PimpriChinchwad Education Trust's

PIMPRI CHINCHWAD COLLEGE OF ENGINEERING

SECTOR NO. 26, PRADHIKARAN, NIGDI, PUNE 411044

(An Autonomous Institute Approved by AICTE and Affiliated to SPPU, Pune)

Curriculum Structure and Syllabus

of

First and Second Year M. Tech. (VLSI and Embedded System)

(Regulations 2026)

Effective from Academic Year 2026-27

Institute Vision

To be one of the top 100 Engineering Institutes of India in coming five years by offering exemplarily Ethical, Sustainable and Value-Added Quality Education through a matching ecosystem for building successful careers.

Institute Mission

1. Serving the needs of the society at large through establishment of a state-of-art Engineering Institute.
2. Imparting right Attitude, Skills, Knowledge for self-sustenance through Quality Education.
3. Creating globally competent and Sensible engineers, researchers and entrepreneurs with an ability to think and act independently in demanding situations.

EOMS Policy

"We at PCCOE are committed to offer exemplarily Ethical, Sustainable and Value Added Quality Education to satisfy the applicable requirements, needs and expectations of the Students and Stakeholders.

We shall strive for technical development of students by creating globally competent and sensible engineers, researchers and entrepreneurs through Quality Education.

We are committed for Institute's social responsibilities and managing Intellectual property.

We shall achieve this by establishing and strengthening state-of-the-art Engineering Institute through continual improvement in effective implementation of Educational Organizations Management Systems (EOMS)."

Course Approval Summary

Board of Studies - Department of E&TC Engineering

Sr. No.	Name of the Course	Course Code	Page number	Signature and stamp of BoS chairman
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Approved by Academic Council:

Chairman, Academic Council

Pimpri Chinchwad College of Engineering

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CURRICULUM FRAMEWORK

(2026 Course)

LIST OF ABBREVIATIONS

Sr. No.	Abbreviation	Type of Course
1	PCC	Programme Core Course
2	PEC	Programme Elective Course
3	VSEC	Vocational and Skill Enhancement Course
4	ELC	Experiential Learning Courses

COURSE WISE CREDIT DISTRIBUTION

Sr. No.	Type of Course	No. of Courses	Total Credits	
			NO.	**%**
1	Programme Core Course	**7**	**16**	**20.00**
2	Programme Elective Course	**8**	**20**	**25.00**
3	Vocational and Skill Enhancement Course	**1**	**1**	**1.25**
4	Experiential Learning Courses	**5**	**43**	**53.75**
	Total	**21**	**80**	**100.00**

SEMESTER-WISE COURSE DISTRIBUTION

Course Distribution: Semester Wise						
Sr. No.	**Type of Course**	**No. of Courses / Semester**				**Total**
		1	**2**	**3**	**4**	
1.	Programme Core Course	4	2	-	1	**7**
2.	Programme Elective Course	4	4	-	-	**8**
3.	Vocational and Skill Enhancement Course	-	1	-	-	**1**
4.	Experiential Learning Courses	-	2	2	1	**5**
Total		8	9	2	2	**21**

SEMESTER-WISE CREDIT DISTRIBUTION

Credit Distribution: Semester Wise						
Sr. No.	**Type of Course**	**No. of Credits / Semester**				**Total**
		1	**2**	**3**	**4**	
1.	Programme Core Course	10	4		2	**16**
2.	Programme Elective Course	10	10			**20**
3.	Vocational and Skill Enhancement Course		1			**1**
4.	Experiential Learning Courses		5	20	18	**43**
Total		20	20	20	20	**80**

Curriculum Structure

First Year M. Tech.

E&TC Engineering

CURRICULUM STRUCTURE

M.Tech. (E&TC Engineering) Semester – I

M.Tech E&TC Engineering (Regulations 2026) (With effect from Academic Year 2026-27)															
Semester I															
Course Code	**Course Name**	**Credit Scheme**				**Teaching Scheme (Hours/Week)**			**Evaluation Scheme and Marks**						
		L	**P**	**T**	**Total**	**L**	**P**	**T**	**FA**		**SA**	**TW**	**PR**	**OR**	**Total**
									FA1	**FA2**					
MET31PC01	Digital Design using HDL	**3**	**-**	**-**	**3**	**3**	**-**	**-**	**20**	**20**	**60**	**-**	**-**	**-**	**100**
MET31PC02	Embedded System Design	**3**	**-**	**-**	**3**	**3**	**-**	**-**	**20**	**20**	**60**	**-**	**-**	**-**	**100**
MET31PE01	Elective-I	**3**	**-**	**-**	**3**	**3**	**-**	**-**	**20**	**20**	**60**	**-**	**-**	**-**	**100**
MET31PE02	Elective-II	**3**	**-**	**-**	**3**	**3**	**-**	**-**	**20**	**20**	**60**	**-**	**-**	**-**	**100**
MET31PC03	Digital Design using HDL Lab	**-**	**2**	**-**	**2**	**-**	**4**	**-**	**-**	**-**	**-**	**25**	**-**	**25**	**50**
MET31PC04	Embedded System Design Lab	**-**	**2**	**-**	**2**	**-**	**4**	**-**	**-**	**-**	**-**	**25**	**-**	**25**	**50**
MET31PE03	Elective -I Lab	**-**	**2**	**-**	**2**	**-**	**4**	**-**	**-**	**-**	**-**	**50**	**-**	**-**	**50**
MET31PE04	Elective-II Lab	**-**	**2**	**-**	**2**	**-**	**4**	**-**	**-**	**-**	**-**	**50**	**-**	**-**	**50**
Total		**12**	**8**	**-**	**20**	**12**	**16**	**-**	**80**	**80**	**240**	**150**	**-**	**50**	**600**

L-Lecture, **P**-Practical, **T**-Tutorial,**FA**–Formative Assessment,**SA**-Summative Assessment, **TW**-Term Work, **OR**-Oral, **PR**-Practical

CURRICULUM STRUCTURE

M.Tech. (E&TC Engineering) Semester – II

M.Tech E&TC Engineering (Regulations 2026) (With effect from Academic Year 2026-27)																
Semester II																
Course Code	Course Name	Credit Scheme				Teaching Scheme (Hours/Week)			Evaluation Scheme and Marks							
		L	P	T	Total	L	P	T	FA		SA	TW	PR	OR	Total	
									FA 1	FA 2						
MET32PC05	Research Methodology	2	-	-	2	2	-	-	25	25	-	-	-	-	50	
MET32PE05	Elective-III	3	-	-	3	3	-	-	20	20	60	-	-	-	100	
MET32PE06	Elective-IV	3	-	-	3	3	-	-	20	20	60	-	-	-	100	
MET32PE07	Elective –III Lab	-	2	-	2	-	4	-	-	-	-	25	-	25	50	
MET32PE08	Elective-IV Lab	-	2	-	2	-	4	-	-	-	-	25	-	25	50	
MET32PC06	MOOCS (Project oriented)	2	-	-	2	2	-	-	-	-	-	50	-	-	50	
MET32EL01	Seminar	-	2	-	2	-	4	-	-	-	-	25	-	25	50	
MET32VS01	Skill Development Lab (Oral Communication and Professional Skills)	-	1	-	1	-	2	-	-	-	-	50	-	-	50	
MET32EL02	Mini-Project / Case Study Analysis	-	3	-	3	-	6	-	-	-	-	50	-	50	100	
Total		10	10	-	20	10	20	-	65	65	120	225	-	125	600	

L-Lecture, **P**-Practical, **T**-Tutorial,**FA**–Formative Assessment,**SA**-Summative Assessment, **TW**-Term Work, **OR**-Oral, **PR**-Practical

LIST OF ELECTIVES

List of Program Electives I and II

Subject Code	Elective-I	Subject Code	Elective-II
MET31PE01A	Digital CMOS Design and Analysis	MET31PE02A	VLSI Testing and Design for Testability
MET31PE01B	Device Modeling for VLSI	MET31PE02B	Micro computer Architecture and modeling
MET31PE01C	Advanced Embedded Processors	MET31PE02C	Embedded Processor Architecture and Design
MET31PE01D	Embedded Communication Protocol	MET31PE02D	IOT in Embedded systems

List of Program Electives III and IV

Subject Code	Elective-III	Subject Code	Elective-IV
MET32PE05A	System Verilog For Verification.	MET32PE06A	System on Programmable Chip
MET32PE05B	Analog CMOS design	MET32PE06B	ASIC Design
MET32PE05C	Real Time Operating System	MET32PE06C	Edge Computing
MET32PE05D	Embedded Systems Applications	MET32PE06D	Embedded AI

Curriculum Structure

Second Year M. Tech.

E&TC Engineering

CURRICULUM STRUCTURE

M.Tech. (E&TC Engineering) Semester – III

M.Tech E&TC Engineering (Regulations 2026) (With effect from Academic Year 2026-27)															
Semester III															
Course Code	Course Name	Credit Scheme				Teaching Scheme (Hours/Week)			Evaluation Scheme and Marks						
		L	P	T	Total	L	P	T	FA		SA	TW	PR	OR	Total
									FA1	FA2					
MET33EL03	Dissertation-Phase - I	-	16	-	16	-	32	-	-	-	-	200	-	100	300
MET33EL04	Research/ Industry Internship	-	4	-	4	-	8	-	-	-	-	100	-	-	100
Total		-	20	-	20	-	40	-	-	-	-	300	-	100	400

L-Lecture, **P**-Practical, **T**-Tutorial,**FA**–Formative Assessment,**SA**-Summative Assessment, **TW**-Term Work, **OR**-Oral, **PR**-Practical

M.Tech. (E&TC Engineering) Semester – IV

M.Tech E&TC Engineering (Regulations 2026) (With effect from Academic Year 2026-27)															
Semester IV															
Course Code	Course Name	Credit Scheme				Teaching Scheme (Hours/Week)			Evaluation Scheme and Marks						
		L	P	T	Total	L	P	T	FA		SA	TW	PR	OR	Total
									FA1	FA2					
MET34EL05	Dissertation-Phase - II	-	18	-	18	-	36	-	-	-	-	250	-	100	350
MET34PC07	MOOCS (Interdisciplinary)	-	2	-	2	-	4	-	-	-	-	50	-	-	50
Total		-	20	-	20	-	40	-	-	-	-	300	-	100	400

L-Lecture, **P**-Practical, **T**-Tutorial,**FA**–Formative Assessment,**SA**-Summative Assessment, **TW**-Term Work, **OR**-Oral, **PR**-Practical

Syllabus

Semester -I

M. Tech.

E&TC Engineering

<table>
<tr><td>Program :</td><td colspan="4">M. Tech. (E&TC)-VLSI and Embedded Systems</td><td colspan="3">Semester: I</td></tr>
<tr><td>Course :</td><td colspan="4">Digital Design using HDL</td><td>Code :</td><td colspan="2">MET31PC01</td></tr>
<tr><td rowspan="3">Credits</td><td colspan="3">Teaching Scheme (Hrs./Week)</td><td colspan="4">Evaluation Scheme and Marks</td></tr>
<tr><td rowspan="2">Lecture</td><td rowspan="2">Practical</td><td rowspan="2">Tutorial</td><td colspan="2">FA</td><td rowspan="2">SA</td><td rowspan="2">Total</td></tr>
<tr><td>FA1</td><td>FA2</td></tr>
<tr><td>03</td><td>03</td><td>-</td><td>-</td><td>20</td><td>20</td><td>60</td><td>100</td></tr>
</table>

Prior knowledge of

Digital Logic Design is essential.

Course Objectives:

This course aims at enabling students to

1. Understand Verilog HDL fundamentals, design abstractions, and the digital design flow from RTL to implementation.
2. Develop the ability to model and design combinational and sequential circuits using gate-level, dataflow, and behavioral modeling styles.
3. Apply synthesizable RTL coding practices and design finite state machines (FSMs) for digital systems.
4. Analyze digital circuits using different abstraction levels including structural and switch-level modeling.
5. To construct and verify digital designs using testbenches, self-checking mechanisms, and basic verification methodologies.

Course Outcomes:

After learning the course, the students should be able to:

1. Explain Verilog HDL fundamentals, design abstractions, and the digital design flow from RTL to implementation.
2. Design combinational circuits using gate-level and dataflow modeling techniques in Verilog.
3. Design sequential circuits and finite state machines (FSMs) using behavioral modeling with synthesizable RTL practices.
4. Analyze digital designs across different abstraction levels including structural and switch-level modeling with respect to functionality and timing.
5. Verify digital systems using testbenches, self-checking techniques, and basic verification methodologies.

Detailed Syllabus:

Unit	Description	Duration [Hrs]

1.	**Fundamentals of Verilog HDL and Design Flow** Verilog as HDL, Levels of Design Description, Concurrency, Simulation vs. Synthesis. Lexical conventions, Datatypes, systems tasks and compiler directives, Digital design flow, Module definition, Port declaration, hierarchical referencing	**09**
2.	**Gate level and Dataflow Modeling** Gate Level Modeling: Gate-level modeling: Built-in primitives, strength, delays (rise/fall/turn-off), Delay modeling: min/typ/max delays Dataflow modeling: Continuous assignments, expressions, operators Introduction to synthesis concepts: RTL vs Gate-level mapping, basic synthesis guidelines	**09**
3.	**Behavioral Modeling:** Introduction, Operations and Assignments, Functional Bifurcation, Initial Construct, Always Construct, Design at Behavioral Level FSM modeling (Mealy & Moore machines) **Structural Modeling**: Component declaration, component instantiation,	**09**
4.	**Switch Level Modeling:** MOS transistor modeling using switches, CMOS switches and bidirectional gates, Strength modeling and contention, Delays in switch-level modeling	**09**
5	**Test bench:** Test bench for sequential and combinational circuits, Test pattern generation, test bench with initial block. Introduction to assertions, scoreboards and and self-checking testbenches, Overview of verification flow (RTL verification vs functional verification)	**09**
	Total	45

Text Books:

1. Taraate, Vaibbhav. *Digital Logic Design Using Verilog*. Springer Singapore, Edition 1st . 2022.
2. J. Bhaskar, "A Verilog Primer'', BSP, 2nd edition 2003.

Reference Books:

1. Samir Palnitkar, "Verilog HDL", Pearson Education, 2nd Edition,2003.
2. Thomas and Moorby, "The Verilog Hardware Description Language", kluwer academic publishers, 5th edition, 2002
3. Stephen Brown and ZvonkoVranesic, "Fundamentals of Logic Design with Verilog", TMH publications, 2007.
4. Charles.H.Roth,Jr., Lizy Kurian John "Digital System Design using VHDL" , Thomson, 2nd Edition, 2008

e-sources:

1. http://vol.verilog.com
2. https://www.mooc-list.com/tags/verilog

Program :	M. Tech. (E&TC)-VLSI and Embedded Systems					Semester: I	
Course :	Embedded System Design					Code : MET31PC02	
Credits	Teaching Scheme (Hrs./Week)			Evaluation Scheme and Marks			
	Lecture	Practical	Tutorial	FA		SA	Total
				FA1	FA2		
3	3	-	-	20	20	60	100

Prior knowledge of

Microcontroller Applications and Advanced Microprocessors is Essential.

Course Objectives:

This course aims at enabling students

1. To explain need and application of ARM Microprocessors in embedded system.
2. To introduce basics of the architecture of ARM series microprocessor
3. To explore architecture and features of typical ARM7& ARM Cortex Processors.
4. To improve the skills related interfacing of real world input and output devices and embedded communication systems.

Outcomes:

After learning the course the students should be able to:

1. Apply knowledge about the basic functions of embedded systems.
2. Analyze the evolution of ARM from ARM7 to ARM11.
3. Program ARM7 interfacing configurations for design of application
4. Design interfacing of peripheral with ARM7 microcontroller
5. Evaluate case studies to explore design parameters and its selection in embedded applications.

Detailed Syllabus:

Unit	Description	Duration [Hrs]
1.	**Introduction to Embedded Systems:** Introduction to Embedded Systems, Basic architecture of Embedded System, Design Metrics, Embedded Processor Technology, IC Technology, Embedded System Design Flow, Ideal top-down design process, Design Technology, Development tools, Role of Embedded C.	8

2.	**ARM Processor Architecture:** Introduction to ARM processors and its versions, ARM7, ARM9 & ARM11 features, advantages & suitability in embedded application, registers, CPSR, SPSR, ARM and RISC design philosophy, ARM7 data flow model, programmers model, modes of operations.	**9**
3.	**ARM7 Microcontroller:** Memory Organization and Interfacing, Peripherals and Interfacing Techniques, Embedded C Programming for ARM7, GPIO Interfacing, Communication Protocols: I2C, SPI, UART, Interrupt Handling in ARM7, Real-Time Operating Systems for ARM7	**9**
4.	**Interfacing Techniques:** Analog Sensors Interfacing, 16x2 LCD Display Interfacing, UART Communication Modules Interfacing, Actuators and Control Systems Interfacing, Interfacing Pulse Width Modulation (PWM) Devices, External Memory and Storage Devices Interfacing.	**9**
5.	**Embedded System Design Case Studies:** Automated Meter Reading Systems (AMR), Digital Camera, Multimedia System, Electronic Control Unit (ECU) of Car and Medical Instrumentation. Ant braking System. Introduction Advanced Topics in Embedded: Embedded Computing and Edge Computing.	**10**
	Total	**45**

Text Books:

1. David E. Simon, "An Embedded Software Primer",Perason Education,2003.
2. Frank Vahid and Tony Givargis, "Embedded System Design: A Unified Hardware/Software Introduction", Wiley Publication, 2006.

Reference Books:

1. Noergaard Tammy, "Embedded Systems Architecture", Elsevier Publication, 2005.
2. Shibu," Introduction to Embedded Systems", Tata McGraw-Hill, 2016
3. Rajkamal, Embedded Systems: Architecture, Programming and Design, Tata McGraw-Hill Education, 2008

Program:	**M. Tech (VLSI &Embedded Systems)**	**Semester:**	I
Course:	**Digital CMOS Design and Analysis**	**Code:**	MET31PE01A

Credits	Teaching Scheme (Hrs./Week)			Evaluation Scheme and Marks			
3	Lecture	Practical	Tutorial	FA		SA	Total
				FA1	FA2		
	3	-	-	20	20	60	100

Prior knowledge of

Basic fundamentals of electronic devices and integrated circuits

is essential.

Course Objectives:

This course aims at enabling students to

1. Explain the fundamentals of CMOS Technology and its various performance parameters.
2. Explore the techniques of designing digital VLSI systems.
3. Describe design concepts of data path and memory subsystems

Course Outcomes:

After learning the course, the students should be able to:

1. Explain basic MOS transistor theory and effects of scaling.
2. Estimate the delay of logic networks and also analyse logical efforts
3. Compare combinational circuit design using CMOS, transmission gate and pass transistor logic.
4. Prepare the layout and estimate the area on chip of combinational circuits and sequential using CMOS
5. Explain design principles and techniques of data path and memory subsystems

Detailed Syllabus:

Unit	Description	Duration
1.	**MOS Transistor Theory and Analysis:** Basic Electrical Properties of MOS Circuits: Ids-Vds Relationships, MOS Transistor Threshold Voltage Vth, MOS Capacitance models, MOS Gate Capacitance Model, MOS Diffusion Capacitance Model, Technology scaling, Lambda parameter, non-ideal I-V Effects CMOS Inverter Transfer Characteristics and Analysis and Design, Latch up in CMOS Circuits.	8
2.	**CMOS Performance Parameters:** Static, dynamic and short circuit power dissipations, Propagation delay, Power delay product, Fan in, fan out and dependencies. Delay Estimation: RC Delay Models, Linear Delay Model, Logical Effort, Parasitic Delay. Logical Effort and Transistor Sizing: Delay in a Logic Gate, Delay in Multistage Logic Networks.	8

3.	**Logic Design-I:** Static CMOS Logic: Inverter, NAND Gate, NOR Gate, Design of Combinational logic, Multiplexers, decoders, Compound Gates, Pass Transistors and Transmission Gates, Tristate, Stick Diagram and Layout Design, Design calculations for combinational logic and active area on chip; Hazards, sources and mitigation techniques, Design Examples	10
4.	**Logic Design – II** Timing Metrics for Sequential Circuits, Static Latches and Registers, Dynamic Transmission-Gate Based Edge-triggered Registers, Pulse Registers, Sense-Amplifier Based Registers, Meta-stability issues and solutions; Design Examples,	9
5.	**Datapath and Memory Subsystems:** Adders, Multipliers, Comparators, Parity Generators, Registers and Counters, Introduction to SRAM, DRAM, ROM, Serial access memories; CAM	10
	Total	**45**

Text Books:

1. NeilH. Weste, David Money, "CMOS VLSI Design: A circuit & System Perspective", 3rd Edition Pearson Publication.
2. M. Rabaey, A. Chandrakas an and B. Nikolic, Digital Integrated Circuits: A Design Perspective, Pearson.

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Reference Books:

1. S-M. Kang and Y.Leblebici, CMOS Digital Integrated Circuits: Analysis and Design, Third Edition, McGraw-Hill.
2. Wayne Wolf, "Modern VLSI Design ", third edition, PrenticeHall,1998.

Program:	**M. Tech. (E&TC)-VLSI and Embedded Systems**	**Semester: I**	
Course :	**Device Modelling for VLSI**	**Code :**	**MET31PE01B**

Credits	Teaching Scheme (Hrs./Week)			Evaluation Scheme and Marks			
	Lecture	Practical	Tutorial	FA		SA	Total
				FA1	FA2		
03	03	--	--	20	20	60	100

Prior knowledge of

1. Basic electronics devices and circuits **is essential.**

Course Objectives:

This course aims at enabling students to

1. Understand various device modeling techniques with analytical, and numerical approaches.
2. Explore advanced device models such as high-frequency.
3. Learn methods for validating device models through comparison with experimental data or theoretical predictions.

Course Outcomes:

After completion of this course, students will be able to,

1. Explain semiconductor device physics, and device operation principles.
2. Develop proficiency in using simulation tools to model semiconductor devices and circuits accurately.
3. Utilize device models to optimize the design of integrated circuits.
4. Apply device modeling techniques to solve engineering problems related to circuit design, optimization, and performance prediction.
5. Analyze device models, understand their limitations, and select appropriate models for specific applications.

Detailed Syllabus:

Unit	Description	Duration
1.	**MOSFET Fundamentals: MOS** capacitor structure and operation. MOSFET operation modes. **Advanced Semiconductor Devices:** High-frequency effects in semiconductor devices, Temperature-dependent behaviour and thermal effects, Reliability considerations: breakdown mechanisms, aging effects. **Device Modelling Basics:** Introduction to device modelling: empirical, analytical, and numerical methods, Overview of SPICE and TCAD simulation tools for device modelling.	**9**
2.	**Introduction to Simulation Tools:** Overview of simulation tools used in VLSI design. Introduction to SPICE (Simulation Program with Integrated Circuit Emphasis) / TCAD (Technology Computer-Aided Design) tools. **Basic SPICE Simulation:** Understanding SPICE syntax and input file formats. Building basic circuit models for passive components and ideal sources. Performing DC, AC, and transient analyses. Modelling semiconductor device characteristics	**9**

3.	**Introduction to IC Design Optimization**: Overview of design optimization objectives. Importance of accurate device modeling in IC design optimization. **Device Modeling Techniques for Optimization:** Modeling techniques: empirical, analytical, and numerical. Parameter extraction methods for accurate device modeling. **Power Consumption Optimization:** Understanding power consumption sources in ICs: dynamic power, static power, and leakage power. Power optimization techniques including voltage scaling, clock gating, and power gating.	**9**
4.	**Introduction to Device Modelling Applications:** Overview of the role of device modelling in circuit design, optimization, and performance prediction. Importance of accurate device models in engineering problem-solving. **Modelling Techniques for Circuit Design:** Introduction to compact models for circuit simulation. Techniques for designing and optimizing electronic circuits using device models.	**9**
5	**Understanding Device Limitations:** Identifying key parameters and characteristics of devices, Sources of inaccuracies and limitations in device models. Matching device models to application requirements. Selecting between different types of device models. **Advanced Topics in Device Modelling** :Multi-scale modelling approaches Machine learning and artificial intelligence techniques in device modelling Emerging trends and future directions in device modelling.	9
	Total	45

Text Books:

1. Semiconductor Device Modeling With Spice / Edition 1 by Paolo Antognetti, Giuseppe Massabrio, SBN-13:9780071349550 ,12/01/1998,McGraw Hill LLC
2. Compact Modeling: Principles, Techniques and Applications. Editor, Gennady Gildenblat. Edition, illustrated. Publisher, Springer Science & Business Media, 2010.

Reference Books:

1. Device Modeling for Analog and RF CMOS Circuit Design. TrondYtterdal, Yuhua Cheng, Tor A. Fjeldly. ISBN: 978-0-470-86434-0 August 2003
2. Advanced semiconductor fundamentals / Robert F. Pierret ; Publication details: USA Pearson Education 2003 ; Edition: 2nd ed
3. Compact Models for Integrated Circuit Design : : Conventional Transistors and Beyond. by: Saha, Samar K. Published: (2015.)

e-sources:

1. IISc Microelectronics Course - VLSI Online Training

<table>
<tr><td>Program:</td><td colspan="5">M. Tech. (E&TC)-VLSI and Embedded Systems</td><td>Semester:</td><td>I</td></tr>
<tr><td>Course:</td><td colspan="5">Advanced Embedded Processors</td><td colspan="2">Code: MET31PE01C</td></tr>
<tr><td rowspan="3">Credit</td><td colspan="3" rowspan="2">Teaching Scheme (Hrs./Week)</td><td colspan="4">Evaluation Scheme and Marks</td></tr>
<tr><td colspan="2">FA</td><td rowspan="2">SA</td><td rowspan="2">Total</td></tr>
<tr><td>Lecture</td><td>Practical</td><td>Tutorial</td><td>FA1</td><td>FA2</td></tr>
<tr><td>03</td><td>03</td><td>--</td><td>--</td><td>20</td><td>20</td><td>60</td><td>100</td></tr>
</table>

Course Objectives:

This course aims at enabling students to

1. Develop a strong foundational understanding of embedded systems and processor evolution.
2. Cultivate proficiency in analyzing, designing, and implementing ARM-based processor systems, utilizing ARM development tools effectively.
3. Foster critical thinking and problem-solving skills through practical exercises and projects focusing on SoC design and embedded system security.

Course Outcomes:

After completion of this course, students will be able to,

1. Explain embedded systems basics, processor evolution, and ARM architecture's and Cortex-M series's significance.
2. Comprehend ARM processor architecture, including instruction sets, operating modes, and key features of ARM Cortex-M variants.
3. Utilize ARM development tools for cross-compiling, debugging, optimization, and troubleshooting.
4. Demonstrrate the knowledge and skills to design and integrate processors, memories, and peripherals into SoC architectures.
5. Identify and mitigate embedded system security threats, implement secure booting mechanisms, and design secure communication protocols.

Detailed Syllabus:

Unit	Description	Duration
1.	**Introduction to Embedded Processors** Basics of embedded systems, design challenges, evolution of processors (CISC, RISC), embedded processor applications, ARM architecture introduction, ARM Cortex-M overview, ARM advantages, industry adoption, trends in embedded processors (low-power, AI acceleration).	9
2.	**ARM Architecture Fundamentals** ARM processor architecture, core components, ARM instruction sets (ARM, Thumb, Thumb-2), ARM operating modes, exception handling, ARM registers, memory organization, ARM Cortex-M variants, key features, ARM design considerations (power, performance, cost), advanced ARM features (NEON, TrustZone).	9
3.	**ARM Development Tools** ARM toolchain overview (compilers, debuggers, IDEs), ARM cross-compilation, build systems, debugging techniques (JTAG, SWD), emulators, simulators, virtual platforms, real-time analysis, profiling	9

	tools, code optimization tools, optimization techniques, integrating ARM tools into workflows, troubleshooting, debugging common issues.	
4.	**System-on-Chip (SoC) Design** SoC design fundamentals, challenges, integration of processors, memories, peripherals, advanced SoC architectures (multicore, heterogeneous), hardware accelerators, co-processors, low-power SoC design techniques, FPGA-based SoC design, prototyping, case studies, examples of SoC designs.	9
5	**Embedded System Security** Introduction to system security, threats, secure booting, chain of trust, cryptographic principles, algorithms, hardware security modules, trusted execution environments, secure communication protocols (TLS, IPsec), secure software development practices, security case studies, real-world examples, implementing security measures, future trends in embedded system security.	9
	Total	45

Text Books:

1. Steve Furber, "ARM System-on-Chip Architecture", Addison-Wesley Professional, 2nd Edition, 2000.
2. Joseph Yiu, "The Definitive Guide to ARM Cortex-M3 and Cortex-M4 Processors", Newnes, 3rd Edition, 2013.
3. David Kleidermacher and Mike Kleidermacher, "Embedded Systems Security: Practical Methods for Safe and Secure Software and Systems Development", Newnes, 1st Edition, 2012.
4. Peter Marwedel, "Embedded System Design: Embedded Systems Foundations of Cyber-Physical Systems", Springer, 3rd Edition, 2018.

Reference Books:

1. Peter Cockcroft, "ARM Assembly Language Programming", CRC Press, 1st Edition, 2021.
2. Andrew N. Sloss, Dominic Symes, and Chris Wright, "ARM System Developer's Guide: Designing and Optimizing System Software", Morgan Kaufmann, 1st Edition, 2004.
3. Chris P. Freeman, "Exploring ARM Processor Architectures: The Fundamentals", CRC Press, 1st Edition, 2022.
4. M. Ghaseemirizadeh and A. Ghaseemirizadeh, "Embedded System Design with ARM Cortex-M Microcontrollers", CRC Press, 1st Edition, 2022.
5. Mohammad S. Obaidat and Noureddine A. Boudriga, "Embedded System Security: Threats, Vulnerable Points, and Countermeasures", CRC Press, 1st Edition, 2022.
6. Jack Ganssle and Michael Barr, "Embedded Security: A Guide for the Uncharted World of Embedded Computing", CRC Press, 1st Edition, 2021.
7. Robert C. Seacord, "Secure Coding Principles and Practices", Addison-Wesley Professional, 1st Edition, 2021.

Program :	M. Tech. (E&TC)-VLSI and Embedded Systems						Semester: I
Course :	Embedded Communication Protocols						Code : MET31PE01D
Credits	**Teaching Scheme (Hrs./Week)**			**Evaluation Scheme and Marks**			
	Lecture	**Practical**	**Tutorial**	**FA**		**SA**	**Total**
				FA1	**FA2**		
3	**3**	**-**	**-**	**20**	**20**	**60**	**100**

Prior Knowledge of

Microcontrollers, Microprocessors Programming language 'C', Embedded C **is essential.**

Course Objectives:

This course aims at enabling students to

1. Explain Serial and parallel communication protocols
2. Perform Application Development using wired and wireless communication protocols

Outcomes:

After learning the course the students should be able to:

1. Select Protocols for real time Application
2. Interface USB protocol for real time applications.
3. Program and Interface CAN based communication protocol.
4. Select appropriate wireless protocol on the basis of applications
5. Design and estimate use of communication protocol in real time applications

Detailed Syllabus:

Unit	Description	Duration (Hrs)
1.	**Embedded Communication Protocols** Embedded Networking: Introduction–Serial / Parallel Communication–Serial communication protocols -RS232 standard – RS485 – Synchronous Serial Protocols - Serial Peripheral Interface (SPI) – Inter Integrated Circuits (I2C) – PC Parallel port programming -ISA/PCI Bus protocols – Firewire	**10**
2.	**USB and CAN bus** USB bus – Introduction – Speed Identification on the bus – USB States – USB bus communication: Packets –Data flow types –Enumeration –Descriptors – Microcontroller USB Interface, CAN Bus – Introduction - Frames –Bit stuffing –Types of errors – Nominal Bit Timing	**9**
3.	**Controller Area Network** Controller Area Network – Underlying Technology, CAN Overview – Selecting a CAN Controller – CAN development tools. Implementing CAN open Communication layout and requirements – Comparison of implementation methods – Micro CAN open – CAN open source code – Conformance test – Entire design life cycle.	**8**

Program :	M. Tech. (E&TC)-VLSI and Embedded Systems					Semester: I	
Course :	**Embedded Communication Protocols**					**Code : MET31PE01D**	
Credits	**Teaching Scheme (Hrs./Week)**			**Evaluation Scheme and Marks**			
	Lecture	**Practical**	**Tutorial**	**FA**		**SA**	**Total**
				FA1	**FA2**		
3	**3**	**-**	**-**	**20**	**20**	**60**	**100**

4.	**Wireless Protocol;** Zigbee, Bluetooth protocol, WiFi Protocol, DSRC Communication protocol in Vehicles, RFID, GSM, GPRS, Radar, LIDAR	**8**
5.	Embedded Communication based applications : Embedded systems in Automotive applications, Communication Protocols in vehicles, Communication in IOT systems examples, Communication in Multimedia	**10**
	Total	**45**

Text Books:

1. Frank Vahid, Givargis “Embedded Systems Design: A Unified Hardware/Software Introduction”, Wiley Publications
2. BhaskarKrishnamachari, “Networking wireless sensors”, Cambridge press 2005
3. GlafP.Feiffer, Andrew Ayre and Christian Keyold, “Embedded networking with CAN and CAN open”, Embedded System Academy 2005.

Reference Books:

1. Jan Axelson, ‘Parallel Port Complete’, Penram publications
2. Jan Axelson ‘Embedded Ethernet and Internet Complete’, Penram publications.
3. Tanenbaum, Andrew “Computer Networks” 4th Edition , Pearson Education Pte. Ltd., Delhi,
4. Stallings, William, “Data and Computer Communications” 6th Edition, Pearson Education Pte., Ltd., Delhi,

Program:	M. Tech. (E&TC)-VLSI and Embedded Systems					Semester:	I
Course:	VLSI Testing and Design for Testability					Code:	MET31PE02A
Credits	Teaching Scheme (Hrs./Week)			Evaluation Scheme and Marks			
	Lecture	Practical	Tutorial	FA		SA	Total
				FA1	FA2		
3	3	-		20	20	60	100

Course Objectives:

This course aims at enabling students to:

1. Understand the fundamentals of VLSI testing methodologies.
2. Analyze VLSI technology trends and their impact on testing strategies.
3. Apply design verification techniques and evaluate test effectiveness.
4. Explain Built-In Self-Test (BIST) architectures and their implementation concepts.
5. Explain boundary scan testing techniques and standards.

Course Outcomes:

After completion of this course, students will be able to,

1. Demonstrate comprehension of testing philosophies, digital VLSI testing methods, fault modelling, and the significance of testing in ensuring VLSI design reliability.
2. Develop skills in logic and fault simulation for design verification, including circuit modelling, true value/fault simulations, and applying ATPG algorithms.
3. Apply expertise in SCOAP and DFT techniques and analyze methods for enhancing testability and simplifying testing processes.
4. Demonstrate mastery in implementing BIST systems, including random logic BIST, pattern generation, response compaction, and selecting appropriate BIST architectures for different types of faults.
5. Exhibit proficiency in the Boundary Scan Standard, configuring systems, interpreting test instructions, and proficiently using Boundary Scan Description Language for scan chain and pin configurations.

Detailed Syllabus:

Unit	Description	Duration
1.	**Introduction to Testing:** Testing Philosophy, Role of Testing, Digital VLSI Testing, VLSI Technology Trends affecting Testing, Types of Testing, Fault Modeling: Defects, Errors, and Faults, Functional Versus Structural Testing, Levels of Fault Models, Single Stuck-at Fault.	9
2.	**Logic and Fault Simulation:** Simulation for Design Verification and Test Evaluation, Modeling Circuits for Simulation, Algorithms for True-value Simulation, Algorithms for Fault Simulation, ATPG.	9
3.	**Testability Measures:** SCOAP Controllability and Observability, High Level Testability Measures, Digital DFT and Scan Design: Ad-Hoc DFT Methods, Scan Design, Partial-Scan Design, Variations of Scan.	9

4.	**Built-In Self-Test**: The Economic Case for BIST, Random Logic BIST: Definitions, BIST Process, Pattern Generation, Response Compaction, Built-In Logic Block Observers, Test-Per-Clock, Test-Per Scan BIST Systems, Circular Self-Test Path System, Memory BIST, Delay Fault BIST.	9
5	**Boundary Scan Standard:** Motivation, System Configuration with Boundary Scan: TAP Controller and Port, Boundary Scan Test Instructions, Pin Constraints of the Standard, Boundary Scan Description Language: BDSL Description Components, Pin Descriptions.	9
	Total	**45**

Text Books:

1. M.L. Bushnell, V. D. Agrawal, "Essential of Electronic Testing for Digital, Memory and Mixed Signal VLSI Circuits", Kluwer Academic Publishers.

Reference Books:

1. M Abromovici, M A Breuer & A. D. Friedman "Digital Systems Testing and Testable Design ", Jaico Publications, Paperback Impression, 2001.
2. H. Fujiwara, "Logic Testing and Design for testability" MIT Press, 1985.
3. P. K. Lala, "Digital Circuits Testing and Testability", Academic Press.

NPTEL Online Courses / MOOCs

1. https://onlinecourses.nptel.ac.in/noc20_ee76/preview(Digital VLSI Testing)

Program :	M. Tech. (E&TC)-VLSI and Embedded Systems						Semester: I	
Course :	Micro computer Architecture and modelling						Code :	MET31PE02B

Credits	Teaching Scheme (Hrs./Week)			Evaluation Scheme and Marks			
	Lecture	Practical	Tutorial	FA		SA	Total
				FA1	FA2		
03	03	--	--	20	20	60	100

Prior knowledge of

1. Basic computer organization and architecture and HDL

is essential.

Course Objectives:

This course aims at enabling students to:

1. Understand the fundamentals of microcomputer architecture, including instruction set architecture (ISA), memory hierarchy, and I/O subsystems.
2. Analyze advanced microarchitecture design concepts and techniques.
3. Evaluate microcomputer architectures in terms of performance, power consumption, and reliability.
4. Explore emerging trends and technologies in microcomputer design.

Course Outcomes:

After completion of this course, students will be able to,

1. Describe the key components and organization of a microcomputer system, including the CPU, memory subsystem, and I/O interfaces.
2. Analyse and compare different microcomputer architectures based on their performance, power efficiency, and scalability.
3. Design and implement basic microarchitectural features such as pipelining, instruction-level parallelism, and memory hierarchy optimizations.
4. Develop models and simulations of microcomputer systems using industry-standard tools such as Verilog, VHDL, or System Verilog.
5. Evaluate the performance and efficiency of microcomputer architectures through simulation, profiling, and benchmarking techniques.

Detailed Syllabus:

Unit	Description	Duration
1.	**Introduction to Microcomputer Systems,Central Processing Unit (CPU):** Role and function of the CPU in a microcomputer system, Components of ALU, CPU architecture and instruction set architecture (ISA), Types of instruction formats and addressing modes. **Memory Subsystem:** Types of memory, Memory hierarchy, management techniques. Memory organization and addressing schemes. **Input/Output (I/O) Interfaces:** Role of I/O interfaces in connecting external devices to the microcomputer system, Types of I/O devices, operations. Communication protocols and standards for I/O interfaces (e.g., USB, PCI).	8

2.	Instructions and Operations: MIPS Architecture, MIPS subroutine. Addition, Subtraction, Logic Operations and ALU Design, Multiply, Shift and Divide, Floating Point arithmetic and, Designing a single cycle datapath	**8**
3.	Single cycle control, Designing a multicycle Processor,Exceptions and pipelining basics, Pipeline data path design.Pipeline control and exceptions, Memory Hierarchy and Cache Design	**8**
4.	**Introduction to Verilog/ VHDL for microcomputer design:** Microarchitecture Design: CPU architecture overview (e.g., RISC, CISC),Instruction set architecture (ISA) design,Pipeline architecture design.Designing basic components: registers, multiplexers, ALU,Developing modules for CPU components: control unit, arithmetic logic unit (ALU), registers,Hierarchical design and module instantiation.	**8**
5	Calculating and improving cache performance.Cache Associativity and Virtual Memory.VLIW processor Introduction, Instruction Scheduling,Compiler Design issues , 32 bit processor architecture: case study-1, 64 bit processor architecture: case study	8
	Total	45

Text Books:

1. "RTL Hardware Design Using VHDL: Coding for Efficiency, Portability, and Scalability" by Pong P. Chu.
2. "Computer Organization and Design: The Hardware/Software Interface" by David A. Patterson and John L. Hennessy.
3. "Digital Design: With an Introduction to the Verilog HDL" by M. Morris Mano and Michael D. Ciletti.

Reference Books:

1. Verilog HDL: A guide to Digital design and Synthesis by Samir Palnitkar (softcopy available in Digilib)
2. Computer Organization & Design, The Hardware/Software Interface by David A. Patterson and John L. Hennessy, 2004
3. Computer Architecture: A Quantitative Approach by David A. Patterson and John L. Hennessy, 2006

e-sources:

1. IISc Microelectronics Course - VLSI Online Training

Program :	M. Tech. (E&TC)-VLSI and Embedded Systems					Semester: I	
Course :	**Embedded Processor Architecture and Design**					**Code : MET31PE02C**	
Credits	**Teaching Scheme (Hrs./Week)**			**Evaluation Scheme and Marks**			
	Lecture	**Practical**	**Tutorial**	**FA**		**SA**	**Total**
				FA1	**FA2**		
3	**3**	**-**	**-**	**20**	**20**	**60**	**100**

Prior Knowledge of

Basics of Embedded Systems, VHDL programming **Is Essential**

Course Objectives:

This course aims at enabling students to:

1. Explain the fundamental architectural concepts of processor design.
2. Analyze memory management techniques in CISC and RISC processors.
3. Understand architectural features and design considerations of digital signal processors (DSP).
4. Explore runtime reconfigurable processor architectures and their applications.

Course Outcomes:

After learning the course the students should be able to:

1. Apply knowledge about basic components of embedded processor architecture and visualize probable Problems, fallacies and Pitfalls in Processor Design.
2. Explain Extreme CISC and RISC, Very Long Instruction Word (VLIW), overly aggressive pipelining, unbalanced processor.
3. Implement Processor functional components like Datapath and Control..
4. Analyse the difference between DSP and Customizable processor architecture.
5. Select appropriate Clock distribution and power distribution in SoC design.

Detailed Syllabus:

Unit	Description	Duration (Hrs)
1.	**Embedded Computer Architecture Fundamentals I:** Components of an embedded computer, Architecture organization, ways of parallelism, I/O operations and peripherals. Problems, Fallacies, and Pitfalls in Processor Design for a high level computer instruction set architecture to support a specific language or language domain. Use of intermediate ISAs to allow a simple machine to emulate it's betters, stack machines, overly aggressive pipelining, unbalanced processor design, Omitting pipeline interlocks, Non-power-of-2 data-word widths for general-purpose computing	**9**
2.	**Processor Design Flow and Memory :** Capturing requirements, Instruction coding, Exploration of architecture organizations, hardware and software development. Extreme CISC and extreme RISC, Very long instruction word (VLIW).Memory: Organization, Memory segmentation, Multithreading, Symmetric multiprocessing.	**8**

Program :	M. Tech. (E&TC)-VLSI and Embedded Systems					Semester: I	
Course :	Embedded Processor Architecture and Design					Code : MET31PE02C	
Credits	Teaching Scheme (Hrs./Week)			Evaluation Scheme and Marks			
	Lecture	Practical	Tutorial	FA		SA	Total
				FA1	FA2		
3	3	-	-	20	20	60	100

3.	**Processor Design Methodology:** CISC Processor Design: Defining microprocessor, hardware flowchart, implementing from flowchart, exception, control store, microcode design. RISC Processor Design: Building data path and controller, single cycle implementation, multi cycle implementation, pipelined implementation, exception and hazards handling.	10
4.	**Digital Signal Processor:** Digital signal processor and its design issues, evolving architecture of DSP, next generation DSP. **Customizable processors:** Customizable processors and processor customization, **Run time Re-configurable Processors:** Run time Re-configurable Processors, Embedded micro-processor trends, instruction set metamorphosis, reconfigurable computing.	8
5.	**Clock Generation and Distribution:** Clock parameters and trends, Clock distribution networks, de-skew circuits, jitter reduction techniques, low power clock distribution. **Power Distribution and consumption:**Impact of physical technology, trends in power consumption, low power techniques, low voltage techniques. **Asynchronous Processor Design:** Asynchronous and self-timed processor design, need of asynchronous design, development of asynchronous processors, asynchronous design styles, features of asynchronous design.	10
	Total	**45**

Text Books:

1. NurmiJari,“ Processor Design-System on Chip Computing for ASICs and FPGA”, Springer Publications.
2. Frantz G, “The DSP and Its Impact on the Technology”.
3. JP Shen and MH Lipasti, Modern Processor Design, MC Graw Hill, Crowfordsville, 2005

Reference Books:

1. Leibson S, Tensilica, “Customizable Processors and Processor Customization”.
2. Campi F, “Run-Time Reconfigurable Processors”.
3. Garside J, Furber S, “Asynchronous and Self-Timed Processor Design”.
4. Rusu S, “Processor Clock Generation and Distribution”.
5. Dehon Andre, “Reconfigurable Architecture for General purpose Computing”.

<table>
<tr><td>Program :</td><td colspan="5">M. Tech. (E&TC)-VLSI and Embedded Systems</td><td colspan="2">Semester: I</td></tr>
<tr><td>Course :</td><td colspan="5">IoT in Embedded Systems</td><td>Code:</td><td>MET31PE02D</td></tr>
<tr><td rowspan="3">Credits</td><td colspan="3">Teaching Scheme (Hrs./Week)</td><td colspan="4">Evaluation Scheme and Marks</td></tr>
<tr><td rowspan="2">Lecture</td><td rowspan="2">Practical</td><td rowspan="2">Tutorial</td><td colspan="2">FA</td><td rowspan="2">SA</td><td rowspan="2">Total</td></tr>
<tr><td>FA1</td><td>FA2</td></tr>
<tr><td>03</td><td>03</td><td>-</td><td>-</td><td>20</td><td>20</td><td>60</td><td>100</td></tr>
</table>

Prior knowledge of

Digital Communication, Microcontrollers & Computer Networks **is essential.**

Course Objectives:

This course aims at enabling students to:

1. Understand the fundamentals of IoT and embedded systems, including design strategies and process modeling.
2. Analyze advanced concepts in embedded IoT systems and their networking aspects.
3. Design low-cost embedded IoT systems using an integrated and systematic approach.
4. Explain security fundamentals in IoT and evaluate real-world applications with respect to their societal and economic impact.

Course Outcomes:

After learning the course, the students should be able to:

1. Describe basic components of IoT and identify different components of IoT based design
2. Demonstrate the knowledge of basics of Embedded System.
3. Select IoT protocols for designing of IoT based application
4. Apply appropriate security mechanisms for IoT based real time applications
5. Select appropriate cloud platform for IoT based applications.

Detailed Syllabus:

Unit	Description	Duration [Hrs]
1	**Introduction to Internet of Things** IoT: Definition and characteristics of IoT, Sensors, actuators and other devices employed in IoT, Physical design of IoT, Logical design of IoT, IoT architecture, IoT Gateway, IoT Issues and Challenges, IoT Enabling Technologies.	9
2	**Introduction to Internet of Things** An introduction to Embedded System, Types and applications of embedded system, The embedded system constraints: Processing units: microprocessors, microcontrollers, SoCs, ASICs, DSPs, FPGAs, etc.	9
3	**IoT Protocols** Introduction to IoT Protocols: Bluetooth, Zigbee, Wi-Fi, IPv4, IPv6, 6LowPAN, Mod Bus, CAN bus, MQTT, CoAP, AMQP	9

4	**IoT Security** Vulnerabilities of IoT, Security Requirements, Challenges for Secure IoT, Key elements of IoT Security: Identity establishment, Access control, Data and message security, IoT attacks, Security model for IoT	9
5	**Cloud Offerings:** Introduction to Cloud: Thingspeak, IFTTT, Case Studies: Home Automation System, Home Intrusion System, Smart irrigation system, Waste Management System.	9
	Total	45

Text Books:

1. ArshdeepBahga and Vijay Madisetti, Internet of Things: A Hands-on Approach, Universities Press, 2017.

2. Pethuru Raj and Anupama C. Raman, The Internet of Things: Enabling Technologies, Platforms, and Use Cases ,CRC Press, 2017.

3. Raspberry Pi Cookbook, 3rd Edition, by Simon Monk, Publisher: O'Reilly Media, Inc., 2019, ISBN: 978149204322

Reference Books:

1. WaltenegusDargie, Christian Poellabauer, "Fundamentals of Wireless Sensor Networks: Theory and Practice"
2. Daniel Minoli, ―Building the Internet of Things with IPv6 and MIPv6: The Evolving World of M2M Communications‖, ISBN: 978-1-118-47347-4, Wiley Publications
3. Olivier Hersent, David Boswarthick, and Omar Elloumi, ―The Internet of Things: Key Applications and Protocols‖, Wiley Publications
4. HakimaChaouchi, ― The Internet of Things Connecting Objects to the Web‖ ISBN : 978- 1-84821-140-7, Wiley Publications

<table>
<tr><td>Program</td><td colspan="3">M.Tech. E&TC- VLSI and Embedded Systems</td><td>Semester</td><td colspan="3">I</td></tr>
<tr><td>Course</td><td colspan="3">Digital Design using HDL Lab</td><td>Code</td><td colspan="3">MET31PC03</td></tr>
<tr><td rowspan="2">Credits</td><td colspan="3">Teaching Scheme (Hrs./Week)</td><td colspan="4">Evaluation Scheme and Marks</td></tr>
<tr><td>Lecture</td><td>Practical</td><td>Tutorial</td><td>TW</td><td>PR</td><td>OR</td><td>Total</td></tr>
<tr><td>2</td><td>-</td><td>4</td><td>-</td><td>25</td><td>-</td><td>25</td><td>50</td></tr>
</table>

Prior knowledge of: Digital logic design is essential.
Course Objectives: This course aims at enabling students to: 1. Understand behavioral and RTL modeling of digital circuits using Verilog HDL, including verification and synthesis of RTL designs on FPGAs. 2. Design digital circuits through modeling, implementation, and verification using industry-relevant practices.
Course Outcomes: After learning the course, the students will be able to: 1. Design combinational and sequential digital circuits using Verilog HDL. 2. Implement digital designs on FPGA platforms using synthesis and hardware verification. 3. Verify HDL models using test benches and simulation tools.

Detailed Syllabus

Assignment No.	Suggested List of Assignments (Any 6)
1.	**Introduction to Front-End Design Flow and PLDs (FPGA)** a. Study the front-end design flow: specification → RTL design → simulation → synthesis → implementation b. Introduction to Programmable Logic Devices (PLDs) and FPGAs
2.	**Modeling of Adders – Half and Full Adder** a. Model adders using dataflow and structural modeling b. Perform synthesis and verify functionality using a testbench c. Implement the verified design on FPGA
3.	**Modeling of Arithmetic Logic Unit (ALU)** a. Design an ALU supporting at least 8 arithmetic and logical operations using behavioral modeling b. Perform synthesis and verify using test bench. c. Implement the verified design on FPGA
4.	**Modeling of Multiplexer and Decoder.** a. Model n:1 Multiplexer and n: 2n decoder using behavioral meddling b. Perform synthesis and verify using test bench. c. Implement the verified design on FPGA.
5.	**Modeling a Flip Flop and shift register** a. Model Flip flops with Active low asynchronous reset and active high synchronous reset b. Design shift registers using behavioral modeling c. Perform synthesis and verify using test bench. d. Implement the verified design on FPGA
6.	**FSM-Based Sequence Detector Design** a. Write Verilog code for a sequence detector FSM using both Moore and Mealy machines b. Detect alternating sequence “1010” or “0101” (4-bit pattern) c. Verify using a testbench and implement on FPGA

7.	**Modeling a counter** a. Model a counter using behavioral modeling b. Perform synthesis and verify using test bench. **c.** Implement the verified design on FPGA.

Reference Books:

1. Fundamentals of Digital Logic with Verilog Design - Stephen Brown,ZvonkocVranesic, TMH, 2nd Edition.2010
2. Advanced Digital Logic Design using Verilog, State Machines & Synthesis for FPGA - Sunggu Lee, Cengage Learning, 2012.
3. Verilog HDL - Samir Palnitkar, 2nd Edition, Pearson Education, 2009.
4. Advanced Digital Design with Verilog HDL - Michel D. Ciletti, PHI,2009

Program	M.Tech. E&TC- VLSI and Embedded Systems				Semester	I	
Course	**Embedded System Design Lab**				Code	MET31PC04	
Credits	**Teaching Scheme (Hrs./Week)**			**Evaluation Scheme and Marks**			
	Lecture	**Practical**	**Tutorial**	**TW**	**PR**	**OR**	**Total**
2	-	4	-	25	-	25	50

Prior knowledge of

Microcontroller Applications and Advanced Microprocessors **Is Essential.**

Course Objectives:

This course aims at enabling students to:

1. Understand the architecture and features of the ARM7 processor.
2. Apply the software design flow for ARM7 using Keil development tools.
3. Develop skills for interfacing real-world input/output devices and embedded communication systems.

Outcomes:

After learning the course the students should be able to:

1. Apply multi-pin functionality of ARM7 Pin connect block for GPIO interfacing.
2. Write an ARM 7 microcontroller-based programs to interface various peripherals
3. Implement interfacing for peripheral-specific applications.

Guidelines :

Total experiments to be conducted are **6 experiments of 24 hours**

Detailed Syllabus:

Expt.	**Description**	**Duration** (Hrs)
1.	Design and Configure programming model for GPIO in ARM7 Implement LED Blinking on pressing a switch using GPIO	**6**
2.	Design and configure GPIO for Keypad and LCD interfacing with ARM7 Implement Keypad and LCD interfacing on LPC2148	**6**
3.	Design and configure UART Programming model and Implement of UART interfacing with ARM7 board and PC for sending and receiving message.	**6**
4.	Design and configure External Interrupt handling using External Interrupt Pin : P0.30 (EINT3) Implement response program for handling external interrupt	**6**
5.	Design and configure register model I2C protocol Implement I2C protocol for interfacing on board EEPROM	**6**

6.	Design and implement Temperature control circuit using LM 35 and DC motor (PWM Generation)	**6**
7.	Design and Implement RTC interfacing with ARM7 and LCD display	**6**
8.	Design Real time Application using ARM 7 and peripheral : A Case Study	**12**
	Total	**60**

Text Books:

1. David E. Simon, "An Embedded Software Primer", Perason Education,2003.
2. UM10139 LPC214x User manual, NXP Semiconductor, https://www.nxp.com

Reference Books:

1. Shibu," Introduction to Embedded Systems", Tata McGraw-Hill, 2016
2. Rajkamal, Embedded Systems: Architecture, Programming and Design, Tata McGraw-Hill Education, 2008

Program	M.Tech. E&TC- VLSI and Embedded Systems			Semester	I		
Course	**Digital CMOS Design and Analysis Lab**			**Code**	**MET31PE03A**		
Credits	**Teaching Scheme (Hrs./Week)**			**Evaluation Scheme and Marks**			
	Lecture	**Practical**	**Tutorial**	**TW**	**OR**	**PR**	**Total**
2	-	4	-	50	-	-	50

Prior knowledge of:
Digital Systems **is essential.**

Course Objectives:
This course will enable students
1. To illustrate fundamentals of NMOS, PMOS and CMOS
2. To expose to practical experience by designing, modelling, implementing and verifying several digital circuits.

Course Outcomes:
After learning the course, the students will be able to:
1. Analyse the characteristics of NMOS, PMOS and CMOS circuits
2. Demonstrate the function of digital circuits using suitable tool
3. Design the layout of combinational and sequential circuits

Detailed Syllabus:

Expt. No.	Description	Duration
1	To plot the (i) output characteristics & (ii) transfer characteristics of an n-channel and p-channel MOSFET.	2
2	To design and plot the static (VTC) and dynamic characteristics of a digital CMOS inverter.	2
3	To design and plot the output characteristics of a 3-inverter ring oscillator.	6
4	To design and plot the dynamic characteristics of 2-input NAND, NOR, XOR and XNOR logic gates using CMOS technology	6
5	To design and plot the characteristics of a 4x1 digital multiplexer using pass transistor logic.	6
6	To design and plot the characteristics of a positive and negative latch based on multiplexers.	6
7	To design and plot the characteristics of a master-slave positive and negative edge triggered registers based on multiplexers.	6
8	To design and implement memory subsystem	6
9	To prepare a stick diagram and layout of combinational circuit	4
10	To prepare a stick diagram and layout of sequential circuit	4
11	Miniproject / Case study implementation	12
	Total	**60**

Text Books:

NeilH. Weste, David Money, "CMOS VLSI Design: A Circuit & System Perspective", 3rd Edition Pearson Publication.

M. Rabaey, A.Chandrakas and B. Nikolic, Digital Integrated Circuits: A Design Perspective, Pearson.

Reference Books:

S-M. Kang and Y.Leblebici, CMOS Digital Integrated Circuits: Analysis and Design, Third Edition, McGraw-Hill.

Wayne Wolf," Modern VLSI Design ",third edition 2ndEdition,PrenticeHall,1998.

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<table>
<tr><td>Program</td><td colspan="3">M.Tech. E&TC- VLSI and Embedded Systems</td><td colspan="2">Semester</td><td colspan="2">I</td></tr>
<tr><td>Course</td><td colspan="3">Device Modelling for VLSI Lab</td><td colspan="4">Code: MET12PE03B</td></tr>
<tr><td rowspan="2">Credits</td><td colspan="3">Teaching Scheme (Hrs./Week)</td><td colspan="4">Evaluation Scheme and Marks</td></tr>
<tr><td>Lecture</td><td>Practical</td><td>Tutorial</td><td>TW</td><td>OR</td><td>PR</td><td>Total</td></tr>
<tr><td>02</td><td>-</td><td>4</td><td>-</td><td>50</td><td>--</td><td>-</td><td>50</td></tr>
</table>

Prior knowledge of:

Basics of electronics devices and circuits **Is essential.**

Course Objectives:

This course aims at enabling students to:

1. Understand various device modeling techniques using analytical and numerical approaches.
2. Analyze advanced device models, including high-frequency, temperature-dependent, and reliability models.
3. Validate device models through comparison with experimental data and theoretical predictions.

Course Outcomes:

After completion of this course, students will be able to,

1. Explain semiconductor device physics and device operation principles.
2. Develop proficiency in using simulation tools to model semiconductor devices and circuits accurately.
3. Apply device modeling techniques to solve engineering problems related to circuit design, optimization, and performance prediction.

Detailed Syllabus

Assignment No.	**Suggested List of Assignments**	Duration
1.	Introduction to SPICE Simulation: Familiarize students with SPICE simulation software (e.g., LTspice)	**6**
2.	Introduction to SPICE Simulation: Create simple circuit simulations (e.g., resistor networks, basic diode circuits) to understand SPICE syntax and simulation setup.	**6**
3.	DC Characteristics of Diodes: Simulate the current-voltage (IV) characteristics of different diode types.	**6**
4.	MOSFET DC Modeling: Simulate the DC characteristics of MOSFETs (NMOS and PMOS). Investigate the threshold voltage, transconductance, and output characteristics of MOSFETs under different biasing conditions.	**6**
5	Small-Signal Analysis of MOSFETs: Perform small-signal AC analysis of MOSFET amplifiers. Study the gain, input/output impedance, and	**6**

	frequency response of MOSFET amplifier circuits.	
6	MOSFET Transient Analysis: Simulate transient response in MOSFET circuits Analyze rise/fall times, propagation delays, and ringing effects in MOSFET-based digital circuits.	**6**
7	Advanced MOSFET Modeling: Implement advanced MOSFET models (e.g., BSIM, PSP) in SPICE simulations. Compare the accuracy and performance of different MOSFET models for various circuit configurations.	**6**
8	Project-Based Experiment: Assign a project where students design and simulate a VLSI circuit (e.g., an amplifier, an oscillator) using device modeling techniques learned throughout the course.	**6**
	Total	48

Reference Books:

1. Device Modeling for Analog and RF CMOS Circuit Design. TrondYtterdal, Yuhua Cheng, Tor A. Fjeldly. ISBN: 978-0-470-86434-0 August 2003
2. Advanced semiconductor fundamentals / Robert F. Pierret ; Publication details: USA Pearson Education 2003 ; Edition: 2nd ed
3. Compact Models for Integrated Circuit Design : : Conventional Transistors and Beyond. by: Saha, Samar K. Published: (2015.)

Program:	M. Tech. (E&TC)-VLSI and Embedded Systems				Semester:	I	
Course:	Advanced Embedded Processors Lab				Code:MET31PE03C		
Credits	Teaching Scheme (Hrs. /Week)			Evaluation Scheme and Marks			
	Theory	Practical	Tutorial	TW	OR	PR	Total
02	--	04	--	50	-	--	50

Course Objectives:

This course aims at enabling students to:

1. Apply ARM development tools for installation, configuration, and efficient utilization.
2. Develop efficient programs using ARM assembly language and C.
3. Design embedded applications by integrating programming, debugging, and system-level understanding.

Course Outcomes:

After completion of this course, students will be able to,

1. Demonstrate proficiency in installing, configuring, and utilising ARM Development Tools.
2. Exhibit competence in writing ARM assembly and C programs to perform basic arithmetic and bitwise operations.
3. Apply embedded software skills to practical tasks like controlling devices.
4. Utilize problem-solving skills by applying software principles effectively to develop efficient embedded software solutions.

Detailed Syllabus: Perform any 8 experiments.

Unit	Description	Duration
1.	Install and configure the ARM Development Tools (ARM Keil MDK, DS-5, etc.) on a development workstation.	**06**
2.	Write an ARM assembly program to perform basic arithmetic operations (addition, subtraction, multiplication, division) using the ALU.	**06**
3.	Develop an ARM assembly program to implement bitwise operations (AND, OR, XOR, shift) on data using the ALU.	**06**
4.	Write a C program to blink an LED using GPIO on the ARM development board (e.g., STM32F4 Discovery Board).	**06**
5.	Develop a C program to communicate with an external device using UART on the ARM development board.	**06**
6.	Develop a C program to read analog data from an ADC and display it on an LCD using the ARM development board.	**06**
7.	Write a C program to handle external interrupts from a push-button on the ARM development board.	**06**
8.	Write a C program to interface with an SPI-based external memory device on the ARM development board.	**06**
9.	Develop a C program to interface with a sensor (e.g., temperature, accelerometer) using I2C or SPI protocol on the ARM development board.	**06**

10.	Develop a program to control an external servo motor using PWM on the STM32F4 Discovery Board.	**06**
11.	Implement a simple user interface with buttons and LEDs to control the servo motor on the STM32F4 Discovery Board.	**06**
12.	Develop a C program to implement a simple real-time operating system (RTOS) task scheduler and task management on the ARM development board.	**06**
	Total	**48**

Text Books:

1. Steve Furber, "ARM System-on-Chip Architecture", Addison-Wesley Professional, 2nd Edition, 2000.
2. Joseph Yiu, "The Definitive Guide to ARM Cortex-M3 and Cortex-M4 Processors", Newnes, 3rd Edition, 2013.
3. David Kleidermacher and Mike Kleidermacher, "Embedded Systems Security: Practical Methods for Safe and Secure Software and Systems Development", Newnes, 1st Edition, 2012.
4. Peter Marwedel, "Embedded System Design: Embedded Systems Foundations of Cyber-Physical Systems", Springer, 3rd Edition, 2018.

Reference Books:

1. Peter Cockcroft, "ARM Assembly Language Programming", CRC Press, 1st Edition, 2021.
2. Andrew N. Sloss, Dominic Symes, and Chris Wright, "ARM System Developer's Guide: Designing and Optimizing System Software", Morgan Kaufmann, 1st Edition, 2004.
3. Chris P. Freeman, "Exploring ARM Processor Architectures: The Fundamentals", CRC Press, 1st Edition, 2022.
4. M. Ghaseemirizadeh and A. Ghaseemirizadeh, "Embedded System Design with ARM Cortex-M Microcontrollers", CRC Press, 1st Edition, 2022.

Program	M.Tech. E&TC- VLSI and Embedded Systems				Semester	I	
Course	Embedded Communication Protocol Lab				Code	MET31PE03D	
Credits	Teaching Scheme (Hrs./Week)			Evaluation Scheme and Marks			
	Lecture	Practical	Tutorial	TW	OR	PR	Total
2	-	4	-	50	-	-	50

Prior knowledge of: Embedded C and basic peripherals **is essential**

Course Objectives:

This course aims at enabling students to:

1. Discuss and demonstrate role of communication protocols in embedded systems
2. Explain communications modes and its applicability

Course Outcomes

After completion of this course, students will be able to,

1. Interface serial communication protocols with microprocessor
2. Design, program and implement Wireless communication Protocol
3. Analyse use and significance of communication protocols in real time applications

Detailed Syllabus: (Any six experiment will be conducted)

Unit	Description	Duration
1.	Design and establish SPI communication between the control devices	**6**
2.	Design and interface I2C with microprocessor and peripherals	**6**
3.	Communicate between two devices using USB interfaces	**6**
4.	Justify and demonstrate use of CAN bus in auto braking systems	**6**
5	Establish connections between two Raspberry Pi boards using DSRC Protocol	**6**
6	Design and analyze communication protocols used in Vehicles and demonstrate at least two protocol implementation	**6**
7	Build Wireless sensor nodes and communication with microprocessor/ Cloud/ PC	**12**
8	Design and analyze Bluetooth communication in multimedia applications	**12**
TOTAL		**60**

Reference Books:

1. Bhaskar Krishnamachari, “Networking wireless sensors”, Cambridge press 2005
2. Glaf P.Feiffer, Andrew Ayre and Christian Keyold, “Embedded networking with CAN and CAN open”, Embedded System Academy 2005.

Program:	M. Tech. (E&TC)-VLSI and Embedded Systems				Semester :	I	
Course:	VLSI testing and DFT Lab				Code:	MET31PE04A	
Credits	Teaching Scheme (Hrs./Week)			Evaluation Scheme and Marks			
	Lecture	Practical	Tutorial	TW	PR	OR	Total
02	-	04		50	-	-	50

Course Objectives:

This course aims at enabling students to:

1. Apply VLSI testing techniques and methodologies through hands-on practical sessions.
2. Analyze testing strategies for complex VLSI circuits using appropriate tools.
3. Develop practical skills for effective testing and evaluation of digital integrated circuits.

Course Outcomes:

After completion of this course, students will be able to,

1. Demonstrate proficiency in designing and implementing fault simulation programs for single stuck-at faults in VLSI circuits.
2. Design and apply test patterns using scan design methodologies, measure fault coverage improvements compared to non-scan designs and effectively evaluate the impact of DFT techniques on testing efficiency and reliability.
3. Showcase proficiency in developing Random Logic BIST processes for complex VLSI designs.

Detailed Syllabus:

Unit	Description	Duration
1.	**Fault Simulation and Analysis:** Design a fault simulation program that can analyze a given VLSI circuit for single stuck-at faults. Evaluate the effectiveness of the simulation by comparing simulated results with expected outcomes and generate a detailed fault report.	**8**
2.	**DFT Implementation:** Implement a scan design technique for a specific VLSI circuit to enhance testability. Design and apply test patterns to the circuit using the implemented scan design, and measure the improvement in fault coverage compared to non-scan designs.	**8**
3.	**BIST Process Development:** Develop a Random Logic BIST process for a complex VLSI design. Generate test patterns, perform pattern compression, and evaluate the efficiency of the BIST process in detecting and diagnosing faults within	**8**

	the circuit.	
4.	**Boundary Scan Testing:** Configure a VLSI circuit with Boundary Scan Standard compliance. Write Boundary Scan Test Instructions (BSTI) to perform comprehensive testing, including connectivity testing and boundary scan chain verification, and validate the effectiveness of the boundary scan testing methodology.	**8**
5	**Memory BIST Implementation:** Implement a Memory BIST (MBIST) system for testing embedded memories within a VLSI design. Develop pattern generation algorithms, implement response compaction techniques, and evaluate the MBIST system's performance in detecting and diagnosing memory-related faults	**8**
6	**Advanced Testability Measures:** Explore advanced testability measures such as SCOAP controllability and observability analysis for a VLSI circuit. Conduct a comprehensive testability analysis, identify critical nodes for testing, and optimize test patterns to maximize fault coverage while minimizing testing overhead	**8**
7	**Mini Project**	**12**
	Total	**60**

Text Books:

1. M.L. Bushnell, V. D. Agrawal, “Essential of Electronic Testing for Digital, Memory and Mixed Signal VLSI Circuits”, Kluwer Academic Publishers.

Reference Books:

4. M Abromovici, M A Breuer & A. D. Friedman "Digital Systems Testing and Testable Design “, Jaico Publications, Paperback Impression, 2001.

NPTEL Online Courses / MOOCs

1. https://onlinecourses.nptel.ac.in/noc20_ee76/preview(Digital VLSI Testing)

Program	M.Tech. E&TC- VLSI and Embedded Systems			Semester	I		
Course	**Micro computer Architecture and Modeling Lab**			Code	MET31PE04B		
Credits	**Teaching Scheme (Hrs./Week)**			**Evaluation Scheme and Marks**			
	Lecture	**Practical**	**Tutorial**	**TW**	**OR**	**PR**	**Total**
02	-	4	-	50	--	-	50

Prior knowledge of:

Basics of computer organization, architecture and HDL **Is essential.**

Course Objectives:

This course aims at enabling students to:

1. Introduce fundamentals of microcomputer architecture like instruction set architecture (ISA), memory hierarchy, and I/O subsystems.
2. Explore advanced concepts in microarchitecture design.
3. Make students aware of performance, power consumption, and reliability aspects of microcomputer architectures.
4. Explore emerging trends and technologies in microcomputer design

Course Outcomes:

After completion of this course, students will be able to,

1. Describe the key components and organization of a microcomputer system, including the CPU, memory subsystem, and I/O interfaces.
2. Analyse and compare different microcomputer architectures based on their performance, power efficiency, and scalability.
3. Design and implement basic microarchitectural features such as pipelining, instruction-level parallelism, and memory hierarchy optimizations.
4. Develop models and simulations of microcomputer systems using industry-standard tools such as Verilog, VHDL, or System Verilog.
5. Evaluate the performance and efficiency of microcomputer architectures through simulation, profiling, and benchmarking techniques.

Detailed Syllabus

Unit	Suggested List of Assignments	Duration
1.	Design basic CPU architecture and finalize the specification. It should include ● Instruction Memory (IM): Stores the instructions to be executed. ● Data Memory (DM): Stores data accessed by the CPU. ● Arithmetic Logic Unit (ALU): Performs arithmetic and logic operations. ● Control Unit (CU): Decodes instructions and controls the operation of CPU. ● Registers: Temporary storage for data and instructions.	**6**

2.	Design and implement ALU in VHDL /Verilog for above specification and verify using test bench.	**6**
3.	Design and implement CU-control unit in VHDL /Verilog for above specification and verify using test bench.	**6**
4.	Design and implement DM-Data path in VHDL /Verilog for above specification and verify using test bench.	**6**
5	Design and implement pipelined data path in VHDL /Verilog for above specification and verify using test bench.	**6**
6	Design and implement 16 bit adder in VHDL /Verilog for above specification and verify using test bench.	**6**
7	Design and implement 16 bit multiplier in VHDL /Verilog for above specification and verify using test bench.	**6**
8	Integrate above all units a s top level module and synthesis a complete CPU architecture.	**6**
	Total	48

Reference books :

1. Verilog HDL: A guide to Digital design and Synthesis by Samir Palnitkar (softcopy available in Digilib)
2. Computer Organization & Design, The Hardware/Software Interface byDavid A. Patterson and John L. Hennessy, 2004
3. Computer Architecture: A Quantitative Approach by David A. Patterson and John L. Hennessy, 2006

Program:	M. Tech. (E&TC)-VLSI and Embedded Systems			Semester:		I	
Course:	**Embedded Processor Architecture and Design Lab**			**Code: MET31PE04C**			
Credit	**Teaching Scheme (Hrs./Week)**			**Evaluation Scheme and Marks**			
	Lecture	**Practical**	**Tutorial**	**TW**	**PR**	**OR**	**Total**
02	--	04	--	50	-	-	50

Course Objectives:

1. To demonstrate Datapath and control design in Processor architecture
2. To explain processor architecture design flow

Course Outcomes:

After completion of this course, students will be able to,

1. Describe design modeling of datapath and control for processor architecture.
2. Design, program and implement instruction set for specific application
3. Estimate performance distribution in processor design
4. Design Processor architecture , instructions and control unit for real time application

Detailed Syllabus: (Any six experiment will be conducted)

Unit	Description	Duration (Hrs.)
1.	Design Datapath and control unit for simple 4 bit ALU operations	**6**
2.	Design Instruction set for MAC processing unit using horizontal and vertical encoding	**6**
3.	Design datapath and controller with hardware design for GCD algorithm	**6**
4.	Design processor architecture for 4 bit sequence generator	**6**
5	Design controller for 4 bit decade counter with hardware design	**6**
6	Design and analyze Clock distribution and power distribution in processor architecture	**6**
7	Design Processor architecture for Barrel Shifter with hardware design details	**6**
8	Design and Implement processor architecture for simple peripheral interface	**6**
	Total	48

Reference Books:

1. NurmiJari,“ Processor Design-System on Chip Computing for ASICs and FPGA”, Springer Publications.
2. Leibson S, Tensilica, “Customizable Processors and Processor Customization”.

Program	M.Tech. E&TC- VLSI and Embedded Systems				Semester	I	
Course	**IoT in Embedded Systems Lab**				**Code**	**MET31PE04D**	
Credits	**Teaching Scheme (Hrs./Week)**			**Evaluation Scheme and Marks**			
	Lecture	**Practical**	**Tutorial**	**TW**	**OR**	**PR**	**Total**
02	-	4	-	50	--	-	50

Prior knowledge of:

Basics of programming language such as C, basics of Microcontrollers.

Course Objectives:

This course will enable students

1. To discuss and demonstrate role of communication protocols in IoT Systems
2. To explain IoT Stack and its applicability

Course Outcomes:

After learning the course, the students will be able to:

1. Interface sensors and Actuators to the IoT development boards
2. Design real-time IoT based system with suitable selection of IoT Protocol
3. Analyse use and significance of cloud in real time applications

Detailed Syllabus

Unit	Suggested List of Assignments (Any 6)	Duration
1.	Weather forecasting system using any cloud applications and IoT hardware platforms	**6**
2.	Smart Agriculture irrigation System	**6**
3.	Motion detection-based Intrusion detection and alert system.	**6**
4.	Home Automation	**6**
5	Smart Television using Raspberry Pi and OSMC	**6**
6	Air Pollution Monitoring and alert System	**6**
7	Robotic autonomous vehicle	**6**
8	Alert generation using any cloud	**6**
	Total	**48**

Syllabus

Semester -II

M. Tech.

E&TC Engineering

Program:	M. Tech. (E&TC)-VLSI and Embedded Systems						Semester: II
Course:	**Research Methodology**						**Code:MET32PC05**
Credits	**Teaching Scheme (Hrs./Week)**			**Evaluation Scheme and Marks**			
	Lecture	**Practical**	**Tutorial**	**FA**		**SA**	**Total**
				FA1	**FA2**		
02	**02**	**--**	**--**	**25**	**25**	**--**	**50**

Prior knowledge of

Project and seminar in undergraduate **is essential.**

Course Objectives:

This course aims at enabling students,

1. To select and define appropriate research problem and parameters with appropriate methodology.
2. To understand statistical techniques for the specific perspective data in an appropriate manner.
3. To understand the mathematical modeling and its predicting capability.
4. To learn the various aspects of research report writing, publication and Intellectual Property Rights (IPR) fundamentals.

Course Outcomes:

After learning the course, the students should be able to:

1. Define a research problem and use appropriate research methodology
2. Examine data using different hypothesis tests and make conclusions about acceptance or rejection of sample data.
3. Develop a mathematical model and analyze the prediction capabilities
4. Write a report, research paper and prepare to file an IPR.

Guidelines:

1. Student need to find the specific area of research under the guidance of allocated supervisor.
2. Student need to collect at least 25 papers in specified area.
3. They have to prepare Literature review on the basis of papers collected.
4. Student is supposed to appropriate writing tools such as Latex for preparation of material.
5. Student need to learn tools for good English writing such as Grammarly.
6. Students need to use plagiarism and AI writing checking tools for their document.
7. Review will be scheduled to assess progress of the research work.
8. Student must publish the good review paper in conference/ journal.

Detailed Syllabus:

Unit	Description	Duration [Hrs.]
I	**Research Problem and Research Design** Objectives, Motivation, Types of Research, Research Approaches, Significance of Research, Research Methods versus Methodology, Criteria of Good Research Definition and Feasibility study of research problem, Sources of research problem, Meaning of Hypothesis, Characteristic.	**6**

II	**Applied Statistics** Measures of Variability: Standard Deviation, variance, Quartiles, Interquartile Range Inferential Statistics: Statistical Significance (p values), Pearson 's test, t- test, Chi square test, ANOVA (Analysis of variance)	**7**
III	**Mathematical Modeling and prediction of performance** Types of Modeling, Types of solutions to mathematical models, Steps in Setting up a computer model to predict performance of experimental system, Validation of results, multi-scale modeling and verifying performance of process system, Nonlinear analysis of system and asymptotic analysis, Sensitivity analysis.	8
IV	**Research Report writing, Publication and Intellectual Property Rights** *Research Report:* Dissemination of research findings, outline and structure of research report, different steps and precautions while writing research report, methods and significance of referencing. *Publishing Research work:* Selection and identification of indexing of suitable journal along with impact factor for publishing research work, structure of research paper, Check for plagiarism of the article, Research paper submission and review process. *IPR:* Definition of IPR, Classification of IP, Patentable and non-patentable inventions, Case Study of Patent and Copyright.	9
	Total	**30**

Textbooks:
1. C. R. Kothari, "Research Methodology: Methods and Techniques", New Age International, 2nd Edition, 2004.
2. Ranjit Kumar, "Research Methodology: A Step-by-Step Guide for Beginners", 2nd Edition, 2010.
3. Ramakrishna B and Anil Kumar H S., "Fundamentals of IPR", Notion Press, 2016.
4. Virendra Kumar Ahuja, "IPR in India", LexisNexis ButterworthsWadhwa Nagpur, 2017.

Reference Books:
1. Stuart Melville and Wayne Goddard, "Research methodology: An Introduction for Science & Engineering students", Juta Education, 1996.
2. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction", Juta and Company Ltd, 2004.

e-sources:
1. https://onlinecourses.nptel.ac.in/noc23_ge36/preview
2. https://onlinecourses.swayam2.ac.in/ntr24_ed08/preview

<table>
<tr><td>Program:</td><td colspan="5">M. Tech. (E&TC)-VLSI and Embedded Systems</td><td>Semester:</td><td>II</td></tr>
<tr><td>Course:</td><td colspan="5">System Verilog For Verification</td><td colspan="2">Code:MET32PE05A</td></tr>
<tr><td rowspan="3">Credit</td><td colspan="3">Teaching Scheme (Hrs./Week)</td><td colspan="4">Evaluation Scheme and Marks</td></tr>
<tr><td rowspan="2">Lecture</td><td rowspan="2">Practical</td><td rowspan="2">Tutorial</td><td colspan="2">FA</td><td rowspan="2">SA</td><td rowspan="2">Total</td></tr>
<tr><td>FA1</td><td>FA2</td></tr>
<tr><td>03</td><td>03</td><td>--</td><td>--</td><td>20</td><td>20</td><td>60</td><td>100</td></tr>
</table>

Prior knowledge of is essential. Digital Design and Verilog HDL.

Course Objectives:

This course aims at enabling students to:

1. Understand verification methodologies using SystemVerilog and object-oriented programming (OOP) concepts.
2. Apply SystemVerilog assertions and develop testbenches for functional verification.
3. Analyze randomization techniques and functional coverage for effective verification.
4. Develop advanced verification environments using Universal Verification Methodology (UVM)

Course Outcomes:

After completion of this course, students will be able to,

1.Implement the various Verification Methodologies.

2.Illustrate the concepts of System Verilog OOP terminology.

3.Identify common randomization problems and learn debugging techniques to address them.

4.Analyze the concepts of functional coverage.

5.Create an essential UVM Environment.

Detailed Syllabus:

Unit	Description	Duration
1.	**Verification Methodology Overview:** Introduction to Verification Methodology, Verification Process, Verification Environment Architecture, System Verilog Introduction & Logic Data Type, Operators, Procedures Statements and Procedural Blocks, System Verilog Tasks & Functions, System Verilog Interfaces.	**9**
2.	**Object Oriented Programming:** Introduction, Class Data Type & Objects, User-Defined Data Types and Structures, Inheritance & Super, Static properties & methods and Pass by ref, Polymorphism, Virtual & Parameterized classes, System Verilog Assertions, Immediate Assertions, Concurrent Assertions, Building a Testbench.	**9**
3.	**Randomization:** Introduction, randomization, Randomization in SystemVerilog, Constraint details, solution probabilities, controlling multiple constraint blocks, Valid constraints, In-line constraints, The pre_randomize and post_randomize functions, Constraints tips	**9**

	and techniques, common randomization problems.	
4.	**Functional Coverage:** Interprocess Communication, Events, Semaphores, Mailboxes, Coverage Types, Functional Coverage Strategies, Simple Functional Coverage Example, Anatomy of a Cover Group, triggering a Cover Group, Data Sampling, Cross Coverage, Generic Cover Groups, Coverage Options, Analyzing Coverage Data, Measuring Coverage Statistics During Simulation.	**9**
5	**Universal Verification Methodology (UVM):** Introduction to UVM Methodology, UVM Environment & Components, Stimulus Modeling, Simulation Phases, and Building a Basic UVM testbench.	**9**
	Total	**45**

Textbooks:

1. System Verilog for Design: A Guide to Using System Verilog for Hardware Design and Modeling, 2nd Edition, Stuart Sutherland, Simon Davidman and Peter Flake, Springer 2006.
2. Bergeron, Janick. Writing testbenches using System Verilog, 1st Edition, Springer Science & Business Media, 2007.
3. System Verilog for Verification: A Guide to Learning the Testbench Language Features Third Edition by Chris Spear and Greg Tumbush, 2012.

Reference Books:

1. Open Verification Methodology Cookbook, Mark Glasser, Springer, 2009
2. Donald Thomas, "Logic Design and Verification Using System Verilog", CreateSpace Independent Publishing Platform, 2014.

NPTEL Online Courses / MOOCs

2. https://www.udemy.com/course/soc-verification-systemverilog/

Program:	M. Tech (VLSI & Embedded Systems)					Semester: II	
Course:	Analog CMOS Design and Analysis					Code: MET32PE05B	
Credits	Teaching Scheme (Hrs./Week)			Evaluation Scheme and Marks			
3	Lecture	Practical	Tutorial	FA		SA	Total
				FA1	FA2		
	3	-	-	20	20	60	100

Prior knowledge of

Basic fundamentals of electronic devices and integrated circuits

is essential.

Objectives:

This course will enable students to

1. Explain the concepts of analog circuits design using MOS small signal models
2. Demonstrate design principles and techniques of CMOS sub-circuits and CMOS Amplifiers
3. Describe the concept of stability and explain methods of frequency compensation.

Outcomes:

After learning the course, the students should be able to:

1. Describe the small signal models MOS technologies
2. Design current sources and voltage references
3. Design single-ended differential amplifiers
4. Analyze and design operational amplifiers
5. Explain different techniques of frequency compensation

Detailed Syllabus:

Unit	Description	Duration
1.	**MOS DEVICES AND MODELING:** Introduction to analog design,Analog integrated circuit design considerations, The MOS Transistor, Passive Components- Capacitor & Resistor MOSFET Modeling: MOS transistor Low frequency MOSFET Models, High frequency MOSFET Models, temperature effects in MOSFET, Noise in MOSFET	8
2.	**CMOS Sub circuits:** MOS as a switch, MOS Diode/Active resistor, Current Source, Sinks, Simple current sinks and mirror, Basic current mirrors, advance current mirror, Current and Voltage references, Bandgap references	8
3.	**Single stage amplifiers:** Common-Source stage (with resistive load, diode connected load, current-source load, triode load, source degeneration), source follower, common-gate stage, Cascode stage, Folded Cascode stage. Frequency responses of CS stage, CD stage, CG stage, Cascode stage, simulation of CMOS amplifiers using SPICE. Performance’s matrices of amplifier circuits	10

4.	**CMOS Differential Amplifier:** Single ended and Differential Operation, Qualitative and Quantitative Analysis of Differential pair, Common Mode response, Gilbert Cell. Differential signaling: Differential to single ended conversion, source coupled pair, Current source load, CMOS Differential amplifier with current mirror load, small signal analysis of differential amplifier, Performance parameters,	9
5.	**CMOS Operational Amplifier:** Block diagram of Op-amplifier, Ideal characteristics of Op-Amplifier, Design procedure of two stage Op Amplifier, Compensation of Op-Amplifier, Frequency response of Op-Amplifier, Gain Boosting, Comparison of various topologies, slew rate, Offset effects, PSRR	10
	Total	**45**

Text Books:

1. BehzadRazavi, Design of Analog CMOS Integrated Circuits, Boston: McGraw Hill, 2001.
2. D.A. Johns and K. Martin, Analog Integrated Circuit Design, New York: Wiley, 1997. P.E.

Reference Books:

1. Allen and D.R. Holberg, CMOS Analog Circuit Design, 2nd Ed., Oxford University Press, 2002.
2. P.R. Gray, P.J. Hurst, S.H. Lewis, and R.G. Meyer, Analysis and Design of Analog Integrated Circuits, 4th ed., New York: Wiley, 2001.

Program:	M. Tech. (E&TC)-VLSI and Embedded Systems					Semester:	II
Course:	Real Time Operating System					Code:	MET32PE05C
Credits	Teaching Scheme (Hrs./Week)			Evaluation Scheme and Marks			
				FA		SA	Total
	Lecture	Practical	Tutorial	FA1	FA2		
03	03	--	--	20	20	60	100

Course Objectives:

This course aims at enabling students

1. To get a comprehensive understanding of real-time operating systems
2. To equip with the necessary skills and knowledge to develop real-time applications
3. To foster critical thinking and problem-solving abilities for evaluating real-time system requirements, constraints, and performance metrics

Course Outcomes:

After successful completion of the course, students will be able to:

1. Explain the fundamentals and characteristics of real-time operating systems (RTOS).
2. Apply task management and scheduling techniques in real-time systems.
3. Analyze design considerations and constraints in real-time system development.
4. Describe the architecture and components of RTOS kernels and their internal functioning.
5. Analyze and optimize real-time systems for performance and reliability.

Detailed Syllabus:

Unit	Description	Duration
1.	**Introduction to Real-Time Operating Systems** Definition and characteristics of real-time systems, Types of real-time systems: hard real-time vs. soft real-time, Basic concepts of RTOS: tasks, scheduling, synchronization, and communication, Examples of popular RTOS: FreeRTOS, VxWorks, QNX, Comparison with general-purpose operating systems,	9
2.	**Task Management and Scheduling** Task states: ready, running, blocked, terminated, Task creation and termination mechanisms, Task scheduling algorithms: Rate Monotonic (RM), Earliest Deadline First (EDF), Fixed Priority, Round Robin, Preemption and non-preemption scheduling, Task synchronization mechanisms: semaphores, mutexes, condition variables, Inter-task communication mechanisms: message queues, mailboxes, pipes,	9

3.	**Real-Time System Design Considerations** Memory management in RTOS: static vs. dynamic memory allocation, Memory protection and partitioning, Real-time system constraints: timing requirements, resource limitations, System reliability and fault tolerance, Power management considerations in real-time systems,	9
4.	**Real-Time Operating System Kernel** RTOS kernel architecture and components: scheduler, memory manager, interrupt handler, Real-time kernel services: task management, scheduling, memory management, Task context switching and stack management, Interrupt handling and real-time responsiveness.	9
5	**Real-Time System Analysis and Optimization** Timing analysis and worst-case execution time (WCET) estimation, Schedulability analysis and feasibility tests, Performance optimization techniques: priority inheritance, priority ceiling protocol, deadline monotonic analysis, Real-time system debugging and troubleshooting, Case studies and real-world examples of optimized real-time systems.	9
	Total	45

Text Books:

2. J. J Labrosse, "MicroC/OS-II: The Real –Time Kernel", Newnes, 2002.
3. Jane W. S. Liu, "Real-time systems", Prentice Hall, 2000

Reference Books:

5. W. Richard Stevens, "Advanced Programming in the UNIX Environment", 2nd Edition, Pearson Education India, 2011.
6. Philips A. Laplante, "Real-Time System Design and Analysis", 3rd Edition, John Wiley & Sons, 2004.
7. Doug Abbott, "Linux for Embedded and Real-Time Applications", Newnes, 2nd Edition, 2011.

Program: M. Tech (E&TC)-VLSI and Embedded Systems	Semester: II
Course: Embedded System Applications	Code: MET32PE05D

Credits	Teaching Scheme (Hrs./Week)			Evaluation Scheme and Marks			
	Lecture	Practical	Tutorial	FA		SA	Total
				FA1	FA2		
3	3	-	-	20	20	60	100

Prior Knowledge of automotive electronics, embedded systems, control systems, and communication engineering, is essential

Course Objectives:

This course aims at enabling the students to

1. To conceptualize automotive electronic technologies for future
2. To deliver knowledge of Signal Processing and Time-frequency transforms required for biomedical processing and data mining, biomedical pre-processing methodologies, instrumentation and its applications.

Course Outcomes:

After successful completion of the course, students will be able to:

1. Explain the fundamentals of ADAS and the architectural overview of automotive control systems.
2. Describe automotive standards, communication protocols, and sensor technologies used in ADAS.
3. Explain intelligent transport systems and the AUTOSAR architecture.
4. Analyze bio-electric signals such as EEG, ECG, and EMG with respect to normal and abnormal conditions.
5. Design real-time pre-processing systems for medical signal processing and medical imaging applications.

Detailed Syllabus:

Unit	Description	Duration
1.	**Automotive Embedded systems , Standards and Protocols:** Introduction to functional building blocks of embedded systems, Criteria to choose the right microcontroller/processor for various automotive applications, The need for Protocol, LIN, CAN, KWP2000 & J1939, FlexRay, Test calibration and diagnostics tools for networking of electronic systems like ECU, Vehicle network simulation	**8**
2.	**Sensor Technology for Advanced Driver Assistance Systems**: Basics of Advanced driver assistance systems, Radar Technology and Systems, Ultrasonic Sonar Systems, Lidar Sensor Technology and Systems, Camera Technology, Night Vision Technology, Other Sensors, Use of Sensor Data Fusion, Integration of Sensor Data to On-Board Control Systems	**10**

3.	**Intelligent Transportation Systems and AUTOSAR:** Vehicle-to-X (V2X) Communication for Intelligent Transportation Systems (ITS), Safety and non-safety applications, Use cases, **AUTOSAR :** Constituent elements of AUTOSAR, AUTOSAR methodology and implementations Case study : e vehicles	**8**
4.	**Signal processing biomedical signals**: Introduction to biomedical sensors: ECG, EEG, EMG, ECG signal origin, ECG parameters-QRS detection different techniques, ST segment analysis. Signal averaging: Basics of signal averaging, Signal averaging as a digital filter, Adaptive Filtering: Introduction, General structure of adaptive filters, LMS adaptive filter, adaptive noise cancellation.	**10**
5.	**Medical Imaging:** Magnetic Resonance Imaging: Introduction, principles of MRI and fMRI, MRI instrumentation, image acquisition and reconstruction techniques, Application of MRI. **Data Acquisition and Case studies:** Introduction, Measurement and Automation Explorer, DAQ Assistants, Analysis Assistants. Biomedical toolkit- ECG signal acquisition & feature extraction, Patient Monitoring Systems, Intelligent Health care system, Telemedicine	**9**
		45

Text Books:

1. William B. Ribbens, "Understanding Automotive Electronics- An Engineering Perspective", Seventh edition, Butterworth-Heinemann Publications.
2. Nicolas Navet "Automotive Embedded Systems Handbook", by, CRC press
3. Arnon Cohen, "Biomedical Signal Processing Time and Frequency Domains Analysis" (Volume I), Edition, 1986, CRC press, ISBN: 978-1-111-42737-5.
4. D.C.Reddy , Biomedical Signal Processing Principles and Techniques, Tata McGraw-Hill, ISBN: 978-1-111-42737-5, 2012.

Reference Books:

1. G. Meyer, J. Valldorf and W. Gessner: "Advanced Microsystems for Automotive Applications", Springer.
2. AUTOSAR Documentation [on line]. Available on: www.autosar.org
3. R. S. Khandpur , Handbook of Biomedical Instrumentation, 3 rd Edition, 2011, Tata Mc Graw-Hill , ISBN: 9780070473553.
4. Willis J. Tompkins, Biomedical Digital Signal Processing, , edition, 2000, PHI, ISBN: 978-1-111- 42737-5
5. E.S. Gopi, Digital Signal Processing for Medical Imaging Using Matlab, Springer, 2013.

Program :	M. Tech. (E&TC)-VLSI and Embedded Systems					Semester: II	
Course :	**System on Programmable Chip**					**Code : MET32PE06A**	
Credits	**Teaching Scheme (Hrs./Week)**			**Evaluation Scheme and Marks**			
	Lecture	**Practical**	**Tutorial**	**FA**		**SA**	**Total**
				FA1	**FA2**		
3	**3**	**-**	**-**	**20**	**20**	**60**	**100**

Prior knowledge of Microprocessor Architecture and VLSI Design flow **Is Essential**

Objectives:

1. To explain the System Architecture and Processor Architecture, Processor, Micro Architecture and approach for a SoC Design
2. To provide knowledge of Hardware and Software Design flow of SoC Design
3. To demonstrate design of SoC based real time application

Outcomes:

After learning the course, the students should be able to:

1. Understand concept of system on chip and significance of SoC design and Modelling.
2. Design FSMD and Micro-programmed architectures for digital applications.
3. Analyze the performance measures of SoC circuits and processor architectures.
4. Understand recent trends in Soc Prototyping, Testing and Verification
5. Analyze the impact of Platform-Centric Soc Design Approach.

Detailed Syllabus:

Unit	Description	Duration (Hrs)
1.	**Basic Concepts of SoC:** The nature of hardware and software, data flow modelling and implementation, the need for concurrent models, analyzing synchronous data flow graphs, control flow modelling and the limitations of data flow models.	**8**
2.	**FSM Datapath and Controller :** Software and hardware implementation of data flow, analysis of control flow and data flow, Finite State Machine with data-path, cycle based bit parallel hardware, hardware model, FSM Data-path (FSMD), limitations of FSMD. **Micro-programmed Architecture:** Micro-programmed : control, encoding, data- path, Micro-programmed machine implementation, SOC modelling, hardware/software interfaces.	**10**
3.	**Processor Architectures:** Basic concepts in Processor Architecture, More Robust Processors such as Vector Processors, VLIW Processors and Superscalar Processors, Processor Selection for SOC, Memory Design. A SOC controller for digital still camera, portable multimedia system, SoC	**9**
4.	**Soc Prototyping And Verification :** Soft Prototyping: Soc Design Flow, Transaction Level Modeling, Hw-Sw Co-Verification, HDL Simulator With HDL Processor Model, Hard Prototyping: Classification Of Hard Prototyping, Requirements Of Hard Prototyping, Examples Of Conventional Hard Prototyping System, Issues On Hardware/Software Co-Emulation	**10**

Program :	M. Tech. (E&TC)-VLSI and Embedded Systems					Semester: II	
Course :	System on Programmable Chip					Code : MET32PE06A	
Credits	Teaching Scheme (Hrs./Week)			Evaluation Scheme and Marks			
	Lecture	Practical	Tutorial	FA		SA	Total
				FA1	FA2		
3	3	-	-	20	20	60	100

Prior knowledge of Microprocessor Architecture and VLSI Design flow **Is Essential**

5.	**Programmable SOCs :** Platforms OMAP SOCs and development boards, PSoC 3 and PSoC5 Development Board, PSOC creator IDE. ZynQ and Zybo Platform for SOC application design flow	8
	Total	45

Text Books:

1. Patrick R. Schaumont, "A Practical Introduction to Hardware/Software Co-design", Springer Publications.
2. Vijay Madisetti, ChonlamethArpnikanondt, A Platform-Centric Approach to System-on-Chip (SOC) Design (2004)

Reference Books:

1. Weng Fook Lee - Verilog Coding for Logic Synthesis (2003, Wiley-Interscience)
2. VaibbhavTaraate, Advanced HDL Synthesis and SOC Prototyping - RTL Design Using Verilog (2019)
3. KatalinPopovici, Frédéric Rousseau, et al., Embedded Software Design and Programming of Multiprocessor System-on-Chip - Simulink and System C Case Studies (2010)
4. Youn-Long Steve Lin, Essential Issues in Soc Design - Designing Complex Systems-On-Chip (2010)

e-sources:

1. https://www.infineon.com/dgdl/Infineon-PSOC_5LP_CY8C54LP_FAMILY_DATASHEET_PROGRAMMABLE_SYSTEM-ON-CHIP_(PSOC_)-DataSheet-v14_00-EN.pdf?fileId=8ac78c8c7d0d8da4017d0ec58c723b5b
2. https://www.ti.com/product/OMAP-L138?utm_source=supplyframe&utm_medium=SEP&utm_campaign=not_alldatasheet&DCM=yes&dclid=CMXEmaqvj4YDFeMVgwMd-NAK1g

Program:	**M.Tech (E&TC)-VLSI and Embedded Systems**					**Semester : II**	
Course :	**ASIC Design**					**Code :MET32PE06B**	
Credit	**Teaching Scheme (Hrs./Week)**			**Evaluation Scheme and Marks**			
	Lecture	**Practical**	**Tutorial**	**FA**		**SA**	**Total**
				FA1	**FA2**		
3	**3**	**-**	**-**	**20**	**20**	**60**	**100**

Prior Knowledge of the Basics of PLDs Is Essential.

Course Objectives:

This course aims at enabling students to:

1. Develop the skills required to become entry-level ASIC/FPGA designers.
2. Understand the design issues and tools involved in ASIC/FPGA design and implementation.
3. Explain the fundamentals of System-on-Chip (SoC) and platform-based design.

Outcomes:

After learning the course, the students should be able to:

1. Explain ASIC design flow and architectures of different types of ASICs.
2. Apply ASIC design methodologies and synthesis concepts for digital systems.
3. Explain ASIC physical design processes including partitioning, floorplanning, placement, and routing.
4. Analyse the trade-offs in ASIC design
5. Explain timing analysis and testability concepts in ASIC design.

Detailed Syllabus:

Unit	Description	Duration h
1.	**INTRODUCTION TO ASICS**: IC Design Technologies, VLSI Design flow, Programmable ASICs - Antifuse, SRAM, EPROM, EEPROM based ASICs. Programmable ASIC logic cells, I/O cells and programmable interconnects.	**8**
2.	**ASIC Design flow:** Introduction to PLDS, ASIC and FPGA Design flows, Top-Down and Bottom-Up design methodologies, Gate arrays, Standard cells, FPGA and their synthesis.	**8**
3.	**ASIC Physical Design:** System partition -partitioning – partitioning methods – floor planning – placement – Routing: global routing – detailed routing – special routing – circuit extraction – DRC	**10**
4.	**Trade off in ASIC Design:** Introduction to Trade off issues at System Level,Optimization with regard to speed, area and power, asynchronous and low power system design. ASIC physical design issues, SI issues. Parameter extraction with Post layout simulation and Pre layout simulation.	**9**
5.	**Static Timing Analysis:**	**10**

	Basics of timing, Basics of STA, Timing paths, Skew, Slack, Timing issues, Maximum Frequency Calculation, Clock domain crossing. **Resent trends in ASIC design** ASIC Verification and its issues, Types and features of existing available EDA tools. High performance algorithms for ASICS/ SoCs as case studies	
	Total	**45**

Text Books:

1. M.J.S. Smith,"Application Specific Integrated Circuits", Pearson, 2003
2. Weste, Neil HE, and Kamran Eshraghian. "Principles of CMOS VLSI design: a systems perspective.", Wesley Pub.Co.1985

Reference Books:

1. Douglas A. Pucknell& Kamran Eshraghian, Basic VLSI Design :Systems and Circuits, Prentice Hall of India Private Ltd. , New Delhi , 1989.
2. Mead C, Conway L. Introduction to VLSI systems. Reading, MA: Addison-Wesley; 1980.
3. Mukherjee A. Introduction to n MOS & VLSI systems design. Prentice-Hall, Inc.; 1986.
4. L. A. Glassey & D. W. Dobbepahl, The Design & Analysis of VLSI Circuits, Addison Wesley Pub Co. 1985.
5. Rabaey JM, Chandrakasan AP, Nikolić B. Digital integrated circuits: a design perspective. Upper Saddle River, NJ: Pearson Education; 2003.

Program:	**M. Tech. (E&TC)-VLSI and Embedded Systems**	**Semester: II**

Course:	Edge Computing					Code :	MET32PE06C
Credits	Teaching Scheme (Hrs./Week)			Evaluation Scheme and Marks			
	Lecture	Practical	Tutorial	FA		SA	Total
				FA1	FA2		
03	03	-	-	20	20	60	100

Prior knowledge of Computer Networks **is essential.**

Course Objectives:

This course aims at enabling students,

1. Understand the fundamentals of Edge Computing.
2. Master Edge Infrastructure and Technologies.
3. Develop Edge applications and solutions.
4. Explore future trends and emerging topics.

Course Outcomes:

After learning the course, the students should be able to:

1. Analyze and Design Edge Computing Solutions
2. Evaluate Edge Infrastructure and Technologies
3. Develop and Implement Edge Applications
4. Analyze Security and Privacy in Edge Computing
5. Synthesize Future Trends in Edge Computing

Detailed Syllabus:

Unit	Description	Duration [Hrs]
1	**Introduction to Edge Computing** Overview of Edge Computing: Definition, principles, and importance. Evolution of computing paradigms: From centralized to distributed to edge. Characteristics and advantages of Edge Computing. Challenges and limitations of Edge Computing.	9
2	**Edge Infrastructure and Technologies** Edge Infrastructure: Hardware components and architectures. Edge Computing Platforms: Frameworks and middleware for managing edge resources. Networking for Edge Computing: Communication protocols and architectures. Edge Devices: Sensors, actuators, and IoT devices. Edge Software: Operating systems, virtualization.	9
3	**Edge Computing Ecosystem** Edge Orchestration: Deployment, provisioning, and management of edge resources. Edge Analytics: Real-time data processing, analytics, and machine learning at the edge. Security and Privacy in Edge Computing: Threats, vulnerabilities, and countermeasures.	9

4	**Edge Application Development** Programming Models for Edge Computing: frameworks, and APIs. Edge Application Design Patterns: Microservices, serverless, and event-driven architectures. Edge Development Tools and Environments: simulators, and debugging tools. Case Studies: Developing and deploying edge applications in different scenarios.	9
5	**Future Trends and Emerging Topics :** Edge Computing in Industry 4.0 and Smart Cities. Edge AI: Integration of artificial intelligence and machine learning at the edge. Edge Computing for 5G, Ethical and Societal Implications of Edge Computing.	9
	Total	45

Text Books:

1. IoT and Edge Computing for Architects - Second Edition, by Perry Lea, Publisher: Packt Publishing, 2020, ISBN: 9781839214806.
2. Mung Chiang, BharathBalasubramanian "Edge Computing : A primer" 2022

Reference Books:

1. Satyanarayanan, Pillai, GáborKecskemeti, "Edge Computing: Principles and Applications", CRC Press, 2020.
2. SudipMisra, Subhadeep Sarkar. "Designing and Building Edge Computing Infrastructure"

e-resources:

1. https://onlinecourses.nptel.ac.in/noc24_cs66/preview\
2. https://www.cognixia.com/course/edge-computing-training/

Program :	M. Tech. (E&TC)-VLSI and Embedded Systems					Semester: II	
Course :	Embedded AI					Code: MET32PE06D	
Credits	Teaching Scheme (Hrs./Week)			Evaluation Scheme and Marks			
	Lecture	Practical	Tutorial	FA		SA	Total
				FA1	FA2		
3	3	-	-	20	20	60	100

Prior knowledge of Artificial Intelligence and Machine Learning **is essential.**

Course Objectives:

This course aims at enabling students to:

1. To introduce Embedded AI and its significance
2. To elaborate concept of embedded computing and its applications in real time environment
3. To discuss Edge AI algorithms and hardware significance.
4. To give insights of TinyML and Arduino.

Course Outcomes:

After the completion of this course, the students will be able to:

1. Understand AI and ML to embedded real time systems
2. Analyze role of embedded computing concepts in embedded applications.
3. Design real time applications using Edge computing
4. Interpret significance of hardware and software AI integrations in Edge AI
5. Create AI ML model using TinyML and deploy on hardware platform.

Detailed Syllabus:

Unit	Description	Duration
1	Introduction: embedded AI, applications of embedded AI merits and metrics of embedded AI, Abstract workflow of embedded AI. Abstract workflow of embedded AI., Examples of hardware and software for embedded AI, Sensing, Perception, and Actuation, Data capturing from sensors, Building, and training a neural network embedded board.	8
2	Introduction to ML and Embedded Computing, Machine Learning on Embedded Devices – Edge computing, Fundamentals of Edge Computing Artificial Intelligence	7
3	Applications on Edge: Real-time Video Analytic, Autonomous Internet of Vehicles (IoVs), Smart Home and City, Hardware acceleration for AI, Software optimization for AI , AI Accelerators	
4	Edge AI: Introduction to Edge AI, Edge AI in the Real World, The Hardware of Edge AI, Algorithms for Edge AI, Demystifying the Edge AI Paradigm, Edge AI for Industrial IoT Applications, Artificial Intelligence in 5G and Beyond Networks, Edge Computing: Opportunities and Challenges.	8

Program :	M. Tech. (E&TC)-VLSI and Embedded Systems			Semester: II			
Course :	Embedded AI			Code: MET32PE06D			
Credits	Teaching Scheme (Hrs./Week)			Evaluation Scheme and Marks			
	Lecture	Practical	Tutorial	FA		SA	Total
				FA1	FA2		
3	3	-	-	20	20	60	100

5	Tiny ML: Wake-Word Detection: Building an Application, Training Model, Deploying to Microcontrollers: Arduino, Spark Fun Edge, ST Microelectronics STM32F746G Discovery Kit, Arduino TinyML, Training a Model for Arduino in TensorFlow	7
	Total Hrs.	30

Text Books:

1. Xiaofei Wang, Yiwen Han, Victor C. M. Leung, DusitNiyato, Xueqiang Yan, Xu Chen - Edge AI_ Convergence of Edge Computing and Artificial Intelligence-Springer Singapore_Springer (2020)

2. Pete Warden, Daniel Situnayake - TinyML_ Machine Learning with TensorFlowLite on Arduino and Ultra-Low-Power Microcontrollers-O'Reilly Media, 2019

Reference Books:

1. OvidiuVermesan, Mario Diaz Nava, BjörnDebaillie - Embedded Artificial Intelligence_ Devices, Embedded Systems, and Industrial Applications, River Publishers Series in Communications and Networking, 2023.

2. R. I. Minu, G. Nagarajan, Pethuru Raj Chelliah - Applied Edge Ai_ Concepts, Platforms, and Industry Use Cases-CRC Press (2022)

Papers:

1. H. Lin, "Embedded Artificial Intelligence: Intelligence on Devices" in Computer, vol. 56, no. 09, pp. 90-93, 2023. doi: 10.1109/MC.2023.3280397

Online courses Links:

https://www.coursera.org/learn/introduction-to-embedded-machine-learning

Program:	M. Tech. (E&TC)-VLSI and Embedded Systems			Semester:		II	
Course:	**System Verilog for Verification Lab**			**Code:**		**MET32PE07A**	
Credits	**Teaching Scheme (Hrs./Week)**			**Evaluation Scheme and Marks**			
	Lecture	**Practical**	**Tutorial**	**TW**	**PR**	**OR**	**Total**
02	**--**	**04**	**--**	25	-	25	50

Prior knowledge of: Verilog HDL and Digital Logic Design

Course Objectives:

This course aims at enabling students to:

1. Understand advanced SystemVerilog concepts and verification methodologies.
2. Apply digital circuit verification techniques using SystemVerilog.
3. Analyze functional coverage metrics for effective verification.
4. Develop verification environments using Universal Verification Methodology (UVM).

Course Outcomes:

After successful completion of the course, students will be able to:

1. Develop SystemVerilog testbenches for verification of digital circuits.
2. Analyze functional coverage metrics for effective verification.
3. Design UVM-based verification environments for memory modules.

Detailed Syllabus:

Expt. No.	Description	Duration
1.	Develop a System Verilog testbench to verify the functionality of a Full Adder digital circuit.	**8**
2.	Implement a System Verilog testbench to verify the functionality of an Arithmetic Logic Unit (ALU) digital circuit.	**8**
3.	Develop a System Verilog testbench to verify the functionality of synchronous and an asynchronous Up-Down Counter digital circuit.	8
4.	Create a System Verilog testbench to generate random numbers and evaluate their distribution.	8
5.	Develop a System Verilog program to measure the functional coverage of a BCD to Seven-segment decoder.	8
6.	Develop a System Verilog program to measure the functional coverage of a Serial-in-Parallel-Out (SIPO) register.	8
7.	Design a UVM (Universal Verification Methodology) Environment for an 8-bit adder/subtractor.	

8.	Design a UVM (Universal Verification Methodology) Environment for a RAM (Random Access Memory).	8
	Total	60

Text Books:

1. System Verilog for Verification: A Guide to Learning the Testbench Language Features Third Edition by Chris Spear and Greg Tumbush, 2012.

Reference Books:

2. Donald Thomas, "Logic Design and Verification Using System Verilog", CreateSpace Independent Publishing Platform, 2014.

NPTEL Online Courses / MOOCs

1. https://www.udemy.com/course/soc-verification-systemverilog/

Program:	M.Tech. E&TC- VLSI and Embedded Systems			**Semester**	II		
Course:	**Analog CMOS Design and Analysis Lab**			**Code:**	**MET32PE07B**		
Credits	**Teaching Scheme (Hrs./Week)**			**Evaluation Scheme and Marks**			
	Lecture	**Practical**	**Tutorial**	**TW**	**PR**	**OR**	**Total**
2	-	4	-	25	-	25	50

Prior knowledge of:
Electronics Circuits and Devices **is essential.**

Course Objectives:
This course will enable students

1. To illustrate concepts of analog CMOS circuits starting from specifications, design and simulation using circuit design software

Course Outcomes:
After learning the course, the students will be able to:

1. To model basic analog IC building blocks like current sinks, current source, current mirrors.
2. To design and simulate different types of basic amplifiers

Detailed Syllabus:

Expt. No.	**Description**	**Duration**
1.	To study different types of MOSFET models and analyze their performance	4
2.	To design and simulate CMOS subcircuits	8
3.	To design and simulate CMOS current and voltage references	8
4.	To design CMOS single stage amplifiers	8
5.	Design and simulate CMOS differential amplifier and calculate UGB, phase margin, CMRR	8
6.	Design and simulate CMOS two stage operational amplifier and calculate on UGB, phase margin, CMRR	12
7.	Miniproject / Case study implementation	12
Total		**48**

Text Books:

1. Behzad Razavi, Design of Analog CMOS Integrated Circuits, Boston: McGraw Hill, 2001.
2. Allen and D.R. Holberg, CMOS Analog Circuit Design, 2nd Ed., Oxford University Press, 2002.

Reference Books:

1. D.A. Johns and K. Martin, Analog Integrated Circuit Design, New York: Wiley, 1997. P.E.
2. P.R. Gray, P.J. Hurst, S.H. Lewis, and R.G. Meyer, Analysis and Design of Analog Integrated Circuits, 4th ed., New York: Wiley, 2001.

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Program:	M. Tech. (E&TC)-VLSI and Embedded Systems					Semester:	II
Course:	Real-Time Operating System Lab					Code: MET32PE07C	
Credits	Teaching Scheme (Hrs. /Week)			Evaluation Scheme and Marks			
	Theory	Practical	Tutorial	TW	PR	OR	Total
2	--	04	--	25	-	25	50

Course Objectives:

This course aims at enabling students to:

1. Understand the fundamentals of real-time operating systems (RTOS).
2. Develop and implement real-time applications with debugging techniques.
3. Analyze and optimize the performance of real-time systems.

Course Outcomes:

After completion of this course, students will be able to,

1. Explain real-time operating system fundamentals.
2. Develop and debug real-time applications.
3. Analyze and optimize real-time system performance.
4. Port real-time operating systems and create advanced applications.

Detailed Syllabus: Perform any 8 experiments.

Unit	Description	Duration
1.	Develop an application with two tasks waiting on a timer while the main task loops.	06
2.	Create an application where a task is scheduled upon a button press, demonstrating event sets between an ISR and a task.	06
3.	Demonstrate interruptible ISRs, prioritizing the timer over an external interrupt button.	06
4.	Write applications to test message queues, memory blocks, and byte queues.	06
5.	Develop an application with two tasks to blink different LEDs at different timings.	06
6.	Implement tasks displaying different messages on an LCD display across two lines.	06
7.	Develop tasks to send and receive messages through a mailbox.	06
8.	Create tasks to send messages to a PC through a serial port based on priority.	06
9.	Port Linux and develop a simple application on the embedded platform.	06
10.	Develop an image processing application using Linux OS on the embedded platform.	06
	Total	48

Text Books:

1. J. J Labrosse, "MicroC/OS-II: The Real –Time Kernel", Newnes, 2002.
2. Jane W. S. Liu, "Real-time systems", Prentice Hall, 2000

Reference Books:

1. W. Richard Stevens, "Advanced Programming in the UNIX Environment", 2nd Edition, Pearson Education India, 2011.
2. Philips A. Laplante, "Real-Time System Design and Analysis", 3rd Edition, John Wley& Sons, 2004.
3. Doug Abbott, "Linux for Embedded and Real-Time Applications", Newnes, 2nd Edition, 2011.

Program:	M. Tech. (E&TC)-VLSI and Embedded Systems					Semester: II	
Course:	Embedded System Applications Lab					Code: MET32PE07D	
Credits	Teaching Scheme (Hrs./Week)			Evaluation Scheme and Marks			
	Lecture	Practical	Tutorial	TW	PR	OR	Total
02	-	04	-	25	-	25	50

Course Objectives:

This course aims at enabling students to:

1. Explain real-time embedded system applications.
2. Understand the embedded system design flow.

Course Outcomes

After completion of this course, students will be able to,

1. Finalize design requirements and specification of embedded systems
2. Design Automotive applications using microprocessors
3. Analyse use and significance of sensors in real time medical applications

Detailed Syllabus: (Any six experiments will be conducted)

Unit	Description	Duration
1.	Design and analyse requirements and specifications of ADAS in vehicle system	**6**
2.	Design vehicle to vehicle communication prototype	**6**
3.	Design and implement Audio signal processing on microprocessor / DSP Processor platform	**6**
4.	Design and implement real time application on Arduino using MATLAB Deployment	**6**
5	Implementation of Real-Time ECG QRS Detection using Simulink	**6**
6	Develop attention dataset using EEG Nerosky headset on PC	**6**
7	Design and implement simple application of STM32 Edge AI development board	**12**
8	Complete the Embedded Design Flow case study for RADAR application.	**12**
	Total	60

Reference Books:

1. Nicolas Navet "Automotive Embedded Systems Handbook", by, CRC press
2. Arnon Cohen, "Biomedical Signal Processing Time and Frequency Domains Analysis" (Volume I), Edition, 1986, CRC press, ISBN: 978-1-111-42737-5.

Program:	M. Tech. (E&TC)-VLSI and Embedded Systems					Semester: II	
Course:	System on chip Lab					Code: MET32PE08A	
Credits	Teaching Scheme (Hrs./Week)			Evaluation Scheme and Marks			
	Lecture	Practical	Tutorial	TW	PR	OR	Total
02	--	04	--	25	-	25	50

Course Objectives:

This course aims at enabling students:

1. To demonstrate conversion of programming requirements in to hardware
2. To explain role of CFG and DFG in hardware design

Course Outcomes:

After completion of this course, students will be able to,

1. Understand construction of CFG and DFG from C programing
2. Design, program and implement FSMD for specific application
3. Design and Implement micro-program architecture

Detailed Syllabus: (Any five experiment from 1-6 and 7 or 8 will be conducted)

Unit	Description	Duration
1.	Design and Implement CFG and DFG for given C Program	**6**
2.	Design FSMD for 4 bit sequence detector	**6**
3.	Design 16 bit and 32 byte size Look up table	**6**
4.	Design micro programmed architecture , instruction frame format for 4bit simple architecture	**6**
5	Design controller for 4 bit decade counter with hardware design	**6**
6	Design and analyze Clock distribution and power distribution in processor architecture	**6**
7	Design Processor architecture for Barrel Shifter with hardware design details with Vivado wrapper design flow	**12**
8	Design and Implement processor architecture for simple peripheral interface using Vivado Wrapper design flow	**12**
	Total	60

Reference Books:

1. NurmiJari," Processor Design-System on Chip Computing for ASICs and FPGA", Springer Publications.
2. Leibson S, Tensilica, "Customizable Processors and Processor Customization".
3. https://www.xilinx.com/support/documents/sw_manuals/xilinx2022_1/ug892-vivado-design-flows-overview.pdf

Program:	M. Tech. (E&TC)-VLSI and Embedded Systems					Semester:	II
Course:	ASIC Design Lab					Code: MET32PE08B	
Credits	Teaching Scheme (Hrs./Week)			Evaluation Scheme and Marks			
	Lecture	Practical	Tutorial	TW	PR	OR	Total
02	-	04		25	-	25	50

Prior knowledge of Digital CMOS Logic design and HDLs

Course Objectives:

This course aims at enabling students to:

1. Develop the ability to design CMOS digital and analog circuits using EDA tools and evaluate their performance through simulation.
2. Apply HDL-based design methodologies to implement and verify digital systems using synthesis and timing analysis.
3. Understand the complete ASIC design flow, including layout generation, verification (DRC/LVS), parasitic extraction, placement & routing, and static timing analysis.

Course Outcomes:

After completion of this course, students will be able to,

1. Design CMOS digital and analog circuits using EDA tools and evaluate their performance through simulation.
2. Implement digital systems using HDL and verify them through synthesis reports and timing analysis.
3. Apply ASIC design flow for layout generation, verification (DRC/LVS), parasitic extraction, placement & routing, and static timing analysis.

Detailed Syllabus: (Any six experiments will be conducted)

Expt. No.	Description	Duration
1.	**CMOS Inverter Design and Transient Analysis:** a) Design a CMOS inverter circuit using 180 nm technology. b) Perform transient analysis to evaluate its performance characteristics.	**8**
2.	**XOR Gate Design Using NAND and NOR Gates:** Design an XOR gate using NAND and NOR gates. Perform transient analysis to verify its functionality and performance	**8**
3.	**CMOS Transmission Gate Design and Analysis:** a) Design a CMOS transmission gate using 180 nm technology. b) Perform all necessary analyses to verify its characteristics (e.g., transient, DC, AC).	**8**

4.	**Modulo-6 Counter Implementation with Scan:** Implement a modulo-6 counter with full scan and mux-DFF elements.	**8**
5.	**HDL Design, Synthesis and STA** a) Design an 8-bit adder using HDL (e.g., Verilog or VHDL). b) Simulate the design, synthesis it for the target technology, and estimate power dissipation. c) Generate and analyze reports: Area, Power , Timing	**8**
6.	**Layout Design and Post-Layout Analysis** Layout generation, DRC and LVS Checking, Parasitic Extraction and resimulation of CMOS Inverter.	**8**
7.	**PSPICE Simulation of Analog Circuits:** a) Design a simple 5-transistor differential amplifier. b) Perform PSPICE simulation to measure gain, bandwidth (BW), output impedance, input common-mode range (ICMR), and common-mode rejection ratio (CMRR). c) Design and simulate a ring oscillator using PSPICE	**8**
8.	**Post-Placement and Routing (P&R) Simulation:** For the design in Experiment 7b (ring oscillator): a) Perform floor planning, placement, and routing (P&R). b) Perform power and clock routing. c) Conduct post-P&R simulation to validate the design's functionality and performance.	**8**
	Total	**60**

Text Books:

1. M.D. Fisher, Edward. 2019. ‘Introductory Chapter: ASIC Technologies and Design Techniques’. Application Specific Integrated Circuits - Technologies, Digital Systems and Design Methodologies.

Reference Books:

1. Williams, John. ASIC Design: Real World Applications.
2. "Digital Integrated Circuit Design" by Ken Martin and Richard S. Soderstrand

Program	M.Tech. E&TC- VLSI and Embedded Systems			Semester	II		
Course	**Edge Computing Lab**			**Code**	**MET32PE08C**		
Credits	**Teaching Scheme (Hrs./Week)**			**Evaluation Scheme and Marks**			
	Lecture	**Practical**	**Tutorial**	**TW**	**PR**	**OR**	**Total**
2	-	4	-	25	-	25	50

Prior knowledge of:

Basics of programming language such as C, basics of networking

Course Objectives:

This course will enable students to

1. Understand the concept of edge computing
2. Understand the Edge computing Architecture
3. Implement the edge computing in IOT

Course Outcomes:

After learning the course, the students will be able to:

1. Identify the benefits of edge computing
2. Create use cases in IOT with edge computing

Detailed Syllabus

Assignment No.	Suggested List of Assignments (Any 6)	Hours
1.	Set up the Arduino IDE for ESP8266-12 module and program it to blink a LED light.	6
2.	Create an IoT hub.	6
3.	Register an IoT Edge device to your IoT hub.	6
4.	Install and start the IoT Edge for Linux on Windows runtime on your device.	6
5.	Remotely deploy a module to an IoT Edge device and send telemetry.	6
6.	Python based basic programs using Raspberry Pi.	6
7.	Publishing Data using HTTP.	12
8.	Temperature Logger	12
Total		60

Reference Books:

1. Learn Edge Analytics - Fundamentals of Edge Analytics: Automated analytics at source usingMicrosoft Azure by Ashish Mahajan
2. Peter Waher, "Mastering Internet of Things: Design and create your own IoT applications usingRaspberry Pi 3", First Edition, Packt Publishing, 2018
3. John C. Shovic, "Raspberry Pi IoT Projects: Prototyping Experiments for Makers", Packt Publishing, 2016
4. Python for Microcontrollers: Getting Started with MicroPython Paperback – 16 December 2016,by Donald Norris, McGraw-Hill Education TAB
5. Programming with MicroPython: Embedded Programming with Microcontrollers and Python, byNicholas H. Tollervey, OReilly ′
6. R. Buyya, S.N. Srirama (2019), Fog and Edge Computing: Principles and Paradigms, Wiley-Blackwell, 2019

Program:	M. Tech. (E&TC)-VLSI and Embedded Systems			Semester: II			
Course:	Embedded AI Lab			Code:MET32PE08D			
Credits	Teaching Scheme (Hrs./Week)			Evaluation Scheme			
	Lecture	Practical	Tutorial	TW	PR	OR	Total
02		04		25	-	25	50

Prior knowledge of:

Embedded System and Communication protocol **is essential**

Course Objectives:

This course aims at enabling students

1. To explore Embedded AI platforms such as STM Edge AI board
2. To demonstrate AI applications of Embedded Platform

Course Outcomes

After completion of this course, students will be able to,

1. Use Embedded Tools for AI applications
2. Design and implement AI applications on Embedded platform

Detailed Syllabus: (Any six experiment will be conducted)

Unit	Description	Duration
1.	To study STMicroelectronics Edge AI Developer Kit and STM Cube IDE design Flow	**6**
2.	To interface Motion, Vibration and Body Temperature sensor with EDGE AI board and detect abnormal behavior.	**6**
3.	To interface Pulse Oxymeter with edge AI board to detect threshold based variation in oxygen level in human body. & EKG Sensor	**6**
4.	To read simple standardize dataset from 4GB Micro SD Card with Module and plot on OLED Display.	**6**
5	To interface EKG Sensor with edge AI board to measure and analyze the heart rate	**6**
6	To create database for heart rate variability and save in SD Card	**6**
7	To install and run Tiny ML: TensorFlowLite Micro examples on a Arduino Nano 33 BLE Sense.	**12**
8	To interface Temperature , humidity and pressure sensor with Arduino Nano 33 BLE Sense using Tiny ML	**12**
	Total	60

Reference Books:

1. Xiaofei Wang, Yiwen Han, Victor C. M. Leung, DusitNiyato, Xueqiang Yan, Xu Chen - Edge AI_ Convergence of Edge Computing and Artificial Intelligence-Springer Singapore_Springer (2020)

2. Pete Warden, Daniel Situnayake - TinyML_ Machine Learning with TensorFlowLite on Arduino and Ultra-Low-Power Microcontrollers-O'Reilly Media, 2019

3. OvidiuVermesan, Mario Diaz Nava, BjörnDebaillie - Embedded Artificial Intelligence_ Devices, Embedded Systems, and Industrial Applications, River Publishers Series in Communications and Networking, 2023.

4. R. I. Minu, G. Nagarajan, Pethuru Raj Chelliah - Applied Edge Ai_ Concepts, Platforms, and Industry Use Cases-CRC Press (2022)

Program	M. Tech. (E&TC)-VLSI and Embedded Systems			Semester:	II		
Course	**Massive Open Online Course (MOOCS) (Project oriented)**			Code	MET33PC06		
Credits	Teaching Scheme (Hrs./Week)			Evaluation Scheme			
	Lecture	Practical	Tutorial	TW	PR	OR	Total
2	2	-	-	50	-	-	50

Course Objectives:

This course aims at enabling students to:

1. Develop diversified knowledge and multidisciplinary skills on a unified platform.
2. Explore new areas of interest and emerging technologies.
3. Foster innovation, creativity, and independent learning abilities.

Course Outcomes:

After learning the course, the students will be able to:

1. Explain concepts across various technical domains.
2. Apply domain knowledge to solve real-life problems.

Guidelines for Students:

Individual students can register for MOOC courses related to their area of interest to conduct their project work.

A. **Selection of Course:**

- Students can select any MOOC Course from an Online Certification provider with guidance from MOOC Mentor.
- The selected course should not be from courses offered in the program curriculum earlier.
- The selected MOOC course should be approved by the Department.
- The selected course should be from NPTEL / Coursera / Udemy/Any foreign University approved course.
- Certification and Grade report is mandatory for the course to be selected.

B. **Duration of Course:** A selected course should be of Minimum 25-30 Hrs(or two courses of 15 Hrs each)

C. **Assessment of Course:**

- At the end of Course submission the MOOCs report of 10-15 Pages in hardcopy is mandatory along with certificate of completion.
- Assessment will be done through Certification exam report.
- Assessment will be done by MOOC Mentor.

Evaluation Guidelines and Rubrics:

- MOOC Mentor will observe the progress of the student.
- Students will be evaluated progressively for a total 100 Marks. (i.e. 70 Marks Progressive and 30 Marks Completion of Certificate) and scale down to 50 marks.

Sr. No.	Rubrics	Marks
1	Presentation of the topic Selected	20
2	Scores of Assignments	50
	Total Marks	**70**

The **30** marks will be based on Certification Completion.

Program:	**M. Tech. (E&TC)-VLSI and Embedded Systems**			**Semester:**		**II**	
Course:	**Seminar**			**Code:**		**MET32EL01**	
Credits	**Teaching Scheme (Hrs. /Week)**			**Evaluation Scheme and Marks**			
	Theory	**Practical**	**Tutorial**	**TW**	**PR**	**OR**	**Total**
2	--	04	--	25	-	25	50

Course Objectives

This course aims at enabling students to:

1. Analyze current research trends in VLSI and embedded systems through literature review.
2. Develop the ability to critically evaluate research problems and methodologies.
3. Communicate research findings effectively through technical reports and presentations.

Course Outcomes:

After learning the course, the students will be able to:

1. Analyze existing research work and identify key findings and research gaps.
2. Develop structured technical reports based on literature review and analysis.
3. Present research outcomes effectively and explain their significance in a chosen domain.

Guidelines:

1. Under the supervision of a designated guide, each student must study current trends in the fields of VLSI and embedded systems.
2. Students can select an embedded system or VLSI topic based on current trends and the significance of the topic to society or individual.
3. A comprehensive review of the literature, mathematical modeling using a specific technique, and a useful conclusion are anticipated from the seminar research.
4. The expected research outcome of the seminar is the publication of the paper.
5. As part of their term work related to the subject, students must prepare a seminar report and submit it.

Rubrics For Seminar Evaluation:

	Criteria	**Weightage**
1	**Topic**	**10**
2	Literature Review	**10**
3	Subject Knowledge	**20**

4	Presentation: Presentation Skills , Interaction , Appearance , Organization of data	**40**
5	Conclusions and Future Scope	**10**
6	Report	**10**
	Total weightage	**100**

Detailed Syllabus:

Seminar Activities

Sr. No.	Activity	Duration
1.	Week 1 &3 : Guide allotment, finalization of topic, Planning of the work. Review-1 conduction	**6**
2.	Week 4&5: Literature review, Specification and Methodology Finalization, of detail topic.	**4**
3.	Week 6&8: Detail Topic Mathematical model, methodology and findings Review-2 conduction	**6**
4.	Week 9&10 : Comparison of detail topic with other existing methods	**4**
5.	Week 11 & 12: Seminar Report writing and publication or copyright planning Final Review conduction.	**4**
	Total	**24**

Program:	M. Tech (All branches)					Semester :	II
Course :	Skill Development Lab (Oral Communication & Professional Skills)					Code :	MET22VS01
Credits	Teaching Scheme (Hrs./Week)			Teaching Scheme (Hrs./Week)			
	Lecture	Practical	Tutorial	TW	PR	OR	Total
1	-	2	-	50	--	--	50

Prior Knowledge: Basic Communication skills

Course Objectives:

This course aims at enabling students to:

1. Analyze existing research work in selected domains of VLSI and embedded systems.
2. Develop the ability to prepare structured technical reports based on literature review.
3. Present and communicate research findings effectively with clarity and significance.

Course Outcomes:

After learning the course, the students should be able to:

1. Demonstrate effective verbal communication skills in structured activities such as presentations and discussions
2. Perform effectively in group discussions, interviews, meetings, and presentations
3. Apply teamwork, interpersonal skills, conflict management, and leadership principles in multidisciplinary and heterogeneous teams

Guidelines :

1. Total of 6 assignments out of 8 are to be carried out.

Detailed Syllabus:

Skill Development Lab

Expt.	Description	Duration (Hrs.)
1.	**Group Discussion:** Perform effectively in a structured group discussion by presenting logical, solution-oriented arguments, demonstrating active listening, and adhering to professional and ethical communication practices.	2
2.	**Public Speaking:** Deliver a structured speech (prepared or extempore) demonstrating clarity, confidence, organization of ideas, and appropriate use of verbal and non-verbal communication.	2
3.	**Article Writing:** Compose a well-structured article/report on a contemporary social issue, demonstrating coherence, grammatical accuracy, and critical thinking.	2
4.	**Debate on Current Affairs** Present and defend arguments in a formal debate on current or socially relevant topics while respecting opposing viewpoints and maintaining logical consistency.	2

5.	**Telephonic Etiquettes** Demonstrate professional telephonic communication skills through role-play scenarios, ensuring clarity, tone, etiquette, and effective information exchange.	2
6.	**Email etiquettes:** Draft professional emails **for** formal scenarios (e.g., job application, meeting request), ensuring proper structure, tone, and clarity.	2
7.	**Resume Building & Professional Profile Development**: Develop a professional resume and online profile highlighting skills, achievements, and career objectives aligned with industry expectations.	2
8.	**Mock interviews:** Perform effectively in a mock interview by demonstrating communication skills, confidence, subject clarity, and appropriate professional behavior.	2
	Total	16

Text Books:

1. BarunMitra, Personality Development and SoftSkills
2. *Stephen Lucas,The Art of PublicSpeaking*

Reference Books:

1. Marcia Weaver,Empowering Employees Through BasicSkills
2. Gerald Ratigan, Aced: Superior Interview Skills to Gain an Unfair Advantage to Land Your DREAMJOB!

Program:	M.Tech (E&TC)-VLSI and Embedded System					Semester : II	
Course :	Mini-Project / Case Study Analysis					Code : MET32EL02	
Credits	Teaching Scheme (Hrs./Week)			Evaluation Scheme			
	Lecture	Practical	Tutorial	TW	PR	OR	Total
3	-	6	-	50	--	50	100

Prior Knowledge of

1. Basics of Electronics Circuits, VLSI and Embedded
2. Basics of C, MATLAB,VHDL

Is Essential.

Objectives:

1. To make aware of ―Product Development Process" including budgeting through Mini Project /case study.
2. To introduce build, design and implement process for real time application using available platforms.
3. To inculcate problem solving and analyzing skills through case study

Outcomes:

After learning the course the students should be able to:

1. Understand, plan and execute a Mini Project / Case study.
2. Study and Design real time problems.
3. Prepare a technical report based on the Mini project case study.
4. Deliver technical seminar based on the Mini Project/ case study work carried out.

Guidelines Mini Project :

1. Individual student need to design and demonstrate Mini-project under the guidance of allocated guide.
2. Students can choose platform of VLSI or Embedded system considering their future implementation in Major Project in second year
3. **The hardware implementation on the board and software simulation is compulsory.**
4. Mini-Project Report should be submitted as a compliance of term work associated with subject.
5. Paper publication associated with mini-project as research outcome is appreciable.
6. Mini-project work preferably should be completed in laboratory.
7. **Students should spend 45 hours for experimentations**

Guidelines Case Study:

1. Select Topic which may belongs to existing application/ product/research/ Tools/Society Problem and analysis it on the basis of its impact on community.
2. The Analysis based case study must be conducted by students
3. Statistical Analysis is appreciable.
4. Prepare a paper justifying your analysis and publish in conference.
5. **Students should spend 45 hours for experimentations**
6. **Submission of case study report is compulsory.**

Detailed Syllabus:

Integrated Mini-Project		
Sr. No.	**Activity**	**Duration (Hrs)**
1.	Week 1 &2 : Mini-project/ Case study guide allotment, finalization of topic and platform, Planning of the work	**8**
2.	Week 3&4: Literature review and specification and Methodology Finalization, Review 1 for finalization of topic and specification.	**8**
3.	Week 5&6 : Simulation of Idea on appropriate software tools and finalization of hardware platform	**8**
4.	Week 7 &8 : understanding platform implementation and related software flow and execute block level design , Review 2 to understand the progress of the project/ case study	**8**
5.	Week 9 & 10: Mini Project Report writing and publication or copyright planning and execution.	**6**
6.	Week 11&12: Demonstration of Project work and Final Review for submission and term work compliances./ case study seminar	**7**
	Total	**45**

Reference:

1. Robert Boylested,, Essentials of Circuit Analysis ,PHI Puublications
2. Thomas C Hayes, Paul Horowitz, The Art of Electronics Newens Publication
3. A.F.Ward.Angus,, Electronic Product Design, Stanley Thornes Publishers, UK.
4. William Ellet. The Case Study Handbook, Revised Edition: A Student's Guide, Harvard Business Press, 2018

Syllabus

Semester -III

M. Tech.

E&TC Engineering

Program	M.Tech. E&TC-VLSI and Embedded Systems			Semester	III		
Course	**Dissertation Phase – I**			**Code**	MET33EL03		
Credits	**Teaching Scheme (Hrs./Week)**			**Evaluation Scheme and Marks**			
	Lecture	**Practical**	**Tutorial**	**TW**	**PR**	**OR**	**Total**
16	-	32	-	200	-	100	300

Prior knowledge of:

1. Basics of VLSI and Embedded System Concepts
2. Basics of Programming Languages

is essential

Course Objectives:

This course will enable students

1. To make student expert in software and hardware co-design .
2. To engage in independent research, apply theoretical concepts to practical problems, and make a meaningful contribution to the field of study.

Course Outcomes:

After learning the course, the students will be able to:

1. Identify a realistic problem of societal, industry, or research relevance.
2. Compare the literature to find the most appropriate and feasible solution for the selected problem statement.
3. Apply the research methodology tools for data collection and analysis.
4. Design real-life applications considering Emerging areas in technology

Guidelines:

1. Students should get the approval of authorities for dissertation title.
2. Students shall provide an overview of the research problem, its significance, and the objectives of the study. Briefly discuss the background literature and highlight the gap your research aims to address.
3. Students shall conduct a comprehensive review of relevant literature and research in the chosen field. Critically analyze existing work and identify gaps, controversies, or areas needing further exploration.
4. Students shall describe the research methodology he/she intend to employ. This includes detailing the research design, data collection methods, tools or instruments to be used, and any statistical techniques for data analysis.
5. Students should outline the specific tasks or activities he/she plan to undertake in Phase I of your dissertation. This may include literature survey, preliminary data collection, feasibility studies, or development of prototypes.
6. Student should clearly articulate the expected outcomes or contributions of the

research.

7. Students shall develop a realistic timeline for completing Phase I of their dissertation. They can break down the tasks into smaller milestones and allocate time for each activity.
8. Students shall identify the resources they need to carry out their research effectively. This may include access to databases, laboratory facilities, equipment, or software tools.
9. Student need to design and demonstrate project under the guidance of allocated guide.
10. Sponsored Project Internship is acceptable considering postgraduate scope.
11. Project Report-1should be submitted as a compliance of term work associated with the subject.
12. At least 1 Paper publicationis expected as research outcome of Project Stage-I (Scopus indexed Conference or Journal) and 40% of planned project work should be completed for submission of Dissertation Phase-I.
13. Total Duration: 240 hours are contact hours with guides and for reviews; 240 hours are expected to be spend by student to satisfy all project requirements and implementation

Detailed Syllabus

Assignment No.	**Description**
1.	Week1, 2, 3: Guide allotment, applying for sponsorship and project internship, finalization of topic and platform, Planning of the work.
2.	Week4,5,6:Literature review, Specification and Methodology Finalization, Review1for finalization of topic and specification
3.	Week 7, 8,9: Understanding platform for implementation and related software flow and execute block level design , Review 2 to understand the progress of the project
4.	Week10,11: Simulation of proposed methodology on appropriate software tools and finalization of hardware platform
5.	Week 12, 13, 14, 15: Project Report writing and publication or copyright planning and Execution. Demonstration of Project work and Final Review for submission and term work compliances

Program	M.Tech. E&TC- VLSI and Embedded Systems			Semester	III		
Course	**Research/ IndustryInternship**			**Code**	MET33EL04		
Credits	**Teaching Scheme (Hrs./Week)**			**Evaluation Scheme and Marks**			
	Lecture	**Practical**	**Tutorial**	**TW**	**OR**	**PR**	**Total**
4	-	8	-	100	-	-	100

Prior knowledge of:

Basics of programming language such as Java, MATLAB, Python etc

Course Objectives:

This course will enable students

1. To provide the opportunities to learn, understand and sharpen the research acumen, as well as the communication/ technical/managerial skills required for conducting research.
2. To enhance their problem-solving and critical-thinking abilities.
3. To provide an opportunity to the students to carry out research in a real work environment with supervisor guidance over a specific period.
4. To familiarize students with research methods, analytical tools and techniques along with their appropriate usage.

Course Outcomes:

After learning the course, the students will be able to:

1. Develop the ability to learn the concept of Literature Review, Technical Reading, critical evaluation, Attributions and Citations.
2. Identify and apply the algorithm or mechanism to solve the research problem.
3. Adapt Ethics in Engineering Research.
4. Prepare a technical report based on the results obtained.

Guidelines:

1. Individual student need to attempt for research internship under the guidance of allocated supervisor.
2. Student can do research internship in the industry or in the institute under guidance of allocated supervisor.
3. Student doing research internship in the industry can work on the problem statement provided by the industry.
   For student doing internship in the institute, supervisor will assign a research task (problem statement or part of funding proposal).
4. Student is supposed to provide a feasible solution to the assigned problem statement.
5. Student will synthesize research findings by drafting a research report.
6. Three reviews will be scheduled to assess progress of the research work. Review-I: Student will present current state of the art of the literature for the assigned research task.
   Review-II: Explanation of the partial results obtained through implementation of the proposed algorithm is expected.
   Review-III: Demonstration and explanation of the complete solution of the assigned research task is expected.
7. Student should try to publish the results in the reputed journal or register a patent.
8. Student is supposed to submit research internship report as a compliance of term work associated with subject.

Detailed Syllabus	
Assignment No.	**Suggested List of Assignments**
1.	Assignment of research task ● Presentation of domain knowledge in the interested area of research ● Guide allotment ● Assignment of research task by supervisor
2.	Finalize problem statement and define objectives
3.	Conducting critical literature review: Selection of appropriate research papers Critical reading and thinking Comparative analysis of the papers Finding a research Gap
4.	Review-1 (Will be conducted in Week 5-6): Expectation: Discussion on the problem statement and defined objectives
6.	Data Collection: Techniques of data collection. Sources used for Data collection, creation and publishing own Data Sets if required
7.	Implementation of the problem statement: Identification of technology/methodology/algorithm, system architecture, flow diagram, mathematical modeling, front end, back end
9.	Review-2 (Will be conducted in Week 11): Expectations: Discussion on methodology, system architecture, implementation and partial results.
10.	Result Analysis and discussion
11.	Write a research paper/funding proposal/patent draft. Software for paper formatting like LaTeX/MS Office etc can be used Citing styles and tools such as Google scholar, Mendleyetc Reference Management Software like Zotero/Mendeley

Syllabus
Semester -IV
M. Tech.
E&TC Engineering

Program	M.Tech. E&TC-VLSI and Embedded Systems			Semester	IV		
Course	**Dissertation Phase – II**			**Code**	MET34EL05		
Credits	**Teaching Scheme (Hrs./Week)**			**Evaluation Scheme and Marks**			
	Lecture	**Practical**	**Tutorial**	**TW**	**PR**	**OR**	**Total**
18	-	36	-	250	-	100	350

Prior knowledge of:

1. Basics of VLSI and Embedded Systems Concepts
2. Basics of Programming Languages

is essential

Course Objectives:

This course will enable students

1. To understand the Hardware and Software Co-design Development Process.
2. To conduct original research, contribute new knowledge or insights to the field, and demonstrate mastery of the subject matter.

Course Outcomes:

After learning the course, the students will be able to:

1. Develop a prototype based on the design of the project.
2. Analyze and synthesize research findings to the agreed area of research.
3. Evaluate the methods and knowledge to solve the specific research problem.
4. Write thesis/report based on evaluation and analysis undertaken.

Guidelines:

1. Semester III major project is continued to be completed in this section under the guidance of allocated project guide.
2. Hardware Interfacing is compulsory for this submission
3. Provide a brief recap of the research problem, objectives, and methodology outlined in Phase I. Highlight any adjustments or refinements made based on Phase I feedback.
4. Detail the steps taken to implement your proposed solution or research methodology. This may involve software development, prototype construction, experimental setup, or data collection procedures.
5. Describe the experiments or studies conducted to test your hypotheses or validate your solution. Provide details on the experimental setup, data collection methods, and any variables or parameters investigated.
6. Present the results of your experiments or studies in a clear and organized manner. Use tables, charts, graphs, or other visual aids to summarize your findings. Analyze the data to draw meaningful conclusions and insights.
7. Interpret the results of your research in the context of existing literature and theoretical frameworks. Discuss any unexpected findings, limitations of your study, and implications for

theory or practice.

8. If applicable, discuss the validation of your solution or methodology. Address any validation criteria or benchmarks used to assess the effectiveness or performance of your work.
9. Summarize the key findings of your research and their implications. Reflect on how your work contributes to the existing body of knowledge in your field and any future research directions.
10. Reflect on your overall research experience, including challenges faced, lessons learned, and strategies for overcoming obstacles. Discuss any changes in your understanding of the research problem or your approach to solving it.
11. Final Project Report including all process of project should be submitted as a compliance of term work associated with subject and permission to appear for examination.
12. Minimum2 Paper publications are expected as research outcome of Dissertation Phase - I and II (Scopus Indexed Conference or Journal) and 100% of planned project work should be completed for submission of Dissertation Phase-II
13. Total Duration: 32 hours/ week are contact hours with guides, implementation, research outcomes and for reviews.

Detailed Syllabus

Assignment No.	Description
1.	Week1, 2:60 %Work should be completed.
2.	Week 3,4: Software Simulation and Hardware Implementation should be completed.Review1conduction.
3.	Week 5,6,7: Paper Publication should be in process or completed during this week,80%work should be completed.
4.	Week8,9,10: Compliance of 100% work. Review-2 will be conducted
5.	Week11,12: Department Reviews will be conducted to check the quality of project and requirements fulfilment to permit project submission
6.	Week 13,14,15: Project Report writing and copyright planning and execution. Demonstration of Project work and Final Research Review Committee (RRC) reviews will be conducted for submission and term work compliances.

Course	Massive Open Online Course (MOOCS)-(Interdisciplinary)			Code			MET34PC07
Credits	Teaching Scheme (Hrs./Week)			Evaluation Scheme			
	Lecture	Practical	Tutorial	TW	PR	OR	Total
2	-	4	-	50	-	-	50

Course Objectives:

1. To provide diversified knowledge and skills in a single platform
2. To provide opportunity to students to explore new areas of interest
3. To foster student engagement in self learning

Course Outcomes: After learning the course, the students will be able to:

1. Acquire knowledge about various technical or non-technical domains.
2. Apply interdisciplinary concepts in various fields
3. To analyze the new state- of- art for life-long learning.

Guidelines for Students:

Individual students can register for MOOC courses of their interest in III Semester as MOOC Course offered by the institute.

Selection of Course:

1. Students can select any MOOC Course from an Online Certification provider with guidance from MOOC Mentor.
2. The selected course should not be from courses offered in the program curriculum earlier.
3. The selected MOOC course should be approved by the Department.
4. The selected course should be from Nptel / Coursera / Udemy/Any foreign University approved course.
5. Certification and Grade report is mandatory for the course to be selected.

Duration of Course: A selected course should be of Minimum 60 Hrs(or two courses of 30 Hrs each)

Assessment of Course :

1. At the end of Course submission, the MOOCs report of 10-15 Pages in hardcopy is mandatory along with certificate of completion.
2. Assessment will be done through Certification exam report.
3. Assessment will be done by MOOC Mentor.

Evaluation Guidelines and Rubrics:

1. MOOC Mentor will observe the progress of the student.
2. Students will be evaluated progressively for a total 100 Marks. (i.e. 70 Marks Progressive and 30 Marks Completion of Certificate)

Sr. No.	Rubrics	Marks
1	Presentation of the topic Selected	20
2	Scores of Assignments	50
Total Marks		**70**

The 30 marks will be based on Certification Completion.

Pimpri Chinchwad College of Engineering

Department of Electronics and Telecommunication Engineering

VISION

To be recognized as a distinguished department in the field of Electronics and Telecommunication transforming students into competent technocrats by providing an Ethical, Sustainable and Value-Added Quality Education.

MISSION

1. To create competent Electronics and Telecommunication engineers with Knowledge, Skill, and Attitude by establishing a conducive learning environment.
2. To nurture technical competency, and entrepreneurship skills and promote higher studies through the state-of-the-art facilities for building successful careers.
3. To facilitate research by engaging in projects of industrial requirement and national importance.
4. To impart Life skills, Ethical and Social values for self-sustainability.

M.Tech (E&TC)-VLSI and Embedded Systems

PROGRAM OUTCOMES

1. An ability to independently carry out research /investigation and development work to solve practical problems
2. An ability to write and present a substantial technical report/document
3. Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
4. Acquire competency in areas of VLSI and Embedded Systems, Design, Testing, Verification and prototype development focusing on applications.