HALDIA INSTITUTE OF TECHNOLOGY

M. Tech. - ECE (Microelectronics & VLSI Designs)

Semester – 1:

Paper Type	Paper Code	Paper Name	Instruction Hours			Credit
			L	T	P	
C-Th	MVLSI 101	Advanced Engg. Maths	3	0	0	3
C-Th	MVLSI 102	VLSI Device & Modeling	3	0	0	3
C-Th	MVLSI 103	Digital IC Design	3	0	0	3
C-Th	MVLSI 104	Microelectronic Technology & IC Fabrication	3	0	0	3
E-Th	MVLSI 105A 105B 105C 105D	Elective – I: 1. Bioelectronics System *2. Embedded System Fundamentals* *3. AI & Neural Networks* 4. Advanced Digital Communication	3	0	0	3
		Total of Theory	15	0	0	15
C-Pr	MVLSI 191	CAD Tools for VLSI Design Lab	0	0	3	1.5
E-Pr	MVLSI 192A 192B	*1. Microelectronic Technology Lab* 2. Embedded Systems Lab (part I)	0	0	3	1.5
		Total of Practical	0	0	6	3
S	MVLSI 181	Seminar	0	2	0	1
		Total	15	2	6	**19**

Semester – 2:

Paper Type	Paper Code	Paper Name	Instruction Hours			Credit
			L	T	P	
C-Th	MVLSI 201	*Processor Architecture for VLSI*	3	0	0	3
C-Th	MVLSI 202	Digital Signal Processing & Applications	3	0	0	3
C-Th	MVLSI 203	*Analog IC Design*	3	0	0	3
E-Th	MVLSI 204A 204B 204C	Elective – II: 1. Quantum & Nano-science 2. *Sensors* 3. *VLSI Testing*	3	0	0	3
E-Th	MVLSI 205A 205B 205C 205D	Elective – III: 1. *Low Power VLSI Design* 2. Mobile Communication 3. *Advanced Micro & Nano-Devices* 4. Physical Design Automation	3	0	0	3
		Total of Theory	15	0	0	15
E-Pr	MVLSI 291A 291B	1. *Microelectronic Technology Lab* 2. Embedded Systems Lab (Part II)	0	0	3	1.5
		Total of Practical	0	0	3	1.5
S	MVLSI 281	Term paper leading to Thesis / Mini Project	2	0	0	2
		Total	17	0	6	**18.5**

Semester – 3:

Paper Type	Paper Code	Paper Name	Instruction Hours			Credit
			L	T	P	
C-Th	MVLSI 301	1. Research Methodologies and IPR	4	0	0	4
AE-Th	MVLSI 302	1. Architectural Design of Integrated Circuits	4	0	0	4
		Total of Theory	8	0	0	8
S	MVLSI 383	Dissertation – Part I	0	0	20	8
		Total	8	0	20	**16**

Semester – 4:

Paper Type	Paper Code	Paper Name	Instruction Hours			Credit
			L	T	P	
S	MVLSI 481	Dissertation – Part II (Completion)	0	0	32	16
		Total	0	0	32	**16**

Total Credits: 19+18.5+16+16=69.5

Details:

VLSI Devices & Modelling [Sem - 1] (40 lectures)

Pre- requisite: Knowledge of basic physics of diodes, BJTs, FETs, MOS structures.
Semiconductors, Junctions and MOSFET Overview: Introduction, Semiconductors, Conduction, Contact Potentials, P- N Junction, Overview of the MOS Transistor.

Basic Device Physics:
Two Terminal MOS Structure: Flat- band voltage, Potential balance & charge balance, Effect of Gate- substrate voltage on surface condition, Inversion, Small signal capacitance;
Three Terminal MOS Structure: Contacting the inversion layer, Body effect, Regions of inversion, Pinch- off voltage;
Four Terminal MOS Transistor: Transistor regions of operation, general charge sheet models, regions of inversion in terms of terminal voltage, strong inversion, weak inversion, moderate inversion, interpolation models, effective mobility, temperature effects, breakdown p- channel MOS FET, enhancement and depletion type, model parameter values, model accuracy e tc;
Small dimension effects: channel length modulation, barrier lowering, two dimensional charge sharing and threshold voltage, punch- through, carrier velocity saturation, hot carrier effects, scaling, effects of surface and drain series resistance, effects due to thin oxides and high doping. Sub threshold regions.

CMOS Device Design: Scaling, Threshold voltage, MOSFET channel length;
CMOS Performance Factors: Basic CMOS circuit elements; parasitic elements; sensitivity of CMOS delay to device parameters; performance factors of advanced CMOS devices.
Bipolar Devices, Design & Performance:
Outcome: Student will be able to model devices and study their performance in analog and digital, circuits.

Assignment: Simple Circuit simulation using Spice.

Text:
Fundamentals of Modern VLSI Devices by Yuan Taur & Tak H. Ning (Cambridge)
The MOS Transistor (second edition) Yannis Tsividis (Oxford)
Reference:
CMOS Analog Circuit Design (second edition) Phillip E. Allen and Douglas R. Holberg (Oxford)

Digital IC Design [Sem– 1] (40 lectures)

Course Outcomes:
After completion of this course, students will be able to
CO1: Learn the basics of CMOS Integrated Circuit (IC), different Domains of VLSI design, design automation tools and the state-of-the-art VLSI circuits.
CO 2: Learn CMOS logic behaviour, advantages and drawbacks using static, dynamic, Domino logic and Bi-CMOS logic
CO3.Learn the basics of CMOS fabrication and Layout.
CO4: Learn EDA tools and their advantages, concept of test bench, simulation, design verification, synthesis and hardware description language (Verilog/VHDL/System ‘C’)
CO5: learn the concept of Programmable Hardware and their requirements, FPGA -architecture, configuration and design flow, concept of System on Chip (SOC) .
CO6: Learn logical effort, path effort, path effort delay, path parasitic delay, designing fast circuits and multistage logic networks and the concept of delay vs fan out,

MODULE 1: Introduction to VLSI Design

Basics of Integrated Circuit (IC), SSI, MSI, LSI, VLSI, ULSI, Integration levels. History of IC development, Moore's Law, Different types of IC chips; Digital, Analog & Mixed signal ICs; Different Domains of VLSI design; EDA- the VLSI design CAD tools, VLSI design state-of-the-art, some emerging applications of VLSI, Quality metrics of a digital design: Cost, Functionality, Robustness, Power, and Delay VLSI design of complex processor, VLSI Design Flow, Synthesis, layout generation, Verification and simulation, VLSI chip manufacturing process flow.

Module2 : CMOS logic Basics:

Basics of MOS transistors and MOS as switches, Complementary CMOS logic , CMOS logic behaviour , advantages and drawbacks of CMOS logic, Pull up and pull down network, conduction complement, complex logic function using CMOS, pass transistors, transmission gates, tri-state buffers, Flip- flops(D- F/F, JK F/F etc.), transistor count, Delay , drawbacks of CMOS, Dynamic logic, Domino logic , Bi-CMOS to overcome the drawbacks of CMOS, standard cell design, full custom design. example of standard cell., combinatorial and Sequential Logic circuits –asynchronous and synchronous sequential circuits , Moore machine, Mealy machine , examples, Finite state machine design ,

Module3:Basics of CMOS Layout :

Introduction to VLSI fabrication and fabrication steps, Concept of MASK, Lithography, etching, polysilicon patterning, ion implementation , metallization etc.,fabrication error, concept of layout , feature size, Lamda (□) rule, concept of process technology , stick diagram, general design rules for layout, width spacing rule, poly diffusion interaction, contacts, VIA and contact spacing, examples of CMOS layout of an inverter, NAND /NOR gates, simplified design rule, full custom and standard cell layout, placement , routing .floor planning ,

Module 4: Programmable Hardware and FPGA (6)

Concept of Programmable Hardware (PLA, PLD, CPLD, FPGA) and their requirements, FPGA --Architecture, configuration and design flow, system design using FPGA , concept of System on Chip(SOC). FPGA as reconfigurable computing and programmable System on Chip (pSOC). FPGA as validation of custom design or ASIC.

Module 5 : Logical Effort

Logical effort -Path Logical Effort, Path Electrical Effort , Path Effort , branching effort, delay in a logic gate, path effort delay, path parasitic delay, designing fast circuits and gate sizes, multistage logic networks, choosing the best number of stages, delay vs fan out,

Module 6: Hardware description language & EDA tools

EDA tools and their advantages, concept of test bench, simulation, design verification, synthesis, hardware description language (HDL) -VHDL/VERILOG/SYSTEM C etc.

Text:

1. Carver Mead, Lynn Conway, Introduction to VLSI Systems",B.S. Publication
2. John P Uyemura ," Chip Design for Submicron VLSI",Thompson Publication.
3. Etienne Scard., Sonia Delmas Bendhia ," Advanced CMOS cell Design :",McGraw Hill Professional .
4. K.V.K.K.Prasad ,Kattula Shyamala, "VLSI Design Black Book", dreamtech Publication
5. Baker, Li, Boyce, "CMOS Circuit Design, Layout, and Simulation", Wiley, 2 nd Edition.

Ref Book:

1r. enJc Pe sR: abaey, A P Chandrakasan, B Nikolic, "Digital Integrated circuits: A design perspective", Prentice Hall electronics and VLSI series, 2 nd Edition.
2. Baker, Li, Boyce, "CMOS Circuit Design, Layout, and Simulation", Wiley, 2 nd Edition.
3. Sung-Mo Kang & Yusuf Leblebici, CMOS Digital Integrated Circuits Analysis

and Design, McGraw-Hill, 1998.

Microelectronics Technology & IC Fabrication: *3(L)* (40 lectures)

Cleanroom technology - Clean room concept – Growth of single crystal Si, surface contamination, cleaning & etching.

(Laboratory Practices : Cleaning of p-type & n-type Si-wafer by solvent method & RCA cleaning)

Oxidation – Growth mechanism and kinetic oxidation, oxidation techniques and systems, oxide properties, oxide induced defects, charactrisation of oxide films, Use of thermal oxide and CVD oxide; growth and properties of dry and wet oxide, dopant distribution, oxide quality; *(Laboratory Practices* : Fabrication of MOS capacitor)

Solid State Diffusion – Fick's equation, atomic diffusion mechanisms, measurement techniques, diffusion in polysilicon and silicon di-oxide diffusion systems.

Ion implantation – Range theory, Equipments, annealing, shallow junction, high energy implementation. Lithography – Optical lithography, Some Advanced lithographic techniques.

Physical Vapour Deposition – APCVD, Plasma CVD, MOCVD.

Metallisation - Different types of metallisation, uses & desired properties.*(Laboratory Practices* : Metallisation & Schottky diode fabrication)

VLSI Process integration. (3+3+3+3+3+3+3+3+3+3+3+3+3+4 = 40 hrs theory)

Reading List

8. Semiconductor Devices Physics and Technology, Author: Sze, S.M.; Notes: Wiley, 1985
9. An Introduction to Semiconductor Microtechnology, Author: Morgan, D.V., and Board, K
10. The National Technology Roadmap for Semiconductors , Notes: Semiconductors Industry Association, SIA, 1994
11. Electrical and Electronic Engineering Series VLSI Technology, Author: Sze, S.M. Notes: Mcgraw-Hill International Editions

Electives:

Embedded Systems Fundamentals

UNIT – I Introduction to Embedded Electronic Systems and Microcontrollers: An Embedded System-Definition, Embedded System Design and Development Life Cycle, An Introduction to Embedded system Architecture, The Embedded Systems Model, Embedded Hardware: The Embedded Board and the von Neumann Model, Embedded Processors: ISAArchitectureModels, Internal Processor Design, Processor Performance, Board Memory: Read-Only Memory (ROM), Random-Access Memory (RAM), Auxiliary Memory, Memory Management of External Memory and Performance, Approaches to Embedded Systems, Small Microcontrollers, Anatomy of a Typical Small Microcontroller, Small Microcontrollers Memory, Embedded Software, Introduction to small microcontroller (MSP430).

UNIT-II MSP430 – I: Architecture of the MSP430 Processor: Central Processing Unit, Addressing Modes, Constant Generator and Emulated Instructions, Instruction Set, Examples, Reflections on the CPU and Instruction Set, Resets, Clock System, Memory and Memory Organization. Functions, Interrupts, and Low-Power Mode: Functions and Subroutines, Storage for Local Variables, Passing Parameters to a Subroutine and Returning a Result, Mixing C and Assembly Language, Interrupts, Interrupt Service Routines, Issues Associated with Interrupts, Low-Power Modes of Operation.

UNIT – III MSP430 – II: Digital Input, Output, and Displays:Parallel Ports, Digital Inputs, Switch Debounce, Digital Outputs, Interface between Systems, Driving Heavier Loads, Liquid Crystal Displays, Simple Applications of the LCD. Timers: Watchdog Timer, Timer_A, Timer_A Modes, Timer_B,Timer_B Modes, Setting the Real-Time Clock, State Machines.

UNIT – IV MSP430 Communication: Communication Peripherals in the MSP430, Serial Peripheral Interface, SPI with the USI, SPI with the USCI, A Thermometer Using SPI Modes, Inter-integrated Circuit Bus(I^2C) and its operations, State Machines for I^2C Communication, A Thermometer Using I^2C, Asynchronous Serial Communication, Asynchronous Communication with the USCI_A, A Software UART Using Timer_A, Other Types of Communication.

UNIT – V MSP430 Case Studies: Introduction to Code Composer studio (CC Studio Ver. 6.1) a tutorial, A Study of blinking LED, Enabling LED using Switches, UART Communication, LCD interfacing, Interrupts, Analog to Digital Conversion, General Purpose input and output ports,I2C.

TEXT BOOKS: 1. Tammy Noergaard “Embedded Systems Architecture: A Comprehensive Guide for Engineers and Programmers”, Elsevier(Singapore) Pvt.Ltd.Publications, 2005.
2. John H. Davies “MSP430 Microcontroller Basics”,Elsevier Ltd Publications, Copyright 2008.

REFERENCE BOOKS: 1. Manuel Jiménez Rogelio,PalomeraIsidoroCouvertier “Introduction to Embedded SystemsUsing Microcontrollers and the MSP430” Springer Publications, 2014.
2. Frank Vahid, Tony D. Givargis, “Embedded system Design: A Unified Hardware/Software Introduction”, John Wily & Sons Inc.2002.
3. Peter Marwedel, “Embedded System Design”, Science Publishers, 2007.
4. Arnold S Burger, “Embedded System Design”, CMP Books, 2002.
5.Rajkamal, “Embedded Systems: Architecture, Programming and Design”, TMH Publications,Second Edition, 2008.

Advanced digital communication

- *Pre-requisites*:
    - Fourier Expansion, Fourier transform, Normalized power spectrum, Power spectral density, Effect of transfer function on output power spectral density, Perseval’s theorem.
    - Autocorrelation & cross correlation between periodic signals, cross correlation power.
    - Relation between power spectral density of a signal, its autocorrelation function and its spectrum.
    - Distinction between a random variable and a random process.
    - Probability, sample space, Venn diagramme, joint probability, bay’s theorem, cumulative probability distribution function, probability density function, joint cumulative probability distribution function, joint probability density function.
    - Mean/average/expectation of a random variable and of sum of random variables.
    - Standard deviation, variance, moments of random variables, - explanation with reference to common signals.
    - Tchebycheff’s inequality.
    - Gaussian probability density function – error function & Q function
    - Central limit theorem.

- Spectral analysis of signals:
    - Orthogonal & orthonormal signals. Gram-Schmidt procedure to represent a set of arbitrary signals by a set of orthonormal components; - numerical examples.
    - The concept of signal-space coordinate system, representing a signal vector by its orthonormal components, measure of distinguishability of signals.

- Characteristics of random variables and random processes:
    - Common probability density functions, - Gaussian, Rayleigh, Poisson, binomial, Rice, Laplacian, log- normal, etc.
    - Probability of error in Gaussian Binary symmetric channel.
    - Random processes – time average, ensemble average, covariance, autocorrelation, cross correlation, stationary process, ergodic process, wide sense stationary process.
    - Power spectral density and autocorrelation, power spectral density of a random binary signal.
    - Linear mean square estimation methods.

- *Revision* of source coding: Sampling theorem, instantaneous/ flat top/ natural sampling, band width of PAM signal, quantization, quantization noise, principle of pulse code modulation, delta modulation & adaptive delta modulation.

- Parametric coding/ hybrid coding/ sub band coding: APC, LPC, Pitch predictive, ADPCM, voice excited vocoder, vocal synthesizer.

- Line codes:
    - UPNRZ, PNRZ, UPRZ, PRZ, AMI, Manchester etc.
    - Calculation of their power spectral densities.
    - Bandwidths and probabilities of error P_e for different line codes.

- *Revision* of digital modulation: Principle, transmitter, receiver, signal vectors, their distinguish ability (d) and signal band width for BPSK, QPSK, M-ARY PSK, QASK, MSK, BFSK, M-ARY FSK.

- Spread spectrum modulation:
    - Principle of DSSS, processing gain, jamming margin, single tone interference, principle of CDMA, MAI and limit of number of simultaneous users.
    - Digital cellular CDMA system: model of forward link, reverse link, error rate performance of decoder using m-sequence chip codes.
    - Properties of m-sequences, their generation by LFSR, their PSDs, limitations of m-sequences.
    - Gold sequence, Kasami sequence – generating the sequences, their characteristic mean, cross correlation and variance of cross correlation, their merits and limitations as chip codes in CDMA.
- Multiplexing & multiple access:
    - TDM/TDMA, FDM/FDMA, Space DMA, Polarization DMA, OFDM, ALOHA, Slotted ALOHA, Reservation ALOHA, CSMA-CD, CSMA-CA – basic techniques and comparative performances e.g. signal bandwidth, delay, probability of error etc.

- Noise:
    - Representation of noise in frequency domain.
    - Effect of filtering on the power spectral density of noise – Low pass filter, band pass filter, differentiating filter, integrating filter.
    - Quadrature components of noise, their power spectral densities and probability density functions.
    - Representation of noise in orthogonal components.

- Characteristics of different types of channels:
    - Gaussian, Poisson etc.

- Band limited channel:
    - Characteristics of band limited channel, inter symbol interference (ISI) - it's mathematical expression.
    - Niquist's theorem for signal design for no ISI in ideal band limited channel, Niquist's criteria, raised cosine pulse signals.
    - Signal design for controlled ISI in ideal band limited channel, partial response signals, duobinary & partial duobinary signals - their methods of generation and detection of data.
    - Concept of maximum likelihood detection, log likely hood ratio.
    - Detection of data with controlled ISI by linear transverse filters.
    - Performance of minimum mean square estimation (MMSE) detection in channels with ISI.

- Base band signal receiver and probabilities of bit error:
    - Peak signal to RMS noise output ration, probability of error.
    - Optimum filter, it's transfer function.
    - Matched filter, it's probability of error.
    - Probability of error in PSK, effect of imperfect phase synchronization or imperfect bit synchronization.
    - Probability of error in FSK, QPSK.

- Signal space vector approach to calculate probability of error in BPSK, BFSK, QPSK.
- Relation between bit error rate and symbol error rate.
- Comparison of various digital modulation techniques vis-à-vis band width requirement and probabilities of bit error.

Text Books:

1. Digital communication, 4th ed. - J. G. Proakis, MGH International edition.
2. Principle of Communication Systems – Taub, Schilling, TMH
3. Digital and Analog Communication Systems, 7th ed. – Leon W. Couch, PHI.
4. Principles of Digital Communication – Haykin
5. Digital Communication – Zeimer, Tranter.
6. Principle of Digital communication - J. Das, S. K. Mallick, P. K Chakraborty, New Age Int.
7. Communication Systems, 4th ed. – A. Bruce Carlson, Paul B. Crilly, Janet C. Rutledge, MGH International edition.
8. Digital Communications, 2nd ed. – Bernard Sklar, Pearson Education.
9. Electronic Communications, 4th ed. – Dennis Roddy, John Coolen, PHI

Processor Architecture for VLSI

UNIT-I

Programmable DSP Hardware: Processing Architectures (von Neumann, Harvard), DSP core algorithms (FIR, IIR, Convolution, Correlation, FFT), IEEE standard for Fixed and Floating Point Computations, Special Architectures Modules used in Digital Signal Processors (like MAC unit, Barrel shifters), On-Chip peripherals, DSP benchmarking.

UNIT-II

Structural and Architectural Considerations: Parallelism in DSP processing, Texas Instruments TMS320 Digital Signal Processor Families, Fixed Point TI DSP Processors: TMS320C1X and TMS320C2X Family,TMS320C25 –Internal Architecture, Arithmetic and Logic Unit, Auxiliary Registers, Addressing Modes (Immediate, Direct and Indirect, Bit-reverse Addressing), Basics of TMS320C54x and C55x Families in respect of Architecture improvements and new applications fields, TMS320C5416 DSP Architecture, Memory Map, Interrupt System, Peripheral Devices, Illustrative Examples for assembly coding.

UNIT-III

VLIW Architecture: Current DSP Architectures, GPUs as an alternative to DSP Processors, TMS320C6X Family, Addressing Modes, Replacement of MAC unit by ILP, Detailed study of ISA, Assembly Language Programming, Code Composer Studio, Mixed Cand Assembly Language programming, On-chip peripherals, Simple applications developments as an embedded environment.

UNIT-IV

Multi-core DSPs: Introduction to Multi-core computing and applicability for DSP hardware, Concept of threads, introduction to P-thread, mutex and similar concepts, heterogeneous and homogenous multicore systems.

UNIT-V.

Shared Memory parallel programming –OpenMP approach of parallel programming, PRAGMA directives, OpenMP Constructs for work sharing like for loop, sections, TI TMS320C6678 (Eight Core subsystem).

REFERENCES:

1. M. Sasikumar, D. Shikhare, Ravi Prakash, “Introduction to Parallel Processing”, 1st Edition, PHI, 2006.
2. Fayez Gebali, “Algorithms and Parallel Computing”,1st Edition, John Wiley & Sons, 2011
3. Rohit Chandra, Ramesh Menon, Leo Dagum, David Kohr, Dror Maydan, Jeff McDonald, “Parallel Programming in OpenMP”, 1st Edition, Morgan Kaufman,2000.

Analog IC Design: [Sem – II] (40 lectures)

Recapitulation:

12. CMOS models for analog circuits - Small signal equivalent circuit, temperature effect and sensitivity, overview of electrical noise. 2L
13. Analog subcircuits : CMOS switch, resistors, current source, sink, current mirror, voltage and current references. 2L
14. MOSFET Modelling for Circuit Simulation: 2 L *(Assignment using Spice)*

3 . *CMOS Amplifiers & CMOS Operation Amplifiers:* Basic concepts, Performance Parameters, One state OPAMP, Two stage OPAMP, Stability and Phase compensation, Cascode OPAMP, Design of two- stage and Cascode OPAMP, SPICE simulation of Amplifier, High performance CMOS OPAMPs, Micropower OPAMP, 6 L + 6 P
* Design examples, (SPICE s imulation – Laboratory)

2 . *Switch Capacitor circuits:* General considerations, Switched capacitor integrators, First and secnd order switched capacitor f i l ter circuits, 2 L+ 3 P
* Design examples, (SPICE s imulation – Laboratory)

3 . *Data Converter Fundamentals & Architecture:* Ideal D/ A converters, Ideal A/ D converter, Serial and Flash D/ A converters and A/ D converters, Medium and High Speed converters, Over- sampling converters, performance l imitations, Design consideration, SPICE simulation. 4 L

4 . *Special Circuits:* CMOS voltage controlled oscillators, Ring oscillators, Phase locked loops with pump phase comparators, Gm- C Circuits.
* Design examples, (SPICE s imulation – Laboratory) 4L+ 6P

5 . RF Analog Circuits & Subcircuits: Capacitors and Inductors in VLSI circuits, Bandwidth estimation techniques, Design of high frequency amplifiers, Design of low noise amplifiers, Design of Mixers of RF power amplifiers, Architectures of r f receivers and transmitters. 6 L

6 . Camparators: Characterisation, Two state open loop comparators, Discrete t ime comparators, high speed comparator circuits, CMOS S/ H circuits, 4L
* Design examples, (SPICE s imulation – Laboratory)

Text: The MOS Transistor (second edition) Yannis Tsividis (Oxford)
Reference: CMOS Analog Circuit Design (second edition) Phillip E. Allen and Douglas R. Holberg (Oxford)

Intended Knowledge Outcomes
Understand the main elements of hierarchical VLSI design namely interested circuit technology, approaches to system design, architectural issues, design implementation and layout. The ability to analyse the effect of future integrated circuit technologies on device parameters.

Intended Skill Outcomes
Ability to apply VLSI design methodology for the design of Application Specific Integrated Circuits.

Reading List

1. Principles of CMOS VLSI Design (Essential reading) Author: Weste N and Eshraghian K Notes: Addision Wesley 1985
2. Introduction to NMOS and CMOS VlSI Systems Design (Essential reading) Author: Mukherjee A Notes: Prentice-Hall 1986
3. Introduction to VLSI Systems (Essential reading) Author: Mead and Conway Notes: Addison Wesley D C & Co

AI & Neural Networks

Overview of AI - Introduction, hierarchical perspective and foundations. Problems of AI, AI techniques , Tic-Tac-Toe problem.

Basic problem solving methods: Production systems-State space search-Control strategies-Heauristic search techniques-Forward and backward reasoning-Hill climbing techniques-Best search.

Knowledge representation: Predicate logic- Resolution Question answering-Nonmonotic reasoning-Statistical and probabilistic reasoning-Semantic nets-Frames -Scripts.

Neural Network: Biological neurons and brain, mathematical models of neuron, basic structure of a neural network, Learning rules, ANN training, back propagation algorithm, Hopfield nets and application of Neural Network.

Introduction to expert system-Design of an expert system-Fuzzy logic and neural network in control system, modeling estimation and design methodologies and real time application of Intelligent control system like TRMS, Robot and Magnetic levitation system.
AI languages : Important characteristics of AI languages-PROLOG.
Application of AI & neural networks in VLSI and embedded systems.

Electives- II:

Sensors

UNIT 1

Principles of Physical and Chemical Sensors: Sensor classification, Sensing mechanism of Mechanical, Electrical, Thermal, Magnetic, Optical, Chemical and Biological Sensors.
Sensor Characterization and Calibration: Study of Static and Dynamic Characteristics, Sensor reliability, aging test, failure mechanisms and their evaluation and stability study.

UNIT 2
Sensor Modeling: Numerical modeling techniques, Model equations, Different effects on modeling (Mechanical, Electrical, Thermal, Magnetic, Optical, Chemical and Biological) and examples of modeling.
Sensor Design and Packaging: Partitioning, Layout, technology constraints, scaling.

UNIT 3
Sensor Technology: Thick and thin films fabrication process, Micro machining, IOC (Integrated Optical circuit) fabrication process, Ceramic material fabrication process, Wire bonding, and Packaging. Sensor Interfaces: Signal processing, Multi sensor signal processing, Smart Sensors, Interface Systems. Sensor Applications: Process Engineering, Medical Diagnostic and Patient monitoring,

UNIT 2
Introduction, Scaling, MEMS Markets and Applications MEMS materials and fabrication methods, with emphasis on silicon micromachining
Process simulation: basic lithography, deposition, and etching processes for mems.

VLSI Testing:

Testing: Why test? Difference between testing & verification.
Physical faults & their modeling: Fault equivalence, dominance & collapsing.
Fault simulation: parallel, deductive & concurrent techniques, critical path t racing.
Test pattern generation for combinational circuits: Boolean difference, D- algorithm, Podem, etc, exhaustive, random, weighted test pattern generation, aliasing and its effects on fault coverage.
Test pattern generation for sequential circuits: ad- hoc and structures techniques scan path and LSSD, boundary y scan.
Built- in self test techniques:
Design of testability:

Elective – III

RF circuits & Systems

Characterization of materials used for different RF electronic devices. Heterostructure-overview.
High frequency transistors- BJT,field effect transistors .
Basics of resonant tunneling, RT devices.
Introduction to RF/Microwave Concepts .Active and passive RF components , circuit representations of two port RF/MW networks scattering and T parameters , smith chart.

Basic Considerations in Active Networks- Stability and noise considerations, Gain Considerations in Amplifiers. Active Networks - Linear and Nonlinear Design, RF/MW Amplifier.
RF/MW Oscillators- Basic topologies ,VCO, Quadrature and single sideband generators.
Radio frequency Synthesizers- PLLS, Various RF synthesizer architectures and frequency dividers .
Overview of RF Filter design, design of rectifier , detector , mixer , RF/MW control circuit. Small RF/MW antenna and array, RF/MW Integrated circuits - design and applications

Low Power VLSI Design

Introduction to low power VLSI design-Need for low power-CMOS leakage current-static current-Basic principles of low power design-probabilistic power analysis-random logic signal-probability and frequency-power analysis techniques-signal entropy.

Circuit - transistor and gate sizing - pin ordering - network restructuring and reorganization - adjustable threshold voltages - logic-signal gating - logic encoding. Pre-computation logic.

Power reduction in clock networks - CMOS floating node - low power bus - delay balancing - SRAM.

Switching activity reduction - parallel voltage reduction - operator reduction -Adiabatic computation - pass transistor logic

Low power circuit design style - Software power estimation - co

design. TEXT BOOKS

1. Gary Yeap "Practical Low Power Digital VLSI Design", 1997
2. Kaushik Roy , Sharat C. Prasad, "Low power CMOS VLSI circuit design", Wiley Inter science Publications". (1987)

Micro and Nano Devices :

Prerequisite :

Fundamentals of semiconductor physics and basics of p-n junctions, bipolar transistors, JFETs, MOS capacitors, MOSFETs, CMOS, LEDs, laser diodes, photodetectors, solar cells; low and high frequency equivalent circuits of BJTs and MOSFETs, IC technology.

Course content :

Module-1 (14 lectures) – [Recapitulation of MOS scaling laws, Short channel effects, MOSFET models], Nano CMOS, Effects of gate oxide tunneling, Concept of EOT, high-k dielectrics, Effects of nanoscaling on MOSFET characteristics and performance, Technology trend, Advanced CMOS structures, SOI.

Module-2 (8 lectures) – Semiconductor heterojunctions; compound semiconductor and silicon-germanium heterostuctures, superlattice, HBTs, PETs, MESFETs, advanced solar cell structures.

Module-3 (14 lectures) – Fundamental concepts of quantum structures and tunneling junctions, Nanotubes, Devices based on quantum wells, quantum wires/nanotubes and quantum dots – HEMTs, RTDs, CNT MOSFETs, SETs, Terahertz devices, advanced optoelectronic devices.

Module-4 (6 lectures) – Outline of nanofabrication – nanolithography, MBE, MOVPE; Introduction to molecular electronics.

Outcome:

Familiarity with advanced structures, their relative merits and demerits, areas of application,

Text Books: Ning & Taur B.R.Nag S. M. Sze

Elective Paper (MVLSI 302)

Architectural Design Of Integrated Circuits (3-1-0)

Introduction; Design flow in VLSI; Design approaches; VLSI design options; General design methodologies; Concept of hierarchical system design; VLSI design issues: Area, Power, Speed, Latency, Throughput.

Different type of Architectures: Pipelined, Parallel, Folded, Unfolded and systolic; Architecture for low power design; Synchronous circuit design; Clocking strategies; Architecture for addition, subtraction, multiplication and division, GCD, Logarithm, Exponential, Shift; Architecture for floating point arithmetic; Architecture for finite field arithmetic.

Mapping of algorithms into architectures; Fault-tolerant architectures; Introduction to SoC and NoC.

Books:

Keshab K Parhi , VLSI Digital Signal Processing Systems: Design and Implementation, John Wiley, 1999

Hubert Kaeslin, Digital Integrated Circuit Design From VLSI Architectures to CMOS Fabrication, Cambridge University Press, 2008

J.M. Rabaey, A. Chandrakasan and B. Nikolic, Digital Integrated Circuits- A Design Perspective, 2nd edition, PHI, 2003