Bharatiya Vidya Bhavan's
Sardar Patel Institute of Technology
(Empowered Autonomous Institute Affiliated to University of Mumbai)
Bhavan's Campus, Munshi Nagar, Andheri (West), Mumbai-400058-India
B. Tech. EXTC

B. Tech. (Electronics and Telecommunication Engineering)

Syllabus
(Semester V-VI)

2023 ITERATION: ELECTRONICS AND TELECOMMUNICATION ENGG.

Nomenclature of the Courses

Abbreviation	Course Category
BSESC	Basic Science & Engineering Science Courses
BSESEC	Basic Science & Engineering Science Elective Courses
SEC	Skill Enhancement Course
AEC	Ability Enhancement Course
HSSMC	Humanities and Social Science in Management Courses
CC	Cocurricular Courses
IKS	Indian Knowledge System
UHV	Universal Human Values
PCC	Program Core Courses
PEC	Program Elective Courses
OEC	Open Elective Courses
ELC	Experiential Learning Courses
MDM	Multidisciplinary Minor
CP	Community Project
HC	Honor Courses
DMC	Double Minor Course

Abbreviations

L	Lecture Hour	O	Other Work (Self Study)
T	Tutorial Hour	E	Total Engagement in Hours
P	Laboratory Hour	C	Credit Assigned

SEM V										
Sr. No	**Course Category**	**Abbreviation**	**Course Code**	**Course Name**	**L**	**T**	**P**	**O**	**E**	**C**
1	Experiential Learning	ELC	PR1	Mini Project I	0	0	2	4	6	1
2	Program Core Courses	PCC	EC301	Computer Communication Networks	3	0	2	5	10	4
3		PCC	EC302	Control Systems	3	0	0	5	8	3
4		PCC	EC303	Digital Signal Processing	3	0	2	6	11	4
5		PCC	EC304	Microcontrollers	3	0	2	5	10	4
6		PCC	EC305	Mobile Wireless Communication	2	0	2	4	8	3
7	Multidisciplinary Minor	MDM	MDEC2X	MDM-II	To be defined by others					4
				Total	**14**	**0**	**10**	**29**	**50+**	**23**

- **Research internship of minimum 1 month for the "Honors by Research" for 3 credits HR31 (Not for DSY)**
- **For Enrollment to Honors by research, Minimum CGPA must be 8.25**

SEM VI										
Sr. No	**Course Category**	**Abbreviation**	**Course Code**	**Course Name**	**L**	**T**	**P**	**O**	**E**	**C**
1	Program Core Courses (8 credits)	PCC	EC306	Fundamentals of Antenna	3	0	2	5	10	4
2		PCC	EC307	Fundamental of Power Electronics	3	0	2	5	10	4
3	Multidisciplinary Minor	MDM	MDEC3X	MDM-III	To be defined by others					3
4	Experiential Learning	ELC	PR3-I	Main Project Stage I	0	0	4	4	8	2
5	Program Elective Courses	PEC	EC3X1	PE-I	2	0	2	4	8	3
6	Program Elective Courses	PEC	EC3X2	PE-II	2	0	2	4	8	3
7	Skill Enhancement Course #	SEC	AS301	Internet of Things Laboratory	1	0	2	2	5	2
				Total	**11**	**1**	**14**	**19**	**42+**	**21**

No MSE and ESE exam

- **Research internship of minimum 2 month for the "Honors by Research" for 6 credits HR32 (Not for DSY)**
- **For Enrollment to Honors by research, Minimum CGPA must be 8.25**

PROGRAM ELECTIVE COURSES

4 Electives are sufficient to specialize in a particular domain.

Track	PE-I (Sem VI)	PE-II (Sem VI)	PE-III (Sem VII)	PE-IV (Sem VII)
Communication	**EC311** Optical Fiber Communication	**EC312:** Error Coding and Cryptography	**EC413:** Microwave Communication	**EC414:** Space Communication on Technologies
	EC321: Cyber Security and Digital Forensic	**EC322**: Wireless Networks	**EC423:** Network Virtualization	**EC424:** Telecom Network Management
Embedded	**EC331:** Embedded Systems	**EC332:** Real Time Operating System	**EC433:** IoT Protocols	**EC434:** IoT Applications and Analytics
Signal Processing	**EC341:** Advanced Signal Processing	**EC342:** Speech and Audio Processing	**EC443:** Image and Video Processing	**EC444:** DSP based System Design
VLSI	**EC351:** Digital CMOS VLSI Design	**EC352:** Semiconductor Technologies	**EC453:** Analog CMOS VLSI Design	**EC454:** ASIC Verification

Bharatiya Vidya Bhavan's
Sardar Patel Institute of Technology
(Empowered Autonomous Institute Affiliated to University of Mumbai)
Bhavan's Campus, Munshi Nagar, Andheri (West), Mumbai-400058-India

B. Tech. EXTC

Semester-V

Course (Category) Code	Course Name	Teaching Scheme (Hrs/week)					Credits Assigned			
		L	T	P	O	E	L	T	P	Total
ELC	Mini Project I	0	0	4	4	8	0	0	2	2
		Examination Scheme								
		Component	ISE (%)		MSE (%)		ESE (%)			Total
PR1		Theory	--		--		--			--
		Laboratory	--		--		--			--
		Self-Study	80		--		20			100

Pre-requisite Course Codes, if any.	All the Courses till fourth Semester

Course Objective: A mini project serves as a platform for making a meaningful difference in the educational experience, focused on addressing real-world problems. It involves applying scientific methods to understand, correct, and assess decisions surrounding a particular issue. By linking theoretical knowledge with practical experiences, the project nurtures a scientific attitude among students for solving everyday challenges.

Course Outcomes (CO): ***At the end of the course students will be able to***

PR1.1	Identify problems based on societal/environmental issues.
PR1.2	Apply engineering knowledge to propose innovative and sustainable solutions to practical problems in a group.
PR1.3	Analyze the results obtained using theoretical, experimental, or simulation methods and draw appropriate conclusions.
PR1.4	Apply self-learning skills in teamwork with following professional ethics, contributing to the development of lifelong learning habits.
PR1.5	Document the findings and foster communication, organizational abilities, and personal growth through discussions and presentations.
PR1.6	Apply project management principles during the project work.

CO-PO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PR1.1	1	3	3	1	1	3	3	1	1	1	1	1
PR1.2	3	2	3	2	3	1	1	1	3	1	1	1
PR1.3	2	2	2	3	2	1	1	1	1	1	1	1
PR1.4	2	2	2	2	2	2	2	3	3	2	2	3
PR1.5	2	1	1	1	1	1	1	1	1	3	1	1
PR1.6	1	1	1	1	1	1	1	1	1	1	3	1
PR1	**1.83**	**1.83**	**2**	**1.67**	**1.67**	**1.5**	**1.5**	**1.33**	**1.67**	**1.5**	**1.5**	**1.33**

CO-PEO/PSO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)

	PEO1	PEO2	PEO3	PEO4	PSO1	PSO2
PR1.1					2	3
PR1.2					3	2
PR1.3					3	2
PR1.4					2	3
PR1.5					2	3
PR1.6					2	3
PR1					**2.33**	**2.67**

Guidelines for Mini Project I:

- The orientation regarding Mini Project I implementation process and available hardware and software facilities with expertise of faculties shall be given in the last week of semester 4.
- Students must form a group of a minimum of 2 or maximum of 3 students.
- The Mini project topic must contain implementation in terms of Hardware and Software.
- Each group can approach the faculty having the same domain expertise from the department for discussion of the idea. Students can approach the faculty along with their proposed topic/idea or faculty may suggest a topic/idea.
- The details regarding group members, domain of interest and choice of guide based on discussion with him/her must be filled in a sheet shared by Project Co-Ordinator by each group within 1 week of completion of ESE of semester 4.
- For approval of the mentor, the group must write mail to the mentor regarding his/her permission keeping Project Co-Ordinator and HoD in CC. On the same mail mentor must reply for approval of mentoring the group for Mini Project 1.
- Each faculty from the department would be allowed to select 2 groups for Mini project guidance. Considering priority to choice of guide, tentative mentor allocation will be done 2 weeks before commencement date of semester 5.

- The topic approval presentation shall be scheduled in the first week of Semester 5 in front of all the department faculties. Students should do survey and identify needs, which shall be converted into problem statement for mini project in consultation with tentative mentor/head of department/domain experts. Students shall submit an implementation plan which will cover weekly activity of mini project along with objectives, motivation and references for the proposed title.
- Based on topic approval presentation the mentor and co-mentor would be allotted by Head of Department.
- A log book to be prepared by each group, wherein group can record weekly work progress, mentor/co-mentor can verify and record notes/comments.
- Faculty mentor may give inputs to students during mini project activity; however, focus shall be on self-learning.
- Students in a group shall understand problem effectively, propose multiple solution and select best possible solution in consultation with mentor/ co-mentor.
- Students shall convert the best solution into working model using various components of their domain areas and demonstrate.
- The solution to be validated with proper justification and report to be compiled in standard format given by department. Project report should contain project title, student details, certificate, and acknowledgements. Other sections of the report shall be introduction, necessity of project, objectives, hypothesis, plan, observations, analysis of results, conclusion, and references along with other sections related to technology. The report must be written in Latex and must include report of plagiarism check.
- With the focus on the self-learning, innovation, addressing societal problems and entrepreneurship quality development within the students through the Mini Projects, it is preferable that a single project of appropriate level and quality to be carried out in semester 5 by all the groups of the students.
- However, based on the individual students or group capability, with the mentor's recommendations, if the proposed Mini Project adhering to the qualitative aspects mentioned above gets completed in odd semester, then that group can be allowed to work on the extension of the Mini Project with suitable improvements/modifications or a completely new project idea in even semester for Main Project Stage 1. This policy can be adopted on case by case basis.

Guidelines for Assessment of Mini Project: (ISE: Through 2 Phases of Evaluation) and ESE

In Semester Evaluation:

- The review/ progress monitoring committee shall be constituted by Head of Department.
- The progress of mini project to be evaluated on continuous basis, with the help of two-phase evaluation in the semester.
- In continuous assessment focus shall also be on each individual student, assessment based on individual's contribution in group activity, their understanding and response to questions.
- The phase 1 evaluation (during 6th week of semester) shall be done by mentor and co-mentor considering the factors like literature/market survey, formation of problem statement, block diagram, circuit diagram, flow chart, project planning, presentation skill along with attendance in terms of weekly meeting with mentor/co-mentor.
- The phase 2 evaluation (during 12th week of semester) shall be done by mentor and co-mentor considering the factors like demonstration of the work undertaken, project outcome with respect to scope defined, teamwork, ethics, submission of poster and project report (with plagiarism check) in prescribed format given by department.

End Semester Evaluation:

- The ESE shall be scheduled during the last week of semester in terms of exhibition.
- External experts from the other colleges shall be called for the evaluation.
- The exhibition will be conducted in 2 phases.
  - ✓ For phase 1 all groups will participate.
  - ✓ For phase 2 shortlisted groups will demonstrate the project once again to higher authorities and domain experts from the college.
- During the exhibition, the projects will be evaluated by an external examiner based on
  - ✓ Problem Definition/Idea/Originality/Novelty/Feasibility/Application in Society
  - ✓ Work Done (Survey/Design/Simulation/experimentation/Tools Usage/Budget Plan/ Execution Plan)
  - ✓ Presentation (Demo/Oral/Written) and Ethics (Attitude/Deadline/Distribution of Work)
  - ✓ Outcome of project (paper/ patent/winner of competition)
  - ✓ Knowledge/Question-Answer
- Each external examiner will evaluate 8 to 10 groups.
- The best 2 or 3 projects shortlisted by each examiner will be eligible for phase 2 evaluation. The ranking of shortlisted projects will be given by higher authorities and domain experts from the college.
- The prizes will be in terms of reimbursement of the hardware component expenses done for the projects as defined by the department reimbursement policy.

- Each group must write research proposal as per prescribed TIH of Nidhi Prayas proposal format for reimbursement of the hardware component used in project.
- The winning team of the exhibition will be eligible to take part in the AICTE Techfest and YUKTI ideation competition.
- The paper and patent publication of the project or prize obtained after participating in project competition will have weightage in In Semester Evaluation rubric.

Bharatiya Vidya Bhavan's

Sardar Patel Institute of Technology

(Empowered Autonomous Institute Affiliated to University of Mumbai)
Bhavan's Campus, Munshi Nagar, Andheri (West), Mumbai-400058-India

B. Tech. EXTC

Course (Category) Code	Course Name	Teaching Scheme (Hrs/week)					Credits Assigned			
		L	T	P	O	E	L	T	P	Total
PCC	Computer Communication Networks	3	-	2	5	10	3	-	1	4
		Examination Scheme								
		Component	ISE (%)		MSE (%)		ESE (%)		Total	
EC301		Theory	20		20		60		100	
		Laboratory	80		--		20		100	

Pre-requisite Course Codes, if any.	Analog and Digital Communication
Course Objective: The objective of the course is to provide a fundamental understanding of Computer Communication networks.	
Course Outcomes (CO): ***At the end of the course students will be able to***	
EC301.1	Apply Conceptual understanding and functional aspects of computer communication and telecom networks.
EC301.2	Design and configure small/medium sized computer network that meets a specific need for communications.
EC301.3	Understand the transport and application layers in computer networks, enabling them to design, analyse, and troubleshoot network communication systems effectively.
EC301.4	Understand the principles behind the modern network approaches such as NFV and IoT and security issues.

CO-PO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)

	PO1	PO2	PO3	PO4	PO5	PO6	PO8	PO9	PO10	PO11	PO12
EC301.1	3	3			3			2	3		3
EC301.2			2	2		2	2	3	3		3
EC301.3			3		3		3		3		3
EC301.4			2.5		3	2	3	3	3		3

CO-PEO/PSO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)

CO	PEO1	PEO2	PEO3	PSO1	PSO2
EC301.1			2	2	
EC301.2		2		2	
EC301.3				3	
EC301.4	2				2

BLOOM'S Levels Targeted (Pl. Tick appropriate)

Remember	Understand√	Apply √	Analyze√	Evaluate	Create

Theory Component

Module No.	Unit No.	Topics	Ref.	Total Hrs.
1	1.1	**Fundamental of Computer Networks**: Basics of data communication and networking, Networking devices and their functionalities (Router, Switch, Hub, Bridge, Gateway, Modem), Network architectures: OSI Model – layer-wise functions.	1,4	08
	1.2	TCP/IP Protocol Suite and comparison with OSI, Delay types in the Internet: Processing, Queuing, Transmission, Propagation, Switching Techniques: Circuit, Packet, and Message Switching.		
2	2.1	**IP Addressing and Subnetting:** Working with IPv4 family: IP addressing schemes, subnet masks, network-id, host-id, Classful vs. classless addressing, Private and public IP addresses.	2	08
	2.2	Subnetting with Fixed and Variable Length Subnet Mask techniques, class less inter domain routing concepts		
3	3.1	**Transport and Application Layer**: Transport layer: Principles of congestion control, detection and avoidance mechanisms, max-min fairness algorithm	1,3,7	10
	3.2	Application layer: Application layer protocols, Client-server as a key model. Web, HTTPs, FTP, SMTP, POP3, and DNS, peer-to-peer file sharing networks.		
4	4.1	**Network Function Visualization:** Introduction to NFV and its need in modern networks, NFV Architecture: Layers (Infrastructure, VNF, MANO).	6	06
	4.2	Hypervisors and Virtual Machines vs Containers, Key Components: VIM, VNF, NFVO – Functionality and Examples, NFV Deployment Models and Real-world Examples (e.g., 5G Core)		
5	5.1	**Network Security** Threats and attacks, symmetric and asymmetric cryptography: simple substitution cipher, mono alphabetic cipher, ploy-alphabetic cipher, zig-zag cipher, vernem cipher, Diffie-Hellman Key Exchange (DHKE).	5,8	10
	5.2	Secure Socket Layer (SSL), firewalls, proxy server, honeypots.		
6	Self–Study	Types of Networks, Transmission media, Network Topologies		*05
			Total (*Not included)	42

Laboratory:

Sr. No.	Title of the Experiment
1.	Identify and observe the behavior of networking command line tools in Ubuntu/Windows OS

	environment.
2.	To build and test straight through UTP ethernet network cables.
3.	Write a program in C/C++/Python/Java/Scilab to identify the IP address, Subnet mask, DNS server address and Hardware address of the client device.
4.	Building Networks by using Packet Tracer/GNS3
5.	Write a program in C/C++/Python/Java/Scilab to determine the administrator's requirement to define the number of subnets, host/subnet, customized subnet masks and valid subnet ranges for an IP addressing scheme.
6.	Examine Data Breaches and Scan for Malware Using the Microsoft Safety Scanner
7.	Hands-on experience on how to Write-Protect and Disable a USB Flash Drive
8.	Protocol Visualization with open source tools
9.	Network Reconnaissance using open source tools
10.	Web Reconnaissance Using a Web Browser/open source tools
11.	Cryptography using open source tools/Crypt tools and open SSL

Text Books

Sr. No.	Title	Edition	Authors	Publisher	Year
1	TCP/IP protocol suit	4th	Behrouz A. Forouzan (Author)	McGraw Hill Education	2009
2	Introducing Network Design Concepts	-	CCNA Discovery Learning Guide	-	-
3	Computer Networking: A Top-Down Approach	5th	J. F. Kurose and K. W. Ross	Prentice Hall	2009
4	Data Communication and Networking	4th	B. Forouzan	McGraw Hill	2017
5	Information Security: Principles and Practice	1st	Deven Shah	Wiley	2007

Reference Books

Sr. No.	Title	Edition	Authors	Publisher	Year
1	Foundations of Modern Networking: SDN, NFV, QoE, IoT, and Cloud	--	William Stallings	Addison-Wesley ISBN: 9780134175393	2015
2	Computer Networks	5th	A. Tanenbaum	Pearson Education	2013
3	Data and Computer Communications	10th	William Stallings	Pearson Education	2013

Course (Category) Code	Course Name	Teaching Scheme (Hrs/week)					Credits Assigned			
		L	T	P	O	E	L	T	P	Total
PCC	Control Systems	3	0	0	5	08	3	0	0	3
		Examination Scheme								
		Component	ISE (%)		MSE (%)		ESE (%)			Total
EC302		Theory	20		20		60			100

Pre-requisite Course Codes, if any.	MA101: Engineering Calculus MA102: Differential Equations and Complex Analysis EC102: Digital Systems EC101: Basic Electrical Engineering EC203: Signal, Network and System MA203: Probability and Stochastic Processes
Course Objective: To develop a system for real life application by applying the concepts of control system theory and allied techniques for system performance evaluation.	
Course Outcomes (CO): ***At the End of the course students will be able to***	
EC302.1	Classify different types of control systems and formulate mathematical modeling of the given system.
EC302.2	Apply various methods for representation of the given control system and concept of controllability and observability using state variable models.
EC302.3	Analyze the transient and steady state behavior of a given system for standard test inputs and computation of steady state error.
EC302.4	Analyze the stability of systems in the time domain and frequency domain.
EC302.5	Design compensators & controllers to enhance system performance.
EC302.6	Use of computer simulation platforms for analyzing practical control systems in time and frequency domain techniques with the emphasis on controller and compensator design.

CO-PO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
EC302.1	3							2	2	2		
EC302.2	3							2	2	2		
EC302.3	3							2	2	2		
EC302.4	3							2	2	2		
EC302.5	2		2					2	2	2		
EC302.6	2	2			3			2	2	2		

CO-PEO/PSO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)

	PEO1	PEO2	PEO3	PEO4	PSO1	PSO2
EC302.1		3				
EC302.2		3				
EC302.3		3				
EC302.4		3				
EC302.5		3				
EC302.6	2	3			2	2

BLOOM'S Levels Targeted (Pl. Tick appropriate)

Remember	Understand	✓ Apply	✓ Analyze	✓ Evaluate	Create

Theory Component

Module No.	Unit No.	Topics	Ref.	Hrs.
1	Title	**Introduction to control system and system Modeling**	1,2,5	08
	1.1	**Introduction to control system:** Definition of system, Notion of feedback, Open loop and closed loop systems; Understanding the concept of feedback in control systems and its impact on performance.		
	1.2	**Dynamic Response:** Standard test signals; Transient and steady state behavior of first and second order systems; Generalized error coefficients, steady state errors in feedback control systems and their types.		
	1.3	**Control System Modeling:** Types of models, Differential equation model, Impulse response model, State variable model, Transfer function model, Modelling of electrical and electromechanical systems.		
2	Title	**Representation of Control System and State Space Analysis**	1,3,5	10
	2.1	Block diagram representation of systems, Block diagram reduction methods, closed loop transfer function, signal flow graph. Mason's gain rule		
	2.2	**State Space Analysis:** Concepts of state space, State equations, State transition matrix, properties of state transition matrix, Solution of state equation of LTI system		
	2.3	**Controllability and Observability:** Concept of controllability and Observability, Controllability and Observability analysis of LTI systems using Kalman approach.		
3	Title	**Time Domain System Stability Analysis**	1,3,5	08

	3.1	Concepts of Stability Concept of absolute, relative and robust Stability		
	3.2	Routh-Hurwitz stability criteria		
	3.3	Root Locus Analysis: Root-locus concepts; General rules for constructing root-locus, Root-locus analysis of control systems.		
4	**Title**	**Frequency Domain System Stability Analysis**	**1,2,5**	**08**
	4.1	Relation between time and frequency response		
	4.2	Bode Plot: Magnitude and phase plot, Method of plotting Bode plot; Stability analysis by using Gain and phase margins on the Bode plots		
	4.3	Polar plots, Nyquist stability criterions; Nyquist plot; Gain and phase margins.		
5	**Title**	**Compensators & Controllers**	**1,2,3, 5**	**08**
	5.1	**Types of compensators:** Lag, Lead, and Lag-Lead Compensation: Methods for improving system performance by modifying the system's frequency response, Design of lag, lead and lag-lead compensator using Bode plot and Root locus techniques		
	5.2	**Controllers:** Concept of ON/OFF controllers, P, PI, PD and PID Controllers, tuning of PI and PID controllers based on desired system performance.		
	5.3	Discrete time methods for PID controller implementation		
6	**Self-Study**	Examples on open loop and closed loop control system, Modeling of rotational mechanical systems, Pole placement using state feedback Popov–Belevitch–Hautus (PBH) test in state space, Design of real-life applications of control systems. Advanced Control Systems: Introduction to Robust Control, Adaptive control and Model predictive control, Neuro- fuzzy controllers.	**1,5**	
			Total	**42**

ISE Evaluation: CO1-CO6

Mini-Project: Identify the model of control system for real life application and demonstrate controlling action for the same.

This is a group activity. Students will form a group of minimum 3 students. Students will develop the block diagram of the system first, then design each block using appropriate components. Simulate the complete block diagram using any tool like MATLAB, Scilab or LabVIEW. The duration of this activity is a complete semester, but evaluation will be done in phases and rubrics designed. In the first phase students will develop

the block diagram for the given problem statement. In the second phase students will develop the block diagram and simulate each of the block diagrams and test it for input-output relationship. In the third phase students will interface all the designed blocks to obtain the final input output relationship of the system. Hardware implementation is optional.

Text Books

Sr. No.	Title	Edition	Authors	Publisher	Year
1	Control Systems Engineering	Fifth	I. J. Nagrath, M. Gopal	New Age International	2012
2	Modern Control Engineering	Fifth	Ogata. K	Prentice Hall	2010

Reference Books

Sr. No.	Title	Edition	Authors	Publisher	Year
1	Control Systems: Principle and design	First	M. Gopal	Tata McGraw Hill	1998
2	Modern Control System	Eleventh	Richard C. Dorf and Robert H. Bishop	Pearson	2013
3	Control Systems Engineering	Sixth	Norman Nise John	Wiley & Sons	2011
4	Linear Control System	First	Constantine H.	Mcgraw-Hill	1975
5	Linear Feedback Control - Analysis and Design with MATLAB		Dingyü Xue, YangQuan Chen and Derek P. Atherton		2007

NPTEL Link:
https://www.google.com/url?q=https://onlinecourses.nptel.ac.in/noc25_ee15/preview&sa=D&source=editors&ust=1744183318651808&usg=AOvVaw0maJDPEUarSYTIP7U45a8i

Course (Category) Code	Course Name	Teaching Scheme (Hrs/week)					Credits Assigned			
		L	T	P	O	E	L	T	P	Total
PCC	Digital Signal Processing	3	0	2	5	10	3	0	1	4
		Examination Scheme								
EC303		Component	ISE (%)		MSE (%)		ESE (%)			Total
		Theory	20		20		60			100
		Laboratory	80		--		20			100

Pre-requisite Course Codes, if any.	Signals and Systems
Course Objective: To develop mathematical foundation of system and design digital filters	
Course Outcomes (CO): ***At the End of the course students will be able to***	
EC303.1	Classify and perform various operations on signals and systems
EC303.2	Apply DFT properties and illustrate FFT algorithms
EC303.3	Apply Z Transform on discrete time signals
EC303.4	Analyze LTI System using Z Transform
EC303.5	Design and Realize Digital filters
EC303.6	Analyze Multirate Signal Processing

CO-PO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
EC303.1	2	1	3									
EC303.2	2	1	3									
EC303.3	2	1	3									
EC303.4	2	1	3									
EC303.5	2	1	3		2							
EC303.6	2	1	3									1

CO-PEO/PSO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)

	PEO1	PEO2	PEO3	PEO4	PSO1	PSO2
EC303.1	3				3	
EC303.2	3				3	
EC303.3	3				3	
EC303.4	3				3	
EC303.5	3				3	

EC303.6	3			1	3	1

BLOOM'S Levels Targeted (Pl. Tick appropriate)

Remember	Understand	Apply	✓ Analyze	Evaluate	Create

Theory Component

Module No.	Unit No.	Topics	Ref.	Hrs.
1	Title	**Overview of Discrete Time Signals**	6,7,8	08
	1.1	Sampling of Continuous Time Signal, Standard Discrete Time Signals: Impulse Signal, Unit Step, Unit Ramp, Sinusoidal, Exponential.		
	1.2	**Classification of Signals:** Deterministic and non-deterministic, Periodic and aperiodic, Symmetric (even) and Asymmetric (odd), Energy and Power, Causal and Anti-causal signals.		
	1.3	**Operations of Signals:** Shifting, Scaling, Time Reversal, Addition and Multiplication, Convolution (Linear and Circular), Correlation.		
2	Title	**Discrete Fourier Transform (DFT)**	1, 3	12
	2.1	Discrete Time Fourier transform (DTFT), Discrete Fourier Transform (DFT), Properties of DFT, Inverse DFT.		
	2.2	**Fast Fourier Transform:** Radix-2 Decimation in Time Fast Fourier Transform (DIT-FFT) and Decimation in Frequency Fast Fourier Transform (DIF-FFT) algorithms, Real and Complex Calculations using FFT, Linear and Circular Convolution using FFT.		
	2.3	Filtering of long data sequence, Overlap Add Method, Overlap Save Method.		
3	Title	**Analysis of Discrete Time System using Z-Transform**	1,4	08
	3.1	**Z-Transform:** Z-Transform of discrete time signals, Properties of Z-Transform, Relation between Z-Transform and DTFT, Inverse Z-Transform		
	3.2	**Classification of Systems:** Static and Dynamic, Time Variant and Time Invariant, Linear and Nonlinear, Causal and Non-causal, Stable and Unstable Systems.		

	3.3	**Analysis of Systems**: Impulse Response, Transfer Function, Differential Equation, Stability of Systems, Frequency Response LTI systems as frequency-selective filters like; Low Pass, High Pass, Band Pass, Minimum-phase, Maximum-phase, Mixed-phase systems		
4	**Title**	**Digital IIR Filter Design and Implementation**	**1,2**	**07**
	4.1	**Design of Infinite Impulse Response (IIR) filters** using Impulse Invariant Method and Bilinear Transformation Method, Butterworth and Chebyshev Type I filter design.		
	4.2	**Realization structures for IIR filters**: Direct Form Realization, Lattice Form Realization.		
5	**Title**	**Digital FIR Filter Design and Implementation**	**1,5**	**07**
	5.1	**Concepts of Finite Impulse Response (FIR) filter**: Linear Phase Concept, Symmetric and Anti-Symmetric FIR filter, Position of POLEs and ZEROs, FIR Filter Design using Window Method, FIR Filter Design using Frequency Sampling Method.		
	5.2	**Realization Structures for FIR filters**: Linear Phase Realization, Frequency Sampling Realization, Lattice Realization.		
6	**Self-Study**	**Multi-rate Signal Processing:** Down-sampling and Up-sampling by integer factors; Decimator and Interpolator, Sampling rate conversion by non-integer factor.	**1,5**	
			Total	**42**

Laboratory Component

Sr. No	Title of the Experiment
1	Discrete Convolution and Correlation
2	Discrete Fourier Transform
3	Fast Fourier Transform
4	Linear Filtering using Overlap Add Method/ Overlap Save Method.
5	Design of Butterworth IIR Filter using Impulse invariant method
6	Design of Butterworth IIR Filter using Bilinear Transformation method
7	Linear phase FIR Filter Design using Windowing Method
8	Linear phase FIR Filter Design using Frequency Sampling Method
9	Multirate Signal Processing
10	Mini Project on Real Time Signal Processing

Text Books

Sr. No	Title	Edition	Authors	Publisher	Year
1	Digital Signal Processing: Principles, Algorithms and Applications	4th	J. Proakis, D. G. Manolakis, and D. Sharma	Pearson Education	2014
2	Digital Signal Processing	4th	Ramesh Babu	Scitech	2014
3	Digital Signal Processing	2nd	S.Salivahanan, A Vallavaraj, C Gnanapriya	Tata McGraw Hill	2010

Reference Books

Sr. No	Title	Edition	Authors	Publisher	Year
1	Signals and Systems	2nd	Alan V Oppenheim, Alan S, Willsky and A Hamid Nawab	Pearson	2002
2	Signals and Systems	3rd	Simon Haykin and Barry Van Veen	John Wiley & Sons	2002
3	Theory and Applications of Digital Signal Processing	2nd	L. R. Rabiner and B. Gold	Prentice-Hall	2006

NPTEL:

https://archive.nptel.ac.in/courses/108/101/108101174/

https://nptel.ac.in/courses/117102060

Course (Category) Code	Course Name	Teaching Scheme (Hrs/week)					Credits Assigned			
		L	T	P	O	E	L	T	P	Total
PCC	Microcontrollers	3	0	2	5	10	3	0	1	4
EC304		Examination Scheme								
		Component		ISE (%)		MSE (%)		ESE (%)		Total
		Theory		20		20		60		100
		Laboratory		80		--		20		100

Pre-requisite Course Codes, if any.	Digital Systems, Computer Organization & Architecture
Course Objective: To impart knowledge of microcontroller architecture, programming, and interfacing with peripherals. The course covers real-time constraints, debugging, and optimization techniques for interfacing applications.	
Course Outcomes (CO): ***At the End of the course students will be able to***	
EC304.1	Illustrate the architectural features of 8, 16 and 32-bit microcontrollers.
EC304.2	Comprehend 16- and 32-bit microcontrollers and classify various modes of operation.
EC304.3	Examine the addressing modes used in 16- and 32-bit microcontrollers' instructions and classify them accordingly.
EC304.4	Analyze the given problem statement and apply the programming concepts to solve the problem for 16- and 32-bit microcontrollers
EC304.5	Apply and utilize the integrated peripherals of 16- and 32-bit microcontrollers

CO-PO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
EC304.1	3											
EC304.2	3											
EC304.3	3											
EC304.4		3			3			3		3		
EC304.5		3	3									

CO-PEO/PSO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)

	PEO1	PEO2	PEO3	PEO4	PSO1	PSO2
EC304.1	1	1	1			
EC304.2	1	1	1			
EC304.3	1	1	1			
EC304.4	1	1	1			
EC304.5	1	1	1			

BLOOM'S Levels Targeted (Pl. Tick appropriate)

Remember	Understand	Apply	Analyze	Evaluate	Create

Theory Component

Module No.	Unit No.	Topics	Ref.	Hrs.
1	Title	**Introduction of 8-bit Microcontroller - 8051**	1	4
	1.1	Overview of 8051 Family of Controllers		
	1.2	Architecture of 8051 with block diagram schematic		
	1.3	Brief description of integrated components of 8051		
2	Title	**PIC Microcontroller**	2	10
	2.1	Microcontroller architecture and Programming model		
	2.2	Instruction set with addressing modes		
	2.3	Programming and Problem-solving approaches		
3	Title	**PIC Integrated Peripherals**	2	9
	3.1	I/O Ports with its interfacing and Interrupt Structure		
	3.2	Timers with its configuration		

	3.3	Data Converters (ADC and DAC), Serial I/O (SPI and I^2C)) protocol)		
4	**Title**	**ARM7TDMI(ARMv4T) Architecture**	**3,4**	**10**
	4.1	Features and advantages, ARM versions		
	4.2	Processor operating states, ARM core data flow model, operating modes, registers, program status registers, exceptions and pipelined architecture advantage		
	4.3	Instruction set with addressing modes		
5	**Title**	**LPC2148 ARM7 Processor Programming and Interfacing**	**3,4**	**9**
	5.1	Processor state changing (ARM□□THUMB), Exceptions, interrupts and its handling,		
	5.2	Timer Programming, Watchdog Timer		
	5.3	ADC and Sensor Interfacing, SPI and I2C Peripheral Interface		
6	**Self-Study**	ARM-v7-M (Cortex-M3), Comparison of ARM-v&-A (Cortex A8), ARM-v7-R (Cortex R4), ARM-v7-M (Cortex M3). Application Case Study for PIC and ARM controllers		
			Total	**42**

Laboratory Component, if any. (Minimum 10 Laboratory experiments are expected)

Sr. No.	Title of the Experiment
1	LED Blinking and GPIO Control: This fundamental experiment involves setting up a simple program to control General Purpose Input/output (GPIO) pins to blink LEDs. It helps understand basic setup, I/O configuration, and timing in PIC18F microcontroller.
2	Button Input and Debouncing: Implement a circuit with buttons or switches to provide input to the PIC18F. Include debouncing logic to ensure reliable input readings.
3	PWM Control and Motor Control: Demonstrate Pulse Width Modulation (PWM) by controlling the speed of a DC motor or the brightness of an LED. This experiment can also explore using timers to generate PWM signals.
4	Analog-to-Digital Conversion (ADC): Use the built-in ADC on the PIC18F to measure analog signals, such as temperature or light intensity, and convert them to digital values. This experiment covers ADC configuration and data processing.
5	Serial Communication (UART): Set up a simple communication link using Universal Asynchronous Receiver-Transmitter (UART). Connect the PIC18F to a computer or another microcontroller to send and receive data, demonstrating basic serial communication.

6	GPIO (LED/LCD) and Interrupts: This experiment focuses on setting up GPIO and handling interrupts on the ARM microcontroller. It includes GPIO based, emphasizing interrupt-driven programming.
7	PWM and Servo Control: Implement PWM to control servo motors, exploring different duty cycles to set servo angles on the ARM microcontroller. This experiment can also cover generating different frequencies for PWM.
8	I2C / SPI Communication: Set up communication between the ARM microcontroller and an I2C / SPI -based sensor or peripheral (like a temperature sensor or an OLED display). This experiment demonstrates configuring and using the I2C /SPI bus.
9	Analog-to-Digital Conversion (ADC) and Sensor Integration: This experiment demonstrates the use of Analog-to-Digital Conversion (ADC) to read analog signals from sensors and process them digitally on the ARM microcontroller.
10	Real-Time Clock (RTC) and Timers: Use the built-in RTC on the ARM microcontroller to create a real-time clock that keeps track of date and time. This experiment can also cover configuring timers for specific time intervals.

Text Books

Sr. No.	Title	Edition	Authors	Publisher	Year
1	The 8051 Microcontroller and Embedded Systems: Using Assembly and C	Second	Muhammad Ali Mazidi, Janice G. Mazidi and R. D. McKinlay	Pearson	2006
2	Fundamentals of Microcontrollers and Applications in Embedded Systems (with PIC18 microcontroller family)	Fourth	Ramesh Gaonkar	Penram International Publishing Pvt. Ltd	2007
3	ARM System Developer‟s Guide Designing and Optimizing System Software	First	Andrew N. Sloss, Dominic Sysmes and Chris Wright	Elsevier Inc Morgan Kaufmann	2004
4	ARM Architecture ,Reference Manual	Second	David Seal	Addison Wesley	2001

Reference Books

Sr. No.	Title	Edition	Authors	Publisher	Year
1	PIC Microcontroller: An Introduction to Software & Hardware Interfacing	Second	Han- Way Huang	Cengage Learning	2005
2	ARM System-on-Chip Architecture	Second	Steve Furber	Addison-Wesley	2000

MOOC Course (NPTEL): -
https://onlinecourses.nptel.ac.in/noc25_ee49/preview

Course (Category) Code	Course Name	Teaching Scheme (Hrs/week)					Credits Assigned			
		L	T	P	O	E	L	T	P	Total
PCC	Mobile Wireless Communication	2	-	2	2	6	2	-	1	3
		Examination Scheme								
		Component		ISE (%)		MSE (%)		ESE (%)		Total
EC305		Theory		20		20		60		100
		Laboratory		80		--		20		100

Pre-requisite Course Codes, if any.	EC307: Computer Communication Network, Analog & Digital Communication.

Course Objective: This course provides an in-depth understanding of wireless channel characteristics, including multipath, fading, and propagation effects. Students will explore cellular system design, multiple access techniques (TDMA, CDMA, OFDM), antenna diversity, MIMO, and wireless channel capacity. The course includes computer simulations of wireless systems and an overview of emerging technologies such as LTE and IEEE 802.11.

Course Outcomes (CO): ***At the end of the course students will be able to***

EC305.1	Demonstrate the ability to discuss wireless communication concepts, system capacity and grade of service provided.
EC305.2	Evaluate various path loss, fading and multipath effects.
EC305.3	Analyze architecture and protocols of 3G,4G and 5G systems.
EC305.4	Analyze and Compare short-range wireless communication technologies.

CO-PO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)

	PO1	PO2	PO3	PO4	PO5	PO 6	PO 7	PO 8	PO9	PO 10	PO 11	PO 12
EC305.1	2		2									
EC305.2			2	2	2				2	2		
EC305.3	3				2				2	2		2
EC305.4	2	2										

CO-PEO/PSO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)

	PEO1	PEO2	PEO3	PEO4	PSO1	PSO2
EC305.1		2				
EC305.2	2	2	2		2	
EC305.3	2	2	2		2	
EC305.4		2			2	

BLOOM'S Levels Targeted (Pl. Tick appropriate)

Remember	Understand√	Apply √	Analyze√	Evaluate	Create

Theory Component

Module No.	Unit No.	Topics	Ref.	Hrs
1	**Title**	**Introduction to mobile communication**	**1**	**6**
	1.1	Frequency Division Multiple access, Time Division Multiple access, Spread Spectrum Multiple access, Space Division Multiple access, and OFDM.		
	1.2	Frequency reuse, channel assignment strategies, handoff strategies, interference and system capacity, trunking and grade of service, improving the capacity of cellular systems and related design problems		
2	**Title**	**Mobile Radio Propagation**	**2,3**	**8**
	2.1	Introduction to radio wave propagation, reflection, diffraction, scattering. Indoor and Outdoor Propagation Models. Practical Link Budget Design using path loss models.		
	2.2	Small-Scale Multipath propagation, small scale multipath measurements, types of small-scale fading, fading effects due to Doppler spread. Statistical models for multipath fading channels- Clarks model,2-day Rayleigh fading model, Saleh and Valenzuel indoor model.		

3	**Title**	**3G UMTS Network, 4G LTE and 5G Technologies**	**4**	**8**
	3.1	UMTS network architecture, Protocol Structure, Channel Structure, Frame slots and symbols, modulation, coding, multiple antenna techniques, WCDMA, Modulation, Handoff and Power Control.		
	3.2	4G LTE network Architecture, LTE Radio Access, Radio-Interface Architecture, Physical Transmission Resources, Downlink and Uplink Physical-Layer Processing, Scheduling and Rate Adaptation. 5G Concepts and Architectures, Network Slicing Architecture, mm Wave communication, multiple Cell Types.		
4	**Title**	**Personal Area Network Technologies**	**3**	**6**
	4.1	**Bluetooth:** concepts of Piconet, scatter net etc., protocol stack, link types, security, network connection establishments, usage models,		
	4.2	**Wifi and ZigBee:** components, architecture, network topologies, protocol stack etc.		
5	**Self-Study**	Rayleigh fading model, Saleh and Valenzuela indoor model**.** UWB and RFID: technical requirements, components and characteristics, applications, 5G Channel Structure.	**2,3**	**4***
			Total (* Not Included)	**28**

Laboratory Components:

Sr. No.	Title of the experiment
1	Study of GSM modem: i] Install and configure minicom, wvdial & AT Commands ii] Python scripting.
2	Channel Allocation Techniques.
3	Modulation Techniques using GNU Radio.
4	Spread Spectrum Modulation, OFDM Modulation.
5	Wireless Path Loss Computations: i] Free-space Propagation Path Loss Model ii] Indoor Propagation Model - Okumura Model etc
6	Wireless Path Loss Computations: Outdoor Propagation Model - Hata Model etc

7	Open-Source LTE/EPC Network Simulation using NS-3, Omnet++
8	Open-Source Personal Area Network simulation using NS-3, Omnet++
9	Millimeter Wave (5G) Network, WiFi Network simulation using NS-3, Omnet++
10	Virtual Lab.

Text Books

Sr. No.	Title	Edition	Authors	Publisher	Year
1	Wireless Communications	Third	Theodore S. Rappaport	Prentice Hall of India, PTR publication	2010
2	Wireless Communications	Second	Andreas Molisch	Wiley	2010
3	Wireless Network Evolution 2G-3G	First	Vijay Garg	Pearson Education	2001
4	4 G Roadmap and Emerging Communication Technologies	Second	Young Kyun Kim and Ramjee Prasad	Artech house	2005

Reference Books

Sr. No.	Title	Edition	Authors	Publisher	Year
1	Wireless Communication	Second	Singhal	TMH	2017
2	Mobile Communication	Second	C.Y Lee	Wiley	1995

MOOC Course Link: Introduction to Wireless and Cellular Communications by Prof. R. David Koilpillai (IIT Madras)

Link: https://onlinecourses.nptel.ac.in/noc20_ee61/preview

Bharatiya Vidya Bhavan's
Sardar Patel Institute of Technology
(Empowered Autonomous Institute Affiliated to University of Mumbai)
Bhavan's Campus, Munshi Nagar, Andheri (West), Mumbai-400058-India
B. Tech. EXTC

Semester-VI

Course (Category) Code	Course Name	Teaching Scheme (Hrs/week)					Credits Assigned			
		L	T	P	O	E	L	T	P	Total
PCC	Fundamentals of Antenna	3	0	2	6	11	3	0	1	4
EC306		Examination Scheme								
		Component	ISE (%)		MSE (%)		ESE (%)			Total
		Theory	20		20		60			100
		Laboratory	80		--		20			100

Pre-requisite Course Codes, if any.	EC201: Electromagnetic Wave Engineering
Course Objective: The objective of the course is to prepare the students to apply fundamental antenna parameters to analyse simple antenna configurations and ultimately design an antenna for the desired specifications/application.	
Course Outcomes (CO): ***At the end of the course students will be able to***	
EC306.1	Interpret and calculate the fundamental parameters of Antenna.
EC306.2	Analyze basic wire and loop antennas
EC306.3	Design antennas for the given specifications
EC306.4	Select an antenna based on the intended application

CO-PO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
EC306.1	3	2										
EC306.2	3	3		2	3							
EC306.3	3		2		3							
EC306.4	3											

CO-PEO/PSO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)696

	PEO1	PEO2	PEO3	PEO4	PSO1	PSO2
EC306.1		2				-
EC306.2		2			2	2
EC306.3	1	2			2	2
EC306.4	1	2			2	2

BLOOM'S Levels Targeted (Pl. Tick appropriate)

Remember	Understand	Apply✓	Analyze✓	Evaluate✓	Create

Theory Component

Module No.	Unit No.	Topics	Ref.	Hrs.
1	Title	**Fundamental Concepts**	1	10
	1.1	Introduction, types of Antennas, Radiation mechanism		
	1.2	Antenna Parameters: Steradian concept, Power intensity Radiation pattern, co-polar and cross-polar pattern, Radiation power density, Radiation Intensity, Gain, Directivity, HPBW, FNBW, front-to-back ratio, Beam efficiency, Bandwidth, Polarization, Input Impedance, Reflection coefficient, Return loss, VSWR, Antenna Efficiency, Effective Aperture, Communication link and Friis transmission equation.		
2	Title	**Radiation from wires and loops**	1	08
	2.1	Introduction, Infinitesimal dipole: Radiation zones, Total radiated power, Radiation resistance, Directivity, Effective area, Current distribution in thin wire antennas, Short dipole, Finite-length dipole: Radiated power, Radiation resistance, Directivity, Effective area, Half-wave dipole and its properties, Vertical and Horizontal electric dipole, Folded dipole antenna, Design of Yagi-Uda Antenna		
3	Title	**Design of broadband, frequency independent and aperture antennas**	1, 2	07
	3.1	Design of Helix antenna, Log-periodic dipole array, reflector and horn antennas		
4	Title	**Antenna Arrays**	1,3	10
	4.1	Introduction, Two-element array, Example problems, Pattern multiplication concept, N-element array, Uniform array, Array factor, Broad-side and end-fire arrays, Phased array, Directivity and pattern characteristic of linear uniform array, non-uniform array, Binomial array, Dolph-Chebyshev array concept, Design principle of Chebyshev array and examples, Planar arrays		
5	Title	**Microstrip Antennas**		
	5.1	Introduction: Rectangular and circular patch antenna, feeding techniques, design examples, parametric study of microstrip patch.	1,4	07
	5.2	Circularly polarized microstrip antennas, Axial Ratio, Quality factor		
6 (Self Study)	**6.1**	**Current and Next-generation Antennas**	5	06*

		Fractal antennas, Smart Antennas, Vivaldi Antennas, Ultra-wideband antennas, Dielectric Resonator antenna, Artificial Magnetic Conductors/High-Impedance Surfaces, Metamaterial based antennas, Reconfigurable antennas		
			Total	**42**

Laboratory Component, if any. (Minimum 10 Laboratory experiments are expected)

Sr. No.	Title of the Experiment
1	Design a Dipole Antenna using CAD tool
2	Design a monopole Antenna using CAD tool
3	Design a Horn Antenna using CAD tool
4	Design a Helical Antenna using CAD tool
5	Design a Microstrip Patch Antenna using CAD tool
6	To calculate and infer various fundamental parameters of antenna like Radiation pattern, Radiation power density, Radiation Intensity, Gain, Directivity, HPBW and FNBW using MATLAB/Scilab.
7	To analyse the effects of finite ground and antenna height on antenna performance using NEC tool
8	To design a Pyramidal Horn Antenna in E-plane and H-plane
9	To show Pattern Multiplication phenomena in an Antenna using two infinitesimal dipoles.
10	To design Array factor pattern of *N*-element of uniform amplitude of Broadside Array.
11	To design Array factor pattern of *N*-element of uniform amplitude of End-fire Array
12	To design Array factor pattern of *N*-element of non-uniform amplitude of Broadside / End-fire Array using Binomial Array method.
13	To design Array factor pattern of *N*-element of non-uniform amplitude of Broadside /End-fire Array using DolphTschebyscheff Array method.

Text Books:

Sr. No.	Title	Authors	Edition	Publisher	Year
1	Antenna Theory: Analysis and Design	Constantine A. Balanis	Third	Wiley	2012

Reference Books/NPTEL courses:

Sr. No.	Title	Authors	Edition	Publisher	Year
1	Antennas & Wave Propagation	J.D. Kraus, R.J. Marhefka, and A.S. Khan	Fourth	McGraw Hill	2011
2	Antenna Theory: Analysis and Design	Warren L. Stutzman, Gary A. Thiele	Third	John Wiley & Sons, Inc.	2012
3	NOC: Antennas https://nptel.ac.in/courses/108101092	Girish Kumar	-	NPTEL	2022
4	Broadband Microstrip antennas	Girish Kumar and K.P. Ray	First	Artech House	2003
5	Frontiers in Antennas: Next Generation Design & Engineering	Frank Gross	First	Mcgraw Hill	2011

Course (Category) Code	Course Name	Teaching Scheme (Hrs/week)					Credits Assigned			
		L	T	P	O	E	L	T	P	Total
PCC	Fundamentals of Power Electronics	3	0	2	4	9	3	0	1	4
EC307		Examination Scheme								
		Component		ISE (%)		MSE (%)		ESE (%)		Total
		Theory		20		20		60		100
		Laboratory		80		--		20		100

Pre-requisite Course Codes, if any.	EC102 (Basic Electrical Engineering), Signal, EC203 (Network and Systems), EC302 (Control Systems)
Course Objective To equip students with the knowledge and skills to understand, analyze, and design power electronic circuits and systems.	
Course Outcomes (CO): ***At the end of the course students will be able to***	
EC307.1	Select Power semiconductor switches with gate driving circuits for a specific application
EC307.2	Analyze various single / three phase AC-DC power converter circuits.
EC307.3	Illustrate the operating principle and construct specified DC-DC converter.
EC307.4	Analyze various single/ three phase DC-AC power converter circuits
EC307.5	Design AC-AC converter and matrix converter for ac-to-ac power conversion applications
EC307.6	Simulate and implement a given power electronics system catering to specific application

CO-PO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
EC307.1		3										
EC307.2		3										
EC307.3			3	2								
EC307.4			3									
EC307.5					3							
EC307.6					3							

CO-PEO/PSO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)

	PEO1	PEO2	PEO3	PEO4	PSO1	PSO2
EC307.1						
EC307.2	2					
EC307.3	3				3	
EC307.4	2					
EC307.5	2				3	
EC307.6	3					

BLOOM'S Levels Targeted (Pl. Tick appropriate)

Remember	Understand	Apply	Analyze	Evaluate	Create

Theory Component

Module No.	Unit No.	Topics	Ref.	Hrs.
1	Title	**Power Semiconductor Devices**	1	8
	1.1	Principle of operation, constructional features, characteristics, and specifications according to data sheets of Power Devices viz; Power Diode, SCR and Thyristor Family, MOSFET, IGBT and Wide Band-gap devices such as Ga-As and Silicon Carbide devices; Packaging of multiple devices and common type of power modules.		
	1.2	Gate driving circuits for different devices and topologies		
2	Title	**AC to DC Converter**	2,3	8
	2.1	Analysis and Design of Single phase and three phase uncontrolled rectifiers with filters, Introduction to Single phase and three phase Controlled Rectifiers using SCRs, Different topologies of phase-controlled rectifiers operation and analysis with resistive load, Performance parameters of ac to dc converters: ripple factor, power factor, distortion factor and efficiency,		
	2.2	Introduction to single phase PWM rectifier using Power MOSFETs and IGBTs.		
3	Title	**DC to DC Converters**	2,3	8
	3.1	Primary non-isolated DC to DC converters such as Buck, Boost and Buck Boost converter. Synchronous primary Converter, Isolated converters such as push pull, fly back, forward, half bridge and full bridge converter, design of active and passive components for all the converters, generation of different PWM waveforms for DC-to-DC converters		
	3.2	Introduction to the design of magnetic components for SMPS circuits		
4	Title	**DC to AC converter**	3	8
	4.1	Principle of operation of inverter and inverter classifications, six step operation with R- load, PWM control of Voltage Source Converter (VSC)		
	4.2	Voltage source inverters: Principle of operation and analysis of: Single phase Half bridge, full bridge inverters and three phase bridge inverters with resistive load		
	4.3	PWM techniques: Sinusoidal PWM and Space Vector PWM		
5	Title	**AC to AC converters**	3	6

	5.1	AC voltage controllers, phase-controlled converters using SCR, concept of single-phase bidirectional ac switches using MOSFETs / IGBTs, Primary single phase		
	5.2	Matrix converters with buck, boost and buck boost operation using bidirectional switches		
6	**Title**	**Power Electronics Applications**	**1,3**	**4**
	6.1	1. Analysis and Design of single-phase power factor correction circuits using DC to DC boost converters and Totem pole topology 2. Design of LLC resonant DC to DC converters for telecom power supplies/ EV battery charging applications / server rack supplies		
Self-Study		Protection and loss computation for PE devices, study of snubber circuits, heat sinks and cooling methods. Different isolated and non-isolated methods for measurement of voltage and currents in PE circuits, EMI EMC consideration, harmonic standards like IEEE 519-1994/2014 and IEC 61000, generalized safety consideration in PE circuits. PCB implementation. Design of single-phase pure sine wave inverter for PV -solar and domestic applications.		**6 ***
Total (*not included)				**42**

Laboratory Component, if any. (Minimum 10 Laboratory experiments are expected)

Sr. No	**Title of the Experiment**
1	Operation and characteristics of an SCR, Power MOSFETs /IGBT
2a	Demonstration of SCR firing circuits
2b	Demonstration of MOSFET/IGBT Gate Driver Circuits
3	Single phase Line Commuted Full/Semi-converter using SCRs
4	Design and Verification of Diode Rectifier Circuits and its output side performance indices
5	Design and Demonstration of a DC-DC Buck-Converter in CCM Mode
6	Design and Demonstration of a DC-DC Boost Converter in CCM Mode
7	Design and Demonstration of a DC-DC Buck-Boost Converter/Fly back Converter in CCM Mode
8	Demonstration of PWM three Phase bridge Voltage Source inverter with R Load, 120 degree and 180-degree conduction mode (Part-1)

9	Demonstration of PWM three phase bridge Voltage Source inverter with Sinusoidal Pulse width Modulation (Part-2)
10	AC-AC Buck-Boost PWM Voltage Controller with bidirectional switches
11	To measure Harmonics and Power Quality Indices at the SPIT Electrical feeder for 24 hours using Fluke/Hikoi/Yokogawa Power Quality Analyzer and to make a consolidated report on the same.
12	Demonstration of PWM three phase bridge Voltage Source inverter with Sinusoidal Pulse width Modulation (Part-2)
13	LAB-Course Project - Boost Converter /Bridgeless Totem-pole Power Factor Correction in Single Phase PWM Inverter - Half Bridge LLC Resonant Converter

Textbooks:

S. N.	Title	Authors	Edition	Publisher	Year
1	Power Electronics: converters, Application and design	Ned Mohan, Undeland and Robbin	3rd	John Wiley and sons	2003
2	Power Electronics Circuits, Devices and Applications	Rashid M.H	4th	Pearson Education	2004
3	First course in power electronics	Ned Mohan	2nd	John Wiley and sons	2012

Reference Books/NPTEL courses:

Sr. No.	Title	Authors	Edition	Publisher	Year
1	Electric Machinery	A.E. Fitzerald, Charles Kignsley, Jr. Stephen D Umans	6	Mc Graw Hill	2017
2	Design of magnetic components for Switched Mode Power Converters	L. Umamand, S R Bhat	1	New Age International Pvt. Ltd.	2009

3	Electric Motor Drives, Modeling, Analysis, and Control	R Krishnan	1	Pearson	2001
4	Electrical Machinery	P S Bimbhra	6	Khanna Publishers	2007
5	Power Electronics	Vedam Subrahmanyam	2	New Age International Pvt. Ltd.	2006
6	Simulation of Power Electronic Circuits	M. B. Patil, V. Ramanarayanan, V T Ranganathan	1	Narosa	2009
7	Power Electronics	Vedam Subrahmanyam	2	New Age International Pvt. Ltd.	2006
8	Internet Resources: Application notes from Manufacturers like Infineon, Texas Instruments, ST Microelectronics, Microchips, Semikron and others .NPTEL Videos of FPE (L. Umanand)				

Course (Category) Code	Course Name	Teaching Scheme (Hrs/week)					Credits Assigned			
		L	T	P	O	E	L	T	P	Total
ELC	Main Project Stage 1	0	0	4	4	4	0	0	2	2
PR3-I		Examination Scheme								
		Component		ISE (%)		MSE (%)		ESE (%)		Total
		Theory		--		--		--		--
		Laboratory		--		--		--		--
		Self-Study		80		--		20		100

Pre-requisite Course Codes, if any.	All the Courses till fourth Semester

Course Objective: Main Project Stage 1 provides an opportunity to create a significant impact on the educational experience by tackling real-world problems. This phase involves using scientific methods to analyze, correct, and evaluate decisions related to a specific issue. By connecting theoretical knowledge with practical application, it encourages students to develop a scientific mindset, helping them address everyday challenges more effectively.	
Course Outcomes (CO): ***At the end of the course students will be able to***	
PR3-I.1	Identify problems based on societal/environmental issues.
PR3-I.2	Apply engineering knowledge to propose innovative and sustainable solutions to practical problems in a group.
PR3-I.3	Analyze the results obtained using theoretical, experimental, or simulation methods and draw appropriate conclusions.
PR3-I.4	Apply self-learning skills in teamwork with following professional ethics, contributing to the development of lifelong learning habits.
PR3-I.5	Document the findings and foster communication, organizational abilities, and personal growth through discussions and presentations.
PR3-I.6	Apply project management principles during the project work.

CO-PO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PR3-I.1	1	3	3	1	1	3	3	1	1	1	1	1
PR3-I.2	3	2	3	2	3	1	1	1	3	1	1	1
PR3-I.3	2	2	2	3	2	1	1	1	1	1	1	1
PR3-I.4	2	2	2	2	2	2	2	3	3	2	2	3
PR3-I.5	2	1	1	1	1	1	1	1	1	3	1	1
PR3-I.6	1	1	1	1	1	1	1	1	1	1	3	1
PR3-I	**1.83**	**1.83**	**2**	**1.67**	**1.67**	**1.5**	**1.5**	**1.33**	**1.67**	**1.5**	**1.5**	**1.33**

CO-PEO/PSO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)

	PEO1	PEO2	PEO3	PEO4	PSO1	PSO2
PR3-I.1					2	3
PR3-I.2					3	2
PR3-I.3					3	2
PR3-I.4					2	3
PR3-I.5					2	3
PR3-I.6					2	3
PR3-I					**2.33**	**2.67**

Guidelines for Main Project Stage I:

- The orientation regarding Main Project stage I implementation process and available hardware and software facilities with expertise of faculties shall be given in the last week of semester 5.
- Students must form a group of a minimum of 2 or maximum of 3 students.
- The Main project topic must contain implementation in terms of Hardware and Software.
- Each group can approach the faculty having the same domain expertise from the department for discussion of the idea. Students can approach the faculty along with their proposed topic/idea or faculty may suggest a topic/idea.
- The details regarding group members, domain of interest and choice of guide based on discussion with him/her must be filled in a sheet shared by Project Co-Ordinator by each group within 1 week of completion of ESE of semester 5.
- For approval of the mentor, the group must write mail to the mentor regarding his/her permission keeping Project Co-Ordinator and HoD in CC. On the same mail mentor must reply for approval of mentoring the group for Main Project Stage 1.
- Each faculty from the department would be allowed to select 2 groups for Main Project guidance. Considering priority to choice of guide, tentative mentor allocation will be done 2 weeks before commencement date of semester 6.
- The topic approval presentation shall be scheduled in the first week of Semester 6 in front of all the department faculties. Students should do survey and identify needs, which shall be converted into problem statement for main project in consultation with tentative mentor/head of department/domain experts. Students shall submit an implementation plan which will cover weekly activity of main project along with objectives, motivation and references for the proposed title.
- The main project topic can be the extension of the mini project done in semester 5 based on mentor's recommendation. Students must justify the improvements/modifications required in the problem statement for extension of the mini project during topic approval presentation.
- Based on topic approval presentation the mentor and co-mentor would be allotted by Head of Department.
- A log book to be prepared by each group, wherein group can record weekly work progress, mentor/co-mentor can verify and record notes/comments.

- Faculty mentor may give inputs to students during mini project activity; however, focus shall be on self-learning.
- Students in a group shall understand problem effectively, propose multiple solution and select best possible solution in consultation with mentor/ co-mentor.
- Students shall convert the best solution into working model using various components of their domain areas and demonstrate.
- The solution to be validated with proper justification and report to be compiled in standard format given by department. Project report should contain project title, student details, certificate, and acknowledgements. Other sections of the report shall be introduction, necessity of project, objectives, hypothesis, plan, observations, analysis of results, conclusion, and references along with other sections related to technology. The report must be written in Latex and must include report of plagiarism check.

Guidelines for Assessment of Main Project Stage I: (ISE: Through 2 Phases of Evaluation) and ESE

In Semester Evaluation:

- The review/ progress monitoring committee shall be constituted by Head of Department.
- The progress of mini project to be evaluated on continuous basis, with the help of two phase evaluation in the semester.
- In continuous assessment focus shall also be on each individual student, assessment based on individual's contribution in group activity, their understanding and response to questions.
- The phase 1 evaluation (during 6^{th} week of semester) shall be done by mentor and co-mentor considering the factors like literature/market survey, formation of problem statement, project planning, references along with attendance in terms of weekly meeting with mentor/co-mentor.
- The phase 2 evaluation (during 12^{th} week of semester) shall be done by mentor and co-mentor considering the factors like methodology used, hardware and software design, presentation skills, attendance in terms of weekly meeting with mentor/co-mentor, project report(with plagiarism check) in prescribed format given by department.

End Semester Evaluation:

- The ESE shall be scheduled during the last week of semester.
- External experts from the other colleges shall be called for the evaluation.
- The projects will be evaluated by an external examiner based on
  - ✓ Problem Definition/Idea/Originality/Novelty/Feasibility/Application in Society

- ✓ Work Done (Survey/Design/Simulation/experimentation/Tools Usage/Budget Plan/Execution Plan)
- ✓ Presentation (Demo/Oral/Written) and Ethics (Attitude/Deadline/Distribution of Work)
- ✓ Knowledge/Question-Answer

Course (Category) Code	Course Name	Teaching Scheme (Hrs/week)					Credits Assigned			
		L	T	P	O	E	L	T	P	Total
PEC	Optical Fiber Communication	2	0	1	5	10	2	0	1	3
		Examination Scheme								
		Component	ISE (%)		MSE (%)		ESE (%)			Total
EC311		Theory	20		20		60			100
		Laboratory	80		--		20			100

Pre-requisite Course Codes, if any.	AS101: Engineering Physics EC201: Electromagnetic Wave Engineering
Course Objective: The objective of the course is to provide an understanding of usage of optical fiber for communication.	
Course Outcomes (CO): ***At the end of the course students will be able to***	
EC311.1	Understand the Fundamentals of Optical Communication Systems
EC311.2	Analyze the Propagation of Light in Optical Fibers
EC311.3	Examine Optical Components and Devices
EC311.4	Evaluate Optical Network Performance and Losses
EC311.5	Explore Optical Network Architectures and Technologies

CO-PO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
EC311.1	2	2										
EC311.2	2	2	2									
EC311.3				2	2							
EC311.4					2	2						
EC311.5				2		2						

CO-PEO/PSO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)

	PEO1	PEO2	PEO3	PSO1	PSO2
EC311.1	2	2		2	
EC311.2	2	2		2	
EC311.3	2	2			2
EC311.4			2		
EC311.5			2		

BLOOM'S Levels Targeted (Pl. Tick appropriate)

Remember	Understand	Apply✓	Analyze✓	Evaluate	Create

Theory Component

Module No.	Unit No.	Topics	Ref.	Hrs.
1	Title	**Optical communication fundamentals**	1,2	10
	1.1	Block diagram of Optical Communication system, advantages, loss and bandwidth window, ray theory transmission, total internal reflection, acceptance angle, numerical aperture, skew rays and meridional rays		
	1.2	EM waves, modes in planar guide, phase and group velocities, types of fiber according to refractive index profile and mode transmission.		
	1.3	Couplers, Isolators, circulators, multiplexers, filters, fiber gratings, Fabry Perot filters, arrayed waveguide grating, switches and wavelength converters		
2	Title	**Optical communication Components**	1,2	8
	2.1	Sources (LED, LASER), Detectors (PIN, APD) and Amplifiers		
3	Title	**Optical Networks and losses in the system**	1,2, 3	10
	3.1	Attenuation, absorption, linear and nonlinear scattering losses, bending losses, modal dispersion, waveguide dispersion, dispersion and pulse broadening, dispersion shifted, and dispersion flattened fibers, and nonlinear effects Measurements of attenuation, dispersion and OTDR		
	3.2	Optical Networks: Link budget, SONET, SDH, WDM, DWDM		
4	Self-Study	Review of latest optical fiber application and research	1,2, 3	
				28

Laboratory Component, if any. (Minimum 10 Laboratory experiments are expected)

Sr. No.	Title of the Experiment
1	Setup of Optical fiber communication link and measurement of Bit Error Rate (BER) and Eye pattern analysis A) Setup of analog fiber optic communication link B) Setup of digital fiber

	optic communication link C) Measurement of Bit Error Rate D) Study and measurement of Eye pattern
2	Measurement of Numerical Aperture (NA) of optical fiber
3	Measurement of Losses in Optical Fiber
4	Study characteristics of LED and Photodetector in optical fiber communication link.
5	To verify Brewster's law and to find Brewster's angle Michelson's Interferometer- Refractive index of glass plate: To determine the refractive index of a thin glass plate.
6	To verify the Brewster's law and to find the Brewster's angle
7	Analysis of Speech using Cepstral and Linear Prediction methods To Demonstrate the working of LASER using Phet virtual Lab
8	Measure propagation loss in plastic fiber and to measure the bending loss
9	Hands-On Speech Analysis and Signal Processing Techniques Plotting optical link power budget.
10	Mini project on optical network.

Text Books

Sr. No.	Title	Edition	Authors	Publisher	Year
1	Optical Fiber Communication	Fourth	John M. Senior	Prentice Hall of India Publication	2013
2	Optical Fiber Communication	Third	Gred Keiser	Mc-Graw Hill Publication	2012
3	Optical Networks: A Practical Perspective	Third	Rajiv Ramaswamy and Kumar N. Sivarajan	Elsevier Publication	2010

Course (Category) Code	Course Name	Teaching Scheme (Hrs/week)					Credits Assigned			
		L	T	P	O	E	L	T	P	Total
PEC	Cyber Security and Digital Forensics	2	-	2	3	7	2	-	1	3
EC 321		Examination Scheme								
		Component	ISE (%)		MSE (%)		ESE (%)			Total
		Theory	20		20		60			100
		Laboratory	80		--		20			100

Pre-requisite Course Codes, if any.	EC302-: Computer communication Networks
Course Objective: The objective of the course is to provide a fundamental understanding of Computer Communication networks.	
Course Outcomes (CO): ***At the end of the course students will be able to***	
EC321.1	Identify different cybercrimes, cyber threats, and security vulnerabilities.
EC321.2	Perform cyber risk assessments, vulnerability analysis, and penetration testing for security evaluation.
EC321.3	Apply forensic techniques to collect and analyze digital evidence using appropriate tools
EC321.4	Analyze digital forensic artifacts from various sources and generate investigative reports.

CO-PO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
EC321.1	3			3				2				
EC321.2		2			3			2				
EC321.3			3					2				
EC321.4				3				2				

CO-PEO/PSO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)

	PEO1	PEO2	PEO3	PSO1	PSO2
EC321.1	3	M		2	3
EC321.2		3		2	
EC321.3	3		3		3
EC321.4		2		3	

BLOOM'S Levels Targeted (Pl. Tick appropriate)

Remember	Understand ✓	Apply ✓	Analyze ✓	Evaluate	Create

Theory Component

Module No.	Unit No.	Topics	Ref	Total Hrs.
1		**Fundamentals of Cybersecurity**:	1,3	8
	1.1	Introduction to Cybersecurity, Tenets of Security (CIA Triad), cybercrime and its classifications: phishing, DoS/DDoS, Ransomware, Malware, SQL Injection, etc.		
	1.2	Identity and Access Management (IAM), Multi-Factor Authentication, Biometric Security, cryptographic techniques: Hash Functions, Digital Signatures, PKI, and their applications, Intrusion Detection and Prevention: IDS, IPS, Honeypots, Firewalls		
2		**Cybersecurity Risk Assessment and Management:**	1,3	06
	2.1	Security Risk & Assessment: Definition of risk, threat modeling, attack surface analysis.		
	2.2	Vulnerability Assessment (VA) & Penetration Testing (PT): Network VAPT, Web VAPT, Cloud VAPT.		
3		**Fundamentals of Digital Forensics**:	4,5, 6	06
	3.1	Definition and scope of digital forensics, types of digital forensics (Computer, USB, Windows, RAM), digital forensics investigation process, legal and ethical considerations.		
	3.2	Types of Digital Evidence (Volatile vs. Non-Volatile), methods of Evidence Collection (Live vs. Dead Acquisition), chain of custody and data integrity challenges in handling encrypted and deleted data.		
4		**Advanced Digital Forensics Techniques:**	4,5, 6	08
	4.1	Disk imaging techniques (FTK imager/Encase/Autopsy), memory forensics (ramp dump analysis using volatility), file hashing and integrity verification, best practices for data preservation, file system forensics (NTFS, FAT, ext3/4, linux artifacts), windows forensics (registry, event logs, prefetch, LNK files)		

	4.2	Cloud Forensics (Data Acquisition Challenges in SaaS, PaaS, IaaS), antiforensics techniques.		
5	**Self Study**	Cybersecurity and Digital Forensic Standards.	**2**	**4***
			Total (*Not included)	**28**

Laboratory:

Sr. No.	Title of the Experiment
1.	Network and Web Server Vulnerability Scanning (Nmap, Nikto, OpenVAS)
2.	To provide confidentiality using OpenPuff : a professional steganography tool
3.	Find Last Connected USB on your system (USB Forensics)
4.	To determine the security of web servers and your local web browser using digital certificates
5.	Live Forensics Case Investigation using Autopsy
6.	Recover Deleted Files using Forensics Tools
7.	View Last Activity of Workstation
8.	File Signature Analysis
9.	Extracting Browser Artifacts
10.	Extract Exchangeable image file format (EXIF) Data from Image Files using Exif-reader Software
11.	Capturing a RAM Memory Using Redline
12.	Windows Forensics Analysis
13.	Web Browser Forensics

Text Books

Sr. No.	Title	Edition	Authors	Publisher	Year
1	Security in Computing	5th	Charles Pfleeger Shari Pfleeger Jonathan Margulies	PrenticeHall	2015
2	Effective Cybersecurity Understanding and Using Standards and Best Practices	1st	William Stallings	Addison Wesley	2019
3	Cybersecurity – Attack and Defense Strategies	2nd	Yuri Diogenes Erdal Ozkaya	Packt Publications	2019
4	Digital Forensics with Kali Linux Second Edition	2nd	Shiva V. N. Parasram	Packt Publications	2020

Reference Books

Sr. No.	Title	Edition	Authors	Publisher	Year
1	Digital Forensics and Incident Response	2nd	Gerard Johansen	Packt Publications	2020
2	A Practical Guide to Digital Forensics Investigations	2nd	Darren R. Hayes	Pearson	2020

B. Tech. EXTC

Course (Category) Code	Course Name	Teaching Scheme (Hrs/week)					Credits Assigned			
		L	T	P	O	E	L	T	P	Total
PEC	Embedded Systems	3	--	--	5	8	3	--	--	3
		Examination Scheme								
EC331		Component	ISE (%)		MSE (%)		ESE (%)			Total
		Theory	20		20		60			100
		Laboratory	--		--		--			--

Pre-requisite Course Codes, if any.	EC206: - Computer Architecture and Organization EC306: - Microcontrollers
Course Objective: To empower the students in system design skills using modeling practices and learn key concepts in reliability of embedded systems with respect to Industrial standards.	
Course Outcomes (CO): After successful completion of the course, student will be able to	
EC331.1	Discuss design metrics of embedded system to design real time applications to match recent trends in technology.
EC331.2	Analyze the reliability of embedded system with respect to fault detection and fault tolerance
EC331.3	Apply the industry standards for assessment of embedded product
EC331.4	Analyze the given embedded application with respect to security
EC331.5	Choose suitable criteria for selection of embedded application.
EC331.6	Demonstrate hardware and software skills based on embedded case studies.

CO-PO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
EC331.1	2	2	2									
EC331.2	2	2	2									
EC331.3	2	2	2									
EC331.4	2	2	2									
EC331.5	2	2	2									
EC331.6	2	2	2	2	2							

CO-PEO/PSO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)

	PEO1	PEO2	PEO3	PEO4	PSO1	PSO2
EC331.1		1				
EC331.2	1		1			
EC331.3	1		1			
EC331.4	1	1	1			
EC331.5		1	1			
EC331.6	1		1			

BLOOM'S Levels Targeted (Pl. Tick appropriate)

Remember✔	**Understand✔**	**Apply✔**	**Analyze✔**	**Evaluate**	**Create**

Theory Component

Module No.	Unit No.	Topics	Ref.	Hrs
1	**Title**	**Fundamentals of Embedded System**		**12**
	1.1	Introduction to Embedded Systems, Characteristics of Embedded System, Design Process, Design Metrics and optimization of various parameters of embedded system. Design trade-offs due to process compatibility, thermal considerations, etc. Real time System's requirements, real time issues, interrupt latency	**1,2**	
	1.2	Embedded Product development lifecycle. Program Modeling concepts with design examples: DFG, FSM, Petri-net, UML, Use case, Object and Class Structuring		
	1.3	Technological aspects of embedded systems: Embedded microcontroller cores, embedded memories, interfacing between analog and digital blocks, signal conditioning, digital signal processing, sub system interfacing, interfacing with external systems and user interfacing. Introduction to real time programming languages and operating systems for embedded systems.	**1,5**	

2	**Title**	**Reliable Embedded System**		**08**
	2.1	Reliable Embedded System: Single-program, real-time embedded systems, TT vs. ET architectures, Modeling system timing characteristics, basic tick lists, determining the required tick interval, short tasks, importance of task offsets, task sequence initialization, task jitter, response times, importance of WCET/BCET information, challenges with WCET/BCET measurements, TTC scheduler, Fault-tolerance Techniques	**3**	
3	**Title**	**Industry Standards**		**06**
	3.1	Introduction to IEC 61508 standard: Organizing and managing the life-cycle, Requirements involving the specification, Requirements for design and development, Integration and test, Operations and maintenance, Validation, Modifications, acquired sub-systems, Organizing and managing the software engineering	**6,7**	
	3.2	Introduction to IEC 60601 standard: Protection of radio services, Protection of the Public Mains network, Immunity, Electrostatic Discharge, Radiated RF electromagnetic fields, Electrical fast transients and bursts.	**8**	
	3.3	Introduction to IEC 26262: Introduction of ISO/DIS 26262 (ISO 26262), Parts of ISO 26262, ASIL Levels, Product Development System Level, Product Development Software Level, Fitting software tools into ISO 26262 process	**9**	
4	**Title**	**Security in Network Embedded System**		**08**
	4.1	Networked Embedded System: Network Fundamentals, Layers and Protocols. Network Architectures, Network Components-Bridges, Routers, Switches, Distributed Embedded Architectures, Elements of Protocol Design, High Level Protocol Design Languages, Network Based Design, Internet-Enabled Systems: Protocols for industrial and control applications, Internetworking Protocols. Wireless Applications: Blue-tooth	**10**	
5	**Title**	**Case Studies ***		
	5.1	**Embedded Control Applications:** Introduction, Open-loop and Closed Loop Control Systems Examples: Speed Control. PID Controllers: Software Coding of a PID Controller, PID tuning. Fuzzy Logic Controller Application Examples: Washing Machine, Auto-focusing digital camera and Air-conditioner	1,2	

	5.2	**Automotive Embedded Systems**: Automotive Architectures, embedded communication, embedded software and development processes, Verification, Testing and Timing Analysis		
	5.3	Embedded systems in Healthcare domain.		
6	**Self Study**	**Simulation-Based Exploration:** Students will simulate real-time embedded control systems (e.g., temperature monitoring, motor speed control) using platforms like MATLAB/Simulink, Proteus, or Tinkercad to better understand timing, task scheduling, and control loop dynamics. **Mini Project (Design + Prototype)**: Students are encouraged to build a mini project such as a smart irrigation controller, PID-based fan system, or Bluetooth-based home automation using low-cost microcontrollers and evaluate system reliability and performance. **Exploration of Industry Standards**: Students can explore and present short reports on additional standards like: • **IEC 62304** (Medical device software lifecycle) • **ISO/IEC 27001** (Information Security) **ISO/TS 16949** (Automotive industry quality)		
			Total	**42**

*** Students are supposed to do some experiments/mini-projects as per instructions of teacher and requires individual efforts of students**

Text Books

Sr. No.	Title	Edition	Author	Publisher	Year
1	Embedded System: Architecture, Programming and Design	2nd edition	Rajkamal	Tata McGraw-Hill	2011
2	The Engineering of Reliable systems: LPC1769	-	Pont M. J	SafeTTy Systems	2014
3	Security in Embedded Devices	2010th edition	Gebotys, Catherine H.	Springer	2010
4	Functional Safety, A Straightforward Guide to applying IEC 61508 and Related Standards	2nd edition	David Smith	Elsevier	2004
5	IEC 61508: IEC standard for the functional safety for electrical, electronics and programmable electronics equipment	-	-	https://www.iec.ch/safety	-

6	IEC 60601: IEC standard on Medical Electric Equipment	-	-	https://www.iec.ch/safety	-
7	IEC 26262: IEC standard on Road vehicles	-	-	https://www.iec.ch/safety	
8	Embedded Systems Handbook: Networked Embedded Systems	2nd edition	Richard Zurawski	CRC Press	2009

Reference Books

Sr. No.	Title	Edition	Author	Publisher	Year
1	Introduction to Embedded Systems	2nd edition	Shibu K. V	Tata McGraw-Hill	2017
2	Embedded Microcomputer Systems: Real time Interfacing	3rd edition	Jonathan W. Valvano	Cengage Learning	2012

Online Learning Material
NPTEL Course:
Embedded Systems - IIT Kharagpur (Prof. D. Mukhopadhyay): https://nptel.ac.in/courses/108105057
NPTEL Course:
Secure Systems Engineering: IIIT Bangalore (Prof. Ashish Choudhury):
https://nptel.ac.in/courses/106106221
Courseera Course: https://www.coursera.org/learn/iot-connectivity-security?specialization=embedded-systems-security

Course (Category) Code	Course Name	Teaching Scheme (Hrs/week)					Credits Assigned			
		L	T	P	O	E	L	T	P	Total
PEC	Advanced Signal Processing	2	0	2	5	10	2	0	1	3
EC341		Examination Scheme								
		Component	ISE (%)		MSE (%)		ESE (%)			Total
		Theory	20		20		60			100
		Laboratory	80		--		20			100

Pre-requisite Course Codes, if any.	Signals and Systems
Course Objective: To develop mathematical foundation of system and design digital filters	
Course Outcomes (CO): ***At the End of the course students will be able to***	
EC341.1	Explain the fundamentals and need for adaptive signal processing.
EC341.2	Analyze and apply multirate signal processing techniques.
EC341.3	Estimate the power spectral density of signals using parametric methods.
EC341.4	Apply Discrete Cosine Transform (DCT) and Wavelet Transform.
EC341.5	Explore advanced applications of signal processing.

CO-PO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
EC341.1	2	1	3									
EC341.2	2	1	3									
EC341.3	2	1	3									
EC341.4	2	1	3									
EC341.5	2	1	3		2							

CO-PEO/PSO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)

	PEO1	PEO2	PEO3	PEO4	PSO1	PSO2
EC341.1	3				3	
EC341.2	3				3	
EC341.3	3				3	
EC341.4	3				3	
EC341.5	3				3	

BLOOM'S Levels Targeted (Pl. Tick appropriate)

Remember	Understand	✓ Apply	✓ Analyze	✓ Evaluate	Create

Theory Component

Module No.	Unit No.	Topics	Ref.	Hrs.
1	Title	**Adaptive Signal Processing**	1,3	06
	1.1	Concept of Adaptive Filter, Minimum MSE Criterion, LMS Algorithms		
	1.2	Steepest descent search and the LMS algorithm.		
	1.3	Weiner Filter and Kalman filter		
2	Title	**Multi-rate Signal processing**	1	06
	2.1	Sampling rate reduction: decimation by integer factors, Sampling rate increase: interpolation by integer factors		
	2.2	Sampling rate conversion by non-integer factors, Multistage approach to sampling rate conversion		
	2.3	Polyphase decomposition		
3	Title	**Power Spectrum Estimation**	1	06
	3.1	Non-parametric Methods for Power Spectrum Estimation - Bartlett Method, Welch Method, Blackman & Tukey Methods.		
	3.2	Parametric Methods for Power Spectrum Estimation: Yule and Walker methods for the AR Model Parameters, Burg Method for the AR Model parameters, Unconstrained least-squares method for the AR Model parameters, Sequential estimation methods for the AR Model parameters.		
	3.3	ARMA Model for Power Spectrum Estimation.		
4	Title	**Transform Techniques**	1,4	06
	4.1	Discrete Cosine Transform: Forward and Inverse DCT, Properties of DCT		
	4.2	Wavelet Transform: Introduction to continuous and discrete wavelet transform, Haar Scaling functions, Haar wavelet functions, Signal decomposition, Relation with filter banks, Frequency response		
5	Title	**Applications of DSP**	3	04
	5.1	Applications of adaptive filters: Noise cancellation, echo-cancellation and equalization. Fast adaptive algorithms. Frequency domain analysis of adaptive filters.		
	5.2	Channel Equalization, Active Noise Control, Echo Cancellation		
	5.3	Signal Compression: Sub-band coding, Vector Quantization, DCT and Wavelet based Signal Compression		

6	**Self Study**	**Linear prediction and Optimum Linear Filters:** Random signals, Correlation Functions and Power Spectra, Representation of a Stationary Random Process. Forward and Backward Linear Prediction.	**1,5**	**04**
			Total	**28**

Laboratory Component

Sr. No.	Title of the Experiment
1	Implementation of LMS / RLS algorithm
2	Implementation of LMS / RLS algorithm
3	Implementation of signal decimation and interpolation using rational factor
4	Design and analyze polyphase filter structures
5	Implementation of multirate filter banks
6	analyze signal energy compaction using DCT coefficients
7	Implementation of implement Autoregressive (AR) model-based spectral estimation
8	Apply multilevel wavelet decomposition for denoising a noisy signal.
9	Apply spectral estimation techniques to analyze real-world EEG/ECG signals.
10	Noise cancellation using adaptive filtering (LMS/RLS) in speech signals.

Text Books

Sr. No.	Title	Edition	Authors	Publisher	Year
1	Digital Signal Processing: Principles, Algorithms and Applications	4th	J. Proakis, D. G. Manolakis, and D. Sharma	Pearson Education	**20**14
2	Digital Signal Processing	2nd	S.Salivahanan, A Vallavaraj, C Gnanapriya	Tata McGraw Hill	2010
3	Adaptive Signal Processing	1st	Bernard Widrow and Samual Stearns	Person	2002

Reference Books

Sr. No.	Title	Edition	Authors	Publisher	Year
1	Multirate Digital Signal Processing: Multirate Systems - Filter Banks – Wavelets	1st	N. J. Fliege	John Wiley and Sons Ltd	1999
2	Signals and Systems	3rd	Simon Haykin and Barry Van Veen	John Wiley & Sons	2002
3	Theory and Applications of Digital Signal Processing	2nd	L. R. Rabiner and B. Gold	Prentice Hall	2006

4	A Wavelet Tour of Signal Processing	3rd	Stephane Mallat	Academic Press	1998

NPTEL:

1) Introduction to Adaptive Signal Processing by Prof. Mrutyunjoy Chakraborty

   weblink : https://onlinecourses.nptel.ac.in/noc23_ee138/preview

Course (Category) Code	Course Name	Teaching Scheme (Hrs/week)					Credits Assigned			
		L	T	P	O	E	L	T	P	Total
PEC	Digital CMOS VLSI Design	2	0	1	4	7	2	0	1	3
		Examination Scheme								
		Component	ISE (%)		MSE (%)		ESE (%)			Total
EC351		Theory	20		20		60			100
		Laboratory	80		--		20			100

Pre-requisite Course Codes, if any.	EC101: Digital Systems and Microprocessors EC102: Basic Electrical Engineering AS101: Engineering Physics EC202: Electronic Devices & Circuits EC207: Mixed Signal Integrated Circuits
Course Objective: The objective of this course is to provide a strong foundation in Digital CMOS VLSI Design, aligning with the evolving Industry 4.0 trends in the Indian semiconductor industry. This course will equip students with fundamental of MOSFET technologies, models, analysis of MOSFET-based digital logic circuits and memory architectures, preparing them for advanced studies and industry applications in semiconductor and chip design.	
Course Outcomes (CO): ***At the end of the course students will be able to***	
EC351.1	Analyze MOSFET technologies and MOSFET models.
EC351.2	Analyze MOSFET based Inverter circuits.
EC351.3	Design MOSFET based logic circuits with different design styles.
EC351.4	Analyze MOSFET based semiconductor memories.

CO-PO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)

	PO1	PO2	PO3	PO 4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
EC351.1	3	2		2	1							
EC351.2	3	2		2	2							
EC351.3	3	2	2	2	2							
EC351.4	3	2		2	2							

CO-PEO/PSO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)

	PEO1	PEO2	PEO3	PEO4	PSO1	PSO2
EC351.1	2		2		1	
EC351.2	2		2		1	
EC351.3	2		2		1	
EC351.4	2		2		1	

BLOOM'S Levels Targeted (Pl. Tick appropriate)

Remember	Understand✓	Apply✓	Analyze✓	Evaluate	Create

Theory Component

Module No.	Unit No.	Topics	Ref.	Hrs.
1	**Title**	**Technology Trend**		**04**
	1.1	**Technology Comparison:** Comparison of BJT, NMOS and CMOS technology	**1**	
	1.2	**MOSFET Scaling:** Types of scaling , MOSFET capacitances		
2	**Title**	**MOSFET Inverters**		**08**
	2.1	**Circuit Analysis:** Static and dynamic analysis (Noise, propagation delay and power dissipation) of resistive load and CMOS inverter, comparison of all types of MOS inverters, design of CMOS inverters, CMOS Latch-up	**1**	
	2.2	**Logic Circuit Design:** Analysis and design of 2-I/P NAND and NOR using equivalent CMOS inverter		
3	**Title**	**MOS Circuit Design Styles**		**10**
	3.1	**Design Styles:** Static CMOS, pass transistor logic, transmission gate, Pseudo NMOS, Domino, NORA, Zipper, C^2MOS	**1,7**	
	3.2	**Circuit Realization:** SR Latch, JK FF, D FF, 1 Bit Shift Register, MUX, decoder using above design styles		
4	**Title**	**Semiconductor Memories**		**06**
	4.1	**SRAM:** ROM Array, SRAM (operation, design strategy, leakage currents, read/write circuits), DRAM (Operation 3T, 1T, operation modes, leakage currents, refresh operation, Input-Output circuits), Flash (mechanism, NOR flash, NAND flash)	**1,2**	
	4.2	**Peripheral Circuits:** Sense amplifier, decoder	**1,2,3**	
5	**Self Study**	Data path design for 1 Bit adder circuit, Partial-product generation, partial-product accumulation, final addition, barrel shifter, CMOS clocking styles, Clock generation, stabilization and distribution	**5,6**	**4***

Total (*Not Included)	**28**

Laboratory Component, if any. (Minimum 10 Laboratory experiments are expected)

Sr. No.	Experiment Details
1	To analyze NMOS and PMOS Transistor characteristics.
2	To simulate Resistive Load Inverter and CMOS Inverter, verify the VTC. Compare both the topologies. Comment on the Noise Margins.
3	Implement CMOS NAND, NOR, AND, OR using Static CMOS Logic.
4	Design and Implement AB+CD bar using different CMOS Logic styles.
5	Simulate Pseudo NMOS Inverter and comment on the result.
6	Simulate 6 Transistor SRAM and check the read and write stability
7	Design and Implement given equation using Pseudo NMOS.
8	Design and Implement given equation using Domino Logic and C^2MOS Logic
9	Simulate Clocked JK and D Flip Flop using Static CMOS Logic.
10	Simulate 1 T DRAM and analyze the capacitor refresh logic.

Text Books

Sr. No.	Title	Edition	Authors	Publisher	Year
1	CMOS Digital Integrated Circuits Analysis and Design	Third	Sung-Mo Kang and Yusuf Leblebici	Tata McGraw Hill	2017
2	Digital Integrated Circuits: A Design Perspective	Second	Jan M. Rabaey, Anantha Chandrakasan and Borivoje Nikolic	Pearson Education	2009
3	Introduction to VLSI Circuits and Systems	Student Edition	John P. Uyemura	Wiley	2013

Reference Books

Sr. No.	Title	Edition	Authors	Publisher	Year
1	VLSI Design	First	Debaprasad Das	Oxford	2010
2	CMOS VLSI Design: A Circuits and Systems Perspective	Third	Neil H. E. Weste, David Harris and Ayan Banerjee	Pearson Education	2013

Online Resources:

1. CMOS Digital VLSI Design, By Prof. Sudeb Dasgupta, IIT Roorkee
   Link: - https://onlinecourses.nptel.ac.in/noc21_ee09/preview

Course (Category) Code	Course Name	Teaching Scheme (Hrs/week)					Credits Assigned			
		L	T	P	O	E	L	T	P	Total
PEC	Error Coding and cryptography	3	0	2	5	10	3	0	1	4
		Examination Scheme								
		Component	ISE (%)		MSE (%)		ESE (%)			Total
EC312		Theory	20		20		60			100
		Laboratory	80		--		20			100

Pre-requisite Course Codes, if any.	Analog and Digital communication
Course Objective:	
Course Outcomes (CO): ***At the end of the course students will be able to***	
EC312.1	Apply Galois field concepts to various error correction techniques.
EC312.2	Analyze encoding and decoding of various source codes and error correction codes.
EC312.3	Estimate various performance parameters of error correction coding algorithms.
EC312.4	Examine various encryption and encryption techniques and cryptography algorithms.

CO-PO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
EC312.1	3											
EC312.2	3		2		2							
EC312.3	3		2	2	2				2	2		
EC312.4	3	3			1							

CO-PEO/PSO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)

	PEO1	PEO2	PEO3	PEO4	PSO1	PSO2
EC312.1		2				
EC312.2		2	2			

EC312.3		2	2		3	
EC312.4		1				

BLOOM'S Levels Targeted (Pl. Tick appropriate)

Remember	Understand√	Apply √	Analyze√	Evaluate	Create

Theory Component

Module No.	Unit No.	Topics	Ref.	Hrs.
1	**Title**	**Introduction to Finite Field**	**1,2**	**6**
	1.1	Groups, Fields, Binary Field Arithmetic, Construction of Galois Field GF (2), Basic Properties of Galois Field GF(2^n), Computations Using Galois Field GF(2^n) Arithmetic, Vector Spaces		
	1.2	Types of Codes, Modulation and Demodulation, Maximum Likelihood Decoding, Types of Errors, Error Control Strategies		
	1.3	Review of Shannon's Channel capacity, Discrete memoryless channels and capacity, Examples of channel capacity, symmetric channels, AWGN channel, fading channels, Channel coding theorem		
2	**Title**	**Cyclic Codes**	**1,2**	**6**
	2.1	Introduction, Generator and Parity check· Polynomials, Systematic Cyclic codes – Encoding and decoding using Feedback shift register circuits and polynomial method.		
	2.2	Generator matrix for Cyclic codes, Syndrome computation and Error detection, Meggitt decoder.		
	2.2	Cyclic Hamming codes, Shortened cyclic codes, BCH/Reed Solomon codes		
3		**LDPC Codes**	**1,2**	**4**
	3.1	Low Density Parity Check (LDPC) Codes: Low-Density Parity Check Codes, Different Systematic Forms of a Block Code Description of LDPC Codes, Construction of LDPC Codes: Regular LDPC Codes, Irregular LDPC Codes		

	3.2	Decoding of LDPC Codes: The Tanner Graph, The Sum–Product Algorithm for LDPC Codes: An Example, Bit flipping algorithm		
4	**Title**	**Convolution Codes**	**1,2**	**6**
	4.1	Encoding and decoding: polynomial and time domain method, generator matrix, transfer function matrix, structural properties and distance properties of convolutional codes, stack's algorithm and fano's algorithm for sequential decoding of convolutional codes		
	4.2	Introduction to Turbo coding, Construction Methods for Turbo Codes		
	4.3	Interleaver, Block Interleaver, Convolutional Interleaver , Random Interleaver , Linear Interleaver , Code Concatenation Methods, Turbo Code Performance as a Function of Size and Type of Interleaver.		
5	**Title**	**Introduction to cryptography**	**1,2**	**6**
	5.1	Cryptography Algorithms: Introduction, modular arithmetic		
	5.2	Overview of various types of ciphers		
6	**Self Study**	DES, IDEA, RSA, RC-4 Symmetric (Secret Key) Cryptography & asymmetric (Public-Key) Cryptography algorithms		**6**
			Total	**28**

Laboratory Component, if any. (Minimum 10 Laboratory experiments are expected)

Sr. No	Title of the Experiment
2	Single error correction by rectangular parity
3	Encoding and decoding of cyclic codes using polynomial division
4	BER performance of cyclic codes for a coded and uncoded BPSK and QPSK communication system in AWGN channel
5	Bit flipping algorithm/ sum product algorithm for LDPC codes
6	ECC applications to QR codes and ISBN
7	Stack's algorithm for decoding of convolutional codes
8	BER performance of convolutional codes and turbo codes in OFDM system with and without AWGN channel

9	Generation of cipher output using various techniques
10	Case study: IDEA, DES, RSA, RC-4 algorithms

Text Books:

Sr. No	Title	Edition	Authors	Publisher	Year
1	Error Control Coding: Fundamentals and Applications	2nd Edition	Shu Lin and Daniel Costello	Pearson	2004
2	Essentials of Error-Control Coding	First	Patrick Guy Farrell	Wiley	2006
3	Information theory coding and cryptography	Third	Ranjan Bose	Prentice Hall	1995
4	Digital communication systems	fourth	Simon Haykin	John wiley	2014

Course (Category) Code	Course Name	Teaching Scheme (Hrs/week)					Credits Assigned			
		L	T	P	O	E	L	T	P	Total
EC	Wireless Networks	2	0	2	4	7	2	0	1	3
		Examination Scheme								
		Component	ISE (%)		MSE (%)		ESE (%)			Total
322		Theory	20		30		100			150
		Laboratory	80		--		20			100

Pre-requisite Course Codes, if any.	Mobile and Wireless Communication, Computer Communication Networks
Course Objective:	
Course Outcomes (CO): ***At the end of the course students will be able to***	
EC322.1	***Describe*** the fundamental principles of wireless communication, including signal propagation, modulation, MAC protocols, and WLAN technologies.
EC322.2	***Analyze*** the architectures and protocols of cellular networks and Personal Area networks such as CDMA, UMTS, LoRa,Telemetry and M2M along with their operational procedures.
EC322.3	***Design*** *and* ***simulate*** wireless networks including Mobile IP, ad hoc networks, and wireless sensor networks using appropriate tools (e.g., NS-3, Cooja).
EC322.4	***Evaluate*** *and* ***implement*** security mechanisms to counter threats in wireless networks, and understand emerging technologies such as Wi-Fi 6/7 and IoT security.

CO-PO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
EC322.1	3	2										
EC322.2	2	3	2									
EC322.3		2	3	2								
EC322.4			2		2	3						

CO-PEO/PSO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)

	PEO1	PEO2	PEO3	PSO1	PSO2	PSO3
EC322.1	2			2		
EC322.2		2				2

EC322.3			2		2	
EC322.4	1			2	2	

BLOOM'S Levels Targeted (Pl. Tick appropriate)

Remember✓	Understand✓	Apply✓	Analyze✓	Evaluate	Create

Theory Component

Module No.	Unit No.	Topics	Ref.	Hrs.
1	Title	**Wireless Communication Fundamentals**	1,2	06
2	1.1	Characteristics of Wireless Communication, Comparison with Wired Communication, Frequency band, spectrum allocation.		
	1.2	**Wireless Transmission Techniques:** Signal propagation, path loss, fading, interference,Modulation techniques (ASK, FSK, PSK, QAM) Multiplexing: FDM, TDM, CDM		
	1.3	**MAC and WLAN Technologies:** MAC mechanisms in wireless networks, IEEE 802.11 architecture, protocols, services, CSMA/CA, DCF, PCF, RTS/CTS mechanism, WLAN deployment, hotspots, roaming.		
2	Title	**Cellular Networks and Personal Area Network Technologies**	1,2	06
	2.1	Digital Cellular Technology:2.5G TDMA Evolution Path, GPRS Technology,Edge Technology, 2.5G CDMA one cellular technology, UMTS Technology, W-CDMA Air Interface, TD-SCDMA Technology, CDMA2000 Cellular Technology.		
	2.2	LoRa and LPWAN Technologies: LoRa physical layer: chirp spread spectrum modulation.LoRaWAN protocol architecture: Classes A, B, C.Link budget analysis and coverage.Applications: smart cities, agriculture, logistics, environmental monitoring		
	2.2	Telemetry and M2M Communication: Fundamentals of telemetry systems. Wireless M-Bus, Sigfox, NB-IoT overview.Applications in industrial monitoring, smart metering, remote sensing		
3	Title	**Mobile IP and Transport Layer in Wireless Networks**	1,2	06
	3.1	Mobile IP: Basic concepts, motivation, Entities: Home Agent, Foreign Agent, Mobile Node, Registration, tunneling, route optimization		
	3.2	Network Protocols and Configuration: DHCP operation in wireless networks, Routing protocols in mobile environments, Proactive vs reactive routing		

	3.3	Wireless Transport Layer: Issues with TCP over wireless: congestion, error rates, TCP variants for wireless: Snoop, Freeze-TCP, TCP Westwood, UDP performance in mobile networks		
4	**Title**	**Ad Hoc Networks and Wireless Sensor Networks**	1,2	**06**
	4.1	Ad Hoc Networks: Characteristics, design challenges, Applications in disaster recovery, military, vehicular networks.		
	4.2	Routing in Ad Hoc Networks: Reactive protocols: AODV, DSR Proactive protocols: DSDV, OLSR, Hybrid protocols (ZRP)		
	4.3	Wireless Sensor Networks (WSNs): Node architecture, network topology, Data aggregation, cluster formation, Energy-efficient protocols (LEACH, PEGASIS)		
5	**Title**	**Wireless Network Security and Emerging Technologies**	1,2, 3	**04**
	5.1	Wireless Network Security and Attacks: Security requirements and threats, WEP, WPA, WPA2: weaknesses and improvements, mechanisms and encryption techniques.		
	5.2	Emerging Trends: Wi-Fi 6 and Wi-Fi 7, mm-Wave communication and beam forming.		
6	**Self Study**	Authentication mechanisms (EAP, RADIUS), Eavesdropping, spoofing, denial of service, Man-in-the-middle attacks, Defense, Edge computing, IoT over wireless, Blockchain for secure wireless networking.		**06***
			Excluding Self Study Topics Total	**28**

Laboratory Component, if any. (Minimum 10 Laboratory experiments are expected)

Sr. No	**Title of the Experiment**
1	Implementation and Analysis of Various Wireless Modulation Techniques in GNU Radio and Pluto SDR.
2	Wireless Topology Simulation in NS-3/OMNET++.
3	Wireshark Analysis of Wireless Packets.
4	Mobile IP Simulation./ LTE, 5G Network simulation in NS-3
5	ADOC Routing Protocol Simulation in NS-3/OMNET++.
6	WSN Simulation in COOJA.
7	WiFi Coverage and Heat Mapping using LoRa WAN Gateway.
8	Wireless Security Lab. (WEP/WPA Simulation)
9	IOT Device Integration over WiFi.(Cloud Platform)
10	Bluetooth based Communication between devices (using TerMux).

Text Books

Sr. No	Title	Edition	Authors	Publisher	Year
1	Wireless Communications and Networks	2nd	William Stallings	Pearson	2005
2	Ad Hoc Wireless Networks: Architectures and Protocols	2nd	C. Siva Ram Murthy & B.S. Manoj,	Pearson	2004

Reference Books

Sr. No	Title	Edition	Authors	Publisher	Year
1	Wireless Communications: Principles and Practice	2nd	Theodore S. Rappaport	Pearson	2002
2.	Wireless Sensor Networks: Technology, Protocols, and Applications	1st	Kazem Sohraby, Daniel Minoli, Taieb Znati	Wiley	2007
3.	Security in Wireless Mesh Networks	1st	Yan Zhang, Jun Zheng, Honglin Hu	Auerbach Publications (Taylor & Francis)	2006

Course (Category) Code	Course Name	Teaching Scheme (Hrs/week)					Credits Assigned			
		L	T	P	O	E	L	T	P	Total
PEC	Real Time Operating System	2	0	2	4	7	2	0	1	3
EC332		Examination Scheme								
		Component		ISE (%)		MSE (%)	ESE (%)		Total	
		Theory		20		20	60		100	
		Laboratory		80		--	20		100	

Pre-requisite Course Codes, if any.	Computer Organization & Architecture, Microcontrollers
Course Objective: The objective of this course is to provide students with a deep understanding of Real-Time Operating Systems, their design, functionality, and application in real-time embedded systems.	
Course Outcomes (CO): *At the End of the course students will be able to*	
EC332.1	Comprehend the key concepts of RTOS that includes task, task states, process and shared data
EC332.2	Illustrate Inter-process Communication techniques.
EC332.3	Analyze various scheduling algorithms used in real-time environments
EC332.4	Analyze the core features, mechanisms, and capabilities of a Real-Time Operating System (RTOS), including resource management and real-time constraints.
EC332.5	Design and implement application that meet real time requirements using appropriate RTOS.

CO-PO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
EC332.1	3											
EC332.2	3											
EC332.3		3			3							
EC332.4	3	3			3							
EC332.5		3			3							

CO-PEO/PSO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)

	PEO1	PEO2	PEO3	PEO4	PSO1	PSO2
EC332.1	1	1	1			
EC332.2	1	1	1			
EC332.3	1	1	1			
EC332.4	1	1	1			
EC332.5	1	1	1			

BLOOM'S Levels Targeted (Pl. Tick appropriate)

Remember	Understand	Apply	Analyze✓	Evaluate	Create

Theory Component

Module No.	Unit No.	Topics	Ref.	Hrs.
1	**Title**	**Real Time Operating System Concepts**	**1,2**	**06**
	1.1	Tasks and Task States, Task and Data		
	1.2	Concept of Semaphores		
	1.3	Shared Data and Inter-process Communication		
	1.4	Signal functions, Semaphore functions, Message Queue functions, mailbox functions, Pipe functions, Socket functions, RPC functions		
2	**Title**	**Functionalities of RTOS**	**2,3**	**06**
	2.1	Process Management, Timer and Event Functions		
	2.2	Memory Management, Strategy: Static and Dynamic, Memory Protection		
	2.3	I/O Management, Interrupt routines in RTOS environment and its handling		
3	**Title**	**Real Time Task Scheduling**	**2,4**	**06**
	3.1	Schedulability Problem: Classification, schedulability test,		
	3.2	Static and Dynamic Scheduling,		
4	**Title**	**Types of RTOS and Examples**	**3,4**	**06**

	4.1	RTOS VxWorks		
	4.2	RTOS mCOS		
	4.3	POSIX Standards and RTLinux	**5**	
5	**Title**	**RTOS Application Domains**	**2,3**	**04**
	5.1	Embedded RTOS for VOIP		
	5.2	RTOS for Control Systems		
6	**Self Study**	RTOS tools and technologies, RTOS Development environments, Debugging tools.		
			Total	**28**

Laboratory Component, if any. (Minimum 10 Laboratory experiments are expected)

Sr. No.	Title of the Experiment
1	Implement multitasking by creating multiple tasks and scheduling them using an RTOS. **Implementation:** ● Use FreeRTOS or an equivalent RTOS. ● Create tasks with different priorities. ● Implement Round-Robin and Priority-based scheduling. ● Observe task execution order.
2	Implement message queue-based communication between two tasks. **Implementation:** ● Create two tasks: **Task A (Sender)** and **Task B (Receiver)**. ● Use **FreeRTOS message queues** to send and receive messages. ● Display received messages via **serial monitor (UART/printf)**.
3	Use **binary and counting semaphores** for task synchronization. **Implementation:** ● Create two tasks: **Task 1 (Producer)** and **Task 2 (Consumer)**. ● Implement **binary semaphore** for mutual exclusion. ● Implement **counting semaphore** for resource management. ● Observe task execution sequence using debugging tools or LED toggling.
4	Demonstrate the use of software timers in RTOS for periodic task execution. **Implementation:** ● Create a timer task that executes at fixed intervals. ● Implement periodic event triggering using RTOS timer APIs. ● Measure execution time using an oscilloscope or system logs.
5	Implement external **interrupt-driven task execution** in an RTOS. **Implementation:** ● Configure an **external hardware interrupt (e.g., button press)**. ● Use an **ISR (Interrupt Service Routine)** to trigger an RTOS task. ● Measure **response time** and analyze **latency** using an oscilloscope or software logs.
6	Configure and use a **Real-Time Clock (RTC)** in an RTOS environment.

	Implementation: ● Initialize the **RTC module** on an embedded board (e.g., STM32, ESP32). ● Fetch **current time and date** from the RTC. ● Display the **formatted time** via UART or an LCD screen.
7	Implement dynamic memory allocation using **RTOS heap management**. **Implementation:** ● Allocate and deallocate memory dynamically using `pvPortMalloc()` and `vPortFree()`. ● Observe the impact on heap memory using **debugging tools**. ● Compare different **memory management schemes (Heap_1, Heap_2, Heap_4 in FreeRTOS)**.
8	Implement a real-time data acquisition and logging system. **Implementation:** ● Interface sensors (temperature, pressure, etc.) with an embedded system. ● Use RTOS tasks for data acquisition, processing, and storage. ● Log data to an SD card or transmit it via UART.

Text Books

Sr. No.	Title	Edition	Authors	Publisher	Year
1	Embedded / Real-Time Systems: Concepts, Design and Programming Black Book	First	Dr. K.V.K. Prasad	Dreamtech Press	2003
2	Real-Time Systems: Theory and Practice	First	Rajib Mall	Prentice Hall	2009
3	Embedded System: Architecture, Programming and Design	Second	Rajkamal	Tata McGraw-Hill	2011
4	Introduction to Embedded Systems	Second	Shibu K. V	Tata McGraw-Hill	2017

Reference Books

Sr. No.	Title	Edition	Authors	Publisher	Year
1	An Embedded software premier	Second	David Simon	Pearson Education	2007

2	Real–Time systems – Design Principles for distributed Embedded Applications	Second	Hermann Kopetz	Springer	2011
3	Micro C OS II reference manual, programmers manual				
4	VX works Programmers manual.				
5	POSIX, issue 7. IEEE 1003.1-2008.				

MOOC Course (NPTEL):-

https://onlinecourses.nptel.ac.in/noc20_cs16/preview

Course (Category) Code	Course Name	Teaching Scheme (Hrs/week)					Credits Assigned			
		L	T	P	O	E	L	T	P	Total
PEC	Speech and Audio Processing	2	0	1	5	10	2	0	1	3
		Examination Scheme								
		Component	ISE (%)		MSE (%)		ESE (%)			Total
EC342		Theory	20		20		60			100
		Laboratory	80		--		20			100

Pre-requisite Course Codes, if any	Digital Signal Processing
Course Objective: To help students understand how speech is produced and perceived, and to enable them to analyze speech signals using time and frequency domain methods. The course also aims to introduce speech processing models such as linear prediction, and to develop skills in building and evaluating systems for speech modeling and synthesis.	
Course Outcomes (CO): ***At the end of the course students will be able to***	
EC342.1	Understand the Mechanisms of Speech Production
EC342.2	Analyze Human Auditory Perception in Speech Processing
EC342.3	Apply Time and Frequency Domain Techniques for Speech Analysis
EC342.4	Explore Linear Predictive Analysis and Speech Processing Models
EC342.5	Develop and Evaluate Speech Modeling and Synthesis Techniques

CO-PO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
EC342.1	2											
EC342.2		2										
EC342.3			2									
EC342.4					2							
EC342.5				2								

CO-PEO/PSO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)

	PEO1	PEO2	PEO3	PSO1	PSO2
EC342.1	2	2		2	
EC342.2	2	2		2	
EC342.3	2	2			2
EC342.4			2		
EC342.5			2		

BLOOM'S Levels Targeted (Pl. Tick appropriate)

Remember	Understand✓	Apply✓	Analyze✓	Evaluate	Create

Theory Component

Module No.	Unit No.	Topics	Ref.	Hrs.
1	Title	**Mechanics of speech**	1,2	6
	1.1	Speech production: Mechanism of speech production, Acoustic phonetics – Digital models for speech signals -Sampling speech signals, basics of quantization, delta modulation, and Differential PCM		
	1.2	Signal Processing Models of Audio Perception: Basic anatomy of hearing System. Auditory Filter Banks, Psycho-acoustic analysis: Critical Band Structure, Absolute Threshold of Hearing, Simultaneous Masking, Temporal Masking, Quantization Noise Shaping, MPEG psycho-acoustic model.		
2	Title	**Time domain methods for speech processing**	1,2	6
	2.1	Time domain parameters of Speech signal – Methods for extracting the parameters Energy, Average Magnitude, zero crossing Rate – Silence Discrimination using ZCR and energy		
	2.2	Short Time Auto Correlation Function – Pitch period estimation using Auto Correlation Function.		
3	Title	**Frequency domain method for speech processing**	1,2	6
	3.1	Short Time Fourier analysis: Fourier transform and linear filtering interpretations.		
	3.2	Sampling rates - Spectrographic displays - Pitch and formant extraction - Analysis by Synthesis - Analysis synthesis systems: Phase vocoder, Channel Vocoder.		
	3.3	Homomorphic speech analysis: Cepstral analysis of Speech, Formant and Pitch Estimation, Homomorphic Vocoders, Speech coding, speech enhancement.		
4	Title	**Linear predictive analysis, synthesis of speech**	1,2, 3	4
	4.1	Basic Principles of linear predictive analysis – Auto correlation method – Covariance metho		
	4.2	Solution of LPC equations – Cholesky method – Durbin's Recursive algorithm.		
	4.3	Application of LPC parameters – Pitch detection using LPC parameters – Formant analysis – VELP – CELP, Speech synthesis: basics of articulatory, source-filter, and concatenative synthesis – VOIP.		

5	Title	**Speech modeling and synthesis**	1,2, 3	6
	5.1	Speech Modeling: Hidden Markov Models: Markov Processes, HMMs – Evaluation, Optimal State Sequence – Viterbi Search, Baum-Welch Parameter Re-estimation		
	5.2	Speech Synthesis: Text-to-Speech Synthesis: Concatenative and waveform synthesis methods, subword units for TTS, intelligibility and naturalness – role of prosody		
6	Self Study	Audio compression methods, Audio quality analysis, Spatial Audio Perception and rendering, Speaker identification and verification		
				28

Laboratory Component, if any. (Minimum 10 Laboratory experiments are expected)

Sr. No.	Title of the Experiment
1	Applying and Analyzing Speech Production Techniques
2	Analysis of speech signal with Formant Frequency Estimation
3	Practical Analysis of Speech Signals and Short-Time Spectrum
4	Spectrographic and Pitch Detection Analysis for Speech Processing
5	Emotion Recognition from Speech and extract features related to prosody, pitch, and energy to identify emotions in speech recordings
6	Implement MFCC extraction to capture spectral features important for speech recognition tasks.
7	Analysis of Speech using Cepstral and Linear Prediction methods
8	Implement Speech-to-Text Conversion and Advanced Analysis Techniques
9	Hands-On Speech Analysis and Signal Processing Techniques
10	Mini-Project: Speech Signal Analysis and Text Conversion

Text Books

Sr. No	Title	Edition	Authors	Publisher	Year
1	Speech Communications: Human & Machine	Second	Douglas O'Shaughnessy	IEEE Press, Hardcover 2/e, ISBN:	1999

				0780334493.	
2	Discrete-Time Speech Signal Processing	First	Thomas F, Quatieri,	Prentice Hall /Pearson Education	2004

Reference Books

Sr. No	Title	Edition	Authors	Publisher	Year
1	Speech and Audio Signal Processing	Second	Ben Gold and Nelson Morgan	John Wiley and Sons Inc., Singapore	2011
2.	Digital Processing of Speech Signals	First	L.R.Rabiner and R.W.Schaffer	Prentice Hall	1979
3.	Discrete-Time Speech Signal Processing: Principles and Practice	First	Thomas F. Quatieri	Pearson	2002

Course (Category) Code	Course Name	Teaching Scheme (Hrs/week)					Credits Assigned			
		L	T	P	O	E	L	T	P	Total
PEC	Semiconductor Technologies	02	--	02	4	8	2	--	1	3
		Examination Scheme								
		Component		ISE (%)		MSE (%)		ESE (%)		Total
EC352		Theory		20		20		60		100
		Laboratory		80		--		20		100

Pre-requisite Course Codes	AS101: Engineering Physics EC101: Digital Systems and Microprocessors EC102: Basic Electrical Engineering EC202: Electronic Devices EC207: Mixed Signal Integrated Circuits EC304: Digital CMOS VLSI Design
Course Objective: This course aims to develop a foundational understanding of the science, technology, and practical considerations involved in semiconductor device fabrication and layout design. It emphasizes the essential knowledge and design principles required for working in cleanroom environments and modern semiconductor labs. The course introduces the basics of integrated circuits, MEMS devices, and display technologies, highlighting their growing significance in India's semiconductor ecosystem. By connecting core concepts with practical exposure, the course prepares students to contribute effectively as skilled professionals supporting India's goal of building a strong domestic semiconductor and MEMS industry.	
Course Outcomes: After successful completion of the course, student will be able to	
EC352.1	Discuss integrated circuit fabrication processes and use modern/open-source tools for process simulation.
EC352.2	Apply the sequence of fabrication processes and design rules for layout design and characterization of a given semiconductor device/MOS circuit.
EC352.3	Discuss fundamental principles of MEMS devices including physical operation and mathematical modeling.
EC352.4	Apply various fabrication processes, choose suitable materials for MEMS device FEM modeling, fabrication and characterization.
EC352.5	Illustrate fundamental principles and fabrication process steps for semiconductor memories and displays.

CO-PO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
EC352.1	3	1		2	3							
EC352.2	3	1	3	2	3							
EC352.3	3	3		2	3							
EC352.4	3	3	3	2	3							
EC352.5	3	1		2	1							

CO-PEO/PSO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)

CO	PEO1	PEO2	PEO 3	PEO4	PSO1	PSO2
EC352.1	3				3	
EC352.2	3		3		3	
EC352.3	3				3	
EC352.4	3		3		3	
EC352.5	3				3	

BLOOM'S Levels Targeted (Pl. Tick appropriate)

Remember√	Understand√	Apply√	Analyze√	Evaluate√	Create

Theory Component

Module No.	Unit No.	Topics	Ref.	Hrs.
1	**Title**	**Environment and Crystal Growth for VLSI Technology**	**1,3**	**04**
	1.1	**Environment**: Semiconductor technology trend, clean rooms		
	1.2	**Semiconductor Substrate:** Phase diagram and solid solubility, Crystal structure, Crystal defects, Czochralski growth, Bridgman growth of GaAs, Float Zone growth, Wafer Preparation and specifications.		
2	**Title**	**Fabrication Processes Part 1**	**1,3**	**06**
	2.1	**Cleaning of Silicon wafer, Deposition:** Evaporation, Sputtering and Chemical Vapor Deposition.		

	2.2	**Epitaxy:** Molecular Beam Epitaxy, Vapor Phase Epitaxy, Liquid Phase Epitaxy, Evaluation of epitaxial layers		
	2.3	**Silicon Oxidation:** Thermal oxidation process, Kinetics of growth, Properties of Silicon Dioxide, Oxide Quality, high κ and low κ dielectrics.		
	2.4	**Diffusion:** Nature of diffusion, Diffusion in a concentration gradient, diffusion equation, impurity behavior, diffusion systems, problems in diffusion, evaluation of diffused layers.		
	2,5	**Ion Implantation**: Penetration range, ion implantation systems, process considerations, implantation damage and annealing.		
3	**Title**	**Fabrication Processes Part 2**	**1,3**	**06**
	3.1	**Etching:** Wet chemical etching, dry physical etching, dry chemical		
	3.2	**Lithography:** Photoreactive materials, Pattern generation and mask making, pattern transfer, Electron beam, Ion beam and X-ray lithography.		
	3.3	Device Isolation, Contacts and Metallization: Junction and oxide isolation, LOCOS, trench isolation, Schottky contacts, Ohmic contacts, Metallization	**2**	
	3.4	**CMOS Process Flow:** N well, P-well and Twin tub		
	3.5	Design rules, Layout of MOS based circuits (gates and combinational logic), Buried and Butting Contact.		
4	**Title**	**Introduction to MEMS, MEMS Materials Properties, Fabrication**	**3**	**08**
	4.1	Introduction to MEMS Technology, Difference between ICT & MEMS Technology, Difference between ICs and MEMS Devices and Real-world Sensors/Actuators examples with brief description, Bulk, Surface & LIGA Micromachining		
	4.2	Architecture, working and basic quantitative behavior of MEMS devices like Cantilever, Microheaters, Accelerometers, and Pressure Sensors		
	4.3	Materials (e.g. Si, SiO2, SiN, SU8, PMMA); Important properties: Young modulus, Poisson's ratio, density, piezoresistive coefficients, TCR, Thermal Conductivity, Material Structure.		
	4.4	Understanding steps involved and materials used in Fabricating MEMS Cantilevers, Micro-heaters, Accelerometers, Pressure Sensors, Thermal Inkjet Printer Heads, and DMD		
5	**Title**	**Semiconductor Memories and Display**		04
	5.1	Memory: SRAM, DRAM, MRAM, Flash: Working Principle, structures and fabrication steps of one/two memory structures	**4**	
	5.2	Display: AMOLED/OLED: Working Principle, structures, fabrication steps	**5**	

6	**Self-Study**	Integrated circuit packages, package reliability, die, wire & wafer bonding, dicing, and packaging of MEMS devices, Characterization of IC using Automated Test Equipment (ATE), Characterization of MEMS devices for stiffness and Resonant frequency, TCR.	**1,3**	**04***
			Total (*Not included)	**28**

ISE Evaluation:

1) **Fault identification and correction of a given CMOS circuit Layout: Group Activity within Laboratory Batch [Evaluation during laboratory session. CO3-CO4. (5 Marks)**
2) **Case Study of MEMS device fabrication and characterization: Group Activity within Laboratory Batch [Evaluation during laboratory session. CO3-CO4. (5 Marks)**
3) **Visit to CEN Lab, IIT Bombay and Report on visit (CO1-CO5) (10 Marks)**

Each Experiment carries 05 Marks. Any 08 Experiments covering all COs.

Rubrics: Performance (3.5M), Oral Questions based on Experiment (0.5) and Documentation (01)

Sr. No.	Topics	CO
1	**Aim:** Use Nano hub platform to simulate and analyze the Oxidation process for various process parameters and wafer specifications. **Problem Statement:** Simulate the oxidation process with Deal - Groove model for different conditions (e.g. Oxidation type, orientation, time, temperature, thickness etc.) and comment on the results obtained.	CO1
2	**Aim:** Use Nano hub platform to simulate and analyze the diffusion process for various given conditions. **Problem Statement:** Simulate the diffusion process for various given conditions. Such as e.g. Source, time, temperature, dopant etc. and comment on the results obtained.	CO1
3	**Aim:** Use Virtual Hall Effect Experimental set-up for the measurement of semiconductor material parameter measurements. **Problem Statement:** Use Hall Effect Experimental set-up available at Vlab to determine various parameters of semiconductor material like Hall's coefficient, carrier density, mobility. Compare these values with calculated values. Also study the dependence of Hall voltage on the magnetic field and the current passing through the probe.	CO1
4	**Aim:** To use Industry graded VLSI CAD tools to draw layout and analyze CMOS Inverter circuit. **Problem Statement:** Draw and simulate CMOS Inverter. Carry out static as well as transient simulation. Analyze CMOS Inverter for i) (W/L) PMOS> (W/L) NMOS ii) (W/L) PMOS = (W/L) NMOS iii) (W/L) PMOS < (W/L) NMOS. **Do parasitic extraction. Feed these parasitic in circuit simulator and do the layout versus schematic verification.**	CO2
5	**Aim:** To use Industry graded VLSI CAD tools to draw layout and analyze MOS based	CO2

	circuit. **Problem Statement:** Draw and simulate layout for the following circuits. Size them with respect to reference inverter. i: CMOS NAND ii: CMOS NOR iii. 6T SRAM cell for high reliability and lowest area. iv. A given flipflop (SR, D, T, JK). v. Half adder. vi. Logic equation using Static CMOS, dynamic logic, transmission gate. **(Any one problem statement for a group of students)**	
5	**Aim:** To analyze MEMS cantilever in Sugar Tool using Nano hub platform. **Problem Statement:** Choose proper dimensions of MEMS cantilever modelled in Sugar. Choose the proper co-ordinate and node for applying a point contact load (force). a) Observe and tabulate the maximum displacement at free end of the cantilever for at least two different values of point contact load, verify one of the readings with given analytical expression of maximum displacement of the cantilever. Comment on the results obtained. b) Observe and tabulate the maximum displacement of the cantilever for at least two different values of point contact force applied on cantilever, verify one of the readings with given analytical expression of maximum displacement of the cantilever. Comment on the results obtained.	CO3 - CO4
6	**Aim:** To model and analyze MEMS cantilever in COMSOL Multiphysics. **Problem Statement:** For the given dimensions and material create MEMS cantilever model in COMSOL a) Observe the dependence of resonance frequency of the cantilever on material. b) For the cantilever model analyze dependence of fundamental resonance frequency on varying length (given range), plot the result and also compare the result with analytical expression of resonance frequency.	CO3 - CO4
7	**Aim:** To analyze MEMS capacitive pressure sensor in COMSOL Multiphysics. **Problem Statement:** For the given dimensions, model MEMS capacitive pressure sensor in COMSOL. a) Observe, plot changes in pressure sensor diaphragm displacement and capacitance at constant temperature (room temperature) and varying applied pressure (given range) and compare it with given analytical expressions of diaphragm displacement and capacitance of sensor. b) Observe, plot the change in pressure sensor diaphragm displacement and capacitance for fixed value of applied pressure and varying temperature to analyze the effect of package stress.	CO3 - CO4
8	**Aim:** To evaluate the static and dynamic performance of the MEMS micro-heater using FEM tool. **Problem Statement:** For the given model of the MEMS micro-heater, a) Measure the temperature of the heated membrane for the input excitation voltage and compare it with the given analytical expression. b) To plot the temperature response of heated membrane to standard test voltages like square, Ramp, and sinusoidal.	CO3 - CO4

9	9) **Aim:** To model and analyze MEMS electrostatically actuated microcantilever in COMSOL. **Problem Statement:** For the given model of electrostatically actuated micro-cantilever in COMSOL. a) To plot tip displacement of the microcantilever for different values of applied voltage. b) To plot shape of the microcantilever displacement for different values of applied voltage. c) To plot capacitance of the micro-cantilever different values of applied voltage.	CO3 - CO4
10	**Aim:** To model and analyze Piezo-resistive Pressure Sensor in MEMS Design and Simulation FEM Tool. **Problem Statement:** Choose the proper substrate; define the process flow and Layout of Piezo-resistive pressure sensor in MEMS Design and Simulation FEM Tool. a) Create its 3- D Layout. b) Observe the change in resistance of piezo-resistance for given input pressure. Compare this reading with the given analytical expression of the change in resistance of the piezo-resistance.	CO3 - CO4
11	**Aim:** To analyze the operation of semiconductor memory using NI Tool. **Problem Statement:** Using Multisim configure a word generator, observe the reading and writing of a 2-bit code on a RAM chip, and design, construct and simulate the writing and reading of a 4-bit code on a RAM chip	CO5
12	**Aim:** Develop and test low-cost self-made OLEDs. **Problem Statement:** Develop and test the low-cost standard-OLED on ITO2 glass with three individually controllable emission spots using the process steps described.	CO5

*Student has to perform any one experiment from 8, 9 and 10 as per the allotment by the faculty.

Text Books:

Sr. No.	Title	Edition	Authors	Publishers	Year
1	Silicon VLSI Technology	Indian Edition, First	James D. Plummer, Michael D. Deal and Peter B. Griffin	Pearson	2000
2	Fundamentals of Semiconductor Fabrication	First	G. S. May and S. M. Sze	Wiley	2011
3	Micro Electro Mechanical System Design	e-book	J. Allen	CRC Press	2005
4	Semiconductor Memories Technology, Testing and Reliability	-	A.K. Sharma	IEEE	2022
5	Frontiers in Electrical Engineering Vol. 1: Active-Matrix Organic Light-Emitting Display Technologies	-	Shuming Chen, Jianning Yu, YibinJiang, Rongsheng Chen, Tsz Kin Ho	Bentham Books	2015

Reference Books:

Sr. No.	Title	Edition	Authors	Publishers	Year
1	The Science and Engineering of Microelectronic Fabrication	Second Edition	Stephen A. Campbell	Oxford University Press	2001
2	VLSI Fabrication Principles	Student Edition	Sorab K. Gandhi	Wiley	2008
3	An Introduction to Microelectromechanical Systems Engineering	Second	N. Maluf, K Williams	Artech House Inc	2004
4	Practical MEMS	First	Ville Kaajakari	Small Gear Publishing	2009
5	Microsystem Design	First	S. Senturia	Springer	2005
6	Fundamentals of Microfabrication	Second	M. Madou	CRC Press	2002

References:

[1] www.nanohub.org
[2] www.vlab.com
[3] www.microwind.com
[4] ICMT Laboratory Manual
[5] https://www.sciencedirect.com/science/article/pii/S0187893X13731902

Course (Category) Code	Course Name	Teaching Scheme (Hrs/week)					Credits Assigned			
		L	T	P	O	E	L	T	P	Total
SEC	Internet of Things Laboratory	1	-	2	2	5	1	–	1	2
		Examination Scheme								
		Component		ISE (%)		MSE (%)	ESE (%)			Total
AS301		Theory		20		--	--			20
		Laboratory		80		--	20			100

Pre-requisite Course Codes	EC101: Digital Systems and Microprocessors EC205: Computer Organization & Architecture EC306: Embedded System
Course Objective: This hands-on course provides a structured introduction to the fundamental concepts, technologies, data communication protocols, analytics, security, and practical applications of the Internet of Things (IoT).	
Course Outcomes (CO): ***After successful completion of the course, student will be able to***	
AS301.1	Identify the key challenges and opportunities in IoT development and deployment.
AS301.2	Acquire real world signals and perform remote process monitoring utilizing the concept of IoT
AS301.3	Apply appropriate communication protocols for IoT devices.
AS301.4	Evaluate security risks and apply relevant measures to protect IoT systems

CO-PO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
AS301.1	1											
AS301.2			2	2	3							
AS301.3			2	2	3							
AS301.4				2	3							

CO-PEO/PSO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)

	PEO1	PEO2	PEO3	PEO4	PSO1	PSO2
AS301.1	1					
AS301.2	1	1	1		2	
AS301.3		1				
AS301.4				1		

BLOOM'S Levels Targeted (Pl. Tick appropriate)

Remember✓	Understand✓	Apply✓	Analyze✓	Evaluate	Create

Theory Component

Module No.	Unit No.	Topics	Ref.	Hrs
1	**Title**	**Fundamentals of IOT Systems:**	**1,2**	**05**
	1.1	Evolution of Internet of Things, Enabling Technologies, IoT Architectures: M2M, IoT configurations, IoT architecture and components, IoT Network Layers and Communication Models, Gateways, Fog computing, Edge and Cloud in IoT, Functional blocks of an IoT ecosystem, Sensors and Actuators: Types, Selection Criteria, and Integration, Power Management and Energy Efficiency in IoT Devices.		
2	**Title**	**Functionality based IoT Protocol Organization:**	**3**	**06**
	2.1	**Connectivity Protocols:** 6LoWPAN, Lora WAN, NB-IoT **Communication/Transport Protocols:** WIFI, Bluetooth, Zigbee, Z-wave, NFC **Data Protocols:** MQTT, CoAP, WebSocket, AMQP, HTTP/HTTPS, RESTful APIs **Device Management:** JSON-LD, Web Thing Model, Multilayer Framework Interoperability and Standardization Challenges in IoT		

3	**Title**	**Security, trust, and privacy issues in IoT**	**3**	**03**
	3.1	IoT security challenges and vulnerabilities, Authentication and access control in IoT, Distributed Denial of service (DDoS), Privacy considerations and regulation		
4	**Self-study**	**IoT Applications and Case Studies:** ● Smart Homes: Home Automation, Smart Lighting, Smart Security Systems ● Smart Cities: IoT for Traffic Management, Waste Management, and Public Safety ● Healthcare IoT: Remote Patient Monitoring, Wearable Health Devices ● Industrial IoT (IIoT): Smart Manufacturing, Predictive Maintenance, Digital Twins ● Agriculture IoT: Smart Irrigation, Precision Farming, IoT-Enabled Drones ● Retail and Supply Chain IoT: Smart Inventory Management, RFID, Asset Tracking ● Automotive IoT: Connected Vehicles, Telematics, V2X Communication ● Energy and Environment: Smart Grid, Renewable Energy Monitoring, Environmental Sensing	**1,2**	**04***
			Total	**14**

Reference Books

Sr. No.	Title	Edition	Author	Publisher	Year
1	Internet of Things: Architecture and Design Principles	First edition	Raj Kamal	McGraw Hill Education	2017
2	Internet of Things, A Hands-on Approach		Vijay Madisetti, ArshdeepBahga	UniversityPress	2015.
3	The Internet of Things: Enabling Technologies, Platforms and Use Cases	-	Pethuru Raj and Anupama C. Raman	CRC Press	2017

Suggested List of Laboratory Experiments:

1. Getting started with IoT development board in the IDE and GPIO Interfacing and programming
2. IoT Sensor Integration: Design and implement a small-scale IoT system that includes sensors such as temperature, humidity, and light sensors. Collect data from these sensors and transmit it wirelessly to a central hub or cloud platform for analysis and visualization.
3. Design and implement a weather station on display module and mobile phone using the IoT based microcontroller with WEBSOCKET API that can collect data from various sensors to monitor and display real-time weather conditions
4. Communication Protocols: Implement a simple IoT system using different communication protocols (e.g., MQTT, CoAP) on IoT based microcontroller. Set up a MOSQUITTO broker on laptop/PC to handle the communication of IoT based microcontroller to laptop. Develop programs on IoT devices to publish and subscribe to sensor data using the chosen protocol.
5. Implement an MQTT-based communication between two devices, with one device acting as a sender and the other as a receiver. Implement a MQTT broker on single board computer to facilitate data exchange between the devices.
6. Implement a SMTP protocol to send data from IoT based microcontroller devices to email.
7. Integrate the Blynk protocol with a microcontroller to capture sensor data and display it on a mobile application in real-time.
8. Implementation of Bluetooth or Zigbee Communication in IoT-Based Remote Monitoring and Control Systems
9. Develop AWS IoT Core's message broker feature to securely transmit and receive messages to and from a microcontroller board running MicroPython. AWS IoT Core enables devices to connect to the cloud securely and easily.
10. IoT Application Development:
    - Choose an IoT application domain (e.g., smart home, healthcare, agriculture).
    - Develop a prototype application using appropriate hardware components, sensors, and actuators.
    - Integrate the application with cloud services or a mobile app for remote monitoring and control.

Online Resources:

1. NPTEL Lecture series: Introduction to Internet of Things by Prof. Sudip Misra, IIT Kharagpur https://onlinecourses.nptel.ac.in/noc24_cs35/preview
2. NPTEL Lecture series: Foundation of Cloud IoT Edge ML By Prof. Rajiv Misra, IIT Patna https://onlinecourses.nptel.ac.in/noc24_cs26/preview