro-machined ultrasonic Transducer (CMUT). **(10)**

Recommended Books

1. Ristic L, “Sensor Technology and Devices”, Artech House, London,1994.
2. Sze S.M ,“Semiconductor Sensors”, John Wiley, New York, 1994 .
3. WiseK.D., “Integrated Sensors, Microp-actuators and micro-systems (MEMS)”, Special Issue of proceedings of IEEE, Vol. 86, No.8, August 1998.
4. Mohamed Gad-el-Hak, ,”The MEMS Handbook”, CRC Press, Baco Raton,2001.
5. Gregory T.A.,Kovacs “Micromachined Transducers Sourcebook”, WCB McGraw-Hill, 1998.

EC-570	Cluster and Grid Computing	[3 0 0 3]

Course Objectives

The purpose of this course is to introduce students to the fundamentals of cluster computing and grid computing. Students shall be able to compare and contrast the cluster and grid computing and shall be able to use parallel programming techniques for the target applications. The student shall be well equipped to use the existing architectures and techniques and shall be in a position to innovate further the existing techniques in grid and cluster computing.

Course Contents

Cluster Computing: An overview of Beowulf Cluster Computing, Definition and Taxonomy, Opportunities and Advantages, Elements of a Cluster, Node Hardware, Why Linux for a Beowulf Cluster, Interconnect Technologies, Software, Setting up and Configuring Clusters, Parallel Programming with MPI, Job Scheduler, Cluster Management, Applications **(20)**

Grid Computing: Introduction, Grid versus other distributed systems, Motivations for using a Grid, Grids and Grid Technologies, Programming models and Parallelization Techniques, Standard application development tools and paradigms such as message-passing and parameter parallel programming, Grid Security Infrastructure, Data Management, Application Case Studies, Resource management and scheduling, Setting up Grid, deployment of Grid software and tools, and application execution. **(20)**

Recommended Books

1. Thomas Sterling, "Beowulf Cluster Computing with Linux", MIT Press, 2001.
2. Peter Pacheco, "Parallel Programming with MPI", Morgan Kaufmann, 1996.
3. Frederic Magoules, Jie Pan, Kiat-An Tan, Abhinit Kumar, "Introduction to Grid Computing", CRC Press, 2009.
4. Borja Sotomayor, Lisa Childers, "Globus® Toolkit 4 : Programming Java Services", Morgan Kaufmann, 2005.
5. Ian Foster, Carl Kesselman (Eds), "The Grid 2: Blueprint for a New Computing Infrastructure", Morgan Kaufmann, 2003.

EC-571	GPU Computing	[3 0 0 3]

Course Objectives

The purpose of this course is to introduce and teach students the fundamentals of graphics processing unit (GPU). To learn the programming skills of GPU using CUDA and OpenCL programming models using various tools and libraries available. Student shall have an understanding of the architectural details of the GPU. Student shall be able to program and use the GPU efficiently while having a complete knowledge of its architectural details.

Course Contents

Introduction to GPU Basics: Introduction to trends in graphics processing unit (GPU) hardware, progression of NVIDIA GPUs, background information & history on GPGPU (general purpose GPU) computing, hardware considerations in GPU design, General Purpose GPU computing community & resources, CUDA programming basics, CUDA programming model and terminology, Asynchronous CPU/GPU compute model, Work flow for a GPU computation, Allocating storage arrays on the GPU device, Transferring data between host and device, The CUDA thread hierarchy, Invoking a CUDA kernel through special syntax. **(13)**

Memory Hierarchy, Optimizations and Libraries: A simple CUDA kernel to add two vectors together, Catching CUDA errors, Timing CUDA kernels, How to compile and link CUDA programs using the nvcc compiler, Non-uniform memory architecture of GPGPU devices, Overview of NVIDIA's CUDA Toolkit, the nvcc compilation chain and intermediate compiler files, Debugging kernels with the NVIDIA's CUDA gdb debugger, Profiling CUDA kernels with NVIDIA's Visual Profiler. **(8)**

Programming Tools and Math Libraries: Building blocks for high-performance computing, CUDA Programming Tools, Profiling tools, Debugging tools and strategies, Standard libraries**. (7)**

Background to OpenCL: OpenCL standard for heterogeneous computing on multicore architectures, CUDA vs. OpenCL (syntax, functionality, terminology, memory models), CUDA vs. OpenCL case examples. **(12)**

Recommended Books

1. David B. Kirk, Wen-mei W. Hwu, "Programming Massively Parallel Processors: A Hands-on Approach", Morgan Kaufmann, 2010.
2. Jason Sander, "CUDA by Example: An Introduction to General-Purpose GPU Programming", Addison-Wesley Professional, 2010.
3. Rob Farber, "CUDA Application Design and Development", Morgan Kaufmann, 2011.
4. Benedict Gaster, "Heterogeneous Computing with OpenCL", Morgan Kaufmann, 2011.

EC-572	Advanced Computer Networks	[3 0 0 3]

Course Objectives

This course will provide the basic introduction of reference models such as OSI and TCP/IP model. The objective of this course is to make the students familiar with various network types and topologies. This course focuses onnetworking & internetworking and provides introduction of operating system support.

Course Contents

Introduction to Computer Networks: Reference models: OSI model, TCP/IP model, Comparison of TCP/IP and OSI models, Types of data transmission, error detection and correction, multiple access protocols. **(8)**

Network Types and Topologies: LANs, WANs, others and hybrids, Ethernet, Token Bus, Token Ring; Star, Ring, Bus, Other. Network Hardware: Wiring, Network Interface Cards, Hubs, Routers, Switches. Introduction to Novell netware, and ARPANET. **(8)**

Introduction to Distributed Systems: Characteristics of distributed Systems, examples, resource sharing, system models, architectural fundamentals: Basic concepts, Client-server Model, Cooperation between client and servers, Extension to the client Server model: Mobile agents, proxy servers **(8)**

Networking and internetworking: Network types, principles, IP delivery review, options and encapsulation. IPv4 Vs. IPv6 .Inter process communication: external data representation, client server communication, group communication. **(8)**

Operating system support: Operating system layers, protection, process and threads, O.S. Architecture. **(8)**

Recommended Books

1. Andrew S. Tanenbaum, "Computer Networks" 2nd edition, PHI, 1988.
2. James Martin, "Computer network and Distributed processing" Prentice-Hall, Englewood Cliffs,NJ, 1981.
3. Doug Lowe,"Networking All-in-One For Dummies" (Kindle Edition) 4th Edition,Wiley Publishing ,2010.
4. Andrew S. Tanenbaum ,"Modern Operating Systems" 3rd Editio, Prentice Hall of India,2007.
5. Weijia Jia, Wanlei Zhou Distributed Network Systems: From Concepts to Implementations (Network Theory and Applications) Springer science + business media, Inc. 2005.

EC-573	Evolutionary Algorithms for Engineering Design	[3 0 0 3]

Course Objectives

Evolutionary algorithms are very powerful techniques used to find solutions too many real-world search and optimization problems. Many of these problems have multiple objectives, which leads to the need to obtain a set of optimal solutions, known as effective solutions. This course provides an introduction to optimization and its various categories; understanding of various nature inspired optimization methods with applications, principles and concepts of multi-objective optimization for engineering design, and familiarizes students with high performance computing paradigms for evolutionary design

Course Contents

Introduction to Optimization: What is optimization, categories of optimization, minimum seeking algorithms. **(8)**

Natural Optimization Methods: Simulated annealing, evolutionary algorithms (GAs, EP, ES, GP, PSO, BBO etc.), a simple evolutionary algorithm, Selection Schemes, Crossovers, Mutation, Applications. **(8)**

Multi-Objective Evolutionary Optimization: Multi-Objective Optimization Problem, Principles of Multi-Objective Optimization, Difference with Single-Objective Optimization, Dominance and Pareto-Optimality, Some applications of Multi-Objective Evolutionary Algorithms. **(8)**

High Performance Computing for Evolutionary Algorithms: Some HPC paradigms viz. Cluster computing, GPU computing **(8)**

Some Case Studies for Engineering Design **(8)**

Recommended Books

1. Kalyanmoy Deb, "Multi Objective Optimization using Evolutionary Algorithms", John Wiley and Sons, 2001.
2. David A Coley, "An introduction to Genetic Algorithms for Scientists and Engineers", World Scientific Publishing Company, 1997.
3. Mitsuo Gen, Runwei Cheng, "Genetic Algorithms and Engineering Design", Wiley-Interscience, 1997.
4. Thomas Back, "Evolutionary Algorithms in Theory and Practice: Evolution Strategies, Evolutionary Programming, Genetic Algorithms", Oxford University Press, 1996.
5. William B. Langdon, Riccardo Poli, "Foundations of Genetic Programming", Springer, 2010.

EC-574	Advanced Computer Architecture	[3 0 0 3]

Course Objectives

This course will help students to achieve the following objectives:
1. Describe the principles of computer design and classify instruction set architectures.
2. Describe the operation of performance enhancements such as pipelines, dynamic scheduling, branch prediction, caches, and vector processors.
3. Describe the operation of virtual memory, modern architectures such as RISC, Super Scalar, VLIW (very large instruction word), and multi-core and multi-CPU systems.

Course Contents

Parallel computer models: The state of computing, Classification of parallel computers, Multiprocessors and multicomputer, Multivector and SIMD computers. **(4)**

Program and network properties: Conditions of parallelism, Data and resource Dependences, Hardware and software parallelism, Program partitioning and scheduling, Grain Size and latency, Program flow mechanisms, Control flow versus data flow, Data flow Architecture, Demand driven mechanisms, Comparisons of flow mechanisms. **(8)**

System Interconnect Architectures: Network properties and routing, Static interconnection Networks, Dynamic interconnection Networks, Multiprocessor system Interconnects, Hierarchical bus systems, Crossbar switch and multiport memory, Multistage and combining network. **(6)**

Advanced processors: Advanced processor technology, Instruction-set Architectures, CISC Scalar Processors, RISC Scalar Processors, Superscalar Processors, VLIW Architectures, Vector and Symbolic processors. **(7)**

Pipelining: Linear pipeline processor, nonlinear pipeline processor, Instruction pipeline Design, Mechanisms for instruction pipelining, Dynamic instruction scheduling, Branch Handling techniques, branch prediction, Arithmetic Pipeline Design, Computer arithmetic principles, Static Arithmetic pipeline, Multifunctional arithmetic pipelines. **(7)**

Multiprocessor architectures: Symmetric shared memory architectures, distributed shared memory architectures, models of memory consistency, cache coherence protocols (MSI, MESI, MOESI), scalable cache coherence, overview of directory based approaches, design challenges of directory protocols, memory based directory protocols, cache based directory protocols, protocol design tradeoffs, synchronization. **(8)**

Recommended Books

1. Kai Hwang, "Advanced computer architecture"18th reprint, TMH,2003.
2. D. A. Patterson and J. L. Hennessey, "Computer organization and design," 4th edition, Morgan Kaufmann
3. J.P.Hayes, "computer Architecture and organization" 2nd Edtion; MGH, 1988.
4. Harvey G. Cragon, "Memory System and Pipelined processors" Narosa Publication, 1996.
5. V.Rajaranam & C.S.R.Murthy, "Parallel computer" PHI.
6. R.K.Ghose, Rajan Moona & Phalguni Gupta, "Foundation of Parallel Processing" Narosa Publications.

EC-575	Solid State Circuits	[3 0 0 3]

Course Objectives

It provide overview of principles, operations and applications of analog and digital building blocks for performing various functions and relies on elementary treatment, qualitative analysis and makes use of simple models.

Course Contents

Analog Circuits: OPAMP design techniques and performance characteristics, OPAMP instrumentation in low and high power circuits, Applications of Operational Amplifiers, Filters and Precision Diode, Schmitt Trigger and Relaxation Oscillator, Phase lock techniques; PLL design parameters and systems; Analog multipliers and modulators. **(20)**

Digital Circuits: Introduction to different logic families, Bipolar, CMOS and BICMOS logic; CVSL, domino, C2MOS, pass transistor logic, low voltage low power circuits. **(10)**

Sequential Logic circuits and their applications, Memory: Read-only memory, read/write memory - SRAM and DRAM. **(10)**

Recommended Books

1. R.S. Muller and T.I. Kamins, "Device Electronics for Integrated Circuits",2nd edtion,Wiley,1986.
2. S. Wolf, "The Submicron MOSFET, volume 3 of Silicon Processing for the VLSI Era" Lattice Press.
3. Carver Mead and Lynn Conway, "Introduction to VLSI Systems" BS Publications, Indian Reprint 2003.
4. Neil H. E. Weste & Kamran Eshraghian, "Principles of CMOS VLSI Design", 2nd edition, 9th Indian reprint, Pearson education Asia, 2003.

EC-576	Digital Voice and Picture Communication	[3 0 0 3]

Course Objectives

To present the fundamentals of modern digital voice and picture communication system design and to evaluate the performance of digital signaling schemes on realistic communication channels. Emphasis is placed on physical layer digital communications, including waveform design and receiver design. Analyze the error performance of digital modulation techniques.

Course Contents

Introduction: Digital speech communication; Digital TV communication; Characteristics of speech signals; Characteristics of picture signals; Subjective and objective testing; Bit rates in speech and picture communication CCITT recommendations for speech digitization; HDTV, Low resolution TV and Videoconferencing requirements. **(14)**

Time domain waveform: Coding of speech-PCM, DPCM, ADPCM, DM and sub band coding; Frequency domain waveform coding of speech-LTC, ATC. **(10)**

Parameter: Coding of speech-channel, format and LPC vocoders; Coding of monochrome and colour video signals-Transform and Adaptive transform coding; Subband coding; Vector quantization; Interframe and Hybrid coding; Delayed decision and run length coding; Effects of transmission errors; Audio and Video conferencing; Video telephone. **(16)**

Recommended Books

1. John R. Barry, Edward A. Lee, and David G. Messerschmitt, **"**Digital Communication" 3rd edition, Springer, 2004.
2. Arun N. Netravali and Barry G. Haskell, "Digital Pictures: Representation, Compression and Standards (Applications of Communications Theory)" 2nd edition, Plenum Press, 1995.
3. Walter S. Ciciora, James Farmer, David Large**,** "Modern Cable Television Technology: video, voice, and data communications**"** Morgan Kaufmann Publishers, 1999.
4. Walter S. Ciciora, "Modern Cable Television Technology: Video, Voice, and Data Communications", 2nd edition, Morgan Kaufmann, 2004.

EC-577	Fluctuation Phenomena in Microelectronics	[3 0 0 3]

Course Objectives

This course will give knowledge about to put much more emphasis on behaviour of devices upon process variation, its statistical mechanics of and much less emphasis on thermodynamics, yet to retain fundamental issues of the latter, like the significance of the thermodynamic potentials and basic relationships among them, area.

Course Contents

Stochastic variables of interest in physical electronics (e.g. carrier concentration, potential, barrier heights, mobility, diffusion constant, G-R time, avalanche coefficients etc.). Thermodynamic considerations. Manifestation of stochastic processes in physical electronics. Instrumentation **(40)**

Recommended Books

1. S M Sze, G S May, "Fundamentals of semiconductor fabrication" Wiley, 1st Ed. 2004.
2. S. Wolf, "The Submicron MOSFET, volume 3 of Silicon Processing for the VLSI Era" Lattice Press, 1995.
3. DA. and Eshrachian K, "Basic VLSI design systems & circuits" PHI, 4th Indian Reprint 2005 , 1988.
4. Geigar BR, Allen PE & Strader ME, "VLSI design techniques for analog & digital circuits" Mc Graw Hill, 2nd edition, 1990.
5. A.S. Grove "Physics and technology of semiconductor devices" John Wiley and Sons, 1st edition, 1967.
6. C Y Chang & SM Sze "ULSI Technology ", McGraw-Hill Companies Inc., 2nd edition, 1996.

EC-578	**Quantum Computing**	**[3 0 0 3]**

Course Objectives

The objective of this course is to introduce the basic ideas and mathematical machinery of quantum computing - a rapidly developing field that has the potential to revolutionize computer science and information theory. The idea is to describe several cutting-edge quantum algorithms and to discuss the relative merits of competing implementations of quantum computers. After completing this course, the students will be able to explain how a quantum computer works and to design simple quantum circuits and maybe even discover your own quantum algorithms.

Course Contents

Bits and qubits. Introduction to quantum states with motivating examples. Comparison with classical discrete state systems. Linear algebra. Review of linear algebra. Vector spaces, linear operators, Dirac notation. Quantum mechanics. Postulates of quantum mechanics. Evolution and measurement. Entanglement. Computation and algorithms. Models of quantum computation. Quantum circuits, finite state systems, machines and algorithms. Quantum complexity. Quantum complexity classes and their relationship to classical complexity. Comparison with probabilistic computation. **(40)**

Recommended Books

1. Nielsen, M.A. & Chuang, I.L., "Quantum computation and quantum information", Cambridge University Press, 2000.
2. Gruska, J., "Quantum computing", McGraw-Hill, 1999.
3. Kitaev, A.Y., Shen, A.H. & Vyalyi, M.N., "Classical and quantum computation", AMS, 2002.

EC-579	Testing and Fault Tolerance	[3 0 0 3]

Course Objectives

This course aims at providing the students with the knowledge of physical faults and their modelling, understanding of testing algorithms and their application in test pattern generation to combinational and sequential circuits.It also enables the students with the ability to analyze memory elements and study of algorithms used to generate test patterns for the same. The students will also learn about the design for testability concepts and fault tolerant systems.

Course Contents

Introduction: Physical Faults and their Modeling: Stuck-at Faults, Bridging Faults Fault Collapsing; Fault Simulation, Deductive, Parallel, and Concurrent Fault. **(12)**

Testing Algorithms: D-Algorithm, Boolean Difference, Podem Random, Deterministic and Weighted Random Test Pattern Generation Aliasing and its effect on Fault Coverage PLA Testing, Cross Point Fault Model and Test Generation. **(14)**

Memory Testing: Permanent, Intermittent and Pattern Sensitive Faults, Marching tests Delay Faults.ATPG for Sequential Circuits Time Frame Expansion; Controllability and Observability Scan Design, BILBO, Boundary Scan for Board Level Testing, BIST and Totally Self checking Circuits System level Diagnosis. **(16)**

Recommended Books

1. Laung-Terng Wang,Cheng-Wen, Wu,Xiaoqing Wen "VLSI Test principles and Architectures: Design for Testability",Morgan Kaufmaan,2006.
2. Mike Tien Chienlee, "High level Test Synthesis of Digital VLSI circuits", Artech House Boston London,2005.
3. Viswani D.Agarval Michael L.Bushnell, "Essentials of Electronic Testing for Digital Memory & Mixed Signal VLSI Circuit ", Kluwer Academic Publications, 1999.
4. Parag K. Lala "Digital Circuit Testing and Testability" Academic Press USA, 1997.
5. Parag K. Lala "An Introduction to Logic Circuit Testing" Morgan & Claypool Publishers, 2009.

EC-580	Process Characterization and Device Modelling	[3 0 0 3]

Course Objectives

The main purpose of this course is to introduce the students about the basics of semiconductor materials and various electronic instruments. The students will be able to learn about various types of imperfections and defects in semiconductor materials and also learn about the characterization of semiconductor materials. They will have the opportunity to learn about how to design optoelectronics integrated circuits and modeling of the devices.

Course Contents

Resistivity: Wafer mapping, two point versus four point probe, resistivity profiling (differential hall effect, spreading resistance profiling), contactless methods. **(6)**

Carrier Doping: Capacitance-voltage(C-V), current-voltage(I-V), optical techniques. Contact resistance and Schottky Barriers: metal-semiconductor contacts, measurement techniques, schottky barrier height. **(6)**

Defects: Generation-recombination statistics, deep-level transient Spectroscopy (DLTS), Carrier life time: recombination lifetime/surface recombination velocity, generation lifetime/surface generation velocity. **(7)**

Recombination lifetime: Optical measurements : photoconductance decay, quasi-steady state photoconductance,free carrier absorption, electron beam induced current, short circuit current/open circuit voltage decay. Recombination lifetime-electrical measurements: diode current-voltage, reverse recovery, open circuit voltage decay, pulsed MOS capacitor. Generation lifetime-Electrical measurements: gate-controlled diode, pulsed MOS Capacitor. **(11)**

Physical Characterization: Thin Film Thickness-Measurements-ellipsometry, surface profiling, spectrophotometry, FTIR Critical Dimension Measurements: Optical microscope, Scanning Electron Microscope, Transmission Electron Microscope Material and Impurity Characterization: SIMS, XRD, EDAX Electrical Characterization:, sheet resistance C-V measurements, DLTS, Carrier lifetime, impurity profiling, I-V measurements, Process and SPICE model parameter Extraction. **(10)**

Recommended Books

1. W.R. Reunyan, "Semiconductor Measurements and Instrumentation", Mc-Graw Hill, 2nd Edition, 1998.
2. Schroder, "Semiconductor Material And Device Characterization", 2nd edition, Wiley-Interscience, 2nd edition, 1998.
3. Philips F. Kare and Greydon B. Lauabee, "Characterization of semiconductor Materials", Mc-Graw Hill, 2nd edition, 2000.
4. K.V. Ravi, "Imperfections and Impurities In Semiconductor Silicon", John Wiley & Sons Inc., 1st edition, 1981.
5. Tor A. Fjeldly, Trond Ytterdal, Michael Shur "Introduction to device modeling and circuit simulation" Wiley, 3rd edition, 1998.
6. By Jianjun Gao "Optoelectronic Integrated Circuit Design and Device Modeling" Wiley, 2011.

EC-581	Memory Design and Testing	[3 0 0 3]

Course Objectives

The objective of this subject is to provide insights into the design of Static Random Access Memories (SRAMs); Dynamic Random Access Memories (DRAMs); Non-volatile Memories. This course also provides the different memory modelling and testing technique and also Semiconductor Memory Reliability and Radiation Effects.

Course Contents

Random Access Memory Technologies: Static Random Access Memories (SRAMs): SRAM Cell Structures-MOS SRAM Architecture-MOS SRAM Cell and Peripheral Circuit Operation-Bipolar SRAM Technologies-Silicon On Insulator (SOl) Technology-Advanced SRAM Architectures and Technologies-Application Specific SRAMs. **(10)**

Dynamic Random Access Memories (DRAMs): DRAM Technology Development-CMOS DRAMs-DRAMs Cell Theory and Advanced Cell Strucutures -BiCMOS DRAMs-Soft Error Failures in DRAMs-Advanced DRAM Designs and Architecture-Application Specific DRAMs **(8)**

Nonvolatile Memories: Masked Read-Only Memories (ROMs)-High Density ROMs-Programmable Read-Only Memories (PROMs)-Bipolar PROMs-CMOS PROMs-Erasable (UV) -Programmable Read-Only Memories (EPROMs)-Floating-Gate EPROM Cell-One-Time Programmable (OTP) EPROMS-Electrically Erasable PROMs (EEPROMs)-EEPROM Technology & Architecture-Nonvolatile SRAM-Flash Memories- Advanced Flash Memory Architecture. **(12)**

Memory Fault Modeling: Testing, And Memory Design For Testability And Fault Tolerance RAM Fault Modeling, Electrical Testing, Pseudo Random Testing-Megabit DRAM Testing-Nonvolatile Memory Modeling and Testing-IDDQ Fault Modeling and Testing-Application Specific Memory Testing. Semiconductor Memory Reliability and Radiation Effects. **(10)**

Recommended Books

1. A.K Sharma, "Semiconductor Memories Technology, Testing and Reliability", illustrated Edition, IEEE Press, 1997.
2. Gerald Luecke, Jack P. Mize, William N. Carr, "Semiconductor Memory design & application", illustrated Edition,Mc-Graw Hill, 1973.
3. Memory Technology design and testing, IEEE International Workshop on: IEEE Computer Society Sponsor (S), 1999.
4. Parag K. Lala ,"An Introduction to Logic Circuit Testing" Morgan & Claypool Publishers, 2009.
5. Viswani D.Agarval Michael L.Bushnell, "Essentials of Electronic Testing for Digital Memory & Mixed Signal VLSI Circuit" Kluwer Academic Publications, 1999.

EC-582	Hardware Description Languages	[3 0 0 3]

Course Objectives

The objectives of this course are to provide students with a working knowledge required to describe digital system designs in HDL at behavioural, register transfer, and structural (gate) levels; to validate and/or to verify through simulation, and to synthesize their designs to various target technologies. The hardware description language such as VHDL and Verilog HDL will be used in this course.

Course Contents

Basic concepts: Hardware description languages. Design phases, different style of modeling in HDL, Architecture of event driven simulators. Syntax and Semantics of VHDL. **(6)**

VHDL/Verilog Elements: Entity, Archicture, Process, Library, Packages, Generic, Data Type, Sub programs, Bus, Driver, Sequential Statements. **(9)**

VHDL/Verilog Object: Variable and signal,Constant types, arrays and attributes. Operators, expressions and signal assignments. Component instantiation. Concurrent and sequential constructs. Use of Procedures and functions. **(10)**

Operators: Expressions and signal assignments. Modules, nets and registers, Concurrent and sequential constructs. Tasks and functions, Examples of design using Verilog. Synthesis of logic from hardware description. Case Study and Mini Project. **(15)**

Recommended Books

1. Douglas Perry, "VHDL", McGraw Hill International (NY), The Institute of Electrical and Electronics Engineers, 1993
2. Navabi, "VHDL Analysis & Modeling of digital systems" McGraw Hill, 1998
3. S. Palnitkar, "Verilog HDL: A Guide to Digital Design and Synthesis" Prentice Hall (NJ, USA), 1996.
4. J. Bhaskar, "Verilog HDL Synthesis-A Practical Primer" Star Galaxy Publishing, Allentown, PA, 1998.

EC-583	System On Chip	[3 0 0 3]

Course Objectives

This course will help students to understand the System on Chip with its need, evolution, challenges, goals, superiority over system on board & stacked ICs in package. It will them comprehend the importance of integrating memory components in the SoC and need, selection criteria, types, principle of operation of different memory components (RAM Cache memories with coherency protocols, Flash memories). The students will be able to analyze how the on chip components are interconnected in a SoC and understand problems in using traditional bus based communication architecture and solve the problems imposed by bus based architecture using network on chip.

Course Contents

Introduction: Architecture of the present-day SoC - Design issues of SoC- Hardwar-Software Codesign – Core Libraries – EDA Tools. **(7)**

Design Methodology for Logic Cores: SoC Design Flow – guidelines for design reuse – Design process for soft and firm cores – Design process for hard cores – System Integration, SoC and Interconnect centric Architectures. **(9)**

Design Methodology for Memory and Analog Cores: Embedded memories – design methodology for embedded memories – Specification of analog circuits – High speed circuits. **(9)**

Design Validation: Core-Level validation – Core Interface verification - SoC design validation, SoC Component Emulation ,Co-Simulation, Physical Verification. **(8)**

Core and SOC Design Examples: Microprocessor Cores – Core Integration and On-chip bus – Examples of SoC. **(7)**

Recommended Books

1. Rochit Rajsuman, "System-on-a-Chip: Design and Test" Artech House, 2000
2. Prakash Rashnikar, Peter Paterson, Lenna Singh "System-On-A-Chip Verification methodlogy &Techniques" Kluwer Academic Publishers, 2000.
3. Steve Furber, "ARM System-on-Chip Architecture", 2nd edition, Addison-Wesley Professional, 2000.
4. Ricardo Reis & Jochen A.G. Jess, "Design of System on a Chip : Devices & Components" Kluwer, 2004
5. Laung-Terng Wang, Charles E. Stroud, Nur A. Touba, "System-on-Chip Test Architectures" Morgan Kaufmann, 2007
6. Alberto Sangiovanni Vincentelli, "Surviving the SOC Revolution: A Guide to Platform based Design" Kluwer Academic Publishers.

EC-584	RF Measurements & Design	[3 0 0 3]

Course Objectives

This course explores the concept of high frequency components, their behavior and design. It includes the Signal power and noise measurements at high frequency and bandwidth estimation by different methods. Basically it explain the design and working of each component needed in transreceivers so by studying this course one can design transmitter and receiver and realize the whole chain of these.

Course Contents

Introduction: RF Electronics, Basic concepts in RF design: transmission media and reflections, maximum power transfer. MOS Review. **(4)**

Distributed Systems: Transmission lines, reflection coefficient, lossy transmission lines, Path Loss, smith charts-plotting gamma. **(4)**

High frequency Amplifier Design: Bandwidth estimation using open-circuit time constants and short circuit time constants, rise time, delay and bandwidth, zeros to enhance bandwidth, Shunt-series amplifiers, tuned amplifiers, cascaded amplifiers. **(7)**

Noise: Thermal noise, flicker noise review, noise figure. **(3)**

LNA Design: Intrinsic MOS noise parameters, power match versus noise match, large signal performance, design examples and multiplier based mixers. **(6)**

Mixers Design: Sub sampling mixers. RF Power amplifiers: Class A, AB, B, C, D, E, F amplifiers, RF Power amplifiers design examples. **(6)**

Voltage controlled oscillator: Resonators, Negative resistance oscillators. **(3)**

Phase lock loop: Liberalized PLL models, phase detectors, charge pump, loop filter, PLL design examples. Small Signal Model, Receiver Design, RF Transreceivers, Low Noise RF amplifiers and RF Oscillators. **(7)**

Recommended Books

1. Behzad Razavi, "RF Microelectronics" Pearson Education,1st edition 1997.
2. Reinhold Ludwig, Paul Bretchko, "RF Circuit Design: Theory & Applications" 2nd edition, 2002.
3. Peter b. Kenington, "High Linearity RF Amplifier Design" Artech House Microwave Library, 1st edition, 2000.
4. Jeremy Everard, "Fundamentals of RF Circuit Design With Low Noise Oscillators" John Wiley & Sons Ltd., 1st edition, 2001.
5. Unai Alvarado, Guillermo Bistué and Iñigo Adín "Low Power RF Circuit Design in Standard CMOS Technology", vol.104, Springer.

EC-585	Data Structures and Algorithm Analysis	[3 0 0 3]

Course Objectives

The main purpose of this course is to introduce the students about the fundamental basics of C, C++ languages and different computer algorithms. Students will be able to learn about basic data structures and their use in various algorithms. They will also learn about standard sorting algorithms and will sort out problems related to non-deterministic algorithms.

Course Contents

Arrays: Representation and basic operations, Linked list : Singly linked list, Doubly linked list and Circular linked list-definition, representation and their basic operation, Stacks and queues : insertion, deletion, Trees : Binary Search trees, AVL trees, B-trees and B+ trees : insertion, deletion, traversal (in order, preorder and post order). **(13)**

Introduction to Algorithm Design: Growth of functions, Summations and Recurrences, The substitution method, the iteration method, the master method, Divide and Conquer paradigm, Dynamic programming, Greedy Algorithms. **(10)**

Sorting and Order Statistics: Merge Sort, Heap sort, Quick sort, Priority Queues

Searching and Disjoint Sets: Hash Tables, Binary Search Trees, Red-Black trees, Disjoint-set Operations -Linked list representation of disjoint sets, Disjoint set forests, NP-Complete Problem, Polynomial-time non-deterministic algorithms, NP Completeness and Reducibility, NP-Completeness Proof and NP Complete problems. **(17)**

Recommended Books

1. T .H. Cormen, C. E. Leiserson, R. L. Rivest "Introduction to Algorithms", 2nd Ed.PHI, 2001.
2. A .V. Aho, J . E . Hopcroft, J . D . Ulman "The Design & Analysis of Computer Algorithms",4th Impression., Pearson Education, 2009.
3. Udi . Manber "Introduction to Algorithms – A Creative Approach", illustrated, reprint ,Addison Wesley, 1989.
4. Ellis Harwitz and Sartaz Sahani "Fundamentals of Computer Algorithms", Galgotia Publications, 1984.

EC-586	Computational Techniques	[3 0 0 3]

Course Objectives

Throughout the last fifty years fast numerical methods have revolutionised the applications of mathematics, making it possible to simulate huge problems in science and engineering that are intractable by analytic methods. This course is designed to give an overview of the design, analysis and implementation of the most fundamental numerical techniques in numerical linear algebra, the interpolation of functions, and the evaluation of integrals and also application to optimization and numerical Solution of Linear equation & matrix Eigen value problem.

Course Contents

Roots Finding for Non Linear equation: Functions and Polynomials, Zeros of a function, Roots of a Nonlinear equation, Bracketing, Bisection and Newton-Raphson Methods, Globally convergent methods in more than one dimension. **(8)**

Interpolation & Approximation: Interpolation, Polynomial fits, Chebyshev approximation **Numerical Integration:** Evaluation of Integrals, Elementary Analytical Methods, Trapezoidal and Simpson's Rules, Summation of series, Gaussian Quadrature, and orthogonal polynomials, Multidimensional Integrals, Numerical differentiation and Estimation of errors. **(12)**

Optimization: Extremisation of functions, Optimization and simple search, Simplex method of Nelder and Mead, Powells method, Gradient based methods. **(8)**

Numerical Solution of Linear equation & matrix Eigen value problem: Vectors and Matrices, Solutions of linear algebraic equations by direct and iterative methods, Gaussian elimination, LU, Cholesky and singular value decompositions, Matrix diagonalization, Eigen value problems. **(12)**

Recommended Books

1. Pradip Niyogi, "Numerical Analysis & Algorithms", TMH, 2003
2. Kreyszig, E, "Advanced Engineering Mathematics", John Wiley & Sons, Seventh Edition, 1993
3. Kendal Atkeinson "Introduction to Numerical Analysis" 2 edition, John Wiley, 1989.

EC-587	Low Power VLSI Design	[3 0 0 3]

Course Objectives

The objective of this course is to study the concepts on different levels of power estimation and optimization techniques and introduce the fundamental principles of VLSI circuit design. To examine the basic building blocks of large-scale digital integrated circuits, understand transistor operations, circuit families, layout design techniques, area-power-performance analysis, signal integrity analysis, memory design and clocking issues and to provide hands-on design experience.

Course Contents

Introduction: Need for low power VLSI chips, Sources of power dissipation on Digital Integrated circuits. Emerging Low power approaches. Physics of power dissipation in CMOS devices. **(8)**

Device & Technology Impact on Low Power: Dynamic dissipation in CMOS, Transistor sizing & gate oxide thickness, Impact of technology Scaling, Technology & Device innovation. **(8)**

Power estimation: Simulation Power analysis**:** SPICE circuit simulators, gate level logic simulation, capacitive power estimation, static state power, gate level capacitance estimation, architecture level analysis, data correlation analysis in DSP systems. Monte Carlo simulation**.** **(8)**

Probabilistic power analysis: Random logic signals, probability & frequency, probabilistic power analysis techniques, signal entropy. **(8)**

Low Power Design **Circuit Logic levels:** Power consumption in circuits. Flip Flops & Latches design, high capacitance nodes, low power digital cells library, Gate reorganization, signal gating, logic encoding, state machine encoding, pre-computation logic. **(8)**

Recommended Books

1. Gary K. Yeap, “Practical Low Power Digital VLSI Design”, KAP, 2002
2. Rabaey, Pedram, “Low power design methodologies” Kluwer Academic, 1997
3. Kaushik Roy, Sharat Prasad, “Low-Power CMOS VLSI Circuit Design” Wiley, 2009

EC-588	**Real Time Systems and Softwares**	**[3 0 0 3]**

Course Objectives

The course emphasizes on the introduction to real time (R-T) systems and R-T kernel with the extensive coverage on scheduling algorithms, design specification and validation techniques.

Course Contents

Introduction: Real-time Versus Conventional Software, Computer Hardware for Monitoring and Control, Software Engineering Issues. Process and State-based Systems model, Periodic and Sporadic Process, Cyclic Executives, CE definitions and Properties, Foreground-Background Organizations. **(12)**

Standard OS and Concurrency: Architectures, Systems Objects and Object-Oriented Structures, Abstract Data Types, General Object Classes. Requirements and Design Specifications **(8)**

Classification: Notations Data Flow Diagrams, Tabular Languages, State Machine, Communicating Real Time State Machine-Basic features, Timing and clocks, Semantics Tools and Extensions, Statecharts-Concepts and Graphical Syntax, Semantics and Tools. Declarative Specifications: Regular Expressions and Extensions, Traditional Logics. Operating Systems: Real Time Functions and Devices, OS Architectures-Real Time UNIX and POSIX, Issues in Task management-Processes and Threads, Scheduling, Synchronization and communication. **(20)**

Recommended Books

1. Real – Time Systems and software by Alan C. Shaw ; John Wiley & Sons Inc.

EC-589	Algorithms for VLSI Design Automation	[3 0 0 3]

Course Objectives

This course is intended to expose students to the key themes, ideas, and techniques in main aspects of VLSI physical design automation (electronic design automation). This course will cover various design automation problems in the physical design process of VLSI circuits, but it will be mainly focused on circuit floor-planning, placement and logic partitioning, etc. The students will have research ability to solve VLSI physical design automation problems.

Course Contents

Logic synthesis & verification: Introduction to combinational logic synthesis, Binary decision diagram, Hardware models for High-level synthesis. **(6)**

VLSI automation Algorithms Partitioning: Problem formulation, classification of partitioning algorithms, Group migration algorithms, simulated annealing & evolution, other partitioning algorithms. **(8)**

Placement, floor planning & pin assignment: Problem formulation, simulation base placement algorithms, other placement algorithms, constraint based floor plannning, floor planning algorithms for mixed block & cell design. General & channel pin assignment. **(9)**

Global Routing: Problem formulation, classification of global routing algorithms, Maze routing algorithm, line probe algorithm, Steiner Tree based algorithms, ILP based approaches **(8)**

Detailed routing: Problem formulation, classification of routing algorithms, single layer routing algorithms, two layer channel routing algorithms, three layer channel routing algorithms, and switchbox routing algorithms. **(9)**

Recommended Books

1. Naveed Shervani, "Algorithms for VLSI physical design Automation" Kluwer Academic Publisher, 3rd edition, 1999.
2. Christophn Meinel & Thorsten Theobold, "Algorithm and Data Structures for VLSI Design", KAP, 2002.
3. Rolf Drechsheler : "Evolutionary Algorithm for VLSI CAD" 2nd edition, Kluwer Academic publisher,2010.
4. Trimburger, "Introduction to CAD for VLSI" Kluwer Academic publisher, 2002.

EC-590	Process, Devices & Circuit Simulation	[3 0 0 3]

Course Objectives

To understand and appreciate the underlying physics and principles involved in silicon processing and device characterization. To relate theory on semiconductor processing and device physics to practical technology development and device design considerations. To get familiarized with the use of TCAD tools as a design aid in process and device simulation.

Course Contents

Introduction: Main data structure & program organization, Geometrical manipulations, Ion implantation, A novel measurement technique for 2D implanted ion distributions, Introduction to partial differential equation solver, the merged multi grid method, Isothermal device modeling & simulation, Non Isothermal device modeling & simulation, hydrodynamic device modeling & simulation. **(12)**

Circuit Design Module: CMOS IC fabrication flow. IC design cycle, design considerations, simulation and CAD tools. Transistor circuits, SPICE model and design rules **(10)**

Process Module: Introduction to physical simulation and TCAD. Process simulation and CMOS process flow. Design of experiment and wafer split. **(9)**

Device Module: Virtual Device Characterization, Device physical models, Numerical algorithms and solutions. Device simulation and electrical characterization. **(9)**

Recommended Books

1. Graham F. Carey, W. B. Richardson, C. S. Reed, B. Mulvane, "Circuit, Device and Process Simulation: Mathematical and Numerical Aspects" John Wiley & Sons, 1st edition.
2. P. Antognetti, D.A. Antoniadis , Robert W. Dutton, Oldham, "Process and Device Simulation for MOS-VLSI Circuits" kluwer Academic Publisher, 2000.
3. Dutton R W and Yu Z, " Computer Simulation of IC Processes and Devices" Technology CAD Kluwer Academic, 1993.
4. Tsividis Y, "Operation and Modeling of the MOS Transistor" 2nd edition, McGraw-Hill, 1999.
5. Tsividis Yannis, "Operation and Modeling of the MOS Transistor" 3rd edition, Oxford University Press, 2005.

EC-591	**Nano Technology**	**[3 0 0 3]**

Course Objectives

This course helps in understanding what nanotechnology is about and how to use it. It will help in enhancing knowledge of structure, properties, manufacturing, and applications of silicon and carbon materials; fabrication methods in nanotechnology and also characterization methods in nanotechnology (optical, electrical, AFM, SEM, TEM, and nanoindentation).

Course Contents

Introduction: Introduction to nanoscale systems, Length energy and time scales, Top down approach to Nano lithography, Spatial resolution of optical, deep ultraviolet, X-ray, electron beam and ion beam lithography, Single electron transistors, coulomb blockade effects in ultra small metallic tunnel junctions **(12)**

Quantum Mechanics: Quantum confinement of electrons in semiconductor nano structures, Two dimensional confinement (Quantum wells), Band gap engineering, Epitaxy, Landaeur – Buttiker formalism for conduction in confined geometries, One dimensional confinement, Quantum point contacts, quantum dots and Bottom up approach, Introduction to quantum methods for information processing. **(17)**

Molecular Techniques: Molecular Electronics, Chemical self assembly, carbon nano tubes, Self assembled mono layers, Electromechanical techniques, Applications in biological and chemical detection, Atomic scale characterization techniques, scanning tunneling microscopy, atomic force microscopy. **(11)**

Recommended Books

1. Beenaker and Van Houten "Quantum Transport in Semiconductor Nanostructures in Solid state Physics" Ehernreich and Turnbell, Academic press, 1991.
2. David Ferry " Transport in Nano structures" Cambridge University press 2000.
3. Y. Imry " Introduction to Mesoscopic Physics" Oxford University press 1997.
4. S. Dutta " Electron Transport in Mesoscopic systems" Cambridge University press 1995.

EC-592	Hardware- Software Co-design	[3 0 0 3]

Course Objectives

The purpose of this course is to learn about the fundamentals of hardware and software co-design including applications of embedded systems in various areas. The course also identify the various bottlenecks in a given hardware-software architecture and optimize them by transformations on hardware and software co-design components.

Course Contents

Introduction: Motivation hardware & software co-design, system design consideration, research scope & overviews. **(4)**

Hardware Software back ground: Embedded systems, models of design representation, the virtual machine hierarchy, the performance3 modeling, Hardware Software development. **(5)**

Hardware Software co-design research: An informal view of co-design, Hardware Software tradeoffs, crosses fertilization, typical co-design process, co-design environments, limitation of existing approaches, ADEPT modeling environment. **(7)**

Co-Design concepts: Functions, functional decomposition, virtual machines, Hardware Software partitioning, Hardware Software partitions, Hardware Software alterations, Hardware Software tradeoffs, co-design. **(7)**

Methodology for co-design: Amount of unification, general consideration & basic philosophies, a framework for co-design. **(5)**

Unified representation for Hardware & Software: Benefits of unified representation, modeling concepts. **(3)**

An abstract Hardware & Software model: Requirement & applications of the models, models of Hardware Software system, abstract Hardware Software models, generality of the model. **(6)**

Performance evaluation: Application of the abstract Hardware & Software model, examples of performance evaluation. **(3)**

Recommended Books

1. Sanjaya Kumar, James H. Ayler "The Co-design of Embedded Systems: A Unified Hardware Software Representation" Kluwer Academic Publisher, 2002.
2. Gomaa, "Software Design Methods for Concurrent and Real-time Systems" Addison-Wesley, 1993.
3. H. Kopetz, "Real-time Systems" Kluwer, 1997.
4. R. Gupta, "Co-synthesis of Hardware and Software for Embedded Systems" Kluwer 1995.

EC-593	Cryptology and Crypto Chip Design	[3 0 0 3]

Course Objectives

This course will provide the introduction of security mechanisms used in operating systems. The student will be able to analyze the performance of different encryption techniques. The objective of this course is to make the student able to design firewalls and cyber laws. This course will focuses on the implementation encryption algorithms in various applications and case studies.

Course Contents

Introduction: Information system reviewed, LAN, MAN, WAN, Information flow, Security mechanism in OS, Targets: Hardware, Software, Data communication procedures. **(6)**

Threats to Security: Physical security, Biometric systems, monitoring controls, Data security, systems, security, Computer System security, communication security. **(7)**

Encryption Techniques: Conventional techniques, Modern techniques, DES, DES chaining, Triple DES, RSA algorithm, Key management. **(7)**

Message Authentication & Hash Algorithm: Authentication requirements & functions secure Hash Algorithm, NDS message digest algorithm, digital signatures, Directory authentication service. **(7)**

Firewalls and Cyber laws: Firewalls, Design Principles, Trusted systems, IT act and cyber laws, Virtual private network. **(6)**

Future Threats to Network: Recent attacks on networks, Case study Applications: AES algorithm. Crypto chip design: Implementation of DES, IDEA AES algorithm, Development of digital signature chip using RSA algorithm. **(7)**

Recommended Books

1. William Stalling "Cryptography and Network Security" 4th edtion, Pearson Education, 2009.
2. Charels P. Pfleeger, Shair Lawrence pfleeger "Security in Computing" 3rd edtion, Prentice Hall,2003.
3. Jeff Crume, "Inside Internet Security" Addison Wesley 2000.

EC-594	**Advanced Computational Methods**	**[3 0 0 3]**

Course Objectives

The purpose of this course is to introduce and teach students the different computational methods for nonlinear equations. It gives the numerical solution of elliptic, Dirichlet, Neumann problems and hyperbolic equations for various partial differential equations.

Course Contents

Introduction: Solution of two or more nonlinear equations by iterative methods (Picard and Newton's methods) Spline interpolation, cubic splines, Chebyshev polynomials, Minimax approximation. Eigen values and vectors of a real symmetric matrix – Jacobi method. Eigen value problem for ordinary differential equations. Numerical solution of a parabolic equation. **(18)**

Method: Explicit method, simple implicit method and Crank-Nicholson method. Stability. Numerical Solution of elliptic problems. Dirichlet and Neumann problems (Cartesian and Polar coordinates). Numerical solution of hyperbolic equations. Explicit method. Method of characteristics. Stability. The finite element method – Ritz, collocation and Galerkin methods. Boundary value problems for ordinary differential equations. Shape functions. Assembly of element equations. **(22)**

Recommended Books

1. Smith G. D. "Numerical Solution of Partial Differential Equation", Oxford, 1965.
2. Chapra, S.C, Canale R P "Numerical Methods for Engineers" 3rd edition, McGraw-Hill 1998.
3. Kreyszig, E, "Advanced Engineering Mathematics", 8th edition, John Wiley, 2002.
4. Gerald, C.F., "Applied Numerical Analysis", 6th Ed., Pearson, 1999.

EC-595	High Speed Digital Systems Design	[3 0 0 3]

Course Objectives

The purpose of this course is to introduce and teach students the fundamentals of digital systems design. It gives the overview of PCBs and chip packaging technology. The students will get familiar with electromagnetic and transmission line theory. They will learn to model and simulate digital systems. The student will be able to incorporate these concepts into their electronic system designs.

Course Contents

Introduction: Overview, Trends & Challenges, Interconnect Technologies Overview - PCI Express, USB & SATA, Serial Rapid IO (SRIO) & Hyper-Transport, Overview of PCBs and chip packaging technology - System Overview, Chip Packages & their construction, Multi- Layer PCB construction, Multi Board, Multi-Rack systems. **(8)**

Electromagnetic Theory: Basics, Vector Calculus, Electrostatic Fields, Magneto static Fields, EM waves & Maxwell's Equations, Phasor representation, Uniform plane waves, Skin effect, TEM waves, Pointing Vector, Reflections, Assignment on EM theory. **(8)**

Transmission Line: Basics, Transmission Line Theory, Basic I/O Circuits, Reflections, Parasitics & Loading, Modeling & Simulation, Measurement Equipment, Time Domain Reflectometry, Lattice Diagrams. **(7)**

Metrics: Synchronous Timing, Signal Quality, Source Synchronous Timing, Embedded Clock Timing, AC Coupled Lines & 8b/10b line encoding, Modern Design Methodology, Routing Topology & Terminations, Assignment on Clock Domain crossing techniques. **(8)**

Advanced Link Analysis: Losses, Intersymbol Interference (ISI), Crosstalk, SSN, Even/Odd modes, Frequency Domain Analysis's-Parameters, ABCD Parameters. **(5)**

Multi-Gb/s Signaling: Projections, Limits & Barriers, Differential Signaling, Equalization Modulation. **(4)**

Recommended Books

1. S. Hall, G. Hall, and J. McCall, "High Speed Digital System Design" John Wiley & Sons, Inc. (Wiley Interscience), 2000, 1st edition, ISBN 0-471-36090-2.
2. H. Johnson and M. Graham, "High Speed Digital Design: A Handbook of Black Magic" Prentice Hall, Indian subcontinent edition.
3. M.N.O. Sadiku, "Principles of Electromagnetics", 4th edition, Oxford University Press, New Delhi, 2009,.
4. S. J. Orfanidis, "Electromagnetic Waves and Antennas" 1st edition, 2008.

EC-597	ASIC Design and FPGA	[3 0 0 3]

Course Objectives

To understand the practical approach and inherent limitations of the VLSI design and then use these properties to design the chip for the maximum utilization. It also explains the memory technology and different ASIC designs.

Course Contents

Introduction: ASICs, CMOS Logic and ASIC Library Design Types of ASICs -Design flow -CMOS transistors CMOS Design rules -Combinational Logic Cell – Sequential logic cell -Data path logic cell. **(11)**

Review of VHDL/Verilog, Anti fuse static RAM -EPROM and EEPROM technology, Xilinx I/O blocks. Programmable ASIC Interconnect **(10)**

Logic Synthesis: Half gate ASIC -Schematic entry -Low level design language -PLA tools -EDIF-CFI design representation. ASIC Construction, Floor Planning, Placement and Routing, System partition. **(10)**

FPGA partitioning: Floor planning -placement -physical design flow -global routing -detailed routing -special routing circuit extraction -DRC. Design using Xilinx family FPGA. **(9)**

Recommended Books

1. M.J.S .Smith, "Application -Specific Integrated Circuits" Pearson Education, 2003.
2. Kevin Skahill, Jay Legenhausen,"VHDL for programmable logic" Addison–Wesley, 1997.
3. John F. Wakerly," Digital Design: Principles and Practices", 2nd edition, PHI, 1994,
4. Charles W. Mckay, "Digital Circuits A proportion for microprocessors" Prentice Hall.

EC/ME-635	**Thermal Management of Electronics System (to be offered jointly by Departments of ECE and Mechanical Engineering)**	**[3 0 0 3]**

Course Objectives

Thermal management has become a critical aspect in the design of contemporary electronic systems. Power dissipation levels have grown due to increased functionality and greater degrees of integration, and careful thermal design is imperative in order to meet today's stringent requirements for reliability. The objective of this course is to get familiar with the relevant theory and the application of contemporary tools and techniques to achieve a successful thermal design.

Course Contents

Why Thermal Management? Heat generation in electronic circuits **(2)**

Thermal Effects on Electronic Circuits: Passive and Active Components, Reliability Considerations, Thermal Properties of Electronic Materials **(5)**

Basic Fluid Mechanics and Heat Transfer: Types of Flow**,** Boundary Layer, Brief about Turbulence, Conduction, Convection and Radiation, Thermal Contact Resistance, Combined Modes and Transient Heat Transfer, Simple Calculations on Heat Transfer **(9)**

Thermal Management: Thermal Stress Analysis, Die Attach Materials, Substrate material, Wire bonding, Heat Exchange, Thermal Measurement, Thermal Analysis **(7)**

Cooling Techniques for Electronic Components and Systems **(4)**

Thermal Management Trends, Drivers and Challenges, Key Technologies, Advanced Materials for Thermal Management of Electronic Packaging , Computer Aided Thermal Design Tools **(6)**

Case Studies **(7)**

Recommended Books

1. Jery Sergent, Al Krum, "Thermal Management Handbook: For Electronic Assemblies", TMH, Edition (1998).
2. Ali Jamnia, "Practical Guide to the Packaging of Electronics: Thermal and Mechanical Design and Analysis", CRC Press (2008).
3. Dave S. Stienberg, "Cooling Techniques for Electronic Equipment", Wiley Interscience (1991).
4. Gordon Ellison, "Thermal Computations for Electronics: Conductive, Radiative and Convective Air Cooling", CRC Press (2010).
5. Younes Shabany, "Heat Transfer: Thermal Management of Electronics", CRC Press (2009).
6. X. C. Tong, "Advanced Materials for Thermal Management of Electronic Packaging", Springer (2011).
7. Yunus A. Cengel and John M. Cimbala, "Fluid Mechanics", Tata McGraw-Hill, Third Edition (2013).
8. Incropera, Dewitt, Bergmann, Lavine, "Fundamentals of Heat and Mass Transfer", Wiley India Pvt Ltd (2012).

EC-637	**Autism and Assisted Technologies**	[3 0 0 3]

Course Objectives

Children who have been diagnosed with Autism Spectrum Disorder (ASD) are part of the fastest growing neural development disorder worldwide. Autism is characterized by impaired social interaction and verbal and non-verbal communication, and by restricted, repetitive or stereotyped behaviour. Most of the children suffering from ASD show an affinity to computers and hence technology is being recognised as an effective and efficient mechanism in research and treatment. Development, deployment and evaluation of appropriate technologies for individuals with autism have been rapidly increasing and can prove to be very promising to enrich interventions, facilitate communication and support data collection. Emerging technologies in this area also have the immense potential to enhance assessment and diagnosis of individuals with autism and to help researchers conduct basic and applied research. The objectives of this course are:

- To develop a deep understanding of the complex conceptual issues in Autism, and the key theories, principles and issues in the field
- To understand the current trends and methodologies in working with children with autism
- To understand and develop skills in a variety of strategies for teaching students with autism
- To develop collaborative partnerships with individuals on the spectrum, parents, colleagues and other agencies
- To critically evaluate the use of computer assisted technology and current research in the field
- To conduct professional enquiries and use research evidence to generate professional knowledge and enhance understanding and practice

To apply acquired knowledge and understanding of autism to formulate effective technology based support for learners on the spectrum.

Course Contents

Introduction to Autism Spectrum Disorders: The Myths and History of ASD, Differences and Similarities between Autism, Asperger Syndrome and PDD-NOS, Autism screening and diagnosis Treatments, Therapies and Interventions for children and adults with autism, Applied Behaviour Analysis, Test batteries, Family Life, Education and Community Life. **(10)**

Technology Tools for ASD: Personal Computers and the Web, Specialized software and websites for individuals with ASD, Classroom tools, Language Tools, Social Skills and Emotion Regulation Management Tools, Data Collection Tools, EEG Analysis in the assessment of autistic disorders, Eye tracking equipment and its usage for autism, Review of existing technology products for Autism. **(15)**

Field-based experience with students with autism: Based on field experience complete the following compulsory assignments in addition to other assignments to given by the course co-ordinator(s):

- Prepare a comprehensive report to show your understanding of the unique challenges an ASD student faces in the classroom or in the school environment. Prepare a roadmap of technology based interventions to address the issues. Be sure to include how you would evaluate the effectiveness of these interventions.
- Interview a parent of an ASD child. Ask them to discuss their child's strengths and the difficulties that their child experiences due to the impact of the ASD and design a technology based solution and its evaluation. **(15 hours of fieldwork experience)**

The students are required to maintain a hardcopy of the field experience log that must describe in detail the activity and observations during each visit. The observations should focus on the teaching and behavioural support strategies that the professionals used in the classroom.

Contd…

Recommended Books

1. Sven Boelte and Joachim Hallmayer (Editors), "Autism Spectrum Conditions: FAQs on Autism, Asperger Syndrome, and Atypical Autism Answered by International Experts", Hogrefe Publishing (2011).
2. Mark Reber (Editor), "The Autism Spectrum: Scientific Foundations and Treatment", Cambridge University Press (2012).
3. Manuel F. Casanova, Ayman S. El-Baz and Jasjit S. Suri(Editors), "Imaging the Brain in Autism", Springer (2013).
4. Ilona Roth and PayamRezaie(Editors), "Researching the Autism Spectrum: Contemporary Perspectives", Cambridge University Press (2011).
5. Mickey Keenan, Mary Henderson, Ken P. Kerr and Karola Dillenburger(Editors), "Applied Behaviour Analysis and Autism: Building a Future Together", Jessica Kingsley Publishers (2005).
6. Katharina Boser, Matthew Goodwin and Sarah Wayland (Editors), "Technology Tools for Students With Autism: Innovations that Enhance Independence and Learning", Brookes Publishing (2013).
7. Julie A. Kientz, Matthew S. Goodwin, Gillian R. Hayes, and Gregory D. Abowd, "Interactive Technologies for Autism", Morgan & Claypool Publishers (2013).
8. Raphael Bernier and Jennifer Gerdts, "Autism Spectrum Disorders: A Reference Handbook (Contemporary World Issues)", ABC-CLIO (2010).

Evaluation of this course:
Mid Terms I, II and End Semester: 60%
Assignments (Classroom and Based on Field Experience): 40%

EC-639	Nanoelectronics	[3 0 0 3]

Course Objectives

The purpose of this course is to have knowledge of vast scope and capabilities of nanoelectronics. Students will have acquaintance with various kinds of nanostructures and nanomaterial and awareness of behaviour of electron transport in nanoscale devices. Further students will also be made familiar with various applications of nanodevices.

Course Contents

Introduction: concept of nanotechnology, Origin of nanotechnology: change in optical, mechanical, electronic and magnetic behavior at nanoscale, Advantages and Scope of nanotechnology **(3)**

Conventional MOSFET Issues: Moore's Law, study of ITRS Roadmap, Definition of Technology node, MOSFET Scaling Theory, Scaling Issues: Short Channel Effects, Drain Induced Barrier Lowering, Sub-threshold conduction. **(5)**

Materials for Nanoelectronics: Semiconductors, Crystal lattices: bonding in crystals, Electron energy bands, Semiconductor heterostructures, Organic semiconductors, Carbon nanomaterials: nanotubes and fullerenes. **(5)**

Electron Transport in Semiconductors and Nanostructures: Wave–particle duality, Schrodinger wave equation, Transport in Nano MOSFET, velocity saturation, ballistic transport, injection velocity, velocity overshoot. **(5)**

SoI Technology: SOI Technology and comparisons with Bulk Silicon CMOS technology, SOI MOSFET structures, Partially Depleted (PD)and Fully Depleted (FD) SOIMOSFETs, Metal Semiconductor contacts. **(5)**

Germanium and Compound Semiconductor Nano MOSFETs: Germanium as an alternate to silicon for high performance MOSFETs and the challenges in Germanium Technology, Compound semiconductors and hetero junction FETsfor high performance, GaAs MESFETs: Enhancement and depletion types . Velocity Overshoot effcts in GaAs MESFETs. **(7)**

Nanoscale Devices : Resonant-tunneling diodes, Field-effect transistors, Single-electron-transfer devices, Potential-effect transistors, Light-emitting diodes and lasers, Nanoelectromechanical system (NEMS) devices, Quantum-dot cellular automata. **(6)**

Applications of Nanoscale Devices: Case Studies involving design and simulations. **(4)**

Recommended Books

1. Introduction to Nanoelectronics: Science, Nanotechnology, Engineering, and Applications by Vladimir V. Mitin, Viatcheslav A. Kochelap, and Michael A. Stroscio, Cambridge University Press 2008.
2. Nanotechnology and Naoelectronics: Materials, Devices, Measurement Techniques, by W R Frahrner, Springer.
3. Nanoscience and Nanotechnology: Fundamentals to Frontiers, by M S Ramachandra Rao and Shubra Singh, Wiley.