National Institute of Technology Hamirpur
Electronics and Communication Engineering

M.Tech. VLSI Design Automation and Techniques

Teaching Scheme (2011 onwards)

A. Distribution of Credits

Minimum Credits Through Course Work			Minimum Credits Through Research		Total Credits
Programme Core (PC)	Programme Electives (PE)	Open Electives (OE)	Dissertation-3rd Sem	Dissertation-4th Sem	
24	11	3	12	20	70

B. Semester-wise Distribution of Credits

(may vary as per the need of specific programme, but the requirement of minimum overall credits listed in **A** must be satisfied)

Sem-1	Sem-2	Sem-3	Sem-4	Total Credits
17	17	16	20	70

C. Grade of Dissertation (EC-801)

Semester	**Credits for Dissertation Work**	**Grade**	**Remarks**
Sem-3	12	AAA	$A \in S \mid X$ A is awarded for each set of 4 units, [S: Satisfactory, X: Unsatisfactory]
Sem-4	20	AAAAA	

D. Self Study Course

Self-study course will be related to the research/specialization area of a candidate. The concerned supervisor will act as course coordinator who will be responsible for proposing the course name and syllabus for approval of the DPGC. If the same course is offered to more than one student, there may only be one course coordinator. The candidate has to be continuously evaluated in same pattern as applicable to other courses (two mid-term exams, one semester exam, assignments, quizzes, etc.).

Department of Electronics & Communication Engineering
M.Tech. VLSI Design Automation and Techniques
Teaching Scheme (2011 onwards)

FIRST SEMESTER

S.No	Course No.	Course Title	L	T	P	Hours/ Week	C
1.	EC-601	Device Modeling for Circuit Simulation	3	0	0	3	3
2.	EC-602	VLSI Technology & Applications	3	0	0	3	3
3.	EC-603	CAD of VLSI	3	0	0	3	3
4.		Programme Elective-1	3	0	0	3	3
5.		Programme Elective-2	3	0	0	3	3
6.	EC-604	Electronic Design Automation Lab	0	0	3	3	2
Total			**15**	**0**	**3**	**18**	**17**

SECOND SEMESTER

S.No	Course No.	Course Title	L	T	P	Hours/ Week	C
1.	EC-605	Digital VLSI Design	3	0	0	3	3
2.	EC-606	Digital Signal Processing	3	0	0	3	3
3.	EC-607	Analog VLSI Design	3	0	0	3	3
4.		Programme Elective-3	3	0	0	3	3
5.		Open Elective-1 (from other Dept)	3	0	0	3	3
6.	EC-608	VLSI & MEMS Design Lab	0	0	3	3	2
Total			15	0	3	18	17

THIRD SEMESTER

S.No	Course No.	Course Title	L	T	P	Hours/ Week	C
1.	EC-799	Self Study				3	2
2.	EC-800	Seminar	0	0	3	3	2
3.	EC-801	Dissertation (to be continued in 4th Sem)				24	12
Total						30	16

FOURTH SEMESTER

S.No	Course No.	Course Title	L	T	P	Hours/Week	C
1.	EC-801	Dissertation				40	20
Total							20

Programme Elective-1

EC-701	MEMS & Microsensor Design
EC-702	Nano-Electronics
EC-703	Microwave & Optoelectronic Devices
EC-704	Modeling & Simulation
CS-761	Advanced Computer Architecture

Programme Elective-2

EC-705	Characterization of Semiconductor Materials & Devices
EC-706	CMOS RF Circuit Design
EC-707	Digital Logic Design with HDL
EC-708	VLSI Interconnects

Programme Elective-3

EC-709	Low Power VLSI Design
EC-710	VLSI Test & Testability
EC-711	Digital Image Processing
EC-712	Embedded System Design

Open Electives

EC-751	VLSI Design
EC-752	MEMS & Micro Sensor Design

EC-601 Device Modelling for Circuit Simulation

1. Fundamentals

Semiconductor Physics, Principle of circuit simulation and its objectives.

2. Introduction to SPICE

AC, DC, Transient, Noise, Temperature extra analysis.

3. Junction Diodes

DC, Small signal, Large signal, High frequency and noise models of diodes, Measurement of diode model-parameters.

4. Modelling BJT

DC, small signal, high frequency and noise models of bipolar junction transistors. Extraction of BJT model parameters.

5. MOSFETs

DC, small signal, high frequency and noise models of MOSFETs, MOS Capacitors. **MOS Models**: Level-1 and level-2 large signal MOSFET models. Introduction to BSIM models. Extraction of MOSFET model parameters.

6. Device SCALING

Short and narrow channel MOSFETs. MOSFET channel mobility model, DIBL, charge sharing and various non-linear effects.

7. JFET, MESFETs & HBTs

Modeling of JFET & MESFET and extraction of parameters. Principles of hetro-junction devices, HBTs, HEMT.

Text Books

1. S.M.Kang & Y.Leblibici, CMOS Digital Integrated Circuits-Analysis & Design, TMH, 3rd Ed.
2. S.M. Sze, Physics of Semiconductor Devices, Wiley Pub.

References

1. Sedra and Smith, SPICE.
2. H.M. Rashid, Introduction to PSPICE, PHI.
3. B.G. Streetman & S. Baneerjee, Solid State Electronic Devices, PHI.
4. R. Raghuram, Computer Simulation of Electronic Circuits, Wiley Eastern Ltd.
5. Bar Lev, Basic Electronics.

EC-602 VLSI Technology & Applications

1.Crystal growth
Wafer preparation, Processing considerations, Chemical cleaning, Getting the thermal stress factors etc.

2.Epitaxy
Vapors phase epitaxy basic transport processes & reaction kinetics, Doping & Auto doping, equipments, & Safety considerations, Buried layers, Epitaxial defects, Molecular beam epitaxy, Equipment used, Film characteristics, SOI structure.

3.Oxidation
Growth mechanism & kinetics, Silicon oxidation model, Interface considerations, Orientation dependence of oxidation rates thin oxides, Oxides, Oxidation technique & systems dry & wet oxidation.,Masking properties of SiO_2.

4.Diffusion
Diffusion from a chemical source in vapor form at high temperature, Diffusion from doped oxide source, Diffusion from an ion implanted layer.

5.Lithography
Optical lithography, Optical resists, Contact & proximity printing, Projection printing, Electron lithography, resists, Mask generation, Electron optics, Roster scans & vector scans, Variable beam shape, X-ray lithography, Resists & printing, X-ray sources &masks, Ion lithography.

6.Etching
Reactive plasma etching, AC & DC plasma excitation, Plasma properties, Chemistry & surface interactions, Feature size control & apostrophic etching, Ion enhanced & induced etching, Properties of etch processing. Reactive ion beam etching, Specific etches processes, poly/polycide, Trench etching.

7.Simulation & Analytical Techniques
Introduction to process modelling, SUPREM. Reliability issues in VLSI technology, Geometrical manipulations, A novel measurement technique for 2D implanted ion distributions, Introduction to partial differential equation solver, The merged multi grid method, Modeling & simulation of isothermal, Non isothermal and hydrodynamic devices.

8.MEMS
System-level design methodology, Equivalent Circuit representation of MEMS, Signal-conditioning circuits, and sensor noise calculation. Pressure sensors with embedded electronics(Analog/Mixed signal), Accelerometer with transducer, Gyroscope, RF MEMS switch with electronics, Bolometer design. RF MEMS and Optical MEMS

Text

1. SM Sze, “Modern Semiconductor Device Physics”, John Wiley & Sons, 2000.
2. SM Sze, “VLSI Technology”, John Wiley & Sons, 2000.

References

1. B.G. Streetman, “Solid State Electronics Devices”, Prentice Hall, 2002.
2. Chen, “VLSI Technology” Wiley, March 2003.
3. Circuit, Device and Process Simulation: Mathematical and Numerical Aspects by Graham F. Carey (Editor), W. B. Richardson, C. S. Reed, B. Mulvaney, John Wiley & Sons; 1 edition.
4. Process and Device Simulation for MOS-VLSI Circuits, edited by P. Antognetti, D.A. Antoniadis , Robert W. Dutton, W.G. Oldham, kluwer Academic Publisher, 2000.
5. Gregory T.A. Kovacs, Micromachined Transducers Sourecbook, The McGraw-Hill, Inc. 1998
6. Stephen D. Senturia, Microsystem Design, Kluar Publishers, 2001
7. Nadim Maluf, An Introduction to Microelectromechanical Systems Engineering, Artech House, 2000.

MV-603 CAD of VLSI

1.Introduction to Hierarchical and Structured Design,
Role of CAD Tools in the VLSI design process, CAD Algorithms for switch level and circuits simulation, Techniques and algorithms for symbolic layout, Algorithms for physical design – Placement and routing Algorithms, Compaction, Circuit extraction and Testing.

2.Specification of Combinational Systems Using VHDL
Introduction to VHDL, Basic language element of VHDL, Behavioral Modeling, Data flow modeling, Structural modeling, Subprograms and overloading, VHDL description of gates.

3. Description and Design of Sequential Circuits
Standard combinational modules, Design of a Serial adder with accumulator, State graph for control network, Design of a binary multiplier, Multiplication of a signed binary number, Design of a binary divider.

4. Register-Transfer Level Systems
Execution graph, Organization of system, Implementation of RTL Systems, Design of RTL systems, Analysis of RTL systems.

5. Data Subsystems
Storage modules, Functional modules, Data paths, Control subsystems, Micro programmed controller, Structure of a micro programmed controller, Micro instruction format, Micro instruction sequencing, Micro instruction Timing, Basic component of a micro system, Memory subsystem.

6. I/O Subsystem
Processors, Operation of the computer and cycle time. Binary decoder, Binary encoder, Multiplexers and demultiplexers, Floating Point arithmetic-representation of floating point number, Floating point multiplication, Adders, Multipliers.

7. PLA based synthesis
Multilevel logic synthesis, Logic optimization, Logic simulation, Compiled and event simulators, Relative advantages and disadvantages, Layout Algorithms, Circuit partitioning, Placement and routing algorithms, Automatic test program generation, Combinational testing, D-Algorithm and PODEM algorithm, Scan-based testing of sequential circuits, Testability measures for circuits.

Text Books

1. J. Bhaskar, “A VHDL Primer”, Addison Wesley, 1999.
2. M. Ercegovac, T. Lang and L.J. Moreno, “Introduction to Digital Systems”, Wiley, 2000
3. C. H. Roth, “Digital System Design using VHDL”, PWS Publishing
4. G. DeMicheli, “Synthesis and optimization of digital circuits”, McGraw Hill.

References

1. J.F. Wakerly, “Digital Design-Principles and Practices”, PHL
2. Douglas Perry, “VHDL”, MGH

EC-605 Digital VLSI Design

1. Introduction
Basic principle of MOSFETs, Introduction to large signal MOS models (long channel) for digital design.

2. MOS Inverters
Static and Dynamic characteristics: Inverter principle, Depletion and enhancement load inverters, the basic CMOS inverter, transfer characteristics, logic threshold, Noise margins, and Dynamic behavior, transition time, Propagation Delay, Power Consumption.

3. MOS Circuit Layout & Simulation
Layout design rules, MOS device layout: Transistor layout, Inverter layout, CMOS digital circuits layout & simulation, Circuit Compaction; Circuit extraction and post-layout simulation.

4. Combinational MOS Logic Design
Static MOS design: Complementary MOS, Ratioed logic, Pass Transistor logic, Complex logic circuits, DSL, DCVSL, Transmission gate logic.

5. Dynamic MOS design
Dynamic logic families and performances.

6. Memory Design
ROM & RAM cells design

7. Sequential MOS Logic Design
Static latches, Flip flops & Registers, Dynamic Latches & Registers, CMOS Schmitt trigger, Monostable sequential Circuits, Astable Circuits.
Adders, Multilpier Circuits.

8. VLSI Interconnects
Interconnect delays, Cross Talks. Introduction to low power design, Input and Output Interface circuits.

9. BiCMOS Logic Circuits
Introduction, Basic BiCMOS Circuit behavior, Switching Delay in BiCMOS Logic circuits.

Text Books

1. Kang & Leblebigi “CMOS Digital IC Circuit Analysis & Design”- McGraw Hill, 2003
2. JM Rabey, “Digital Integrated Circuits Design”, Pearson Education, Second Edition, 2003
3. NHE Weste & K. Eshraghian, Principles of CMOS VLSI Design:A Sys.Pers., McGraw Hill Pub.

References

1. B.G. Streetman & S. Banerjee, Solid State Electronics.
2. Uyemera, CMOS Logic Circuit Design, Springer India Pvt. Ltd. New Delhi, 2007.
3. Eshraghian & Pucknell, Introduction to VLSI, PHI
4. David A. Hodges, Horace G. Jackson, Resve Saleh, “Analysis & Design of Digital Integrated Circuits”, 3rd Edi Mc Graw Hill, 2003.
5. Sedra & Smith, SPICE.

EC-606 DIGITAL SIGNAL PROCESSING

1. Discrete time signals and systems

2. Time Domain Representation of Signals & Systems
Discrete Time Signals, Operations on Sequences, the sampling process, Discrete-Time systems, Time-Domain characterization of LTI Discrete-Time systems, state-space representation of LTI Discrete-Time systems, random signals.

3. Transform-Domain Representation of Signals
Discrete-Time Fourier Transform, Discrete Fourier Transform, DFT properties, computation of the DFT of real sequences, Linear Convolution using the DFT. Z-transforms, Inverse z-transform, properties of z-transform

4. Transform-Domain Representation of LTI Systems
the frequency response, the transfer function, types of transfer function, minimum-phase and maximum-Phase transfer functions

5. Digital Processing of Continuous-Time Signals
Sampling of Continuous Signals, Analog Filter Design, Anti-aliasing Filter Design, Sample-and-hold circuits, A/D & D/A converter, Reconstruction Filter Design.

6. Digital Filter Structure
Block Diagram representation, Signal Flow Graph Representation, Equivalent Structures; bone FIR Digital Filter Structures, IIR Filter Structures, State-space structure, all pass filters, tunable IIR Digital filters, cascaded Lattice realization of IIR and FIR filters, Parallel all pass realization of IIR transfer function

7. Digital Filter Design
Impulse invariance method of IIR filter design, Bilinear Transform method of IIR Filter Design, Design of Digital IIR notch filters, FIR filter Design based on truncated fonner sens, FIR filter design based on Frequency Sampling approach.

8. Applications of VLSI DSP

Text Books:

1. Sanjit K. Mitra, Applications DSP a Computer based approach , TMH.
2. Proakis, Digital Signal Processing, PHI, Second edition
3.Allan Y. Oppenhein & Ronald W. Schater , Digital Signal Processing, PHI

References:

1. Monson H. Hayes, Schaum's Outline of Digital Signal Processing, Mcgraw Hill, 1999.
2. Lars Wanhammar, DSP Integrated Circuits, Academic Press, First edition, 1999.

EC-607 Analog VLSI Design

1. Introduction to Analog VLSI

Analog integrated circuit design, Circuit design consideration for MOS challenges in analog circuit design, Recent trends in analog VLSI circuits.

2. Analog MOSFET Modelling

MOS transistor, Low frequency MOSFET Models, High frequency MOSFET Models, Temperature effects in MOSFET, Noise in MOSFET.

3. Current Source, Sinks and References

MOS Diode/Active resistor, Simple current sinks and mirror, Basic current mirrors, Advance current mirror, Current and Voltage references, Bandgap references.

4. CMOS Amplifier

Performances matrices of amplifier circuits, Common source amplifier, Common gate amplifier, Cascode amplifier, Frequency response of amplifiers and stability of amplifier.

5. CMOS Feedback Amplifier

Feedback equation, Properties of negative feedback on amplifier design, Feedback Topology, Stability.

6. CMOS Differential Amplifier

Differential signalling, source coupled pair, Current source load, Common mode rejection ratio, CMOS Differential amplifier with current mirror load,, Differential to single ended conversion.

7. CMOS Operational amplifier

Block diagram of Op-amplifier, Ideal characteristics of Op-Amplifier, Design of two stage Op-Amplifier, Compensation of Op-Amplifier, Frequency response of Op-Amplifier, Operational Transconductance Amplifier (OTA).

8. CMOS Comparator

Characteristic of a comparator, Two stage open loop comparator, Special purpose comparator, Regenerative comparator, High output current amplifier, High speed comparator.

9. Introduction to Switched Capacitor Circuits

Switched capacitor circuits, Switched capacitor amplifiers, Switch capacitor integrators.

Text Book:

1. Design of Analog CMOS Integrated Circuits by Behzad Razavi McGraw Hill.
2. CMOS: Circuit Design , Layout and Simulation by R. Jacob Baker, Harry W. Li, and David E. Boyce, Prentice Hall of India

Reference Books

1. Analog Integrated circuit Design by David A. Johns and Ken Martin, John Wiley & Son

EC-701 MEMS & Micro Sensor Design

1. Introduction to MEMS

MEMS Fabrication Technologies, Materials and Substrates for MEMS, Processes for Micromachining, Characteristics, Sensors/Transducers, Piezoresistance Effect, Piezoelectricity, Piezoresistive Sensor.

2. Mechanics of Beam and Diaphragm Structures

Stress and Strain, Hooke's Law. Stress and Strain of Beam Structures: Stress, Strain in a Bent Beam, Bending Moment and the Moment of Inertia, Displacement of Beam Structures Under Weight, Bending of Cantilever Beam Under Weight.

3. Air Damping

Drag Effect of a Fluid: Viscosity of a Fluid, Viscous Flow of a Fluid, Drag Force Damping, The Effects of Air Damping on Micro-Dynamics. Squeeze-film Air Damping: Reynolds' Equations for Squeeze-film Air Damping, Damping of Perforated Thick Plates. Slide-film Air Damping: Basic Equations for Slide-film Air Damping, Couette-flow Model, Stokes-flow Model.

4. Electrostatic Actuation

Electrostatic Forces, Normal Force, Tangential Force, Fringe Effects, Electrostatic Driving of Mechanical Actuators: Parallel-plate Actuator, Capacitive sensors. Step and Alternative Voltage Driving: Step Voltage Driving, Negative Spring Effect and Vibration Frequency.

5. Thermal Effects

Temperature coeficient of resistance, Thermo-electricity, Thermocouples, Thermal and temperature sensors.

6. Applications of MEMS in RF

MEMS Resonator Design Considerations, One-Port Micromechanical Resonator Modeling Vertical Displacement Two-Port Microresonator Modeling, Micromechanical Resonator Limitations.

Text Books

1. S.M. Sze, “Semiconductor Sensors”, John Wiley & Sons Inc., Wiley Interscience Pub.
2. M.J. Usher, “Sensors and Transducers”, McMillian Hampshire.

References

1. RS Muller, Howe, Senturia and Smith, “Microsensors”, IEEE Press.

EC-702 Nano-Electronics

1. Introduction of Nano-electronics

The "Top-Down" Approach; The "Bottom-Up" Approach; Why Nano-electronics; Nanotechnology Potential; MOS Scaling theory-Issues in scaling MOS transistors; Short channel effects; Requirements for non-classical MOS transistor; Metal gate transistor-Motivation, requirements, Integration Issues; High-k gate based MOSFET-Motivation, requirements, integration issues of high-k.

2. Quantum Mechanics of Electrons

General postulates of quantum mechanics; Time-independent Schrodinger's equation-boundary conditions on the Wave function; Analogies between quantum mechanics and classical electromagnetic; probabilistic current density; Multiple particle systems; Spin and angular Momentum.

3. Free and Confined Electrons

Free Electrons; Free electron gas theory of metals; Electrons confined to a bounded region of space and quantum numbers; Partially confined electrons- finite potential wells; Quantum wells; Quantum wires; Quantum dots.

4. Tunnel Junctions and Applications of Tunneling

Tunneling through a potential barrier; Potential energy profiles for material interfaces; Applications of tunneling; Coulomb blockade, Single-Electron Transistor (SET).

5. Germanium Nano MOSFETs

Strain, Quantization; Advantages of germanium over silicon; PMOS versus NMOS; Compound semiconductors - material properties; MESFETs; Compound semiconductors MOSFETs in the context of channel quantization and strain; Hetero structure MOSFETs exploiting novel materials, strain, quantization.

6. Non-Conventional MOSFET Structures

SOI-PDSOI and FDSOI; Ultrathin body SOI-double gate transistors, integration issues; Vertical transistors – FinFET and Surround gate FET; Carbon Nano-tube Transistors (CNT); Semiconductor Nano-wire FETs and SETs; Molecular SETs and Molecular Electronics.

Text Books

1. Fundamentals of Modern VLSI Devices, Y. Taur and T Ning, Cambridge University Press.
2. Fundamental of Nanoelectronics, George W. Hanson Pearson Education.

References

1. Silicon VLSI Technology, Plummer, Deal, Griffin, Pearson Education India.
2. Encyclopedia of Materials Characterization, Edited by Brundle, C.Richard; Evans, Charles A. Jr.; Wilson, Shaun ; Elsevier.

EC-703 Microwave & Optoelectronic Devices

1. Microwave Solid State Devices
Microwave frequencies, Tunnel diode, Backward diode, MIS tunnel diode, Transferred electron devices-Gunn diode, Avalanche transit time devices: IMPATT Diode, BARRITT Diode, and TRAPATT Diode, Microwave transistor, Microwave field effect transistor

2. Microwave Integrated Circuit
Introduction, Transmission lines for MICs, Lumped elements for MICs, Material for MICs: Substrate, Conductor, Dielectric and resistive materials, Fabrication techniques, Typical example of fabrication, Hybrid fabrication.

3. Microwave Tubes
Klystron, Reflex Klystron and Magnetron, Traveling wave tubes, microwave detection diodes, application of microwave

4. Optoelectronic Devices
Photovoltaic devices, Solar Radiation, PN-homojunction solar cells, Antireflection coatings, Ideal conversion efficiency, Spectral response, I-V Characteristics, Temperature and radiation effects, Heterojunction solar cells, Schottky barrier solar cell, Thin film and amorphous silicon solar cell, Solar arrays

5. Lasers
Stimulated emission: ruby lasers, other lasers, p-n-p-n switching devices, Switching mechanism, Semiconductor controller rectifier, Negative conductance.
Laser Diodes, Spontaneous and stimulated emission, Population inversion, Semiconductor optical amplifiers, Optical feedback, Modes of a laser cavity, Condition for threshold, Current density, Transparency current, Threshold current, Double heterostructure laser for improved confinement of carriers and lower threshold currents, Quantum wells for wavelength “tuning” and reduced drive currents, Factors influencing device design from infrared to blue lasers.

Text Books

1. S M Sze, Physics of Semiconductor Devices by, Willy Eastern Pub.
2. S. Y. Liao, Microwave Devices and Circuits, PHI
3. O.P. Gandhi, Microwave Engineering and Application, Maxwell Macmillan Pub.

References

1. J.I. Pankove, Topic in applied physics – Vol. 40 , Springer Verlag
2. E. S . Yang, Microelectronic Devices, MGH
3. A. G. Milness, Semiconductor Devices and Integrated Electronics, CBS Pub
4. J. Wilson & J.F.B. Hawkers, Optoelectronics : An introduction, PHI

EC-704 Modeling and Simulation

1.Component model for ICs

Design rule checks, timing verification worst case delay simulation, setup and hold times for clocked devices; Behaviour modeling, structural modeling, simulation with the physical model; Hardware Description Language.

2.Statistical

Description of data, Data-fitting methods, Regression analysis, Analysis of Variance, Goodness of fit.

3.Probability and Random Processes

Discrete and Continuous Distribution, Central Limit theorem, Measure of Randomness, Monte Carlo Methods.

4. Stochastic Processes

Stochastic Processes and Markov Chains, Time Series Models.

5. Modelling and simulation

Concepts, Discrete-event simulation: Event scheduling/Time advance algorithms, Verification and validation of simulation models.

6. Continuous simulation: Modelling with differential equations, Example models, Bond Graph Modelling, Population Dynamics Modelling, System dynamics.

Text Books

1. James R., Armstrong J.R., Chip-level Modelling with VHDL., Prentice Hall, 1989.
2. Navalih, Z., VHDL, Analysis and Modelling of Digital Systems, 1993.
3. Banks J, Carson JS and Nelson B, discrete-Event System simulation, 2nd Edition, Prentice-Hall of India, 1996.
4. Winston, W.L., Operations Research : applications and algorithms, 3rd Edition, Duxbury press, Belmont, Califomia, 1994.

CS-761 Advanced Computer Architecture

1. Parallel Computer Models
The state of computing, Classification of parallel computers, Multiprocessors and multicomputers, Multivector and SIMD computers.

2. 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.

3. 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.

4.Advanced Processors
Advanced processor technology, Instruction-set architectures, CISC Scalar processors, RISC Scalar processors, Superscalar processors, VLIW architectures, Vector and symbolic processors.

5.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.

6.Memory Hierarchy Design
Cache basics & cache performance, Reducing miss rate and miss penalty, Multilevel cache hierarchies, Main memory organizations, Design of memory hierarchies.

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.

Text

1. Kai Hwang, “Advanced computer architecture”, TMH.
2. D. A. Patterson and J. L. Hennessey, “Computer organization and design,” Morgan Kaufmann, 2nd Ed.

References

1. J.P.Hayes, “computer Architecture and organization”, MGH.
2. Harvey G.Cragon,”Memory System and Pipelined processors”; Narosa Publication.
3. V.Rajaranam & C.S.R.Murthy, “Parallel computer”; PHI.
4. R.K.Ghose, Rajan Moona & Phalguni Gupta, “Foundation of Parallel Processing”; Narosa Publications.

EC-705 Characterization of Semiconductor Materials and Devices

1. Introduction
Various Semiconductor materials and their advantages & disadvantages applied to VLSI and Nano-electronics.

2. Properties of Semiconductor
Crystal structure, Band theory, Carrier concentration at thermal equilibrium, Density of states, Fermi energy, Ionization of impurity in semiconductor, Quantum aspect of semiconductors.

3. Semiconductor Carrier Dynamics
Scattering of carrier in semiconductors, Low field effect in semiconductor, Very high field effect in semiconductor, Carrier transport phenomena, Charge injection and quasi equilibrium, Generation and recombination of electron and holes and Basic equation for semiconductor device operation.

4. Measurement of Semiconductor Properties
Resistivity, conductivity, Band gap etc

5. Semiconductor Junction with Metal, Insulator and Semiconductors
Characteristics and energy band diagrams of PN Junction diodes-step and graded junction, Schottky barrier diode, Ohmic contact, Insulator-semiconductor junction.

6. Compound Semiconductor
Classifications; Energy band diagram; Phase diagram, Electronic properties of compound Semiconductor materials; Microwave Devices.

7. Applications of Compound Semiconductors
PN Junction, Solar cells; P-I-N photodetector; Semiconductor lasers.

Text Books

1. S.M. Sze, “Physics of semiconductor devices”, Wiley Pub.
2. B.G. Streetman, “Solid State Electronics Devices”, Prentice Hall, 2002.

References

1. M.S.Tyagi, “Semiconductor Materials and Devices,” Wiley Pub.

EC-706 CMOS RF Circuit Design

1. Introduction to RF design and Wireless Technology

Design and applications, Complexity and choice of Technology, Basic concepts in RF design, Nonlinearly and time Variance, Intersymbol interference, Random processes and noise. Sensitivity and dynamic range, Conversion of gains and distortion.

2. RF Modulation

Analog and digital modulation of RF circuits, Comparison of various techniques for power efficiency, Coherent and non-coherent detection, Mobile RF communication and basics of Multiple Access techniques. Receiver and Transmitter architectures, Direct conversion and two-step transmitters.

3. RF Testing

RF testing for heterodyne, Homodyne, Image reject, Direct IF and sub sampled receivers.

4. BJT and MOSFET Behavior at RF Frequencies

BJT and MOSFET behavior at RF frequencies, Modeling of the transistors and SPICE model, Noise performance and limitations of devices, Integrated parasitic elements at high frequencies and their monolithic implementation

5. RF Circuits Design

Overview of RF Filter design, Active RF components & modeling, Matching and Biasing Networks. Basic blocks in RF systems and their VLSI implementation, Low noise Amplifier design in various technologies, Design of Mixers at GHz frequency range, Various mixers-working and implementation. Oscillators- Basic topologies VCO and definition of phase noise, Noise power and trade off. Resonator VCO designs, Quadrature and single sideband generators. Radio frequency Synthesizers- PLLS, Various RF synthesizer architectures and frequency dividers, Power Amplifier design, Liberalization techniques, Design issues in integrated RF filters.

Text Books

1. Thomas H. Lee, Design of CMOS RF Integrated Circuits, Cambridge University press 1998.

References

1. B. Razavi, RF Microelectronics, PHI 1998
2. R. Jacob Baker, H.W. Li, D.E. Boyce, CMOS Circuit Design, layout and Simulation, PHI, 1998
3. Y.P. Tsividis, Mixed Analog and Digital Devices and Technology, TMH, 1996

EC- 707 Digital Logic design with HDL

1. **Introduction to logic circuits**:
   Variables and functions, Synthesis using AND, OR and NOT gates, Introduction to CAD tools, Introduction to HDL(VHDL/Verilog)

2. **Implementation Technology**:
   Transistor switches, CMOS Logic, PLD, Transmission gates

3. **Optimized Implementation of Logic Functions**:
   Strategy for minimization, minimization of POS, Multiple Output circuits, Analysis of Multilevel Circuits

4. **Number Representation and Arithmetic Circuits**:
   Positional Number representation, Addition of unsigned numbers, signed Numbers, Fast adders, Design of arithmetic circuits using CAD tools, Multiplication

5. **Combinational Circuit Building blocks**:
   Multiplexers, Decoder, Encoder, Code Converters, Arithmetic Comparison circuits, Verilog for combinational circuits , Design of Sequential design, Design Asynchronous Sequential Design

Text Books

1. Fundamental of digital Logic with Verilog design by S. Brown & Z. Vransesic, TMH.
2. A VHDL Primer by J. Bhaskar, Addison Wesley.

EC-708 VLSI Interconnects

1. Interconnects
Interconnect Parameters: Resistance, Inductance, and Capacitance, Interconnect RC Delays**:** Elmore Delay Calculation. Interconnect Models: The lumped RC Model, the distributed RC Model, the transmission line model. SPICE Wire Models: Distributed RC lines in SPICE, Transmission line models in SPICE.

2. Scaling issues in interconnects
Gate and Interconnect Delay

3. CMOS Repeater
The Static Behavior- Switching Threshold, Noise Margins, The Dynamic Behavior- Computing the capacitances, Propagation Delay: First order Analysis, Propagation Delay from a Design perspective, Power, energy and Energy-Delay- Dynamic Power Consumption, Static Consumption, Analyzing Power Consumption using SPICE

4. Repeater Design: Driving Interconnects for Optimum speed and power
Short channel model of CMOS Repeater - Transient Analysis of an RC loaded CMOS repeater, Delay Analysis, Analytical power expressions: Dynamic power, Short circuit Power, Resistive Power Dissipation, CMOS Repeater insertion: Analytical expressions for delay and power of a repeater chain driving an RC load.

5. Advanced Interconnect Techniques
Reduced-swing Circuits, Current-mode Transmission Techniques

6. Crosstalk
Theoretical basis and circuit level modeling of crosstalk, Energy dissipation due to crosstalk: Model for energy calculation of two coupled lines. Contribution of driver and interconnect to dissipated energy, Crosstalk effects in logic VLSI circuits: Static circuits, Dynamic circuits and various remedies.

Text Books

1. Jan M. Rabaey, Analysis and Design of Digital Integrated Circuits– A design Perspective, TMH, 2nd Edition 2003.

2. F.Moll, M.Roca, Interconnection Noise in VLSI Circuits, Kluwer Academic Publishers.

Reference Books:

1.John P. Uymera, Introduction to VLSI Circuits and Systems, Wiley Student Edition.

2. S.M. Kang, L. Yusuf, CMOS Digital Integrated Circuits-Analysis and Design TMH, 3rd Edition.

EC -709 Low Power VLSI Design

1. Introduction
Need for low power VLSI chips, Sources of power dissipation in Digital Integrated circuits. Emerging low power approaches. Physics of power dissipation in CMOS devices.

2. Device & Technology Impact on Low Power
Dynamic dissipation in CMOS, Transistor sizing & gate oxide thickness, Impact of technology Scaling, Technology & Device innovation.

3. 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.
Probabilistic power analysis- Random logic signals, Probability & frequency, Probabilistic power analysis techniques.

4.Low Power Design
Circuit level- Power consumption in circuits, Flip Flops & Latches design, High capacitance nodes, Low power digital cells library
Logic level- Gate reorganization, Signal gating, Logic encoding, State machine encoding, Pre-computation logic

5. Low Power Architecture & Systems
Power & performance management, Switching activity reduction, Parallel architecture with voltage reduction, Flow graph transformation, Low power arithmetic components, Low power memory design.

6. Low Power Clock Distribution: Power dissipation in clock distribution, single driver vs distributed buffers, zero skew vs tolerable skew, chip & package co design of clock network

7.Algorithm & Architectural Level Methodologies: Introduction, design flow, algorithmic level analysis & optimization, architectural level estimation & synthesis.

Text Books
1. Gary K. Yeap, Practical Low Power Digital VLSI Design, KAP, 2002
2. Rabaey and Pedram, Low power design methodologies, Kluwer Academic,1997

References
1. Kaushik Roy, Sharat Prasad, Low-Power CMOS VLSI Circuit Design, Wiley, 2000

EC-710 VLSI Test & Testability

1.Motivation for Testing

Design for testability, The problems of digital and analog testing, Design for test, Software testing.

2.Faults in Digital Circuits

General introduction, Controllability and Observability, Fault models - stuck-at faults, Bridging faults, Intermittent faults.

3.Digital Test Pattern Generation

Test pattern generation for combinational logic circuits, Manual test pattern generation, Automatic test pattern generation - Roth's D-algorithm, Developments following Roth's D-algorithm, Pseudorandom test pattern generation, Test pattern generation for sequential circuits , Exhaustive, non-exhaustive and pseudorandom 70 test pattern Generation, Delay fault testing .

4.Signatures and Self Test

Input compression output compression arithmetic, Reed-Muller and spectral coefficients, Arithmetic and Reed-Muller coefficients ,Spectral coefficients, Coefficient test signatures, Signature analysis and online self test .

5.Testability Techniques

Partitioning and ad-hoc methods and scan-path testing , Boundary scan and IEEE standard 1149.1, Offline built in Self Test (BIST), Hardware description languages and test .

6.Testing of Analog and Digital circuits

Testing techniques for Filters, A/D Converters, RAM, Programmable logic devices and DSP, Test generation algorithyms for combinational logic circuits – fault table, Boolean difference, Path sensitilization, D-algorithm, Podem, Fault simulation techniques – serial single fault propogation, Deductive, Parallel and concurrent simulation, Test generation for a sequential logic, Design for testability – adhoc and structured methods, Scan design, Partial scan, Boundary scan, Pseudo-random techniques for test vector generation and response compression, Built –in-Self- test, PLA test and DFT.

Text Books

1. M. Abramovici , M.A Breuer and A.D. Friendman, Digital systems and Testing and Testable Design, Computer Science Press 1990.

2. Stanley L. Hurst, VLSI Testing: digital and mixed analogue digital techniques Pub: Inspec / IEE, 1999

EC-711 Digital Image Processing

1. Introduction

Steps in Digital Image Processing, Components of an Image Processing system, Applications. Human Eye and Image Formation; Sampling and Quantization, Basic Relationship among pixels- neighbour, connectivity, regions, boundaries, distance measures.

2. Image Enhancement

Spatial Domain-Gray Level transformations, Histogram, Arithmetic/Logical Operations, Spatial filtering, Smoothing & Sharpening Spatial Filters; Frequency Domain- 2-D Fourier transform, Smoothing and Sharpening Frequency Domain Filtering; Convolution and Correlation Theorems;

3. Image Restoration

Inverse filtering, Wiener filtering; Wavelets- Discrete and Continuous Wavelet Transform, Wavelet Transform in 2-D;

4. Image Compression

Redundancies- Coding, Interpixel, Psycho visual; Fidelity, Source and Channel Encoding, Elements of Information Theory; Loss Less and Lossy Compression; Run length coding, Differential encoding, DCT, Vector quantization, entropy coding, LZW coding; Image Compression Standards-JPEG, JPEG 2000, MPEG; Video compression;

5. Image Segmentation

Discontinuities, Edge Linking and boundary detection, Thresholding, Region Based Segmentation, Watersheds; Introduction to morphological operations; binary morphology- erosion, dilation, opening and closing operations, applications; basic gray-scale morphology operations; Feature extraction; Classification; Object recognition.

6. Pattern recognition

Introduction to pattern recognition, Pattern Recognition Methods, Pattern Recognition System Design, Statistical Pattern recognition – Classification, Principle, Classifier learning, Neural networks for pattern classification.

Text Books

1. Fundamentals of Digital Image processing- A. K. Jain, Pearson Education
2. Digital Image Processing- R. C. Gonzalez and R. E. Woods, Pearson Education
3. Digital Image Processing using MATLAB- R. C. Gonzalez , R. E. Woods and S. L Eddins, Pearson Education
4. Digital Image Processing and Analysis- Chanda and Mazumdar, PHI

EC-712 Embedded System Design

1. Microcontroller

Microprocessors vs. Microcontrollers, MCS-51 Family Overview, Important Features, Architecture. 8051 Pin Functions, Architecture, Addressing Modes, Instruction Set, Instruction types, Interrupts.

2. Embedded Systems:

Background and History of Embedded Systems, Definition and Classification, Programming languages for embedded systems: desirable characteristics of programming languages for embedded systems, Low-level versus high-level languages, Main language implementation issues: control, Typing. Major programming languages for embedded systems. Embedded Systems on a Chip (SoC) and the use of VLSI designed circuits.

3. Real Time Operating Systems (RTOS):

Architecture of an RTOS, Important features of VxWorks and Montavista Linux, Embedded Systems Programming, Locks and Semaphores, Operating System Timers and Interrupts, Exceptions, Tasks: Introduction, Defining a task, Task states and scheduling, Task structures, Synchronization, Communication and concurrency, Kernel objects: Semaphores, Queues, Pipes, Event registers, Signals, And condition variables. Real-time clock and system clock, Programmable interval timers, Timer ISRs, Timing wheels, Soft timers.

4. 32-Bit RISC Based ARM Architecture:

Important features, Instruction set, Programming Examples, Core based Embedded Systems, Soft and Hard Cores, Xilinx FPGA architectures, 8-bit Picoblaze Microcontroller Core, 32-bit Microblaze Soft Core, Power PC

Text Books

1. Mckenzie, Scott, The 8051 Microcontroller, PHIs, (1995) 5th ed.
2. Simon, David E., An Embedded System Primer, Pearson Education, (2005) 4th ed.
3. K.V.K.K.Prasad, Embedded/Real-time Systems: Concepts, Design and Programming – Dreamtech press.
4. Proramming for Embedded Systems – Dreamtech Software team, Willey - dreamtech

EC-751 VLSI Design

1. Introduction
Basic principle of MOSFETs, Introduction MOS models for digital design.

2. MOS Inverters
Static and Dynamic characteristics: Inverter principle, Depletion and enhancement load inverters, the basic CMOS inverter, transfer characteristics, logic threshold, Noise margins, and Dynamic behavior, transition time, Propagation Delay, Power Consumption.

3. MOS Circuit Layout & Simulation
Layout design rules, MOS device layout: Transistor layout, Inverter layout, CMOS digital circuits layout & simulation, Circuit Compaction; Circuit extraction and post-layout simulation.

4. Combinational MOS Logic Design
Static MOS design, Complementary MOS, Ratioed logic, Pass Transistor logic, Complex logic circuits, Transmission gate logic, Adders.

5. Dynamic MOS design
Dynamic logic families and their performance.

6. Sequential MOS Logic Design
Static latches, Flip flops & Registers, Dynamic Latches & Registers, CMOS Schmitt trigger, Monostable sequential Circuits, Astable Circuits, ROM & RAM cells design

7. MOS Amplifier

Performances metrices of amplifier circuits, Common source amplifier, Cascode amplifier, Frequency response of amplifiers and stability.

Text Books

1. Kang & Leblebici “CMOS Digital IC Circuit Analysis & Design”- McGraw Hill, 2003
2. J.M. Rabaey, “Digital Integrated Circuits Design”, Pearson Education, Second Edition, 2003

References

3. B.G. Streetman & S. Banerjee, Solid State Electronics.
4. Uyemera, CMOS Logic Circuit Design, Springer India Pvt. Ltd. New Delhi, 2007.
5. Eshraghian & Pucknell, Introduction to VLSI, PHI
6. Sedra & Smith, SPICE.

EC-752 MEMS & Microsensor Design

1. Introduction to MEMS

MEMS Fabrication Technologies, Materials and Substrates for MEMS, Processes for Micromachining, Characteristics, Sensors/Transducers, Piezoresistance Effect, Piezoelectricity, Piezoresistive Sensor.

2. Mechanics of Beam and Diaphragm Structures

Stress and Strain, Hooke's Law. Stress and Strain of Beam Structures: Stress, Strain in a Bent Beam, Bending Moment and the Moment of Inertia, Displacement of Beam Structures Under Weight, Bending of Cantilever Beam Under Weight.

3. Air Damping

Drag Effect of a Fluid: Viscosity of a Fluid, Viscous Flow of a Fluid, Drag Force Damping, The Effects of Air Damping on Micro-Dynamics. Squeeze-film Air Damping: Reynolds' Equations for Squeeze-film Air Damping, Damping of Perforated Thick Plates. Slide-film Air Damping: Basic Equations for Slide-film Air Damping, Couette-flow Model, Stokes-flow Model.

4. Electrostatic Actuation

Electrostatic Forces, Normal Force, Tangential Force, Fringe Effects, Electrostatic Driving of Mechanical Actuators: Parallel-plate Actuator, Capacitive sensors. Step and Alternative Voltage Driving: Step Voltage Driving, Negative Spring Effect and Vibration Frequency.

5. Thermal Effects

Temperature coeficient of resistance, Thermo-electricity, Thermocouples, Thermal and temperature sensors.

6. Applications of MEMS in RF

MEMS Resonator Design Considerations, One-Port Micromechanical Resonator ModelingVertical Displacement Two-Port Microresonator Modeling, Micromechanical Resonator Limitations.

Text Books

1. S.M. Sze, “Semiconductor Sensors”, John Wiley & Sons Inc., Wiley Interscience Pub.
2. M.J. Usher, “Sensors and Transducers”, McMillian Hampshire.

References

1. R.S. Muller, Howe, Senturia and Smith, “Microsensors”, IEEE Press.