CENTER FOR VLSI DESIGN AND NANOTECHNOLOGY

Course Book for
M. Tech. in VLSI Design

Visvesvaraya National Institute of Technology, Nagpur

Center for VLSI Design and Nanotechnology offers various programmes as follows-

- M. Tech program
- M. Tech. (By Research) program
- Ph.D. program

M.Tech. program: The M.Tech. program is a two-year course oriented graduate program. The student has to take a set of core courses and a set of electives. The course work is spread across the first two semesters with an option of taking electives in the third semester. This is followed by a project in the third and fourth semester in which the student can take up a project of his or her interest, supervised by a faculty member of the department.

Postgraduate Research Programs:

M. Tech. (By Research) program and Ph.D. programs: The M. Tech. (By Research) program and PhD. programs are postgraduate research oriented programs. The scholar works in an area of his/her interest under the supervision of a faculty member(s) of the department. The scholar has to obtain a minimum number of credits by taking courses. The highlight of the program is the independent research work taken by scholar, leading to a dissertation at the end of the program.

Brief about M Tech in VLSI Design programs:

Center for VLSI Design and Nanotechnology offers M. Tech program, *M. Tech. in VLSI Design.* This is four semester program, wherein student has to complete certain number of credits as indicated in Table 1. Each subject (or course) has certain number of credits. There are two types of subjects: Core and Elective. Core courses are compulsory and some courses from Electives are to be taken to complete the required credits.

TABLE 1. CREDIT REQUIREMENTS FOR POST GRADUTE STUDIES

Postgraduate Core (PC)		**Postgraduate Elective (PE)**	
Category	Credit	Category	Credit
Departmental Core (DC)	36	Departmental Electives (DE)	16
Basic Science (BS)	00	Other Courses (OC)	00
Total	36	Total	16
Grand Total PC + PE			52

The number of credits attached to a subject depends on number of classes in a week. For example a subject with 3-1-0 (L-T-P) means it has 3 Lectures, 1 Tutorial and 0 Practical in a week. This subject will have four credits (3 + 1 + 0 = 4). If a student is declared pass in a subject, then he/she gets the credits associated

with that subject. Depending on marks scored in a subject, student is given a Grade. Each grade has got certain grade points as follows:

Grades	AA	AB	BB	BC	CC	CD	DD	FF
Grade Points	10	09	08	07	06	05	04	Fail

The performance of a student will be evaluated in terms of two indices, viz. the Semester Grade Point Average (SGPA) which is the Grade Point Average for a semester and Cumulative Grade Point Average (CGPA) which is the Grade Point Average for all the completed semesters at any point in time. SGPA & CGPA are:

$$\boldsymbol{SGPA} = \frac{\sum_{semester}(Course\ credits\ X\ Grade\ points)for\ all\ courses\ except\ audit}{\sum_{semester}(Course\ credits\ )for\ all\ courses\ except\ audit}$$

$$\boldsymbol{CGPA} = \frac{\sum_{All\ semester}(Course\ credits\ X\ Grade\ points)for\ all\ courses\ with\ pass\ grade\ except\ audit}{\sum_{All\ semester}(Course\ credits\ )for\ all\ courses\ except\ audit}$$

Students can Audit a few subjects. i.e., they can attend the classes and do home work and give exam also, but they will not get any credit for that subject. Audit subjects are for self enhancement of students.

Details about Faculty members of Center for VLSI Design and Nanotechnology
(In alphabetical order of surname)

Name of Faculty Member	Designation	Qualifications	Areas of specialization
Deshmukh R. B.	Professor	Ph. D.	VLSI Design, MEMS
Dhok S. B.	Associate Professor	Ph.D.	Digital Signal Processing, VLSI
Patrikar R. M.	Professor	Ph. D.	VLSI, MEMS, Nano Electronics

Scheme of Instructions for M Tech (VLSI Design)

I Semester				II Semester			
CORE				**CORE**			
Code	**Course**	**L-T-P**	**credits**	**Code**	**Course**	**L-T-P**	**credits**
ECL 431	Physical Electronics	3-0-0	3	ECL504	VLSI System Design	3-0-0	3
ECP 431	Device simulation Lab	0-0-2	1	ECL505	Nano Electronics	3-0-0	3
ECL 432	Adv. VLSI Design	3-0-0	3	ECL503	Analog IC Design	3-0-0	3
ECP 432	Adv. VLSI Design Lab	0-0-2	1	ECP503	Analog IC Design lab	0-0-2	1
ECL 433	Digital IC Design	3-0-0	3				
ECP 433	Digital IC Design Lab	0-0-2	1				
PHL 401	VLSI Technology	3-0-0	3				
		15 +1					10+8
ELECTIVE (Any)				**ELECTIVE (Any Two)**			
ECP 510	VLSI Technology lab	0-0-2	1	ECL 435	MEMS	3-0-0	3
ECP515	High Level Design Practices	0-0-2	1	ECL 409	Radio Frequency Circuit Design	3-0-0	3
				ECP 504	VLSI System Design lab	0-0-2	1
				ECP 505	Nano Electronics lab	0-0-2	1
				ECP 435	MEMS lab	0-0-2	1
				ECP 409	Radio Frequency Circuit Design lab	0-0-2	1
				ELC506	Computer Organization and Operating Systems	3-0-0	3
				ECL514	High Speed Electronic System Design	3-0-0	3
	Total	**16**			**Total**	**16 to18**	

III Semester				**IV Semester**			
CORE				**CORE**			
ECD 501	Project - Phase I	0-0-3	3	ECD 502	Project Phase-II		9
ELECTIVES (Any Two)				**ELECTIVES (Any)**			
ECL 423	Image analysis and computer vision	3-0-0	3				
ECP 423	Image analysis and computer vision lab	0-0-2	1				
ECL 412	Advanced Digital Signal Processing	3-0-0	3				
ECP 412	Advanced Digital Signal Processing Lab	0-0-2	1				
ECL 434	Wireless Digital Communication	3-0-0	3				
ECL 507	Design for Testability Yield and Reliability	3-0-0	3				
ECL 512	VLSI Signal Processing	3-0-0	3				
	Total	**6 or 8**			**Total**	**9**	
		3+ 6				**9+0**	

ECL431-PHYSICAL ELECTRONICS **[(3-0-0); Credits: 3]**

Objectives: To understand the basics of semiconductor physics. To understand the details of semiconductor junctions. To understand the MOS transistor details and it various models.

Syllabus: Introduction to semiconductor Physics: Review of quantum mechanics, Electrons in periodic lattices, E-k diagrams, Quasiparticles in semiconductors, electrons, holes and phonons. Boltzmann transport equation and solution in the presence of low electric and magnetic fields - mobility and diffusivity; Carrier statistics; Continuity equation, Poisson's equation and their solution; High field effects: velocity saturation, hot carriers and avalanche breakdown.
Semiconductor junctions: Schottky, homo- and hetero-junction band diagrams and I-V characteristics, and small signal switching models; Two terminal and surface states devices based on semiconductor junctions.
MOS structures: Semiconductor surfaces; The ideal and non ideal MOS capacitor band diagrams and CVs; Effects of oxide charges, defects and interface states; Characterization of MOS capacitors: HF and LF CVs, avalanche injection; High field effects and breakdown.
The MOS transistor: Pao-Sah and Brews models; Short channel effects in MOS transistors. Hot-carrier effects in MOS transistors; Quasi-static compact models of MOS transistors; Measurement of MOS transistor parameters; Scaling and transistors structures for ULSI; Silicon-on-insulator transistors; High-field and radiation effects in transistors.

TEXT BOOKS

1. MOS Physics and Technology ,E. H. Nicollian and J. R. Brews John Wiley 1982 Semiconductor Material and Device Characterization ,DK. Schroder John Wiley1990
2. Physics of Semiconductor Devices ,S. M. Sze John Wiley, 2nd edition, 1981

REFERENCE BOOKS

1. Fundamentals of Solid-State Electronic Devices, C. T. Sah Allied Publishers and World Scientific 1991
2. Solid State Electronic Devices ,B.G. Streetman and S. Banerjee ,Prentice Hall India
3. Introduction to Solid State Electronics ,E. F. Y. Waug North Holland1980
4. MOSFET Models for VLSI Circuit Simulation, N. D. Arora Springer-Verlag, 1993
5. Operation and Modelling of the MOS Transistor, Y. P. Tsividis McGraw Hill1987
6. Hot-carrier Effects in MOS Trasistors, E. Takeda Academic Press 1995

ECL 432-ADVANCED VLSI DESIGN **[(3-0-0); Credits: 3]**

Objectives: To understand different CMOS logic families and their circuit layout. To understand various VLSI design methodologies.

Syllabus: Review of MOS transistor models. CMOS logic families including static, dynamic and dual rail logic. Integrated Circuit Layout: Design Rules, Parasitics.
Building blocks: ALU's, FIFO's, counters. VLSI system design: data and control path design, floorplanning,
Design methodology: Introduction to hardware description languages (VHDL), logic, circuit and layout verification. Design examples.

TEXT BOOKS

1. Principles of CMOS VLSI Design, Addison Wesley N. Weste and K. Eshranghia Addison Wesley. 1985
2. The Design and Analysis of VLSI Circuits ,L. Glaser and D. Dobberpuhl ,Addison Wesley,1985

REFERENCE BOOKS

1. Introduction to VLSI Systems ,C. Mead and L. Conway ,Addison Wesley1979
2. Digital Integrated Circuits: A Design Perspective, J. Rabaey, Prentice Hall India, 1997
3. VHDL ,D. Perry, McGraw Hill International 1995 2nd Ed.,

ECL433-DIGITAL IC DESIGN **[(3-0-0); Credits: 3]**

Objectives: To understand hardware description languages with various design styles useful to implement digital IC designs.

Syllabus: Basic concepts of hardware description languages. Hierarchy, Concurrency, Logic and Delay modeling. Structural, Data-flow and Behavioural styles of hardware description. Architecture of event driven simulators. Syntax and Semantics of VHDL. Variable and signal types, arrays and attributes. Operators, expressions and signal assignments. Entities, architecture specification and configurations. Component instantiation. Concurrent and sequential constructs. Use of Procedures and functions, Examples of design using VHDL.
Syntax and Semantics of Verilog. Variable types, arrays and tables. 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.

TEXT BOOKS

1. VHDL,Z. Navabi, McGraw Hill International Ed. 1998
2. Verilog HDL: A Guide to Digital Design and Synthesis, S. Palnitkar, "Prentice Hall NJ, USA),1996

REFERENCE BOOKS

1. VHDL Primer, J.Bhaskar, Pearson Education Asia,2001
2. Verilog HDL Synthesis - A Practical Primer, “J. Bhaskar”, Star Galaxy Publishing,(Allentown, PA)",1998

PHL401-VLSI TECHNOLOGY **[(3-0-0); Credits: 3]**

Objectives: To study various VLSI fabrication steps such as oxidation, lithography, etc. To understand the process of VLSI circuit fabrication.

Syllabus: Solid state diffusion modeling and technology, ion implantation technology and damage annealing, characterization of impurity profiles.
Oxidation: Kinetics of Silicon dioxide growth both for thick, thin and ultra thin films. Oxidation techniques in VLSI and ULSI, characterization of oxides films, low k and high k dielectrics for ULSI.
Environment for VLSI Technology, Clean room and safety requirements, Wafer cleaning process and wet chemical etching techniques.
Lithography: Photolithography, e-beam lithography and newer lithography techniques for VLSI/ ULSI, mask generation.
chemical vapor deposition techniques : CVD techniques for deposition of polysilicon, silicon dioxide, silicon nitrite and metal films, epitaxial growth of silicon.
Metal film deposition: Evaporation and sputtering techniques, failure mechanisms in metal interconnect multilevel metallization schemes.
Plasma and rapid thermal processing, PECVD, plasma etching and RIE techniques, RTP techniques for annealing, growth and deposition of various films for use in ULSI

TEXT BOOKS

1. VLSI Technology, S. M. Sze, McGraw Hill, II , 1988

REFERENCE BOOKS

1. VLSI fabrication principles, S. K. Gandhi, "John Wiley, New York",1983
2. ULSI Technology, C. Y. Chang. S. M. Sze, McGraw Hill companies,1996

ECL504-VLSI SYSTEM DESIGN **[(3-0-0); Credits: 3]**

Objectives: To study Basics of system hardware design. To understand the use of finite state machines in VLSI system design. To understand various design issues in the VLSI system implementation.

Syllabus: Basics of system hardware design. Hierarchical design using top-down and bottom-up methodology. System partitioning techniques, interfacing between system components. Handling multiple clock domains,

Synchronous and asynchronous design styles. Interface between synchronous and asynchronous blocks. Meta-stability and techniques for handling it. Interfacing linear and digital systems, data conversion circuits.

Design of finite state machines, state assignment strategies. Design and optimization of pipelined stages. Use of data flow graphs, Critical path analysis, retiming and scheduling strategies for performance enhancement.

Implementation of DSP algorithms. Signal integrity and high speed behavior of interconnects: ringing, cross talk and ground bounce.

Layout strategies at IC and board level for local and global signals. Power supply decoupling.

Test strategies: Border Scan, Built In Self Test and signature analysis.

TEXT BOOKS

1. Digital Integrated Circuits, Jan M. Rabaey, "Prentice Hall of India, (New Delhi",1997
2. Digital Integrated Circuits, Jan M. Rabaey, Prentice Hall of India, (New Delhi",1997

REFERENCE BOOKS

1. Application Specific Integrated Circuits, M.J.S. Smith, "Addison Wesley (Reading, MA), "1999
2. VLSI Digital Signal Processing, Vijay K. Madisett, "IEEE Press (NY, USA)",1995

ECL505-NANO ELECTRONICS **[(3-0-0); Credits: 3]**

Objectives: Nanoelectronics the aggressive scaling of CMOS devices resulted in the reduction of dimensions of active devices in the nanometer region. At the same time research has also being done to fabricate devices with different methodology and also with different materials and not limited to silicon. In this course modeling aspects of these devices are discussed from perspective of circuit applications.

Syllabus: Shrink-down approaches: Introduction, CMOS Scaling, The nanoscale MOSFET, Finfets, Vertical MOSFETs, limits to scaling, system integration limits (interconnect issues etc.), Resonant Tunneling Transistors, Single electron transistors, new storage, optoelectronic, and spintronics devices. Atoms-up approaches: Molecular electronics involving single molecules as electronic devices, transport in molecular structures, molecular systems as alternatives to conventional electronics, molecular interconnects; Carbon nanotube electronics, bandstructure and transport, devices, applications

TEXT BOOKS

1. Introduction to Nanotechnology, C.P. Poole Jr., F.J. Owens, Wiley (2003), C.P. Poole Jr. ,F.J. Owens, Wiley (2003).
2. Nanoelectronics and Information Technology (Advanced Electronic Materials and Novel Devices), Waser Ranier,Wiley-VCH,2003

REFERENCE BOOKS

1. Nanosystems, K.E. Drexler, Wiley (1992),1992
2. The Physics of Low-Dimensional Semiconductors, John H. Davies, "Cambridge University Press, "1998

ECL503-ANALOG IC DESIGN **[(3-0-0); Credits: 3]**

Objectives: To study Basics of analog IC designing. To understand the Frequency response, stability and noise issues in amplifiers. To understand the implementation of linear and non – linear analog block implementation and their testing.

Syllabus: Introduction to analog VLSI and mixed signal issues in CMOS technologies. Basic MOS models, SPICE Models and frequency dependent parameters.
Basic MNOS/CMOS gain stage, cascade and cascode circuits. Frequency response, stability and noise issues in amplifiers. CMOS analog blocks:
Current Sources and Voltage references. Differential amplifier and OPAMP design. Frequency Synthesizers and Phased lock-loop.
Non-linear analog blocks: Comparators, Charge-pump circuits and Multipliers. Data converters. Analog Interconnects.
Analog Testing and Layout issues. Low Voltage and Low Power Circuits.
Introduction to RF Electronics. Basic concepts in RF design

TEXT BOOKS

1. "CMOS Circuit Design, Layout and Simulation" R.Jacob Baker, 2nd edition Wiley2005
2. Analog VLSI Signal and Information Process, Mohammed Ismail and Terri Faiz, McGraw-Hill Book company,1994

REFERENCE BOOKS

1. "Paul R. Gray and R.G. Meyer, Analysis and design of Analog Integrated circuits" Paul R. Gray and R.G. Meyer, John Wiley and sons, USA"",(3rd Edition),1993"
2. "RF Microelectronics, Prentice-Hall PTR,1998",
3. Journals: {1} IEEE Journal of Solid state Circuits
   {2} IEEE Trans. on Communications, B. Razavi, Prentice-Hall PTR",1998

ECL435-MEMS **[(3-0-0); Credits: 3]**

Objectives: The Micro electromechanical devices are new generation devices which are used as the sensor, transducers and actuators. Many of these devices are being developed and they are replacing many bulky electro-mechanical devices. The fabrication technology design and analysis of these devices is the major part of this course.

Syllabus: Historical Background: Silicon Pressure sensors, Micromachining, Micro ElectroMechanical Systems Microfabrication and Micromachining : Integrated Circuit Processes, Bulk Micromachining : Isotropic Etching and Anisotropic Etching, Wafer Bonding, High Aspect-Ratio Processes (LIGA)
Physical Microsensors : Classification of physical sensors, Integrated, Intelligent, or Smart sensors, Sensor Principles and Examples : Thermal sensors, Electrical Sensors, Mechanical Sensors, Chemical and Biosensors Microactuators : Electromagnetic and Thermal microactuation, Mechanical design of microactuators, Microactuator examples, microvalves, micropumps, micromotors-Microactuator systems : Success Stories, Ink-Jet printer heads, Micro-mirror TV Projector
Surface Micromachining: One or two sacrificial layer processes, Surface micromachining requirements, Polysilicon surface micromachining, Other compatible materials, Silicon Dioxide, Silicon Nitride, Piezoelectric materials, Surface Micromachined Systems : Success Stories, Micromotors, Gear trains, Mechanisms
Application Areas: All-mechanical miniature devices, 3-D electromagnetic actuators and sensors, RF/Electronics devices, Optical/Photonic devices, Medical devices e.g. DNA-chip, micro-arrays.

TEXT BOOK

1. Micro and Smart Systems, G.K. Ananthasuresh, K.J. Vinoy, S. Gopalkrishnan, K.N. Bhat, V.K. Aatre, Wiley India

REFERENCE BOOKS

1. Stephen D. Senturia, "Microsystem Design" by, Kluwer Academic Publishers, 2001.
2. Marc Madou, “Fundamentals of Microfabrication” by, CRC Press, 1997.Gregory Kovacs, “Micromachined Transducers Sourcebook” WCB McGraw-Hill, Boston, 1998.
3. M.-H. Bao, “Micromechanical Transducers: Pressure sensors, accelrometers, and gyroscopes” by Elsevier, New York, 2000.

ECL409-RADIO FREQUENCY CIRCUIT DESIGN [(3-0-0); Credits: 3]

Objectives: To understand issues involved in design for GHz frequencies. To understand theoretical background relevant for design of active and passive circuits for RF front end for wireless digital communication systems.

Syllabus: Characteristics of passive components for RF circuits. Passive RLC networks. Transmission lines. Two-port network modeling. S-parameter model. The Smith Chart and its applications.
Active devices for RF circuits: SiGe MOSFET, GaAs pHEMT, HBT and MESFET. PIN diode. Device parameters and their impact on circuit performance.
RF Amplifier design: single and multi-stage amplifiers. Review of analog filter design. Low-pass, high-pass, band-pass and band-reject filters. Bandwidth estimation methods. Voltage references and biasing.
Low Noise Amplifier design: noise types and their characterization, LNA topologies, power match vs noise match. Linearity and large-signal performance.
RF Power amplifiers: General properties. Class A, AB and C PAs. Class D, E and F amplifiers. Modulation of power amplifiers.
Analog communication circuits: Mixers, phase-locked loops, oscillators and synthesizers.
Design and performance characterization. Transreceiver design

TEXT BOOK

1. The Design of CMOS Radio Frequency Integrated Circuits,Lee Thomas H,Cambridge University Press.

REFERENCE BOOKS

1. Design of Analog CMOS integrated circuits, Razavi Behzad, McGraw Hill
2. VLSI for wireless communication, Bosco Leung, Pearson Education

ECL 423-IMAGE ANALYSIS AND COMPUTER VISION [(3-0-0); Credits: 3]

Objectives: to understand the role of digital image processing in the field of computer vision. To understand various mechanisms responsible for image segmentation, motion analysis, motion estimation, computational imaging and super resolution. To study and understand the 3 dimensional imaging mechanisms. To study and understand the image and video compression mechanisms. To understand the basics of color image processing. To study various applications of computer vision systems.

Syllabus: Review of basics of Digital image processing, Introduction about computer vision: What is computer vision, advantages and disadvantages of computer vision, general applications of computer vision
Feature detection and matching: Points and patches, edges, lines, Segmentations:
Feature based alignment: 2D and 3D feature based alignments algorithms and applications, Pose estimation algorithms.
Motion estimation: Differential motion analysis methods, optical flow, detection of specific motion patterns, image stitching, motion models for tracking, alignments, compositing.
Image and video Compression techniques.
Computational imaging: super resolution, blur removal, image matting and compositing, texture analysis and synthesis, stereo imaging, basic concepts, and applications.
3D image processing techniques: basics of 3D images, 3D sensing, camera calibrations, and reconstructions, 3D from 2D image, surface based representations, point based representations, and volumetric based representations, and model based reconstruction, recovering textures from 3D images and applications of 3D imaging techniques, 3D shape recognition.
Object Recognition techniques
Basics Colour image processing: Color fundamentals, color models, color transformation, color segmentation, smoothing, and sharpening.
Case studies of computer vision projects such as content-based image retrieval, face recognition etc.

TEXT BOOKS

1. "Computer Vision: Algorithms and Applications" by "Richard Szeliski" Springer, 2010
2. "Computer Vision", "Shapiro and Stockman," Prentice Hall, 2001
3. "Image Processing, Analysis, and Machine Vision", "Sonka, Hlavac, and Boyle" Cengage Learning, 2009.

REFERENCE BOOKS

1. "Fundamentals Of Machine Vision", by "Harley R. Myler" PHI Learning (2003)
2. "Computer Vision: A Modern Approach" by "Forsyth, David A., Ponce, Jean" PHI Learning (2009)
3. "Pattern Recognition and Image Analysis" by", " Earl Gose Steve Jost and Richard Johnsonbaugh", PHI (2009)
4. "Fundamentals of Digital image processing", by "Anil K. Jain", PHI, 2010
5. "Digital image processing", by Rafael C. Gonzalez and Richard E. Woods," Pearson Education 3rd Edition.

ECL412-ADVANCED DIGITAL SIGNAL PROCESSING [(3-0-0); Credits: 3]

Objective: To study the advances in digital signal processing mechanism. To study various data compression mechanism such as DCT, DWT, LZW, etc. To study the DSP processors used for digital signal processing applications.

Syllabus: Introduction to Speech processing, Speech production model, Linear predictive coding for speech, Yule-Walker equations, Short Time Fourier Transform (STFT) , analysis of speech signals using STFT.
Multi rate signal processing, decimator, interpolator, poly-phase decomposition, Noble identities, application to Discrete multi-carrier transmission, sigma-delta ADC.
Data compression, lossy and lossless compression, LZW compression, Arithmetic coding, Discrete Cosine Transform (DCT) and its application to still image compression, audio compression
Introduction to Wavelet transform: Properties of wavelet transform, DWT, filter implementation of DWT, applications of DWT for image denoising and Scaling functions as signaling pulses in communication
Introduction to commercial DSP processors & DSP architecture

TEXT BOOKS

1. Introduction to data compression, Second Edition, Khalid Sayood, Elsevier
2. Digital signal processing a computer based approach, S.K.Mitra,TMH,Third edition

REFERENCE BOOKS

1. Digital signal processing & applications, Dag stranneby and William walker, Elsevier, Second Edition.
2. Wavelet Transforms: Introduction to Theory and Applications, A.M.Rao & A.S. Bopardikar, Pearson Edition
3. Wavelet tour of signal processing, the sparse way, Stephane Mallat, Elsevier 2009

ECL434-WIRELESS DIGITAL COMMUNICATION [(3-0-0); Credits: 3]

Objective: To understand the basics of wireless digital communication used for mobile telephony. To study the basic methodologies of cellular system designing. To study various modulation mechanisms. To understand the wireless channel characterization. To understand the various multiplexing mechanisms. To understand the interference measurement and reduction techniques.

Syllabus: Introduction to wireless digital communication systems; block diagram of a typical RF transceiver, radio propagation and cellular engineering concepts; frequency reuse, frequency management and channel assignment, handoff and handoff strategies, trunking theory, coverage and capacity improvements, medium access techniques, FDMA, TDMA, CDMA, SDMA.
Modulation methods: Basic digital modulation methods; ASK, PSK and FSK; Quadrature multiplexing and its applications; advanced modulation methods QPSK, QAM, MSK, GMSK, applications of differential coding, OFDM, MIMO.
Spread Spectrum methods: basics; generation and properties of PN sequences, DS-SS system analysis; slow and fast FH-SS system; performance analysis.
Interference measurement and reduction, co-channel and other interference, Diversity methods for Mobile Wireless Radio Systems, concepts of diversity branch and signal paths, combining and switching methods, C/N and C/I ratio improvements, average Pe improvements

TEXT BOOKS

1. Wireless Communication: Principles and Practices ,Theodore Rappaport, Pearson Education 2nd edition
2. Wireless Digital Communication, Feher, PHI

REFERENCE BOOKS

1. Digital communication, John Proakis, Tata- McGraw-Hill, 3rd edition
2. Digital communication, Simon Haykin ,Wiley
3. Communication systems, Simon Haykin ,Wiley, 4th edition

ECL507-DESIGN FOR TESTABILITY, YIELD AND RELIABILITY [(3-0-0); Credits: 3]

Objectives: To understand basic concepts of testing and verification of VLSI design process. To understand the fundamentals of VLSI testing. To understand various approaches for system testing.

Syllabus: Scope of testing and verification in VLSI design process. Issues in test and verification of complex chips, embedded cores and SOCs.
Fundamentals of VLSI testing. Fault models. Automatic test pattern generation. Design for testability. Scan design. Test interface and boundary scan. System testing and test for SOCs. Iddq testing. Delay fault testing. BIST for testing of logic and memories. Test automation.
Design verification techniques based on simulation, analytical and formal approaches. Functional verification. Timing verification. Formal verification. Basics of equivalence checking and model checking. Hardware emulation.
Parametric testing, Reliability modeling, Yield models.

TEXT BOOKS

1. Essentials of Electronic Testing for Digital, Memory and Mixed-Signal VLSI Circuits, M. Bushnell and V. D. Agrawal, Kluwer Academic Publishers,2000
2. Digital Systems Testing and Testable Design, IEEE Press, 1990., M. Abramovici, M. A. Breuer and A. D. Friedman, IEEE Press, 1990

REFERENCE BOOKS

1. Introduction to Formal Hardware Verification, T. Krop, Springer Verlag,,2000
2. System-on-a-Chip Verification-Methodology and Techniques, P. Rashinkar, Paterson and L. Singh, Kluwer Academic Publishers, 2001.

ECL512 VLSI Signal Processing [(3-0-0); Credits: 3]

Objectives: To understand advanced concepts in signal processing elements for 1D and 2D signals. To understand the fundamentals of VLSI implementation methodologies for the signal processing systems. To understand various approaches for Signal processing system implementation.

Syllabus:

Introduction to Digital Signal Processing Systems. Iteration Bound. Pipelining and Parallel Processing. Retiming. Unfolding. Folding. Systolic Architecture Design.

Fast Convolution. Algorithmic Strength Reduction in Filters and Transforms. Pipelined and Parallel Recursive and Adaptive Filters.

Scaling and Roundoff Noise. Concepts in Synchronous, Wave, and Asynchronous Pipelines. Low-Power Design.

TEXT BOOKS

1. VLSI Digital Signal Processing Systems: Design and Implementation, Keshab K. Parhi John Wiley & Sons, 2007.

REFERENCE BOOKS

1. FPGA-based Implementation of Signal Processing Systems, Roger Woods,John McAllister, Gaye Lightbody, Ying Y. John Wiley and Sons.
2. Oppenheim A. V., Schaefer R.W.; Discrete time Signal Processing; Prentice-Hall of India, 1989.
3. Proakies, J. G.; Monolakis, D. G.; Digital signal Processing: Principles, Algorithms and application (Third Edition): Prentice-Hall of India, 1996.
4. Jain, A. K. ; Fundamentals of Digital Image Processing ; Prentice-Hall of India, 1989
5. Gonzalez, R. C.; woods, R. E.; Digital Image Processing (Second Edition); Pearson Education,2002.

ECL506 Computer Organization and Operating Systems [(3-0-0); Credits: 3]

Objectives: To understand advanced concepts in computer organization and role of operating system in the system design. To understand various approaches for design of computer based systems.

Syllabus:

Basic structure of computers, machine instructions and programs, memory locations and addresses, addressing modes and their applications, subroutines and their implementation

Basic processing unit, execution of a complete instruction, hardwired control, microprogrammed control, microprogram sequencing, wide-branch addressing

The memory system, different types of memories, cache memories, mapping functions, replacement algorithms, concept of virtual memory and its implementation

Input/Output organization, interrupts, direct memory access, computer peripherals, input devices, output devices

Elementary concepts of operating system, Process Management, concept of a process, threads, interprocess communication, CPU scheduling, scheduling criteria, scheduling algorithms, process synchronization, critical section problem, semaphores, monitors, deadlocks, deadlock prevention, avoidance and detection

Storage Management, memory management, paging and segmentation, virtual memory, demand paging, page replacement algorithms, thrashing, file system interface, file concept, access methods, and file-system implementation

I/O Systems, I/O hardware, secondary-storage structure, disk structure, disk scheduling, disk management

TEXT BOOKS

1. Hamacher Carl et. al; Computer Organisation(Fifth Edition); Mc Graw Hill.
2. Silberchatz A., Galvin P. B.; Operating System Concepts; Addison-Wesley.

REFERENCE BOOKS

1. Operating Systems, William Stallings, PHI, New Delhi.
2. Tanenbaum A.S.; Modern Operating Systems; PHI, New Delhi.
3. Tanenbaum A.S.; Structured Computer Organisation (Fourth Edition); PHI, New Delhi.

ECL514 HIGH SPEED ELECTROIC SYSTEM DESIGN [(3-0-0); Credits: 3]

Objectives: To understand advanced concepts in high speed system architecture and design from chip to board for high speed systems.

Syllabus:

The concept of embedded systems design. Embedded microcontroller cores, embedded memories. Examples of embedded systems.

Technological aspects of embedded systems: interfacing between analog and digital blocks, signal conditioning, digital signal processing. Sub-system interfacing, interfacing with external systems, user interfacing. Design tradeoffs due to process compatibility, thermal considerations, etc.

Software aspects of embedded systems: real time programming languages and operating systems for embedded systems.

Hardware software co-design, allocation, Multiprocessor embedded design

Concepts of high speed electronic design

TEXT BOOKS

1. J.W. Valvano, "Embedded Microcomputor System: Real Time Interfacing", Brooks/Cole, 2000.

REFERENCE BOOKS

1. Jack Ganssle, "The Art of Designing Embedded Systems", Newnes, 1999.
2. V.K. Madisetti, "VLSI Digital Signal Processing", IEEE Press (NY, USA), 1995.
3. David Simon, "An Embedded Software Primer", Addison Wesley, 2000.
4. K.J. Ayala, "The 8051 Microcontroller: Architecture, Programming, and applications", Penram Intl, 1996.
5. Current research papers, application notes, handbooks on high speed design

ECL513 CAD for VLSI [(3-0-0); Credits: 3]

Objectives: To understand concepts mathematics and algorithms programming techniques, data structures for the CAD tools in VLSI..

Syllabus:

Matrices: Linear dependence of vectors, solution of linear equations, bases of vector spaces, orthogonality, complementary orthogonal spaces and solution spaces of linear equations.

Graphs: representation of graphs using matrices; Paths, connectedness; circuits, cutsets, trees; Fundamental circuit and cutset matrices; Voltage and current spaces of a directed graph and their complementary orthogonality.

Algorithms and data structures: efficient representation of graphs; Elementary graph algorithms involving bfs and dfs trees, such as finding connected and 2- connected components of a graph, the minimum spanning tree, shortest path between a pair of vertices in a graph; Data structures such as stacks, linked lists and queues, binary trees and heaps. Time and space complexity of algorithms.

TEXT BOOKS

1. K. Hoffman and R.E. Kunze, Linear Algebra, Prentice Hall (India), 1986
2. N.Balabanian and T.A. Bickart, Linear Network Theory: Analysis, Properties, Design and Synthesis, Matrix Publishers, Inc., 1981.

REFERENCE BOOKS

1. T.Cormen, C.Leiserson and R.A.Rivest, Algorithms, MIT Press and McGraw-Hill, 1990.

ECP515 HIGH LEVEL DESIGN PRACTICE [(0-0-2); Credits: 1]

Objectives: To understand current concepts in computer simulation of various VLSI design CAD tools. To practice various approaches for design of VLSI systems..

Syllabus:

Theory: Introduction to Unix; Circuit simulation using SPICE, application of SPICE for analog design. Timing simulation with IRSIM, Design of static and dynamic digital circuits with IRSIM. Layout of integrated circuits. Use of the layout tool MAGIC for analog and digital integrated circuits.

Laboratory: Tutorials on UNIX and vi. Tutorials and design exercises on linear circuit design with SPICE; Tutorial and exercises on digital design and timing analysis using IRSIM; Tutorials and exercises on IC layout using MAGIC; Group projects on design, analysis and layout of integrated circuits.

This laboratory will also cover experiments on the courses

TEXT BOOKS

1. Manuals of the CAD tools and UNIX