



M.Tech. - ECE (Microelectronics & VLSI Designs) Common 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	<b>VLSI Device &amp; Modelling</b>	4	0	0	4
C-Th	MVLSI 103	<b>Digital IC Design</b>	4	0	0	4
C-Th	MVLSI 104	<b>Microelectronic Technology &amp; IC Fabrication</b>	4	0	0	4
E-Th	MVLSI 105A 105B 105C 105D	Elective – I: 1. Bioelectronic System 2. <i>Embedded System Fundamentals</i> 3. <i>AI &amp; Neural Networks</i> 4. Advanced Digital Communication	4	0	0	4
		Total of Theory	19	1	0	<b>20</b>
C-Pr	MVLSI 191	CAD Tools for VLSI Design	0	0	3	2
E-Pr	MVLSI 192A 192B	1. <i>Microelectronic Technology</i> 2. Embedded Systems	0	0	3	2
		Total of Practical	0	0	6	<b>4</b>
S	MVLSI 181	Seminar	0	2	0	<b>1</b>
		<b>Total</b>	19	3	6	<b>25</b>



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**Semester – 2:**

Paper Type	Paper Code	Paper Name	Instruction Hours			Credit
			L	T	P	
C-Th	MVLSI 201	<i>Processor Architecture for VLSI</i>	4	0	0	4
C-Th	MVLSI 202	Digital Signal Processing & Applications	4	0	0	4
C-Th	MVLSI 203	<i>Analog IC Design</i>	4	0	0	4
E-Th	MVLSI 204A 204B 204C 204D	Elective – II: 1. Quantum & Nano-science 2. Error Control & Coding 3. <i>Sensors</i> 4. <i>Physical Design &amp; Testing</i>	4	0	0	4
E-Th	MVLSI 205A 205B 205C 205D 205E	Elective – III: 1. <i>RF Circuits &amp; Systems</i> 2. <i>Low Power VLSI Design</i> 3. Mobile Communication 4. <i>Advanced Micro &amp; Nano Devices</i> 5. Advanced FET Technology	4	0	0	4
		Total of Theory	20	0	0	<b>20</b>
E-Pr	MVLSI 291A 291B	1. <i>Microelectronic Technology</i> 2. Embedded Systems	0	0	3	2
		Total of Practical	0	0	3	<b>2</b>
S	MVLSI 281	Term paper leading to Thesis	0	1	0	<b>1</b>
		Total credit	20	1	3	<b>25</b>

**Semester – 3:**

Paper Type	Paper Code	Paper Name	Instruction Hours			Credit
			L	T	P	
C-Th	MVLSI 381A 381B	1. Project Management or 2. Teaching & Research Methodologies	4	0	0	4
AE-Th/Pr	MVLSI 302/392	Elective Theory or Practical Papers to be suggested by College.	4	0	0	4
		Total of Theory	8	0	0	<b>4+4</b>
S	MVLSI 383	Dissertation – Part I	0	2	0	<b>12</b>
		<b>Total of Credit</b>				<b>20</b>



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### 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 defence of dissertation				18
V	MVLSI 483	Comprehensive Viva Voce				4
		<b>Total of Credit</b>				<b>28</b>

### Details:

#### MVLSI101

#### 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

#### MVLSI102

#### VLSI Devices & Modelling [Sem - 1] 3 (L) (401 credits)

Pre-requisite: Knowledge of basic physics of diodes, BJTs, FETs, MOS structures.

Semiconductor, Junctions and MOSFET Overview: Introduction, Semiconductor, 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



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in version, interpolation models, effective mobility, temperature effects, breakdown - 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. Subthreshold 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 a log 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 Tsivdis** (Oxford)

Reference:

**CMOS Analog Circuit Design** (second edition) **Phillip E. Allen** and **Douglas R. Holberg** (Oxford)

### MVLSI103

**Digital IC Design [Sem - 1] 3(L) 1(T) 2(P)**

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 Practises: RTL description of combinational and sequential circuits using Verilog/VHDL and simulation of the designs using open source and proprietary softwares)
2. Synthesis tools: High level synthesis; Scheduling allocation, communication and control. (**Laboratory Practises** : Synthesis of the RTL designs using an industry standard synthesis tool and power and timing analysis of the synthesised designs)
3. Module Generation: Finite State machines, state encoding, parameterised blocks PLA, RAM, ROM generation. Gate Level Synthesis; Binary Decision Diagrams, Logic minimisation, optimisation and retargetting. (Laboratory Practises : 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 Practises** ) Case Study Lecture: Design of MSI chip using proprietary CAD system; use of circuit description language; layout considerations. (**Laboratory Practises** : A complete VLSI design example : from RTL to GDSII)
6. 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 Practises**: Schematic and layout creation of basic and complex gates based on different design libraries). Emerging concepts: Synchronisers and arbiter 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.



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### 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 [David Harris](#)

### MVLSI104

#### 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, characterisation 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+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:

#### MVLSI105B

##### Embedded Systems Fundamentals

(Syllabus Updated)

**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



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### MVLSII05D

#### Advanced digital communication

- *Pre-requisites:*
  - Fourier Expansion, Fourier transform, Normalized power spectrum, Power spectral density, Effect of transfer function on output power spectral density, Parseval'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:



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- 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) - its mathematical expression.
  - Nyquist's theorem for signal design for no ISI in ideal band limited channel, Nyquist'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 likelihood 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 ratio, 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.
  - 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, 4<sup>th</sup> ed. - J. G. Proakis, MGH International edition.
2. Principle of Communication Systems – Taub, Schilling, TMH
3. Digital and Analog Communication Systems, 7<sup>th</sup> ed. – Leon W. Couch, PHI.
4. Principles of Digital Communication – Haykin
5. Digital Communication – Ziemer, Tranter.
6. Principle of Digital communication - J. Das, S. K. Mallick, P. K Chakraborty, New Age Int.
7. Communication Systems, 4<sup>th</sup> ed. – A. Bruce Carlson, Paul B. Crilly, Janet C. R utledge, MGH International edition.
8. Digital Communications, 2<sup>nd</sup> ed. – Bernard Sklar, Pearson Education.
9. Electronic Communications, 4<sup>th</sup> ed. – Dennis Roddy, John Coolen, PHI

**MVLSI192B****Embedded System****LTP:003****Credit:2****Syllabus –Lab:**

1. Interfacing and programming GPIO ports in C using MSP430 (blinking LEDs , push buttons)
2. Usage of Low Power Modes:
  - a. Use MSP430FR5969 as hardware platform and demonstrate the low power modes and measure the active mode and standby mode current.
3. Interrupt programming examples through GPIOs
4. PWM generation using Timer on MSP430 GPIO
5. Interfacing potentiometer with MSP430
6. PWM based Speed Control of Motor controlled by potentiometer connected to MSP430 GPIO
7. Using ULP advisor in Code Composer Studio on MSP430
8. Connect the MSP430 to terminal on PC and echo back the data
9. Master Slave Communication between 2 MSP430s using SPI
10. A basic Wi-Fi application – Communication between two MSP430 based sensor nodes
11. Enable Energy Trace and Energy Trace ++ modes in CCS for any of the above [exp. 4-7]
12. Compute Total Energy, and Estimated life time of a battery

**Lab Manual:**

- 1) [www.ti.com/lab-manuals](http://www.ti.com/lab-manuals)
  - Embedded System Design using MSP430 Launchpad Development Kit - Lab Manual,





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### MVLSI105C

#### 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- Heuristic search techniques-Forward and backward reasoning-Hill climbing techniques-Best search.

Knowledge representation: Predicate logic- Resolution Question answering-Nonmonotonic 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.

### MVLSI201

#### Processor Architecture for VLSI

##### **Fundamentals:**

Components of (an embedded) computer, Architecture organization, Von-Neumann vs Harvard, Microcoded 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,



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### MVLSI202

#### Digital Signal Processing & Applications

#### (Syllabus Updated)

#### Syllabus for the M.Tech. ( MicroElectronics & VLSI Design) 2nd Semester ( Duration: 40 Hrs. )

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  $\mu$ -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)



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### Books:

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

### **M VLSI 203**

**Analog IC Design: [Sem – I I] 3 (L) 0 T 0 (P) 3 Lectures**

#### Recapitulation:

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

5. **CMOS Amplifiers & CMOS Operation Amplifiers:** Basic concepts, Performance Parameters, One stage 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, 6L + 6P  
\*Design examples, (**SPICE simulation – Laboratory**)
2. **Switch Capacitor circuits:** General considerations, Switched capacitor integrators, First and second orders with switched capacitor filter circuits, 2L + 3P  
\*Design examples, (**SPICE simulation – 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 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. 4L + 6P  
\*Design examples, (**SPICE simulation – Laboratory**)
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 rf receiver and transmitters. 6L
6. **Comparators:** Characterisation, 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 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.



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### Reading List

1. **Principles of CMOS VLSI Design** (Essential reading) Author: Weste N and Eshraghian  
K Notes: Addison 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:

#### MVLSI204A

#### 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 layer 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 Optoelectronics" by V.V. Mitin, V.A. Kochelap and M.A. Strosio ( 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 Heterostructures" by Jasprit Singh.
  4. "Quantum Wells, Wires, and Dots" by P.Harrison Chester: ( Wiley 2000)
  5. "Nanotechnology" by M. Wilson, K. Kannangara, G. Smith, M. Simmons, and B. Ragus ( Overseas Press, 2005)

#### MVLSI204C

#### 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



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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.



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### **M V L S I 2 0 4 D**

#### ***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, aliasing and its effect on fault coverage. Test pattern generation for sequential circuits: ad-hoc and structured techniques scan path and LSSD, boundary scan.

Built-in self test technique

s: Design 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, waveform viewers, code & functional coverage.

Language: Outline of eand Vera, temporal models & assertions, Linear Time Temporal Logic (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 & checkers. Verification practices & architecture: overview of reference verification methodology (RVM) & verification methodology manual (VMM).

Design for verification:

### **Elective – II**

#### **IMVLSI205A**

#### **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



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### **MVLSI205B**

#### **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 heterostructures, 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