

# RAJASTHAN TECHNICAL UNIVERSITY

## M.Tech. (VLSI Design) Teaching & Examination Scheme (Full Time)

### Semester : I

Course Code	Course	Hrs. / Week			22		
		L	T	P	IA*	Exam	Total
<b>Compulsory Courses</b>							
1MVL1	Advanced Mathematics	3	1		25	100	125
1MVL2	VLSI Design	3	1		25	100	125
1MVL3	Digital System Design	3	1		25	100	125
<b>Elective I</b>							
1MVL4.1	Low Power VLSI Design	3	1		25	100	125
1MVL4.2	Micro Electro Mechanical Systems	3	1		25	100	125
1MVL4.3	Microelectronics	3	1		25	100	125
1MVL5	VLSI Physical Design Lab			3	60	40	100
<b>TOTAL</b>							<b>600</b>

### Semester : II

Course Code	Course	Hrs. / Week			Marks		
		L	T	P	IA*	Exam	Total
<b>Compulsory Courses</b>							
2MVL1	Digital Signal Processing	3	1		25	100	125
2MVL2	Analog & Mixed Signal ICs	3	1		25	100	125
2MVL3	CAD of ICs	3	1		25	100	125
<b>Elective II</b>							
2MVL4.1	High Level System Design & Modeling	3	1		25	100	125
2MVL4.2	FPGA Based System Design	3	1		25	100	125
2MVL4.3	Biomedical Electronics	3	1		25	100	125
2MVL5	Digital System Design Lab			3	60	40	100
<b>TOTAL</b>							<b>600</b>

\* I.A. – Internal Assessment

**M.Tech. (VLSI Design)**  
**Teaching & Examination Scheme (Full Time)**

**Semester : III**

Course Code	Course	Hrs. / Week			Marks		
		L	T	P	IA*	Exam	Total
	<b>Compulsory Course</b>						
3MVL1	Embedded System Design	3	1		25	100	125
	<b>Elective III</b>						
3MVL2.1	VLSI Testing & Testability	3	1		25	100	125
3MVL2.2	Nanoelectronics	3	1		25	100	125
3MVL2.3	Advance IC Technology and Characterization techniques	3	1		25	100	125
3MVL3	Dissertation ( Stage-I )				100	-	100
3MVL4	Seminar			3	90	60	150
	<b>TOTAL</b>						<b>500</b>

**Semester : IV**

Course Code	Courses	Hrs. / Week			Marks		
		L	T	P	IA*	Exam	Total
4MVL1	Dissertation ( Stage-II )				-	500	500
	<b>TOTAL</b>						<b>500</b>
<b>GRAND TOTAL</b>							<b>2200</b>

\* I.A. – Internal Assessment



## **SYLLABUS: M.TECH (VLSI DESIGN)**

### **1MVL1 ADVANCED MATHEMATICS**

Optimization problem-Convex sets and functions.

The SIMPLEX Algorithm- Forms of linear programming problem, geometry of linear programming, Organization of Tableau. Computational considerations for SIMPLEX Algorithm. Duality: Dual of linear programming, dual simplex problem, Primal-dual algorithm.

Algorithms and Complexity-shortest path, max-flow, Dijkstra's algorithm, min-cost flow, algorithm for graph search and matching; spanning trees and matroids; Integer Linear programming, Greedy algorithm, approximation algorithms; branch-and-bound; dynamic programming.

#### **BOOKS**

- Numerical methods in engg. & sc. by B.S. Grewal
- Numerical methods for engg & sc. by Iyengar & M.K. Jain
- Advanced Mathematics for Engineers by Chandrika Prasad

### **1MVL 2 VLSI DESIGN**

Basic operation of CMOS inverter, detailed analysis of its noise margin propagation delay, power dissipation concept of layout & area, layout optimization & area estimation for a single as well as combinational logic circuits.

Design of sequential logic circuits: Static & dynamic latches registers, dynamic transmission gate, CMOS

gate, pipelining approach for optimize sequential circuits, NDRA-CMOS pipelined structure, non-bistable sequential circuits, Schmitt trigger.

Implementation strategies for digital ICs, introduction of custom and circuit design, hierarchy cell based design array based implementation, building blocks of adder, multiplier, shifter, barrel shifter, algorithmic shifter and other arithmetic operators, power speed tradeoff in data path structure.

Design memory & array structure memory architectures & building blocks, address decoder, sense amplifiers, driver/ buffers, timing control, power dissipation in memories, idea of testability and fault detection models.

#### **BOOKS**

- CMOS Digital Integrated Circuits Analysis , Sung-Mo (Steve) Kang, TMH
- Essentials Of Vlsi Circuits And Systems, Kamran Eshraghian, Eshraghian, PHI
- Introduction To Vlsi Circuits And Systems, John P. Uyemura, John Wiley & Sons
- Modern Vlsi Design, Wayne Wolf, Pearson
- Principles Of Cmos Vlsi Design, Neil H.E.Weste, Pearson
- Cmos Logic Circuit Design, Uyemura, John P., Springer
- Vlsi Design, Shanthi, A. Kavitha, A., New Age International
- Vlsi Design And Technology, Bose, D.N., New Age International

### **1MVL 3 DIGITAL SYSTEM DESIGN**

Sequential Logic Design- Introduction, Basic Bistable Memory Devices, reduced characteristics and excitation table for bistable devices.

Synchronous Sequential Logic Circuit Design: Introduction, Moore, Mealy and Mixed type Synchronous State Machines. Synchronous sequential design of Moore, Mealy Machines, Synchronous Counter Design, Hazards, Duality of sequential circuits, Different methods of minimization.

Asynchronous Sequential logic design- Introduction, Primitive flow table and reduction, type of delays, Cycles and races, Excitation Map, Hazards, Essential hazards, Analysis of asynchronous sequential circuits.

Symmetric and Iterative circuits- Symmetric functions, iterative functions, realization in tree form.

Algorithmic State Machine: An Algorithm with inputs, digital solution, Implementation of traffic light controller, ASM charts, Design Procedure for ASMs.

Introduction to programmable logic devices: PALs, PLDs, CPLDs and FPGAs.

Introduction to VHDL: Data types, Concurrent statements, sequential statements, behavioral modeling.

### **BOOKS**

- M.Morris Mano, "Digital Design", 3rd edition, Pearson Education.
- Charles H.Roth, Jr. "Fundamentals of Logic Design", 4th Edition, Jaico Publishing House
- Donald D.Givone, "Digital Principles and Design", Tata McGraw-Hill.
- Cmos Logic Circuit Design, Uyemura, John P., Springer
- Vlsi Design, Shanthi, A. Kavitha, A., New Age International
- Vlsi Design And Technology, Bose, D.N., New Age International

### **2MVL 1 DIGITAL SIGNAL PROCESSING**

DFT & its properties. Decimation in time and decimation in frequency FFT algorithms, discrete cosine transform.

IIR Filter design: Butterworth design, bilinear transformation. Low Pass, High Pass, Band Pass and Band Stop digital filters. Spectral transformation of IIR filters.

FIR filter design: Symmetric and antisymmetric linear phase. FIR filter by rectangular, triangular and Blackman window functions.

Finite word length effects in FIR and IIR digital filters: Quantization, round off errors and overflow errors.

Multi rate digital signal processing: Concepts, design of practical sampling rate converters, Decimators, interpolators. Polyphase decompositions.

### **BOOKS**

- Digital Signal Processing, Sanjit K Mitra, TMH
- Digital Signal Processing, S.Salivahanan A Vallavaraj, C.Gnanapriya, TMH
- Digital Signal Processing: Principals, Algorithms And Applications, John G.Proakis, Dimitris G Manolakis, PHI
- Digital Signal Processing, A.V. Oppenheim And R.W. Schaffer, PHI
- Digital Signal Processing, Thomas J. Cavicchi, John Wiley & Sons
- Digital Signal Processing, Emmanuel Ifeachor, Barry Jervis, Pearson
- Digital Signal Processing, Chi-Tsong Chen, Oxford
- Digital Signal Processing, Engelberg, Shlomo, Springer
- Digital Signal Processing For Measurement , D Antona, Gabriele, New Age International

### **2MVL 2 ANALOG & MIXED SIGNAL ICs**

Review of BJT and MOS transistor operation, models and equivalent circuits, single-stage amplifiers, differential amplifiers. Passive and active current mirrors: Cascade current mirror, Wilson current mirror. Mismatch & nonlinearity.

Theory & design of MOS operational amplifiers, complete CMOS operational amplifier including frequency compensation, stability, frequency response and transient response. Comparator & voltage reference sources.

Switches capacitor circuits: Principles of operation of switches, capacitor circuits, switched capacitor filters. D/A and A/D converter.

Nonlinear analog circuits: Timer, function generators, multipliers and PLL.

Bi CMOS: Devices & technology, basic analog & digital sub circuits, inverters.

### **BOOKS**

- Semiconductor Devices: Modelling And Technology, Nandita Dasgupta, Amitava Dasgupta, PHI
- Fundamentals Of Semiconductor Fabrication, Gary S. May, S.M.Sze, John Wiley & Sons
- Semiconductor Devices: Physics And Technology, Simon M. Sze, John Wiley & Sons
- Introduction To System Design Using Integrated Circuits, Sonde, B.S., New Age International
- Micro-Nanofabrication technologies And Applications, Cui, Zheng, Springer

### **2MVL 3 CAD of ICs**

Introduction to concept of design, design methodologies, semi-custom and custom design approaches.

Data path & control design.

Elements of device and circuit simulation, logic simulation.

Stick diagram and representation, layout of ICs, lambda based design rules.

Deep submicron interconnects modeling and synthesis.

Topics in design-yield and redundancy, low power design techniques.

### **BOOKS**

- Giovanni De Micheli, Synthesis and Optimization of Digital Circuits, Tata McGraw Hill.
- S.H. Gerez, Algorithms for VLSI Design Automation, Wiley-India.
- D.D Gajski et al., High Level Synthesis: Introduction to Chip and System Design, Kluwer Academic Publishers.
- N.A. Sherwani, Algorithms for VLSI Physical Design Automation, Kluwer Academic Publisher.
- M. Sarrafzadeh and C.K. Wong, An Introduction to VLSI Physical Design, McGraw Hill.

### **3MVL 1 EMBEDDED SYSTEM DESIGN**

The concept of embedded systems design: definitions and constraints, hardware and processor requirements, embedded microcontroller cores, embedded memories. Examples of embedded systems.

Technological aspects of embedded systems: special purpose processors; input-output design and I/O communication protocols; design space exploration for constraint satisfaction; co-design approach; example system design, interfacing between analog and digital blocks, signal conditioning, digital signal processing. sub-system interfacing, interfacing with external systems, user interfacing. Design trade offs due to process compatibility, thermal considerations etc.

Software aspects of embedded systems: real time programming languages and operating systems for embedded systems. specification refinement and design; design validation; Real Time operating system issues with respect to embedded system applications; time constraints and performance analysis.

### **BOOKS**

- Readings in Hardware/Software Co-Design by G. De Micheli, Rolf Ernst, and Wayne Wolf, eds. Morgan Kaufmann, Systems-on-Silicon Series
- Embedded System Design: A Unified Hardware/Software Introduction by Frank Vahid and Tony D. Givargis, Addison Wesley.
- Programming Embedded Systems in C and C++ by Michael Barr, O'Reilly.
- An Embedded Software Primer by David E. Simon, Addison Wesley.
- The Art of Designing Embedded Systems by Jack Ganssle, Newnes.

### 1MVL 4.1 LOW POWER VLSI DESIGN

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

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

**Simulation Power analysis:** SPICE circuit simulators, gate level logic simulation, capacitive power estimation, static state power, gate level capacitance estimation, architecture level analysis, data correlation analysis in DSP systems. Monte Carlo simulation.

**Probabilistic power analysis:** Random logic signals, probability & frequency, probabilistic power analysis techniques, signal entropy.

**Low Power Design Circuit level:** Power consumption in circuits. Flip Flops & Latches design, high capacitance nodes, low power digital cells library

**Logic level:** Gate reorganization, signal gating, logic encoding, state machine encoding, pre-computation logic.

**Low power Architecture & Systems:** Power & performance management, switching activity reduction, parallel architecture with voltage reduction, flow graph transformation, low power arithmetic components, low power memory design.

**Low power Clock Distribution:** Power dissipation in clock distribution, single driver Vs distributed buffers, Zero skew Vs tolerable skew, chip and package co-design of clock network

**Algorithm and architectural level methodologies:** Introduction, design flow, algorithmic level analysis and optimization, Architectural level estimation and synthesis.

#### BOOKS

- Semiconductor Devices: Modelling And Technology, Nandita Dasgupta, Amitava Dasgupta, PHI
- Fundamentals Of Semiconductor Fabrication, Gary S. May, S.M.Sze, John Wiley & Sons
- Semiconductor Devices: Physics And Technology, Simon M. Sze, John Wiley & Sons
- Introduction To System Design Using Integrated Circuits, Sonde, B.S., New Age International
- Micro-Nanofabrication technologies And Applications, Cui, Zheng, Springer

### 1MVL 4.2 MICRO-ELECTRO-MECHANICAL-SYSTEMS (MEMS)

Micro electro mechanical system (MEMS) origins. MEMS impetus/ motivation. Material for MEMS. The toolbox: processes for micro machining. MEMS fabrication technologies.

Fundamentals MEMS device physics: Actuation. Fundamental MEMS devices: The cantilever beam. Microwave MEMS applications:

MEM switch design considerations. The micro-machined transmission line. MEMS-based microwave circuit and system.

#### BOOKS

- Max J. Madou: "Fundamentals Of Micro Fabrication"- The science of miniaturization-, Nanogen corporation, USA, CRC press.
- Sergey Edward Lyshevski: "Nano-And Micro Electro Mechanical Systems" – Second edition, CRC press, Boca Raton London.
- Sherif sedky: "Integrated MEMS"- Artech House, Boston London.
- N. Maluf : Introduction To Micro Mechanical Systems Engineering, Artech House.
- Tai – Ran Hsu: "Mems And Micro Systems: Design And Manufacture" – Tata Mc Graw Hill.

### 1MVL 4.3 MICROELECTRONICS

Introduction to semiconductor physics: Review of quantum mechanics, electrons in periodic lattices, E-k diagrams, Quasi-particles in semiconductors, electrons, holes and phonons. Boltzmann transport equation and solution in the presence of low electric and magnetic fields -

mobility and diffusivity; carrier statistics; continuity equation, poisson's equation and their solution; high field effects: velocity saturation, hot carriers, avalanche breakdown, punch through and kirk effects.

Semiconductor junctions: Schottky, homo- and hetero-junction band diagrams and I-V characteristics, small signal switching models; two terminal and surface states devices based on semiconductor junctions.

Bipolar transistor working, its charge control, and gummel poon model, structure of graded base, graded emitter transistor, hetro junction transistor.

MOS structures: Semiconductor surfaces; the ideal and non ideal MOS capacitor band diagrams and CVs; Effects of oxide charges, defects and interface states; characterization of MOS capacitors: HF and LF CVs, avalanche injection; high field effects and breakdown. Long & short channel effects.

### **BOOKS**

- Allen and Holberg, "CMOS Analog Circuit Design", Oxford Publication.
- Pucknell and Kamran, "CMOS VLSI Design", PHI Publication.
- Perry, "VHDL", TMH Publication.
- Wayne Wolf, "Modern VLSI Design", Pearson Publication.

### **2MVL 4.1 HIGH LEVEL SYSTEM DESIGN & MODELING**

System level design, description languages- SDL, SpecChart etc.

Architectural synthesis for DSP applications.

Formal Verification of digital systems- BDD based approaches, functional equivalence, finite state automata,  $\omega$ -automata, FSM verification.

Hardware-software partitioning, interface synthesis, case studies.

### **BOOKS**

- Abstract State Machines: A Method for High-Level System Design and Analysis, Egon Boerger, Robert Staerk, Springer.

### **2MVL 4.2 FPGA BASED SYSTEM DESIGN**

Evolution of programmable devices: Introduction to AND-OR structured Programmable Logic Devices PROM, PLA, PAL and MPGAs; Combinational and sequential circuit realization using PROM based Programmable Logic Element (PLE); Architecture of FPAD, FPLA, FPLS and FPID devices.

FPGA Technology: FPGA resources - Logic Blocks and Interconnection Resources; Economics and applications of FPGAs; Implementation Process for FPGAs Programming Technologies - Static RAM Programming, Anti Fuse Programming, EPROM and EEPROM Programming Technology; Commercially available FPGAs - Xilinx FPGAs, Altera FPGAs; FPGA Design Flow Example - Initial Design Entry, Translation to XNF Format, Partitioning, Place and Route, Performance Calculation and Design Verification.

Technology Mapping for FPGAs: Logic Synthesis - Logic Optimization and Technology Mapping; Lookup Table Technology Mapping - Chortle-crf Technology Mapper, Chortle-d Technology Mapper, Lookup Table Technology Mapping in mis-pga, Lookup Table Technology Mapping in Asyl and Hydra Technology Mapper; Multiplexer Technology Mapping - Multiplexer Technology Mapping in mis-pga.

Routing for FPGAs: Routing Terminology; Strategy for routing in FPGAs; Routing for Row- Logic Block Architecture: Logic Block Functionality versus Area-Efficiency - Logic Block Selection, Experimental Procedure, Logic Block Area and Routing Model and Results.

Based FPGAs - Segmented channel routing, 1-channel routing algorithm, K - channel routing algorithm and results.

## **BOOKS**

- FPGA-Based System Design Wayne Wolf, Verlag: Prentice Hall
- Modern VLSI Design: System-on-Chip Design (3rd Edition) Wayne Wolf, Verlag

### **2MVL 4.3 BIOMEDICAL ELECTRONICS**

Brief introduction to human physiology. Biomedical transducers: displacement, velocity, force, acceleration, flow, temperature, potential, dissolved ions and gases.

Bioelectrodes and biopotential amplifiers for ECG, EMG, EEG, etc. Measurement of blood temperature, pressure and flow. Impedance plethysmography. Ultrasonic and nuclear imaging.

Prostheses and aids: pacemakers, defibrillators, heart-lung machine, artificial kidney, aids for the handicapped. Safety aspects.

Telemetry – Transmission of the original through wire & wireless.

Imaging techniques – Ultrasound, CAT, X-Rays, PET, NMR, Nuclear.

Physiological effect of electric current, safety.

Cardiological Signal Processing: Basic Electrocardiography, ECG data acquisition, ECG lead system, ECG parameters & their estimation, the use of multi scale analysis for parameters estimation of ECG waveforms, Arrhythmia analysis, monitoring, long form continuous ECG recording.

ECG data reduction technique, Direct data compression techniques, Direct ECG data compression techniques. Transformation compression techniques. Other data compression techniques. Data compression techniques, comparison.

## **BOOKS**

- Medical Instrumentation: Application And Design, 3ed-,Webster ,Wiley
- Biomedical Signal Processing, D Reddy ,TMH
- Electronics In Medicine And Biomedical Instrumentation, ,Phi
- Biomedical Signal Processing, D.Reddy ,TMH
- Medical Instrumentation Application And Design,John G. Webster,Oxford
- Advanced Methods Of Biomedical Signal Processing,Sergio Cerutti, Oxford

### **3MVL 2.1 VLSI TESTING & TESTABILITY**

Physical Faults and their modeling; Stuck at Faults, Bridging Faults; Fault collapsing; Fault Simulation: Deductive, Parallel, and Concurrent Fault Simulation.

Critical Path Tracing; ATPG for Combinational Circuits: D-Algorithm, Boolean Differences, PODEM Random, Deterministic and Weighted Random Test Pattern Generation; Aliasing and its effect on Fault Coverage. PLA Testing, Cross Point Fault Model and Test Generation.

Memory Testing Permanent Intermittent and Pattern Sensitive Faults, Marching Tests; Delay Faults. ATPG for Sequential Circuits : Time Frame Expansion ; Controllability and Observability Scan Design, BILBO , Boundary Scan for Board Level Testing ; BIST and Totally self checking circuits.

System Level Diagnosis: Introduction; Concept of Redundancy, Spatial Redundancy, Time Redundancy, Error Correction Codes. Reconfiguration Techniques; Yield Modeling, Reliability and effective area utilization.

## **BOOKS**

- M. L. Bushnell and V. D. Agrawal, Essentials of Electronic Testing for Digital, Memory, and mixed-Signal VLSI Circuits, Kluwer Academic Publishers
- M. Abramovici, M. A. Breuer, and A. D. Friedman, Digital Systems Testing and Testable Design, Computer Science Press,
- L. T. Wang, C. W. Wu, and X. Wen, VLSI Test Principles and Architectures, Morgan Kaufmann

### **3MVL 2.2 NANOELECTRONICS**

Shrink-down approaches: Introduction, CMOS scaling, the nanoscale MOSFET, finfets, vertical MOSFETs, limits to scaling, system integration limits (interconnect issues etc.), resonant tunneling transistors, single electron transistors, new storage, optoelectronic, and spintronics devices.

Atoms-up approaches: Molecular electronics involving single molecules as electronic devices, transport in molecular structures, molecular systems as alternatives to conventional electronics, molecular interconnects; Carbon nanotube electronics, bandstructure & transport, devices, MEMS applications.

#### **BOOKS**

- S.M.Sze, Ed, High Speed Semiconductor Devices, Wiley, New York.
- S.M. Sze, Ed, Modern Semiconductor Device Physics, Wiley, New York
- K. Seeger, Semiconductor Physics, 7th Ed, Springer-Verlag, Berlin,
- C.Y. Chang and S.M. Sze, Eds, ULSI Devices, Wiley New York
- S.M. Sze, Semiconductor Devices: Physics and Technology, 2nd Ed. Wiley, New York.
- S.M. Sze and K.K. Ng, Physics of Semiconductor Devices, 3rd Ed, Wiley, Hoboken.
- H. Iwai, Y. Nishi, M.S. Shur, H. Wong, Frontier in Electronics, World Scientific.
- R. D. Doering and Y. Nishi, Handbook of Semiconductor Manufacturing Technology, CRC Press, Boca Raton.

### **3MVL 2.3 ADVANCE IC TECHNOLOGY AND CHARACTERIZATION TECHNIQUES**

#### **INTRODUCTION**

Tools for technological processing in microelectronics. survey of methods for analysis of microelectronic materials and devices. Classification of different tools for bulk , surface and thin film characterization.

#### **FABRICATION OF NANOSCALE AND SUBMICRON STRUCTURES**

Physical and chemical techniques for nanomaterial synthesis, Assembling and self organization of nanostructures, Nanoscale manipulation, Nanotube and wire formation ,Importance of size distribution control, size measurement and size selection. Fabrication of hetrostructure in submicron and quantum level for microelectronic and optical applications

#### **VARIOUS CHARACTERISATION TECHNIQUES**

Theory and working principle of XRD, SEM , IR, RHEED ,LEED, XPS, AFM ,STM .working of thermal, optical and electrical measurement techniques.

#### **BOOKS**

- “Silicon VLSI Technology”, James Plummer, M. Deal & P. Griffin, Prentice Hall Electronics & VLSI Series.
- “The Science and Engineering of Microelectronics”, Stephen Canbel, Oxford University Press.

### **1MVL 5 VLSI PHYSICAL DESIGN LAB**

#### PART A

Draw the Layout, do circuit partitioning , placement and routing, circuit compaction, check DRC , Circuit extraction and finally post layout simulation for different combinational and sequential circuits.

#### PART B

Use the feature of automation test program generation, multilevel logic synthesis for design smaller application chips like multi bit parallel adder priority encoder, general purpose register, ALU, microcontroller/ dsp processor/ traffic light controller /sequential adder etc.

### **2MVL 5 DIGITAL SYSTEM DESIGN LAB**

Design ,implement and experiment with digital system, this will include ASIC design, FPGA based design. design of relevant hardware and software for microcontroller ,processor and DSP based embedded system.

Custom design and simulation of different higher level analog and digital circuits using advance EDA tools like Tanner Spice S-edit and L- edit