4. Assembling the microwave bench.
5. Study of UHF & VHF Transmitters.
6. Study of radiation pattern for different antennas.
7. Measurement of characteristic for different antennas

Courses for M. Tech in VLSI:

MOS VLSI Design

Review of digital design (8 lectures)- MUX based digital design (1), Design using ROM, Programmable Logic Arrays (PLA) and Programmable Array Logic (PAL) (2), Sequential circuits and timing - Setup and hold times (1), Sequential circuit design - design of Moore and Mealy circuits (2), Design of a pattern sequence detector using MUX, ROM and PAL (1), and Design of a vending machine controller using PAL (1). Introduction to Verilog coding (6 lectures)- Introduction to Verilog (1), Realization of Combinational and sequential circuits (2), RTL coding guidelines (1), Coding organization and writing a test bench (2). Simulation, Synthesis, Place and Route, and Back Annotation (12 lectures)- Design flow (1), Simulation using Modelsim (4), Synthesis using Synplify (4), Place and Route, and Back Annotation using Xilinx (3) Design using Algorithmic State Machine Charts (7 lectures)- Derivation of ASM charts (1), Design examples such as dice game, etc. using ASM charts (3), Implementation of ASM charts using microprogramming (2), and Verilog design of bus arbitrator (1) Design of memories (3 lectures)- Verilog realization of Read Only Memory (ROM) (1), Verilog realization of Random Access Memory (RAM) , and Verilog coding of controller for accessing external memory (2). Design of Arithmetic functions (5 lectures)- Pipelining concept, Verilog design of a pipelined adder/subtractor (1), Design of Multipliers (3), and Verilog design of a pipelined multiplier (1).Design for testability (3 lectures)- Testing combinational and sequential logic (1), Boundary scan testing, and Built-in self test (2). Design Applications (4 lectures)-Design of a traffic light controller using Verilog (1), and Design of discrete cosine transform and quantization processor for video compression using Verilog (3). Hardware implementation using FPGA board (2 lectures)- Features of FPGA board and demonstration of traffic light controller design (1), and Universal, asynchronous, receiver-transmitter design using FPGA board (1).

Text/ Reference Books:

- N. Weste and K. Eshranghian, Principles of CMOS VLSI Design, Addison Wesley. 1985
- L. Glaser and D. Dobberpuhl, The Design and Analysis of VLSI Circuits, Addison Wesley, 1985
- C. Mead and L. Conway, Introduction to VLSI Systems, Addison Wesley, 1979.
- J. Rabaey, Digital Integrated Circuits: A Design Perspective, Prentice Hall India, 1997.
- D. Perry, VHDL, 2nd Ed., McGraw Hill International, 1995.

VLSI Design laboratory

Design of Half-Adder, Full Adder, Half Subtractor, Full Subtractor , Design a parity generator, Design a 4 Bit comparator, Design a RS & JK Flip flop , Design a 4: 1 Multiplexer , Design a 4 Bit Up / Down Counter with Loadable Count , Design a 3:8 decoder, Design a 8 bit shift register, Design a arithmetic unit , Implement ADC & DAC interface with FPGA , Implement a serial communication interface with FPGA, Implement a Telephone keypad interface with FPGA , Implement a VGA interface with FPGA, Implement a PS2 keypad interface with FPGA, Implement a 4 digit seven segment display,

Hardware Description Languages

Introduction covering, Introduction to computer organization; Evolution of Operating Systems; Machine languages, Assembly Languages and High Level Languages; Key Software and Hardware Trends, Procedural & Object Oriented Programming Methodologies; Program Development in C, Structured Programming - Algorithm, Pseudocode; The C Standard Library, Data types in C, Arithmetic operators, Control Structures – Ifelse, While, for, do-while, Switch, break and continue statements; Formatted input-output for printing Integers, floating point numbers, characters and strings; Simple C Programming examples; Designing Structured Programs in C covering, Top Down Design and Stepwise refinement; Program Modules in C, Math Library Functions, Function Definition, Prototypes; Header files, Parameter passing in C, Call by Value and Call by Reference; Standard functions, Recursive functions, Preprocessor commands, Example C programs; Scope, Storage classes; Arrays covering, Declaring arrays in C, Passing arrays to functions, Array applications, Two – dimensional arrays, Multidimensional arrays, C program examples; Pointers in C covering, Pointer variable declaration and Initialization. Pointer operators, Pointer expressions and Arithmetic, Relationship between pointers and arrays; Strings including Concepts, String Conversion functions, C Strings, String Manipulation Functions and String Handling Library; Derived types covering, Structures – Declaration, definition and initialization of structures, accessing structures, structures in functions, self-referential structures, unions; Data Structuresincluding Introduction to Data Structures, Stacks, Queues, Trees, representation using arrays, Insertion and deletion operations; Dynamic Memory Allocation covering Linked List Implementation, Insertion, Deletion and Searching operations on linear list; Searching and Sorting – Sorting- selection sort, bubble sort, insertion sort, quick sort, merge sort, Searching-linear and binary search methods;

Text/ Reference Books:

- Dietel & Dietel (2000), *C – How to Program,* Pearson Education
- Ellis Horowitz, Sartaj Sahni, Susan Anderson (1993), *Fundamentals of Data Structures in C,* Prentice Hall of India
- B.W. Kernighan and Dennis M.Ritchie (1988), *The C Programming Language,* Pearson Education
- J.R. Hanly and E.B. Koffman (2007), *Problem Solving and Program Design in C,* Pearson Education 51
- A.M. Tanenbaum, Y. Langsam & M.J. Augenstein(2005),*Data Structures using C,* Pearson Education

Embedded System Design

Introduction: Embedded system, software embedded in system, embedded system on chip in VLSI circuit, Categories and requirements of embedded systems, Challenges and issues related to embedded software developments, Embedded system Design: Concepts of concurrency, processes, threads, mutual exclusion and inter-process communication, Models and languages for embedded software, Synchronous approach to embedded system design, Scheduling paradigms, Scheduling, Algorithms, Hardware/Software Co-design, Introduction to RTOS: Basic Design using RTOS, Interfacing, RISC Processor: Architecture, Memory, Reset and Interrupt, Functions, Parallel I/O ports, Timers/Counters, Serial Communication, Analog Interfaces Case Studies and Applications of embedded systems

Text/ Reference Books:

1. Raj Kamal, Embedded Systems, TMH
2. FrancVahid, Tony Givargis, Embedded System Design: A Unified Hardware/Software Introduction, John Wiley

Analog IC Design

Basic concepts of transistors and diodes, their modeling, large signal and small signal analysis, CMOS technology, clock feedthrough; Reference sources : bias circuits, bandgap reference circuit, cascode current mirror; Single stage amplifier, common source amplifier, drain and gate amplifier, differential amplifier; Operational amplifier; Comparators; Switched capacitor circuits; Introduction to data converters; Issues of analog layout and device noise.

Text/ Reference Books:

- R.Jacob Baker,H.W.Li, and D.E. Boyce CMOS Circuit Design ,Layout and Simulation, Prentice-Hall of ,1998.
- Mohammed Ismail and Terri Faiz Analog VLSI Signal and Information Process, McGraw-Hill Book company,1994.
- Paul R. Gray and R.G.Meyer, Analysis and design of Analog Integrated circuits John Wiley and sons,,(3rd Edition),1993.
- B. Razavi, RF Microelectronics, Prentice-Hall PTR,1998.

Embedded System Design-II

PIC Architecture Introduction to PIC microcontrollers, PIC architecture, comparison of PIC with other CISC and RISC based systems and microprocessors, memory mapping, assembly language programming, addressing modes, instruction set. **I/O Programming** PIC I/O ports, I/O bit manipulation programming, timers/counters, programming to generate delay and wave form generation, I/O programming, LEDs, 7segment led's, LCD and Keypad interfacing.

Text/ Reference Books:

- Instructor reference material.
- Programming PIC microcontrollers with PIC basic by chuck helebuyck

- PIC microcontrollers-programming in basic by Milan verle.
- The C programming Language by Brian W.kernighan and Dennis M.Ritchie
- Let Us C by YashvantP.kanetkar
- Object-Oriented Programming With C++ by E Balaguruswami

Low Power VLSI Design

Basics of MOS circuits: MOS Transistor structure and device modeling MOS Inverters MOS Combinational Circuits - Different Logic Families Sources of Power dissipation: Dynamic Power Dissipation Short Circuit Power Switching Power Gliching Power Static Power Dissipation Degrees of Freedom Supply Voltage Scaling Approaches: Device feature size scaling Multi-Vdd Circuits Architectural level approaches: Parallelism, Pipelining Voltage scaling using high-level transformations Dynamic voltage scaling Power Management Switched Capacitance Minimization Approaches: Hardware Software Tradeoff Bus Encoding Two's complement Vs Sign Magnitude Architectural optimization Clock Gating Logic styles Leakage Power minimization Approaches: Variable-threshold-voltage CMOS (VTCMOS) approach Multi-threshold-voltage CMOS (MTCMOS) approach Power gating Transistor stacking Dual-Vt assignment approach (DTCMOS)

Text/ Reference Books:

- Sung Mo Kang, Yusuf Leblebici, CMOS Digital Integrated Circuits, Tata Mcgrag Hill.
- Neil H. E. Weste and K. Eshraghian, Principles of CMOS VLSI Design, 2nd Edition, Addison Wesley (Indian reprint).
- A. Bellamour, and M. I. Elmasri, Low Power VLSI CMOS Circuit Design, Kluwer Academic Press, 1995.
- Anantha P. Chandrakasan and Robert W. Brodersen, Low Power Digital CMOS Design, Kluwer Academic Publishers, 1995.
- Kaushik Roy and Sharat C. Prasad, Low-Power CMOS VLSI Design, Wiley-Interscience, 2000

Adaptive Digital Signal Processing

General concept of adaptive filtering and estimation, applications and motivation. Review of probability, random variables and stationary random processes; Correlation structures, properties of correlation matrices.Optimal FIR (Wiener) filter, Method of steepest descent, extension to complex valued signals.The LMS algorithm (real, complex), convergence analysis, weight error correlation matrix, excess mean square error and mis-adjustmentVariants of the LMS algorithm : the sign LMS family, normalized LMS algorithm, block LMS and FFT based realization, frequency domain adaptive filters, Subband adaptive filtering.Signal space concepts - introduction to finite dimensional vector space theory, subspace, basis, dimension, linear operators, rank and nullity, inner product space, orthogonality, Gram-Schmidt orthogonalization, concepts of orthogonal projection, orthogonal decomposition of vector spaces. Vector space of random variables, correlation as inner product, forward and backward projections, Stochastic lattice filters, recursive updating of forward and backward prediction errors, relationship with AR modeling, joint process estimator, gradient adaptive lattice. Introduction to recursive least squares (RLS), vector

space formulation of RLS estimation, pseudo-inverse of a matrix, time updating of inner products, development of RLS lattice filters, RLS transversal adaptive filters. Advanced topics : affine projection and subspaced based adaptive filters, partial update algorithms, QR decomposition and systolic array.

Text/ Reference Books:

1. S. Haykin, Adaptive filter theory, Prentice Hall, 1986.
2. B. Widrow and S.D. Stearns, Adaptive signal processing, Prentice Hall, 1984.

MMICS

Microwave Integrated Circuits: Thick and thin film technology, Hybrid MIC's, Monolithic MIC technology, Analysis of Strip line and Microstrip Line: Method of conformal transformation, Charactetic parameters of Strip, Microstrip lines, Microstrip circuit design, Impedance transformers, Filters, Lumped constant microstrip circuits, Coupled Microstrip and Directional Coupler. Microwave Measurements – Concept of vector network analyzer, Basic block diagram of vector network analyzer (VNA), Application of vector network analyzers.Basic block diagram of a spectrum analyzer, functions & applications of a spectrum analyzer.Time Domain Electrometer (TDR) & IC Technology.Microwave Measurements using Vector Network Analyzer, Spectrum Analyser, etc. MMIC Planar circuit Design.MMIC Mixer Design and Simulation.Design of RF Power Amplifier. Design Microwave voltage controlled oscillator (VCO). Design MMIC Mixer and Simulation. Design Microstrip Filter. Designing mm-wave integrated filters.Design of a Broadband MMIC Frequency Doubler. Fabrication processes for microstrip line and co-planar wave guide geometry. In-corporation of magnetic nanostructures like ultra-thin film, nano-wires and nano-particles into magnetic-MMICs. Characterization & theory of magnetically tunable Monolithic microwave reciprocal and non-reciprocal devices. ***Review of current research in MMICs design, fabrication and testing.***

Text/ Reference Books:

- D.Pozar," Microwave Engineering", 2nd Ed, John Wiley
- T.S.Laverghetta-" Hand book on Microwave Testing",Artech House,1981
- Samuel. Y. Liao,"Microwave devices and circuits", Pearson Edn., 2003.
- Rainee N. Simons, Coplanar Waveguide Circuits, Components, and Systems (Wiley Series in Microwave and Optical Engineering),

RF MEMS

VLSI and Micro-electromechanical Technologies, materials for MEMS. *Actuationtechniques:* Electrostatic, Electromagnetic, Thermal, Piezoelectric, *Micromachining*: Surfacemicromachining, bulk micromachining, LIGA, *Non-Silicon micromachining techniques: PCB, LCP, PDMS/SU8, Case studies:* MEMS/RF MEMS/BioMEMS, MEMS and NEMS basics, Limitations of Silicon device Fabrication, basic microfabrication techniques, MEMS fabrication techniques, Nanofabrication Techniques, Material aspects of MEMS and NEMS (Si, Ge, Metals, Harsh-environment semiconductors, GaAs, InP and related III-V materials, Ferroelectric materials), MEMS and

NEMS devices and applications, Carbon Nanotube sensor concepts-design considerations, fabrication of the CNT sensors and state of art applications., Failure mechanism of MEMS/NEMS devices: failure modes and failure mechanisms, stiction and charge related failure mechanisms, creep, fatigue, wear and packaging related failures. **Bio-MEMS fabrication technologies** Introduction to bio-MEMS.Nanomaterials for bio-MEMS, Bulk/surface micromachining, UV Lithography, the LIGA Process, nano-imprinting, hot embossing for Lab-on-a-chip application; Soft fabrication and polymers soft-lithography, micro-molding, micro-stereo lithography, thick-film deposition, SAMs. Sensing technologies for Bio-MEMS application

Text/ Reference Books:

1. Stephen D Santuria, Microsystem Design, Kluwer Academic, 2001
2. Marc J. Madou, Fundamentals of Microfabrication, CRC Press, 1997
3. Hector J. De Los Santos, "RF MEMS Circuit Design for Wireless Applications", ArtechHouse, 2002
4. Tai-Ran Hsu MEMS & Microsystem, Design and manufacture, McGraw Hill

IC Fabrication Technology

Environment for VLSI Technology : Clean room and safety requirements. Wafer cleaning processes and wet chemical etching techniques. Impurity incorporation: Solid State diffusion modelling and technology; Ion Implantation modelling, technology and damage annealing; characterisation of Impurity profiles. Oxidation: Kinetics of Silicon dioxide growth both for thick, thin and ultrathin films. Oxidation technologies in VLSI and ULSI; Characterisation of oxide films; High k and low k dielectrics for ULSI. Lithography : Photolithography, E-beam lithography and newer lithography techniques for VLSI/ULSI; Mask generation. Chemical Vapour Deposition techniques : CVD techniques for deposition of polysilicon, silicon dioxide, silicon nitride and metal films; Epitaxial growth of silicon; modelling and technology. Metal film deposition : Evaporation and sputtering techniques. Failure mechanisms in metal interconnects; Multi-level metallisation schemes. Plasma and Rapid Thermal Processing: PECVD, Plasma etching and RIE techniques; RTP techniques for annealing, growth and deposition of various films for use in ULSI. Process integration for NMOS, CMOS and Bipolar circuits; Advanced MOS technology.

Text/ Reference Books:

- S.K. Ghandhi, VLSI Fabrication Principles, John Wiley Inc., New York, 1994 (2nd Edition).
- S.M. Sze (Ed), VLSI Technology, 2nd Edition, McGraw Hill, 1988.
- Plummer, Deal , Griffin "Silicon VLSI Technology: Fundamentals, Practice & Modeling" PH, 2001.
- P. VanZant , "Microchip Fabrication", 5th Edition, MH , 2000.

Nanolithography & Nanoscale Devices

THE SCIENCE OF MINIATURIZATION Moore's Laws (1,2,&3) and technology' Roadmap–clean rooms Processing Methods: - Cleaning – Oxidation – Lithography – Etching- – CVD - Diffusion – Ion implantation – metallization – state of the art CMOS architectures Photolithography Overview – Critical Dimension – Overall Resolution – Line-Width – Lithographic Sensitivity and Intrinsic Resist Sensitivity (Photochemical *Quantum Efficiency*) – Resist Profiles – Contrast and Experimental Determination of Lithographic Sensitivity – Resolution in Photolithography – Photolithography Resolution Enhancement Technology **NANOSTRUCTURING BY PHYSICAL TECHNIQUES Next-Generation Technologies:** – State-Of-The-Art (*including principles, capabilities, limits, applications*) EUV lithography – Phase-shifting photolithography – X-ray lithography – Electron Beam Direct Writing System – Focused ion beam (FIB) lithography – Neutral atomic beam lithography – Plasma-Aided Nanofabrication – Soft Lithography – Nano-sphere Lithography – Nanoimprint – Dip-pen nanolithography – key consequences of adopted techniques **NANOMANIPULATION AND PROCESSING Conventional techniques**: Scanning tunneling microscopy (STM) – Atomic force microscopy (AFM) – Near-field scanning optical microscopy (NSOM) – **Advanced Techniques:** Embossing and surface passivation, Dimensional Subtraction and Addition, Multistep Processing, of –Micro-contact printing– Molding – implications and applications of the conventional and advanced techniques **NANOMETER DEVICES** Material Wave Nanotechnology: Nanofabrication Using a de Broglie Wave-Electron Beam Holography – Atomic Beam Holography- Nanometer Lithography Using Organic Positive/Negative Resists – Sub-10 nm Lithography Using Inorganic Resist – 40 nm-Gate-Length Metal-Oxide-Semiconductor Field-Emitter-Transistors-14 nm Gate-Length Electrically Variable Shallow Junction MOSFETs-Operation of Aluminum-Based Single-Electron Transistors at 100 Kelvins- Room Temperature Operation of a Silicon Single-Electron Transistor **SUB-LITHOGRAPHIC ARCHITECTURES** Fundamental scaling limits to the transistors – Beyond CMOS: Self-Assembled structures – Gravitational field assisted assembly – Template-assisted assembly-Shear force assisted assembly - Electroforming and Molding (LIGA) – Fundamentals of Quantum Computing – Quantum Algorithms - Realizing quantum computers – Physical Implementations (*Josephson junction Circuits and semiconductor quantum dots)*

Text/ Reference Books:

- Guozhong Cao, *Nanostructures &Nanomaterials Synthesis, Properties G; Z: Applications*, World Scientific Publishing Private, Ltd., Singapore (2004).
- W.R.Fahrner, *Nanotechnology and Nanoelectronics – Materials, Devices, Measurement Techniques,* Springer-Verlag Berlin, Germany (2006).
- R. H. J. Hannink and A. J. Hill, *Nanostructure control of materials*, Woodhead Publishing Limited and CRC Press LLC, Cambridge, England (2006).
- Zheng Cui, *Nanofabrication, Principles, Capabilities and Limits*, Springer Science + business media, New York (2008).
- Hari Singh Nalwa, *Handbook of Nanostructured Materials and Nanotechnology* (Vol. 3)- *Electrical Properties,* Academic Press, San Diego, USA (2000).
- Huff, Howard, *Into The Nano Era: Moore's Law Beyond Planar Silicon CMOS (*Vol. 106), Springer Series in Materials Science, Springer-Verlag Berlin (2009).
- Marc J. Madou, *Fundamentals of Microfabrication: The Science of Miniaturization*, 2nd Edition, CRC Press, California, USA (2002).
- Kostya (Ken) Ostrikov and ShuyanXu, *Plasma-Aided Nanofabrication: From Plasma Sources to Nanoassembly,* WILEY-VCH Verlag GmbH & Co. KGaA (Weinheim) (2007).

Introduction to MEMS

MEMS MICROFABRICATION 10 Historical Development of Microelectronics, Evolution of Microsensors, Evolution of MEMS, Emergence of Micromachines, Modeling - Finite Element Analysis, CAD for MEMS, Fabrication – ALD, Lithography Micromachining, LIGA and Micromolding, Saw-IDT Microsensor Fabrication, Packaging – Challenges, Types, Materials and Processes. **SCALING OF MEMS 9** Introduction to Scaling Issues, Scaling effects on a cantilever beam, Scaling of electrostatic actuators, Scaling of thermal actuator, Scaling of Thermal Sensors, mechanics and electrostatistics. Influence of scaling on material properties. **MICROSYSTEMS 10** Microsensors, microaccelerometer, microfluidics, Mechanics for Microsystems design-Thermomechanics, fracture mechanics, thin film mechanics. Microfluid mechanics.**MATERIALS FOR MEMS 8** Materials for mems and pro mems-silicon-metals and polymers-Substrate Materials for MEMS-Silicon-quartz-ceramics-Bulk metallic glasses-Sharp Memory alloys, Carbon based MEMS

Text/ Reference Books:

- Marc Madou, Fundamentals of Micro-fabrication, CRC Press 1997.
- MEMS and Microsystems design and manufacture, Tai-Ran Hsu, TataMcGraw Hill 2011.
- Sergey Edward Lyshevski, Nano- and Micro-electromechanical Systems, CRC Press 2000.
- Vijay Varadan, Xiaoning Jiang, and VasundaraVaradan, Microstereolithography and other Fabrication Techniques for 3D MEMS, Wiley 2001.
- Tai-Ran Hsu, MEMS and Microsystems: Design and Manufacture, McGraw-Hill 2001.
- Ken Gilleo. MEMS/MOEMS Packaging: Concepts, Designs, Materials and Processes. McGraw-Hill, 2005.