## Course of study in M.Tech.

| Sl. No. | Subject Code | Subject Name | L | T | P | Credit | Page No. |
|---|---|---|---|---|---|---|---|
| | | FIRST SEMESTER | | | | | |
| | CORE | | | | | | |
| 01 | EL41108 | Analog VLSI System design | 3 | 0 | 0 | 3 | |
| 02 | EL41109 | Embedded System Design | 3 | 0 | 0 | 3 | |
| 03 | EL41110 | Semiconductor Device Modeling | 3 | 0 | 0 | 3 | |
| 04 | EL41111 | Digital VLSI System design | 3 | 1 | 0 | 4 | |
| 05 | | ELECTIVE-1 | 3 | 1 | 0 | 4 | |
| 06 | EL41108 | DSP Lab | 0 | 0 | 3 | 2 | |
| 07 | EL41108 | VLSI Lab | 0 | 0 | 3 | 2 | |
| 08 | EL41108 | Seminar | 0 | 0 | 3 | 2 | |
| | | TOTAL CREDIT | 15 | 02 | 9 | 23 | |
| | | ELECTIVE-1 | | | | | |
| 09 | EL41103 | Soft Computing | 3 | 1 | 0 | 4 | |
| 10 | EL41104 | DSP Architecture& Application | 3 | 1 | 0 | 4 | |
| 11 | EL41111 | Computer Communication and Network | 3 | 1 | 0 | 4 | |
| | | SECOND SEMESTER | | | | | |
| | CORE | | | | | | |
| 01 | EL42101 | VLSI CAD | 3 | 0 | 0 | 3 | |
| 02 | EL42108 | Low Power VLSI design | 3 | 0 | 0 | 3 | |
| 03 | EL42101 | Embedded Computer System | 3 | 1 | 0 | 4 | |
| 04 | EL42101 | VLSI Testing & testability | 3 | 0 | 0 | 3 | |
| 05 | EL42101 | ELECTIVE-2 | 3 | 1 | 0 | 4 | |
| 06 | EL42201 | VLSI Lab | 0 | 0 | 3 | 2 | |

| 07 | EL42203 | Embedded Computing Lab | 0 | 0 | 3 | 2 | |
|----|---------|------------------------|---|---|---|---|---|
| 08 | EL42301 | Seminar | 0 | 0 | 3 | 2 | |
| | | TOTAL CREDIT | 15 | 2 | 9 | 23 | |
| | | ELECTIVE-2 | | | | | |
| 09 | EL42211 | VLSI Signal processing | 3 | 1 | 0 | 4 | |
| 10 | EL42212 | Architecture of  Digital  Signal processing | 3 | 1 | 0 | 4 | |
| 11 | EL42213 | Mixed Signal Design | 3 | 1 | 0 | 4 | |
| 12 | EL42214 | VLSI Technology | 3 | 1 | 0 | 4 | |
| 13 | EL42211 | ASIC Design | 3 | 1 | 0 | 4 | |
| | | THIRD SAMESTER | | | | | |
| 01 | EL43402 | Project Work-1 | - | - | - | 15 | |
| 02 | EL43502 | Comprehensive viva voice | - | - | - | 3 | |
| | | TOTAL CREDIT | - | - | - | 18 | |
| | | FOURTH  SAMESTER | | | | | |
| 01 | EL44402 | Project Work-2 | - | - | - | 20 | |
| | | | | | | | |

1<sup>st</sup> semester

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**Department of Electronics and Communication Engineering**

**(VLSI Design and Embedded System)**

**Analog VLSI System design   (EL41108)**

### UNIT –I

Principle of analog circuit desigm.MOS based analog building blocks.

### UNIT –II

OPAMP design, techniques and performance characteristic, OPAMP instrument in low and high power circuits.

### UNIT –III

Switched capacitor circuits; High pass, low pass, band pass filters, switched capacitor filter.Analog multiplier and modulators.

### UNIT –IV

Phase lock techniques, PLL design parameters and systems.

### UNIT –V

A to D and D to A Converters.

### Reference book:-

CMOS Analog Circuit Design By Phillip E Allen (Author), P E Allen (Author), Douglas R Holberg (Author) Publisher: Oxford University Press, U                                    Analysis and Design of Analog Integrated Circuits, 4th Edition ; Paul R. Gray, Paul J. US Hurst, Stephen H. Lewis, Robert G. Meyer ;March 2001,Wiley

VLSI Design Techniques for Analog and Digital Circuits, R. L. Geiger, P. E. Allen, and N. R. Strader, McGraw-Hill, 1990.

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**Digital VLSI System design (EL41110)**

# UNIT -I

Introduction to VLSI design, Different types of VLSI design styles; Full custom, standard cell based, gate array based, programmable logic, field programmable gate array etc. VLSI design flow.

# UNIT -II

CMOS logic, pass transistor, PMOS,NMOS and CMOS ,electrical characteristics  Operation of MOS transistor as a switch and an amplifier.

# UNIT -III

MOS inverter, Stick diagram, design rules and layout, delay analysis, Different type of MOS circuits; Dynamic logic, BICMOS, CMOS process,

# UNIT -IV

Combinational logic cells, Dynamic logic, Datapath logic cell, I/O cells. ASIC library design: Transistor as resistor and parasitic capacitance, logical effort, gate array, standard cell and datapath cell design.

# UNIT -V

Introduction to hard -ware description language (HDL), Verilog/VHDL .A logic synthesis example. Floor planning and placement; I/O and power planning, clock planning. Routing, global and detailed. Example design technique; mapping of architecture to silicon.

## Reference books:-

1. CMOS Digital Integrated Circuits Analysis and Design, Third Edition, Sung-Mo (Steve) Kang and Yusuf Leblebici, McGraw-Hill, 2002.
2. CMOS VLSI Design: A Circuits And Systems Perspective, Neil H. E. Weste and Kamran Eshraghian, Publisher: Pearson Education India

3. W.Wolf: Modern VLSI Design: system on silicon. Pearson education,2000

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## Embedded System Design (EL41109)

## UNIT -I

Introduction to embedded systems- Definitions and constraints; hardware and processor requirements.

## UNIT –II

Special purpose processors; input-output design and I/O communication protocol.

## UNIT –III

Design space exploration for constraints satisfaction; co-design approach; Example system design.

## UNIT –IV

Formal approach to specification; specification languages; specification requirement and design; design validation.

## UNIT –V

Real time operating system issues with to embedded system applications; time constraints and performance analysis.

## Reference book:-

Embedded System Design; Marwedel, P.; 2006 Springer L

Daniel D. Gajski, Frank Vahid, Sanjiv Narayan, and Jie Gong. Specification and Design of Embedded Systems. Prentice-Hall, July 1994

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## Semiconductor Device Modeling (EL41110)

## UNIT –I

Integrated circuits diodes and transistors; currents – voltage characteristics.

## UNIT –II

Ebers-Moll model and Gummel – Poon model of bipolar transistors; current gain; Early effect and high level injection; 2-D effect; transient parameters.

## UNIT –III

MOSFET; Analysis of MOSFET parameters; short channel and narrow width effects ; hot electron effects.

## UNIT –IV

MOSFET models; JFET and MESFETs; Modulation doped FETs ; HEMTs ; Hetrojunction and HBTs.

## UNIT –V

Microwave and Optonics devices; Outline of numerical approach to 2D and 3D device modes; introduction to device simulation programs.

## Reference book:-

Solid State Electronic Devices, Fifth Edition, Ben Streetman, Sanjay Banerjee, Prentice Hall, 2000.

# Electives:

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**Department of Electronics and communication Engineering**

**(VLSI Design and Embedded System)**

## Computer Communication Network (EL41112)

## UNIT –I

**Introduction:** Communication Model, Data Communication, Computer Communication Architecture, Standard Making Organisations.

**Data Communication:** Concepts and Terminology, Asynchronous and Synchronous Data Communication, Multiplexing Techniques.

## UNIT –II

**Data Communication Networking:** Communication Networking Techniques, Circuit Switching, Packet Switching, Local Area Networks.

**Protocols and Architectures:** Protocols, Layered Approach, TCP/IP Protocol Suite, System Network Architecture.

## UNIT –III

**Internetworking:** The Bridge and Routing, Connectionless internetworking, Connection oriented internetworking.

**Transport Protocols:** Transport and Network Services TCP/UDP.

## UNIT –IV

**Session Services and Protocols:** Session Characteristics, OSI Session and Service Protocol.

**Presentation Facilities:** Presentation Concepts, Encryption and Authentication Codes, Virtual Terminal Protocols.

## UNIT –V

**Distributed Application:** Network Management, File Transfer and Electronic Mail

**Frame Relay and Cell Relay:** Communication Switching Techniques, Frame Mode Bearer Service, Frame Relay Congestion Control, Synchronous Transfer Mode.

**Text Books:**

1. Data and computer Communications, 2$^{nd}$ Ed, W. Stallings, PHI, New Delhi.

**Reference Books:**

1. A.S. Tanenbaum, "Computer Networks", 2<sup>nd</sup> Ed, PHI, New Delhi, 1995.
2. A.G. Wates, "Computer Communication Network", McGraw Hill, 1991.
3. Fred Halsall, "Data Communications, Computer Networks and Open Systems", Pearson Education.

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**Department of Electronics and communication Engineering**

**(VLSI Design and Embedded System)**

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## DSP Architecture and application (EL41104)

## UNIT –I

**An overview of features of DSPs:** Requirements for DSP, Typical tasks involved in DSP, Von Neumann & DSP Harward architecture, DSP family of fixed and floating point processors(Analog Devices and Texas Instruments.)

## UNIT –II

**Reference Books:**

1. A.S. Tanenbaum, "Computer Networks", 2nd Ed, PHI, New Delhi, 1995.
2. A.G. Wates, "Computer Communication Network", McGraw Hill, 1991.
3. Fred Halsall, "Data Communications, Computer Networks and Open Systems", Pearson Education.

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**Department of Electronics and communication Engineering**

**(VLSI Design and Embedded System)**

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## DSP Architecture and application (EL41104)

## UNIT –I

**An overview of features of DSPs:** Requirements for DSP, Typical tasks involved in DSP, Von Neumann & DSP Harward architecture, DSP family of fixed and floating point processors(Analog Devices and Texas Instruments.)

## UNIT –II

**An overview of features of DSPs:** Software and hardware development tools, typical applications of DSP family, **Architecture and Programming of a DSP 2100 family DSPs:** Pin description, Computational units (ALU,MAC, Barrel Shifter).

## UNIT-III

**Architecture and Programming of a DSP 2100 family DSPs:** Program control, data transfer, system interface, Memory interface, Instruction set, Software and hardware examples. **Architecture and Programming of TMS 320XX family DSPs:** Functional block diagram,

## UNIT-IV

**Architecture and Programming of TMS 320XX family DSPs:** Memory organization, CALU, System control, Interrupts Serial ports, multiprocessing and DMA, instruction set, software and hardware examples.

## UNIT-V

**An Overview of MATLAB:** Arithmetic & relational operators, Elementary math functions, polynomial functions, Matrix manipulation, Typical programming examples.

**Text Books:**

1. A DSP-2100 family applications handbook VOL 1
2. DSP applications Using the ADSP-2100 family
3. A DSP-2100 family User's manual
4. Texas TMS 32020 User's manual
5. Matlab User's manual

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**Department of Electronics and communication Engineering**

**(VLSI Design and Embedded System)**

**Soft Computing (EL41103)**

**UNIT –I**

**Introduction to soft computing**

Soft computing constituents and conventional Artificial intelligence, Neuro-Fuzzy and soft computing characteristics.

**Fuzzy Sets, Fuzzy Rules and Fuzzy reasoning**

Introduction, Basis definitions and terminology, Set- theoretic operations, MF formulation and parameterization, More on fuzzy union, Intersection and Complement , Extension principal and fuzzy relations, Fuzzy If- Then rules, fuzzy reasoning.

## UNIT –II

**Fuzzy interference System**
Mamdani fuzzy models, Sugeno fuzzy models, Tsukamoto fuzzy models, Other considerations.

**Neuro- fuzzy Networks**

## UNIT –III

**Artificial Neural Networks[3]**

 1. **Supervised Learning Neural Network**

   i) Preceptron, Adaline, multi layer neural networks. Back propagation algorithm, Radial basis function networks.
   ii)Functional Link Artificial Neural network, update algorithms, trigonometric and power  series expansions
2. **Unsupervised Learning Neural Network**

   Competitive learning networks, Kohonen self-organizing networks, Hopfield network.

## UNIT –IV

## Derivative – free Optimization [4&2]

Genetic Algorithm, Adaptive Genetic Algorithm, Ant Colony Algorithm,

## UNIT –V

 Bacteria foraging Algorithm, Particle Swarm Intelligence.

**Reference book:-**

1. Neuro-Fuzzy and soft Computing –J.S.R.  Jng, C.T.Sun and E.Mizutani, PHI.
2. Neutral Networks, Fuzzy Logic and Genetic Algorithm Rajasekaran, G.A. Vijayalaksmi, PHI.
3. Neural Networks A Comprehensive foundation-Simon Haykin, Pearson Education
4. Lecture Notes

# 2<sup>nd</sup> semester

**National Institute of Technology, Jamshedpur**

**Department of Electronics and communication Engineering**

**(VLSI Design and Embedded System)**

## Embedded Computing System (EL42109)

## UNIT -I

Circuits and DSP Architecture: Circuit Design basics, Deep submicron issues, low power techniques, High level power models, algorithm transformation techniques, Dedicated architectures for embedded systems

## UNIT -II

Architectures Design: Embedded processor architectures, architectural techniques for low power design methods for core based ASICs.

## UNIT -III

Compiler and OS: Introduction to compiler optimization, power models for compiler optimizations, core size vs. performance/power trade off.

## UNIT -IV

DSP Algorithm Design: A/D conversion and finite precision analysis, algorithms for embedded systems, source and channel processing, potable embedded code.

## UNIT -V

Networking: Networking Basics (addressing and routing), wireless vs. wire-line networking, distributed OS for networked embedded systems, Case study of JINI.

## Text books:-

1. K.Hwang, "Advance Computer Architecture: Parallelism, Scalability and Programmability", New York McGraw Hill Inc., 1993.
2. S.Y.Kung, "VLSI Array Processor ", Prentice Hall, Englewood Cliffs, NJ,1988.

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## Department of Electronics and Communication Engineering

### (VLSI Design and Embedded System)

## LOW POWER VLSI DESIGN (EL42108)

## UNIT –I
Analysis of components of power dissipation in digital circuit techniques for low power at technology level.

## UNIT –II

Techniques for low power design at logic design level (analysis of various logic styles for their power consumption).

## UNIT –III

Low power design techniques at architecture levels.

## UNIT –IV

Low power design techniques at system levels.

## UNIT –V

Power consumption of dedicated hardware vs. Software implementations of systems.

## Text books:-

1. A.P. Chandrakasan and R.W. Broderson, "Low Power CMOS Design", IEEE Press, 1998.
2. J.B. Kuo and J.H. Lou, "Low Voltage CMOS VLSI Circuits".


# National Institute of Technology, Jamshedpur

## Department of Electronics and communication Engineering

### (VLSI Design and Embedded System)

## VLSI CAD (EL42101)

## UNIT -I

Introduction: VLSI design flow, challenges. Verilog/VHDL: Introduction and use in synthesis, modelling combinational and sequential logic, writing test benches.

# UNIT -II

Logic synthesis: two-level and multilevel gate-level optimization tools, state assignment of finite state machines.

# UNIT -III

Basic concepts of high-level synthesis: Hierarchical view of VLSI Design, Architectural design, High level synthesis.

# UNIT -IV

Basic concepts of high-level synthesis: Scheduling data path synthesis, Logic synthesis, Minimization techniques, Circuit design and simulation.

# UNIT -V

Basic concepts of high-level synthesis: Layout synthesis, placement and routing, DRC, Silicon compiler, Array processors.

## Text books:-

1. S. Palnitkar, Verilog HDL: A Guide to digital design and synthesis, Second Edition, Prentice-Hall, 2003(Cheap Edition).
2. G. De Micheli, "Synthesis and Optimization of Digital circuits", McGraw-Hill, 1994. (Cheap Edition)
3. S.H. Gerez, "Alogorithm for VLSI Design Automation", Wiley, 1998.
4. N. Sherwani, "Alogorithm for VLSI Physical Automation", Third Edition, Kluwer, 1998. (Cheap Edition)

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### Department of Electronics and communication Engineering

### (VLSI Design and Embedded System)

**VLSI Testing and Testability (EL42110)**

# UNIT -I

Defects and their modeling as faults at gate level and transistor level, Various types of faults, Functional vs. Structural approach to testing.

## UNIT -II

Complexity of testing problem, controllability of observability, Generating test for a single stuck at fault in combinational logic, D-Algorithm.

## UNIT -III

FAN and PODEM Algorithm, Test optimization and fault coverage, The problem of testing of sequential DFT hardware.

## UNIT -IV

Adhoc and structured approaches of DFT, Various kinds of scan design, Fault models for PLAs, Bridging and delay faults and their tests

## UNIT -V

Memory testing, Testing with random patterns, The LFSR and their use in random test generation and response compression(including MISRS), Built-in self test.

## Text Books:-

1. M. Abramoviel, M.A. Breuer and A.D. Friedman, "Digital system testing and Testable Design", IEEE Press1995 (Revised).

2. V. Agrawal and S.C. Seth,"Test Generation for VLSI Chips",IEEE CS Press,1989.

# Electives

**National Institute of Technology, Jamshedpur**

**Department of Electronics and Communication Engineering**

**(VLSI Design and Embedded System)**

## Architecture of DSP (EL42212)

## UNIT –I

**Digital Signal Processors:** The Programmable DSP Architecture, Top-Down Design of Dedicated DSPs, A Library-Based Systems Design Environment.

## UNIT –II

**Classification of Architectures:** An Abstract Computing Machine, Optimization of performance, Interconnection between Functional Units, A Multi-level Classification.

## UNIT –III

**Data and Instruction Memories:** SISC Architectures, Addressing Modes, External Interface Units.

**VLSI SISC Processors:** The SISC Processor, Pipeline Control in SISCs, Superscalar Processors.

## UNIT –IV

**Data Path Logic Design:** Introduction, Synchronous Data Path Design, Monolithic Arithmetic Circuits, Implementation of Pipleline, High level Synthesis (HLS) of Data Path, Low power Data Design, Floating Point Arithmetic.

## UNIT –V

**Rapid Prototyping:** Introduction, High Level Languages(HLLs) in DSP, Haedware Description Languages (HDLs), Optimizing Compilers, DSP Prototyping Environment, Real-Time SISC Prototyping.

## Text Books:

1. Vijay.K. Madisetti, "VLSI Digital Signal Processors- An Introduction to Rapid Prototyping and Design Synthesis", IEEE Press, 1999.
2. Richard J.Higgins, "Digital Signal Processing in VLSI", Prentice Hall,1990.

## National Institute of Technology, Jamshedpur

### Department of Electronics and Communication Engineering

### (VLSI Design and Embedded System)

## ASIC Design (EL42215)

## UNIT –I

**Introduction to ASICs:** Types of ASIC Design Flow, Case Study, Economics of ASICs, ASIC Cell Libraries.

**Overview of CMOS Logic:** CMOS Transistors, CMOS Process, CMOS Design Rules, Combinational Logic Cells, Sequential Logic Cells, Data path Logic cells, I/O cells, cell compilers.

**ASIC Library Design:** Transistors as resistors, Transistor parasitic capacitance, Logical Effort, Library Cell Design, Library Architectures, Gate Array Design, Standard Cell Design, Data path-cell Design.

## UNIT –II

**Programmable ASICs:** The Anti-fuse, Static RAM, EPROM and EEPROM Technology, Practical Issues, Specifications, PREP Benchmarks, FPGA Economics, Programmable ASIC logic Cells, Programmable ASIC I/O Cells, Programmable ASIC Interconnect, Programmable ASIC Design Software, Example: The Halfgate ASIC, Programmable ASIC Logic Cells, Programmable ASIC I/O Cells, Programmable ASIC Interconnect, Programmable ASIC  Design Software.

## UNIT –III

**Low Level Design Entry:** Schematic Entry, Low Level Design Languages, PLA Tools, EDIF,CFI Design Representation.

**Over-view of VHDL & Verilog HDL:**  Example: a Counter, Example: A 4 bit Multiplier, Syntax and Semantics of VHDL, Identifiers and Literals, Entities and Architectures, Packages and Libraries, Interface Declarations, Type Declarations, Other Declarations, Sequential statements, Operators, Arithmetic Concurrent Statements, Execution, Configurations and Specifications, Example: An Engine Controller.

## UNIT –IV

**Logic Synthesis, Simulation and Test:** The Comparator /MUX Examples, Logic System, How Logic Simulation Works, Cell Models, Delay Models, Static Timing Analysis, Formal Verification, Switch Level Simulation, Transistor Level Simulation, The Importance of Test, Boundary Scan Test, Faults, Fault Simulation, Automatic Test-pattern Generation, Scan Test, Built-in Self-test, A Simple test Example, Example: The Viterbi Decoder.

## UNIT –V

**System Partitioning, Floor Planning and Placement:** Floor Planning, Placement, Physical Design Flow, Information Formats.

**Routing:** Routing, Global Routing, Detailed Routing, Special Routing, Circuit Extraction and DRC.

## Text Books:

1.  Smith, M.J.S., "Application-Specific Integrated Circuits" , Reading, M.A. Addison Wesley,1997.

### National Institute of Technology, Jamshedpur

**Department of Electronics and Communication Engineering**

**(VLSI Design and Embedded System)**

# Mixed Signal Design (EL42213)

## UNIT –I

**Building blocks for CMOS Amplifier**: Design of current mirrors. Defrenceal Amplifiers

## UNIT –II

**CMOS Operational trans-conductance Amplifiers:** Design of folded Cascade and two-Stage amplifiers, Frequency Compensation schemes, Miller Compensation .

## UNIT –III

Design of fully deferential amplifiers, Discussion commom mode feedback circuits.Effect of OPAM finite gain, bandwidth an offset.

## UNIT –IV

Circiut technics for reducing effect of OPAM imperfection, Switch and charge injection and clock feed-through effect, design of simple and holds circuits and comparators.

## UNIT –V

Fundamentals of data convertors: Nyquist Rate A/D converters(Flash, interpolating, over sampled A/D and D/A converters), Design of PLL's and DLL's and frequency synthesizers.

## Text Books:

3.  R.Gregorian and Themes," Analog MOS Integrated Circuits for Signal Processing".
4.  R.Gregorian. "Introduction to CMOS OPAMPs and Comparators"
5.  D¸johns and K.Martin, " Analog Integrated Circiuts Design".
6.  Mohammed Ismail and Terri Fiez, "Analog VLSI", McGraw Hill, 1994

Reference Books:

1.  B.Razavi, "Monolithic Phase Locked Loops and Clock Recovery Circuits".


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### Department of Electronics and Communication Engineering

### (VLSI Design and Embedded System)

## VLSI Technology(EL42214)

## UNIT –I

Crystal structure,crystal growth and vapour phase epitaxy.

## UNIT –II

Unit processes for VLSI Oxidation, Photolithography, diffusion ion implantation.

## UNIT –III

Deposition of metal and dielectric films by vacuum evaporation, sputtering and CVD techniques, Wet chemical and Dry Etching techniques.

## UNIT –IV

Device and Circuit fabrication-Isolation, Self alignment and local oxidation techniques. OS based silicon ICs-NMOS and CMOS IC, memory Devices, SOI Devices.

## UNIT –V

BJT based ICs  choices of transistor types, pnp transistors, advanced structures Bipolar-CMOS (BICMOS) ICs, Resisters, Capacitors.

## Text Books:

1.  S.K.Gandhi, "VLSI Fabrication Principles", John Wiley and Sons, NY, 1994.
2. S.M.Sze, "VLSI Technology", McGraw Hill Book Company, NY, 1988.
3. D.Nagchoudhari, "Principles of Microelectronics Technology", Wheeler(India), 1998.

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### Department of Electronics and Communication Engineering

### (VLSI Design and Embedded System)

## VLSI Signal Processing (EL42211)

## UNIT –I

Introduction:

(a) Typical signal processing algorithm

(b) Overview of VLSI Architectures

(c) Representation of DSP Algorithm

General Techniques:

(a) Iteration bound

(b) Pipelining

(c) Parallel processing

# UNIT –II

Retiming Techniques:

(a) Definition and Properties

(b) General Methodology

# UNIT –III

Unfolding and Folding Techniques:

(a) Unfolding Algorithm

(b) Critical Path, Unfolding and Retiming

(c) Folding Transformation

(d) Register Minimization

# UNIT –IV

Systolic Architectures:

(a) Overview

(b) Design Methodology

(c) Matrix Operations and 2-D systolic Array Design

Mapping Algorithm onto Array Structures:

(a) Parallel Algorithm Expressions

(b) Canonical Mapping Methodology

(c) Generalized Mapping

# UNIT –V

Integer Arithmetic on Arrays:

(a) Carry-Look Ahead Addition

(b) Prefix Computations

(c) Carry-Save Addition

(d) Multiplication and Convolution

Programmable Signal Processors:

(a) Important Features
(b) DSP Processors for Mobile and Wireless Communications
(c) Processors for Multidimensional Signal Processing

## Text Books:

7. Keshab K. Parhi, "VLSI Digital Signal Processing Systems:Design and Implementation", John Wiley, 1999.

## Reference Books:

1. S.Y. Kung, "VLSI Array Processors", Prentice-Hall, 1988.
2. W. Wolf, "Modern VLSI Design", Prentice-Hall, 1994.