Indian Institute of Technology Patna

Electrical & Electronics Engineering Department

M. Tech – Electrical and Electronics Engineering (VLSI & Embedded Systems)

Course Curriculum

SEMESTER-1

Sl.No.	Course Number	Course Title	L	T	P	C
1	EExxx	Digital VLSI System	3	0	0	3
2	EExxx	Embedded system	3	0	0	3
3	EExxx	Elective-I	3	0	0	3
4	EExxx	Elective-II	3	0	0	3
5	EExxx	Elective-III	3	0	0	3
6	EExxx	VLSI Laboratory	0	0	3	1.5
7	HSS 513	Technical Communications	3	0	0	3
TOTAL			**17**	**0**	**3**	**19.5**

SEMESTER-2

Sl.No.	Course Number	Course Title	L	T	P	C
1		Analog & Mixed Signal System	3	0	0	3
2		High Performance Computing System	3	0	0	3
3		Elective-IV	3	0	0	3
4		Elective -V	3	0	0	3
5		Elective-VI	3	0	0	3
6		Embedded System laboratory	0	0	3	1.5
7		Seminar	0	0	0	2
8		Mini Project				2
TOTAL			**12**	**0**	**7**	**20.5**

SEMESTER-3

Sl.No.	Course Number	Course Title	L	T	P	C
1		*Project Thesis-I	0	0	0	20
2		Grand Viva	0	0	0	4
TOTAL						**24**

***As per institute academic policy. Course Number will be assigned as per institute policy.**

SEMESTER-4

Sl.No.	Course Number	Course Title	L	T	P	C
1		*Project Thesis-II	0	0	0	24
TOTAL						**24**

***As per institute academic policy.**

Total Credits= 19.5+20.5+24+24 = 88

Summary of Core and elective courses and its credits

Core Courses: 24 credits

- Elective courses including HSS elective: 40 credits
- Laboratory courses: 6 credits
- Seminar: 4 credits
- Projects: 48 credits

Total credits: 122

5. List of Core and Elective Courses

List of Core Courses:

- Digital VLSI System
- Embedded System
- Analog & Mixed Signal System
- High Performance Computing Architecture
- VLSI Laboratory

- Embedded System Laboratory

List of Elective Courses (Elective/Open Elective Courses shall be selected by students with the concern faculty advisor depending on the availability of courses on that semester)

- VLSI Testing and Verification
- Fault Tolerant System Design
- Modeling & Simulation of MOS Devices
- Embedded System for CPC
- CAD VLSI
- Real time and Embedded Operating Systems
- Network on Chip
- Low Power Circuits and Systems
- MEMS
- VLSI Technology
- Bio Sensors and Circuits
- RFIC
- Embedded System Integration
- System-on-Programmable-Chip Design
- Sensors and Actuators
- Hardware Security
- VLSI DSP
- FPGA Based system Design:
- VLSI Architectural Design
- Pattern Recognition and applications
- Advanced Digital Signal Processing
- Image Processing
- Video Surveillance
- HSS Elective: One course (5xx) from HSS department.

6. Course Details

Digital VLSI System

Introduction: Digital Systems and its applications; Basics on manufacturing process of Digital systems; Device and Wire Model; Design and implementation strategies of digital VLSI systems: Full and Semi-custom; Static and Dynamic MOS Logic design and Characteristics: Combinational and sequential circuits and systems; Introduction to ASIC and FPGA based system Design; Architecture design and HDL; synthesis and Timing Analysis in digital systems; Digital Arithmetic circuits; Memory cell and peripheral circuits; introduction to physical Design and verification; Digital IC testing methodologies;

Text/Reference Books:

1. Ming-Bo Lin, "Introduction to VLSI Systems: A Logic, Circuit, and System Perspective" Indian Edition, CRC Press, 2011.
2. Seetharaman Ramachandran, "Digital VLSI Systems design", 1st Edition, Springer, 2007.
3. Michael John Sebastian Smith, "Application Specific Integrated Circuit" Addison Wesley, Reprint edition, 1997.
4. J. M. Rabaey, A. Chandrakasan, and B. Nikolic, "Digital Integrated circuits: A design perspective" 2nd Edition, Pearson Education India, 2016.
5. Sung-Mo Kang, and Yusuf Leblebici, "CMOS Digital Integrated Circuits", 3rd Edition McGraw-Hill Education, 2002.
6. Michael, D. Ciletti, "Advanced Digital Design with the VeriolgHDL", PHI Learning Private Limited, 2012.
7. Samir Palnitkar, "Verilog HDL: A Guide to Digital Design and Synthesis", Second Edition, Prentice Hall PTR, 2003.

Embedded System

Typical Embedded System: Core of the Embedded System, Memory, Sensors and Actuators, Communication Interface, Embedded Firmware, Other System Components. **Characteristics and Quality Attributes of Embedded Systems: Program Modeling:** Fundamental Issues in Hardware Software Co-Design, Computational Models in Embedded Design, Introduction to Unified Modeling Language, Hardware Software Trade-offs. **Embedded Hardware Design and Development :**EDA Tools, How to Use EDA Tool, Schematic Design – Place wire, Bus , port, junction creating part numbers, Design Rules check, Bill of materials, Netlist creation , PCB Layout Design – Building blocks, Component placement, ARM -32 bit Microcontroller family. Architecture of ARM Cortex M3 –General Purpose Registers, Stack Pointer, Link Register, Program Counter, Special Register,. Nested Vector Interrupt Controller. Interrupt behavior of ARM Cortex M3. Exceptions Programming. Advanced Programming Features. Memory Protection. Debug Architecture. **Embedded Firmware Design and Development:** Embedded Firmware Design Approaches, Embedded Firmware Development Languages **Real-Time Operating System (RTOS) based Embedded System Design:** Operating System Basics, Types of OS, Tasks, Process and Threads,Multiprocessing and Multitasking, Task Scheduling, Threads, **Processes and Scheduling:** Putting them altogether, Task Communication, Task Synchronization, Device Drivers, How to Choose an RTOS

Text/Reference Books:

1. Shibu K V, "Introduction to Embedded Systems", Tata McGraw Hill Education Private Limited, 2009.
2. Joseph Yiu, "The Definitive Guide to the ARM Cortex-M3", 2nd Edition, Newnes, (Elsevier), 2009.
3. James K Peckol, "Embedded Systems - A contemporary Design Tool", John Weily, 2008.

Analog & Mixed Signal System

Data converter fundamentals: Analog versus Digital Discrete Time Signals, Converting Analog Signals to Data Signals, Sample and Hold Characteristics, DAC Specifications, ADC Specifications, Mixed-Signal Layout Issues. Data Converters Architectures: DAC Architectures, Digital Input Code, Resistors String, R-2R Ladder Networks, Current Steering, Charge Scaling DACs, Cyclic DAC, Pipeline DAC, ADC Architectures, Flash, 2-Step Flash ADC, Pipeline ADC, Integrating ADC, Successive Approximation ADC. Non-Linear Analog Circuits: Basic CMOS Comparator Design, Analog Multipliers, Multiplying Quad, Level Shifting (Excluding Input Level Shifting For Multiplier). Su-Microns CMOS circuit design: Process Flow, Capacitors and Resistors, MOSFET Switch (upto Bidirectional Switches), Delay and adder Elements, Analog Circuits MOSFET Biasing (upto MOSFET Transition Frequency). OPAmp Design

Text/Reference Books:

1. R. Jacaob Baker, Harry W Li, David E Boyce, "CMOS Circuit Design, Layout, Stimulation" Prentice-Hall of India Private Ltd.,2003.
2. R. Jacaob Baker, "CMOS- Mixed Signal Circuit Design" (Vol ll of CMOS: Circuit Design, Layout and Stimulation), IEEE Press and Wiley Interscience, 2002.
3. B. Razavi, "Design of Analog CMOS Integrated Circuits" 1st Edition, McGraw Hill, 2000.
4. P. E. Allen and D. R. Holberg, "CMOS Analog Circuit Design" 2nd Edition, Oxford University Press, 2002.

High Performance computing architecture

Basics of Computer Design & Performance Evaluation: Defining Computer Architecture, Dependability, Quantitative Principles of Computer Design, CPU Performance & its factors, SPEC Benchmarks. Computational model: Basic computational models, von Neumann Computation Model Instruction level Parallelisms: ILP concepts, Dependencies between instructions, preserving sequential consistency ROB, Limitations of ILP. Pipe lining: Introduction to pipelining, Instruction pipeline design, Pipeline hazards Superscalar Processors: Introduction, Parallel decoding, Superscalar instruction issue, Shelving, Register Renaming, Case Study Pentium Pro, and Power PC 620. Memory System: Memory hierarchy, Cache Coherence, Memory

Consistency, Cache Performance Issues, Shared Memory Organization Distributed Systems: Parallel Virtual Machine, Architecture of PVM, Programming model of PVM. Multicore architecture design, Power 6 Architecture. VLIW processor architectures. Array and vector processors. Multiprocessor architecture: taxonomy of parallel architectures. Centralized shared-memory architecture: synchronization, memory consistency, interconnection networks. Distributed shared memory architecture. Cluster computers. Non von Neumann architectures: data flow computers, reduction computer architectures, systolic architectures.

Text/Reference Books:

1. John L. Hennessy and David A. Patterson, "Computer Architecture-A Quantitative Approach", 4th Edition, Elsevier, 2007.
2. Sima, Fauntain, Kscucle, "Advanced Computer Architecture a design space approach", Pearson, 7th Edition, 2009.
3. Kai Hwang, "Advanced Computer Architecture", McGrawHill publication, 2003.
4. David Culler and Palsingh J, "Parallel Computer Architecture", Morgan Kaufmann Publishers, 1999.
5. Salim Hariri, Manesh Parashar and John A, "Tools & Environments for Parallel and Distributed Computing" Wiley & Sons INC. Publication 2004.

VLSI Testing and Verification

Testing Philosophy, Role of Testing, Digital and Analog VLSI Testing, Test Economics, Defects, Errors, and Faults Levels of Fault Models, Controllability and Observability. Algorithms and Representations: Structural vs. Functional Test, Search Space Abstractions ATPG Algebras, Redundancy Identification, Combinational ATPG Algorithms, Test Generation Systems, Simulation-Based Sequential Circuit ATPG, Complexity of Sequential ATPG. Memory Test: Memory Density and Defect Trend, Memory Test Levels, Fault Modeling,Memory Testing Delay Test, IDDQ test, Design for Testability. Built in Self-test.

Design Verification: The importance of verification, Reconvergence model, Formal verification, Equivalence checking, Model checking, Functional verification. Verification Tools. Simulators: Stimulus and response, Event based simulation, cycle based simulation, Co-simulators, verification intellectual property: hardware modelers, waveform viewers.[Ref4-Chapter2] The verification plan: The role of verification plan: specifying the verification plan, defining the first success. Levels of verification: unit level verification, reusable components verification, ASIC and FPGA

verification, system level verification, board level verification, verifying strategies, verifying responses

Text/Reference Books:

1. P. K. Lala, “Digital Circuit Testing and Testability”, Academic Press, 1997.
2. M. L. Bushnell and V.D. Agrawal, “Essentials of Electronic Testing for Digital, Memory and Mixed-Signal VLSI Circuits”, Kluwar Academic Publishers 2002.
3. M. Abramovici, M.A. Breuer and A.D. Friedman, "Digital Systems and Testable Design", Jaico Publishing House, 2002.
4. Janick Bergeron, “Writing Test benches: functional verification of HDL models”, 2nd Edition, Kluwer Academic Publishers, 2003
5. Jayaram Bhasker and Rakesh Chadha, “Static Timing Analysis for Nanometer Designs” A practical approach, 1st Edition, Springer publications, 2009.
6. Prakash Rashinkar, Peter Paterson, Leena Singh “System on a Chip Verification”, Kulwer Publications, 2002.

Fault Tolerant System

Fundamental concepts in the theory of reliable computer systems design. Introduction to redundancy theory, limit theorems; decision theory in redundant systems. Hardware fault tolerance, redundancy techniques, detection of faults, replication and compression techniques, self-repairing techniques, concentrated and distributed voters, models of fault tolerant computing systems. Case studies. Software fault tolerance: fault tolerance versus fault intolerance, errors and their management strategies. Implementation techniques: software defense, protective redundancy, architectural support. Fault recovery techniques. Coding theory: application to fault tolerant system design. Fault-tolerance and reliability of multicomputer networks (direct and indirect) including fault-tolerant routing and sparing techniques. Yield and reliability enhancement techniques for VLSI/WSI array processors.

Text/Reference Books:

1. Israel Koren and C. Mani Krishna, “Fault-Tolerant Systems”, Morgan-Kaufman Publishers, 2007.
2. Dhiraj Pradhan, “Fault Tolerant Computer Design”, Prentice Hall, 2002.

3. Michael R. Lyu (Edited by) , “Handbook of Software Reliability Engineering”, McGraw-Hill, 1996.
4. Kishore S. Trivedi , “Probability and statistics with reliability, queuing and computer science applications” 2nd Edition, Wiley Publishers, 2001.

Modeling & Simulation of MOS Devices

2-terminal MOS device: threshold voltage modeling (ideal case as well as taking into account the effects of Qf, Φms and Dit.); C-V characteristics (ideal case as well as taking into account the effects of Qf, Qm and Dit); MOS capacitor as a diagnostic tool (measurement of non-uniform doping profile, estimation of Qf, Qm and Dit)

4-terminal MOSFET: threshold voltage (considering the substrate bias); above threshold I-V modeling (SPICE level 1,2,3 and 4); subthreshold current model; scaling; effect of threshold tailoring implant (analytical modeling of threshold voltage using box approximation); buried channel MOSFET; short channel, DIBL and narrow width effects; small signal analysis of MOSFETs (Meyer’s model)

SOI MOSFET: basic structure; threshold voltage modeling

Advanced topics: hot carriers in channel; EEPROMs; CCDs; high-K gate dielectrics

Text/Reference Books:

1. D. G.Ong, “Modern MOS Technology: Processes, Devices and Design”, McGraw Hill, 1984.
2. Y. Taur and T. H. Ning, “Fundamentals of modern VLSI Devices”, Cambridge Univ. Press, 1998.
3. S.M. Sze, “Physics of Semiconductor Devices”, 3rd Edition, Wiley-Interscience, 2006

Embedded System for CPC

Introduction to Cyber-Physical Systems, Memory Architectures, Interrupts, Modeling Continuous Dynamics, Sensors and Actuators, Modeling Discrete Dynamics, Modeling Discrete Dynamics (contd.) , Composition of State Machines , Hierarchical State Machines , Specification and Temporal Logic , modeling and analysis tools for continuous-time and discrete-time systems, finite state machines, timed and hybrid automata, concurrency, invariants, linear temporal logic, verification, and numerical simulation. Modeling of physical processes; Linear time-invariant systems; Numerical simulation of dierential equations;

Text/Reference Books:

1. Rajeev Alur, "Principles of Cyber-Physical Systems", MIT Press, 2015.
2. Danda B. Rawat, Joel Rodrigues and Ivan Stojmenovic, "Cyber-Physical Systems: From Theory to Practice", CRC Press, 2015.
3. Suh, S.C., Tanik, U.J., Carbone, J.N. and Eroglu, A. (Eds.), " Applied Cyber-Physical Systems", Springer, 2014.

CAD VLSI

Introduction: VLSI design flow, challenges. Verilog/VHDL: introduction and use in synthesis, modeling combinational and sequential logic, writing test benches. Logic synthesis: two-level and multilevel gate-level optimization tools, state assignment of finite state machines. Basic concepts of high-level synthesis: partitioning, scheduling, allocation and binding. Technology mapping. Testability issues: fault modeling and simulation, test generation, design for testability, built-in self-test. Testing SoC s. Basic concepts of verification. Physical design automation. Review of MOS/CMOS fabrication technology. VLSI design styles: full-custom, standard-cell, gate-array and FPGA. Physical design automation algorithms: floor-planning, placement, routing, compaction, design rule check, power and delay estimation, clock and power routing, etc. Special considerations for analog and mixed-signal designs.

Text/Reference Books:

1. Naveed Shervani, "Algorithms for VLSI physical design Automation", 2nd Edition, Kluwer Academic Publisher, 1999. Christophn Meinel and Thorsten Theobold, "Algorithm and Data Structures for VLSI Design", KAP, 2002.
2. Rolf Drechsheler, "Evolutionary Algorithm for VLSI", 2nd Edition

3. Trim burger, “Introduction to CAD for VLSI”, Kluwer Academic publisher, 2002.
4. Randal L and Schwartz Tom Phoenix, “Learning PERL”, Oreilly Publications, 3rd Edition, 2000.
5. Samir Palnitkar, “Verilog HDL: A Guide to Digital Design and Synthesis”, Second Edition, Prentice Hall PTR, 2003.

Real time and Embedded Operating Systems

Introduction to real time system, embedded systems and reactive systems; Hard and soft real time systems; handling real time; specification and modeling; design methods; real time operating systems; validation and verification; real time process and applications; distributed real time systems. Secure coding practices, memory management, timeline design and analysis using metrics and schedulability tests, hardware interfacing, device driver programming, memory maps and boot kernels, firmware and ROM- resident system code, communications and networking, and debugging live systems. These concepts will be reinforced through C programming assignments using the Linux operating system.

Text/Reference Books:

1. Sam Siewert, “Real-Time Embedded Systems and Components”, Cengage Learning India Edition, 2007.
2. Myke Predko, “Programming and Customizing the PIC microcontroller”, 3rd Edition, TMH, 2008.
3. Dreamtech Software Team, “Programming for Embedded Systems”, Jhon Wiley India Pvt. Ltd., 2008.
4. Tanenbaum A S, “ Modern Operating System”, 3rd Edition, PHI learning private limited, , 2009.

Network on Chip

Introduction to Network layers and Network Architecture; Network on Chip: System-on-Chip Integration and Its Challenges; SoC to Network-on-Chip: A Paradigm Shift; NOC: Interconnection Networks, Architecture Design, Evaluation of Network-on-Chip Architectures, Application Mapping, Low-Power Techniques, Signal Integrity and Reliability, Testing, On-Chip multiprocessors; SoCs based NoCs: Examples;

Text/Reference Books:

1. Santanu Kundu, Santanu Chattopadhyay, "Network-on-Chip: The Next Generation of System-on-Chip Integration", CRC press, 2014.
2. Jose Flich, Davide Bertozzi, "Designing Network On-Chip Architectures in the Nanoscale Era", CRC press, 2010.
3. De Micheli & Benini, "Networks on Chips", Elsevier, 2006

Low Power Circuits and Systems

Introduction: Need for Low Power Circuits, Low Power Techniques at different Hierarchical levels; CMOS basics: MOS Transistors, Short Channel Effects, Spice models for MOS transistors, MOS Invertors characteristics, Delay Estimation, BICMOS logic circuits; MOS Logic Styles: Static CMOS, Dynamic CMOS and Pass transistor circuits; Sources of Power dissipation: Diode Leakage Power, Short Circuit Leakage Power, Switching Power and Switching Activity of Static and Dynamic Circuits, Parameters involved in power dissipation; Low-power Design Methodologies: Supply voltage scaling approaches at different levels of hierarchy, Multi-threshold CMOS circuit design, Dynamic Voltage Scaling, Minimizing Switched Capacitance at different levels; Adiabatic switching concepts; Low Power CMOS RAM Circuits.

Text/Reference Books:

1. Ajit Pal, "Low-Power VLSI Circuits and Systems", Springer, 2015
2. J. B. Kuo and J-H. Lou, "Low-Voltage CMOS VLSI Circuits", Wiley, 1999.
3. K. Roy and S. C. Prasad, "Low-Power CMOS VLSI Circuit Design", Wiley, 2000.

MEMS*

MEMS and Microsystems, Miniaturization, Typical products, Micro sensors, Micro actuation, MEMS with micro actuators, Microaccelorometers and Micro fluidics, MEMS materials, Micro fabrication , Elasticity, Stress, strain and material properties, Bending of thin plates, Spring configurations, torsional deflection, Mechanical vibration, Resonance, Thermo mechanics – actuators, force and response time, Fracture and thin film mechanics. Electrostatics: basic theory, electro static instability. Surface tension, gap and finger pull up, Electro static actuators, Comb

generators, gap closers, rotary motors, inch worms, Electromagnetic actuators. bistable actuators. Electronic Interfaces, Feedback systems, Noise , Circuit and system issues, Case studies – Capacitive accelerometer, Peizo electric pressure sensor, Modelling of MEMS systems, CAD for MEMS. Optical MEMS, - System design basics – Gaussian optics, matrix operations, resolution. Case studies, MEMS scanners and retinal scanning display, Digital Micro mirror devices. RF Memes – design basics, case study – Capacitive RF MEMS switch, performance issues

Text book

1. Stephen Santuria, "Microsystems Design", Kluwer publishers, 2000.

References

1. Nadim Maluf, "An introduction to Micro electro mechanical system design", Artech House, 2000
2. Mohamed Gad-el-Hak, editor," The MEMS Handbook", CRC press Baco Raton, 2000.
3. Tai Ran Hsu, "MEMS & Micro systems Design and Manufacture", Tata McGraw Hill, New Delhi, 2002.

*As an alternative to this course, students can be offered the approved course # PH515 (MEMS & NEMS).

VLSI Technology

General Overview of current status of VLSI Technology- Interaction between Technology and Design , - Interaction between Physics and Technology, - Limits of Technology, Environment for Integrated Circuits Manufacture, - Clean Rooms and Wafer cleaning procedures., - Technology details of the Laboratory.

Unit- Processes in Fabrication, - Oxidation, Diffusion, Ion Implantation, Etching and Deposition, techniques., - Characterization of Processes.

Lithography and Mask generation techniques - Advanced Unit-Processors for ULSI Circuit Technologies., - Use of RTP, - Plasma processes in the fabrication in the fabrication of circuits., Basic Bipolar process Technologies., NMOS Technology

Mask sequence based fabrication process for NMOS transistors, - Silicon Gate and Metal Gate Technologies. Limitations of NMOS Technology.

CMOS Technology - Process Sequence for CMOS Technology, Advanced CMOS Processes, "Design – Rules" for NMOS and CMOS Technologies as "Constraints" for Layouts.

Process Simulation - Use of SUPREM-IV ans STEP Simulators for process Design, - Some Examples of actual technologies.

References

1. S.K. Ghandhi, “VLSI Fabrication principles”, John Wiley Inc., New York, 1983
2. S.M. Sze “VLSI Technology”, 2nd Edition, McGraw Hill Co. Inc., New York, 1988
3. C. Y. Chang and S. M. Sze, “VLSI Technology”, McGraw Hill Co. Inc., New York, 1996

Bio Sensors and Circuits

Transducers Principles, Biochemical Transducers: Electrode theory, electrode impedance, metal-electrolyte interface and electrode-tissue interface, Bio-potential electrodes: microelectrodes, body surface electrodes, needle electrodes, electrodes for ECG, EEG, and EMG. Electrodes: hydrogen electrodes, Ag/AgCl electrodes, Calomel electrodes, specific ion electrodes, pH electrode, O2 and CO2 electrode, Optical Sensor and Radiation Detectors: Principles of optical sensors and types of optical sensors, Optical fibers, LASERs, Radiation detectors: Proportional counter, Gas-ionization chamber, Geiger counters, Scintillation detectors., Biological Sensors: Receptors in the human body, Ion exchange membrane electrodes, enzymatic biosensors, Basic principles of MOSFET biosensors & BIOMEMS, basic idea about Smart sensors, Biomedical Measurement

Reference Books

1. Josheph J. Carr and John M. Brown, “Introduction to Biomedical Equipment Technology”, 4th Edition, Pearson Education, 2001.
2. John. G. Webster, “Medical Instrumentation- Application and Design”, 4th Edition, John Wiley & Sons, 2010.
3. Willis J. Tompkins, “Biomedical Digital Signal Processing” Prentice-Hall of India, 1993.
4. Rangraj M. Rangayyan, “Biomedical Signal analysis- A Case Study Approach”, Wiley India Pvt. Ltd., 2009.
5. Suresh R. Devashahayan, “Signals and Systems in Biomedical Engineering”, Revised 2nd Edition, Kluwer academics/ Plenum publication, 2013.
6. Josheph J. Carr and John M. Brown, “Introduction to Biomedical Equipment Technology”,4th Edition, Prentice Hall, 2000.
7. Leslie Cromwell, Fred J. Weibell, and Erich A. Pfeiffer “Biomedical Instrumentation and Measurements”, 2nd Edition, Prentice-Hall of India, 2000.

RFIC

Introduction to RF and Wireless technology; Basic concepts in RF & Wireless Integrated Circuits Design; Receiver and Transmitter Architectures.

Low noise RF Amplifiers- LAN basic topologies, Linearity and Noise in amplifiers, Stability, Matching Considerations, Differential and Broadband Amplifier;

Mixers- Mixer Operation, Passive and Active Mixers, Single & Double-Balanced Mixers, Noise in Mixers, Image Reject and Single Sideband Mixers;

Oscillators- Voltage Controlled- Oscillator, Negative Resistance Oscillator, Oscillator as a Feedback system, Oscillator Analysis, Colpitts, Hartley, Clapp, Pierce crystal Oscillators, Noise in Oscillators, Quadrature Oscillators, Tunable Oscillator;

Frequency Synthesizers- Phase Locked Loop (PLL), Analysis of PLL Synthesizers, Phase Noise in PLL Synthesis, PLL Frequency Synthesizers, Integer-N and Fractional-N PLL Synthesizers, PLL System Frequency Response and Bandwidth;

RF Power Amplifiers-Efficiency, Matching Considerations, Analysis of Basic Classes-A, AB, B, C, Class B Push-Pull Arrangements, Switch mode classes- D, E, F Amplifiers, Doherty Power Amplifier.

Prerequisite: Basic Electronics and Basic Electromagnetic Engineering.

Text/Reference Books:

1. Thomas H Lee, “The design of CMOS Radio Frequency Integrate Circuits”, 2nd Edition, Cambridge University Press, 2003.
2. Behzad Razavi, “RF MicroElectronics”, 2nd Edition, Pearson India, 2013.
3. John W M Rogers and Calvin Plett, “Radio Frequency Circuit Design”, Artech House, Boston, 2003.
4. Les Besser and Rowan Gilmore, “Practical RF Circuit Design for modern Wireless Systems”, vol.2, Artech House, Boston, 2003.
5. David M Pozar, “Microwave and RF design of Wireless Systems”, 4th Edition, John Wiley and sons, 2001.

Reference Books:

1. Guillermo Gonzalez, "Microwave Transistor Amplifier- Analysis and Design", 2nd Edition, Prentice Hall, New Jersey, 1996.
2. Richard C-H Li, "RF Circuits Design", John Wiley, 2008.

Embedded System Integration

General system design: Embedded Computing : Introduction, Complex Systems and Microprocessor, The Embedded System Design Process, Formalisms for System Design, Design Examples. ARM Introduction: Introduction to processor design-architecture and organization, Abstraction in hardware design, Instruction set design, Processor design tradeoffs, RISC. Overview of ARM architecture – Architecture inheritance, Programmer`s model, Development tools. ARM Instruction Set. Architectural support for high level languages Architectural support for system development - ARM memory interface, AMBA, ARM reference peripheral specifications, JTAG, Embedded trace, signal processing support, ARM processor cores. Memory hierarchy Memory size and speed, On-chip memory, Caches, Memory management. Memory hierarchy Architectural support for OS-Embedded ARM applications

Text/Reference Books:

1. David E. Simon, "An Embedded Software Primer", Pearson Education Asia, 2005
2. Wayne Wolf "Computers as Components: Principles of Embedded Computing System Design", 3rd Editions, Morgan Kaufman Publishers, 2012.
3. Rajkamal, "Embedded Systems Architecture, Programming and Design", 3rd Edition, TATA McGraw Hill, 2008.

System-on-Programmable-Chip Design

Introduction: Driving Forces for SoC - Components of SoC - Design flow of SoC - Hardware/Software nature of SoC - Design Trade-offs - SoC Applications

System-level Design: Processor selection-Concepts in Processor Architecture: Instruction set architecture (ISA), elements in Instruction Handing-Robust processors: Vector processor, VLIW, Superscalar, CISC, RISC—Processor evolution: Soft and Firm processors, Custom-Designed processors- on-chip memory.

Interconnection: On-chip Buses: basic architecture, topologies, arbitration and protocols, Bus standards: AMBA, CoreConnect, Wishbone, Avalon - Network-onchip: Architecture-topologies-switching strategies - routing algorithms - flow control, Quality-of-Service- Reconfigurability in communication architectures.

IP based system design: Introduction to IP Based design, Types of IP, IP across design hierarchy, IP life cycle, Creating and using IP - Technical concerns on IP reuse – IP integration - IP evaluation on FPGA prototypes.

SOC implementation: Study of processor IP, Memory IP, wrapper Design - Real-time operating system (RTOS), Peripheral interface and components, High-density FPGAs - EDA tools used for SOC design.

SOC testing: Manufacturing test of SoC: Core layer, system layer, application layer- P1500 Wrapper Standardization-SoC Test Automation (STAT).

References

1. Michael J.Flynn, Wayne Luk, "Computer system Design: Systemon-Chip", Wiley-India, 2012.
2. Sudeep Pasricha, Nikil Dutt, "On Chip Communication Architectures: System on Chip Interconnect", Morgan Kaufmann Publishers, 2008.
3. W.H.Wolf, "Computers as Components: Principles of Embedded Computing System Design", Elsevier, 2008.

Sensors and Actuators

Brief overview of measurement systems, classification, characteristics and calibration of different sensors. Measurement of displacement, position, motion, force, torque, strain gauge, pressure flow, temperature sensor sensors, smart sensor. Optical encoder, tactile and proximity, ultrasonic transducers, opto-electrical sensor, gyroscope. Principles and structures of modern micro sensors, micro-fabrication technologies: bulk micromachining, surface micromachining, LIGA, assembly and packaging. Pneumatic and hydraulic systems: actuators, definition, example, types, selection. Pneumatic actuator. Electro-pneumatic actuator. Hydraulic actuator, control valves, valve sizing valve selection. Electrical actuating systems: solid-state switches, solenoids, voice coil; electric motors; DC motors, AC motors, single phase motor; 3-phase motor; induction motor; synchronous motor; stepper motors. Piezoelectric actuator: characterization, operation, and fabrication; shape memory alloys.

Text Books

1. John G. Webster, Editor-in-chief, "Measurement, Instrumentation, and Sensors Handbook", CRC Press (2014).
2. Jacob Fraden, "Handbook of modern Sensors", AIP Press, Woodbury (2016).
3. Nadim Maluf, "An Introduction to Microelectromechanical Systems Engineering", Artech House Publishers, Boston (2004).
4. Marc Madou, "Fundamentals of Microfabrication", CRC Press, Boca Raton (2002).
5. Gregory Kovacs, "Micromachined Transducers Sourcebook", McGraw-Hill, New York (1998).
6. E. O. Deobelin and D. Manik, "Measurement Systems – Application and Design", Tata McGraw-Hill (2004).
7. D. Patranabis, "Principles of Industrial Instrumentation", Tata McGraw-Hill, eleventh reprint (2004).
8. B. G. Liptak, "Instrument Engineers' Handbook: Process Measurement and Analysis", CRC (2003).

Hardware Security

Review of modular arithmetic, Groups, rights and Fields, Polynominal fields, Galois Field arithmetic. Mapping between Binary and Composite Fields. Overview of Modern Cryptography: Stream ciphers, Block Ciphers, DES, AES, Rijndael in Composite Field,Elliptic Curves, Montgomery's Algorithm for Scalar Multiplication. Modern Hardware Design: FPGA architecture,Mapping an Algorithm to Hardware, Hardware Design of Cryptographic Algorithms. Overview of Different

Issues of Hardware Security, Useful hardware Security Primitives, Side-channel Attacks on Cryptographic Hardware, Testability and Verification of Cryptographic Hardware, Modern IC Design and Manufacturing Practices and Their Implications, Hardware Trojans. Differential Fault Analysis of Ciphers

References

1. Christof Paar, Jan Pelzl, "Introduction to Cryptography" Springer 2010, ISBN: 978-3-642-44649-8 (Print) 978-3-642-04101-3 (Online)
2. Ingrid Verbauwhede (Eds), "Secure Integrated Circuits and Systems" Springer 2010, ISBN: 978-0-387-71827-9 (Print) 978-0-387-71829-3 (Online) Stefan Mangard, Elisabeth Oswald, Thomas Popp, "Power Analysis Attacks," Springer 2007, ISBN: 978-0-387-30857-9 (Print) 978-0-387-38162-6 (Online)
3. Debdeep Mukhopadhyay, Rajat Subhra Chakraborty, "Hardware Security: Design, Threats, and Safeguards," CRC Press 2015, ISBN 9781439895832
4. Marc Joye, Michael Tunstall, "Fault Analysis in Cryptography," Springer 2012, ISBN: 978-3-642-29655-0 (Print) 978-3-642-29656-7 (Online)

VLSI DSP

Introduction to DSP systems: Representation of DSP algorithms; Iteration Bound: Definition, Examples, Algorithms for computing Iteration bound; Pipelining and Parallel Processing: Definitions, Pipelining and parallel processing of FIR filters, Pipelining and parallel processing for low power; Retiming: Definitions and Properties, Solving system of Inequalities, Retiming techniques; Unfolding: Definition, An algorithm for unfolding, Applications of unfolding; Folding: Definition, Folding transformations, Register minimization techniques, Register minimization in folded architectures; Systolic Architecture Design: Introduction, Systolic array design methodology, FIR systolic arrays, Selection of scheduling vector, Matrix-Matrix multiplication and 2D systolic array design; CORDIC based Implementations: Architecture, Implementation of FIR filter and FFT algorithm; Bit-Level arithmetic architectures: Parallel multipliers, Bit-serial multipliers, Bit-Serial FIR filter design and Implementation; Redundant arithmetic: Redundant number representation, Carry-free radix-2 addition and subtraction, radix-2 hybrid redundant multiplication architectures; Low-power design: Theoretical background, Scaling versus power consumption, Power analysis, Power reduction techniques, Power estimation approaches.

Texts / References:

1. U. Meyer-Baese, " DSP with FPGA", Springer,4th Edition, 2014.
2. K. K. Parhi, " VLSI DSP Systems", Wiley, 2003.
3. R.G. Lyons, " Understanding Digital Signal Processing", Pearson Education,3rd Edition, 2011.

FPGA Based system Design:

Introduction to reconfigurable and FPGA based system Design; Basic and Advanced FPGA Fabrics; Combinational and Sequential logic realization on FPGA; Issues on FPGA based system Design: Area, Timing and Power; Design; Behavioral /high level Design and implementation methodologies: HDL, IP Core, System Generator; Processor and memory cores; Timing analysis; Clock distribution and management systems; Large scale System Design: Platform FPGA, Multi-FPGA System; Busses and I/O communication system; DSP system Design and Implementation using FPGA; Introduction to FPGA based Embedded system platform.

Text Books:

1. Wayne Wolf, "FPGA-Based System Design", Prentice Hall Modern Semiconductor Design Series, 2004.
2. Ron Sass and Andrew G. Schmidt, Morgan Kaufmann (MK), "Embedded System design with Platform FPGAs", Elsevier,2010.
3. Steve Kilts, "Advanced FPGA design – Architecture, Implementation and Optimization", Wiley publications,2007.

VLSI Architectural Design

Introduction to design and implementation methodologies; Architectural mapping with case studies: Data path, Control path Synthesis; Control Strategies: Hardware implementation of various control structures; Micro-program control techniques; Design issues: Timing, Area, power; FSM Architecture and Synthesis, Semiconductor Memory and Peripheral Architectures;

Computer arithmetic architectures: Integer and Floating point Arithmetic, Fast Adder/Subtractors, Sequential and Array multipliers & dividers, square root, Absolute Difference Value, CORDIC.

Hardware architecture design and performance analysis: Sequential/Folding architectures; bit and word serial architecture; High performance architectures: pipelined, parallel and Systolic Array with examples; Architectural performance Analysis: Throughput and Latency; Low Power VLSI Architectures;

Basic Hardware Architectures for Digital Signal and Communication Systems:

Introduction to VLSI Chip testing Architectures: Introduction to Chip Fault Model, DFT Architecture, BIST Architecture.

Text/Reference Books:

1. Peter Pirsch, "Architectures for Digital Signal Processing", John Willy & sons,2nd Edition,2014.
2. K. K. Parhi, " VLSI Digital Signal Processing Systems: Design and Implementation", A Wiley-Interscience publications,2011.
3. Behrooz Parhami, " Computer Arithmetic: Algorithm and Hardware Design", Behrooz Parhami, Oxford University Press, 2nd Edition,2009.
4. A. Bellaouar, M. I. Elmarsny, "Low Power Digital VLSI Design", A. Bellaouar, M. I. Elmarsny, Kluwe academic Publication,1995.
5. DSP Integrated Circuit, L. Wamhammer, Academic Press,1999.

EE 520 ADVANCED DIGITAL SIGNAL PROCESSING

Discrete Time Signals: Sequences; representation of signals on orthogonal basis; Sampling and Reconstruction of signals;

Discrete systems: attributes, Z-Transform, Analysis of LSI systems, Frequency Analysis, Inverse Systems, Discrete Fourier Transform (DFT), Fast Fourier Transform algorithm, Implementation of Discrete Time Systems.

Design of FIR Digital filters: Window method, Park-McClellan's method.

Design of IIR Digital Filters: Butterworth, Chebyshev and Elliptic Approximations; Lowpass, Bandpass, Bandstop and High pass filters.

Effect of finite register length in FIR filter design

Parametric and non-parametric spectral estimation: Introduction to multi-rate signal processing. Application of DSP to Speech and Radar signal processing.

Texts/ References

1. A.V. Oppenheim and Schafer, Discrete Time Signal Processing, Prentice Hall, 1989.
2. S. K. Mitra, Digital Signal Processing: A computer-Based Approach, 3/e, TMcHl, 2006.
3. John G. Proakis and D. G. Manolakis, Digital Signal Processing: Principle, Algorithms and Applications, Prentice Hall, 1997.
4. L.R. Rabiner and B. Gold, Theory and Application of Digital Signal Processing, Prentice Hall, 1992.
5. J.R. Johnson, Introduction to Digital Signal Processing, Prentice Hall, 1992.
6. D. J. DeFatta, J. G. Lucas and W. S. Hodgkiss, Digital Signal Processing, J Wiley and Sons, Singapore, 1988.

Pattern Recognition and applications

Feature extraction and Pattern Representation , Concept of Supervised and Unsupervised Classification , Introduction to Application Areas **Statistical Pattern Recognition** Bayes Decision Theory , Minimum Error and Minimum Risk Classifiers , Discriminant Function and Decision Boundary , Normal Density Discriminant Function for Discrete Features , Parameter Estimation **Dimensionality Problem;**Dimension and accuracy , Computational Complexity , Dimensionality Reduction , Fisher Linear Discriminant , Multiple Discriminant Analysis , **Nonparametric Pattern Classification:**Density Estimation, Nearest Neighbour Rule , Fuzzy Classification, **Linear Discriminant Functions,** Separability, Two Category and Multi Category Classification , Linear Discriminators, Perceptron Criterion , Relaxation Procedure, Minimum Square Error Criterion , Widrow-Hoff Procedure , Ho-Kashyap Procedure , Kesler's Construction **Neural Network Classifier** Single and Multilayer Perceptron , Back Propagation Learning , Hopfield Network Fuzzy Neural Network **Time Varying Pattern Recognition** First Order Hidden Markov Model , Evaluation , Decoding , Learning

References:

1. Richard O. Duda, Peter E. Hart and David G. Stork, "Pattern Classification", John Wiley & Sons, 2nd Editions,2001.

2. Earl Gose, Richard Johsonbaugh and Steve Jost, "Pattern Recognition and Image Analysis", Prentice Hall, 2008.

Image Processing

Introduction to Digital Image Processing & Applications, Sampling, Quantization, Basic Relationship between Pixels, Imaging Geometry. Image Transforms, Image Enhancement, Image Restoration, Image Segmentation , Morphologyical Image Processing Shape Representation and Description , Object Recognition and Image Understanding Texture Image Analysis , Motion Picture Analysis, Image Data Compression

References:

1. Rafael C. Gonzalez; Richard E. Woods, " Digital Image Processing", Prentice Hall,2008.

2. Anil K. Jain, "Fundamentals of Digital Image Processing", Pearson Education, 2015

Video Surveillance

Basics of Image and Video Processing: Introduction to Image Processing methods, Image Transforms, Color spaces, An overview of Video Compression Standards: H. 261, H. 263, MPEG-1, MPEG-2, MPEG-4, MPEG-7, and MPEG-21, Video shot boundary detection.

Motion Analysis: Real versus apparent motion, Optical Flow Methods, Block Based Methods, Pel Recursive Methods, Mesh-based methods, Region-based (parametric), motion modeling, Categorization of motion segmentation technique.

Object Classification and Tracking- Shape based object classification, motion based object classification, Haar like feature based object detection, Viola Jones object detection framework, Multiclass classifier boosting.

Multi-Object Tracking- Video monitoring for detection and tracking of multiple interacting objects, Classification of multiple interacting objects from video, Region-based Tracking, Contour-based Tracking, Feature-based Tracking, Model-based Tracking, Hybrid Tracking, Particle filter based object tracking, Mean Shift based tracking.

Human Activity Recognition Techniques- Template based activity recognition, Hidden Markov Models (HMMs), Dynamic Time Warping (DTM), Finite-State Machine (FSM), Nondeterministic-Finite-State Automaton (NFA), Time-Delay Neural Network (TDNN), and Syntactic/Grammatical Techniques.

Camera Network Calibration - Types of CCTV (closed circuit television) camera- PTZ (pan-tilt zoom) camera, IR (Infrared) camera, IP (Internet Protocal) camera, wireless security camera, Multiple view geometry, camera network calibration, PTZ camera calibration, camera placement, smart imagers and smart cameras.

Security and Privacy of visual surveillance- Reliable visual data protection technique without sacrificing perceptual utility, secure authentication and privacy of visual surveillance. Implementation of algorithms based on OpenCV (or Matlab) is covered in the course.

Text Books

1. Murat A. Tekalp, "Digital Video Processing", Prentice Hall, 1995.

2. Y. Ma and G. Qian (Ed.), "Intelligent Video Surveillance: Systems and Technology", CRC Press, 2009.

3. H. Aghajan and A. Cavallaro (Ed.), Multi-Camera Network: Principles and Applications", Elsevier, 2009.

4. A senior (Ed.), "Privacy Protection in Video Surveillance", Elsevier, 2009

Reference Books

1. Dr. Richard Szeliski, "Computer Vision: Algorithms and Applications", Springer Publication, 2010

Cryptography

Mathematical Background: Modular Arithmetic , Finite Fields, The Group Law, Elliptic Curves over Finite Fields , Projective Coordinates. Symmetric Encryption: Shift Cipher, Substitution Cipher, Permutation Cipher, Stream Cipher Basics , Linear Feedback Shift Registers, RC4; Block Ciphers: DES, AES, and Different modes of Block ciphers. Key Management, Secret Key Distribution. Hash Functions and Message Authentication Codes: SHA,MD5, HMAC. Public Key Encryption: RSA, ElGamal Encryption, Rabin Encryption, Elliptic curve based encryption. Digital Signatures: RSA based, DSA, ECDSA. Public key based infra structure. Key Exchange: Diffie–Hellman Key Exchange, Authenticated Key Agreement. Zero knowledge based protocols.

Text:

1. Doug Stinson, Cryptography: Theory and Practice, Third Edition or later, Publisher: Chapman and Hall/CRC, 2005

References: 1. A.J. Menezes, P. van Oorschot and S.A. Vanstone. The Handbook of Applied Cryptography. CRC Press, 1997.

2. W. Mao, Modern Cryptography : Theory and Practice. Pearson Education, 2003 or later

VLSI Laboratory

Exposure to EDA tools, Full custom design flow: Circuit design & simulation, Physical Layout design and verification with case studies, I/O Pad design and Implemenation. Semi-custom design flow: Architecture design, RTL Coding, synthesis, timing analysis, power analysis, physical design and verifications, Back annotation simulation and tape out with case studies, Device simulation with case studies, Exposure to the VLSI technology.

References:

1. Michael, D. Ciletti, “Advanced Digital Design with the VeriolgHDL”, PHI Learning Private Limited, 2012.

2. Samir Palnitkar, “Verilog HDL: A Guide to Digital Design and Synthesis”, Second Edition, Prentice Hall PTR, 2003.

3. Michael John Sebastian Smith, “Application Specific Integrated Circuit” Addison Wesley, Reprint edition, 1997.

4. J. M. Rabaey, A. Chandrakasan, and B. Nikolic, “Digital Integrated circuits: A design perspective” 2nd Edition, Pearson Education India, 2016.

5. Sung-Mo Kang, and Yusuf Leblebici, “CMOS Digital Integrated Circuits”, 3rd Edition McGraw-Hill Education, 2002.

6. Y. Taur and T. H. Ning, “Fundamentals of modern VLSI Devices”, Cambridge Univ. Press, 1998.

Embedded Systems Laboratory

Exposure to Embedded Platform: FPGA based embedded systems and Advance microcontroller based embedded systems with case studies; interfacing techniques and serial protocols: UART, SPI, I2C; experiments on wire and wireless modules using embedded platform: Timers, PWM, ADC, DAC, Display, sensors & actuators, Bluetooth, Wi-Fi, Zigbee, GSM, GPS;

References:

1. Shibu K V, “Introduction to Embedded Systems”, Tata McGraw Hill Education Private Limited, 2009.

2. Andrew N. Sloss, Dominic Symes and Chris Wright, “ARM system Developer’s Guide”, Elsevier, 2011.

3. Wayne Wolf, “FPGA-Based System Design”, Prentice Hall Modern Semiconductor Design Series, 2004.

4. Ron Sass and Andrew G. Schmidt, Morgan Kaufmann (MK), “Embedded System design with Platform FPGAs”, Elsevier, 2010.

5. Steve Kilts, “Advanced FPGA design – Architecture, Implementation and Optimization”, Wiley publications,2007.

7. Proposed number of Seats and Admission Criteria:

Proposed Seats:

Regular & Full time – 12

Sponsored & Full time – 03

Total: 15.

Distribution and Reservations as per GOI.

Admission Criteria:

B. Tech./B.E. /B.Sc.(Engineering) degree in

Electrical/Electronics/Communication/Instrumentations Engineering/Computer Science

& Engineering with valid GATE score in one of these discipline

OR

M. Sc. (Physics/Electronics) with valid GATE score in Electronics Engineering

_____End Of The Draft Proposal_____