

B. Tech. [Electronics and Communication Engineering (ECE)] - M. Tech. [VLSI and Embedded Systems]

<p>Program Learning Objectives:</p> <ol style="list-style-type: none"> 1. Develop a solid foundation in electronics and communication engineering principles, including circuit analysis, electronic devices, signal processing, microprocessor/microcontroller systems, analog communication systems, digital communication, and RF circuits etc. 2. Develop electronics and communication project management skills, including the ability to plan, execute, and complete within specified timelines and budgets. 3. Work collaboratively in multidisciplinary teams, demonstrating effective teamwork and communication to solve complex engineering problems. 4. Recognize the importance of ongoing professional development, engaging in activities such as certifications, workshops, and conferences to stay updated of industry trends. 	<p>Program Learning Outcomes:</p> <p>The graduates of this program will have</p> <ol style="list-style-type: none"> 1. a successful career in an Academia/Industry/Entrepreneur. 2. strong fundamentals in electronics and communications engineering. 3. ability to design prototypes for real world problems related to electronics, communications and interdisciplinary fields. 4. ability to develop soft skills such as effective communications in both verbal and written forms, body language, time management, problem-solving, leadership, work in both team as well as individual in a professional manner.
<p>Program Goal 1: Academic excellence by providing a curriculum that aligns with industry standards and encourages critical thinking in the field of electronics and communication engineering.</p>	<p>Program Learning Outcome 1a: Highly skilled market ready man power to serve the emerging electronic sectors Program Learning Outcome 1b: Skilled Human resource to cater the needs of next generation communication sectors</p>
<p>Program Goal 2: A culture of research and innovation by promoting faculty and student involvement in cutting-edge projects in electronic and communication technologies.</p>	<p>Program Learning Outcome 2a: Trained researchers for implementing research projects in line with national priorities such as CPS, Semiconductors, Clean Energy, Green Technologies Program Learning Outcome 2b: Design and develop innovative smart electronics products as per the societal need</p>
<p>Program Goal 3: To design dynamic and flexible course structures for UG and PG programs as per the changing requirement of the industries</p>	<p>Program Learning Outcome 3a: Industry relevant UG, PG, and research programs Program Learning Outcome 3b: Trained manpower as per the industry requirement</p>

<p>Program Goal 4: To promote entrepreneurship among the students in the field of electronics and communication engineering</p>	<p>Program Learning Outcome 4a: Realization of working prototype towards product development</p> <p>Program Learning Outcome 4b: Promotion of in-house technology-based ventures catering societal needs</p>
<p>Program Goal 5: Equip students with strong communication skills, enabling them to articulate technical concepts clearly and effectively in both written and oral forms.</p>	<p>Program Learning Outcome 5a: Man power with enhanced soft skills to support the vision of developed India</p> <p>Program Learning Outcome 5b: Responsible citizen for the holistic growth of the country</p>
<p>Program Goal 6: Identify, formulate and solve engineering problems in the field of Embedded system and VLSI</p>	<p>Program Learning Outcome 6a: Graduates will be able to take up career in the field of design, testing and implementation of VLSI systems in any said domain in the real world.</p> <p>Program Learning Outcome 6b: Identify and apply appropriate Electronic Design Automation (EDA) tools to solve real world problems in VLSI and Embedded Systems domain to create innovative products and systems.</p>
<p>Program Goal 7: Apply knowledge, proper methodology and modern tools to analyze and solve the problems in the domain VLSI Design and Technology.</p>	<p>Program Learning Outcome 7a: Acquire in-depth knowledge of VLSI and Embedded systems in wider and global perspective, with an ability to discriminate, evaluate, analyze, synthesize and integrate for enhancement of knowledge.</p> <p>Program Learning Outcome 7b: Get exposure in domain from modern semiconductor devices to circuits and systems to address the issues and challenges in Chip Design and fabrication to meet the requirement of today's hardware systems for real time applications.</p>
<p>Program Goal 8: Acquire competency in areas of VLSI and Embedded Systems, IC Fabrication, Design, Testing, Verification and prototype development focusing on applications.</p>	<p>Program Learning Outcome 8a: Pursue career in research in VLSI Design and Embedded Systems domain through self-learning and self-directed on cutting edge technologies</p> <p>Program Learning Outcome 8b: Graduates will be able to achieve broad and in-depth knowledge of analysis and design of micro-electronic components which will support them to pursue research studies.</p>

Program Goal 9: Acquire professional and intellectual integrity and ethics of research and recognize the need to engage in learning with a high level of enthusiasm and commitment to contribute to the community for sustainable development of society.

Program Learning Outcome 9a: Graduates will be able to assess, innovate, implement and serve the end users problems with cutting edge solutions to meet industry standards

Program Learning Outcome 9b: Graduates will be able to work both as an individual and a team on multidisciplinary projects and excel in their career

SEMESTER VII						
Sl. No.	Subject Code	Subject Name	L	T	P	C
1.	EC41PQ	B. Tech. Elective - I	3	0	0	3
2.	EC41PQ	B. Tech. Elective - II	3	0	0	3
3.	XX41PQ	IDE - III	3	0	0	3
4.	HS41PQ	HSS Elective - II	3	0	0	3
5.	EC4194	Summer Internship*	0	0	6	3
6.	EC4195	Project – I	0	0	12	6
7.	EC5104	Digital VLSI System	3	0	2	4
TOTAL			15	0	20	25

*** For specific cases of internship after 6th Semester, extended over to 7th Semester:**

Note :

a) Summer internship (*) period of at least 60 days' (8 weeks) duration begins in the intervening vacation between semester 6 and 7 that may be done in industry/R & D /Academic institutions including IIT Patna. The evaluation would comprise **combined grading based on host supervisor evaluation, project internship report after plagiarism check and seminar presentation at the Department (DAPC to coordinate)** with equal weightage of each of the three components stated herein.

b) (i) In the 7th semester, students can opt for a semester long internship on recommendation of the DAPC and approval of the Competent Authority.

b)(ii) On approval of semester long internship, at the maximum two courses (properly mapped/aligned syllabus) at par with institute electives may be opted from NPTEL and/or SWAYAM and the other two more should be done at the institute through course overloading in any other semester (either before or after the internship) and/or during following summer semester.

b)(iii) Further, on return from internship, students will be evaluated for internship work through combined grading based on host supervisor evaluation, project internship report after plagiarism check, and presentation evaluation by the parent department with equal weightage of each component.

SEMESTER VIII						
Sl. No.	Subject Code	Subject Name	L	T	P	C
1.	RM6201	Research Methodology	3	1	0	4
2.	EC5203	Analog and Mixed Signal Integrated Circuits	3	0	2	4
3.	EC5204	High Performance Embedded Computing system	3	0	2	4
4.	EC52PQ	M. Tech. Elective - I	3	0	0	3
5.	EC4295	Project – II	0	0	12	6
TOTAL			12	1	16	21

SEMESTER IX						
Sl. No.	Subject Code	Subject Name	L	T	P	C
1.	EC51PQ/ EC61PQ	M. Tech. Elective – II	3	0	0	3
2.	XX51PQ/ XX61PQ	M. Tech. Elective – III	3	0	0	3
3.	EC51PQ/ EC61PQ	M. Tech. Elective - IV	3	0	0	3
4.	EC5195	Project – III	0	0	16	8
TOTAL			9	0	16	17

SEMESTER X						
Sl. No.	Subject Code	Subject Name	L	T	P	C
1.	EC5295	Project – IV**	0	0	36	18
TOTAL			0	0	36	18

****Note: M. Tech. Project outside the Institute**

In the IXth Semester, students can opt for a semester long M. Tech. project subject to confirmation from an Institution of repute for research project, on the assigned topic at any external Institution (Industry / R&D lab / Academic Institutions) based on recommendation of the DAPC provided:

(i.) The project topic is well defined in objective, methodology and expected outcome through an abstract and statement of the student pertaining to expertise with the proposed supervisor of the host institution and consent of the faculty member from the concerned department at IIT Patna as joint supervisor.

(ii.) The consent of both the supervisors (external and institutional) on project topic is obtained a priori and forwarded to the academic section through DAPC for approval by the competent authority for office record in the personal file of the candidate.

(iii.) Confidentiality and Non Disclosure Agreement (NDA) between the two organizations with clarity on intellectual property rights (IPR) must be executed prior to initiating the semester long project assignment and committing the same to external organization and vice versa.

(iv.) The evaluation in each semester at Institute would be mandatory and the report from Industry Supervisor will be given due weightage as defined in the Academic Regulation. Further, the final assessment of the project work on completion will be done with equal weightage for assessment of the host and Institute supervisors, project report after **plagiarism check**. The award of grade would comprise **combined assessment based on host supervisor evaluation, project report quality and seminar presentation at the Department (DAPC to coordinate)** with equal weightage of each of the components stated herein.

(v.) In case of poor progress of work and / or no contribution from external supervisor, the student need to revert back to the Institute essentially to fulfill the completion of M. Tech. project as envisaged at the time of project allotment. However, the recommendation of DAPC based on progress report and presentation would be mandatory for a final decision by the competent authority.

GRAND TOTAL (Semester I to X) : 210

ELECTIVE GROUPS

B. Tech. Elective - I						
Sl. No.	Subject Code	Subject	L	T	P	C
1.	EC4101	Introduction to Quantum Computing	3	0	0	3
2.	EC4102	Deep Learning for Video Surveillance Systems	3	0	0	3
3.	EC4103	FPGA based System Design	3	0	0	3

B. Tech. Elective - II						
Sl. No.	Subject Code	Subject	L	T	P	C
1.	EC4104	Introduction to Information Theory	3	0	0	3
2.	EC4105	Digital Image Processing	3	0	0	3
3.	EC4106	Graph Signal Processing	3	0	0	3

M. Tech. Elective - I						
Sl. No.	Subject Code	Subject	L	T	P	C
1.	EC5205	Patterns Recognition and Machine Learning	3	0	0	3
2.	EC5206	Multimedia Communication	3	0	0	3
3.	EC5214	VLSI Technology	3	0	0	3
4.	EC5215	Sensors and Actuators	3	0	0	3
5.	EC5216	Low Power VLSI	3	0	0	3

6.	EC5217	CAD VLSI	3	0	0	3
7.	EC5218	Silicon Photonics	3	0	0	3
8.	EC5219	Embedded System Integration	3	0	0	3
9.	EC5220	High Power Semiconductor Devices	3	0	0	3
10.	EE5203	Recent Trends in Optimization Techniques	3	0	0	3

M. Tech. Elective – II

Sl. No.	Subject Code	Subject	L	T	P	C
1.	EC5108	Internet of Things (IoT) Networks	3	0	0	3
2.	EC5111	VLSI Architecture Design and Implementation	3	0	0	3
3.	EC5114	Opto-Electronics Materials and Devices	3	0	0	3
4.	EC5115	Radio Frequency Integrated Circuits	3	0	0	3
5.	EC5116	Advanced Digital Image Processing	3	0	0	3

M. Tech. Elective - III

Sl. No.	Subject Code	Subject	L	T	P	C
1.	EC5117	VLSI Testing and Verification	3	0	0	3
2.	EC5118	Bio Sensors and Circuits	3	0	0	3
3.	EC5119	Quantum Computing	3	0	0	3

M. Tech. Elective - IV

Sl. No.	Subject Code	Subject	L	T	P	C
1.	EC6105	CMOS Phase Locked Loops	3	0	0	3
2.	EC6106	Computer Vision	3	0	0	3
3.	EC6104	VLSI Signal Processing	3	0	0	3

SEMESTER VII						
Sl. No.	Subject Code	Subject Name	L	T	P	C
1.	EC41PQ	B. Tech. Elective - I	3	0	0	3
2.	EC41PQ	B. Tech. Elective - II	3	0	0	3
3.	XX41PQ	IDE - III	3	0	0	3
4.	HS41PQ	HSS Elective - II	3	0	0	3
5.	EC4194	Summer Internship*	0	0	6	3
6.	EC4195	Project – I	0	0	12	6
7.	EC5104	Digital VLSI System	3	0	2	4
TOTAL			15	0	20	25

B. Tech. Elective - I						
Sl. No.	Subject Code	Subject	L	T	P	C
1.	EC4101	Introduction to Quantum Computing	3	0	0	3
2.	EC4102	Deep Learning for Video Surveillance Systems	3	0	0	3
3.	EC4103	FPGA based System Design	3	0	0	3

Course Number	EC4101
Course Credit	3-0-0-3
Course Title	Introduction to Quantum Computing
Learning Mode	Lectures
Learning Objectives	Complies with Program Goal 1, 2 and 3
Course Description	The course deals with the key components and architecture of quantum computing systems, including qubits, quantum gates, and quantum circuits. It also focuses on comprehending the principles of quantum information theory, including quantum entanglement, quantum entropy, and quantum teleportation. Implementation and analysis of quantum algorithms, such as Shor's algorithm for factoring and Grover's algorithm for search problems is also included.
Course Outline	Introduction: History, Motivation, Need of quantum bits, quantum states, quantum computations, quantum information, and quantum algorithms Overview of complex numbers and Linear Algebra, Introduction to quantum mechanics and its postulates, Bloch sphere Quantum gates: X, Z, Y, H, R, S, T, Square root of NOT Quantum Circuits: Single qubits and multiple qubits operations and quantum teleportation Quantum Algorithms: Deutsch's algorithm, Deutsch-Jozsa algorithm, Simon's algorithm Quantum Tools and Applications: Goal Challenges, Lights and Photon, Decoherence, Ion Trap, Quantum Simulation
Learning Outcomes	Complies with PLO 1b, 2a and 3a
Assessment Method	Quiz, Assignments and Exams
Suggested Reading	Textbooks: <ol style="list-style-type: none"> Nielsen, M. A., and Chuang, I. L., Quantum computation and quantum information, 10th Anniversary Edition, 2010, Cambridge university press. Yanofsky, N. S., and Mannucci, M. A., Quantum computing for computer scientists, 1st Edition, 2008, Cambridge University Press. Reference Books: <ol style="list-style-type: none"> Johnston, E. R., Harrigan, N., and Gimeno-Segovia, M., Programming quantum computers: essential algorithms and code samples, 1st Edition, 2019, O'Reilly Media.

Course Number	EC4102
Course Credit	3-0-0-3
Course Title	Deep Learning for Video Surveillance Systems
Learning Mode	Lectures
Learning Objectives	Complies with Program Goal 1, 2 and 3
Course Description	The course deals with video surveillance tasks such as monitoring and processing of video footage, and understanding and analyzing of machine and deep learning models. The course also develop competence to take logical, scientific and correct decisions while predicting model outcomes. Aptitude and ability of performance measurement and management of video surveillance cameras is also covered.
Course Outline	<p>Introduction to Video Surveillance Systems: Introduction to image processing methods, Edge detection and linking, Image transforms, Introduction to video processing techniques, Video compression standards. Motion detection using optical flow method, motion modeling, Background modeling, Basic building blocks of video surveillance systems.</p> <p>Introduction to Deep Learning: Introduction to neural networks with linear algebra, Matrix mathematics and probability, Introduction to multilayer perceptron networks, forward and back propagation, Hyper-parameter tuning, Regularization and optimization in neural networks, Introduction to tensor-flow.</p> <p>Convolutional Neural Nets: Introduction to convolutional neural networks, Key concepts like convolution and pooling. Stacking convolutional layers for object detection.</p> <p>Recurrent Neural Nets: Introduction to recurrent neural networks (RNN, LSTM, GRU) for sequence level tasks (time series, video). Bidirectional and deep recurrent nets. Use them for activity recognition.</p> <p>Object Detection and Classification using Deep Learning: Haar like feature based object detection, Viola Jones object detection framework, Deep learning based object classification.</p> <p>Object Tracking using Deep Learning: Video monitoring for detection and tracking of single as well as multiple interacting objects, Region-based tracking, Contourbased tracking, Feature-based tracking, Model-based tracking, KLT tracker, Meanshift based tracking.</p> <p>Deep Learning based Human Activity Recognition: Template based activity recognition, CNN based activity recognition, RNN based activity recognition, abnormal behavior detection in crowded environments using deep learning</p> <p>Camera Networks for Surveillance: Types of CCTV (closed circuit television) camera- PTZ (pan-tilt zoom) camera, IR (Infrared) camera, IP (Internet protocol) camera, wireless security camera, multiple view geometry, camera network calibration, PTZ camera calibration, camera placement, smart imagers and smart cameras, Introducing graph signal processing, consensus networks.</p> <p>Emerging Techniques of Deep Learning in Visual Surveillance System: Augmented surveillance system, Operator attention based visual surveillance system, EEG and eye tracking based visual surveillance system, ONVIF standard for the interface of IP-based physical security products.</p>
Learning Outcomes	Complies with PLO 1b, 2a and 3b
Assessment Method	Quiz, Assignments and Exams

Suggested Reading	<p>Textbooks:</p> <ol style="list-style-type: none"> 1. M H Kolekar, "Intelligent Video Surveillance Systems: An Algorithmic Approach", CRC press Taylor and Francis Group, 2018 2. Q. Huihuan, X. Wu, Y. Xu, "Intelligent Surveillance Systems", Springer Publication, 2011. 3. Ian Goodfellow, Yoshua Bengio and Aaron Courville, "Deep Learning", The MIT Press, 2017. <p>Reference Books:</p> <ol style="list-style-type: none"> 1. Murat A. Tekalp, "Digital Video Processing", Prentice Hall, 1995. 2. Pradeep K Atrey, Mohan Kankanhalli, A Cavallaro, "Intelligent Multimedia Surveillance: Current Trends and Research" Springer Publication, 2013. 3. Y. Ma and G. Qian (Ed.), "Intelligent Video Surveillance: Systems and Technology", CRC Press, 2009. 4. H. Aghajan and A. Cavallaro (Ed.), Multi-Camera Network: Principles and Applications", Elsevier, 2009.
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Course Number	EC4103
Course Credit	3-0-0-3
Course Title	FPGA based System Design
Learning Mode	Lectures
Learning Objectives	Complies with Program Goal 1, 2 and 3
Course Description	The course deals with design of complex digital systems & use the design flow for using FPGA. This also gives exposure to Softcore Processor IP, Memory and other IO IPs and digital IPs, understanding of IP integration for large scale FPGA based digital System. Also, it covers performance analysis and issues of large scale digital system on FPGA and completion of a significant project on the FPGA platform.
Course Outline	Introduction to reconfigurable and FPGA based system Design; Basic and Advanced FPGA Fabrics; Combinational, Sequential logic and FSM realization on FPGA; FPGA Architecting: Speed, Area and Power; Issues on FPGA based system Design: Area, Timing and Power; Design Methodologies: Behavioral /high level Design and Implementation methodologies: RTL, IP Core, System Generator; Processor and memory cores; Timing analysis; Clock distribution and management systems; IP Cores for FPGA: Block and Distributed memory, FIFO, CORDIC, Clock distribution and management systems; Large scale System Design: Platform FPGA, Multi-FPGA System; Busses and I/O communication system; System Design and Implementation using FPGA: DSP and Communication Blocks and Cryptography blocks Introduction to FPGA based Embedded system platform: Soft processor, AHB Bus and I/O interfacing – Case studies.
Learning Outcomes	Complies with PLO 1b, 2b and 3b
Assessment Method	Quiz, Assignments and Exams
Suggested Reading	Text/Reference Books: <ol style="list-style-type: none"> 1. Wayne Wolf, "FPGA Based System Design", Prentice Hall Modern Semiconductor Design Series, 2004. 2. Steve Kilts, "Advanced FPGA design – Architecture, Implementation and Optimization", Wiley publications,2007. 3. Ron Sass and Andrew G. Schmidt, Morgan Kaufmann (MK), "Embedded System design with Platform FPGAs", Elsevier,2010.

B. Tech. Elective - II						
Sl. No.	Subject Code	Subject	L	T	P	C
1.	EC4104	Introduction to Information Theory	3	0	0	3
2.	EC4105	Digital Image Processing	3	0	0	3
3.	EC4106	Graph Signal Processing	3	0	0	3

Course Number	EC4104
Course Credit	3-0-0-3
Course Title	Introduction to Information Theory
Learning Mode	Lectures
Learning Objectives	Complies with Program Goal 1, 2 and 3
Course Description	The course deals with the fundamental concepts of information theory, understanding of coding, quantification, storage, and communication of information and analysis of source coding and channel coding.
Course Outline	Overview of random variable, Function of a random variable and its distribution, Discrete distributions, Continuous distributions, Random vector and its joint distribution. The concept of Amount of Information, Average Information, Information rate. Entropy, Joint Entropy and Conditional Entropy, Relative Entropy and Mutual Information, Chain rule for entropy, relative entropy, and mutual information. Source Coding: Fixed and Variable Length Codes, Kraft Inequality, Shannon-Fano Algorithm, Huffman Algorithm. Maximum entropy distribution for continuous and discrete random variables. Channel Capacity, Capacity of different channels: Noiseless binary channel, Noisy channel with nonoverlapping outputs, Binary symmetric channels, Binary erasure channel, symmetric channels, AWGN channels; Shannon Theorem, Bandwidth-SNR Trade-off, Channel Capacity Theorem, Shannon Limit. Maximum entropy distributions for continuous and discrete cases.
Learning Outcomes	Complies with PLO 1b, 2a and 3b
Assessment Method	Quiz, Assignments and Exams
Suggested Reading	<p>Textbooks:</p> <ol style="list-style-type: none"> 1. T.M. Cover and J. A. Thomas, Elements of Information Theory, 2nd edition, 2006, Wiley. 2. R. Bose, Information Theory and applications, 2nd Edition, 2008, TMH. <p>Reference Books:</p> <ol style="list-style-type: none"> 1. J. G. Proakis, Digital Communications, 1995, McGraw-Hill. 2. Ross, Sheldon. A First Course in Probability. 8th Edition, 2009, Pearson Prentice Hall.

Course Number	EC4105
Course Credit	3-0-0-3
Course Title	Digital Image Processing
Learning Mode	Lectures
Learning Objectives	Complies with Program Goal 1, 2 and 3
Course Description	The course deals with the fundamental concepts of digital image processing, including filtering, transforms, morphology, colour and image analysis. It also covers the basic image processing algorithms in C or Matlab or Python and make ready the students for advanced version of the course.
Course Outline	Introduction to Digital Image Processing & Applications, Sampling, Quantization, Basic Relationship between Pixels, Imaging Geometry, Image Transforms, Image Enhancement, Image Restoration, Image Segmentation, Morphological Image Processing, Shape Representation and Description, Object Recognition and Image Understanding, Texture Image Analysis, Motion Picture Analysis, Image Data Compression.
Learning Outcomes	Complies with PLO 1b, 2a and 3b
Assessment Method	Quiz, Assignments and Exams
Suggested Reading	<p>Textbooks:</p> <ol style="list-style-type: none"> 1. Rafael C. Gonzalez and Richard E. Woods, Digital Image Processing, Pearson 2. Anil K. Jain, Fundamentals of Digital Image Processing, Prentice Hall <p>Reference Books:</p> <ol style="list-style-type: none"> 1. Milan Sonka, Vaclav Hlavac and Roger Boyle, Image Processing, Analysis and Machine Vision, Springer

Course Number	EE4106
Course Credit	3-0-0-3
Course Title	Graph Signal Processing
Learning Mode	Lectures
Learning Objectives	Complies with Program Goal 1, 2 and 3
Course Description	The course deals with explanation of basic graph theory concepts and their extension to graph signal processing, and implementation of filtering, sampling, and reconstruction techniques for graph signals. It also covers spectral analysis of graph signals using the graph Fourier transform, and design and evaluation of graph filters for practical applications in various domains.
Course Outline	Introduction: Why Graph Signal Processing: concepts, applications and challenges Introduction to graph concepts: Linear algebra review, graph shift, graph shift invariance, graph signals, graph filtering, graph Fourier transform, graph convolution and modulation, graph frequency and graph spectral analysis of graph signals, Spectral graph theory: Orthogonal transforms review, Frequency interpretation – Nodal Theorems, Graph filtering: Vertex and Spectral interpretations, Advanced Topic 1: Shift invariance, localization and uncertainty principles, Advanced Topic 2: Down sampling, Advanced Topic 3: Wavelets, Advanced Topic 4: Multiresolution and graph approximation, Advanced Topic 5: Directed Graphs, Geometric Learning to extend deep learning models to learning with data supported by graphs.
Learning Outcomes	Complies with PLO 1b, 2a and 3b
Assessment Method	Quiz, Assignments and Exams
Suggested Reading	<p>Textbooks:</p> <ol style="list-style-type: none"> 1. F. R. Chung, Spectral graph theory, volume92, AMS Bookstore, 1997. 2. D. M. Cvetkovic, P. Rowlinson, and S. Simic, An introduction to the theory of graph spectra. Cambridge University Press Cambridge, 2010. 3. D. K. Hammond, P. Vandergheynst, and R. Gribonval. Wavelets on graphs via spectral graph theory. Applied and Computational Harmonic Analysis, 30(2):129--150, 2011. <p>Reference Books:</p> <ol style="list-style-type: none"> 1. P. Milanfar. A tour of modern image filtering: new insights and methods, both practical and theoretical. Signal Processing Magazine, IEEE , 30(1):106--128, 2013. 2. S. K. Narang and A. Ortega. Perfect reconstruction two-channel wavelet filter banks for graph structured data. Signal Processing, IEEE Transactions on , 60(6):2786--2799, 2012. 3. A. Sandryhaila and J. M. Moura. Discrete signal processing on graphs. IEEE transactions on signal processing, 61(5-8):1644--1656, 2013. 4. D. I. Shuman, S. K. Narang, P. Frossard, A. Ortega, and P. Vandergheynst. The emerging field of signal processing on graphs: Extending high-dimensional data analysis to networks and other irregular domains. Signal Processing Magazine, IEEE, 30(3):83--98, 2013. 5. D. Spielman, Spectral graph theory, Lecture Notes, Yale University, 2009.

Course Number	EC5104
Course Credit	L-T-P-C: 3-0-2-4
Course Title	Digital VLSI System
Learning Mode	Lectures and Labs
Learning Objectives	Complies with Program Goals 6, 7 and 8
Course Description	The Digital VLSI Systems course covers the design, analysis, and implementation of Very-Large-Scale Integration (VLSI) circuits. It focuses on techniques for optimizing digital systems for performance, power, and area.
Course Outline	Digital Systems and its applications; Basics on manufacturing process of Digital systems; Device and Wire Model; Design and implementation strategies of digital VLSI systems: Full and Semi-custom; Static and Dynamic MOS Logic design and Characteristics: Combinational and sequential circuits and systems; Introduction to ASIC and FPGA based system Design; Digital System and HDL; Design Steps of digital systems; Digital Arithmetic circuits; Semiconductor Memory and peripheral circuits and Systems; Digital IC testing and validation methodologies.
Learning Outcomes	Complies with PLOs 6a, 1b, 7 and 8a
Assessment Method	Quizzes/Assignments, Mid Sem, and End Sem
Suggested Readings	<p><u>Text/References</u></p> <ol style="list-style-type: none"> 1. Ming-Bo Lin, "Introduction to VLSI Systems: A Logic, Circuit, and System Perspective" Indian Edition, CRC Press, 2011. 2. Seetharaman Ramachandran, "Digital VLSI Systems design", 1st Edition, Springer, 2007. 3. Michael John Sebastian Smith, "Application Specific Integrated Circuit" Addison Wesley, Reprint edition, 1997. 4. J. M. Rabaey, A. Chandrakasan, and B. Nikolic, "Digital Integrated circuits: A design perspective" 2nd Edition, Pearson Education India, 2016. 5. Sung-Mo Kang, and Yusuf Leblebici, "CMOS Digital Integrated Circuits", 3rd Edition McGraw-Hill Education, 2002. 6. Michael, D. Ciletti, "Advanced Digital Design with the Verilog HDL", PHI Learning Private Limited, 2012. 7. Samir Palnitkar, "Verilog HDL: A Guide to Digital Design and Synthesis", Second Edition, Prentice Hall PTR, 2003.

SEMESTER VIII						
Sl. No.	Subject Code	Subject Name	L	T	P	C
1.	RM6201	Research Methodology	3	1	0	4
2.	EC5203	Analog and Mixed Signal Integrated Circuits	3	0	2	4
3.	EC5204	High Performance Embedded Computing system	3	0	2	4
4.	EC52PQ	M. Tech. Elective - I	3	0	0	3
5.	EC4295	Project – II	0	0	12	6
TOTAL			12	1	16	21

Course Number	RM6201
Course Credit (L-T-P-C)	3-1-0-4
Course Title	Research Methodology
Learning Mode	Lectures
Learning Objectives	The objective of the course is to train student about the modelling of scalar and multi-objective nonlinear programming problems and various classical and numerical optimization techniques and algorithms to solve these problems
Course Description	Advanced Optimization Techniques, as a subject for postgraduate and PhD students, provides the knowledge of various models of nonlinear optimization problems and different algorithms to solve such problems with its applications in various problems arising in economics, science and engineering.
Course Content	<p>Module I (6 lecture hours) – Research method fundamentals: Definition, characteristics and types, basic research terminology, an overview of research method concepts, research methods vs. method methodology, role of information and communication technology (ICT) in research, Nature and scope of research, information based decision making and source of knowledge. The research process; basic approaches and terminologies used in research. Defining research problem and hypotheses framing to prepare a research plan.</p> <p>Module II (5 lecture hours) - Research problem visualization and conceptualization: Significance of literature survey in identification of a research problem from reliable sources and critical review, identifying technical gaps and contemporary challenges from literature review and research databases, development of working hypothesis, defining and formulating the research problems, problem selection, necessity of defining the problem and conceiving the solution approach and methods.</p> <p>Module III (5 lecture hours) - Research design and data analysis: Research design – basic principles, need of research design and data classification – primary and secondary, features of good design, important concepts relating to research design, observation and facts, validation methods, observation and collection of data, methods of data collection, sampling methods, data processing and analysis, hypothesis testing, generalization, analysis, reliability, interpretation and presentation.</p> <p>Module IV (16 lecture hours) - Qualitative and quantitative analysis: Qualitative Research Plan and designs, Meaning and types of Sampling, Tools of qualitative data Collection; observation depth Interview, focus group discussion, Data editing, processing & categorization, qualitative data analysis, Fundamentals of statistical methods, parametric and nonparametric techniques, test of significance, variables, conjecture, hypothesis, measurement, types of data and scales, sample and sampling techniques, probability and distributions, hypothesis testing, level of significance and confidence interval, t-test, ANOVA, correlation, regression analysis, error analysis, research data</p>

	analysis and evaluation using software tools (e.g.: MS Excel, SPSS, Statistical, R, etc.). Module V (10 lecture hours) – Principled research: Ethics in research and Ethical dilemma, affiliation and conflict of interest; Publishing and sharing research, Plagiarism and its fallout (case studies), Internet research ethics, data protection and intellectual property rights (IPR) – patent survey, patentability, patent laws and IPR filing process.
Learning Outcome	On successful completion of the course, students should be able to: 1. Understand the terminology and basic concepts of various kinds of nonlinear optimization problems. 2. Develop the understanding about different solution methods to solve nonlinear Programming problems. 3. Apply and differentiate the need and importance of various algorithms to solve scalar and multi-objective optimization problems. 4. Employ programming languages like MATLAB/Python to solve nonlinear programming problems. 5. Model and solve several problems arising in science and engineering as a nonlinear optimization problem.
Assessment Method	Quiz /Assignment/ Project / MSE / ESE

Textbooks & Reference Books:

1. C. R. Kothari, Research methodology: Methods and Techniques, 3rd Edn., New age International 2014.
2. Mark N K. Saunders, Adrian Thornhill, Phkip Lewis, “Research Methods for Studies, 3/c Pearson Education, 2010.
3. K.N. Krishnaswamy, apa iyer, siva kumar, m. Mathirajan, “Management Research Methodology”, Pearson Education, 2010.
4. Ranjit Kumar; “Research Methodology: A Step by Step Guide for Beginners; 2/e; Pearson Education, 2010.
5. Suresh C. Sinha, Anil K. Dhiman, ess ess, 2006 “Research Methodology” Panner Selvam.R. “Research Methodology”, Prentice Hall of India, New Delhi, 2004.
6. C.G. Thomas, Research methodology and scientific writing, Ane books, Delhi, 2015.
7. H. J. Ader and G. J. Mellenbergh, Research Methodology in the Social, Behavioural and Life Sciences Designs, Models and Methods, 3rd Edn., Sage Publications, London, 2000.

Course Number	EC5203
Course Credit	L-T-P-C: 3-0-2-4
Course Title	Analog and Mixed Signal Integrated Circuits
Learning Mode	Lectures and Labs
Learning Objectives	Complies with Program Goals 6, 7, 8 and 9
Course Description	Analog and Mixed Signal Integrated Circuits explore the design and analysis of circuits that process both analog and digital signals. The course covers topics such as amplifiers, filters, data converters, and their applications in modern electronics.
Course Outline	CMOS Opamp: Basics of Differential amplifier with active load. Two CMOS Opamp Design, Frequency compensation of the CMOS Opamp. Three stage Opamp with output buffer. Reference circuits: Supply-insensitive biasing, Self-biased VTH-reference circuit, PTAT current generation, Temperature-insensitive biasing. Switched capacitor circuits: Switched capacitor amplifiers, integrators and filters. Non-Linear Analog Circuits: Basic CMOS Comparator Design, Analog Multipliers, Multiplying Quad, Level Shifting (Excluding Input Level Shifting For Multiplier). Data converter fundamentals: Analog versus Digital Discrete Time Signals, Converting Analog Signals to Data Signals, Sample and Hold Characteristics, DAC Specifications, ADC Specifications, Mixed-Signal Layout Issues. Data Converters Architectures: DAC Architectures, Digital Input Code, Resistors String, R-2R Ladder Networks, Current Steering, Charge Scaling DACs, Cyclic DAC, Pipeline DAC, ADC Architectures, Flash, 2-Step Flash ADC, Pipeline ADC, Integrating ADC, Successive Approximation ADC. Oversampling Sigma-Delta modulator and converters.
Learning Outcomes	Complies with PLOs 6a, 6b, 7, 8a and 8b
Assessment Method	Quizzes/Assignments, Mid Sem, and End Sem
Suggested Readings	<u>Text/References</u> 1. B. Razavi, "Design of Analog CMOS Integrated Circuits" 1st Edition, McGraw Hill, 2000. 2. P. E. Allen and D. R. Holberg, "CMOS Analog Circuit Design" 2nd Edition, Oxford University Press, 2002. 3. Paul Gray, P J Hurst, S H Lewis and R G Meyer, "Analysis and design of Analog Integrated Circuits", Wiley 4. Sergio Franco, "Analog Circuit Design Discrete and Integrated", McGrawHill 5. Walt Kester, "The Data Conversion Handbook," Elsevier 6. Franco Maloberti, "Data Converters", Springer 7. Rudy van de Plassche, "CMOS Integrated A/D and D/A Converters," Springer 8. Shanthi Pavan, Richard Schreier, "Understanding Delta-Sigma Data Converters" IEEE-Wiley 9. R. Jacob Baker, "CMOS- Mixed Signal Circuit Design " (Vol II of CMOS: Circuit Design, Layout and Simulation), IEEE Press and Wiley Interscience, 2002.

Course Number	EC5204
Course Credit	L-T-P-C: 3-0-2-4
Course Title	High Performance Embedded Computing System
Learning Mode	Lectures and Labs
Learning Objectives	Complies with Program Goals 6, 7, 8 and 9
Course Description	This course focus on the architecture and design of embedded systems that require high computational power. The course covers parallel processing, optimization techniques, and applications in areas such as signal processing and real-time computing.
Course Outline	<p>Introduction and evolution of high-performance embedded computing system.</p> <p>Basics of Computer Design & Performance Evaluation: Defining Computer Architecture, Quantitative Principles of Computer Design, CPU Performance & its factors, SPEC Benchmarks.</p> <p>Computational model: Basic computational models, Abstract level of processor, Open Source ISA, Micro-Architecture,</p> <p>High performance computer arithmetic architectures,</p> <p>Instruction level Parallelisms: ILP concepts, Dependencies between instructions, preserving sequential consistency.</p> <p>Pipelining: Introduction to pipelining, Instruction pipeline design, Pipeline hazards, deep pipeline microarchitecture and micro-operation,</p> <p>Superscalar Processors: Introduction, Parallel decoding, Superscalar instruction issue, Shelving, Register Renaming,</p> <p>Memory System: Memory hierarchy, Memory system Performance, Cache Memory, Cache Coherence, Memory Consistency, Cache Performance Issues, Shared Memory Organization. High performance Bus Architecture, Parallel-Virtual-Machine Architecture and programming model. Multicore and multiprocessor architecture, VLIW processor architectures. Array and vector processors.</p> <p>Introduction Embedded Co-Processor: GPU and ML Accelerator</p>
Learning Outcomes	Complies with PLOs 6a, 6b, 7 and 8a
Assessment Method	Quizzes/Assignments, Mid Sem, and End Sem
Suggested Readings	<p><u>Text/References</u></p> <ol style="list-style-type: none"> 1. John L. Hennessy and David A. Patterson, "Computer Architecture-A Quantitative Approach", 6th Edition, Elsevier, 2019. 2. John L. Hennessy and David A. Patterson, "Computer Organization and Design", Morgan Kaufmann Publisher, 2nd Edition, 2021. 3. S. R. Sarangi, "Advanced Computer Architecture", 1st Edition, 2021. 4. Sima, Fauntain, Kscucle, "Advanced Computer Architecture a design space approach", Pearson, 7th Edition, 2009. 5. Kai Hwang, "Advanced Computer Architecture", McGrawHill publication, 2003.

M. Tech. Elective - I						
Sl. No.	Subject Code	Subject	L	T	P	C
1.	EC5205	Patterns Recognition and Machine Learning	3	0	0	3
2.	EC5206	Multimedia Communication	3	0	0	3
3.	EC5214	VLSI Technology	3	0	0	3
4.	EC5215	Sensors and Actuators	3	0	0	3
5.	EC5216	Low Power VLSI	3	0	0	3
6.	EC5217	CAD VLSI	3	0	0	3
7.	EC5218	Silicon Photonics	3	0	0	3
8.	EC5219	Embedded System Integration	3	0	0	3
9.	EC5220	High Power Semiconductor Devices	3	0	0	3
10.	EE5203	Recent Trends in Optimization Techniques	3	0	0	3

Course Number	EC5205
Course Credit	L-T-P-C: 3-0-0-3
Course Title	Pattern Recognition and Machine Learning
Learning Mode	Lectures
Learning Objectives	Complies with Program Goals 6 and 7
Course Description	Pattern Recognition and Machine Learning focuses on algorithms and techniques for identifying patterns and making predictions from data. The course covers topics such as supervised and unsupervised learning, classification, regression, clustering, and feature extraction using statistical and machine learning methods.
Course Outline	Introduction: Feature extraction and Pattern Representation, Concept of Supervised and Unsupervised Classification, Introduction to Application Areas. Statistical Pattern Recognition: Bayes Decision Theory, Minimum Error and Minimum Risk Classifiers, Discriminant Function and Decision Boundary, Normal Density, Discriminant Function for Discrete Features, Parameter Estimation. Dimensionality Problem: Dimensionality Reduction, Fisher Linear Discriminant and Multiple Discriminant Analysis. Nonparametric Pattern Classification: Density Estimation, Nearest Neighbour Rule, Fuzzy Classification. Linear Discriminant Functions: Separability, Two Category and Multi Category Classification, Linear Discriminators, Perceptron Criterion, Relaxation Procedure, Minimum Square Error Criterion, Widrow-Hoff Procedure, HoKashyap Procedure, Kesler's Construction. Neural Network Classifier: Single and Multilayer Perceptron, Back Propagation, Learning Hopfield, Network Fuzzy and Neural Network. Time Varying Pattern Recognition: First Order Hidden Markov, Model Evaluation, Decoding Learning. Unsupervised Classification: Clustering, Hierarchical Clustering, Graph Based Method, Sum of Squared Error Technique, Iterative Optimization.
Learning Outcomes	Complies with PLOs 6a, 6b, 7 and 8a
Assessment Method	Quizzes/Assignments, Mid Sem, and End Sem
Suggested Readings	<u>Text/References</u> 1. Richard O. Duda, Peter E. Hart and David G. Stork, Pattern Classification, John Wiley & Sons, 2001. 2. Earl Gose, Richard Johnsonbaugh and Steve Jost, Pattern Recognition and Image Analysis, Prentice Hall, 1999

Course Number	EC5206
Course Credit	3-0-0-3
Course Title	Multimedia Communication
Learning Mode	Lectures
Learning Objectives	After learning this course, the students will be able 1. to understand the fundamental knowledge on multimedia system and Multimedia Communication. 2. to understand the knowledge on Multimedia Information Systems. 3. to understand the real-time constraints in Multimedia Communication. 4. to develop problem statement on Multimedia Communication for research direction
Course Description	This course deals with the Multimedia Communication.
Course Outline	Introduction to Multimedia System: Architecture and components, Multimedia distributed processing model, Synchronization, Orchestration and Quality of Service (QOS) architecture. Audio and Speech: Data acquisition, Sampling and Quantization, Human Speech production mechanism, Digital model of speech production, Analysis and synthesis, Psycho-acoustics, low bit rate speech compression, MPEG audio compression. Images and Video: Image acquisition and representation, Composite video signal NTSC, PAL and SECAM video standards, Bilevel image compression standards: ITU (formerly CCITT) Group III and IV standards, JPEG image compression standards, MPEG video compression standards. Multimedia Communication: Fundamentals of data communication and networking, Bandwidth requirements of different media, Real time constraints: Audio latency, Video data rate, multimedia over LAN and WAN, Multimedia conferencing. Hypermedia presentation: Authoring and Publishing, Linear and non-linear presentation, Structuring Information, Different approaches of authoring hypermedia documents, Hyper-media data models and standards. Multimedia Information Systems: Operating system support for continuous media applications: limitations is usual OS, New OS support, Media stream protocol, file system support for continuous media, data models for multimedia and hypermedia information, content based retrieval of unstructured data.
Learning Outcome	Complies with PLO 1b, 7a and 9a
Assessment Method	Quiz, Assignments, and Exams
Suggested Readings	Text Books: 1. J. D. Gibson, Multimedia Communications: Directions and Innovations, 2000, Elsevier. 2. A. Puri and T. Chen, Multimedia Systems, Standards, and Networks, 1st Edition, 2000, CRC Press. 5. Iain E.G. Richardson, H.264 and MPEG-4 Video Compression, 2004, John Wiley & Sons. Reference Books: 1. Ralf Steinmetz and Klara Nahrstedt, Multimedia Systems, 2004, Springer. 2. K. Sayood, Introduction to Data Compression, 2017, Morgan-Kaufmann. 3. Borivoje Furht, Handbook of Multimedia Computing, 1998, CRC Press

Course Number	EC5214
Course Credit	L-T-P-C: 3-0-0-3
Course Title	VLSI Technology
Learning Mode	Lectures
Learning Objectives	Complies with Program Goals 6 and 7
Course Description	VLSI Technology focuses on the processes and methodologies used in the fabrication of Very-Large-Scale Integration circuits. The course covers semiconductor materials, photolithography, etching, doping, and the integration of components into complex systems.
Course Outline	<p>General Overview of current status of VLSI Technology- Interaction between Technology and Design, - Interaction between Physics and Technology, - Limits of Technology, Environment for Integrated Circuits Manufacture, - Clean Rooms and Wafer cleaning procedures., - Technology Processes in Fabrication, - Oxidation, Diffusion, Ion Implantation, Etching and Deposition, techniques., - Characterization of Processes.</p> <p>Lithography and Mask generation techniques - Advanced Unit-Processors for ULSI Circuit Technologies., - Use of RTP, - Plasma processes in the fabrication in the fabrication of circuits., Basic Bipolar process Technologies., NMOS Technology, Mask sequence based fabrication process for NMOS transistors, - Silicon Gate and Metal Gate Technologies. Limitations of NMOS Technology.</p> <p>CMOS Technology - Process Sequence for CMOS Technology, Advanced CMOS Processes, “Design – Rules” for NMOS and CMOS Technologies as “Constraints” for Layouts.</p> <p>Process Simulation - Use of SUPREM-IV and STEP Simulators for process Design, - Some Examples of actual technologies.</p>
Learning Outcomes	Complies with PLOs 6a, 6b, 7 and 8a
Assessment Method	Quizzes/Assignments, Mid Sem, and End Sem
Suggested Readings	<p><u>Text/References</u></p> <ol style="list-style-type: none"> 1. S.K. Gandhi, “VLSI Fabrication principles”, John Wiley Inc., New York, 1983 2. S.M. Sze “VLSI Technology”, 2nd Edition, McGraw Hill Co. Inc., New York, 1988 3. C. Y. Chang and S. M. Sze, “VLSI Technology”, McGraw Hill Co. Inc., New York, 1996

Course Number	EC5215
Course Credit	L-T-P-C: 3-0-0-3
Course Title	Sensors and Actuators
Learning Mode	Lectures
Learning Objectives	Complies with Program Goals 6 and 7
Course Description	Sensors and Actuators involve the study and application of devices that sense physical quantities (sensors) and act upon them (actuators). The course covers principles of transduction, sensor types (e.g., optical, pressure, temperature), actuator mechanisms (e.g., motors, valves), interfacing with electronics, and applications in various fields such as automotive, healthcare, and industrial automation.
Course Outline	Brief overview of measurement systems, classification, characteristics and calibration of different sensors. Measurement of displacement, position, motion, force, torque, strain gauge, pressure flow, temperature sensor, gyroscope. Principles and structures of modern micro sensors, micro-fabrication technologies: bulk micromachining, surface micromachining, LIGA, assembly and packaging. Pneumatic and hydraulic systems: actuators, definition, example, types, selection. Pneumatic actuator. Electro-pneumatic actuator. Hydraulic actuator, control valves, valve sizing valve selection. Electrical actuating systems: solid-state switches, solenoids, voice coil; electric motors; DC motors, AC motors, single phase motor; 3-phase motor; induction motor; synchronous motor; stepper motors. Piezoelectric actuator: characterization, operation, and fabrication; shape memory alloys.
Learning Outcomes	Complies with PLOs 6a, 6b, 7 and 8a
Assessment Method	Quizzes/Assignments, Mid Sem, and End Sem
Suggested Readings	<p><u>Text/References</u></p> <ol style="list-style-type: none"> 1. John G. Webster, Editor-in-chief, "Measurement, Instrumentation, and Sensors Handbook", CRC Press (2014). 2. Jacob Fraden, "Handbook of modern Sensors", AIP Press, Woodbury (2016). 3. Nadim Maluf, "An Introduction to Microelectromechanical Systems Engineering", Artech House Publishers, Boston (2004). 4. Marc Madou, "Fundamentals of Microfabrication", CRC Press, Boca Raton (2002). 5. Gregory Kovacs, "Micromachined Transducers Sourcebook", McGraw-Hill, New York (1998). 6. E. O. Deobelin and D. Manik, "Measurement Systems – Application and Design", Tata McGraw-Hill (2004). 7. D. Patranabis, "Principles of Industrial Instrumentation", Tata McGraw-Hill, eleventh reprint (2004). 8. B. G. Liptak, "Instrument Engineers' Handbook: Process Measurement and Analysis", CRC (2003).

Course Number	EC5216
Course Credit	L-T-P-C: 3-0-0-3
Course Title	Low power VLSI
Learning Mode	Lectures
Learning Objectives	Complies with Program Goals 6 and 7
Course Description	Low Power VLSI focuses on techniques and strategies for reducing power consumption in Very-Large-Scale Integration (VLSI) circuits. The course covers power-aware design, optimization methods, and applications in portable and energy-efficient devices.
Course Outline	Need for Low Power Circuits, Low Power Techniques at different Hierarchical levels; CMOS basics: MOS Transistors, Short Channel Effects, Spice models for MOS transistors, MOS Invertors characteristics, Delay Estimation, BICMOS logic circuits; MOS Logic Styles: Static CMOS, Dynamic CMOS and Pass transistor circuits; Sources of Power dissipation: Diode Leakage Power, Short Circuit Leakage Power, Switching Power and Switching Activity of Static and Dynamic Circuits, Parameters involved in power dissipation; Low-power Design Methodologies: Supply voltage scaling approaches at different levels of hierarchy, Multi-threshold CMOS circuit design, Dynamic Voltage Scaling, Minimizing Switched Capacitance at different levels; Adiabatic switching concepts; Low Power CMOS RAM Circuits.
Learning Outcomes	Complies with PLOs 6a, 6b, 7 and 8a
Assessment Method	Quizzes/Assignments, Mid Sem, and End Sem
Suggested Readings	<u>Text/References</u> 1. Ajit Pal, "Low-Power VLSI Circuits and Systems", Springer, 2015 2. J. B. Kuo and J-H. Lou, "Low-Voltage CMOS VLSI Circuits", Wiley, 1999. 3. K. Roy and S. C. Prasad, "Low-Power CMOS VLSI Circuit Design", Wiley, 2000.

Course Number	EC5217
Course Credit	L-T-P-C: 3-0-0-3
Course Title	CAD VLSI
Learning Mode	Lectures
Learning Objectives	Complies with Program Goals 6 and 7
Course Description	CAD VLSI (Computer-Aided Design for Very-Large-Scale Integration) involves the use of software tools and methodologies to design, simulate, and verify integrated circuits. The course covers topics such as layout design, logic synthesis, timing analysis, and physical design automation (PDA) for efficient and reliable VLSI circuit design.
Course Outline	Introduction: VLSI design flow, challenges. Verilog/VHDL: introduction and use in synthesis, modeling combinational and sequential logic, writing test benches. Logic synthesis: two-level and multilevel gate-level optimization tools, state assignment of finite state machines. Basic concepts of high-level synthesis: partitioning, scheduling, allocation and binding. Technology mapping. Testability issues: fault modeling and simulation, test generation, design for testability, built-in self-test. Testing SoC s. Basic concepts of verification. Physical design automation. Review of MOS/CMOS fabrication technology. VLSI design styles: full-custom, standard-cell, gate-array and FPGA. Physical design automation algorithms: floor-planning, placement, routing, compaction, design rule check, power and delay estimation, clock and power routing, etc. Special considerations for analog and mixed-signal designs.
Learning Outcomes	Complies with PLOs 6a, 6b, 7 and 8a
Assessment Method	Quizzes/Assignments, Mid Sem, and End Sem
Suggested Readings	<p><u>Text/References</u></p> <ol style="list-style-type: none"> 1. Naveed Shervani, "Algorithms for VLSI physical design Automation", 2nd Edition, Kluwer Academic Publisher, 1999. Christophan Meinel and Thorsten Theobold, "Algorithm and Data Structures for VLSI Design", KAP, 2002. 2. Rolf Drechsheler, "Evolutionary Algorithm for VLSI", 2nd Edition 3. Trim burger, "Introduction to CAD for VLSI", Kluwer Academic publisher, 2002. 4. Randal L and Schwartz Tom Phoenix, "Learning PERL", O'Reilly Publications, 3rd Edition, 2000. 5. Samir Palnitkar, "Verilog HDL: A Guide to Digital Design and Synthesis", Second Edition, Prentice Hall PTR, 2003.

Course Number	EC5218
Course Credit	L-T-P-C: 3-0-0-3
Course Title	Silicon Photonics
Learning Mode	Lectures
Learning Objectives	Complies with Program Goals 6 and 7
Course Description	Silicon Photonics involves the study and application of integrating photonic elements such as lasers, modulators, and detectors with silicon-based electronic circuits. The course covers the design, fabrication, and integration of these components for high-speed communication and sensing applications.
Course Outline	Introduction to Silicon Photonics. SOI platform. SOI, SiN, InP, and LNOI platforms. Guided modes in Silicon Photonic Waveguides. Concept of effective index. Coupled Mode theory. Coupling of light to waveguides: grating couplers, butt coupling, mode transformers, inverted tapers. Waveguides loss mechanisms: absorption scattering. Plasma dispersion effect, thermo-optic effect, and stress-optic effect. Passive silicon photonic devices: Mach Zehnder interferometer, ring resonator, directional couplers, waveguide bends, multiplexers. Active silicon photonic devices: Source, Modulators, photodetector. Fundamentals of silicon photonics device fabrication and integration. Applications of silicon photonic devices.
Learning Outcomes	Complies with PLOs 6a, 6b, 7 and 8a
Assessment Method	Quizzes/Assignments, Mid Sem, and End Sem
Suggested Readings	<p><u>Text/References</u></p> <ol style="list-style-type: none"> 1. G T Reed & AP Knights, "Silicon Photonics: An Introduction", Wiley 2004 2. G T Reed, "Silicon Photonics: The state of the art", Wiley 2008 3. L. Pavesi & D J Lockwoodt, "Silicon Photonics", Springer 2004 4. Lorenzo Pavesi & David J. Lockwood, "Silicon Photonics III Systems and Applications", Springer 2016 5. M J Deen & P K Basu, "Silicon Photonics: Fundamentals and Devices", Wiley 2012 6. Jameel Ahmed, Mohammed Yakoob Siyal, Freeha Adeel, Ashiq Hussain, Optical Signal Processing by Silicon Photonics, 2013, Springer 7. Amnon Yariv and Pochi Yeh, "Photonics", Sixth Edition, Oxford University Press

Course Number	EC5219
Course Credit	L-T-P-C: 3-0-0-3
Course Title	Embedded System Integration
Learning Mode	Lectures
Learning Objectives	Complies with Program Goals 6 and 7
Course Description	The course involves the process of combining hardware and software components into a cohesive embedded system. The course covers topics such as system architecture design, interfacing peripherals, real-time operating systems (RTOS), communication protocols, and testing methodologies to ensure the reliability and functionality of the integrated system in various applications.
Course Outline	General system design: Embedded Computing: Introduction, Complex Systems and Microprocessor, Embedded System Design Process, Formalisms for System Design, Design Examples. ARM Introduction: Introduction to processor design-architecture and organization, Abstraction in hardware design, Instruction set design, Processor design tradeoffs, RISC. Overview of ARM architecture – Architecture inheritance, Programmer’s model, Development tools. ARM Instruction Set. Architectural support for high level languages, Architectural support for system development - ARM memory interface, AMBA, ARM reference peripheral specifications, JTAG, Embedded trace, signal processing support, ARM processor cores. Memory hierarchy Memory size and speed, On-chip memory, Caches, Memory management. Memory hierarchy Architectural support for OS-Embedded ARM applications
Learning Outcomes	Complies with PLOs 6a, 6b, 7 and 8a
Assessment Method	Quizzes/Assignments, Mid Sem, and End Sem
Suggested Readings	<u>Text/References</u> 1. David E. Simon, “An Embedded Software Primer”, Pearson Education Asia, 2005 2. Wayne Wolf “Computers as Components: Principles of Embedded Computing System Design”, 3rd Editions, Morgan Kaufman Publishers, 2012. 3. Rajkamal, “Embedded Systems Architecture, Programming and Design”, 3rd Edition, TATA McGraw Hill, 2008.

Course Number	EC5220
Course Credit	L-T-P-C: 3-0-0-3
Course Title	High-Power Semiconductor Devices
Learning Mode	Lectures
Learning Objectives	Complies with Program Goals 6 and 7
Course Description	High-Power Semiconductor Devices focus on components capable of handling high electrical currents or voltages efficiently. The course typically covers topics such as power semiconductor materials (e.g., silicon, gallium nitride), device structures (e.g., MOSFETs, IGBTs), switching characteristics, thermal management, and applications in power electronics, renewable energy systems, electric vehicles, and industrial automation.
Course Outline	<p>Introduction to High-Power Semiconductor Devices: Overview of high-power devices, Applications in power electronics</p> <p>Semiconductor Physics for High-Power Devices: Charge carrier dynamics, Breakdown mechanisms</p> <p>Power Diodes: Structure, operation, and types (e.g., Schottky, PiN), Performance characteristics and applications</p> <p>Power Bipolar Junction Transistors (BJTs): Structure and operation principles, High-power performance characteristics</p> <p>Insulated Gate Bipolar Transistors (IGBTs): Design and operation principles,</p> <p>Power MOSFETs: Structure, operation, and characteristics, Comparison with other high-power devices</p> <p>Thyristors and Related Devices: Structure and types (e.g., SCR, GTO), Switching characteristics and applications</p> <p>Thermal Management in High-Power Devices: Heat generation and dissipation, Thermal modeling and packaging techniques</p> <p>Reliability and Failure Mechanisms: Degradation and failure modes, Reliability testing and improvement strategies</p> <p>Advanced Materials for High-Power Devices: Wide bandgap materials (e.g., SiC, GaN), Advantages and challenges</p> <p>Integration and Application of High-Power Devices: Power modules and converters, Applications in renewable energy and electric vehicles</p> <p>Recent Advances and Research Trends: Innovations in high-power device technology,</p>
Learning Outcome	Complies with PLOs 6a, 6b, 7 and 8a
Assessment Method	Quizzes/Assignments, Mid Sem, and End Sem
Suggested Readings	<p><u>Text/References</u></p> <ol style="list-style-type: none"> 1. "Power Semiconductor Devices" by B. Jayant Baliga, Edition: 1st, Publisher: PWS Publishing Company, Year: 1995 2. "Fundamentals of Power Semiconductor Devices" by B. Jayant Baliga, Edition: 2nd, Publisher: Springer, Year: 2010 3. "Semiconductor Power Devices: Physics, Characteristics, Reliability" by Josef Lutz, Heinrich Schlangenotto, Uwe Scheuermann, Rik De Doncker, Edition: 2nd, Publisher: Springer 4. "Power Electronics: Converters, Applications, and Design" by Ned Mohan, Tore M. Undeland, William P. Robbins, Edition: 3rd, Publisher: Wiley, Year: 2002 5. "Wide Bandgap Semiconductor Power Devices: Materials, Physics, Design, and Applications" by B. Jayant Baliga, Publisher: Woodhead Publishing, Year: 2018

Course Number	EE5203
Course Credit	L-T-P-C: 3-0-0-3
Course Title	Recent Trends in Optimization Techniques
Learning Mode	Lectures
Learning Objectives	Complies with Program goals 1 and 2
Course Description	The course is designed to meet the requirements of Ph.D. and M. Tech students to get sufficient knowledge on optimization and its application to different fields of engineering.
Course Outline	<p>Motivation. mathematical review , matrix factorizations, sets and sequences, convex sets and functions.</p> <p>Linear programming and simplex method, Weierstrass' theorem,</p> <p>Karush Kuhn Tucker optimality conditions, algorithms, convergence, unconstrained optimization,</p> <p>Line search methods, method of multidimensional search, steepest descent methods, Newton's method, modifications to Newton's method , trust region methods, conjugate gradient methods, quasi-Newton's methods.</p> <p>Constrained optimization, penalty and barrier function methods, augmented Lagrangian methods, polynomial time algorithm for linear programming, successive linear programming, successive quadratic programming.</p>
Learning Outcomes	Complies with PLO 1a, 2a, and 3a
Assessment Method	Quizzes/Assignments, Mid Sem, and End Sem
Suggested Readings	<p><u>Text/References</u></p> <ol style="list-style-type: none"> 1. R. Fletcher Practical Optimization (2nd Edition) John Wiley & Sons, New York, 1987. 2. M.S.Bazaraa , H.D.Sherali and C.Shetty , Nonlinear Programming, Theory and Algorithms, John Wiley and Sons, New York, 1993.

SEMESTER IX						
Sl. No.	Subject Code	Subject Name	L	T	P	C
1.	EC51PQ/ EC61PQ	M. Tech. Elective – II	3	0	0	3
2.	XX51PQ/ XX61PQ	M. Tech. Elective – III	3	0	0	3
3.	EC51PQ/ EC61PQ	M. Tech. Elective - IV	3	0	0	3
4.	EC5195	Project – III	0	0	16	8
TOTAL			9	0	16	17

M. Tech. Elective – II						
Sl. No.	Subject Code	Subject	L	T	P	C
1.	EC5108	Internet of Things (IoT) Networks	3	0	0	3
2.	EC5111	VLSI Architecture Design and Implementation	3	0	0	3
3.	EC5114	Opto-Electronics Materials and Devices	3	0	0	3
4.	EC5115	Radio Frequency Integrated Circuits	3	0	0	3
5.	EC5116	Advanced Digital Image Processing	3	0	0	3

Course Number	EC5108
Course Credit	3-0-0-3
Course Title	Internet of Things (IoT) Networks
Learning Mode	Lectures
Learning Objectives	After the successful completion of the course the students will be able to: <ol style="list-style-type: none"> 1. Fundamentally understand the building blocks of the Internet of Things networks. 2. Learning and implementation of various algorithms in the course 3. Design an IoT based network for a given application
Course Description	This course deals with the IoT Networks.
Course Outline	<p>Things and Internet: Overview of Things/Sensors, Smart Object, Open Systems Interconnection (OSI) Model, Transmission Control Protocol/Internet Protocol (TCP/IP) Model, IPv4 & IPv6 Addressing, Routing, Delays in the Networks</p> <p>Markov Chain: Discrete-Time Markov Chain, Continuous-Time Markov Chain, Types of Markov Chain, Time Reversed Markov Chain, Applications</p> <p>Queuing Theory: Little's Formula, Queuing Model - Single and Multiple Servers (M/M/1, M/M/c), Finite and Infinite Queue Length/Population, M/G/1 model, Burke's Theorem, Jackson's Networks</p> <p>IoT Protocols: Short-Range and Long Range Protocols - Bluetooth, Zigbee, Wireless LAN, and LoRaWAN. Application Protocols.</p> <p>Smart Device Localization: Range-based Localization using Received Signal Strength (RSS), Time and Angle Measurements. Range-Free Localization. Performance Metrics. Applications</p> <p>IoT Analytics: Bayesian Fusion, Dempster-Shafer Fusion, Decision Fusion, Types of Learning, Artificial Neural Networks, Bias-Variance Tradeoff, Applications</p> <p>Fog Computing: Cloud Computing, Fog Computing, Edge Computing, Technology for Fog Computing, Task Offloading, Applications</p>
Learning Outcome	Complies with PLO 1b, 2a and 4a
Assessment Method	Quiz, Assignments, and Exams
Suggested Readings	<p>Texts Books:</p> <ol style="list-style-type: none"> 1. Rayes, A., and Salam, S., Internet of Things from hype to reality: the road to digitization, 2nd Edition, 2016, Springer International Publishing. 2. Kumar S., Fundamentals of Internet of Things, 1st Edition, 2021, Chapman and Hall/CRC. 3. Bertsekas, D.P., and Gallager, R. G., Data Networks, 2nd Edition, 2021, Athena Scientific. <p>Reference Books:</p> <ol style="list-style-type: none"> 1. Raj, P., and Raman, A.C., The Internet of Things: Enabling technologies, platforms, and use cases, 1st Edition, 2017, Auerbach Publications.

Course Number	EC5111
Course Credit	L-T-P-C: 3-0-0-3
Course Title	VLSI Architecture Design and Implementation
Learning Mode	Lectures
Learning Objectives	Complies with Program Goals 6 and 7
Course Description	VLSI Architecture Design and Implementation covers the principles of designing and implementing efficient VLSI architectures. The course includes topics such as pipeline and parallel design, data path optimization, and hardware description languages. It also covers performance analysis of various architectures. It presents case studies for the mapping of signal processing and machine learning algorithms to architectures and their performance analysis.
Course Outline	Introduction to VLSI System Design and Implementation; Architectural mapping with case studies: Data path, Control path Synthesis; Control Strategies: Hardware implementation of various control structures; Micro-program control techniques; Design issues: Timing, Area, power analysis; FSM Architecture and Synthesis, HDL design and implementation of VLSI architecture; Semiconductor Memory and Peripheral Architectures; Computer arithmetic architecture design and analysis: Introduction to integer and floating-point arithmetic, Adders, Subtractors, Sequential and Array multipliers & dividers, square root, Absolute Difference Value, CORDIC. Hardware architecture design and performance analysis: Sequential/Folding architectures; bit and word serial architecture; High performance architectures: pipelined, parallel and Systolic Array with examples; Architectural performance Analysis: Throughput and Latency; Low Power VLSI Architectures; Basic Hardware Architectures for Digital Signal processing and machine learning algorithms. Introduction to VLSI Chip testing methods and Architectures: Introduction to Chip Fault Model, DFT Architecture, BIST Architecture.
Learning Outcomes	Complies with PLOs 6a, 6b, 7 and 8a
Assessment Method	Quizzes/Assignments, Mid Sem, and End Sem
Suggested Readings	<u>Text/References</u> 1. Peter Pirsch, "Architectures for Digital Signal Processing", John Willy & sons,2nd Edition,2014. 2. K. K. Parhi, " VLSI Digital Signal Processing Systems: Design and Implementation", A Wiley-Interscience publications,2011. 3. Behrooz Parhami, " Computer Arithmetic: Algorithm and Hardware Design", Behrooz Parhami, Oxford University Press, 2nd Edition,2009. 4. A. Bellaouar, M. I. Elmarsny, "Low Power Digital VLSI Design", A. Bellaouar, M. I. Elmarsny, Kluwe academic Publication,1995. 5. DSP Integrated Circuit, L. Wamhammer, Academic Press,1999.

Course Number	EC5114
Course Credit	3-0-0-3
Course Title	Opto-Electronics Materials and Devices
Learning Mode	Lectures
Learning Objectives	Complies with Program Goals 6 and 7
Course Description	Opto-Electronics Materials and Devices cover the study of materials and devices that interact with light for applications in communication, sensing, and display technologies. The course includes topics such as semiconductor optoelectronics (e.g., LEDs, lasers, photodetectors), optical materials (e.g., semiconductors, polymers), device physics, fabrication techniques, and applications in telecommunications, imaging, solar cells, and optical sensing.
Course Outline	<p>UNIT I ELEMENTS OF LIGHT AND SOLID-STATE PHYSICS Wave nature of light, Polarization, Interference, Diffraction, Light Source, review of Quantum Mechanical concept, Review of Solid-State Physics, Review of Semiconductor Physics and Semiconductor Junction Device.</p> <p>UNIT II DISPLAY DEVICES AND LASERS Introduction, Photo Luminescence, Cathode Luminescence, Electro Luminescence, Injection Luminescence, Injection Luminescence, LED, Plasma Display, Liquid Crystal Displays, Numeric Displays, Laser Emission, Absorption, Radiation, Population Inversion, Optical Feedback, Threshold condition, Laser Modes, Classes of Lasers, Mode Locking, laser applications.</p> <p>UNIT III OPTICAL DETECTION DEVICES Photo detector, Thermal detector, Photovoltaics, Photo Conductors, Sensors, Detector Performance.</p> <p>UNIT IV OPTOELECTRONIC MODULATOR Introduction, Analog and Digital Modulation, Electro-optic modulators, Magneto Optic Devices, Acoustoptic devices, Optical, Switching and Logic Devices.</p> <p>UNIT V OPTOELECTRONIC INTEGRATED CIRCUITS Introduction, hybrid and Monolithic Integration, Application of Opto Electronic Integrated Circuits, Integrated transmitters and Receivers, Guided wave devices.</p>
Learning Outcome	Complies with PLO 6b, 7a and 9a
Assessment Method	Quizzes/Assignments, Mid Sem, and End Sem
Suggested Readings	<p>Text Books</p> <ol style="list-style-type: none"> 1. Pallab Bhattacharya “Semiconductor Opto Electronic Devices”, Prentice Hall of India Pvt., Ltd., New Delhi, 2006. 2. Jasprit Singh, “Opto Electronics – As Introduction to materials and devices”, McGraw-Hill International Edition, 1998 <p>Reference Books</p> <ol style="list-style-type: none"> 1. S C Gupta, Opto Electronic Devices and Systems, Prentice Hal of India,2005. 2. J. Wilson and J.Haukes, “Opto Electronics – An Introduction”, Prentice Hall, 1995.

Course Number	EC5115
Course Credit	L-T-P-C: 3-0-0-3
Course Title	Radio Frequency Integrated Circuits
Learning Mode	Lectures
Learning Objectives	Complies with Program Goals 6 and 7
Course Description	Radio Frequency Integrated Circuits (RFIC) focus on the design and implementation of circuits operating at radio frequencies. The course covers topics such as RF amplifiers, mixers, oscillators, and their applications in wireless communication systems.
Course Outline	<p>Introduction to RF and Wireless technology; Basic concepts in RF & Wireless Integrated Circuits Design; Receiver and Transmitter Architectures.</p> <p>Low Noise RF Amplifiers – Electrical Noises, Two port Noise theory, LNA characteristic parameters and basic topologies, Input impedance and Noise Figure of amplifiers e.g Inductively degenerated, Differential LNA; Broadband Amplifier and amplifier Stability;</p> <p>Mixers – Mixer Operation and linearity, Passive and Active Mixers, Single & Double-Balanced Mixers, Conversion Gain and Port-to-Port Feedthrough (or leakage), Image Reject and Single Sideband Mixers, Noise in Mixers;</p> <p>Oscillators – Oscillator as a Feedback System, Negative Resistance Oscillator Model; LC Oscillators - Colpitts, Hartley, Clapp, Pierce crystal Oscillators, Quadrature Oscillators; Ring oscillators, Voltage Controlled-Oscillator, Phase Noise and Jitter in Oscillators;</p> <p>Frequency Synthesizers – Phase Locked Loop (PLL), Analysis of PLL Synthesizers, Phase Noise in PLL Synthesis, PLL Frequency Synthesizers, Integer-N and Fractional-N PLL Synthesizers, PLL System Frequency Response and Bandwidth;</p> <p>RF Power Amplifiers – Efficiency, Analysis of Basic Classes – A, AB, B, C, Class B Push-Pull Arrangements, Switch mode Classes – D, E, F Amplifiers, Doherty Power Amplifier, Linearization Techniques.</p>
Learning Outcomes	Complies with PLOs 6a, 6b, 7 and 8a
Assessment Method	Quizzes/Assignments, Mid Sem, and End Sem
Suggested Readings	<p>Text</p> <ol style="list-style-type: none"> 1. Thomas H Lee, The Design of CMOS Radio Frequency Integrated Circuits, Cambridge University Press 2. Behzad Razavi, RF Microelectronics, 2/e, Pearson India. 3. David M Pozar, Microwave and RF Design of Wireless Systems, John Wiley and Sons 4. Steven Cripps, RF Power amplifier for wireless communications, Artech House 5. Herbert Krauss, Charles Bostian, and Frederick Raab, Solid state radio engineering, John Wiley and Sons 6. Andrei Grebennikov, Marc J. Franco Switchmode RF and Microwave Power Amplifiers, Academic Press Inc <p>References</p> <ol style="list-style-type: none"> 1. John W M Rogers and Calvin Plett, Radio Frequency Integrated Circuit Design, Artech House, Boston. 2. Frank Ellinger, Radio Frequency Integrated Circuits and Technologies, Springer 3. Richard C-H Li, RF Circuits Design, John Wiley 4. Les Besser and Rowan Gilmore, Practical RF Circuit Design for Modern Wireless Systems, vol. 2, Artech House, Boston

Course Number	EC5116
Course Credit	L-T-P-C: 3-0-0-3
Course Title	Advanced Digital Image Processing
Learning Mode	Lectures
Learning Objectives	Complies with Program Goals 6 and 7
Course Description	Advanced Digital Image Processing involves the manipulation and analysis of digital images using computational algorithms. The course covers topics such as image enhancement, restoration, segmentation, feature extraction, and compression. It also includes applications in fields such as medical imaging, remote sensing, robotics, and multimedia systems.
Course Outline	<p>DIGITAL IMAGE FUNDAMENTALS: Elements of Visual Perception; Image Sensing and Acquisition; Image Sampling and Quantization; Basic Relationships between Pixels; Monochromatic Vision Models; Colour Vision Models; Colour Fundamentals; Colour Models; Conversion of Colour Models; Colour Transformations.</p> <p>ENHANCEMENT & RESTORATION : Homomorphic filtering, inverse and minimum error filtering, Noise types and related filtering.</p> <p>IMAGE ANALYSIS AND REPRESENTATION: Introduction; Image Segmentation - Point, Line, Edge, Boundary Detection; Colour Image Segmentation; Thresholding- Basic Global Thresholding, Multiple Thresholding, Variable Thresholding; Region Based Segmentation; Representation: Chain codes, Signatures, Boundary segments, Skeletons, Description: Boundary Descriptors, Regional Descriptors.</p> <p>MORPHOLOGICAL PROCESSING & COMPRESSION: Morphological Image Processing – Logic Operations involving Binary Images; Dilation and Erosion; Basic Morphological Algorithms – Boundary Extraction, Region Filling, Thickening Image Compression – Compression Model, Different Coding schemes like Arithmetic Coding, LZW coding etc. Baseline jpeg, jpeg 2000, Mpeg etc.</p> <p>CLASSIFICATION AND APPLICATIONS of Object Recognition and Classification, Statistical classification, Structural /Syntactic Classification, 3D Image Processing, 3D Visualization: Surface rendering, Volume rendering; Applications: Motion Analysis, Image Fusion, Image super resolution</p>
Learning Outcome	Complies with PLOs 6a, 6b, 7 and 8a
Assessment Method	Quizzes/Assignments, Mid Sem, and End Sem
Suggested Readings	<p><u>Text/References</u></p> <ol style="list-style-type: none"> 1. 1. Rafael C. Gonzalez and Richard E. Woods, Digital Image Processing, Pearson 2. 2. Milan Sonka, Vaclav Hlavac and Roger Boyle, Image Processing, Analysis and Machine Vision, Springer 3. 3. Anil K. Jain, Fundamentals of Digital Image Processing, Prentice Hall

M. Tech. Elective - III						
Sl. No.	Subject Code	Subject	L	T	P	C
1.	EC5117	VLSI Testing and Verification	3	0	0	3
2.	EC5118	Bio Sensors and Circuits	3	0	0	3
3.	EC5119	Quantum Computing	3	0	0	3

Course Number	EC5117
Course Credit	L-T-P-C: 3-0-0-3
Course Title	VLSI Testing and Verification
Learning Mode	Lectures
Learning Objectives	Complies with Program Goals 6 and 7
Course Description	VLSI Testing and Verification covers methodologies and techniques for ensuring the correctness and reliability of Very-Large-Scale Integration (VLSI) circuits. The course includes topics such as test pattern generation, fault simulation, design for testability (DFT), and verification methodologies using simulation and formal methods.
Course Outline	Testing Philosophy, Role of Testing, Digital and Analog VLSI Testing, Test Economics, Defects, Errors, and Faults Levels of Fault Models, Controllability and Observability. Algorithms and Representations: Structural vs. Functional Test, Search Space Abstractions ATPG Algebras, Redundancy Identification, Combinational ATPG Algorithms, Test Generation Systems, Simulation-Based Sequential Circuit ATPG, Complexity of Sequential ATPG. Memory Test: Memory Density and Defect Trend, Memory Test Levels, Fault Modeling, Memory Testing Delay Test, IDDQ test, Design for Testability. Built in Self-test. Design Verification: The importance of verification, Reconvergence model, Formal verification, Equivalence checking, Model checking, Functional verification. Verification Tools. Simulators: Stimulus and response, Event based simulation, cycle-based simulation, Co-simulators, verification intellectual property: hardware modelers, The verification plan: The role of verification plan: specifying the verification plan, defining the first success. Levels of verification: unit level verification, reusable components verification, ASIC and FPGA verification, system level verification, board level verification, verifying strategies, verifying responses.
Learning Outcomes	Complies with PLOs 6a, 6b, 7 and 8a
Assessment Method	Quizzes/Assignments, Mid Sem, and End Sem
Suggested Readings	<p><u>Text/References</u></p> <ol style="list-style-type: none"> 1. P. K. Lala, "Digital Circuit Testing and Testability", Academic Press, 1997. 2. M. L. Bushnell and V.D. Agrawal, "Essentials of Electronic Testing for Digital, Memory and Mixed-Signal VLSI Circuits", Kluwer Academic Publishers 2002. 3. M. Abramovici, M.A. Breuer and A.D. Friedman, "Digital Systems and Testable Design", Jaico Publishing House, 2002. 4. Janick Bergeron, "Writing Test benches: functional verification of HDL models", 2nd Edition, Kluwer Academic Publishers, 2003 5. Jayaram Bhasker and Rakesh Chadha, "Static Timing Analysis for Nanometer Designs" A practical approach, 1st Edition, Springer publications, 2009. 6. Prakash Rashinkar, Peter Paterson, Leena Singh "System on a Chip Verification", Kulwer Publications, 2002.

Course Number	EC5118
Course Credit	L-T-P-C: 3-0-0-3
Course Title	Bio Sensors and Circuits
Learning Mode	Lectures
Learning Objectives	Complies with Program Goals 6 and 7
Course Description	Bio Sensors and Circuits focus on the design and implementation of circuits and systems for biological sensing applications. The course covers topics such as sensor technologies (e.g., optical, electrochemical), signal conditioning, data acquisition, and integration with biological systems for healthcare monitoring, environmental sensing, and biomedical research.
Course Outline	Transducers Principles, Biochemical Transducers: Electrode theory, electrode impedance, metal-electrolyte interface and electrode-tissue interface, Bio-potential electrodes: microelectrodes, body surface electrodes, needle electrodes, electrodes for ECG, EEG, and EMG. Electrodes: hydrogen electrodes, Ag/AgCl electrodes, Calomel electrodes, specific ion electrodes, pH electrode, O ₂ and CO ₂ electrode, Optical Sensor and Radiation Detectors: Principles of optical sensors and types of optical sensors, Optical fibers, LASERS, Radiation detectors: Proportional counter, Gas-ionization chamber, Geiger counters, Scintillation detectors., Biological Sensors: Receptors in the human body, Ion exchange membrane electrodes, enzymatic biosensors, Basic principles of MOSFET biosensors & BIOMEMS, basic idea about Smart sensors, Biomedical Measurement
Learning Outcomes	Complies with PLOs 6a, 6b, 7 and 8a
Assessment Method	Quizzes/Assignments, Mid Sem, and End Sem
Suggested Readings	<p><u>Text/References</u></p> <ol style="list-style-type: none"> 1. Joseph J. Carr and John M. Brown, "Introduction to Biomedical Equipment Technology", 4th Edition, Pearson Education, 2001. 2. John. G. Webster, "Medical Instrumentation- Application and Design", 4th Edition, John Wiley & Sons, 2010. 3. Willis J. Tompkins, "Biomedical Digital Signal Processing" Prentice-Hall of India, 1993. 4. Rangraj M. Rangayyan, "Biomedical Signal analysis- A Case Study Approach", Wiley India Pvt. Ltd., 2009. 5. Suresh R. Devashahayan, "Signals and Systems in Biomedical Engineering", Revised 2nd Edition, Kluwer academics/ Plenum publication, 2013. 6. Joseph J. Carr and John M. Brown, "Introduction to Biomedical Equipment Technology", 4th Edition, Prentice Hall, 2000. 7. Leslie Cromwell, Fred J. Weibell, and Erich A. Pfeiffer "Biomedical Instrumentation and Measurements", 2nd Edition, Prentice-Hall of India, 2000.

Course Number	EC5119
Course Credit	L-T-P-C: 3-0-0-3
Course Title	Quantum Computing
Learning Mode	Lectures
Learning Objectives	Complies with Program Goals 6 and 7
Course Description	Quantum Computing explores the theory and practical applications of quantum mechanics in computing. The course covers quantum algorithms, quantum gates, qubits, and their potential impact on cryptography, optimization, and simulation problems.
Course Outline	<p>Introduction: History, Motivation, Need of quantum bits, quantum states, quantum computations, quantum information, and quantum algorithms. Overview of complex numbers and Linear Algebra, Introduction to quantum mechanics and its postulates, Bloch sphere</p> <p>Quantum Circuits: Single qubits and multiple qubits operations, architecture, quantum gates; quantum teleportation, quantum Fourier Transform: phase estimation</p> <p>Quantum Algorithms: Deutsch's algorithm, Deutsch-Jozsa algorithm, Simon's algorithm, Grover algorithm and Shor's factoring algorithm. Quantum Information and Error Corrections: Classical vs quantum noise, quantum operations, quantum error correction, entropy and information</p> <p>Quantum Tools and Applications: Goal Challenges, Lights and Photon, Decoherence, Ion Trap, Linear Optics, NMR, Quantum Simulation</p>
Learning Outcomes	Complies with PLOs 6a, 6b, 7 and 8a
Assessment Method	Quizzes/Assignments, Mid Sem, and End Sem
Suggested Readings	<p><u>Text/References</u></p> <ol style="list-style-type: none"> 1. Nielsen, Michael A., and Isaac L. Chuang. Quantum computation and quantum information. Cambridge university press, 2010. 2. Yanofsky, Noson S., and Mirco A. Mannucci. Quantum computing for computer scientists. Cambridge University Press, 2008.\ 3. Johnston, Eric R., Nic Harrigan, and Mercedes Gimeno-Segovia. Programming quantum computers: essential algorithms and code samples. O'Reilly Media, 2019.

M. Tech. Elective - IV						
Sl. No.	Subject Code	Subject	L	T	P	C
1.	EC6105	CMOS Phase Locked Loops	3	0	0	3
2.	EC6106	Computer Vision	3	0	0	3
3.	EC6104	VLSI Signal Processing	3	0	0	3

Course Number	EC6105
Course Credit	L-T-P-C: 3-0-0-3
Course Title	CMOS Phase-Locked Loops
Learning Mode	Lectures
Learning Objectives	Complies with Program Goals 6 and 7
Course Description	CMOS Phase-Locked Loops (PLLs) involve the design and implementation of frequency synthesis circuits using Complementary Metal-Oxide-Semiconductor (CMOS) technology. The course covers topics such as PLL architecture, phase detection and comparison, loop filter design, voltage-controlled oscillator (VCO) characteristics, and applications in clock generation, frequency synthesis, and communication systems.
Course Outline	Introduction to PLL, Various types of PLL PLL building blocks: Phase detectors, Phase/Frequency detectors, Ring and LC Voltage-controlled Oscillators (VCO), Frequency Dividers Analysis of PLL: Type-I and Type-II 2nd order PLL; Higher-order loop filters and PLL; PLL Stability Designing PLL: a 2nd order PLL Jitter and Phase noise in Oscillators and PLLs, PLL-based frequency synthesizer: Integer-N and Fractional-N synthesizers, $\Delta\Sigma$ Fractional-N synthesizers All-Digital PLL: Time-to-Digital Conversion, Digital Filters, Digitally Controlled Oscillators, Delay-locked Loops Low jitter frequency synthesizer: Subsampling PLL Architecture and its components
Learning Outcomes	Complies with PLOs 6a, 6b, 7 and 8a
Assessment Method	Quizzes/Assignments, Mid Sem, and End Sem
Suggested Readings	<u>Text/References</u> 1. B. Razavi, "Design of CMOS Phase-Locked Loops" Cambridge Univ Press, 2020. 2. William F Egan, "Phase-lock Basics," IEEE-Wiley 3. Floyd M. Gardner, "Phase Lock Techniques" 3rd Edition, Wiley-inter-science 4. Ronald E Best, "Phase-locked Loop, Design, Simulation and Applications", 6th edition, McGrawHill 5. Venceslav F Kroupa, "Phase Lock Loops and Frequency Synthesis," Wiley 6. Shanthi Pavan, Richard Schreier, "Understanding Delta-Sigma Data Converters" IEEE-Wiley

Course Number	EC6106
Course Credit	L-T-P-C: 3-0-0-3
Course Title	Computer Vision
Learning Mode	Lectures
Learning Objectives	Complies with Program Goals 6 and 7
Course Description	Computer Vision involves the development of algorithms and systems that enable computers to interpret visual information from the real world. The course covers topics such as image processing, object detection and recognition, image segmentation, feature extraction, 3D reconstruction, and deep learning techniques applied to visual data. Applications include autonomous vehicles, medical imaging, surveillance, augmented reality, and robotics.
Course Outline	Computer vision introduction, image formation, perspective projection, camera response & HDR imaging, nature of image sensors, image filtering, template matching, Fourier transform, convolution and deconvolution, edge and corner detection, canny edge detection, Active contours, Hough transform, SIFT detector and descriptor, Image homography, Image warping and image blending, Face detection, nearest neighbor classifier, support vector machine, Radiometry and reflectance property, Photometric stereo, reflectance map, shape from normal, shape from shading, stereographic projection, shading illusion, dept from focus and depth from defocus, photometric stereo systems, camera calibration, simple stereo, uncalibrated stereo, epipolar geometry, stereo vision in nature, optical flow, Lucas Kanade method, structure from motion, object tracking, gaussian mixture model, feature detection for tracking, image segmentation by k-means, mean-shift and graph cut based methods. PCA and SVD and shape verses appearance. Neural network, Gradient descent, back propagation algorithm.
Learning Outcomes	Complies with PLOs 6a, 6b, 7 and 8a
Assessment Method	Quizzes/Assignments, Mid Sem, and End Sem
Suggested Readings	<p><u>Text</u></p> <ol style="list-style-type: none"> 1. Computer Vision - A modern approach, by D. Forsyth and J. Ponce, Prentice Hall Robot Vision, by B. K. P. Horn, McGraw-Hill. <p><u>References</u></p> <ol style="list-style-type: none"> 1. Computer Vision: Algorithms and Applications: Richard Szeliski 2. Foundations of Computer Vision Antonio Torralba (Author), Phillip Isola (Author), William T. Freeman (Author)

Course Number	EC6104
Course Credit	L-T-P-C: 3-0-0-3
Course Title	VLSI Signal Processing
Learning Mode	Lectures
Learning Objectives	Complies with Program Goals 6 and 7
Course Description	VLSI Signal Processing involves the design and implementation of signal processing algorithms and systems using Very-Large-Scale Integration (VLSI) technology. The course covers topics such as digital signal processing (DSP) algorithms, efficient hardware implementations, optimization techniques, and applications in areas such as telecommunications, audio processing, image processing, and biomedical signal processing.
Course Outline	Introduction to DSP systems: Representation of DSP algorithms; Iteration Bound: Definition, Examples, Algorithms for computing Iteration bound; Pipelining and Parallel Processing: Definitions, Pipelining and parallel processing of FIR filters, Pipelining and parallel processing for low power; Retiming: Definitions and Properties, Solving system of Inequalities, Retiming techniques; Unfolding: Definition, An algorithm for unfolding, Applications of unfolding; Folding: Definition, Folding transformations, Register minimization techniques, Register minimization in folded architectures; Systolic Architecture Design: Introduction, Systolic array design methodology, FIR systolic arrays, Selection of scheduling vector, Matrix-Matrix multiplication and 2D systolic array design; CORDIC based Implementations: Architecture, Implementation of FIR filter and FFT algorithm; Bit-Level arithmetic architectures: Parallel multipliers, Bit-serial multipliers, Bit-Serial FIR filter design and Implementation; Redundant arithmetic: Redundant number representation, Carry-free radix-2 addition and subtraction, radix-2 hybrid redundant multiplication architectures; Low-power design: Theoretical background, Scaling versus power consumption, Power analysis, Power reduction techniques, Power estimation approaches.
Learning Outcomes	Complies with PLOs 6a, 6b, 7 and 8a
Assessment Method	Quizzes/Assignments, Mid Sem, and End Sem
Suggested Readings	<u>Text/References</u> 1. U. Meyer-Baese, "DSP with FPGA", Springer,4th Edition, 2014. 2. K. K. Parhi, "VLSI DSP Systems", Wiley, 2003. 3. R.G. Lyons, "Understanding Digital Signal Processing", Pearson Education,3rd Edition, 2011.