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

Semester – 1:

Paper Type	Paper Code	Paper Name	Instruction Hours			Credit
			L	T	P	
C-Th	MVLSI-101	**Advanced Engg Maths**	3	1	0	4
C-Th	MVLSI-102	**VLSI Device & Modeling**	4	0	0	4
C-Th	MVLSI-103	**Digital IC Design**	4	0	0	4
C-Th	MVLSI-104	**Embedded System Fundamentals**	4	0	0	4
E-Th	MVLSI	Elective – I:	4	0	0	4
	105A	1. **Microelectronic Technology & IC Fabrication**				
	105B	2. **AI & Neural Networks**				
	105C	3. **Advanced Digital Communication**				
		Total of Theory	19	1	0	**20**
C-Pr	MVLSI-191	**CAD Tools for VLSI Design**	0	0	3	2
C-Pr	MVLSI-192	**Embedded Systems-I**	0	0	3	2
		Total of Practical	0	0	6	**4**
S	MVLSI 181	Seminar	0	2	0	**1**
		Total	19	3	6	**25**

Semester – 2:

Paper Type	Paper Code	Paper Name	Instruction Hours			Credit
			L	T	P	
C-Th	MVLSI 201	**Processor Architecture for VLSI**	4	0	0	4
C-Th	MVLSI 202	**Digital Signal Processing & Aplications**	4	0	0	4
C-Th	MVLSI 203	**Analog IC Design**	4	0	0	4
E-Th	MVLSI	Elective – II:	4	0	0	4
	204A	1.**Quantum & Nano-science**				
	204B	2. **Sensors**				
	204C	3**. Physical Design & Testing**				
E-Th	MVLSI	Elective – III:	4	0	0	4
	205A	1.**RF Circuits & Systems**				
	205B	2.**Low Power VLSI Design**				
	205C	3.**Advanced Micro & Nano Devices**				
		Total of Theory	20	0	0	**20**
C-Pr	MVLSI 291	**Embedded Systems-II**	0	0	3	2
		Total of Practical	0	0	3	**2**
S	MVLSI 281	**Term paper leading to Thesis**	0	1	0	**1**
		Total credit	20	1	3	**25**

Semester – 3:

Paper Type	Paper Code	Paper Name	Instruction Hours			Credit
			L	T	P	
C-Th	MVLSI 301	**Teaching & Research Methodologies**	3	1	0	4
C-Th	MVLSI 302	**Architectural Design of Integrated Circuits**	4	0	0	4
		Total of Theory	8	0	0	**4+4**
S	MVLSI 383	**Dissertation – Part I**	0	2	0	12
		Total of Credit				**20**

Semester – 4:

Paper Type	Paper Code	Paper Name	Instruction Hours			Credit
			L	T	P	
S	MVLSI 481	**Dissertation – Part II (Completion)**	24			**6**
	MVLSI 482	**Post submission defense of dissertation**				**18**
V	MVLSI 483	**Comprehensive Viva Voce**				**4**
		Total of Credit				**28**

Details:

MVLSI 101 [Sem - 1] 3 (L) 1(T) (40 lectures) Credit: 4

Advanced Engineering Mathematics

Complex Variables: Elements of set theory, Set notations, Applications of set theory, Open & Closed Sets. Review of Complex variables, conformal mapping and transformations, Functions of complex variables, Integration with respect to complex argument, Residues and basic theorems on residues.

Numerical Analysis: Introduction, Interpolation formulae, Difference equations, Roots of equations, Solutions of simultaneous linear and non-linear equations, Solution techniques for ODE and PDE, Introduction to stability, Matrix eigen value and eigen vector problems.

Optimization Technique: Calculus of several variables, Implicit function theorem, Nature of singular points, Necessary and sufficient conditions for optimization, Elements of calculus of variation, Constrained Optimization, Lagrange multipliers, Gradient method, Dynamic programming.

Probability and Statistics: Definition and postulates of probability, Field of probability, Mutually exclusive events, Bayes' Theorem, Independence, Bernoulli trial, Discrete Distributions, Continuous distributions, Probable errors, Linear regression, Introduction to non-linear regression, Correlation, Analysis of variance.

Reference Books:

1. Sen, M. K. and Malik, D. F.-Fundamental of Abstract Algebra, Mc. Graw Hill
2. Khanna, V. K. and Ghamdri, S. K.- Course of Abstract Algebra, Vikash Pub.
3. Halmos, T. R.-Naïve Set Theory, Van Nostrand
4. Scarborough, J. B.-Numerical Mathematical Analysis, Oxford University Press
5. Cone, S. D.-Elementary Numerical Analysis, Mc. Graw Hill.
6. Mukhopadhyay ,P.-Mathematical Statistics ,New Central Book Agency
7. Kapoor, V. K and Gupta, S.C.-Fundamental of Mathematical Statistics, Sultan Chand and Sons.
8. Uspensky, J. V.-Introduction to Mathematical Probability, Tata Mc. Graw Hill
9. Dreyfus, S. E.-The Art and Theory of Dynamic Programming –Theory and Applications, Academic Press.
10. Rao, S. S.-Optimisation Theory and Application, Wiley Eastern Ltd., New Delhi

MVLSI 102 [Sem - 1] 4 (L) (40 lectures) Credit: 4

<u>VLSI Devices & Modeling</u>

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

<u>Basic Device Physics</u>
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 of 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, break down p-channel MOSFET, enhancement and depletion type, model parameter values, model accuracy etc; 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 Devises, Design and 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)

MVLSI 103 [S e m – 1] 4 (L) (40 lectures) Credit: 4

<u>Digital IC Design</u>

Prerequisite: Overview of CMOS VLSI fabrication, CMOS process steps; fabrication; yield; design rules for custom layout; Layout - hand layout, graphical layout, low-level language; design rule checking; stick diagrams; placement of cells; simulation of design; function generation from masks; test pattern generation; structured design methodology for VLSI; hierarchical design techniques and examples. Concept of Mask design, Mask layout, Stick diagram, Standard cell Vs Custom design,

1. Specification Methods: Language based methods including VHDL/Verilog, hierarchical state machine descriptions such as State Charts and Petri net based methods. Functional languages for formal verification. (Laboratory Practices: RTL description of combinational and sequential circuits using Verilog/VHDL and simulation of the designs using open source and proprietary software)
2. Synthesis tools: High level synthesis; Scheduling allocation, communication and control.(***Laboratory Practices*** : Synthesis of the RTL designs using an industry standard synthesis tool and power and timing analysis of the synthesized designs)
3. Module Generation: Finite State machines, state encoding, parameterized blocks PLA, RAM, ROM generation. Gate Level Synthesis; Binary Decision Diagrams, Logic minimization, optimization and re targeting.(Laboratory Practices : Simulation and Synthesis of finite state machines)
4. Layout Synthesis: Placement; simulated annealing, genetic algorithms, constructive methods. routing; nets, layers, Lees algorithms, cost functions, channel routing. Examples of a channel router with placement expansion.
5. Case Study: Synthesis of a chosen algorithm to the gate level using CAD tools. (***Laboratory Practices)*** Case Study Lecture: Design of MSI chip using proprietary CAD system; use of circuit description language; layout considerations. ***(Laboratory Practices*** : A complete VLSI design example : from RTL to GDSII)

6. Complex gates: pseudo NMOS; dynamic logic; dynamic cascaded logic; domino logic; 2 and 4 phase logic; pass transistor logic. Control and timing; synchronous and asynchronous; self-timed systems; multi-phase clocks; register transfer; examples of ALU, shifters, and registers. (***Laboratory Practices***: Schematic and layout creation of basic and complex gates based on different design libraries). Emerging concepts: Synchronizers and arbiters, networks on a chip.

7. Effects of scaling circuit dimensions: physical limits to develop fabrication. Optional extended course work for final year students, using VLSI design software to produce a chip to meet a given specification; the chip may be fabricated if the design is successful. To study the different stages in the design of integrated chip using VLSI design software. The design is to meet a given specification.

Reading List

1. CAD for VLSI: Author: Russell, G, Kinniment, D.J., Chester, E.G., and McLauchlan, M.R. Notes: Van Norstrand Rheinhold, 1985.
2. Tutorial on High Level Synthesis
   Author: McFarland, M.C., Parker, A.C and Camposano R
   Notes: Proc 25th ACM/IEEE Design Automation Conf pp330-336
3. CMOS VLSI Design A Circuits and Systems Perspective (3rd Edition) Author Neil Weste and <u>David Harris</u>

MVLSI 104 [S e m – 1] 4 (L) (40 lectures) Credit: 4

Embedded Systems Fundamentals

Introduction to embedded systems: Concept, Difference between embedded computer systems and general purpose computer Systems, Classification, Characteristics, Applications

Overview of Embedded Processors: Classification: • GPP, ASIP, SPP, ASSP, MULTI-CORE, SOFT-CORE - Examples

Overview of Embedded Memories & Interfacing: SRAM, DRAM, EEPROM, FLASH, DUAL-PORT, CACHE, INTERLEAVED MEMORIES

Overview of Embedded Networking & Standards: RS232, RS485, SPI, USB, ISA, PCI, I2C, CAN, LIN IrDA, Bluetooth, Zigbee.

Overview of Embedded Sensors and Transducers: Pressure, Temperature, Acceleration, Image, Rain, Proximity, Hall-effect, artificial eyes

Overview of I/P-O/P devices & Interfacing: Keypad, TWS, JoyStick, SSL, LCD, VGA

Case study: The Weather Station

Electives:

MVLSI 105A

Credit: 4

Microelectronics Technology & IC Fabrication:

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, characterization 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, LPCVD, MOCVD. Ion milling. Lift-off technique.
Metallisation - Different types of metallisation, step coverage, uses & desired properties.(Laboratory Practices : Metallisation & Schottky diode fabrication)
VLSI Process integration.

Reading List

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

MVLSI 105B

Credit: 4

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 the VLSI and embedded systems.

MVLSI 105C

Credit: 4

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 diagram, 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 concepts of signal-space coordinate system, representing a signal vector by its orthonormal components, measure of distinguish ability 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 techniq ues 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, differ entiating 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.
  - Nyquist theorem for signal design for no ISI in ideal band limited channel, Nyquist criteria, raised cosine pulse signals.
  - Signal design for controlled ISI in ideal band limited channel, partial response signals, duo binary & partial duo binary 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, its transfer function.
  - Matched filter, its probability of error.
  - Probability of error in PSK, effect of imperfect phase synchronization or imperfect bit

synchronization.

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

Text Books:

1. Digital communication, 4^{th} ed. - J. G. Proakis, MGH International edition.
2. Principle of Communication Systems – Taub, Schilling, TMH
3. Digital and Analog Communication Systems, 7^{th} 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, 4^{th} ed. – A. Bruce Carlson, Paul B. Crilly, Janet C. Rutledge, MGH International edition.
8. Digital Communications, 2^{nd} ed. – Bernard Sklar, Pearson Education.

MVLSI 191

<u>CAD Tools for VLSI Design</u>

LTP: 003
Credit: 2
Syllabus Lab:

A: T-SPICE PROGRAM

1. CMOS LOGIC GATE IMPLEMENTATION USING T-SPICE (MODEL FILE- TSMC018.MD).
2. TRANSIENT RESPONSE OF CMOS INVERTER USING T-SPICE AND CALCULATION OF PROPAGATION DELAY AND POWER DISSIPATION.
3. DC RESPONSE OF CMOS INVERTER USING T-SPICE AND CALCULATION OF PROPAGATION DELAY AND POWER DISSIPATION.
4. TRANSIENT RESPONSE OF CMOS NAND2 USING T-SPICE AND CALCULATION OF PROPAGATION DELAY AND POWER DISSIPATION.
5. TRANSIENT RESPONSE OF CMOS HALF ADDER USING T-SPICE AND CALCULATION OF PROPAGATION DELAY AND POWER DISSIPATION.
6. TRANSIENT RESPONSE OF CMOS 1BIT FULL ADDER USING T-SPICE AND CALCULATION OF PROPAGATION DELAY AND POWER DISSIPATION.

B: VHDL PROGRAM

7. VHDL CODE FOR JK FLIP-FLOP.
8. VHDL CODE FOR D FLIP-FLOP.
9. VHDL CODE FOR 3 to 8 DECODER.
10. VHDL CODE FOR “4:1 MUX”.
11. VHDL CODE FOR 3BIT SHIFT REGISTER.
12. VHDL CODE FOR DECADE COUNTER.
13. VHDL CODE CARRY-RIPPLE ADDER.
14. VHDL CODE & TESTBENCH FOR AN ADDER.
15. VHDL CODE BCD-TO-SEVEN SEGMENT DISPLAY CONVERTER.

MVLSI 192
<u>Embedded System-I</u>
LTP: 003
Credit: 2
Syllabus Lab:

A. Interfacing and programming GPIO ports in C using MSP430 (blinking LEDs , push buttons)
B. Usage of Low Power Modes:
Use MSPEXP430FR5969 as hardware platform and demonstrate the low power modes and measure the active mode and standby mode current.
C. Interrupt programming examples through GPIOs
D. PWM generation using Timer on MSP430 GPIO
E. Interfacing potentiometer with MSP430
F. PWM based Speed Control of Motor controlled by potentiometer connected to MSP430 GPIO

Lab Manual:

1) www.ti.com/lab-maunals
   - Embedded System Design using MSP430 Launchpad Development Kit - Lab Manual,

MVLSI 201 [Sem - 2] 4 (L) (40 lectures) Credit: 4

Processor Architecture for VLSI

Fundamentals:
Components of (an embedded) computer, Architecture organization, Von-Neumann vs Harvard, Micro-coded vs hardwired, scalar and vector processors, Flynn's taxonomy

CISC arch, the RISC movement, ISA arch, basic structure, pipelining, pipeline hazards and solutions, comparison, merging RISC and CISC: the microchip PIC

Superscalar arch: parallel computation, Ways of parallelism, the IBM PowerPC The DSP and Its Impact on Technology: Why a DSP is different. The evolving architecture of a DSP

VLIW arch: the TI TMS320C6x, advancement to EPIC

Coprocessor Approach: Need for accelerators, Accelerators and different types of parallelism, Processor architectures and different approaches to acceleration
General-Purpose Embedded Processor Cores: The ARM

Processors using course-grain parallelism: utilization of course-grain parallelism**,** chip-multiprocessors**,** multithreaded processors, SMT proc

Customizable Processors and Processor Customization: A benefits analysis of processor customization, Using microprocessor cores in SOC design, Benefiting from microprocessor extensibility, how microprocessor use differs between SOC and board-level design

Run-Time Reconfigurable Processors: Embedded microprocessor trends, Instruction set metamorphosis, Reconfigurable computing, Run-time reconfigurable instruction set processors, Coarse-grained reconfigurable processors
Stream Multicore Processors: Introduction, Raw architecture overview

Asynchronous and Self-Timed Processor: Motivation for asynchronous design, The development of asynchronous processors.

MVLSI 202 [Sem - 2] 4 (L) (40 lectures) Credit: 4

Digital Signal processing & Applications

1. **Introduction to Signals & Systems**: Discrete time linear systems, linear time invariant system, impulse response, causality, stability, Difference equation, relation between continuous and discrete system, classification of sequences,

recursive & non-recursive systems, mathematical operations on sequences, convolution, graphical and analytical techniques, overlap and add methods, some example and solutions of LTI systems, MATLAB examples. (4 lectures)

2 **Transform**: Basic concept of transformation, Time frequency analysis, Discrete Fourier transform (DFT), Inverse Discrete Fourier transform (IDFT), linear transformation, basic properties, circular convolution, multiplication of DFT, linear filtering using DFT, filtering of long data sequences, overlap & save method, computation of DFT, Fast Fourier transform (FFT), FFT algorithm, Radix 2 algorithm, Twiddle factor, decimation-in-time and decimation-in-frequency algorithm, spectrum analysis, signal flow graph, butterflies, Chirp Z-transform algorithm, MATLAB examples (tutorial), Wavelet transform, Discrete wavelet transform (DWT) , Multi resolution analysis, DWT and filter banks , orthogonal wavelet filter banks (10 lectures) **Z transform**: Definition, relation between Z transform and Fourier transform of a sequence, properties of Z transform, mapping between S-plane and Z-plane, unit circle, convergence and ROC, inverse Z-transform, solution of difference equation using the one sided Z-transform. (9 +3 lectures)

3. **Digital filter Design**: Principle of digital filter design, digital filter specifications, basic approaches to digital filter design, design of infinite impulse response filters (IIR) from analog filters: Butterworth, Chebyshev, Elliptic filters; optimization method of IIR filters, Bilinear transformation method for IIR filter design, design of IIR notch filters, design of low pass IIR filters, design of high pass, band pass and all pass IIR filters, structures of all-zero filters, design of FIR filters: linear phase, windows --- rectangular, Barlett, Hamming and Blackman, some examples of practical filter design (eg, DTMF detections using Goertzel algorithm), computer aided filter design using MATLAB (tutorial) Introduction to adaptive filter. (12 lectures)

4. **Digital Filter Structures & Analysis** : Basic FIR digital filter structures --- direct forms, cascade forms, polyphase realizations, linear phase FIR structures; basic IIR digital filter structures --- direct form, canonic form, cascade realizations, parallel realizations; Quantization process and errors: quantization of fixed point and floating point numbers, analysis using MATLAB (tutorial), analysis of coefficient quantization effects in FIR filters, signal-to- quantization noise ratio in low order IIR filters, analysis of arithmetic round-off errors, dynamic range scaling. (8 lectures)

5. **Applications of DSP**: applications in image processing: image smoothing, edge detections, image compression, etc., speech processing, speech encoding and speech compression (ADPCM), A-law and -law companding implementations,
, adaptive echo cancellations, Software defined radio. (4 lectures)

Practical:

Hardware & Software Implementation of DSP algorithms: characteristics of the DSP functions, architecture for DSP processors, special purpose hardware for digital filtering & FFT, software implementation of DSP algorithms, fixed point DSP processors (eg, TMS 320C54X), floating point processors (eg, TMS320C6X, ADSP SHARC), custom VLSI and FPGA based implementation. (***These 10 hours may be covered during practical class***) (10 lectures)

Books:

1. J.G.Proakis & D.G.Manolakis, "Introduction to Digit al Signal Processing", PHI
2. S.K.Mitra, "Digital Signal Processing: A Computer B ased Approach", McGraw Hill
3. Antoniou, "Digital Filters Analysis and Design " –TATA McGraw-Hill
4. Keshab K. Parhi "VLSI Digital Signal Processin g Systems Design and Implementation"Willey Int. Publication, ISBN: 9812-53-023-1
5. U.Meyer-Baese , "Digital Signal Processing wit h Field Programmable Gate Arrays",Springer
6. Monson H. Hayes, "Schaum's Outline of Theory a nd Problems of Digital Signal Processing", Tata McG raw-Hill
7. Texas Instruments DSP Processor user manuals and application notes

MVLSI 203 [Sem - 2] 4 (L) (40 lectures) Credit: 4

Analog IC Design

Recapitulation:

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

1. CMOS Amplifiers and CMOS Operation Amplifiers: Basic concepts, performance parameters, One stagte 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 OPAMP6L+6P * Design examples (SPICE simulation-Laboratory)

2. Switched capacitor circuits: General considerations, switched capacitor integrators, First and second order switched capacitor filter circuits 2L+3P

3. Data converter fundamentals and architectures: Ideal D/A converters, Ideal A/D converters, Serial and flash D/A converters and A/D converters, Medium and high speed converters, Over sampling converters, performance limitations, Design consideration, Spice simulation. 4L

4. Special circuits: CMOS voltage controlled oscillators, Ring oscillators, PHASE locked loops with pump phase comparators, Gm –C circuits. Analog multipliers. *Design examples (SPICE simulation-Laboratory)

5. RF Analog Circuits & Sub circuits: 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; MMICs. 6L

6. Comparators: Characterization, two stage open loop comparators, Discrete time comparators, high speed comparator circuits, CMOS S/H circuits 4L
*Design examples (SPICE simulation-Laboratory)

Text: The MOS Transistor (second edition) Yannis Tsividis (Oxford)

Reference:
CMOS A nalog 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

Electives- II: [Sem - 2] 4 (L) (40 lectures)

MVLSI 204A
Credit: 4
Quantum and Nano Science

1. Quantum & Statistical Mechanics:

Wave particle duality and Schrodinger equation, Free and bound particles, Eigen functions, Quantum mechanical operators, Probability current density, Particle in square well potential, Maxwell-Boltzmann statistics, Bose-Einstein and Fermi-Dirac statistics, Concept of phonons. (8)

2. Quasi Low-Dimensional Structures:

Quantum wells, Wires, Dots, Band structure of low-dimensional systems, Quantum confinement, Density-of-states in 2D, 1D and 0D structures, Heterostructures and bandgap engineering, Modulation doping, Strained Layered Structures (8)

3. . Electrical and Optical Properties of Low-Dimensional Systems:

Infinitely deep square wells, Wells of finite depth, Parabolic wells, Superlattices; Scattering mechanisms, Mobility enhancement, Tunneling in heterostructures, Quantum Hall effect, Optical absorption in quantum wells: Intersubband transitions, Quantum well laser, Resonant tunneling. (10)

4. Physics of Nanostructure Devices:

Single electron transistors: Coulomb block phenomenon, Fabrication and applications, Memory devices, Quantum computer, Spintronics, Molecular electronic devices. (8)

5. Carbon Nanotubes:

Types of nanotubes and their formation, Properties of nanotubes, Uses in nanoelectronics, Carbon nanotube transistors, Future prospect. (6)

References:-

1. " Quantum Heterostructure – Microelectronics and Op toelectronics" by V.V. Mitin, V.A. Kochelap and M.A . Stroscio (Cambridge Univ Press, 1999).
2. "The Physics of Low Dimensional Semiconductors – An Introduction" by John H. Davies Cambridge University Press, 1998
3. "Physics of Semiconductors and Their Heterostructur es" by Jasprit Singh.
4. "Quantum Wells, Wires, and Dots" by P.Harrison Chi chester: (Wiley 2000).
5. "Nanotechnology" by M. Wilson, K. Kannangara, G..Sm ith, M..Simmons, and B. Ragus (Overseas Press, 2005)

MVLSI 204B
Credit: 4
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 4

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.

MVLSI 204C
Credit: 4
Physical Design & Testing

Testing:

Testing: Why test? Difference between testing & verification.

Physical faults & their modeling: Fault equivalence, dominance & collapsing .Fault simulation: parallel, deductive & concurrent techniques, critical path tracing .Test pattern generation for combinational circuits: Boolean difference, D - algorithm, Podem, etc , exhaustive , random, weighted test pattern generation , a liasing and its effects on fault coverage . Test pattern generation for sequential circuits: ad-hoc and structures techniques scan path and LSSD, boundary scan.

Built-in self test techniques: De sign of testability:

Verification:

Introduction: Why verify? What is a test bench?

What is being verified: Formal verification, equivalence checking, model checking, functional Verification, different approaches to verification, black box, white box, grey box, design verification and reuse Verification tools: Linting tools simulators, verification intellectual property (VIP) – art of making VIP, wave form viewers, code & functional coverage Languages: Outline of temporal models and assertions, Linear Time Temporal Logical (LTL), Computation Tree Logic (CTL) assertion.

The verification plan role of verification plan, levels of verification, directed test bench approach; coverage based random-based approach (CDV), generators, monitors and checkers. Verification practices and architecture: over view of reference verification methodology (RVM) and verification methodology manual (VMM)

Electives- III: [Sem - 2] 4 (L) (40 lectures)

MVLSI 205A
Credit: 4
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

MVLSI 205B

Credit: 4

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)

MVLSI 205B

Credit: 4

Advanced 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, photo-detectors, 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:

1. Fundamentals of Modern VLSI Devices 2nd Edition by Ning & Taur
2. Physics of Semiconductor Devices, 3rd Edition by S. M. Sze and Kwok K. Ng, John Wiley & Sons.

MVLSI 292
Embedded System-II
LTP: 003
Credit: 2
Syllabus Lab:

1. Using ULP advisor in Code Composer Studio on MSP430
2. Connect the MSP430 to terminal on PC and echo back the data
3. Master Slave Communication between 2 MSP430s using SPI
4. A basic Wi-Fi application – Communication between two MSP430 based sensor nodes
5. Enable Energy Trace and Energy Trace ++ modes in CCS for exp. 4.
6. Compute Total Energy, and Estimated life time of a battery.

MVLSI 301 [Sem - 3] 3 (L) 1(T) (40 lectures) Credit: 4
Teaching & Research Methodologies

Foundations of Research: Meaning, Objectives, Motivation, Utility. Concept of theory, empiricism, deductive and inductive theory. Characteristics of scientific method – Understanding the language of research – Concept, Construct, Definition, Variable. Research Process

Problem Identification & Formulation – Research Question – Investigation Question – Measurement Issues – Hypothesis – Qualities of a good Hypothesis –Null Hypothesis & Alternative Hypothesis. Hypothesis Testing – Logic & Importance

Research Design: Concept and Importance in Research – Features of a good research design – Exploratory Research Design – concept, types and uses, Descriptive Research Designs – concept, types and uses. Experimental Design: Concept of Independent & Dependent variables.

Qualitative and Quantitative Research: Qualitative research – Quantitative research – Concept of measurement, causality, generalization, replication. Merging the two approaches.

Measurement: Concept of measurement– what is measured? Problems in measurement in research – Validity and Reliability. Levels of measurement – Nominal, Ordinal, Interval, Ratio.

Sampling: Concepts of Statistical Population, Sample, Sampling Frame, Sampling Error, Sample Size, Non Response. Characteristics of a good sample. Probability Sample – Simple Random Sample, Systematic Sample, Stratified Random Sample & Multi-stage sampling. Determining size of the sample – Practical considerations in sampling and sample size.

Data Analysis: Data Preparation – Univariate analysis (frequency tables, bar charts, pie charts, percentages), Bivariate analysis – Cross tabulations and Chi-square test including testing hypothesis of association.

Interpretation of Data and Paper Writing – Layout of a Research Paper, Journals in Computer Science, Impact factor of Journals, When and where to publish ? Ethical issues related to publishing, Plagiarism and Self-Plagiarism.

Use of Encyclopedias, Research Guides, Handbook etc., Academic Databases for Computer Science Discipline.

Use of tools / techniques for Research: methods to search required information effectively, Reference Management Software like Zotero/Mendeley, Software for paper formatting like LaTeX/MS Office, Software for detection of Plagiarism

Text Books:-

1. Business Research Methods – Donald Cooper & Pamela Schindler, TMGH, 9th edition

2. Business Research Methods – Alan Bryman & Emma Bell, Oxford University Press.
3. Research Methodology – C.R. Kothari

MVLSI 302 [Sem - 3] 4 (L) (40 lectures) Credit: 4

Architectural Design of Integrated Circuits

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.

Text Books:

1. Keshab K Parhi , VLSI Digital Signal Processing Systems: Design and Implementation, John Wiley, 1999
2. Hubert Kaeslin, Digital Integrated Circuit Design From VLSI Architectures to CMOS Fabrication, Cambridge University Press, 2008
3. J.M. Rabaey, A. Chandrakasan and B. Nikolic, Digital Integrated Circuits- A Design Perspective, 2nd edition, PHI, 2003