SIDDHARTHA ACADEMY OF HIGHER EDUCATION

(Deemed to be University)

M.Tech(VLSI DESIGN and EMBEDDED SYSTEMS)

SCHEME OF INSTRUCTION AND SYLLABUS

M.Tech SU-24

(w.e.f 2024– 2025)

Department of Electronics and Communication Engineering

VELAGAPUDI RAMAKRISHNA SIDDHARTHA SCHOOL OF ENGINEERING

Kanuru, Vijayawada -520 007, Andhra Pradesh

www.vrsiddhartha.ac.in

VISION

To be a Centre of Excellence in Education, Innovation and Research with Global presence in Arts, Science, Technology, Medicine, Management, Legal and Social Studies in enriching the frontier areas of National and International Importance.

MISSION

To create a transformative educational experience for students focused on problem solving skills, communication abilities, and interpersonal relations and leadership.

To cultivate a vibrant university community for attracting and retaining diverse, world-class talent creating a collaborative environment open to the free exchange of ideas where research, creativity, innovation and entrepreneurship can flourish and ensuring individuals to achieve their full potential.

To impact society in a pragmatic manner— regionally, nationally, and globally — by engaging with industry, outstanding national and international universities and research organizations.

To be a global University that nurtures excellence in education and innovation for creating a knowledgeable society.

DEPARTMENT VISION

To produce globally competitive and socially sensitized engineering graduates and to bring out quality research in the frontier areas of Electronics & Communication Engineering.

DEPARTMENT MISSION

To provide quality and contemporary education in the domain of Electronics & Communication Engineering through periodically updated curriculum, best of breed laboratory facilities, collaborative ventures with the industries and effective teaching learning process.

To pursue research and new technologies in Electronics & Communication Engineering and related disciplines in order to serve the needs of society, industry, government and scientific community.

PROGRAM OUTCOMES

PO1 Independently carry out research /investigation and development work to solve practical problems.

PO2 Write and present a substantial technical report/document.

PO3 Demonstrate a degree of mastery over the area as per the VLSI Design and Embedded Systems program.

PO4 Devise and apply appropriate techniques and modern engineering tools to complex engineering activities with an understanding of the limitations

PO5 Recognize the need for and an ability to engage in lifelong learning to keep oneself abreast of the knowledge to be competent.

VELAGAPUDI RAMAKRISHNA SIDDHARTHA SCHOOL OF ENGINEERING
Department of ELECTRONICS AND COMMUNICATION ENGINEERING
SCHEME OF INSTRUCTION FOR TWO YEAR PG PROGRAMME [M.Tech SU-24]
M.Tech in VLSI DESIGN AND EMBEDDED SYSTEMS

SEMESTER I **Contact Hours: 26**

S. No	Course Category	Course Code	Title of the Course	L	T	P	C
1	Programme Core - I	24ECVE501	CMOS VLSI Design(Integrated Course)	2	0	2	3
2	Programme Core - II	24ECVE502	Design and verification through System Verilog	3	0	0	3
3	Programme Core - III	24ECVE503	ARM controllers for embedded systems	3	0	0	3
4	Programme Elective – I	24ECVE504A	Device Modelling	3	0	0	3
		24ECVE504B	IC Fabrication Technology				
		24ECVE504C	VLSI signal processing				
		24ECVE504D	MEMS				
5	Programme Elective - II	24ECVE505A	Embedded Systems Design and Architecture	3	0	0	3
		24ECVE505B	Embedded C Programming& Peripheral Interfacing				
		24ECVE505C	Electronics Design: Sensor and Actuators				
		24ECVE505D	Internet of Things for Real time systems				
6	Mandatory Learning Course	24MTUC501	Research Methodology and IPR	2	0	0	0
7	Laboratory – I	24ECVE581	Digital System Design Lab	0	0	3	1.5
8	Laboratory - II	24ECVE582	Embedded Systems Design Lab	0	0	3	1.5
9	Project	24ECVE591	Capstone project-I	0	0	2	1
Total				16	0	10	19

SEMESTER II **CONTACT HOURS: 28**

S. No	Course Category	Course Code	Title of the Course	L	T	P	C
1	Programme Core - IV	24ECVE506	Hardware/Software codesign (Integrated course)	2	0	2	3
2	Programme Core - V	24ECVE507	Real Time Operating System	3	0	0	3
3	Programme Core - VI	24ECVE508	Analog & Mixed Signal Design	3	0	0	3
4	Programme Elective – III	24ECVE509A	Low Power VLSI Design	3	0	0	3
		24ECVE509B	Semiconductor Packaging and Testing				
		24ECVE509C	High level synthesis				
		24ECVE509D	RF IC Design				
5	Programme Elective - IV	24ECVE510A	LINUX Shell Scripting	3	0	0	3
		24ECVE510B	Embedded Linux Device Drivers				
		24ECVE510C	Communication buses and Interfaces				
		24ECVE510D	Industrial Product Design				
6	Audit Course	24MTUC502	Technical Report Writing	2	0	0	-
7	Laboratory – I	24ECVE583	Real Time Operating Systems Lab	0	0	3	1.5
8	Laboratory - II	24ECVE584	Analog & Mixed Signal Design Lab	0	0	3	1.5
9	Project	24ECVE592	Capstone project-II	0	0	2	1
10	Term Paper	24ECVE593	Term Paper	0	0	2	1
Total				16	0	12	20

SEMESTER III **CONTACT HOURS: 27**

S. No	Course Category	Course Code	Title of the Course	L	T	P	C
1	Programme Elective - V	24ECVE601	Students to complete course in any MOOCS platform such as NPTEL	3	0	0	**3**
2	Internship	24ECVE691	Internship/ Summer training in Research Organizations/Institutions of Higher Learning (After II Sem)	0	0	4	**2**
3	Project (Part-A)	24ECVE692	Dissertation/ Industrial Project - Part A	0	0	20	**10**
Total				**3**	**0**	**24**	**15**

*To be continued in the IV Semester
Program Elective V may be completed in semester I or II by satisfying the pre-requisites

SEMESTER IV **CONTACT HOURS: 32**

S. No	Course Category	Course Code	Title of the Course	L	T	P	C
1	Project (Part-B)	24ECVE693	Dissertation/ Industrial Project	0	0	32	**16**
Total				**0**	**0**	**32**	**16**

L – Lecture, T: Tutorial, P – Practical, C – Credits **Total Credits:70**

Semester	Credits
1	19
2	20
3	15
4	16
Total	70

Note:

1. Student has to carry out a project applying the knowledge and hands on technical skills they have gained through course work and lab sessions in Semester-I under Capstone Project 1

2. Student should carry out literature survey of the selected problem and present it in a Seminar for the yearlong Project Work under Term Paper.

3. Student has to carry out a project applying the knowledge and hands on technical skills they have gained through course work and lab sessions in Semester-II under Capstone Project 2

4. At least one theory course in the I & II semesters can be made as integrated course (Theory coupled with Laboratory).

5. Maximum of three theory courses (40% of courses) can be offered as self-learning courses in each of the First and Second semesters.

SEMESTER I

24ECVE501: CMOS VLSI DESIGN

Course Category:	Program Core-I	Credits:	3
Course Type:	Integrated course	Lecture - Tutorial -Practice:	2-0-2
Prerequisites:	UG VLSI Design	Continuous Evaluation: Semester end Evaluation: Total Marks:	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:					
	CO1	Demonstrate knowledge in Static and dynamic characteristics of CMOS inverter, estimate delay and power. [K2].				
	CO2	Design and analyze combinational MOS logic circuits. [K4].				
	CO3	Design and analyze MOSFET based sequential logic circuits. [K4]				
	CO4	Design and analyze various Datapath Subsystems. [K4]				
	CO5	Classify different semiconductor memories [K3].				
Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)		PO1	PO2	PO3	PO4	PO5
	CO1	2	1	3	3	2
	CO2	2	1	3	3	2
	CO3	2	1	3	3	2
	CO4	3	1	3	3	3
	CO5	3	1	3	3	2
Course Content	**Unit 1: The CMOS Inverter (9 Hrs)** The MOS (FET) Transistor, Introduction, The Static CMOS Inverter- An Intuitive Perspective, Evaluating the Robustness of the CMOS Inverter, The Static Behavior Performance of CMOS Inverter, The Dynamic Behavior, Power, Energy, and Energy-Delay, Technology Scaling, and its Impact on the Inverter Metrics. **Unit 2: Designing Combinational Logic Gates In CMOS (9 Hrs)** Introduction, Static CMOS Design, Dynamic CMOS Design, How to Choose a Logic Style **Unit 3: Designing Sequential Logic Circuits (9 Hrs)** Introduction, Static Latches and Registers, Dynamic Latches and Registers. **Unit 4: Designing Arithmetic Building Blocks (10 Hrs)** Introduction, Datapaths in Digital Processor Architectures, the Adder, the Multiplier, the Shifter, Other Arithmetic Operators **Unit 5: Designing Memory and Array Structures (10 Hrs)** Introduction, the Memory Core, Read-Only Memories, Non-volatile Read-Write Memories, Read-Write Memories (RAM), Contents-Addressable or Associative Memory (CAM), Memory Peripheral Circuitry					

Text books and Reference books	**Textbooks**: 1. Digital Integrated Circuits – A Design Perspective, Jan M. Rabaey, Anantha Chandrakasan, Borivoje Nikolic, 2nd Edition, PHI. **References**: 1. CMOS VLSI Design: A Circuits and Systems Perspective, Neil H. E. Weste, David Money Harris, 4th Edition, Addison- Wesley,2011 2. Digital Integrated Circuit Design – Ken Martin, Oxford University Press, 2011. 3. CMOS Digital Integrated Circuits Analysis and Design – Sung-Mo Kang, Yusuf Leblebici, TMH, 3rd Ed., 2011. 4. Introduction to VLSI Systems: A Logic, Circuit and System Perspective – Ming-BO Lin, CRC Press, 2011
E-resources and other digital material	1. https://www.iitg.ac.in/cseweb/vlab/vlsi/CMOS_theory.html 2. https://sudip.ece.ubc.ca/cadence-virtuoso-schematic-simulations/ 3. https://ocw.mit.edu/courses/6-004-computation-structures-spring-2017/pages/c3/c3s1/ 4. https://sps.ewi.tudelft.nl/~nick/courses/gs/slides/02_inverter.pdf 5. https://archive.nptel.ac.in/courses/108/107/108107129/ 6. http://ee.iitm.ac.in/vlsi/courses/ee5311_2020 7. https://github.com/muhammadaldacher/Layout-Design-of-an-8x8-SRAM-array

24ECVE502: DESIGN AND VERIFICATION THROUGH SYSTEM VERILOG

Course Category:	Programme Core -II	Credits:	3
Course Type:	Theory	Lecture - Tutorial -Practice:	3-0-0
Prerequisites:	Digital Logic Design	Continuous Evaluation: Semester end Evaluation: Total Marks:	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:					
	CO1	Understand the concepts of verification methodologies and data types. [K3].				
	CO2	Summarize the concepts of procedural statements, routines and assertions [K4].				
	CO3	Analyze the concepts of functional coverage. [K5].				
	CO4	Analyze the basic concepts OOP. [K5].				
	CO5	Gain expertise in SystemVerilog testbench development and the use of assertions for robust hardware verification. [K3].				
Contribution of Course Outcomes towards achievement of Program Outcomes **(1 – Low, 2 - Medium, 3 – High)**		PO1	PO2	PO3	PO4	PO5
	CO1	3		3		1
	CO2	2		3		1
	CO3	3		3		1
	CO4	3		3		1
	CO5	3		3		1
Course Content	**Unit 1: Verification Guidelines (9 Hrs)** Verification process, Basic Testbench functionality, Directed Testing, Methodology Basics, Constrained Random Stimulus, Functional coverage, Testbench components, Layered Testbench, Building layered Testbench, Simulation Environment phases. **Unit 2: Data Types (9 Hrs)** Built in data types, Fixed sized arrays, Dynamic arrays, Queues, Associative Arrays, Linked lists, Array methods, Choosing a storage data type, Creating new types with typedef, Creating user defined structures, Packages, Type Conversion, Enumerated types, Defining Enumerated Values, Routines for Enumerated Types, Converting to and from Enumerated Types, Constant, strings, Expression width **Unit 3: Procedural statements and routines (9 Hrs)**					

	Procedural Statements Tasks, Functions, Routine Arguments, Returning from a Routine, Local Data Storage, Time Values **Unit 4: Basic OOP and its control (9 Hrs)** Basic OOP: Introduction, Thinking of Nouns, Not Verbs, Your First Class, Where to Define a Class, OOP Terminology, Creating New Objects, Object Deallocation Using Objects, Static Variable vs. Global Variable, Class Methods, Defining Methods Outside of the Class, Scoping Rules, Using One Class Inside Another, Understanding Dynamic Objects, Public vs. Local, Straying Off-Course: Building a Testbench **Unit 5: Connecting the Testbench and Design, System Verilog Assertions** Separating the testbench and design, Interface constructs, Stimulus timing, Interface driving and sampling, connecting it all together, Top-level scope program – Module interactions, SystemVerilog Assertions: Immediate Assertions, Customizing Assertion Actions, Concurrent Assertions, Exploring Assertions. **(9 Hrs)**
Text books and Reference books	**Textbooks:** 1. "SystemVerilog for Verification: A Guide to Learning the Testbench Language Features" by Chris Spear and Greg Tumbush (3rd Edition, 2012) **References:** 1. "SystemVerilog Assertions and Functional Coverage: Guide to Language, Methodology and Applications" by Ashok B. Mehta (2nd Edition, 2016) 2. "SystemVerilog for Design" by Stuart Sutherland, Simon Davidmann, and Peter Flake (2nd Edition, 2006) 3. "The SystemVerilog Primer: An Introduction to SystemVerilog for Hardware Design and Verification" by J. Bhasker (4th Edition, 2019) "Advanced Digital Design with the Verilog HDL" by Michael D. Ciletti (2nd Edition, 2010)
E-resources and other digital material	1. https://youtu.be/_5PJMHmSfgc?si=Cc0ice970woPw6pB 2. https://verificationguide.com/systemverilog-examples/systemverilog-testbench-example-with-scb/ 3. https://www.youtube.com/watch?v=5LUQxIDRsRI 4. https://www.doulos.com/knowhow/systemverilog/systemverilog-tutorials/ 5. https://www.systemverilog.in/ 6. https://www.chipverify.com/tutorials/systemverilog

24ECVE503: ARM CONTROLLERS FOR EMBEDDED SYSTEMS

Course Category:	Program Core-III	Credits:	3
Course Type:	Theory	Lecture - Tutorial -Practice:	3-0-0
Prerequisites:	-	Continuous Evaluation: Semester end Evaluation: Total Marks:	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:					
	CO1	Describe the ARM processor architecture and explain its design philosophy, including key components such as registers, CPSR, and pipeline structures. [K2].				
	CO2	Apply ARM and Thumb instruction sets to write assembly language programs,.[K3]				
	CO3	Create optimized C programs and ARM assembly code by employing efficient programming techniques.[K6]				
	CO4	Analyze and implement exception and interrupt handling mechanisms in ARM systems.[K4]				
	CO5	Evaluate the role of memory protection units (MPUs) and memory management units (MMUs) in embedded systems. [K5]				
Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)		PO1	PO2	PO3	PO4	PO5
	CO1			2		
	CO2			2		
	CO3				2	
	CO4					1
	CO5					2
Course Content	**UNIT I: ARM Processor Fundamentals (8 Hrs)** **ARM Processor Fundamentals:** ARM Design Philosophy, Registers and CPSR (Current Program Status Register), Pipeline Structure, Exceptions, Interrupts, and Vector Table, Core Extensions **Unit 2: Instruction Set (8 Hrs)** **Introduction to the ARM Instruction Set:** Data Processing Instructions, Branch Instructions, Load-Store Instructions, Software Interrupt Instruction, PSR (Program Status Register) Instructions **Introduction to the Thumb Instruction Set:** Thumb Register Usage, Branch Instructions, Data Processing Instructions, Load-Store Instructions, Stack Instructions, Software Interrupt Instruction **Unit 3: Efficient C Programming and ARM Assembly Code Optimization (10 Hrs)**					

	Efficient C Programming: Basic C Data Types, C Looping Structures, Register Allocation, Function Calls, Structure Arrangement **Writing and Optimizing ARM Assembly Code:** Writing Assembly Code, Profiling and Cycle Counting, Instruction Scheduling, Register Allocation, Conditional Execution, Looping Constructs **Unit 4: Exception and Interrupt Handling, Cache Memory (9 Hrs)** **Exception and Interrupt Handling:** Exception Handling, Interrupts, Interrupt Handling Schemes **Cache Memory:** The Memory Hierarchy and Cache Memory, Cache, architecture, Cache Policy, Flushing and Cleaning Cache Memory **Unit 5: Memory Protection and Management Units (10 Hrs)** **Memory Protection Units (MPUs):** Protected Regions, Initializing the MPU, Caches and Write Buffer **Memory Management Units (MMUs):** Transitioning from an MPU to an MMU, Virtual Memory Concepts, ARM MMU Details, Page Tables, Translation Lookaside Buffer (TLB), Domains and Memory Access Permissions, The Fast Context Switch Extension (FCSE)
Text books and Reference books	**Textbooks:** 1. A.Sloss, D.Symes, C.Wright, "ARM system Developers Guide: Designing and Optimizing System Software", Morgan Kaufmann publishers, 2012 **References:** 1. Steve Furber, "ARM System on Chip Architecture", 2nd ed., Addison Wesley Professional,2000. 2. Valvano, J,"Embedded microcomputer systems: real time interfacing", 3rd Edition, Cengage Learning, 2011. 3. Frank Vahid, TonyGivargis, "Embedded System Design", J Wiley India,2005.
E-resources and other digital material	1. https://community.arm.com/arm-community-blogs/b/architectures-and-processors-blog/posts/getting-started-with-arm-microcontroller-resources 2. https://www.geeksforgeeks.org/arm-processor-and-its-features/ 3. https://developer.arm.com/documentation/102374/latest/Instruction-sets-in-the-Arm-architecture 4. https://www.intel.com/programmable/technical-pdfs/654202.pdf 5. https://www.intel.com/content/dam/www/programmable/us/en/pdfs/literature/third-party/archives/ddi0100e_arm_arm.pdf 6. https://www.embedded.com/reliable-programming-in-arm-assembly-language/ 7. https://developer.arm.com/documentation/dui0056/d/handling-processor-exceptions

24ECVE504A: DEVICE MODELING

Course Category:	Program Elective -I	Credits:	3
Course Type:	Theory	Lecture - Tutorial -Practice:	3-0-0
Prerequisites:	Basic electronics and electrical circuits and devices , electronics properties of semiconductor materials, fundamental law and concepts of electrostatics physics	Continuous Evaluation: Semester end Evaluation: Total Marks:	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:					
	CO1	Understand MOS capacitor working principles, modes of operations, electrostatics of MOS, and leakage in it.[K2]				
	CO2	Analyze the physics the current-voltage characteristics of MOSFET, reliability issues, and advanced MOSFETs.[K4]				
	CO3	Understand the principles of Silicon on Insulator MOSFET, analyse intrinsic MOSFET capacitances and resistances, and evaluate FDSOI MOS and its sub-threshold slope.[K2]				
	CO4	Understand the theory of Ballistic nano transistors, evaluate the modeling of Ballistic planer and nanowire-FET, and analyze advanced MOSFETs such as Strain Engineered Channel materials, Electrostatics of double gate, and Fin-FET device.[K2]				
	CO5	Apply the advanced semiconductor devices for different optoelectronics application.[K3]				
Contribution of Course Outcomes towards achievement of Program Outcomes **(1 – Low, 2 - Medium, 3 – High)**		PO1	PO2	PO3	PO4	PO5
	CO1	2		2		2
	CO2	2		2		2
	CO3	1		2		2
	CO4	3		2		2
	CO5	3		2		2
Course Content	**Unit 1: MOS Transistor Basics** **(9 Hrs)** Electrons and holes in silicon, Energy band diagram of PN Diode, Types of MOSFET, MOSFET Mode of Operations, CV characteristics of MOS capacitor, Low frequency and high frequency capacitor-voltage characteristics, Non-idealities in MOS, Oxide fixed charges, interfacial					

	charges, Poly-Silicon contact, and poly silicon properties, Electrostatics of non-uniform substrate doping, carrier transport in insulating films, ultrathin gate-oxide. **Unit 2: MOSFET (9 Hrs)** Drift-Diffusion Approach for current-voltage analysis, Gradual Channel Approximation, channel conductance, trans conductance, MOSFET equivalent circuit ,Sub-threshold current and slope, Body effect, mobility behavior, temperature behaviors MOSFET two dimensional effects, Buried channels, effect of ion implantation on threshold voltage, High field effects and MOSFET reliability issues **Unit 3: SOI (Silicon on Insulator) (9 Hrs)** Leakage mechanisms in thin gate oxide, High-K-Metal Gate MOSFET devices and technology issues, Intrinsic MOSFET capacitances and resistances, SOI, FDSOI and PDSOI, VT definitions, Back gate coupling and body effect parameter, I-V characteristics of FDSOI-FET, FDSOI-sub-threshold slope, Floating body effect, SOI materials: sapphire, zirconia, spinel, and calcium fluoride. **Unit 4: Advanced Nano-Transistors (9 Hrs)** Modern bipolar transistor structures, Quasi Ballistic & Ballistic Transports, Theory of ballistic nano transistors, Ballistic planer and nanowire-FET modeling, Semi-classical and quantum treatments Advanced MOSFETs , Electrostatics of double gate, and Fin-FET device high-k/metal gate Fin-FET **Unit 5: Device Application (9 Hrs)** Introduction, Photoconductor, Photodiodes, Phototransistor, Metal-Semiconductor-Metal Photodetector, Quantum-Well Infrared Photodetector
Text books and Reference books	**Textbooks:** 1. S.M. Sze & Kwok K. Ng, Physics of Semiconductor Devices, Wiley 2. B. G. Streetman, S. K. Banerjee, Solid State Electronic Devices, Pearson, (2016) 3. Jean-Pierre Colinge Silicon-on-Insulator Technology: Materials to VLSI, Springer Science Business Media, LLC **References:** 1. N. Arora, MOSFET modeling for VLSI Simulation: Theory and Practice, World. 2. Mark S. Lundstrom and Jing Guo Nanoscale Transistors Device Physics, Modeling and Simulation, Springer. 3. Yannis Tsividis, Operation and Modeling of the MOS Transistor, Oxford University Press.
E-resources and other digital material	1. https://web.mit.edu/6.012/www/SP07-L8.pdf 2. https://www.chu.berkeley.edu/wp-content/uploads/2020/01/Chenming-Hu_ch6-1.pdf 3. https://www.researchgate.net/publication/263889224_SILICON_ON_INSULATOR_TECHNOLOGY_REVIEW 4. https://www.slideshare.net/slideshow/simulation-modelling-31263694/31263694 5. https://nanohub.org/resources/35870/download/Fundamentals_of_Nanotransistors.pdf 6. https://www.rp-photonics.com/metal_semiconductor_metal_photodetectors.html

24ECVE504B: IC FABRICATION TECHNOLOGY

Course Category:	Program Elective -I	Credits:	3
Course Type:	Theory	Lecture - Tutorial -Practice:	3-0-0
Prerequisites:	VLSI Design	Continuous Evaluation: Semester end Evaluation: Total Marks:	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:	
	CO1	Discuss the fundamentals involved in the VLSI fabrication process [K2].
	CO2	Analyse different lithography methods, Oxidation and etching process [K4].
	CO3	Explain the film deposition and diffusion mechanisms [K2].
	CO4	Understand the ion implantation and metallization process [K2].
	CO5	Impart knowledge about metallization and back end processing technology [K2].

Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)		PO1	PO2	PO3	PO4	PO5
	CO1	3	2	2	1	2
	CO2	3	3	2	1	2
	CO3	3	2	2	1	1
	CO4	3	2	1	1	1
	CO5	3	3	1	2	1

Course Content

Unit 1: Introduction to IC Technology (8 Hrs)

Basics of wafer preparation and crystal growth, Electronic grade silicon, Czochralski crystal growing process, Introduction of epitaxy, Vapor phase epitaxy, Molecular beam epitaxy , Silicon-on-insulators ,Epitaxial evaluation

Unit 2: Oxidation, Lithography and Etching (10 Hrs)

Introduction of oxidation process, First order planar growth mechanism and kinetics, Effect of pressure and crystal orientation on growth kinetics, 2D oxide growth kinetics , Poly-silicon oxidation, silicide and silicon nitride oxidation, Advanced defect models related to oxidation induced defects, Introduction of lithography and properties of photoresists, Optical lithography, Electron lithography, XRay lithography, Ion lithography, Fundamentals of plasma etching, Plasma properties, Feature size control and anisotropic etch mechanisms, Reactive plasma etching techniques

Unit 3: Thin Film Deposition (9 Hrs)

	Basics of different Chemical and Physical vapour deposition techniques, Film deposition methods for Polysilicon, Silicon dioxide, Silicon Nitride, Metal depositions. **Unit 4: Diffusion and Ion Implantation (9 Hrs)** Introduction of diffusion, Models of diffusion in solids, in damage annealing, in polycrystalline silicon, and in SiO2, Ion Implantation: Introduction, Range theory, Implantation equipment, Annealing, Shallow junctions, High-energy implantation, Limitation and future scope of ion implantation. **Unit 5: Metallization and Back End Processing (9 Hrs)** Metallization: Introduction, Metallization choices, Physical vapor deposition, Patterning, Back-end-process: Introduction, Contacts, Interconnects and Vias, Source, Drain and Gate Contacts.
Text books and Reference books	**Textbooks:** 1. S.M.Sze, "VLSI Technology (2nd edition), McGraw Hill, 2003. 2. W. Wolf, "Modern VLSI Design", (3rd edition), Pearson,2002. **References:** 1. Plummer (2001), "Silicon VLSI Technology: Fundamentals, Practice, and Modeling", Pearson Education India. 2. C.Y. Chang and S.M.Sze (Ed), (1996), "ULSI Technology", McGraw Hill Companies Inc. 3. Stephen Campbell (2012), "The Science and Engineering of Microelectronics", Oxford University Press.
E-resources and other digital material	1. Lecture Series on VLSI Design by Dr.Nandita Dasgupta, Department of Electrical Engineering, IIT Madras. http://nptel.ac.in 2. https://archive.nptel.ac.in/courses/113/106/113106062/ 3. https://www.youtube.com/watch?v=Hp4xFkEZUos&list=PL5060CE8F13023479

24ECVE504C: VLSI SIGNAL PROCESSING

Course Category:	Program Elective -I	Credits:	3
Course Type:	Theory	Lecture - Tutorial -Practice:	3-0-0
Prerequisites:	DSP,VLSI	Continuous Evaluation: Semester end Evaluation: Total Marks:	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:					
	CO1	Apply pipelining and parallel processing techniques to the design of FIR digital filters and low-power systems. [K3]				
	CO2	Solve systems of inequalities related to retiming and apply retiming techniques to optimize digital systems [K3].				
	CO3	Apply folding transformations and register minimization techniques in digital system design, particularly in multirate systems [K3].				
	CO4	Develop and design systolic architectures for FIR filters and matrix multiplication, effectively selecting scheduling vectors and handling space representations with delays [K6].				
	CO5	Implement and design fast convolution algorithms, understand the principles behind Cook-Toom, Winograd, and other iterative cyclic convolution methods to create efficient convolution systems [K3].				
Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)		PO1	PO2	PO3	PO4	PO5
	CO1	2	2	2		
	CO2	2	2	2		
	CO3	3	2	3	2	
	CO4	3	2	2	2	
	CO5	3	2	2	2	
Course Content	**Unit 1: Pipelining and Parallel Processing** **(9 Hrs)** Introduction, Pipelining of FIR, Digital Filters, Parallel processing, Pipelining and Parallel Processing for low power **Unit 2: Retiming** **(9 Hrs)** Introduction, Definition and Properties, Solving System of Inequalities, Retiming Techniques **Unit 3: Unfolding & Folding** **(9 Hrs)** Introduction to Algorithms for Unfolding, Properties of Unfolding, Critical Path, Unfolding and Retiming Application of Unfolding, Introduction to Folding Transformation, Register Minimization Techniques, Register					

	Minimization Technique in Folded Architectures, Folding in Multirate Systems **Unit 4: Systolic Architecture Design (9 Hrs)** Introduction, Systolic Array design Methodology, FIR Systolic Arrays, Selection of scheduling Vector, Matrix Multiplication, 2D Systolic Array Design, Systolic Design for Space Representations containing delays **Unit 5: Fast Convolution (9 Hrs)** Introduction, Cook-Toom Algorithm, Winogard Algorithm, Iterated Convolution, Cyclic Convolution, Design of fast convolution
Text books and Reference books	**Textbooks:** 1. Keshab K. Parhi,"VLSI Digital Signal Processing Systems", Wiley-InterSciences, 1999 **References:** 1. Kung. S.Y., H.J. While house T.Kailath, VLSI and Modern singalprocessing, Prentice Hall, 1985 2. Jose E. France, Yannis Tsividls, Design of Analog Digital VLSI Circuitsfor Telecommunications and Signal Processing' Prentice Hall, 1994.Ramesh, S. (2013). *Engineering chemistry* (2nd ed.). Wiley India.
E-resources and other digital material	1. https://www.win.tue.nl/~wsinmak/Education/2IN35/Parhi/chap3.pdf 2. http://twins.ee.nctu.edu.tw/courses/vsp_12/lecture/VSP-lec01-pipelining%20&%20retiming.pdf 3. https://www.oreilly.com/library/view/vlsi-digital-signal/9780471241867/sec-4.4.html#:~:text=Cutset%20retiming%20only%20affects%20the,4.4(a). 4. http://www.ece.umn.edu/users/parhi/SLIDES/chap4.pdf 5. https://www.eecs.harvard.edu/htk/static/files/1978-cmu-cs-report-kung-leiserson.pdf 6. https://dsp-book.narod.ru/DSPMW/08.PDF

24ECVE504D: MEMS

Course Category:	Program Elective -I	Credits:	3
Course Type:	Theory	Lecture - Tutorial -Practice:	3-0-0
Prerequisites:	Analog Electronics, Linear Integrated Circuit Applications	Continuous Evaluation: Semester end Evaluation: Total Marks:	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:					
	CO1	Understand the basics of MEMS technology and micro actuation methods [K2].				
	CO2	Comprehend and analyze microsystem design mechanics, scaling laws, and packaging technologies [K4].				
	CO3	Analyze the techniques involved in designing and packaging microsystems [K4].				
	CO4	Examine different steps involved in MEMS fabrication, materials selection, and micromachining techniques. [K3]				
	CO5	Understand MEMS switch concepts and their design principles for practical applications. [K4]				
Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)		PO1	PO2	PO3	PO4	PO5
	CO1	2		1		2
	CO2	2		3		2
	CO3	3		2		2
	CO4	1		2		2
	CO5	3		3		2
Course Content	**Unit 1: Introduction to MEMS (9 Hrs)** Introduction to MEMS and Microsystems, Evolution of Microfabrication, Miniaturization, Advantages of MEMS, Working principles of acoustic wave, biomedical, pressure, thermal sensors, Micro actuation: Basics of actuation, thermal forces, shape memory alloys, piezoelectric crystals, electrostatic forces, Micro grippers, micro motors, micro pumps, Bending movement and strain, concept of micro cantilever **Unit 2: Mechanics for Microsystems Design and Scaling Laws (9 Hrs)** Static bending of thin plates, Mechanical vibrations, Thermo mechanics, Fracture Mechanics, Thin film mechanics, Finite element stress analysis, Scaling laws in miniaturization: scaling in geometry, rigid body dynamics,					

	electrostatic forces, electromagnetic forces, Scaling in fluid mechanics, Scaling in heat transfer **Unit 3: Microsystems Design and Packaging (8 Hrs)** Microsystem Design: Introduction, Design considerations, Process design, Mechanical design, Microsystems packaging, Essential packaging technologies, Fluid flow in nanoscale **Unit 4: MEMS Fabrication Process (10 Hrs)** Materials for MEMS and Microsystems, Fabrication techniques: Wafer selection, Photolithography, Ion implantation, Diffusion, Oxidation, Wet and Dry etching, CVD, PVD, RIE, Film deposition, Epitaxy Micromachining: Bulk micromachining, Surface micromachining, Comparison of Bulk and Surface micromachinings, LIGA and UE-LIGA processes, Lift-off techniques, Mechanical design **Unit 5: MEMS Switches and Applications (9 Hrs)** Fabrication of MEMS switches: capacitive switch, DC contact series switch , Integration and biasing issues of MEMS switches, Design of CPW MEMS Shunt Capacitive Switches, Single-Pole Multiple-Throw Switches, Double-Pole Double-Throw switches, Inductive Matching of Shunt Capacitive Switches, Inductively Resonant High-Isolation X-Band Capacitive Shunt Switches, Switch parameters- Basics of switching, Mechanical RF switches, Electronic switches for RF and microwave applications
Text books and Reference books	**Textbooks:** 1. Tai-Ran Hsu, "MEMS and Microsystems: Design and Manufacture," Tata McGraw Hill, 2002. 2. Gabriel M. Rebeiz, "RF MEMS Theory, Design, and Technology," Wiley India Pvt Ltd. 3. Marc J. Madou, "Fundamentals of Microfabrication," CRC Press, 2nd edition, 2002. **References:** 1. Stephen D. Senturia, "Microsystem Design," Springer International Edition, 2010. 2. Maluf, M., "An Introduction to Microelectromechanical Systems Engineering," Artech House, Boston, 2000. 3. Mohamed Gad-el-Hak, "The MEMS Handbook," CRC Press, 2002. 4. Chang Liu, "Foundations of MEMS," 2nd Edition, Pearson Publication.
E-resources and other digital material	1. https://nptel.ac.in/courses/117105082/4 2. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6- 777j-design-and-fabrication-of-microelectromechanical-devices-spring- 2007/lecture-notes/ 3. https://www.edx.org/course/micro-nanofabrication-mems-epflx-memsx-0

24ECVE505A: EMBEDDED SYSTEM DESIGN AND ARCHITECTURE

Course Category:	Program Elective -II	Credits:	3
Course Type:	Theory	Lecture - Tutorial -Practice:	3-0-0
Prerequisites:	Computer Architecture	Continuous Evaluation: Semester end Evaluation: Total Marks:	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:					
	CO1	Know the embedded systems models, standards, block diagrams, and the von Neumann model. [K3].				
	CO2	Understand and implement various ISA architecture models and instruction-level parallelism techniques to optimize processor performance in embedded systems [K2].				
	CO3	Understand the processor hardware, and techniques for assessing and optimizing processor performance. [K2].				
	CO4	Know the hardware components in embedded systems, with practical insights through examples like the PCI bus [K3].				
	CO5	Realize the concepts and practical applications of software in embedded systems with a particular focus on utilizing Java as a programming language in embedded systems development. [K3].				
Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)		PO1	PO2	PO3	PO4	PO5
	CO1	3		2		1
	CO2	2		1		1
	CO3	3	1	2	2	2
	CO4	3	2	2	1	2
	CO5				2	3
Course Content	**Unit 1: Introduction To Embedded Systems (9 Hrs)** Embedded system model, Embedded standards, Block diagrams, Powering the hardware, Embedded board using von Neuman model. **Unit 2: Introduction To Embedded Processors (9 Hrs)** ISA architecture models, Application specific ISA models, General purpose ISA models, Instruction level parallelism **Unit 3: Processor Hardware (9 Hrs)** Internal processor design: ALU , Registers, Control unit, Clock , On chip memory, Processor I/O , Interrupts ,Processor buses, Processor performance **Unit 4: Support Hardware (9 Hrs)**					

	Board memory: ROM , RAM , Cache, Auxiliary memory, Memory management ,Memory performance, Board buses: arbitration and timing, PCI bus example, Integrating bus with Components , Bus performance **Unit 5: Software (9 Hrs)** Middleware And Applications: PPP, IP Middleware, UDP, Java. Application Layer: FTP Client, SMTP, HTTP, Server And Client.
Text books and Reference books	**Textbooks:** 1. Tammy Noergard, "Embedded system architecture", Elsevier, 2022. **References:** 1. Embedded System Design - Frank Vahid, Tony Givargis, John Wiley, 2021. 2. An Embedded Software Primer - David E. Simon, Pearson Education, 2020. 3. The Art of Designing Embedded Systems, Jack Ganssle, Newnes, 2019.
E-resources and other digital material	1. http://nptel.ac.in/courses/108102045/ 2. https://www.coursera.org/learn/embedded-software-hardware 3. https://www.udemy.com/course/introduction-to-embedded-systems-arduino/?couponCode=LETSLEARNNOWPP 4. https://www.coursera.org/learn/real-time-embedded-systems-concepts-practices 5. https://www.coursera.org/learn/m2m-iot-interface-design-embedded-systems 6. https://www.udemy.com/course/embedded-systems-bare-metal-programming/?couponCode=LETSLEARNNOWPP

24ECVE505B: EMBEDDED C PROGRAMMING& PERIPHERAL INTERFACING

Course Category:	Program Elective -II	Credits:	3
Course Type:	Theory	Lecture - Tutorial -Practice:	3-0-0
Prerequisites:	Programming in C, Digital Electronics, Microprocessors and Microcontrollers.	Continuous Evaluation: Semester end Evaluation: Total Marks:	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:					
	CO1	Understand and analyze the design aspects, Architecture, and instruction set associated with ARM processors [K2]				
	CO2	Analyze the GPIO Pins, Interrupt handling, and Timers concepts in task execution [K4]				
	CO3	Apply the concepts of UART, ADC, and DAC to Peripherals [K3]				
	CO4	Design and implementation of embedded system serial protocols [K3]				
	CO5	Understand and implement fixed-point and floating-point DSP and apply skills in practical applications such as smart home systems [K6]				
Contribution of Course Outcomes towards achievement of Program Outcomes **(1 – Low, 2 - Medium, 3 – High)**		PO1	PO2	PO3	PO4	PO5
	CO1			1	3	2
	CO2	2		2	3	3
	CO3	3		3	3	3
	CO4	3		3	3	3
	CO5	3		3	3	3
Course Content	**Unit 1: Embedded System Introduction & ARM Instruction set Architecture (9 Hrs)** Definition of Embedded Systems, Real life examples of embedded systems, Basics of Developing for Embedded Systems, ARM Cortex-M Organization, Arithmetic, Logical and Shift instructions, Data Movement Instructions, Branch instructions and Program Status register, Bitwise logic operations, Sign and Zero extension, Data Comparison, Memory addressing, Branch and conditional execution, Control structures, Subroutines, 64-bit data processing. **Unit 2: Interrupts & GPIO's (9 Hrs)** Introduction to Interrupts, Interrupt Service Routines, Interrupt Vector Table, Interrupt Stacking and Unstacking, Nested Vectored Interrupt Controller (NVIC), Interrupt Priority, GPIO Input Modes, GPIO Output Modes,					

	Memory-mapped I/O, Push button, Programming exercises on GPIO and Push-button, Clock Configuration, Timer Organization, and Counting Modes Timer Update Events, PWM Registers, Configuration and initialization of PWM block, Programming exercises on the selection of clock source, Timer's concept, and PWM **Unit 3: UART, ADC/DAC & Interfacing (9 Hrs)** UART Block, UART Registers, UART baud rate calculation, Configuration and initialization of UART, ADC & DAC registers, pin configuration, ADC modes, Configuring ADC and DAC module, Programming exercises on ADC and DAC, DC motor, Keypad, LCD, and Seven segment display interfacing with ARM Cortex-M3 Microcontroller. **Unit 4: I^2C and SPI (8 Hrs)** I^2C operating modes, Configuration of I^2C, Interface a sensor using I^2C protocol, SPI Modes, Master operation, Slave operation, Configuration of SPI **Unit 5: Digital Signal Processing & Case Study (11 Hrs)** Fixed-point and Floating-point DSP, Fixed-point Data Types in DSP Arithmetic Instructions: Parallel 8-bit Add and Subtract, Parallel 16-bit Add and Subtract & 32-bit Add and Subtract, Add and Subtract Halfwords with Exchange, 16-bit and 32-bit Multiplication Case Study: Smart Home-Smart Door Locks and Interface a temperature sensor with an I^2C Module to measure the room temperature
Text books and Reference books	**Textbooks:** 1. Dr. Yifeng Zhu "Embedded Systems with ARM Cortex-M Microcontrollers in Assembly and C" Third edition, 2018 **References:** 1. Ariel Lutenberg, Pablo Gomez, Eric Pernia "A Beginner's Guide to Designing Embedded System Applications on Arm Cortex-M Microcontrollers" 2. Qing Li, Caroline Yao "Real-time concepts for Embedded Systems" CMP books.
E-resources and other digital material	a. www.digi.com/blog/post/examples-of-embedded-systems b. Embeddedinventor.com/embedded-timers-their-types-and-applications/ c. Tutorialspoint.com/embedded_systems/es_interrupts.html d. https://www.digikey.in/en/blog/adc-dac-tutorial-blog e. https://exploreembedded.com/wiki/LPC1768:_ADC_Programming f. https://www.keil.com/dd/docs/datashts/philips/lpc17xx_um.pdf g. https://www.nxp.com/docs/en/datasheet/LPC1769_68_67_66_65_64_63.pdf h. https://www.mdpi.com/2079-9292/12/20/4236 i. https://www.wiley.com/en-us/Arithmetic+Circuits+for+DSP+Applications-p-9781119206798

24ECVE505C: ELECTRONICS DESIGN: SENSOR AND ACTUATORS

Course Category:	Program Elective -II	Credits:	3
Course Type:	Theory	Lecture - Tutorial -Practice:	3-0-0
Prerequisites:	Basic knowledge of electronics, Understanding of fundamental physics	Continuous Evaluation: Semester end Evaluation: Total Marks:	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:					
	CO1	Understand the working principles of different sensors. [K2].				
	CO2	Analyze the working of different optical, pressure and humidity sensors and actuators. [K4].				
	CO3	Assess the challenges while Interfacing different sensors for diverse applications. [K5].				
	CO4	Understand the working principles of different smart sensors and their applications. [K2].				
	CO5	Understand the fabrication and working of MEMS. [K2].				
Contribution of Course Outcomes towards achievement of Program Outcomes **(1 – Low, 2 - Medium, 3 – High)**		PO1	PO2	PO3	PO4	PO5
	CO1	2				
	CO2	2				
	CO3	2				
	CO4	2		1		
	CO5	2		2		
Course Content	**Unit 1: Sensors (10 Hrs)** Sensor Fundamentals: Basic Sensor Technology, Sensor Systems, Application Considerations: Sensor Characteristics ,System Characteristics ,Instrument Selection ,Data Acquisition and Readout Installation, Capacitive sensor, Inductive sensors, Selecting and Specifying Capacitive and Inductive Sensors, Contact and Non-contact Position Sensors, String Potentiometer and String Encoder Engineering Guide, Linear and Rotary Position and Motion Sensors **Unit 2: Actuators, Optical, Pressure and Humidity Sensors (10 Hrs)** Stepper Motors, Voice-Coil actuators, Fluid actuators Optical and Radiation Sensors: Photosensors, Thermal Infrared Detectors Pressure Sensors: Piezoresistive Pressure Sensing, Piezoelectric Pressure Sensors Humidity Sensors: Sensor Types and Technologies, Selecting and Specifying Humidity Sensors, Applicable Standards and Interfacing and Design Information.					

	Unit 3: Interfacing Sensors and Actuators (9 Hrs) General Requirements for Interfacing Sensors and Actuators, Signal Level, Impedance, Response and Frequency, Input Signal Conditioning, Offset, Scaling, Isolation, Loading, Output Signals, Errors-Resolution Errors, Computation Errors, Sampling and Quantization Errors and Conversion Errors, Sensors and Actuator networks Applications-Environmental monitoring, health care, logistics, transportation, Network Organization, Energy, Communication **Unit 4: Smart Sensor Technologies (8 Hrs)** Smart Sensor basics, Micromachining: Bulk Micromachining, Wafer bonding, Silicon-on-Silicon Bonding, Silicon-on-Glass (Anodic) Bonding, Silicon Fusion Bonding, Wafer Bonding for More Complex Structures and Adding ICs, Combinations of Surface and Bulk Micromachining LIGA Process, Dry-Etching Processes Unit 5: MEMS (8 Hrs) Introduction, Micromachined Actuators, Microvalves, Micromotors, Micropumps, Microdynamometers, Microsteam Engines, Actuators in Other Semiconductor Materials, Other Micromachined Structures, Cooling Channels, Microoptics, Microgrippers, Microprobes, Micromirrors, Heating Elements, Thermionic Emitters, Field Emission Displays, Unfoldable Microelements, Micronozzles, Interconnects for Stacked Wafers
Text books and Reference books	**Textbooks:** 1. Sensor Technology hand book by Jon S. Wilson, Elsevier publications 2. Understanding Smart Sensors, Second Edition by Randy Frank. **References:** 1. Patranabis D, Sensors and Transducers, Tata McGraw Hill, Seventh Edition, 2003. 2. Ian R Sinclair, Sensors and Transducers, Newnes publishers, Third Edition, 2001. 3. Handbook of Modern Sensors Physics, Designs, and Applications , Jacob Fraden,Third Edition, Springer publications 4. Sensors, actuators, and their interfaces : A multidisciplinary introduction by Nathan Ida , SciTech Publishing, Edison, NJ, ©2014 5. Sensors and Actuators by Francisco Andre Correa Alegria, June 2021.
E-resources and other	1. https://www.celeramotion.com/inductive-sensors/support/technical-papers/inductive-and-capacitive-position-sensors/

digital material	2. https://www.machinedesign.com/automation-iiot/sensors/article/21831577/baumer-electric-types-of-proximity-sensors-from-inductive-to-ultrasonic 3. https://www.sciencedirect.com/topics/engineering/optical-sensors 4. https://ptolemy.berkeley.edu/projects/chess/eecs124/lectures/InterfaceToSensorsActuators.pdf 5. https://www.elprocus.com/smart-sensor/ 6. https://www.inseto.co.uk/wafer-bonding-methods/

24ECVE505D: INTERNET OF THINGS FOR REAL TIME SYSTEMS

Course Category:	Program Elective -II	Credits:	3
Course Type:	Theory	Lecture - Tutorial -Practice:	3-0-0
Prerequisites:	UG Embedded Systems	Continuous Evaluation: Semester end Evaluation: Total Marks:	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:					
	CO1	Identify and explain IoT protocols, enabling technologies, and communication models. [K2].				
	CO2	Design and implement IoT systems using a structured methodology [K3].				
	CO3	Develop programming skills in Python. [K3]				
	CO4	Develop IoT applications and projects using Raspberry Pi. [K3]				
	CO5	Analyze real-world case studies representing diverse IoT applications [K4].				
Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)		PO1	PO2	PO3	PO4	PO5
	CO1			2		
	CO2			2		
	CO3			2	2	
	CO4			2	3	
	CO5				3	3
Course Content	**Unit 1: Introduction to IoT** **(9 Hrs)** Introduction: Definition & Characteristics of IoT, Physical Design of loT, Things in loT, loT Protocols, Logical Design of IoT, loT Functional Blocks, loT Communication Models, loT Communication API's, loT Enabling Technologies, Wireless Sensor Networks, Cloud Computing, Big Data Analytics, Communication Protocols, Embedded Systems **Domain Specific IoTs**: Introduction, Home Automation, Cities, Environment, Energy, Retail, Logistics, Agriculture, Industry, Health & Lifestyle. **Unit 2: IoT and M2M** **(9 Hrs)** **IoT and M2M**- Introduction, M2M, Difference between IoT and M2M, SDN and NFV for IoT, Software Defined Networking, Network Function Virtualization. **LoT Platforms Design Methodology**- Introduction, loT Design Methodology, Case Study on loT System for Weather Monitoring **Unit 3: IoT Systems – Logic Design using Python.** **(9 Hrs)**					

	Introduction to Python, Python Data types & Data Structures, Control flow, functions, Modules, Packages, File Input/output, Date/Time Operations, Classes. **Unit 4: loT Physical Devices & Endpoints (9 Hrs)** loT Physical Devices & Endpoints - Basic building blocks of a loT Device, Exemplary Device: Raspberry PI, Raspberry PI Interfaces, serial, SPI, I2C, Programming Raspberry Pi with Python, Controlling LED with Raspberry Pi, Interfacing an LED and Switch with Raspberry Pi, Interfacing LDR with Raspberry Pi. **Unit 5: Case Studies illustrating IoT Design (9 Hrs)** Introduction, Home Automation, Smart lighting, home intrusion detection, Cities, smart parking, Environment, weather monitoring system, weather reporting bot, air pollution monitoring, forest fire detection, Agriculture, smart irrigation.
Text books and Reference books	**Textbooks:** 1. Arshdeep Bahga, Vijay Madisetti, Internet of Things A Hands-on Approach, Universities press (India) Pvt. Ltd, 2023. **References:** 1. Rajkumar Buyya, Amir Vahid Dastjerdi, and Syed Shahrestani, "Internet of Things: Principles and Paradigms", Morgan Kaufmann Publishers, 2016. 2. Maciej Kranz, "Building the Internet of Things: Implement New Business Models, Disrupt Competitors, Transform Your Industry", Jhon Wiley & Sons publishers, 2016. 3. Brian Russell and Drew Van Duren, "Practical Internet of Things Security", PACKT publishers, 2016.
E-resources and other digital material	a. https://www.i-scoop.eu/internet-of-things-guide/ b. https://www.postscapes.com/internet-of-things-protocols/ c. https://www.ibm.com/cloud/learn/internet-of-things d. https://www.link-labs.com/blog/iot-vs-m2m e. https://www.sdxcentral.com/sdn/definitions/what-the-definition-of-software-defined-networking-sdn/ f. https://www.networkworld.com/article/3238446/what-is-nfv-network-functions-virtualization-explained.html g. https://www.learnpython.org/en/Control_Flow h. https://realpython.com/python3-object-oriented-programming/ i. https://www.raspberrypi.org/documentation/usage/python/ j. https://www.smarthome.com.au/smarthome-case-studies k. https://www.smartcitiesworld.net/news/news/smart-city-case-studies-4449 l. https://www.hackster.io/projects/environmental-monitoring m. https://www.iotforall.com/smart-agriculture-iot

24MTUC501: RESEARCH METHODOLOGY AND IPR

Course Category:	Mandatory Learning Course	Credits:	0
Course Type:	Theory	Lecture - Tutorial -Practice:	2-0-0
Prerequisites:	-	Continuous Evaluation: Semester end Evaluation: Total Marks:	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:					
	CO1	Demonstrate proficiency in formulating research problems, applying scientific methods, and understanding the significance of research methodology in academic and professional settings. [K2]				
	CO2	Achieve proficiency in critically reviewing literature, enhancing research methodologies, and designing effective research studies that contribute to knowledge broadening and contextual understanding. [K2]				
	CO3	Gain proficiency in designing reliable sampling strategies, applying measurement scales, and executing data collection methods to minimize errors and enhance research validity.[K2]				
	CO4	Conduct hypothesis tests, interpret test statistics, and utilize data analysis methods to enhance research validity. [K2]				
	CO5	Interpret research results, write impactful reports, and apply knowledge of intellectual property rights to research practices. [K2]				
Contribution of Course Outcomes towards achievement of Program Outcomes **(1 – Low, 2 - Medium, 3 – High)**		PO1	PO2	PO3	PO4	PO5
	CO1	2				
	CO2					2
	CO3				2	
	CO4		1	2		
	CO5			2		
Course Content	**Unit 1: Research Methodology**: and **Research Problem (5 Hrs)** • Introduction to Research Methodology: Meaning, Objectives, Motivation, Approaches, Significance, and Scientific Methods. • Research Process: Steps, Criteria of Good Research, and Common Problems Encountered by Researchers in India.					

	• Defining the Research Problem: Selecting and Defining the Problem, Techniques, and Illustration. **Unit 2: Literature Review and Research Design (5 Hrs)** • Reviewing the Literature: Importance, Methodology Improvement, Knowledge Broadening, and Contextual Findings. • Research Design: Meaning, Need, Features of a Good Design, Concepts, Basic Principles, and Experimental Designs. **Unit 3: Sampling Design , Data Collection, ICT Tools and Techniques in Research: (5 Hrs)** • Design of Sampling: Introduction, Sample Design, Sampling and Non-sampling Errors, Sample vs. Census Survey. • Measurement and Scaling: Qualitative and Quantitative Data, Measurement Scales, Goodness, and Sources of Error. • Data Collection: Experimental and Surveys, Primary and Secondary Data Collection, Case Study Method. • Software for Reference Management (Zotero/ Mendeley), detecting Plagiarism, Research search Engines **Unit 4: Hypothesis Testing and Data Analysis(5 Hrs)** • Testing of Hypotheses: Concepts, Hypothesis Testing, Test Statistics, Critical Region, Value and Decision Rule, Procedure. • Data Analysis: Techniques and Tools for Analyzing Collected Data. **Unit 5: Interpretation, Report Writing, and Intellectual Property (5 Hrs)** • Interpretation and Report Writing: Meaning, techniques, precautions, and significance of report writing. • Intellectual Property: Concept, system in India, development of TRIPS complied regime, Patents Act, Trade Mark Act, Designs Act, Geographical Indications, Copyright Act, Trade Secrets, Utility Models, WTO, Paris Convention, National Treatment, Right of Priority, Common Rules, PCT, and TRIPS Agreement.
Text books and Reference books	**Textbooks:** 1. Research methodology: Methods and Techniques, C.R. Kothari, Gaurav Garg, New Age International, 4th Edition, 2018. 2. Research Methodology a step-by-step guide for beginners. Ranjit Kumar, SAGE Publications Ltd.,3rd Edition, 2011 3. Study Material, Professional Programme Intellectual Property Rights, Law and Practice, The Institute of Company Secretaries of India, Statutory Body under an Act of Parliament, September 2013. **References:** 1. An introduction to Research Methodology, Garg B.L et al ,RBSA Publishers 2002 2. An Introduction to Multivariate Statistical Analysis Anderson T.W, Wiley 3rd Edition, 3. Research Methodology, Sinha, S.C, Dhiman, EssEss Publications2002 4. Research Methods: the concise knowledge base ,Trochim ,Atomic Dog Publishing ,2005 5. How to Write and Publish a Scientific Paper, Day R.A, Cambridge University Press 1992

	6. Conducting Research Literature Reviews: From the Internet to Paper, Fink A, Sage Publications, 2009 7. Proposal Writing, Coley S.M. Scheinberg, C.A, Sage Publications, 1990 8. Intellectual Property Rights in the Global Economy, Keith Eugene Maskus, Institute for International Economics
E-resources and other digital material	1. https://www.techtarget.com/whatis/definition/scientific-method 2. https://www.geophysik.uni-muenchen.de/~valerian/Scientific_Working/SRMTunit2.pdf 3. https://hmhub.in/3rd-4th-sem-research-methodology-notes/criteria-of-good-research/ 4. https://researcher.life/blog/article/what-is-a-research-problem-types-and-examples/ 5. https://www.questionpro.com/blog/data-collection-methods/ 6. https://southcampus.uok.edu.in/Files/Link/DownloadLink/RM%20U2%20P2.pdf 7. https://www.studysmarter.co.uk/explanations/psychology/cognition/formulation-of-hypothesis 8. https://www.aimlaywriting.com/significance-of-research-report-writing/ 9. https://www.lexology.com/library/detail.aspx?g=7045cf52-4a2c-465f-980b-b5af034e2064 10. https://www.trade.gov/country-commercial-guides/india-protecting-intellectual-property

24ECVE581: DIGITAL SYSTEM DESIGN LAB

Course Category:	Laboratory-I	Credits:	1.5
Course Type:	Laboratory	Lecture - Tutorial -Practice:	0-0-3
Prerequisites:	Digital Logic Design	Continuous Evaluation: Semester end Evaluation: Total Marks:	60 40 100

Course outcomes	Upon successful completion of the course, the student will be able to:					
	CO1	Get acquainted with programmable logic design flow.				
	CO2	Implement designed digital circuits using FPGA.				
	CO3	Synthesize the designed circuits using CAD tools				
Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)		PO1	PO2	PO3	PO4	PO5
	CO1		**1**	**2**	**3**	**2**
	CO2	**2**	**1**		**3**	**2**
	CO3		**1**		**3**	**2**
Course Content	**List of Experiments** 1. Implement a System Verilog module for a 4-bit binary-to-BCD (Binary Coded Decimal) converter. 2. Write a 4-bit adder-subtractor module in System Verilog. 3. Write a System Verilog program to define a 4-bit shift register and implement left and right shifts. 4. Implement a finite state machine (FSM) in System Verilog that counts in a sequence: 0, 1, 2, 3, 0, 1, 2, 3, ... 5. Write a System Verilog program to implement a synchronous counter that counts from 0 to 15 and then resets. 6. Implement a System Verilog program to define a 3x3 matrix multiplier. 7. Write a System Verilog module to generate a PWM signal with variable duty cycle. 8. Design a synchronous FIFO memory module in System Verilog. 9. Test bench to Verify Full adder 10. Test bench to Verify D-Flip-flop 11. Test bench to Verify FIFO 12. Test bench to Verify Binary to Gray Converter					

24ECVE582: EMBEDDED SYSTEMS DESIGN LAB

Course Category:	Laboratory-II	Credits:	1.5
Course Type:	Laboratory	Lecture - Tutorial -Practice:	0-0-3
Prerequisites:	Computer Architecture	Continuous Evaluation: Semester end Evaluation: Total Marks:	60 40 100

Course outcomes	Upon successful completion of the course, the student will be able to:					
	CO1	Design and execute the different concepts for embedded system using ARM processor.				
Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)		PO1	PO2	PO3	PO4	PO5
	CO1				2	
Course Content	**Experiments using ARM Cortex-M Microcontroller (NUCLEO board - F429ZI):** Program to configure and control General Purpose Input / Output (GPIO) port pins. 1. Program to demonstrate Serial communication. Transmission from Kit and reception from PC using Serial Port on IDE environment use debug terminal to trace the program. 2. Program to demonstrate Time delay program using built in Timer / Counter feature on IDE environment. 3. Program to demonstrate a simple interrupt handler and setting up a timer. 4. Program to Displaying a message in a 2-line x 16 Characters LCD display and verify the result in debug terminal. 5. Program to demonstrate ADC interfacing. 6. Generation of PWM Signal with the objective of introducing the practical application of timers and fundamental principles of control theory. 7. To integrate a micro-SD card with the computing system for the purpose of storing event logs conveniently on the SD card. 8. To establish a connection between the two computing systems using Bluetooth Low Energy (BLE), with the objective of monitoring pertinent information from one system and facilitating gate control through the other system. 9. To enhance the smart home system by enabling it to host a web page through Wi-Fi connectivity, thereby allowing users to access information using a smartphone or PC. 10. Project					

24ECVE591: CAPSTONE PROJECT-1

Course Category:	Program Core-I	Credits:	1
Course Type:	Project	Lecture - Tutorial -Practice:	0-0-2
Prerequisites:	Core courses in the M.Tech - VLSI Design and Embedded Systems program, including courses in digital design, embedded systems, and relevant electives.	Continuous Evaluation: Semester end Evaluation: Total Marks:	60 40 100

Course outcomes	Upon successful completion of the course, the student will be able to:					
	CO1	Identify methods and resources to carry out analysis and experiments.				
	CO2	Reorganize the procedures with a concern for society, the environment and ethics.				
	CO3	Generate possible alternative solutions to the chosen problem, compare, analyze them and derive performance metrics of the result.				
	CO4	Prepare a comprehensive report of the project work and also explore the possibility of publishing the work.				
Contribution of Course Outcomes towards achievement of Program Outcomes **(1 – Low, 2 - Medium, 3 – High)**		PO1	PO2	PO3	PO4	PO5
	CO1	2			1	1
	CO2	1		1	1	1
	CO3	3		2	3	1
	CO4		3	2		1
Course Content	Week 1-2: Project Topic Selection • Introduction to the course and capstone project expectations • Brainstorm project ideas • Form project teams • Choose a project topic and define initial objectives Week 3-5: Project Proposal • Develop a project proposal that includes a clear problem statement • Outline the methodology and approach to be used					

	• Create a preliminary project timeline • Submit project proposals for approval Week 6-8: Literature Review • Conduct a literature review of relevant research and existing solutions • Identify key papers, articles, and resources • Document gaps in current knowledge and technologies • Week 9-11: Project Planning • Refine project scope and objectives based on literature review • Develop a detailed project plan with tasks, milestones, and deadlines • Allocate resources and budget for the project Week 12-14: Progress Report • Prepare a progress report summarizing work completed to date • Discuss challenges and potential solutions • Review and adjust the project plan if necessary Week 15-16: Midterm Presentation • Present the project proposal, literature review, and project plan to faculty and peers • Receive feedback and suggestions for the next phase (Capstone Project-2)
E-resources and other digital material	• Recommended textbooks and research papers related to the project topic • Access to relevant software and hardware tools • Project management software (e.g., Microsoft Project or equivalent)

SEMESTER II

24ECVE506: Hardware/Software Codesign

Course Category:	Programme Core - IV	**Credits:**	3
Course Type:	Integrated	**Lecture - Tutorial -Practice:**	2-0-2
Prerequisites:	Embedded Systems	**Continuous Evaluation:**	40
		Semester end Evaluation:	60
		Total Marks:	100

Course Outcomes	Upon successful completion of the course, the student will be able to:					
	CO1	Demonstrate an understanding of hardware/software co-design models and methodologies.				
	CO2	Develop and apply hardware/software synthesis algorithms for efficient system partitioning and distributed systems.				
	CO3	Build and simulate hardware/software prototypes and emulations, showcasing architecture specialization techniques.				
	CO4	Analyze and design architectures for control-dominated, data-dominated, and mixed systems tailored to specific applications.				
	CO5	Utilize modern compilation technologies to optimize embedded systems				
Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2-Medium, 3 – High)		PO1	PO2	PO3	PO4	PO5
	CO1	2		3	3	2
	CO2	2		3	3	2
	CO3	2		2	2	
	CO4	2		3		2
	CO5	2		2	3	
Course Content	**UNIT I:** (9Hrs) **Co- Design Issues** Co- Design Models, Architectures, Languages, A Generic Co-design Methodology. **UNIT II:** (9Hrs) **Hardware/ Software Co- Synthesis Algorithms** Hardware software synthesis algorithms: hardware – software partitioning distributed system co-synthesis. **UNIT III:** (9Hrs) **Prototyping and Emulation** Prototyping and emulation techniques, prototyping and emulation environments, future developments in emulation and prototyping architecture specialization techniques, system communication infrastructure.					

	UNIT IV: (9Hrs) **(9 Hrs)** **Target Architectures** Architecture Specialization techniques, System Communication infrastructure, Target Architecture and Application System classes, Architecture for control dominated systems (8051-Architectures for High performance control), Architecture for Data dominated systems (ADSP21060, TMS320C60), Mixed Systems. **UNIT V:** **(9Hrs)** **Compilation Techniques and Tools for Embedded Processor Architectures** Modern embedded architectures, embedded software development needs, compilation technologies, practical consideration in a compiler development environment.
Text books and Reference books	**Text Books:** 1. Hardware / Software Co- Design Principles and Practice – Jorgen Staunstrup, Wayne Wolf – 2009, Springer. **Reference Books:** 1.Hardware / Software Co- Design - Giovanni De Micheli, Mariagiovanna Sami, 2002, Kluwer Academic Publishers. 2. A Practical Introduction to Hardware/Software Co-design -Patrick R. Schaumont - 2010 – Springer Publications.
E-resources and other digital material	1. https://www.coursera.org/learn/computer-hardware-software 2. https://dspace.mit.edu/handle/1721.1/84891

24ECVE507: Real Time Operating Systems

Course Category:	Program Core - V	**Credits:**	3
Course Type	Theory	**Lecture-Tutorial-Practice**	3-0-0
Prerequisites:	Embedded Systems concepts and Operating System	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course Outcomes	Upon successful completion of the course, the student will be able to:					
	CO1	Explain the fundamental principles of real-time operating systems, including task management, scheduling, and the unique characteristics that differentiate RTOS from general-purpose operating systems				
	CO2	Apply various synchronization and communication mechanisms, such as semaphores, message queues, and condition variables, to effectively manage task coordination in real-time systems				
	CO3	Analyze the role of exceptions, interrupts, and timers in RTOS and implement these components to support responsive, real-time functionality in embedded applications				
	CO4	Design and develop I/O subsystems in real-time operating systems, utilizing synchronization methods and handling priority inversion to ensure efficient and reliable system operation				
	CO5	Identify and address common design challenges in RTOS, including resource classification, deadlocks, and priority inversion, to enhance the stability and performance of real-time applications				
Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)		PO1	PO2	PO 3	PO 4	PO5
	CO1	2	1	3	2	2
	CO2	2	1	3	3	2
	CO3	3	1	3	3	2
	CO4	3	1	3	3	3
	CO5	3	1	3	3	3
Course Content	**UNIT I:** (9 Hrs) **Introduction to Real-Time Operating Systems -**Defining an RTOS, The scheduler, Kernel objects and services, Key characteristics of an RTOS. **Task management:** Defining a Task, Task States and Scheduling, Typical Task Operations, Typical Task Structure. Introduction to Synchronization, Communication, and Concurrency in real-time environments. **UNIT II:** (9 Hrs) **Semaphores -**Definition, typical operations, and usage in RTOS.					

	Message Queues -Definition, states, content, storage, operations, and typical use. **Pipes -**Introduction to Pipes, Event Registers, Signals, and Condition Variables as tools for managing synchronization and communication in real-time applications. **UNIT III:** (9 Hrs) **Exceptions and Interrupts -**Definition, applications, and deeper exploration of their nature and management in RTOS, including handling spurious interrupts. **Timer and Timer Services -**Real-time clocks, system clocks, programmable interval timers, and timer interrupt service routines essential for real-time applications. **UNIT – IV:** (9 Hrs) **I/O Subsystems -**I/O concepts and subsystems in RTOS **Synchronization and Communication -**Resource synchronization methods, critical sections, and common design patterns in RTOS. **Priority:** Introduction to Priority Inversion and methods to address it in real-time operating systems. **UNIT – V:** (9 Hrs) **Design Issues:** Analyzing and managing common design issues in real-time systems, including resource classification, deadlocks, and priority inversion. Methods to address and mitigate these issues within the context of RTOS to ensure efficient system functionality and responsiveness.
Text books and Reference books	**Text Books:** 1. Qing Li, Caroline Yao (2023), "Real-Time Concepts for Embedded Systems", CMP Books **Reference Books:** 1. Albert Cheng, (2022), "Real-Time Systems: Scheduling, Analysi Verification", Wiley Interscience. 2. Hermann Kopetz, (2019), "Real-Time Systems: Design Principle Distributed Embedded Applications", Kluwer. 3. Insup Lee, Joseph Leung, and Sang Son, (2018) "Handbook of Real Systems", Chapman and Hall. 4. Krishna and Kang G Shin, (2022), "Real-Time Systems", McGraw Hill
E-resources and other digital material	1. https://nptel.ac.in/courses/106105036/ 2. https://nptel.ac.in/noc/individual_course.php?id=noc18-cs12

24ECVE508: Analog &Mixed Signal Design

Course Category	Program Core-VI	**Credits**	3
Course Type	Theory	**Lecture-Tutorial-Practice**	3-0-0
Prerequisite	CMOS VLSI Design	**Continuous Evaluation:**	40
		Semester end Evaluation:	60
		Total Marks:	100

Course Outcomes	Upon successful completion of the course, the student will be able to:					
	CO1	Design CMOS single-stage amplifiers and current mirrors.				
	CO2	Design CMOS operational amplifiers to meet specific performance requirements.				
	CO3	Design feedback amplifiers, Comparators and ADC's for practical analog and mixed-signal applications.				
	CO4	Design switched-capacitor circuits.				
	CO5	Implement advanced layout techniques for optimal analog and mixed-signal performance.				
Contribution of Course Outcomes towards achievement of Program Outcomes (1–Low, 2-Medium, 3 – High)		PO1	PO2	PO3	PO4	PO5
	CO1	2		3		
	CO2		2	3		
	CO3	3		3		
	CO4	3		3		
	CO5	3		3		

Course Content

UNIT-I: (9 Hrs)

Single Stage Amplifiers and Current Mirrors - Common source, common gate and source follower stages- Cascode and folded cascode structures- Frequency response, MOS current mirrors-sources.

UNIT-II: (9 Hrs)

MOS Differential Amplifiers and Operational Amplifiers - Single ended and differential operation, Basic differential pair, Common mode response, Frequency response- CMOS operational amplifiers - One-stage op-amps and Folded Cascode Op-Amps and Properties.

UNIT-III: (9 Hrs)

Feedback Amplifiers - General considerations, Feedback topologies.

Comparators and Analog-Digital converters –Two stage, Open-loop comparators, Parallel digital-analog converters.

UNIT-IV: (9 Hrs)

Switched-Capacitor circuits – Sampling switches, Switched-Capacitor amplifiers, Switched-Capacitor integrator.

UNIT-V: (9 Hrs)

Layout Design– General Layout Considerations, Analog Layout Techniques, Substrate Coupling.

Textbooks and Reference books

Text Books:

1. Behzad Razavi (2002), "Design of Analog CMOS Integrated Circuits" Tata-Mc Graw Hill.
2. Philip Allen & Douglas Holberg (2002), "CMOS Analog Circuit Design", Oxford University Press.
3. Alan Hastings (2004) The Art of Analog Layout, Second Edition, Pearson Education.

	Reference Books: 1. David A Johns & Ken Martin (2001), "Analog Integrated Circuit Design" John Wiley and Sons
E-resources and other digital material	CMOS Analog VLSI Design by Prof. A.N. Chandorkar, Department of Electronics & Communication Engineering, IIT Bombay. For more details on NPTEL visit http://nptel.ac.in

24ECVE509A: Low Power VLSI Design

Course Category:	Programme Elective-III	**Credits:**	3
Course Type:	Theory	**Lecture - Tutorial -Practice:**	
Prerequisites:	Devices and circuits	**Continuous Evaluation:**	40
		Semester end Evaluation:	60
		Total Marks:	100

Course Outcomes	Upon successful completion of the course, the student will be able to::	
	CO1	Apply different circuit techniques to manage the leakage currents
	CO2	Comprehend and analyze various low power adder and multiplier architectures.
	CO3	Understand the architectural and circuit level techniques for attaining low power ROM.
	CO4	Design and analyze the different types of low power SRAM and DRAM circuits.
	CO5	Decide which level of abstraction is advantageous to implement low power designs.

Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)						
		PO1	PO2	PO3	PO4	PO5
	CO1	3	3	2	1	1
	CO2	3	3	2	1	2
	CO3	3	3	3	1	2
	CO4	3	3	3	1	2
	CO5	2	2	2	1	2

Course Content

UNIT I: (9 Hrs)

Low power CMOS VLSI design - Introduction, sources of power dissipation, static power dissipation, active power dissipation.

Circuit techniques for low power design - Introduction, designing for low-power, circuit techniques for leakage power reduction

UNIT II: (9 Hrs)

Low voltage low power adders - Introduction, standard adder cells, CMOS adder's architectures, low voltage low power design techniques, current mode adders.

Low voltage low power multipliers - Introduction, overview of multiplication, types of multiplier architectures, Braun multiplier, booth multiplier, Wallace tree multiplier

UNIT III: (9 Hrs)

Low- Voltage Low Power Read-Only Memories - Introduction, types of ROM, basics physics of floating gate non-volatile devices, floating gate memories, basics of ROM, low power ROM Technology

UNIT – IV: (9 Hrs)

	Low voltage low power static RAM - Basics of SRAM, memory cell, precharge and equalization circuit, address transition detection, sense amplifier, output latch, low power SRAM technologies, **Low voltage low power dynamic RAM** - Types of DRAM, basics of DRAM, self-refresh circuit, half voltage generator, voltage down converter, future trends and developments of DRAM **UNIT–V:** (9 Hrs) **Architectural Techniques for Low Power:** Parameters effecting power dissipation, Variable frequency, Dynamic voltage Scaling, Dynamic Voltage and Frequency Scaling, Reduced VDD, Architectural clock gating, Power gating, Multi-voltage, Optimizing memory power. **Low Power Implementation Techniques:** Library Selection, Clock Gating, Timing Impact due to Clock gating, Gate-level power optimization techniques, Power Optimization for Sleep Mode
Textbooks and Reference books	**Textbooks:** 1. Kiat Seng Yeo, Kaushik Roy (2012)," Low Voltage, Low Power VLSI Subsystems", TATA McGraw-Hill. 2. Soudris D, Piguet C and Goutis C, Designing CMOS Circuits for Low Power, Kluwer Academic Publishers, 2002 . **Reference Books:** 1. Yeo Rofail, Gohl (2009)," CMOS/BiCMOS ULSI Low Voltage, Low, Power", Pearson Education Asia 1st Indian reprint. 2. Anantha P. Chandrakasan, Robert W. Brodersen, "Low Power Digital 3. CMOS Design", Springer Science 4. Jan M. Rabaey, Anantha P. Chandrakasan, Borivoje Nikolic, (2011) "Digital Integrated Circuits: a Design Perspective", PearsonEducation, 2nd Edition.
E-resources and other digital material	1. http://www.nptelvideos.com/course.php?id=422 2. http://leda.elfak.ni.ac.rs/education/projektovanjeVLSI/predavanja/10%20Low%20Power%20Design%20in%20VLSI.pdf 3. https://www.egr.msu.edu/classes/ece410/salem/files/s16/lectures/Ch2_S2_N.pdf/

24ECVE509B: Semiconductor Packaging and Testing

Course Category:	Programme Elective-III	**Credits:**	3
Course Type:	Theory	**Lecture - Tutorial -Practice:**	3-0-0
Prerequisites:	IC Technology	**Continuous Evaluation:**	40
		Semester end Evaluation:	60
		Total Marks:	100

Course outcomes	Upon successful completion of the course, the student will be able to:					
	CO1	Understand the various packaging types used in modern technology.				
	CO2	Fundamentals of the associated thermal, speed, signal and integrity power issues				
	CO3	Summarize the different concepts of chip packaging, PCB and surmount technology. Design of PCBs which minimize the EMI and operate at higher frequency.				
	CO4	Explore CAD tools for PCB design and board assembly techniques				
	CO5	Analyze the concepts of Testing and reliability of microsystems				
Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)		PO1	PO2	PO3	PO4	PO5
	CO1	1	3	2	2	2
	CO2	2	3	2	1	2
	CO3	2	3	1	2	2
	CO4	1	3	2	2	2
	CO5	1	3	1	2	2

Course Content

Unit 1: Microsystems Packaging (9Hrs)

Introduction of Microsystems Packaging, Packaging Hierarchy, IC packaging: MEMS Packaging, Packaging for communication applications, Packaging Related to Medical Electronics, Future Trends and Challenges, Materials and their properties for Microelectronic Packaging , Ceramics, Polymers, and Metals in Packaging, Materials used for high density interconnect substrates.

Unit 2: Fundamental of Electrical Issues and Precautions in Packaging

Electrical Issues of Systems Packaging: Signal Distribution, Power Distribution, Electromagnetic Interference, Transmission Lines, Clock Distribution, Noise Sources, Digital and RF Issues. Design Process Electrical Design: Interconnect Capacitance, Resistance and Inductance fundamentals; Various Parasitics. **(9Hrs)**

Unit 3: Chip Packages (9Hrs)

IC Assembly - Purpose, Requirements, and Technologies

Wire Bonding and Tape Automated Bonding, Flip Chip

Wafer Level Packaging, Reliability, Wafer Level Burn – in and Test.

Single chip Packaging: Functions, Types, Materials Processes, Properties, Characteristics.

Multi chip Packaging: Types, Design, comparison.

System – in - package (SIP); Passives: Discrete, Integrated, and embedded.

Unit 4: PCB and surface mount technology (9Hrs)

	Printed Circuit Board: Anatomy, CAD Tools for PCB Design, Micro via boards. Board Assembly: Surface Mount Technology, Thorough Hole technology, Process Control and Design Challenges. Thermal Considerations: Thermal management, Heat Transfer Fundamentals, Thermal Conductivity and Resistance, Conduction, Convection and Radiation, Importance of Cooling. **Unit 5: Testing Technology and Reliability (9Hrs)** Basic Concepts, Environmental Interactions. Thermal Mismatch and Fatigue–Failures–Thermo Mechanically Induced, Electrically Induced, Chemically Induced. Electrical Testing: System Level Electrical Testing, Interconnection tests, Active Circuit Testing, Design for Testability, Basics of Reliability of Microsystems
Text books and Reference books	**Textbooks:** 1. Tummala, Rao R., Fundamentals of Microsystems Packaging, McGraw Hill, 2001. **References:** 1. Blackwell (Ed), The electronic packaging handbook, CRC Press, 2000. **2.** Tummala, Rao R, Microelectronics packaging handbook, McGraw Hill, 2008. **3.** Bosshart, Printed Circuit Boards Design and Technology, TataMcGraw Hill, 1988. **4.** R.G. Kaduskar and V.B.Baru, Electronic Product design, Wiley India, 2011. **5.** R.S.Khandpur, Printed Circuit Board, Tata McGraw Hill, 2005.
E-resources and other digital material	An Introduction to Electronics Systems Packaging by Prof. G.V. Mahesh, Department of Electronic system Engineering, IISc Bangalore.For more details on NPTEL visit http://nptel.iitm.ac.in.

24ECVE509C: High Level Synthesis

Course Category:	Programme Elective-III	**Credits:**	3
Course Type:	Theory	**Lecture - Tutorial -Practice:**	3-0-0
Prerequisites:	Digital Logic Design	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:	
	CO1	Apply C++ programming concepts and showcase adeptness in designing modular and optimized code.
	CO2	Design combinational and sequential circuits using high-level synthesis techniques
	CO3	Design advanced memory architectures using high-level synthesis techniques.
	CO4	Design principles for modular systems and efficient control IO management.
	CO5	Design and implement diverse Digital Filters using high-level synthesis techniques.

Contribution of Course Outcomes towards achievement of Program Outcomes (L – Low, M - Medium, H – High)		PO1	PO2	PO 3	PO 4	PO5
	CO1	3		3		2
	CO2	3		3		2
	CO3	3		3		2
	CO4	3		3		2
	CO5	3		3		2

Course Content

UNIT I: (10Hrs)

Bit Accurate Data Types: Introduction, Compilation, Debug, and Simulation Speed, Header Files and Typedefs, Integer Data Types, Unsigned integer, Signed Integer, Fixed Point Data Types, Unsigned Fixed Point, Signed Fixed Point, Quantization and Overflow, Operators, Bitwise Arithmetic Operators: *, +, -, /, &, |, ^,%, Bit Select Operator: [].

Fundamentals of High Level Synthesis: Introduction, The Top-level Design Module, Registered Outputs, Control Ports, Port Width, Port Direction, High-level C++ Synthesis, Data Flow Graph Analysis, Resource Allocation, Scheduling, Classic RISC Pipelining, Loop Pipelining, Loops, Rolled Loops, Loop Unrolling, Loops with Conditional Bounds, Optimizing the Loop Counter, Optimizing the Loop Control Nested Loops, Sequential Loops, Conditions Sharing, Functions and Multiple Conditional Returns.

UNIT II: (10Hrs)

Sequential and Combinational Hardware: Introduction, Shift Registers, Basic Shift Register, Shift Register with Enable, Shift Register with Synchronous Clear, Shift Register with Load, Shift Register Template Function, Class Based Shift Register, Helper Classes for Design Reuse,

	Log2Ceil, NextPow2, Multiplexors, Binary MUX, Automatic Binary to Onehot MUX Optimizations, Manual Optimization of Binary Selection MUXes, One Hot MUX, Finding Leading 1's in a Bit-vector, Finding the Maximum Value in an Array, Absolute Value (abs), Linear Feedback Shift Register (LFSR), Accumulator, Shifters, Barrel shifter, Constant Shifts, Adder Trees, Automatic Tree Balancing, Preventing Automatic Tree Balancing, Coding to Facilitate Automatic Tree Balancing, Lookup Tables (LUT). **UNIT III: (8Hrs)** **Memory Architecture**: Introduction, Memory-based Shift Register, Circular Buffer, Memory Organization, Interleaving Memories, Widening the Word Width of Memories, Caching, Using True Single Port RAM as a Dual port RAM, "Windowing" of 1-D Data Streams, 2-D Windowing. **UNIT IV: (8Hrs)** **Hierarchical Design**: Introduction, Arrays Shared Between Blocks, Out-of-order Array Access, In-order Array Access, Blocks with Common Interface Control Variables, Passing Control Variables Between Blocks, Connecting Interface Control Variables to Multiple Blocks, Duplicating Control IO. **UNIT – V: (9Hrs)** **Digital Filters**: Introduction, FIR Filters, Register Based Filters, External Coefficients, Constant Coefficients, Loadable Coefficients, Symmetric Coefficients, Even Symmetric, Odd Symmetric, Transposed, Systolic, Multi-rate Filtering, Decimation, Interpolation.
Text books and Reference books	**Text Books** 1. Fingeroff, Michael. High-level synthesis: blue book. Xlibris Corporation, 2010. **Reference Books** 1. P Coussy, A Morawiec, "High-level synthesis". Vol. 1. Springer, 2010. 2. Vanhoof, Jan. High-Level Synthesis for Real-Time Digital Signal Processing: The CATHEDRAL-II Silicon Compiler. Springer Science & Business Media, 1993.
E-resources and other digital material	1. https://www.udemy.com/course/hls-combinational-circuits/#instructor-12. 2. https://www.udemy.com/course/fpga-design-with-high-level-synthesis-vivado-hls/

24ECVE509D: RF IC Design

Course Category:	Programme Elective-III	**Credits:**	3
Course Type:	Theory	**Lecture - Tutorial -Practice:**	3-0-0
Prerequisites:	RF& MW Theory, VLSI Design	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:					
	CO1	Analyze different characteristics of RF circuits and Systems				
	CO2	Design active and passive CMOS circuits used in RF applications				
	CO3	Design and measure performance metrics of low-noise amplifiers and power amplifiers				
	CO4	Design and analyze the functionality and performance characteristics of mixers and oscillators				
	CO5	Evaluate the performance and design principles of frequency synthesizers and loop filters				
Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)		PO1	PO2	PO3	PO4	PO5
	CO1	3	2	2	1	1
	CO2	3	3	3	1	1
	CO3	3	2	3	1	1
	CO4	3	3	2	1	1
	CO5	3	3	2	1	1
Course Content	**UNIT I: (9 Hrs)** **Fundamentals of RF circuits and systems**: Duplexing, FDMA, dB, dBm, Voltage gain, Channel, ACR, AACR, Noise factor, NF of a cascaded system, Sensitivity, HD, Gain compression, P1 dB, Cross modulation, Inter modulation, IM3, IIP3, SFDR, Transmit mask. **Transmitter and Receiver Architectures:** Review of modulation schemes, Receiver architectures, Transmitter architectures **UNIT II: (9 Hrs)** **Passive and active components for CMOS RFIC:** Review of MOSFET, RF transistor layout, CMOS process, Capacitors, Varactors, Resistors, Inductors, Transformers, Transmission lines Resonance, Matching, S-parameters, etc. Noise in electrical circuits and NF calculations, Two port noise theory. **UNIT III: (9 Hrs)** **Low Noise Amplifiers**: Resistive terminated CS and CG LNA, Inductive degenerated LNA, Shunt feedback LNA, Noise cancelling LNAs, Linearity improvement techniques **Power Amplifiers**: Class A, B, C, D, E, F and other configurations, Power combining, Linearity improvement techniques.					

	UNIT – IV: (9 Hrs) **Mixers:** Specifications, NL system as a mixer, Active mixers, Passive mixers **Oscillators:** Introduction, LC Oscillators, Phase noise Introduction to PLLs, Type-I PLLs, Charge pump PLLs: Mathematical model, Design issues and Phase noise **UNIT – V: (9 Hrs)** **Frequency synthesizers:** PLL-Based Frequency Synthesizer, Dividers, VCO, Ring Oscillators. **Loop Filter:** General Description, Design Approaches, A Complete Synthesizer Design Example, Implementation of a Frequency Synthesizer with a Fractional Divider.
Text books and Reference books	**Text Books** 1. B. Razavi, "RF Microelectronics", 2nd Edition, Pearson, 2012. **2.** Thomas H. Lee, "The design of CMOS radio-frequency integrated circuits", 2nd Edition, Cambridge University Press, 2004. **3.** Leung, Bosco, "VLSI for wireless communication", 2nd Edition, Springer Science & Business Media, 2011. **Reference Books** 1. Samar K. Saha, "Compact Models for Integrated Circuit Design: Conventional Transistors and Beyond", Taylor & Francis, 2015. 2. H. Ruiz, R. Pérez, "Linear CMOS RF Power Amplifiers: A Complete Design Workflow", Springer, 2014 edition. 3. Manganaro, Gabriele, and Domine MW Leenaerts, "Advances in analog and RF IC design for wireless communication systems", Academic Press, 2013. 4. Noulis, Thomas, Mixed-signal circuits, CRC Press, 2018. 5. Rincon-Mora, Gabriel, "Analog IC design with low-dropout regulators (LDOs)", McGraw-Hill, 2009.
E-resources and other digital material	1. RF Integrated Circuits, IIT Delhi, Dr. Shouribrata Chatterjee https://nptel.ac.in/courses/117102012

24ECVE510A: LINUX Shell Scripting

Course Category:	Program Elective-IV	**Credits:**	3
Course Type:	Theory	**Lecture-Tutorial-Practice:**	3-0-0
Prerequisites:	C Programming	**Continuous Evaluation:** **Semester End Evaluation:** **Total Marks:**	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:					
	CO1	Understand the Linux kernel and Graphical Environment to work confidently.				
	CO2	Explore bash shell commands to manage files and directories.				
	CO3	Develop shell scripts to automate tasks and solve problems.				
	CO4	Understand the signals and functions concepts to effectively control shell scripts.				
	CO5	Apply regular expressions to validate data and perform advanced scripting tasks.				
Contribution of Course Outcomes towards achievement of Program Outcomes: (1 - Low, 2 - Medium, 3 - High)		PO1	PO2	PO3	PO4	PO5
	CO1	2	1	3	2	2
	CO2	2	2	2	3	2
	CO3	3	3	3	3	2
	CO4	2	2	2	3	1
	CO5	2	2	2	3	3

Course Content

UNIT-I **(9 Hrs)**

INTRODUCTION TO LINUX KERNALS- What Is Linux, The GNU utilities, The Linux desktop environment, Linux Distributions, Reaching the Command Line, Accessing CLI via a Linux Console Terminal, Graphical Terminal Emulation, GNOME Terminal, Console terminal and xtern Terminal Emulator.

UNIT-II **(9 Hrs)**

BASH SHELL COMMANDS- Starting the Shell, Using the Shell Prompt, Interacting with the bash Manual, Navigating the File system, Listing Files and Directories, Handling Files, Managing Directories, Viewing File Contents, Monitoring Programs and Disk Space, Working with Data Files, Exploring Environment Variables, Setting User-Defined Variables, Removing Environment Variables.

UNIT-III **(9 Hrs)**

SHELL SCRIPTING- Creating a Script File, Displaying Messages, Structured Commands: Working with the if-then Statement, if-then-else, Nesting ifs, case Command, For Command, While Command, Until Command, Nested loops,

	Controlling the loops, Processing the Output of a Loop, Practical Examples, Presenting Data: Understanding Input and Output, Redirecting Output and Input in Scripts, Creating Your Own Redirection, Practical Example. **UNIT-IV (9 Hrs)** **SCRIPT CONTROL** Handling Signals, Running Scripts in Background Mode, Running Scripts without a Hang-Up, Controlling the Job, Being Nice Command, Running Like Clockwork. Basic Script Functions, Returning a Value, Using Variables in Functions, Array variables and functions, Function Recursion, Creating a Library, Using Functions on the Command Line. **Unit 5: Regular Expression and Alternative Shells (9 Hrs)** Types of Regular Expressions, Defining BRE patterns, Extended Regular Expressions, Counting Directory files, Validating Phone number, Working with Alternative Shells: dash Shell, The dash Shell Features, Scripting in dash, The zsh Shell, Parts of the zsh Shell, Scripting with zsh.
Text Book and Reference Books	**Textbooks**: 2. Richard Blum and Christine Bresnahan, "Linux Command Line and Shell Scripting BIBLE", Third Edition, Wiley. **References**: 5. Neil Matthew and Richard Stones, "Beginning Linux Programming", Fourth Edition, Wiley. 6. B. A. Forouzan and R. F. Gilberg, "Unix and Shell Programming", Cengage Learning. 7. Richard Petersen, "Linux:The Complete Reference", 6th edition, Tata McGraw-Hill. 8. MachteltGarrels, "Introduction to Linux: A Hands on Guide",Third edition,Fultus Corporation.
E-Resources and other digital material	[1]. https://nptel.ac.in/courses/117106113/ [2]. https://vlsiresources.com/linux-and-scripting/ [3]. https://nptel.ac.in/courses/106/105/106105172/

20ECVE510B: Embedded Linux Device Drivers

Course Category:	Programme Elective-IV	**Credits:**	3
Course Type:	Theory	**Lecture - Tutorial - Practice:**	3-0-0
Prerequisites:	C Programming, Microcontrollers & Basic knowledge of embedded systems.	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course Outcomes	**Upon successful completion of the course, the student will be able to:**					
	CO1	Identify and recall the differences between embedded and desktop Linux, as well as the components of embedded Linux architecture				
	CO2	Apply knowledge of memory mapping, interrupt management, and power management to configure embedded systems effectively.				
	CO3	Analyze the role and integration of different drivers in the embedded Linux environment				
	CO4	Differentiate between various architectures and outline the roadmap for application porting				
	CO5	Identify the key components of Linux desktop graphics and display hardware used in embedded systems				
Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)		**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
	CO1			2		2
	CO2			2	3	2
	CO3	3		3	3	3
	CO4	3		3	3	3
	CO5			2	1	2
Course Content	**UNIT-I:Introductionto Embedded Linux (10Hrs)** Embedded Linux Vs Desktop Linux, Embedded Linux Distributions, Embedded Linux Architecture, Kernel Architecture, Hardware abstraction layer (HAL), Memory manager, Scheduler, File System, I/O and Networking subsystem, IPC, User space, Linux Start-up sequence, GNU cross platform tool chain. **UNIT-II: Board Support Package & Embedded Storage (10Hrs)** Inserting BSP in Kernel Build Procedure, The Boot Loader Interface, Memory Map, Interrupt Management, The PCI Subsystem, Timers, UART, Power Management.Memory technology device (MTD), MTD Architecture, Sample MTD Driver for NOR Flash. **UNIT-III: Embedded Drivers (8 Hrs)** Linux Serial driver, Ethernet driver, I^2C subsystem on Linux, Watchdog Timer. **UNIT-IV: Porting Applications, Building and Debugging (10Hrs)** Architectural Comparison, Application Porting Roadmap, Programming with P threads, Operating System Porting Layer (OSPL), Kernel API Driver. Building					

	the Kernel, Building the Root File System, Integrated Development Environment, Kernel Debuggers. **UNIT-V:Embedded Graphics (8 Hrs)** Linux Desktop Graphics, Introduction to Display Hardware, Embedded Linux Graphics Driver, Windowing Environments.
Textbooks and Reference books	**Text Books:** 1. P Raghvan, Amol Lad, Sriram Neelakandan, "Embedded Linux System Design and Development", Auerbach Publications. **Reference Books:** 1. Christopher Hallinan, "Embedded Linux Primer: A Practical Real-World Approach", Prentice Hall, 2nd Edition, 2010. 2. Karim Yaghmour, "Building Embedded Linux Systems", O'Reilly & Associates
E-resources and other digital material	1. https://training.linuxfoundation.org/training/developing-embedded-linux-device-drivers/ 2. https://nptel.ac.in/courses/117106113

24ECVE510C: Communication Buses and Interfaces

Course Category:	Programme Elective-IV	**Credits:**	3
Course Type:	Theory	**Lecture - Tutorial -Practice:**	3-0-0
Prerequisites:	Computer Networks	**Continuous Evaluation:**	40
		Semester end Evaluation:	60
		Total Marks:	100

Course Outcomes	Upon successful completion of the course, the student will be able to:					
	CO1	Understand the Basics of Serial Communication and Data Transmission				
	CO2	Select and apply a particular Low-Speed serial bus Interface suitable for a given application				
	CO3	Analyze and make a decision to use Medium-Speed serial bus Interface for an application.				
	CO4	Examine and decide a High-Speed serial bus Interface for an application.				
	CO5	Investigate the use of Broadband and wireless Interfaces				
Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3– High)		PO1	PO2	PO3	PO4	PO5
	CO1	3				2
	CO2	3				2
	CO3	3				2
	CO4	3				2
	CO5	3				2

Course Content

UNIT I: (10 Hrs)

Introduction to Serial I/O Communications, Serial I/O Primer: A Short Course in Data Communications and Networking

Low-Speed Interfaces: Controller Area Network (CAN), standard CAN, Extended CAN, CAN message, arbitration, message types, CAN bus, Inter-Integrated Circuit (I2C) Bus, RS-232, RS-485.

UNIT II: (10 Hrs)

Medium-Speed Interfaces: Ethernet, Firewire, Joint Test Action Group (JTAG), Media oriented system transport, Serial Peripheral Interface, Universal Serial Bus, host and devices, assigning a driver on the host, transfer types, transactions

UNIT III: (9 Hrs)

High-Speed Interfaces: 100 Gigabit Ethernet attachment unit interface, Fiber channel, high-definition multimedia interface (HDMI), hyper transport, optical

	transport network, PCI express, Synchronous optical network and synchronous digital hierarchy, thunderbolt. **UNIT – IV:** (9 Hrs) **Broadband Interfaces:** Broadband Interface concepts, Data over Cable Service Interface Specifications (DOCSIS), Digital subscriber Line, HomePlug (HP) , Multimedia over cable alliance, PoweRline Intelligent Metering Evolution (PRIME), X10 Interface. **UNIT – V** (9 Hrs) **Wireless Interfaces:** Wireless Interfaces, 802.15.4, Bluetooth, Digital Enhanced Cordless Telecommunications (DECT), EnOcean, Industrial Scientific Medical Wireless, Near Field Communications, Ultra-Wideband, Wi-Fi, Wireless HART, ZigBee.
Text books and Reference books	**Text Books:** 1.Louis E Frenzel Jr, "Hand book of Serial Communication Interfaces", Newness publications, 2016 2.Jan Axelson, "Serial PortComplete **COM Ports, USB Virtual COM Ports, and Ports for Embedded Systems**", Lakeview ResearchPublished,2nd edition Mindshare Press 3.Steve Corrigan, "Introduction to the Controller Area Network (CAN)", Texas Instruments, 2016. **Reference Books:** 1. Jan Axelson, "USB Complete", Penram Publications, 2016 Serial Front Panel Draft Standard VITA 17.1 – 200x
E-resources and other digital material	www.can-cia.org www.pcisig.com www.usb.org

24ECVE510D: Industrial Product Design

Course Category:	Programme Elective-IV	**Credits:**	3
Course Type:	Theory	**Lecture - Tutorial -Practice:**	3-0-0
Prerequisites:	--	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course Outcomes	Upon successful completion of the course, the student will be able to					
	CO1	Understand various processes and systems to address human needs by using tangible Electronic Products.				
	CO2	Demonstrate an understanding of key product design methodologies, including UCD and Electronic Product Design and Development.				
	CO3	Illustrate product design concepts using visual communication techniques.				
	CO4	Apply design principles like figure-ground relationships and visual information.				
	CO5	Design product layouts and structures adhering to industrial standards.				
Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3– High)		PO1	PO2	PO3	PO4	PO5
	CO1	3		2		3
	CO2	3		2		3
	CO3	3	2	3		
	CO4	3	2	3		
	CO5			3	3	3
Course Content	**UNIT I** **(8Hrs)** **Introduction to Industrial Design:** Introduction to the course, role of ID in the domain of industry, product innovation, Designer's philosophy and role in product design, what is good design **UNIT II** **(8Hrs)** **Product Design Methodology:** User centred Design methods, Electronic Product Design and Development Methodology, **UNIT III** **(10 Hrs)** **Product Design-Product Analysis:** Visual Communication Techniques: Free Hand sketching and drawing techniques for concept presentation, Perspectives, and rendering techniques, colour in design, Engineering drawing practice, exploded views. **UNIT IV** **(10Hrs)** **Design Principles:** Visual information through design principles, Figure-ground relationship, Visual information distribution, Gestalt principles, Theory of object					

	perception, Symmetry, Asymmetry, Closure, Continuance, Unifying principles of design. Design Expressions. **UNIT V** **(9Hrs)** **Product Anatomy**: Layout design, structure design, standard and non-standard structures, Industrials standards, Product detailing in sheet metal and plastics for easy of assembling.
Text books and Reference books	**Text Books:** 1. Peter Z. , "German Design Standard Vol. 2", Reddot, 2019. 2. Clarkson P.J, Coleman R. and Keates, S., "Inclusive Design, Design for the whole population", Springer Verlag Gmbh, 2019 3. Jordan P. W., "Designing Pleasurable Products: An Introduction to the New Human Factors." Taylor and Francis, 2002. 4. Otto K. and Wood K., "Product design: Techniques in Reverse Engineering and New Product development", Prentice Hall, 2001. 5. Cross N. "Engineering Design Methods: Strategies for Product Design", Willey, 2020 **Reference Books** 1. Cagan J. and Vogel C. M., Creating Breakthrough Products, "Innovation from Product Planning to Program Approval". Pearson Education, 2018. 2. Coats D., "Watches Tell More than Time: Product Design, Information, Quest for elegance" McGraw Hill, 2002 3. Norman D. A. , "The design of everyday things, Basic Books, 2002. 4. Chakrabarty D.," Indian Anthropometric Dimensions for Ergonomic Design Practice", NID, Ahmedabad, 1999. 5. Kelley T. and Littman J. "The Art of Innovation: Lessons in Creativity from Ideo, America's Leading Design Firm, Doubleday", Ver: 4 November 2011 MI – PDN2524, 2001. 6. E.J. McCormic, Human factors in engineering design, McGraw Hill, 1976.
E-resources and other digital material	1. http://www.ulrich-eppinger.net/ 2. http://www.npd-solutions.com 3. http://www.qfdi.org 4. http://www.cheshirehenbury.com/rapid/

24MTUC502**:** Technical Report Writing

Course Category:	Audit Course	**Credits:**	0
Course Type:	Theory	**Lecture - Tutorial -Practice:**	2-0-0
Prerequisites:	Nil	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	Nil

Course Outcomes	Upon successful completion of the course, the student will be able to					
	CO1	Develop the ability to structure and organize scientific papers and technical documents in alignment with academic and industry standards.				
	CO2	Utilize visual aids such as charts, graphs, tables, and figures effectively to enhance the clarity and impact of technical reports.				
	CO3	Master LaTeX for document preparation, including advanced techniques for formatting, inserting tables, figures, and equations.				
	CO4	Apply effective communication strategies to articulate research findings, project designs, and technical reports clearly and concisely.				
	CO5	Produce high-quality scientific and technical documents that meet rigorous academic and professional standards, enhancing employability and success in both academic and industry settings.				
Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3– High)		PO1	PO2	PO3	PO4	PO5
	CO1	-	2	-	-	-
	CO2	-	2	-	-	-
	CO3	-	2	-	-	-
	CO4	-	2	-	-	-
	CO5	-	2	-	-	-
Course Content	**Unit I: Introduction to Scientific Writing** **(9Hrs)** Title, Abstract, Introduction, Materials and Methods, Results, Discussion, Conclusion Reference Management: Citing, Bibliographies, Acknowledgements, Appendices, Hedging, Paraphrasing, Plagiarism **Unit II: Visual Representation in Technical Reports** **(9Hrs)** Bar Chart, Line Chart, Pie Chart, Area Chart, Cylindrical Chart, Column Bars, Bubble Chart, Flow Diagram, Effective Use of Tables Types of Technical Reports and Writing Guidelines **Unit III: Document Preparation with LaTeX** **(9Hrs)** Introduction to LaTeX, Document Structure: Title, Sections, Labels Table of Contents, Fonts, Colors, Lists, Comments, and Spacing, Special Characters and Symbols in LaTeX **UNIT IV** : **Advanced Techniques in LaTeX** **(9Hrs)** Inserting Equations and Mathematical Symbols, Managing BibTeX Files for Bibliographies, Citing and Formatting References, Styles and Practical Applications, LaTeX Exercises and Projects					

	Unit V: Integrating Tables, Figures, and Equations (9Hrs) Practical Applications of Tables, Figures, and Equations, Advanced LaTeX Features for Technical Documents, Using LaTeX for Complex Document Structures' Enhancing Document Quality with LaTeX Project: Applying LaTeX in Scientific and Engineering Papers
Text books and Reference books	**Text Books** 1. Barun K Mitra, Effective Technical Communication- A Guide for Scientists and Engineers, Oxford University Press, ISBN:978019568291. 2. LATEX for Beginners, Workbook Edition 5, Document Reference: 3722-2014. **Reference Books** 1. Goldbort R, Writing for Science, Yale University Press (available on Google Books) 2. Day R, How to Write and Publish a Scientific Paper, Cambridge University Press
E-resources and other digital material	1. Coursera course on Data Visualization 2. EdX course on Technical Report Writing 3. Overleaf: Online LaTeX Editor 4. LaTeX Project Website

24ECVE583: Real Time Operating Systems Lab

Course Category:	Laboratory-I	Credits:	1.5
Course Type:	Laboratory	Lecture - Tutorial -Practice:	0-0-3
Prerequisites:	Micro controller and Embedded systems lab	Continuous Evaluation: Semester end Evaluation: Total Marks:	60 40 100

Course outcomes	Upon successful completion of the course, the student will be able to:					
	CO1	Design and execute the different RTOS concepts for real time embedded system design.				
	CO2	Developing the RTOS applications for Micro controller boards				
Contribution of Course Outcomes towards achievement of Program Outcomes(1 – Low, 2 - Medium, 3 – High)		PO1	PO2	PO3	PO4	PO5
	CO1	3	3	3	3	3
	CO2	2	2	2	2	2
Course Content	**List of Experiments** 1. Develop a program that involves various operations related to real-time tasks, such as creation, deletion, and synchronization. 2. Implement a program to understand and simulate task scheduling algorithms in a real-time operating system. 3. Create a program to explore the concept and mechanisms of context switching in the context of real-time operating systems. 4. Develop a program to illustrate the use of semaphores for synchronization and communication between different tasks. 5. Implement a program that demonstrates the usage of mutexes for managing critical sections in a multitasking environment. 6. Write a program to handle interrupts effectively, exploring the ways an operating system manages and responds to external interrupts. 7. Develop a program to manage and manipulate queues within the real-time operating system environment. 8. Implement a program that showcases the effective management of pipes for inter-process communication. 9. Write a program to understand and implement signal handling mechanisms within the real-time operating system. 10. Develop a program that explores memory management techniques in the context of real-time operating systems. 11. Project.					

Lab Requirements	Software:1.FreeRTOS 2.Open STM32 System Work bench Hardware: 1.The development kits of ARM Developer Kits/ STM32F4 Discovery and Nucleo board. 2. Serial Cables, Network Cables, and recommended power supply for the board.
E-resources and other digital material	1. https://training.ti.com/ti-rtos-workshop-series-1-10-welcome 2. https://www.udemy.com/share/101XDy3@Lh74iiF3rMDF83Kk7Od1fQ7-RimKmKiI6HvZDtQmMx77GjLqvx7GSt0-52seWg-J/

24ECVE584: Analog & Mixed Signal Design Lab

Course Category:		Laboratory-II	Credits:
Course Type:		Laboratory	Lecture - Tutorial -Practice:
Prerequisites:		Analog and Mixed Signal IC Design	Continuous Evaluation: Semester end Evaluation: Total Marks:

Course outcomes	Upon successful completion of the course, the student will be able to:					
	CO1	Design and analyze analog circuits, with DC, transient, operational, and AC analyses.				
	CO2	Develop and validate the layout through rigorous Design Rule Checks (DRC) and Layout vs. Schematic (LVS) verification.				
	CO3	Extract RC parameters, back-annotate designs, and excel in post-layout analysis.				
Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)		PO1	PO2	PO3	PO4	PO5
	CO1	3	1	3	3	2
	CO2	3	1	3	3	2
	CO3	3	1	3	3	2
Course Content	**List of Experiments:** **Design the following circuits with given specifications, completing the design flow mentioned below:** (Minimum 10 Experiments) a. Design and perform the following analysis as per the requirement i. DC ii. Transient iii. Op iv. AC b. Draw the Layout and verify the DRC and LVS c. Extract RC and back annotate the same and verify the Design d. Verify & Optimize for Power and Area to the given constraint 1. Inverter 2. Common source amplifier 3. Common gate amplifier 4. Common drain amplifier 5. Current mirror 6. MOS Differential amplifier 7. Operational amplifier 8. R-2R DAC					

	9. Ring Oscillator 10. Unity Gain Sampler 11. Phase Locked Loop 12. SAR based ADC
Textbooks and Reference books	**Text Books:** 1. David A Johns & Ken Martin (2001), "Analog Integrated Circuit Design" John Wiley and Sons. 2. Behzad Razavi (2002), 'Design of Analog CMOS Integrated Circuits' Tata-Mc Graw Hill.

24ECVE592: Capstone project-II

Course Category:	Project	**Credits:**	1
Course Type:	Project	**Lecture - Tutorial -Practice:**	0-0-2
Prerequisites:	Capstone Project-I	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	60 40 100

Course Description:

For capstone project, a student under the supervision of a faculty member, shall apply the knowledge and hands on technical skills they have gained through course work and lab sessions and submit it to the department in a report form and shall make an oral presentation before the Departmental Committee.

Course Objectives:

- To integrate knowledge acquired across various courses and disciplines throughout the academic program.
- Apply theoretical concepts and practical skills gained in coursework and laboratory sessions to solve real-world problems or address specific challenges within the chosen field of study.
- Provide practical and hands-on experience that prepares them for the expectations and challenges of the workforce in their respective fields.

Course Materials:

- Recommended textbooks and research papers related to the project topic
- Access to relevant software and hardware tools
- Project management software (e.g., Microsoft Project or equivalent)

24ECVE593: Term Paper

Course Category:	Term Paper	**Credits:**	1
Course Type:	Theory	**Lecture - Tutorial -Practice:**	0-0-2
Prerequisites:	Research Methodology and IPR	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	60 40 100

Course Outcomes	Upon successful completion of the course, the student will be able to					
	CO1	Identify and analyze the real-world problems beyond the curriculum				
	CO2	Get awareness on current trends in specific area of interest.				
	CO3	Prepare and write technical report on the topic selected after literature survey				
	CO4	Develop communication skills to explain and interact with a cross section of audiences.				
Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3– High)		PO1	PO2	PO3	PO4	PO5
	CO1	2		1		2
	CO2	2			1	2
	CO3		3			2
	CO4					2
Course Content	**The following method is adapted by the department for conducting Term Paper.** • Term Paper and Project Work are to be carried out individually by M.Tech. students under the supervision of a faculty member. • The faculty member allotted to supervise the Term Paper in second Semester shall continue to be the supervisor for the Project Work also. • Each faculty member may be permitted to supervise not more than TWO students. • If any student/batch left over without supervisor, HOD shall use his/her discretion to allot the supervisor as supervisors are to be selected by the students themselves. **Expected outcomes of Term Paper** • To carry out literature survey (Reputed international journals / Proceedings of international conferences). • To select a technical topic related to area of specialization. • To submit an abstract at the beginning of second semester.					

	• To critically review the topic selected, prepare a report on the topic reviewed under the guidance of supervisor and submit at the end of second semester. • To present the term paper before review panel and assessment will be done based on scholarship of knowledge, report writing and presentation Skills.

SEMESTER III

24ECVE601: Self Learning Course

Course Category:	Program Elective-V	**Credits:**	3
Course Type	Theory	**Lecture-Tutorial-Practice:**	3-0-0
Prerequisites:	---	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	- - 100

Course Content	The courses under this category shall carry three credits and must have a minimum duration of 12 weeks/36 hours. The department will recommend the self-learning courses from the available open courseware. The self- learning courses shall be taken from the list of approved MOOCs providers (SWAYAM / NPTEL/ EDX / Others). They must be approved/ratified in the respective Board of Studies.

24ECVE691: INTERNSHIP

Course Category:	Internship	**Credits:**	2
Course Type	Practical	**Lecture-Tutorial-Practice**	0-0-4
Prerequisites:		**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	60 40 100

Course Content	The students shall undergo Internship for a period of six weeks in Industry/ Research organizations/ institute of higher learning approved by the Head of the Department during any time after the second semester and shall earn two credits.

24ECVE692: PROJECT- PART A

Course Category:	Project	**Credits:**	10
Course Type	Project	**Lecture-Tutorial-Practice**	0-0-20
Prerequisites:	Research Methodology and IPR Technical Report Writing	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	60 40 100

Course Outcomes	Upon successful completion of the course, the student will be able to:					
	CO1	Identify a topic in relevant areas of Communication Engineering & Signal Processing.				
	CO2	Review literature to identify gaps and define objectives & scope of the work.				
	CO3	Understand the methods and processes from literature and apply appropriate research methodologies.				
	CO4	Develop an analytical/ computational model/ experimental set-up and prepare a report and develop competence in presenting.				
Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)		PO1	PO2	PO3	PO4	PO5
	CO1	2		1		
	CO2	2			1	
	CO3				3	
	CO4		3			2
Course Content	**Expected outcomes of the Project Work from Part-A:** • To select a technical topic (from the literature survey carried out as a part of Term Paper) related to specialization in consultation with supervisor and submit an abstract to Project Review Committee PRC at the beginning of the third semester. • To critically evaluate the recent literature for the problem identified To carry out the project work under the guidance of supervisor on the topic selected. • To submit reports periodically and present before PRC for a review on the progress of work carried out.					

	• To prepare a report on the work carried out and submit at the end of fourth semester.

SEMESTER IV

24ECVE693: PROJECT- PART B

Course Category:	Project	**Credits:**	16
Course Type	Project	**Lecture-Tutorial-Practice**	0-0-32
Prerequisites:	Research Methodology and IPR Technical Report Writing	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	60 40 100

Course Outcomes	Upon successful completion of the course, the student will be able to:					
	CO1	Identify methods and resources to carry out analysis and experiments				
	CO2	Reorganize the procedures with a concern for society, environment and ethics.				
	CO3	Find solutions to complex engineering activities using modern engineering tools.				
	CO4	Analyze and discuss the results to draw valid conclusions.				
	CO5	Prepare a report and defend the work and publish the work in National /International Conferences/journals.				
Contribution of Course Outcomes towards achievement of Program Outcomes (1 – Low, 2 - Medium, 3 – High)		PO1	PO2	PO3	PO4	PO5
	CO1	2		1		
	CO2	2			1	
	CO3				3	
	CO4			2		2
	CO5		3			1
Course Content	**Expected outcomes of the Project Work from Part-B:** • To critically evaluate the recent literature for the problem identified • To carry out the project work under the guidance of supervisor on the topic selected. • To submit reports periodically and present before PRC for a review of the progress of work carried out. • To test the work carried out, report the results obtained and perform comparative analysis • To publish the paper in Peer reviewed journals/conferences • To prepare a report on the work carried out and submit at the end of fourth semester.					