DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

SYLLABUS
BACHELOR OF TECHNOLOGY

in

ELECTRONICS ENGINEERING

(VLSI DESIGN & TECHNOLOGY)

[Effective from Admitted batch 2024 and Admitted batch 2023 (3rd Semester) Onwards]

SMIT SIKKIM MANIPAL UNIVERSITY
SIKKIM MANIPAL INSTITUTE OF TECHNOLOGY

Vision, Mission and Objective of University

VISION

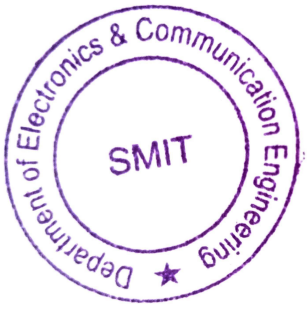
Global Leadership in Human Development, Excellence in Education and Healthcare.

MISSION

Develop professionals of excellent technical calibre in the field of Health Sciences, Engineering, Management and Social Sciences with a humane approach capable of shouldering the responsibility of building the nation and be globally competent.

OBJECTIVES

- To support, promote and undertake the advancement of academics
- To promote use of ICT and modern education technologies
- To encourage research, creation and dissemination of knowledge
- To facilitate extension and community service
- To empower people of Sikkim and contribute to human development in Northeast
- To create environmental and social responsibilities among students and employees
- To ensure steady growth of the University



Vision, Mission and Objective of Institute

VISION

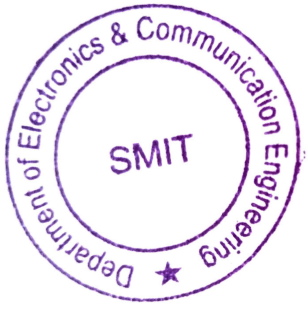
- To achieve eminence in the field of quality technological education and research.

MISSION

- To develop SMIT into an Institution of Excellence capable of producing competent techno-managers who can contribute effectively to the advancement of the society.

OBJECTIVES

- To provide wholesome education to meet the intellectual aspirations of the students.
- To equip students with techno-managerial skills to enable them to take their assigned role in the industry.
- To inculcate essential ethics and values to meet the spiritual needs to the students.
- To provide a sound institutional environment nurturing emotional strength, healthy mind, body and resilience amongst the students.



Vision, Mission and Objective of the Department

VISION

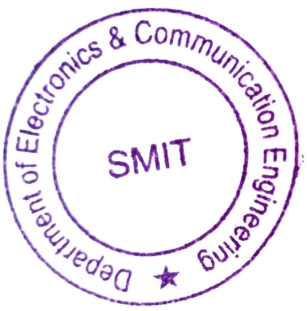
To achieve eminence in the field of quality techno-logical education and research in Communication, Remote Sensing, VLSI & Embedded System and other Electronics related fields.

MISSION

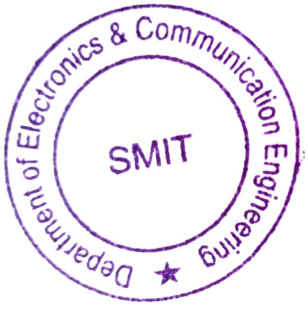
To develop into a department of excellence capable of producing competent techno-managers who can contribute effectively to the advancement of the society.

OBJECTIVES

- To prepare students to identify, formulate and solve real life and industrial problems with their knowledge of electronics and communication engineering.
- To develop techno-managerial ability to execute assigned responsibilities.
- To provide the guidance to develop moral and ethical attitudes.
- To provide education to adopt novel technologies towards the betterment of human life and society.



Program Outcomes



PO 1 Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO 2 Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO 3 Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO 4 Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO 5 Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO 6 The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO 7 Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

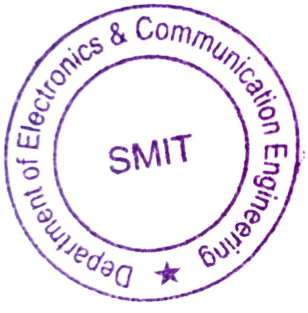
PO 8 Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO 9 Individual and teamwork: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10 Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11 Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12 Life-long learning: Recognize the need for and have the preparation and ability to engage in independent and life-long.



Program Specific Outcomes

PSO 1 The ability to understand, analyze, design and demonstrate the knowledge of electronic circuits, devices, signal processing, radio and communication engineering in terms of real-world problems to meet the challenges of the future in multi-disciplinary domain.

PSO 2 Ability to pursue project-based learning to qualify for employment, higher-studies and research works in Electronics and communication engineering with ethical values.

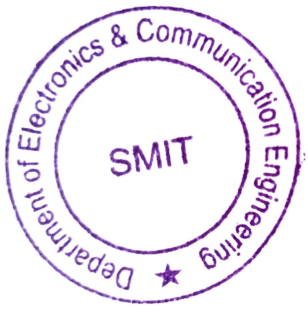


Table of Contents

FIRST YEAR B. TECH CURRICULUM 2024 (Common to all branches)

Semester	FIRST SEMESTER						SECOND SEMESTER					
	Sub. Code	Subject Name	L	T	P	C	Sub. Code	Subject Name	L	T	P	C
1st Yr	PH101A1	Engineering Physics	3	1	0	4	CH101A1	Engineering Chemistry	3	1	0	4
	MA101A1	Engineering Mathematics–I/II	3	1	0	4	CS101A1	Computer Programming in C	3	1	0	4
	EC101A1	Basic Electronics	3	0	0	3	MA102A1	Engineering Mathematics–I/II	3	1	0	4
	CE101A1	Elements of Civil Engineering	3	0	0	3	EE101A1	Element of Electrical Engineering	3	0	0	3
	ME101A1	Engineering Graphics	2	0	0	2	ME102A1	Element of Mechanical Engineering	3	0	0	3
	ME101A4	Workshop Practice	0	0	1	1	CH102A1	Environmental Science*	1	0	0	1
	BA101A1	Communication Skills*	2	0	0	2	CS101A4	Computer Programming Lab	0	0	1	1
	BP101A1	Constitution of India	1	0	0	1	CH101A4	Engineering Chemistry Lab	0	0	1	1
	PH101A4	Engineering Physics Lab	0	0	1	1		NCC (AU)	0	0	0	0
		NCC (AU)	0	0	0	0						
	Total Contact Hours (L + T + P)					21	Total Contact Hours (L + T + P)					21
	*Mandatory audit course						*Mandatory audit course					

Note: UHV–I has been introduced under Mandatory Induction Program.

B.TECH. COURSE STRUCTURE – SEMESTER WISE

THIRD SEMESTER							
Year	**Course Code**	**Course Title**	**Total Number of Contact Hours**				**Credits**
			Lecture (L)	**Tutorial (T)**	**Practical (P)**	**Total Hours**	
2nd	MA207A1	Engineering Mathematics III	3	1	0	4	4
	VT201A1	Electronic Devices and Components	3	1	0	4	4
	VT202A1	Digital Electronics and System Design	3	1	0	4	4
	VT203A1	Signals and Systems	3	1	0	4	4
	VT2xxA3	Program Elective-I	3	1	0	4	4
	VT2xxA2	Open Elective-I/Minor/NCC	3	1	0	4	4
	VT201A4	Electronic Devices and Components Lab	0	0	1	2	1
	VT202A4	Digital Electronics and System Design Lab	0	0	1	2	1
	VT201A5	Project Based Learning-I	0	0	1	2	1
TOTAL			18	6	3	30	27

FOURTH SEMESTER							
Year	**Course Code**	**Course Title**	**Total Number of Contact Hours**				**Credits**
			Lecture (L)	**Tutorial (T)**	**Practical (P)**	**Total Hours**	
2nd	MA208A1	Engineering Mathematics IV	3	1	0	4	4
	VT204A1	Analog Electronic Circuits	3	1	0	4	4
	VT205A1	Microprocessor, Microcontroller, and ARM processor	3	1	0	4	4
	VT2xxA2	Open Elective-II/Minor/NCC	3	1	0	4	4
	VT2xxA3	Program Elective-II	3	1	0	4	4
	GN201A1	Universal human values-II: understanding Harmony and ethical human conduct	3	0	0	3	3
	VT203A4	Analog Electronic Circuits Lab	0	0	1	2	1
	VT204A4	Microprocessor and microcontroller LAB	0	0	1	2	1
	VT202A5	Project Based Learning-II	0	0	1	2	1
TOTAL			18	5	3	29	26

FIFTH SEMESTER						
Year	**Course Code**	**Course Title**	**Total Number of Contact Hours**			**Credits**
			Lecture (L)	**Tutorial (T)**	**Practical (P)**	**Total Hours**	
3rd	VT301A1	Communication Engineering	3	1	0	4	4
	VT302A1	Introduction to Microfabrication	3	1	0	4	4
	VT303A1	VLSI Verification and Testing using EDA tools	3	1	0	4	4
	VT304A1	Embedded System	3	1	0	4	4
	VT3xxA3	Program Elective-III/MOOC	3	3	0	4	3
	VT3xxA2	Open Elective-III/Minor/NCC	3	1	0	4	4
	VT301A4	HDL simulation LAB	0	0	1	2	1
	VT302A4	Python Scripting Lab	0	0	1	2	1
	VT301A5	Project Based Learning-III	0	0	1	2	1
	GN301A1	Quantitative aptitude and logical reasoning	1	0	0	1	1
	VT301A9	Industrial Training-I	0	0	1	-	1
TOTAL			18	6	4	30*	28

SIXTH SEMESTER							
Year	**Course Code**	**Course Title**	**Total Number of Contact Hours**				**Credits**
			Lecture (L)	**Tutorial (T)**	**Practical (P)**	**Total Hours**	
3rd	BA346A1	Industrial Management	2	0	0	2	2
	VT305A1	Semiconductor Materials Synthesis and Characterization	3	1	0	4	4
	VT306A1	Micro Electronics and VLSI Design)	3	1	0	4	4
	VT3xxA3	Program Elective-IV	3	1	0	4	4
	VT3xxA3	Program Elective-V	3	1	0	4	4
	VT3xxA2	Open Elective-IV/Minor/NCC	3	1	0	4	4
	VT303A4	Communication Lab	0	0	1	2	1
	VT304A4	ARM based SoC Design Lab {Foundry Familiarization workshop / MOOC virtual Lab}	0	0	1	2	1
	GN302A1	Quantitative aptitude and logical reasoning	1	0	0	1	1
	VT302A5	Mini Project	0	0	1	1	1
TOTAL			17	5	4	28	26

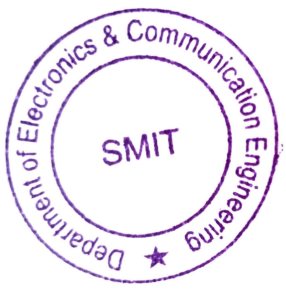
*Audit course

SEVENTH SEMESTER							
Year	**Course Code**	**Course Title**	**Total Number of Contact Hours**				**Credits**
			Lecture (L)	**Tutorial (T)**	**Practical (P)**	**Total Hours**	
4^{th}	VT4xxA2	Open Elective-V/Minor/NCC	3	1	0	4	4
	VT4xxA2	Choice Based Elective (Open Elective)	3	0	0	3	3
	VT401A6	Research based Project / Industrial Project -Phase-I	0	0	7	2	7
	VT401A9	Industrial Training-II	0	0	1	-	1
TOTAL			6	1	1	9*	15
EIGHT SEMESTER							
Year	**Course Code**	**Course Title**	**Total Number of Contact Hours**				**Credits**
			Lecture (L)	**Tutorial (T)**	**Practical (P)**	**Total Hours**	
4^{th}	VT4xxA2	Open Elective-VI/Minor/NCC	3	1	0	4	4
	VT402A6	Major Project work	0	0	12	-	12
TOTAL			3	1	12	4*	16

LIST OF ELECTIVES FOR 3rd. SEMESTER			
PROGRAM ELECTIVE-1			
Year	**COURSE CODE**	**COURSE TITLE**	**CREDIT**
2nd	**VT201A3**	Electromagnetic Theory	4
	VT202A3	Network Analysis and Synthesis	4
	VT203A3	OOPs with C++	4
	VT204A3	Internet of Things	4
	VT205A3	Computer Organization and Architecture	4

LIST OF ELECTIVES FOR 4TH SEMESTER			
PROGRAM ELECTIVE-2			
Year	**COURSE CODE**	**COURSE TITLE**	**CREDIT**
2nd	**VT206A3**	Computer Networks	4
	VT207A3	Electronic Instruments and Measurements	4
	VT208A3	Data Structure	4
	VT209A3	Advanced Electronic Devices	4

LIST OF ELECTIVES FOR 5TH SEMESTER			
PROGRAM ELECTIVE-3			
Year	**COURSE CODE**	**COURSE TITLE**	**CREDIT**
3rd	**VT301A3**	FPGA Architecture	4
	VT302A3	Digital Signal Processing	4
	VT303A3	VLSI Physical Design	4
	VT304A3	JAVA	4
	VT305A3	Database Management System	4



LIST OF ELECTIVES FOR 6TH SEMESTER			
PROGRAM ELECTIVE-4			
Year	**COURSE CODE**	**COURSE TITLE**	**CREDIT**
3rd	**VT306A3**	Advanced Semiconductor Devices and Flexible Electronics	4
	VT307A3	Linear and Digital Control Systems	4
	VT308A3	Information Theory and Coding	4
	VT309A3	MEMS and NEMS	4
	PROGRAM ELECTIVE-5		
	VT310A3	Advance VLSI and SoC Design	4
	VT311A3	Semiconductor Device Modelling	4
	VT312A3	Machine Learning	4

OPEN ELECTIVE/MINOR			
SEMESTER	**COURSE CODE**	**COURSE TITLE**	**CREDIT**
3rd	**VT201A2**	Introduction to Complex Variables	4
	VT202A2	Computer Organization and Architecture	4
	VT203A2	Python Programming	4
	VT204A2	Mathematics for Communication Engineering	
4th	**VT205A2**	Signal Processing for Communication	4
	VT206A2	Semiconductor Devices and Circuits	4
	VT207A2	Sensors and Actuators	4
	VT208A2	Advanced Antenna Design	
5th	**VT301A2**	Optimization Technique	4
	VT302A2	Solid State Devices	4
	VT303A2	IOT Gateways and Edge Computing	4
	VT304A2	Advanced Digital Communication	
	VT305A2	Pattern Recognition	4
	VT306A2	Nano Electronic Devices and Materials	4

6th	**VT307A2**	Communication Pathways between Cloud and IoT	4
	VT308A2	Modern Wireless Communication System	
7th	**VT401A2**	Time Frequency Analysis	4
	VT402A2	Adv. VLSI Design and Applications	4
	VT403A2	Artificial Intelligence and Machine Learning	4
	VT404A2	Coding for MIMO Communication	
8th	**VT405A2**	Advance Digital Signal Processing	4
	VT406A2	ASIC Design	4
	VT407A2	Data Centre and Cloud Computing	4
	VT408A2	5G Mobile Communication	

CHOICE BASED ELECTIVES/OPEN ELECTIVES			
SEMESTER	**COURSE CODE**	**COURSE TITLE**	**CREDIT**
7th	**VT4xxA2**	Any subjects related to foreign language or Indian language.	3

EC101A1 **Credit: 3(L-3, T-0, P-0)**

BASIC ELECTRONICS

Questions to be set: 05 (All Compulsory)

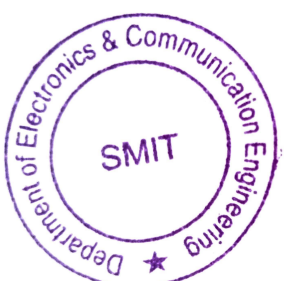
Course Objectives: This course provides the student with the fundamental skills to understand the basic of semiconductor and components like diode and Bipolar Junction Transistor. It will give some idea about the usages and role of electronics in our daily lives. Students will learn basics of digital electronics in this course. Students will be introduced with the basics of a communication system.

Pre-requisites: Basics of semiconductor Physics

Course Outcomes (CO):
After studying this course, students will be able to:
1. Appreciate the significance of electronics in different areas
2. Apply the concept of diodes in rectifiers, voltage regulators and in some other applications
3. Understand the operation of a transistor and its biasing techniques
4. Compile the different building blocks in digital electronics using logic gates and implement simple logic function using logic gates
5. Understand the functioning of a communication system

** not more than 20% of total topics to be allotted for assignment

Module	Topics to be covered	Topics	Hrs	CO
Module 1: **Introduction to Electronics**	in class	Electronics in our daily life, Role of electronics in smart city, Application of electronics in computers, Introduction to special purpose diodes: Photo diode, Tunnel diode, Varactor diode, Light Emitting Diode, Schottky diode	6	1
	****Assignment Topics**			
Module 2: **Semiconductor Diodes and Applications**	in class	p-n junction diode, Characteristics and Parameters, Diode approximations, Half-wave rectifier, Full-wave rectifier - Centre tap rectifier, Bridge rectifier, Zener diode as voltage regulator,	8	2
	****Assignment Topics**			
Module 3: **Introduction to Bipolar Junction Transistor**	in class	Operation of Bipolar Junction Transistors, Regions of operation of BJT, Transistor configurations - Common Base, Common Emitter and Common Collector Characteristics, BJT Biasing - Operating point, DC Load line, ac load line, Fixed bias, Base Resistor bias, Collector to Base bias, Voltage divider Bias	8	3
	****Assignment Topics**			
Module 4: **Introduction to Digital Electronics**	in class	Analog versus Digital electronics, Binary System for digital electronics, Introduction to basic and composite logic gates, realization of a Boolean expression using logic gates, examples of small digital circuits - adder, comparator etc., Introduction to IC technologies	8	4
	****Assignment Topics**			



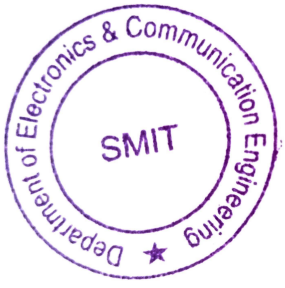
Module 5: **Basics of Communication System**	in class ****Assignment Topics**	Application of electronics in Communication Systems, 1G to 6G, Introduction to IoT. Basics of internet	6	5 5

TEXTBOOKS:

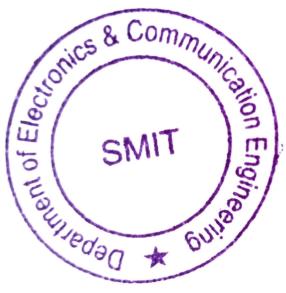
1. Millman and Halkias, Integrated devices & Circuits (2e), PHI, 2017
2. Robert L. Boylestad, Louis Nashelsky, Electronic Devices & Circuit Theory (11e), PHI 2012
3. Malvino and Leach, Digital Principles & applications (7e), TMH 2010
4. George Kennedy, Bernad Davis., Electronic Communication Systems, (4e), TMH, 2004
5. Garcia, Widjaja, Communication Networks, McGraw Hill 2006

REFERENCE BOOKS:

1. Electronics Devices and Circuits-II by A. P. Godre& U. A. Bakshi
2. Electronics Devices and Circuit by G. K. Mithal
3. Raj Pandya, Mobile and Personal Communication Services and Systems, Wiley-IEEE Press, 1999



Third Semester Major Theory Subjects



MA207A1 **Credit: 4 (L-3, T-1, P-0)**

ENGINEERING MATHEMATICS III

Questions to be set: 05 (All Compulsory)

Course Objectives: The objective of this paper is to give emphasis on topics like Partial Differential equations (PDE) and Numerical Methods. Linear algebra plays a major role in helping design and analyze electronic circuits. PDE is required for the study of motion, vibrating strings etc. Many real-life problems arising in communication can be modeled by numerical techniques. In many problems analytical solutions are not readily available or not easy to obtain. Therefore, numerical methods are helpful to solve. Linear Algebra plays a pivotal role in many engineering branches, especially electronics and communication engineering and hence they will enable students to model their problems using matrix theory.

Pre-requisites: Engineering Mathematics-I, Engineering Mathematics-II

Course Outcomes (CO): On successful completion of this course students will be able to:

CO 1: Identify and apply the concepts of vector space in various problems of communications.
CO 2: Associate and apply the concept of linear transformation in various engineering problems of networks and communications.
CO 3: Formulate and apply the concept of partial differential equation in electronics engineering modeling.
CO 4: Analysis and apply the concepts of numerical methods in solving engineering problems numerically.
CO 5: Apply the concepts of initial value problems to find approximate solutions for engineering problems numerically.

** not more than 20% of total topics to be allotted for assignment

Module	Topics to be covered	Topics	Hrs	CO
Module 1: <Vector Space and Linear Transformation>	in class	Linear Algebra: Vector Spaces, Subspaces, Span, Basis and Dimension, Linear Transformation, Matrix representation of Linear Transformation, Eigen Values and Eigen Vectors.	8	1
	****Assignment Topics**	Eigen Values and Eigen Vectors.	1	1
Module 2: <Inner Product Space and Orthogonalization>	in class	Inner product spaces, Orthogonality, projection, Orthogonal and Ortho normal Basis, Gram Schmidt Orthogonalization Process.	8	2
	****Assignment Topics**	Gram Schmidt Orthogonalization Process.	1	2
Module 3: <Partial Differential Equation>	in class	Partial differential equations: Definition, degree, order of a PDE. Formation of PDE. Linear and nonlinear PDE. Solution of first order linear PDE. Derivations of one dimensional wave equation (vibrating string) and its solutions by using method of separation of variables with simple problems.	10	3
	****Assignment Topics**	Method of separation of variables.	1	3

Module 4: <Numerical Methods-I>	in class	Numerical Methods: Interpolation and application: finite difference, central and divided differences, Newton - Gregory and Lagrange's interpolation formulae. Inverse interpolation. Numerical differentiation. Numerical integration: Trapezoidal rule, Simpson's one third and three eight rule, Solution of systems of linear equation: Jacobi, Gauss-Seidal methods. Solution of tridiagonal systems. Eigenvalues and eigenvectors of matrices and elementary properties, computation of largest eigenvalue by power method.	10	4
	****Assignment Topics**	Solution of systems of linear equations by Jacobi method and Gauss-Seidal method.	1	4
Module 5: < Numerical Methods-II>	in class	Numerical solution of algebraic and transcendental equations using Newton Rapson's method, Solution of nonlinear equation by Newton Raphson's method, Numerical solution of initial value problems in ordinary differential equations by Taylor series method, Runge-Kutta Fourth order Method.	7	5
	****Assignment Topics**	Runge-Kutta Fourth order Method.	1	5

Text Books:

1. Erwin Kreyszig : Advanced Engineering Mathematics, Wiley.
2. S. S. Sastry: Introductory Method Numerical Analysis. PHI.
3. I. Sneddon, Elements of Partial Differential Equations, Dover Publications INC.

Reference Books:

1. M. K. Jain and S.R.K. Iyengar and R. K. Jain: Numerical methods for scientific and engineering computations. New Age International.
2. Conte and deBoor: Elementary Numerical Methods, an algorithmic approach, McGraw Hill.

VT201A1 **Credit: 4 (L-3, T-1, P-0)**

ELECTRONIC DEVICES & COMPONENTS

Questions to be set: 05 (All Compulsory)

Course Objectives:

i. To gain insight to the world of Device Electronics
ii. To gain idea about device circuit interaction
iii. To learn about the various biasing techniques which assist in improving system performance

Pre-requisites: Basic Electronics, Engineering Physics.

Course Outcomes (CO): Students should be able to

1. Comprehend the fundamentals of Semiconductor Physics.
2. Insight of P-N Junction diodes and different types of contacts.
3. Apply the knowledge of Bipolar Junction Transistors (BJT) characteristics and implementation on electronic circuit design.
4. Design different transistor amplifier circuits.
5. Apply the knowledge of Field Effect Transistor (FET) characteristics and implementation on electronic circuit design.

** not more than 20% of total topics to be allotted for assignment

Module	Topics to be covered	Topics	Hrs	CO
Module 1: **Semiconductor Fundamentals**	in class	Crystal structure, Fermi level, energy-band diagram, intrinsic and extrinsic semiconductor, carrier concentration, scattering and drift of electrons and holes, diffusion mechanism, Hall effect, generation, recombination and injection of carriers.	9	1
	****Assignment Topics**	Numericals on Drift Velocity, Mass-Action Law, Hall-Effect.		1
Module 2: **PN Junctions & Semiconductor Contacts**	in class	Metal-semiconductor junction: Ohmic and Schottky Contacts. Biasing, forward and reverse characteristics, I-V characteristics, Zener diode, Photodiode, Light Emitting Diode, Solar Cells, Diode as a switch, rectifier, regulator, clipper, clamper circuits.	9	2
	****Assignment Topics**	Numericals on Diode Equation, Experimental Observation of LED, Solar Cell Efficiency Measurement.		2
Module 3: **Bipolar Junction Transistor (BJT)**	in class	Introduction, CE, CB, CC configurations, region of operation, biasing, Graphical analysis (DC and AC load line), Biasing and Stabilization of Q- point.	8	3
	****Assignment Topics**	Numericals on Transistor relations among different configurations, viz. α, β and γ.		3
Module 4: **Transistor As An Amplifier**	in class	Multistage amplifiers-gain calculation. RC Coupled Amplifiers- functions of all components, equivalent circuit and derivation of voltage gain, frequency	10	4

		response characteristics, lower and upper half frequencies, bandwidth. Distortion in Amplifiers. Darlington Amplifiers.		
	****Assignment Topics**	Numericals on gain, frequency, and bandwidth calculations of the amplifier.		4
Module 5: **Field Effect Transistors (FET)**	in class	JFET and its principle of operation. Static characteristics of JFET. Concept of pinch off voltage. Metal insulator semiconductor junction. Accumulation, Depletion and Inversion, Enhancement and Depletion type MOSFET. Static characteristics of MOSFET. MOSFET as amplifier.	12	5
	****Assignment Topics**	Numericals on FET Transconductance expression, pinch-off voltage calculation.		5

Text-Books:

1. Ben Streetman and Sanjay Banerjee, Solid State Electronic Devices, 7e, Prentice-Hall, 2015.
2. Donald A. Neamen, Semiconductor Physics And Devices: Basic Principles, 4e, Tata McGraw-Hill Pvt. Ltd., 2012.
3. Millman J and Halkias, Integrated Electronics, 2e, McGraw Hill Education (India) Pvt.Ltd, 2009.

Reference Books:

1. D Chattopadhyay and P.C. Rakshit, Electronics Fundamentals and Applications, 1e, New Age International Publications, 2008.
2. Boylestead and Nashelsky, Electronic Devices and Circuits Theory: 11e, Prentice-Hall, India, 2012.
3. J. Milman and A. Grabel, Microelectronics, 1e, Tata McGraw-Hill Education, 2001.

VT202A1 **Credit: 4 (L-3, T-1, P-0)**

Digital Electronics and System Design

Questions to be set: 05 (All Compulsory)

Course Objective: To introduce the students with the Digital Electronics and designing of combinational and Sequential circuits. In this subject, students are introduced with digital electronics and the various design methodologies of combinational logic circuits. Brief about Number systems with special emphasis on binary system are encompassed in the subject. In this subject, students learn how to design logic circuits like adder, subtractor, code converters, multiplexers, decoders etc. Students are also introduced to sequential digital circuits.

Pre-requisites: Basics of number systems, Basics of electronics.

Course Outcomes (CO): On Successful Completion of the course, students will be able to

CO	STATEMENT
CO1	Analyze combinational logic circuits for practical applications.
CO2	Explain the internal circuits of various logic family ICs.
CO3	Analyze sequential logic circuit using flip-flop.
CO4	Analyze synchronous sequential machine for practical applications.
CO5	Describe the basics of semiconductors memories.

** not more than 20% of total topics to be allotted for assignment

Module	Topics to be covered	Topics	Hrs	CO
Module 1: **Codes in Binary system & Combinational logic circuits design:**	in class ****Assignment Topics**	BCD code, Excess 3 code, gray code, Boolean algebra, Forms of Expressions SOP, Universal Logic gates, Introduction to K-map, Design of combinational logic circuits: adder, subtractor, Code Converters, Quine-Mc-Cluskey method, Comparators, Parity generator. Concept of fan-in and fan-out of logic cells. Number Systems, POS	10	1
Module 2: **MSI Combinational circuit & Logic families:**	in class	Quine-Mc-Cluskey method, Multiplexers, Demultiplexers, Encoders, Decoders Look Ahead Carry Adder. Logic families: Introduction to logic families, Characteristics of digital ICs, Interfacing of TTL and CMOS. Circuits of TTL family logic gates	8	2
Module 3: **Introduction to sequential logic and Counter design:**	In Class	Need for sequential circuits. Latches and flip-flops. Circuits and characteristics RS, JK, Master-Slave JK, D & T flip flops. Conversion of Flip flops. Design of synchronous, asynchronous and hybrid counters, programmable counter, Ring counter, Shift registers.	10	3
Module 4:	In Class	Fundamentals of Synchronous sequential circuits, Classification of synchronous machines, Design of	12	4

Design and Analysis of Sequential circuits:		Synchronous Sequential circuits - design approaches, state reduction, design of next state decoder and output decoder, ASM charts.		
	****Assignment Topics**	Basics of Asynchronous sequential circuit		
Module 5: **Semiconductor memory and programmable logic devices:**	In Class	Read Only Memory (ROM) -PROM, EPROM, EEPROM, random access memory (RAM)-static, dynamic, memory characteristics, memory organization and applications. Architecture of PAL, PLA, PLD and their application.	8	5

Text Books:

1. Morris Mano, "*Digital Logic and Computer Design,* Pearson Education India", 1st Edition, 2016.
2. William I. Fletcher, "*An Engineering Approach to Digital Design",* Pearson Education India, 1st Edition, 2015.

Reference Books:

1. Ronald J. Tocci, Neal S. Widmer, and Gregory L. Moss, "*Digital Systems: Principles and Applications",* Pearson Education, 11th Edition, 2010.
2. R. P. Jain, "*Modern Digital Electronics"*, Tata McGraw-Hill Publishing Company Ltd., 3rd Edition, 2006.

VT203A1 **Credit: 4 (L-3, T-1, P-0)**

Signals and Systems

Questions to be set: 05 (All Compulsory)

Course Objective : To serve as a beginner course in acquiring knowledge in Signals and Systems. This course describes fundamentals of Signals and systems, Fourier series (CTFS), Fourier transform (CTFT), Laplace transform, Z transform and their application areas.

Pre-requisites: Basic Trigonometry, Coordinate geometry and thorough knowledge of: Complex analysis, Integral and differential calculus, Solution of linear differential and difference equation.

Course Outcomes(CO):

CO1	Students should be able to understand basics of signals and systems and their mathematical representation.
CO2	Students should be able to interpret spectral analysis of periodic and aperiodic signals using Fourier methods.
CO3	Students should be able to understand the LTI systems and their effect on signals passing through them in time and frequency domains.
CO4	Students should be able to apply Laplace transform to continuous-time domain signals/systems for stability analysis.
CO5	Students should be able to apply Z- transform to discrete-time domain signals/systems for stability analysis.

** not more than 20% of total topics to be allotted for assignment

Module	Topics to be covered	Topics	Hrs	CO
Module 1: Basic Signals, Its Operation and Analysis	in class	Unit step, Unit Impulse and Unit Ramp Functions, Properties of different singularity functions, Classification of signals and their mathematical representations, Basic Operations on Signals: Time shifting, Time scaling, Time reversal. Convolution Integrals and Convolution Sum, Properties of Convolution Integrals and Convolution Sum, Correlation of Signals: Cross correlation and autocorrelation of continuous and discrete time energy and power signals, Properties of cross correlation and autocorrelation. Amplitude and Phase spectra of a signal, Physical significance of the exponential form of Sine and Cosine waveform (Vector diagram), Concept of negative frequency, Introduction of Orthogonal basis functions.	9	1
	****Assignment Topics**	Numerical on Signal shifting, scaling, convolution and correlation		
Module 2: Spectral Density and Systems	in class	Energy Spectral Density (ESD), Power Spectral Density (PSD), Properties of ESD and PSD, Relationship between PSD, ESD and the auto correlation function. Introduction to Systems, Classification of continuous and discrete time systems, Mathematical representation of Different types of systems, Linear Time Invariant (LTI) systems, system transfer functions, impulse responses.	9	2

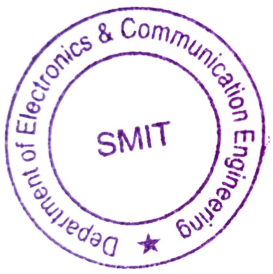
	****Assignment Topics**	Comparison of different type of systems		
Module 3: **Fourier Analysis**	in class	Fourier Series: Dirichlet conditions, Trigonometric Fourier series, Trigonometric Fourier series coefficients, Symmetry conditions, Polar form and exponential form of Fourier Series, relationship between exponential and trigonometric Fourier series, Gibb's Phenomenon. Fourier Transform: Continuous Time Fourier transform (CTFT), Condition for Fourier Transform, Properties of CTFT, Parseval's theorem, Inverse Fourier Transform using Partial fraction.	10	2
	****Assignment Topics**	Numerical on Fourier Series and Transform		
Module 4: **Laplace Transform**	in class	Laplace Transform: Concept of Complex Frequency, Introduction to Laplace Transform, Concept of poles and zeros, System transfer function, Necessity of Laplace Transform, Unilateral and Bilateral Laplace Transform, Condition for existence of Laplace Transform, Region of convergence (ROC), ROC of finite duration signal, Necessity of Unilateral Laplace Transform, Significance of initial condition, Relationship between poles and ROC, Relationship between Laplace transform and Fourier Transform, Properties of Laplace Transform, initial value theorem, final value theorem, Inverse Laplace Transform using partial fraction method.	10	3
	****Assignment Topics**	Numerical on Laplace Transform		
Module 5: **Z Transform**	in class	Z Transform: Sampling, Discrete signals, Z transform, relation between s – plane and z – plane, Relationship between Fourier, Laplace and Z-Transformation; Properties of ROC, ROC of causal and Anti causal signals, Condition for existence of Z transform, Properties of z-transforms, Shifting theorem, Initial and final value theorem, Inverse – Z transforms using long division method and partial fraction method, Transfer function of delay unit, realization of z-domain transfer function, Solution of difference equations using z-transform.	10	4,5
	****Assignment Topics**	Numerical on Laplace and Z Tranform (inverse transforms as well)		

Text Books:

1. A.V. Oppenheim, A.S.Willsky, *Signals and Systems*, 2e, PHI, 1997.
2. Robert A. Grabel and Richard A. Roberts, *Signals and Linear System*, 3e, Wiley 2009

Reference Books:

1. B.P.Lathi, *Principles of Linear Systems and Signals*, 2e, Oxford University Press, 2009.
2. H P Hsu, *Signals and Systems*, Schaum Outline Series, 3e, Tata McGraw Hill,2014.
3. T.K. Rawat, *Signals and Systems*, 1e, Oxford University Press, 2010.
4. P. Rameshbabu, R. Anandanatarajan, *Signals and Systems*, 4e, Scitech Publication, 2011.



Fourth Semester Major Theory Subjects

MA208A1 **Credit: 4 (L-3, T-1, P-0)**

ENGINEERING MATHEMATICS IV

Questions to be set: 05 (All Compulsory)

Course Objectives Objective of teaching Probability is to provide basic foundation on Probability and Random processes (or Stochastic Processes) its applications in the field of Science and Engineering. Random process has enormous applications in Digital Communications & Modeling of physical problems. Complex numbers are applied to study control theory, signal analysis, electromagnetism and electrical engineering etc.

Pre-requisites: Engineering Mathematics I, II, and III.

Course Outcomes (CO): By attending this course, the students will be able to

CO1: Define the concepts of probability, discrete and continuous random variables and apply this knowledge in to different real world situations.

CO2: Apply the concepts of random process and Markov chain which are essentially models of many times dependent processes as a team or individual.

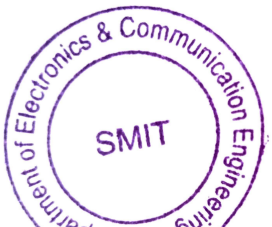
CO3: Students can analyze engineering problems with the solution to the community applying the knowledge of random processes and the concepts of singularity in complex analysis.

CO4: Analyze the properties of analytic functions and use them efficiently.

CO5: Use concepts in Stochastic processes and Complex integrals to apply various problems that arise in Electronics and communication engineering.

** not more than 20% of total topics to be allotted for assignment

Module	Topics to be covered	Topics	Hrs	CO
Module 1: <Vector Space and Linear Transformation>	in class	Basic concepts on Borel sets and measure, Axiomatic definition, conditional probability and independence, Baye's theorem.	10	1
Module 2: <Inner Product Space and Orthogonalization>	in class	One and Two dimensional random variables with moments (up to second order), covariance, correlation coefficients. Distributions: Binomial, Poisson, Uniform, Normal, Gamma, and Exponential distribution. Central Limit Theorem.	10	2
Module 3: <Partial Differential Equation>	in class	Random Processes: Definitions, Classifications. Auto Correlation and Covariance functions, Weak sense and Strong sense stationary processes.	8	2,5
Module 4: <Numerical Methods-I>	in class	Discrete Parameter Markov chain: Basic ideas, Computation of n step transition probabilities using Chapman Kolmogorov Theorem. (Restricted to two state problems).	12	3,5



		Complex variables, functions, continuity, differentiability, analyticity -Cauchy Riemann equations and properties of analytic functions.		
Module 5: < Numerical Methods-II>	in class	Line integrals in complex plane and basic properties of Cauchy's integral theorem and Cauchy's integral formula -derivatives of analytic functions. Taylor, Maclaurin and Laurent's series, residue theorem, evaluation of standard real integrals using contour integrals.	8	5

Text Books:

1. P.L. Meyer; Introductory Probability theory and statistical Applications, Second Ed. Oxford & IBM Publishers, 1997
2. R. V. Churchill and J. W. Brown : Complex variables and applications, McGraw Hill,
3. K.S. Trivedi : Probability & Statistics with Reliability, Queuing and Computer Science Applications, PHI,

Reference Books:

1. Murray R. Spigel : Complex variable, Schaum's Outline Series.
2. Erwin Kreyszig : Advanced Engineering Mathematics, Wiley Eastern
3. William Feller :Introduction to Probability Theory and its Applications, (Vol I & II) 2008, Wiley

VT204A1 **Credit: 4(L-3, T-1, P-0)**

Analog Electronics Circuits

Questions to be set: 05 (All Compulsory)

Course Objectives: To enrich the knowledge of the students with a sound understanding of analog electronic circuit, this will help them in the further course of their studies. It exposes the students to various types of analog electronic circuit which will help them to relate this with the other courses which they have in their future semesters, as well as its importance from industrial point of view.

Pre-requisites: Basic idea on Electrical and Electronic Circuits. Engineering Physics.

Course Outcomes (CO):

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

CO1: Explain and design different types of feedback amplifiers and Oscillator

CO2: Explain and design different types of power amplifiers

CO3: Explain the working principle of Operational Amplifier and implement the linear and non-linear applications of Operational Amplifier

CO4: Analyze and design different types of filter circuits using OPAMPs

CO5: Explain and design Multivibrators and Special functional circuits

** not more than 20% of total topics to be allotted for assignment

Module	Topics to be covered	Topics	Hrs	CO
Module 1: **Feedback Amplifiers & Oscillator**	in class	Basic principles and types of feedback, feedback topology, derivation of expression for gain, effect of negative feedback in gain, stability, distortion and bandwidth of an amplifier, Barkhaushen criterion, Different oscillator circuits: Wien-Bridge, Hartley, and Crystal.	10	1
	****Assignment Topics**	Derivation of expression for frequency of RC Phase Shift and Colpitt Oscillator.		1
Module 2: **Power Amplifiers**	in class	Class A, B, AB, C, Push-Pull Amplifiers, Tuned Amplifiers.	10	2
	****Assignment Topics**	Derivation of Conversion Efficiency of class A, B power amplifier.		2
Module 3: **Operational Amplifiers and its applications**	in class	Characteristics of an ideal operational amplifier and its block diagram, Differential amplifiers and its characteristics-CMRR, Slew-Rate, Offset Voltage and Current, Gain-Bandwidth Product, Open & Closed loop operation, inverting and non-inverting amplifier, voltage follower, Summing amplifier, Differentiator, Integrator, Comparator, Precision rectifiers, Sample and Hold circuits.	10	3

	****Assignment Topics**	Schmitt trigger, Instrumentation amplifier.		3
Module 4: **Active Filters**	in class	Design and analysis of first and second order low pass, high pass, band pass, , Gain-Frequency Curve.	10	4
	****Assignment Topics**	Band reject filters and Notch filters		4
Module 5: **Multivibrators and Special Functional Circuits**	in class	Implementation of Multivibrators using Transistor and 555 Timer, Introduction of VCO and PLL.	8	5
	****Assignment Topics**	A-to-D Converter, D-to-A Converter.		5

Textbooks:

1. Robert L. Boylestad, Louis Nashelsky, *Electronic devices and circuit theory*, Pearson Education, 11th Edition, 2013.
2. Jacob Millman, Christos Halkias, Chetan Parikh, *Integrated Electronics*, McGraw Hill Education, 2nd Edition, Paperback, 2009.
3. RamakantGayakwad, *Opamps& Linear Integrated Circuits*, PHI, 4th Edition, 2004.
4. V S KanchanaBhaaskaran , Salivahanan, *Linear Integrated Circuits*, Tata Mcgraw Hill Education Private Limited 2nd Edition, 2008.

Reference Books:

1. Donald Schilling, Charles Belove, *Electronic Circuits: Discrete and Integrated*, McGraw Hill Education (India) Private Limited; 3rd Edition, 2002.
2. S Salivahanan, N. Suresh Kumar, *Electronic Devices and Circuit*, McGraw Hill Education (India) Private Limited; 3rd Edition, 2012.
3. D. Chattopadhyay, P.C. Rakshit, *Foundations of Electronics*, New Age International Publishers Ltd., 2nd Edition, 2015.
4. Choudhury D. Roy, Shail B. Jain, *Linear Integrated Circuits*, New Age International Publishers Ltd., 4th Edition, 2010.
5. David A. Bell, *Electronic Devices and Circuits*, Oxford Publications, 5th Edition, 2008.
6. Albert Malvino, David Bates, *Electronic Principles*, McGraw Hill Education (India) Private Limited; 7th Edition, 2006.

VT205A1 **Credit: 4(L-3, T-1, P-0)**

Microprocessor, Microcontroller and ARM Processors

Questions to be set: 05 (All Compulsory)

Course Objectives: To provide solid foundation on the fundamentals of microprocessors and microcontrollers and their applications, interfacing the external devices to the processor according to the user requirements thus, enabling to create novel products and solutions for real time problems. The students will also be introduced to basic architecture of ARM Processors

Pre-requisites: Digital Circuits & Logic Design, Basics of PC Hardware and peripherals

Course Outcomes (CO):

After completion of this course, students should be able to

1. Learn about the basics of architecture of a microprocessor
2. Describe the architectures of 8086 microprocessors
3. Know about the architecture of 8051, its interrupts and interfacing applications
4. Understand the features of architecture of ARM7 and Applications
5. Interpret the exception, interrupts, and interrupt handling schemes

** not more than 20% of total topics to be allotted for assignment

Module	Topics to be covered	Topics	Hrs	CO
Module 1: **Introduction to 8085**	in class	CPU architecture – register organization, 8085 instruction set, addressing modes. Instruction cycle, machine cycle, timing diagrams. Programming using 8085 instruction set Interfacing memory: Interfacing I/O – memory mapped I/O and I/O mapped I/O,	10	1
	****Assignment Topics**	8257 – Direct Memory Access Controller (DMAC).		1
Module 2: **Introduction to 8086**	in class	8086 architecture, addressing mode. Instructions and assembly language programming. Interrupts of 8086. Intel 8086 bus cycles, instruction queue, read/write cycle in MIN and MAX mode, reset operation, wait state, halt state, hold state, lock operation, interrupt processing. DOS interrupt 21 h functions	10	2
	****Assignment Topics**	Introduction to 80286, 80386, 80486 & Pentium Microprocessors		2
Module 3: **Introduction to 8051**	in class	8051 Architecture - Registers, Pin diagram, I/O ports functions, Internal Memory organization. External 8051 Stack, Stack and Subroutine instructions. Assembly language program examples on subroutine and involving loops. Real Time Control: Programming Timer interrupts, programming external hardware interrupts, Programming the serial communication interrupts, Programming 8051 timers and counters.	10	3

	****Assignment Topics**			3
Module 4: **ARM Processor Fundamentals**	in class	The RISC design philosophy, ARM design philosophy, ARM core data flow model, Registers, CPSR-Processor modes, Banked registers. Pipeline-Characteristics Fundamentals of ARM instructions, Barrel shifter, Classification, and explanation of instructions with examples Explanation of instructions with examples Data processing, Branch, Load-store, SWI and Program Status Register instruction.	10	4
	****Assignment Topics**			4
Module 5: **Exception and Interrupt handling schemes**	in class	Exception handling- ARM processor exceptions and modes, vector table, exception priorities, link register offsets. Interrupts- assigning interrupts, interrupt latency, IRQ and FIQ exceptions with example	8	5
	****Assignment Topics**	Differences between ARM and THUMB		5

Text Books:

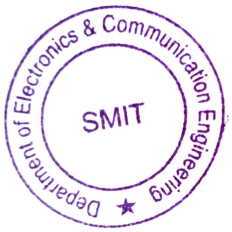
1. Ramesh Gaonkar, Microprocessor Architecture, Programming and Applications with the 8085, Penram International, Sixth Edition, 2013.
2. Douglas V. Hall, "Microprocessor & interfacing programming and hardware", Tata McGraw Hill. 2nd Edition,1992
3. ARM System Developer's guide –Andrew N. SLOSS, ELSEVIER Publications, ISBN
   978-81-8147-646-3, 2016
4. 2. ARM Assembly Language – William Hohl, CRC Press, ISBN:978-81-89643-04-1

Reference Books:

1. B. Ram, Fundamentals of Microprocessors and Microcontrollers, Seventh Edition, Dhanpat Rai Publications, 2010.
2. Bary B. Brey, "The Intel Microprocessors: 8086/8088, 80286, 80386, 80486", Prentice Hall,2nd Edition ,1996.
3. ARM System-on-chip Architecture by Steve Furber, Pearson Education,ISBN978-81-
   317-0840-8, 2E,2012
4. LPC 2148 USER MANUAL
5. IN SIDE R'S GUIDE TO PHILIPS ARM7 BASED MICROCONTROLLERShitex.co.uk
6. ARM Programming Techniques – from ARM website
7. Embedded Systems: A Contemporary Design Tool- James K. Peckol ISBN: 978-0-471-72180-2 October 2007, ©2008

Fifth Semester

Major Theory Subjects



VT301A1 **Credit: 4 (L-3, T-1, P-0)**

Communication Engineering

Questions to be set: 05 (All Compulsory)

Course Objective: This course is designed to teach the analysis and design of analog communication systems. Topics include amplitude modulation, angle modulation and pulse modulation techniques, their generation as well as demodulation. Analysis of random signals and the comparison of receivers based on their noise performances is also included. This course is designed give a brief idea about Digital Communication & its related fundamentals. The course entitles major portions namely Digital Sources, Transmitters, Receivers, Nyquist Sampling theory, Quantization & Companding in PCM, Concept of PSK, FSK, DPSK and Information theory & Coding.

Pre-requisites: Fourier series and Fourier Transforms, probability and random process, and Signals and Systems.

Course Outcomes (CO): On Successful Completion of the course, students should be able to

CO	STATEMENT
CO1	Explain the basic concepts of amplitude modulation and demodulation techniques.
CO2	Analyze continuous angle (frequency and phase) modulation techniques, Evaluate the performance of analog communication systems in presence of noise.
CO3	Explain the basic concepts of digital modulation.
CO4	Analyze various types of multiplexing.
CO5	Analyze various types of digital modulation technique.

** not more than 20% of total topics to be allotted for assignment

Module	Topics to be covered	Topics	Hrs	CO
Introduction to Analog Communication	in class	Types and reasons for modulation. Amplitude Modulation (AM), Demodulation of AM signals-envelope detectors. Single Side Band Modulation (SSB), Double side band suppressed carries (DSB)modulation, Vestigial side band modulation (VSB). Frequency Modulation (FM) and Phase Modulation (PM), Overview of Instantaneous frequency and instantaneous phase, FM and PM, Transmission bandwidth for FM,	10	1
	****Assignment Topics**	Generation of SSB using a side band filter, indirect generation of SSB.		
Frequency modulation and Phase Modulation	in class	Phasor diagram for FM and PM Generation of FM using Armstrong method, Commercial FM requirements. Demodulation of FM and PM signals, the limiter discriminator, PLL Different categories of Noise. Calculation of Noise Power and Noise Figure, Significance of Noise Figure, Noise performance of	10	2

		Analog Communication system, Signal to noise ratio in linear modulation, synchronous detection of DSB. Signal to noise ratio for AM & SSB, comparison of DSB, SSB and AM. Signal to noise ratio for FM		
	****Assignment Topics**	The noise bandwidth of a linear time invariant systems and its use in communication. SNR improvement using pre-emphasis & de-emphasis networks.		
Introduction to Digital Communication:	In Class	Basic block diagram of Digital communication systems, Analog to digital conversion technique: Sampling, Quantizing and Encoding, Nyquist sampling theory, Spectrum of a sampled signal, Aliasing, Effects of aliasing, Reconstruction of sampled signals, Anti-aliasing filter, Interpolation filter. Waveform coding Techniques Pulse code modulation(PCM), Block diagram, Transmitter and Receiver.	10	3
	****Assignment Topics**	Overview of Wireless Channel: AWGN, Rayleigh, Rician, Optimum detection of a pulse in additive white noise,		
Quantizer & Multiplexing:	In Class	Quantizer, Types of quantizer, Working principle of quantizer, Bandwidth of PCM, Quantization Noise in PCM, Signal to Quantization Noise Ratio, Effect of noise in PCM. Application of PCM. The Differential PCM (DPCM), Adaptive DPCM, delta modulation. Necessity of non-uniform quantizing, Companding, μ-law and A-law. Multiplexing(M) and Multiplexing Access (MA) Techniques: FDM/CDM/SDM and comparison of TDM and TDMA, CDM and CDMA, FDM and FDMA	8	4
	****Assignment Topics**			
Baseband Digital Data Transmission	In Class	Base band digital data transmission, Types of Line codes: Unipolar and bipolar NRZ and RZ format, Alternate Mark Inversion (AMI) format, Split phase Manchester code format, Polar quaternary NRZ format. Inter symbol Interference, Eye Diagram, SNR and Probability of error of a)Integrate and Dump Filter b)Optimum Receiver, c)Matched Filter.	10	5
	****Assignment Topics**	Raised Cosine Filter, Nyquist Condition for zero ISI, Band limited Nyquist pulses.		
Digital Modulation Techniques		Generation and detection of ASK, FSK, PSK, DPSK, QPSK,QAM and MSK; Signal space representation, Bandwidth requirement and probability of error calculation of BPSK and QPSK , concept of BER and throughput, Channel coding techniques		
	****Assignment Topics**	Probability of error for QAM		

Text Books:

1. S. Haykin , An Introduction to Analog and Digital communications,4e, Willey Eastern. New York, 1989.
2. B.P.Lathi, Communication systems, oxford series, 4e, 2009

Reference Books:

1. C.W. Couch II. “Digital and Analog Communication Systems” 2e, Macmillan publishing company, New York, 1987.
2. Taub ,D.L.Shelling , Principles of Communication Systems, 2e, McGraw Hill Book Co**.,** 2005.
3. Edward A. Lee, David G Messerschmitt, *Digital Communication*, 2e., Kluwer Academic Press, 2005.
4. Sanjay Sharma, *Communication Systems (Analog and Digital)*, 5e., S.K. Kataria & Sons, 2013.
5. P. Chakrabarty, *Analog and Digital Communication Systems*, 1e., reprint 2013, Dhanpat Rai & Co.
6. Paul L. Meyer, *Introductory Probability and Statistical Applications*, 2e, Addison Wesley,1980.

VT302A1 **Credit: 4 (L-3, T-1, P-0)**

INTRODUCTION TO MICRO-FABRICATION

Questions to be set: 05 (All Compulsory)

Course objectives:

The course aims to provide an overview of fabrication technologies and materials needed to realize modern micro-devices. It demonstrates how common micro-fabrication principles can be applied in different applications, Latest developments in wafer engineering, patterning, thin films, surface preparation and bonding.

Prerequisite: Semiconductors, semiconductor physics and solid state devices.

Course outcomes

On completion of the course, the student will be able to:
1. Elucidate the CMOS process flow.
2. Analyze various critical processing steps in microfabrication.
3. Appreciate the advanced methods involved in IC fabrication.
4. Analyze the advancements in CMOS process fabrication with scaling in technology.
5. Have an understanding and overview of interconnects, metal gate, planarization, etc.

Module	Topics to be covered	Topics	Hrs	CO
1	In Class	Introduction: History of IC's; Operation & Models for Devices of Interest: CMOS and MEMS. Electronic Materials: Crystal Structures, Defects in Crystals, Si, Poly Si, Si Crystal Growth. Clean room and Wafer Cleaning: Definition, Need of Clean Room, RCA cleaning of Si.	10	1
	Assignment Topics:			
2	In Class	Oxidation: Dry and Wet Oxidation, Kinetics of Oxidation, Oxidation Rate Constants, Dopant Redistribution, Oxide Charges, Device Isolation, LOCOS, Oxidation System.	10	2
	Assignment Topics:			
3	In Class	**Lithography:** Overview of Lithography, Radiation Sources, Masks, Photoresist, Components of Photoresist Optical Aligners, Resolution, Depth of Focus, Advanced Lithography: E-beam Lithography, X-ray Lithography, Ion Beam Lithography.	10	3

	Assignment			
	Topics:			
4	In Class	**Diffusion:** Pre-Deposition and Drive-in Diffusion Modeling, Dose, 2-Step Diffusions, Successive Diffusion, Lateral Diffusion, Series Resistance, Junction Depth, Irvin's Curves, Diffusion System. Ion Implantation: Problems in Thermal Diffusion, Advantages of Ion Implantation, Applications in ICs, Ion Implantation System, Mask, Energy Loss Mechanisms, Depth Profile, Range & Straggle, Lateral Straggle, Dose, Junction Depth, Ion Implantation Damage, Post Implantation Annealing, Ion Channeling, Multi Energy Implantation Thin Film Deposition: Physical Vapor Deposition: Thermal evaporation, Resistive Evaporation, Electron beam evaporation, Laser ablation, Sputtering Chemical Vapor Deposition: Advantages and disadvantages of Chemical Vapor deposition (CVD) techniques over PVD techniques, reaction types, Boundaries and Flow, Different kinds of CVD techniques: APCVD, LPCVD, Metalorganic CVD (MOCVD), Plasma Enhanced CVD etc. Concept of atomic layer deposition (ALD).	10	4
	Assignment			
	Topics:			
5	In Class	**Etching:** Anisotropy, Selectivity, Wet Etching, Plasma Etching, Reactive Ion Etching. Overview of Interconnects, Contacts, Metal gate/Poly Gate, Metallization, Problems in Aluminum Metal contacts, Al spike, Electromigration, Metal Silicides, Multi-Level Metallization, Planarization, Inter Metal Dielectric.	8	5
	Assignment			
	Topics:			

Books

1. Silicon VLSI Technology, Plummer, Deal and Griffin,1st Edition, Pearson Education,2009.
2. Fundamental of Semiconductor Fabrication, Sze and May,2nd Edition, Wiley India, 2009
3. Silicon Process Technology, S K Gandhi,2nd Edition, Wiley India,2009

VT303A1 **Credit: 4 (L-3, T-1, P-0)**

VLSI VERIFICATION AND TESTING USING EDA TOOLS

Questions to be set: 05 (All Compulsory)

Course objectives:

Digital VLSI Design flow comprises three basic phases: Design, Verification, and Test. The web course would cover theoretical, implementation, and CAD tools pertaining to these three phases. Although there can be individual full courses for each phase, the present course aims to cover the important problems/algorithms/tools so that students get a comprehensive idea of the whole digital VLSI design flow. VLSI Design: High-level Synthesis, Verilog RTL Design, Combinational and Sequential Synthesis Logic Synthesis (for large circuits). Verification Techniques: Introduction to Hardware Verification and methodologies, Binary Decision Diagrams (BDDs) and algorithms over BDDs, Combinational equivalence checking, Temporal Logics, Modeling sequential systems and model checking, Symbolic model checking. VLSI Testing: Introduction, Fault models, Fault Simulation, Test generation for combinational circuits, Test generation algorithms for sequential circuits, and Built-in Self-test.

Prerequisite: Digital electronics, VLSI

Course outcomes

On completion of the course, the student will be able to:
1. understand scheduling, allocation, and binding.
2. describe the logic synthesis and binary decision diagram.
3. interpret the temporal logic and model checking.
4. realize the concept of testing and fault simulation.
5. understand the test pattern generation and memory testing.

Module	Topics to be covered	Topics	Hrs	CO
1	In Class	**Introduction** Lecture I: Introduction to Digital VLSI Design Flow Lecture II: High Level Design Representation Lecture III: Transformations for High Level Synthesis FPGA and field-programmable analog array (FPAA) **Scheduling, Allocation and Binding** Lecture I: Introduction to HLS:Scheduling, Allocation and Binding Problem Lecture II and III: Scheduling Algorithms Lecture IV:Binding and Allocation Algorithms	10	1

	Assignment			
	Topics:			
2	In Class	**Logic Optimization and Synthesis** Lecture I,II and III: Two level Boolean Logic Synthesis Lecture IV: Heuristic Minimization of Two-Level Circuits Lecture V: Finite State Machine Synthesis Lecture VI: Multilevel Implementation **Verification: Binary Decision Diagram** Lecture-I:Binary Decision Diagram: Introduction and construction Lecture-II: Ordered Binary Decision Diagram Lecture-III: Operations on Ordered Binary Decision Diagram Lecture-IV: Ordered Binary Decision Diagram for Sequential Circuits	10	2
	Assignment			
	Topics:			
3	In Class	**Temporal Logic** Lecture-I: Introduction and Basic Operations on Temporal Logic Lecture-II:Syntax and Semantics of CLT Lecture-III:Equivalence between CTLFormulas **Model Checking** Lecture-I:Verification Techniques Lecture-II, III and IV: Model Checking Algorithm Lecture-V:Symbolic Model Checking	10	3
	Assignment			
	Topics:			
4	In Class	**Test: Introduction to Digital Testing** Lecture-I: Introduction to Digital VLSI Testing Lecture-II: Functional and Structural Testing Lecture-III: Fault Equivalence **Fault Simulation and Testability Measures** Lecture-I, II and III: Fault Simulation Lecture-IV: Testability Measures (SCOAP)	10	4
	Assignment			
	Topics:			
5	In Class	**Combinational Circuit Test Pattern Generation** Lecture-I: Introduction to Automatic Test Pattern Generation (ATPG) and ATPG Algebras	8	5

Lecture-II and III: D-Algorithm

Sequential Circuit Testing and Scan Chains

Lecture-I: ATPG for Synchronous Sequential Circuits Lecture-II and III:Scan Chain based Sequential Circuit Testing

Built in Self test (BIST)

Lecture I and II:Built in Self Test Lecture III and IV: Memory Testing

Assignment

Topics:

Books

1. D. D. Gajski, N. D. Dutt,A.C.-H. Wu and S.Y.-L. Lin, HighLevel Synthesis: Introduction to Chip and System Design, Springer, 1st edition, 1992.
2. S.Palnitkar,Verilog HDL:A Guide to Digital Design and Synthesis,Prentice Hall, 2nd edition, 2003.
3. G. De Micheli.Synthesis and optimization of digital circuits, 1st edition, 1994.
4. M. Huth and M. Ryan, Logic in Computer Science modeling and reasoning about systems, Cambridge University Press, 2nd Edition, 2004.
5. Bushnell and Agrawal,Essentials of Electronic Testing for Digital, Memory & Mixed-Signal Circuits,Kluwer Academic Publishers, 2000

VT304A1 **Credit: 4 (L-3, T-1, P-0)**

EMBEDDED SYSTEMS

No. of questions to be set: 1 from each CO
No. of questions to be answered: Five

Objectives: The objective of this course is to impart a solid understanding of the role of embedded systems and embedded systems design and development. This course delves into the processes of Real-Time Embedded Systems to provide the basic foundation in embedded systems.

Pre-requisites: Concepts of Digital Systems and Computer organization & architecture.

Course outcomes:

On completion of the course, the student will be able to:

1. describe the basics of design, modelling, development of embedded systems

2. develop the hardware for embedded system applications based on the processors

3. simulate and synthesize the embedded system by using the Embedded system and Linux operating system.

4. apply various real-time algorithms and implement the RTOS development tools in building real-time embedded systems.

5. design various advanced embedded systems.

Module	Topic	Hrs	CO
1 **Introduction to Embedded System**	**Introduction. Definition, Categories of embedded systems, components, requirements of embedded systems, Challenges and issues in embedded system.**	8	1
2 **Concept of different Processors**	Design with 8051, Basic knowledge in ARM, PIC and Digital Signal Processor, Architecture of embedded memory, Basic structure and applications of Latch, Buffer, Crystal, reset circuit, Watch dog timer, Display unit and key pad.	10	2
3 **Embedded Programming**	Embedded programming in C for relay, stepper motor, opto-coupler, serial port, timer, interrupt, project study in C for LCD, Keyboard interfacing, elevator. Concepts of Linux Programming, I/O programming, Process and memory management programming, cell programming. Arduino and MSP 430 programming.	10	3
4 **Real time operating System**	Introduction, Basic features, description of Layer model and Kernel operations for general operating system and real time operating system, concept of Task, Process and Thread, Task Scheduling, Task synchronization, Device driver, inter process communication.	10	4

5 **Embedded Software Development**	Embedded software development process, Conversion of ALP and high level language into ROM image, ICE, IDE, Linking and locating software, Contact less Smart card, SoC for cell phone, Internet of Things, Artificial Intelligence	10	5

Books:

1. Raj Kamal, Embedded system: Architecture, programming and Design ,3e, McGraw Hill Education, 2017.
2. Shibu K V, An introduction to Embedded system, 2e, McGraw Hill Education India Private Limited, 2017.
3. Mazidi, Muhammad Ali, the 8051 microcontroller and embedded systems Using Assembly and C, Pearson, 2018.

Sixth Semester Major Theory Subjects

BA346A1 **Credit: 2(L-2, T-0, P-0)**

INDUSTRIAL MANAGEMENT

Questions to be set: 05 (All Compulsory)

Course Objectives: The objective of this course is to acquaint the student with developing deeper understanding of the concept of management by understanding its evolution. It also introduces the functions of general management in detail as well as the quantitative techniques useful to make objective decisions. It also acquaints the students with techniques useful for production planning and control as also materials management.

Course Outcomes (CO):
After successful completion of this course, students will be able to:

CO1 Explain theories of management and their practical applications in solving business/ industrial problems.
CO2 Apply the available resources to achieve the desired goal in a more efficient and effective way.
CO3 Describe the Principles of organizing in management system
CO4 Explain the Quantitative Techniques and Production Management in Managerial Decisions
CO5 Summarize the production technique in solving the issues related with proper management of material and inventory management.

** not more than 20% of total topics to be allotted for assignment

Module	Topics to be covered	Topics	Hrs	CO
Module 1: <**Introduction to Management**>	in class	Philosophy and Development of Management thought. Concept and definition of management, Functions and Roles of Management, Social Responsibilities of Management, Taylor's Scientific Management, Contribution of Henry Fayol, Gilberth and Mayo.	5	1
	****Assignment Topics**			1
Module 2: <**Schools of Management**>	in class	Human Behaviour, Social System, Systems approach, management process school, Nature and purpose of planning objectives, Different types of Plans, steps in planning, schedule planning, product planning, Strategic Planning, Long, medium- and short-term planning, decision making, project planning, management by objectives.	5	2
	****Assignment Topics**			2
Module 3: <**Principles of Organizing**>	in class	Principles of organizing, steps in organizing, organizational structure, levels and span of management, span of control, formal and informal organization, line and staff functions, responsibility and accountability, delegation of authority. Manpower planning and recruitment, selection process, training and development, performance appraisals. Models and styles of leadership,	5	3

		managerial grid, motivation, interpersonal relations, personality, and communication process, types, barriers, effective communication. Concept, nature and purpose, process, methods and practice of control, role of internal audit.		
	**Assignment Topics			3
Module 4: <**Quantitative Techniques and Production Management in Managerial Decisions:**>	in class	Concept of budget and budgetary control. Time- event network analysis; Decision Tables; Concept of productivity, measuring productivity, Use information technology, Types of production; Types of Planning, Manufacturing Planning; Production planning, Scheduling; Work study & Method study, Systems of wage payments, bonus, Automation. Organization of production, planning and control department	6	4
	**Assignment Topics			4
Module 5: <**Materials and Inventory Management**>	in class	Practice of purchasing and materials management, quality, quality standards and inspection, sources of supply; pricing principles and practices. Inventory Management, EOQ model; Value Analysis and Value Engineering, Practical work	6	5
	**Assignment Topics			5

Text Books:

H. Koontz and H. Weihrich, “Management”, McGraw Hill, 1989.

Reference Books:

Dobler W.D. “Purchasing & Materials Management”, TMHC, New Delhi, 1984.

VT305A1 **Credit: 4 (L-3, T-1, P-0)**

SEMICONDUCTOR MATERIALS SYNTHESIS AND CHARACTERIZATION

Questions to be set: 05 (All Compulsory)

Course objectives:

The course aims to provide an overview and understanding of Silicon extraction and purification process. Crystallography of silicon and various methods of crystal growth. Have understanding of key methods of physiochemical, morphological and analytical characterization techniques,

Prerequisite: Semiconductors and semiconductor physics.

Course outcomes

On completion of the course, the student will be able to:

1. Understand the Silicon extraction and purification process.

2. Understand Crystallography of Si.

3. Understand various methods of crystal growth.

4. Understand principle, operation and practice of sub-merged arc furnace, energy and process calculation.

5. Understand key methods of physicochemical, morphological and analytical characterization techniques.

Module	Topics to be covered	Topics	Hrs	CO
1	In Class	Principles of extraction, pyrometallurgical processes, material and heat balance of processes, thermodynamics of processes; introduction to laws, thermodynamic equilibrium, thermochemistry, Ellingham diagram.	10	1
	Assignment			
	Topics:			
2	In Class	Process kinetics; introduction to chemical kinetics and rate processes, heterogeneous kinetics, kinetics of liquid-liquid reactions, concepts of reactor design. Structure & properties of molten liquids.	10	2
	Assignment			
	Topics:			
3	In Class	Production of metallurgical grade (MG) Si: Carbothermic reduction, principle, operation and practice of sub-merged arc furnace, energy and process calculation, refining & impurities	10	3

		control in molten MG Si.Production of electronic grade (EG) Si: Concept of fluidized bed reactor, Siemens Process.		
	Assignment			
	Topics:			
4	In Class	Crystal Growth: Crystal growth processes (Bridgman and its variants, Czochralski), heat and species transfer during non-steady and steady state plane-front growth, interface instability and effect of convection on interface stability.	10	4
	Assignment			
	Topics:			
5	In Class	XRD (Bulk and thin film), Microscopy (Optical, SEM, TEM, SPM), UV-Visible spectroscopy, Photoluminescence, Raman spectroscopy	8	5
	Assignment			
	Topics:			

Books

1. Principles of Extractive Metallurgy, Terkel Rosenqvist, McGraw-Hill Book Company, 1973.
2. Stoichiometry and Thermodynamics of Metallurgical Processes: Y K Rao, Cambridge University Press, 2009.
3. Handbook of Extractive Metallurgy: Fathi Habashi; Wiley-VCH, 1997.
4. Solar-Grade Silicon: Refining and Recycling: L Zhang et al, CRC Press, 2013.
5. Scheel and Capper: Crystal Growth Technology: From Fundamentals and Simulation to Large-scale Production, John Wiley & Sons, 2008.
6. Nakajima and Usami: Crystal Growth of Si for Solar Cell, Springer, 2009.

VT306A1 **Credit: 4 (L-3, T-1, P-0)**

Microelectronics & VLSI Design

Questions to be set: 05 (All Compulsory)

Course Objectives: The course is intended to give students a good understanding of MOS transistor and introduction to Scaling of MOS circuits which will help them to design Very Large Scale Integrated circuits.

Pre-requisites: Digital logic circuits, Basic of transistors, CMOS based digital logic design

Course Outcomes(CO): Student can able to

1. design basic CMOS structure and calculate various numerical parameters related to CMOS design.
2. design different combinational and sequential MOS device.
3. draw the stick diagram and layout of CMOS device in different technology.
4. describe different Micro-electronics process used in VLSI design
5. describe different Physical design and test the validity of design

Module	Topics to be covered	Topics	Hrs	CO
Module 1: **Introduction to VLSI**	**In class Topics**	Introduction**,** Design flow, Modern trends in VLSI, design domains-Y Chart, Device Scaling and its classifications, Construction and operation of CMOS device.	8	1
	Assignment Topics	Application and modern trends of VLSI Design		
Module 2: **Design of Combinational and Sequential CMOS circuits**	**In class Topics**	CMOS inverter, Complex logic circuit, Pass transistors, Transmission gate, Complementary passes logic circuit, Dynamic CMOS circuit, NORA logic, Domino Logic, Pseudo NMOS. CMOS logic circuits (SR latch, D flip flop), Register circuit, memory,	10	2
	Assignment Topics	Design of different analog CMOS deice and Arithmetic logic building blocks.		
Module 3: **Basic CMOS technology & Design rule**:	**In class Topics**	n-well, p-well, Silicon on insulator .Stick diagram, with specific examples, layout and its rules.	10	3
	Assignment Topics	Formation of layout and stick diagram for complex Boolean function.		
Module 4:	**In class Topics**	An overview of clean room, single crystal wafer formation, oxidation, photolithography, ion implantation and metallization.	10	4

Microelectronics process for VLSI	**Assignment Topics**	Numerical from process fabrication.		
Module 5: **Physical design and Testing**	**In class Topics**	Basics of synthesis (Logical and Physical Synthesis), synthesis flow, Basic concept of Floor paining, Placement and routing methods and their important algorithms. Basic concept Faults and their types and models, concept of different testing techniques, Manufacturability and Yeild.	10	5
	Assignment Topics	DRC and Sample case study based on physical design and testing. Role of VHDL/Verilog and FPGA for IC design.		

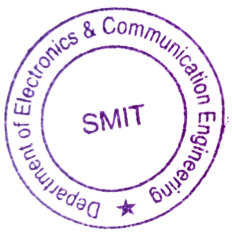
Text Books:

1. S.M Kang, CMOS Digital Integrated Circuits, Tata McGraw Hill,3e, 2018
2. Behzad Razavi, Design of analog CMOS integrated Circuit, McGraw Hill Education.
3. S.M Sze, VLSI Technology, McGraw Hill,2e , 2013
4. J. D. Plummer, M D. Deal, P B. Griffin, Silicon VLSI Technology, Pearsons India,2018

Reference Books:

1. Rabaey-Chandrakasan, Digital Integrated Circuits, Pearson,2nd edition,2013.
2. Mead and Conway, Introduction to VLSI systems, Addison Wesley.2013
3. Amar Mukherjee, Introduction to NMOS and CMOS VLSI design, PHI, 2013.
4. Pucknell and Eshrangian, Basic VLSI Design Systems and Circuits, PHI,2018.

Third Semester
Major Laboratory



VT201A4 **Credit: 1 (L-0, T-0, P-2)**

ELECTRONIC DEVICES AND COMPONENTS LAB.

Course Objectives:

i. To familiarize the students with the electronics circuits.
ii. To design and construct various electronic circuits like rectifier, clipper, clamper, voltage regulator, JFET, etc. both using discrete components and Multisim software.

Pre-requisites: Basic Electronics, Engineering Physics.

Course Outcomes (CO): Students should be able to

1. understand different electronic circuits and equipments and its related techniques.
2. understand and implement the basic diode characteristics and its applications viz. Regulators, Rectifiers, Clippers, Clampers, Multipliers.
3. analyze and study different Passive Filters viz. C-Filter, Π- Filter.
4. design and analyze BJT and JFET characteristics and its biasing circuits.
5. understand and study the different characteristics of Optoelectronic components.

Module	Topics to be covered	Topics	Hrs	CO
Module 1: **Electronic Equipments**	in class	Expt. 0:- Familiarization of Basic Electronics Components, Study of the Lab instruments: Oscilloscope, Function Generator, Multimeter, Resistor Colour Codes, Recognition of PN transistors. etc. Expt. 12:- Case Study: Hardware implementation and Validation of any Basic Electronics Circuit using Vero Board.	3	1
Module 2: **PN Junction Diode Applications**	in class	Expt. 1:- Study the Characteristics of Diodes: Zener, Germanium, Silicon. Expt. 2:- Study of Voltage Regulator. Expt. 3:- Study of Rectifiers: Half wave Rectifier, Full wave Rectifier, Bridge Rectifier. Expt. 4:- Study of Clipper and Clamper Circuit. Expt. 5:- Study of Voltage Multiplier.	15	2
Module 3: **Passive Filters**	in class	Expt. 6:- Study of Passive Filters: C- Filter, Π- Filter	3	3
Module 4: **Transistor Characteristics**	in class	Expt. 7:- Study of Bipolar Junction Transistor Characteristics: CB Configuration. Expt. 8:- Study of Bipolar Junction Transistor Characteristics: CE Configuration. Expt. 9:- Study of Bipolar Junction Transistor Biasing: Fixed Bias, Voltage Divider Bias. Expt. 10:- Study of Field Effect Transistor Characteristics.	12	4
Module 5: **Optoelectronic Devices**	in class	Expt. 11:- Study the Characteristics of Photovoltaic Components: Photodiode, LDR, LED, Photo Transistor.	3	5

VT202A4 **Credit: 1 (L-0, T-0, P-2)**

Digital Electronics and System Design Lab

Minimum number of experiments to be completed: 12 (covering all the modules)

Course Objective: To understand the digital components and the design of basic digital circuits.

Pre-requisites: Elementary knowledge of digital number systems.

Course Outcomes (CO): After the completion of this course, the students should be able to:

CO1. Identify and enlist the various components of combinational digital electronic circuits.
CO2. Design and verify the results of digital multiplexers and decoders.
CO3. Verify and evaluate the digital circuits that use flip-flops.
CO4. Use flip-flops to design counters.
CO5. Design sequential circuits using flip-flops and other digital components.

Module	Topics to be covered	Topics	Hrs	CO
1 Basic Combinational Circuits	Experiment 1	Verification of ICs and familiarization if the Digital Trainer Kits.	2	1
	Experiment 2	Design (i) Half adder and (ii) Full adder (iii) Half subtractor and (iv) Full subtractor	2	
	Experiment 3	Design (i) BCD to Excess-3 Code Converter, (ii) Excess-3 to BCD Code Converter	2	
2 Multiplexers and Decoders	Experiment 4	Design (i) 2-to-4-line active HIGH outputs Decoder, (ii) 1:4 Demultiplexer using logic gates	2	2
	Experiment 5	Design of an 8:1 Multiplexer using two 4:1 Multiplexers using multiplexer IC	2	
	Experiment 6	Construct (i) SR Flip Flop (ii) D Flip Flop (iii) _IK Flip Flop (iv) T Flip Flop using logic gates and verify them	2	
3 Flip-Flops	Experiment 7	Convert a (i) JK FF to a D FF (ii) JK FF to a T FF (iii) D FF to a JK FF (iv) D FF to a T FF	2	3
	Experiment 8	Design a decade asynchronous up counter.	2	
	Experiment 9	Design a mod 8 asynchronous up/down counter with a control line (to control the up or down count)	2	
4 Counters	Experiment 10	Design a mod 16 synchronous up counter using JKFFs.	2	4
	Experiment 11	Design a mod 4 synchronous up/down counter with a control line (to control the up or down count) using DFFs	2	
	Experiment 12	Design (i) 4 BIT ring counter, (ii) 4 BIT twisted ring counter using DFFs	2	
5 Sequential Circuits	Experiment 13	Design a 1-3-5-7 self-correcting to 1 counter using JK FFs	2	5
	Experiment 14	Using D FFs, Construct 3-BIT shift registers in (i) SISO (ii) SIPO (iii) PIPO & (iv) PISO modes	2	
	Experiment 15	Design a circuit that produces a HIGH output if a sample data input is tested three times and found at a relatively HIGH voltage level on odd number of times and then returns to the initial condition and start the testing process again	2	

Fourth Semester
Major Laboratory

VT203A4 **Credit: 1 (L-0, T-0, P-2)**

ANALOG ELECTRONICS & CIRCUITS LAB.

Course Objectives:

i. To familiarize the students with the electronics circuits design.
ii. To design and construct various electronic circuits like power supply, oscillators, multivibrator and uses of operational amplifier.

Pre-requisites: Basic Electronics, Electronic Devices And Circuit.

Course Outcomes (CO): Students should be able to

1. understand different techniques for hardware implementation.
2. design different transistor amplifier electronic circuits.
3. design various types of oscillator circuits for generating frequency of oscillations.
4. analyze and study different Op-Amp applications.
5. design and analyze various types of multivibrators.

Module	Topics to be covered	Topics	Hrs	CO
Module 1: **Electronic Equipments**	in class	Expt.-12:- Case Study: Hardware Implementation And Validation Of Any Basic Electronic Circuit Using PCB (Printed Circuit Board)	2	1
Module 2: **Transistor Amplifier**	in class	Expt.-1:- To plot the Frequency Response Curve of a Voltage Series Without Feedback Amplifier. Expt.-2:- To plot the Frequency Response Curve of a Voltage Series Feedback Amplifier. Expt.-11:- To plot the Frequency response of an FET Amplifier.	6	2
Module 3: **Oscillator Circuits**	in class	Expt.-3:- Design and observe R-C-Phase-Shift Oscillator for a given Frequency and to study the variation of Frequency by verifying the C = C1 = C2 = C3. Expt.-4:- Design a Hartley Oscillator and determine the frequency of oscillations.	4	3
Module 4: **Op-Amp applications**	in class	Expt.-5:- Op-amp based Adders and Subtractor for Inverting and Non-Inverting configuration. Expt.-6:- Op-amp based Integrator & Precision Rectifier (1kHz - 5kHz) Expt.-7:- Op-amp based active filters: High Pass Filter & Low Pass Filter. Expt.-8:- To design a 3-bit R- 2R ladder Digital To Analog Converter using Op-Amp.	8	4
Module 5: **Multivibrator Circuits**	in class	Expt.-9:- To design a Monostable Multivibrator using 555 Timer (for a given frequency). Expt.-10:- To design an Astable Multivibrator using 555 Timer (for a given frequency).	4	5

VT204A4 **Credit: 1 (L-0, T-0, P-2)**

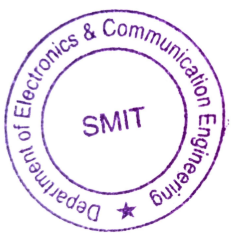
Microprocessor and Microcontroller Lab.

Course Objective: To give the students the practical implementation and programming knowledge of various circuitries with IC 8085 & 8086 microprocessor and its interfacing. In this subject, students are introduced to various microprocessors and its interfacing related design, flow chart and the 8085-programming concept.

Pre-requisites: Digital electronics.
Course Outcomes (CO): Students should be able to

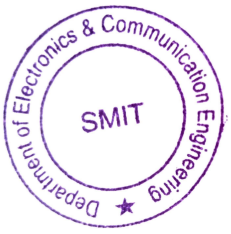
1. Write and execute 8085 assembly language programs.
2. Learn 8085 execution set and try to implement them in the laboratory the same for writing programs in C.
3. Write error free code in assembly for 8085 and 8086 microprocessors.
4. Debug syntax errors prompted by the TASM.
5. Work on ARM processors.

Module	Topics to be covered	Topics	Hrs	CO
Module 1: **Introduction to Micrprocessor 8085**	in class	Expt.-1 Familiarization with the 8085 micro-processor kit. Expt.-2 Binary & BCD addition of two bytes stored in (i) consecutive and (ii) non-consecutive locations. Expt.-3 Binary & BCD addition of more than two bytes stored in consecutive locations. Expt.-4 Finding difference between two bytes/packed BCDs stored either in (i) Consecutive locations and (ii) non-consecutive locations.	4	1
Module 2: **8085 execution set**	in class	Expt.-5 To check whether a given number is even or odd. Expt.-6 To check whether a byte has even parity or odd parity. Expt.-7 Conversion of binary to BCD or BCD to binary code. Expt.-8 Developing a 8 bit binary up counter using 8 LEDs by interfacing logic controller card.	4	1,2
Module 3: **Implementation**	in class	Expt.-9 Rotating the shaft of the stepper motor by interfacing the stepper motor control card. Expt.-10 Controlling all the signals of ADC(IC-0809) during analog to digital conversion and display the digital o/p at the display section of the MP kit.	2	3,4
Module 4: **8086**	in class	Expt.-11 Introduction of Debug to familiar with 8086 processor by developing &executing a small program.	2	4



		Expt.-12 Signed number operations.		
Module 5: **ARM Processors**	in class	Expt.-13 Displaying “Hello World!” on the screen using INT-21H. Expt.-14 Entering a string & after checking for palindrome displaying massage i.e. whether it is palindrome or not using INT-21H. Expt.-15 Overview of ARM architecture.	4	4,5

Fifth Semester
Major Laboratory



VT301A4 **Credit: 1 (L-0,T-0,P-2)**

HDL Simulation LAB

Minimum No. of Experiments to be carried out: 12.

Course Objective: To familiarize the students with the basics of VHDL, Verilog programming, and circuit simulation using EDA tool. Students will be able to design digital electronic circuitry, acquire knowledge of the above programming language, RTL synthesis, simulation, and finally be able to implement it on FPGA (Spartan /Vertex) Board. Students will be able to design the CMOS circuitry and layout of the CMOS circuitry using EDA tools.

Pre-requisites: Digital Electronics, Embedded system, Microelectronics and VLSI Design

Course Outcomes (CO):

The students should be able to:

1. Design various combinational circuits using VHDL (Dataflow and Behavioral style of modeling).
2. Implement various combinational circuits using VHDL (Structural style of modeling)
3. Implement various sequential circuits using Verilog HDL.
4. Design various circuits (CMOS, transmission gate and pass transistor logics) using EDA tools.
5. Design and implement layout of basic gates using EDA tools.

Module	Topics to be covered	Topics	Hrs	CO
Module 1:	in class	Design and Write VHDL code for full adder using half adder, 4:1 Mux using dataflow, behavioral and structural modeling, 3:8-line decoder using case statement, 4-2-line encoder.		1
Module 2:	in class	Design and Write VHDL code for 3-bit comparator using a 1-bit comparator and basic gates, 4-bit parallel adder structural modeling, 4-bit parallel adder/ subtractors using generate statement.		2
Module 3:	in class	Design and Write Verilog code for SR flip flop, asynchronous 4-bit UP counter using J-K FF, 4-bit register, 16-bit ALU.		3
Module 4:	in class	Design and analysis of AND gate, OR gate, 4:1 Multiplexer, Ex-OR gate, Ex-OR gate using Transmission gate, boolean function by Pass Transmission gate, Dynamic CMOS, Domino logic circuit, NORA logic circuit with the help of EDA Tools.		4

Module 5:	in class	Design layout of an Inverter circuit and universal logic gate using an equivalent layout tool. Use any standard Design rules.	5

VT302A4 **Credit: 1(L-0, T-0, P-2)**

PYTHON PROGRAMMING Lab

Minimum number of Experiments to be completed: 12 (Covering all the Modules).

Course Objectives: **Provide knowledge of python code used in various application**

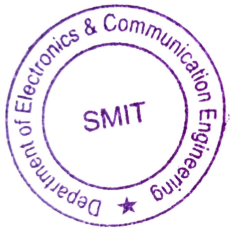
Pre-requisites: Knowledge of basics programming.

Course Outcomes (CO):

After studying this course, students will be able to:

1. Write, test, and debug simple Python programs.
2. Implement Python programs with conditionals and loops.
3. Develop Python programs step-wise by defining functions and calling them.
4. Use Python lists, tuples, dictionaries for representing compound data.
5. Read and write data from/to files in Python

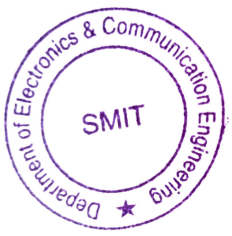
Module	Experiment No.	Experiment Name	Hrs	CO
1. Write and test Simple Python programs using list and tuples.	1	A) Create a list and perform the following methods 1) insert() 2) remove() 3) append() 4) len() 5) pop() 6) clear() B) Create a dictionary and apply the following methods 1) Print the dictionary items 2) access items 3) use get() 4)change values 5) use len() C) Create a tuple and perform the following methods 1) Add items 2) len() 3) check for item in tuple	7	1
2. Python Programs using conditions and loops	2	Write a python program to add two numbers. Write a python program to print a number is positive/negative using if-else. Write a python program to find largest number among three numbers. Write a python Program to read a number and display corresponding day using if_elif_else?	8	



3.Use of Python Functions	3	A) Write a program to create a menu with the following options 1. TO PERFORM ADDITITON 2. TO PERFORM SUBTRACTION 3. TO PERFORM MULTIPICATION 4. TO PERFORM DIVISION Accepts users input and perform the operation accordingly. Use functions with arguments. B) Write a python program to check whether the given string is palindrome or not. C) Write a python program to find factorial of a given number using functions D) Write a Python function that takes two lists and returns True if they are equal otherwise false	7
	4	A) Write a program to double a given number and add two numbers using lambda()? B) Write a program for filter() to filter only even numbers from a given list. C) Write a program for map() function to double all the items in the list? D) Write a program to find sum of the numbers for the elements of the list by using reduce()?	
4. File Handling	5	A) Demonstrate a python code to implement abnormal termination? B) Demonstrate a python code to print try, except and finally block statements C) Write a python program to open and write “hello world” into a file? D) Write a python program to write the content “hi python programming” for the existing file.	7
	6	A) Write a python program to get python version. B) Write a python program to open a file and check what are the access permissions acquired by that file using os module? C) Write a python program to display a particular month of a year using calendar module. D) Write a python program to print all the months of given year.	
	7	A) Write a python program to print date, time for today and now.	

		B) Write a python program to add some days to your present date and print the date added. C) Write a python program to print date, time using date and time functions. D) Write a python program which accepts the radius of a circle from user and computes the area (use math module).	
5. Creating classes and object	8	A) Write a python program to create a package(college), sub-package(alldept), modules (it,cse) and create admin and cabin function to module?	7
		B) Write a python program to create a package (Engg), sub-package(years),modules (sem) and create staff and student function to module?	
	9	A) Write a python Program to display welcome to MRCET by using classes and objects. B) Write a python Program to call data member and function using classes and objects C) Write a program to find sum of two numbers using class and methods D) Write a program to read 3 subject marks and display pass or failed using class and object.	
	10	A) Using a numpy module create an array and check the following: 1. Type of array 2. Axes of array 3. Shape of array 4. Type of elements in array B) Using a numpy module create array and check the following: 1. List with type float 2. 3*4 array with all zeros 3. From tuple 4. Random values C) Using a numpy module create array and check the following: 1. Reshape 3X4 array to 2X2X3 array 2. Sequence of integers from 0 to 30 with steps of 5 3. Flatten array 4. Constant value array of complex type	
	11	A) Write a python program to concatenate the Data frames with two different objects	

	B) Write a python code to read a csv file using pandas module and print the first and last five lines of a file.
12	A) Write a python code to set background color and pic and draw a circle using turtle module B) Write a python code to set background color and pic and draw a square and fill the color using turtle module C) Write a python code to perform addition using functions with pdb module.



Sixth Semester
Major Laboratory

VT303A4 **Credit: 1 (L-0,T-0,P-2)**

Communication Engineering Lab

Minimum No. of Experiments to be carried out: 12.

Course Objective: To give the students the basic ideas on analog communication. In this subject, students are introduced with topics like filters design using OPAMP and various modulation techniques used in analog communication.

Pre-requisites: Signal and systems**.**

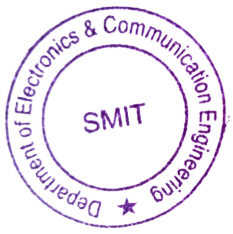
Course Outcomes (CO):

The students should be able to:

1. Design various filters using OPAMPS
2. Implement various Analog Modulation Techniques
3. Implement various Multiplexing Techniques
4. Implement Sampling and Digital Modulation Techniques
5. Implement Differential Modulation Techniques

Module	Topics to be covered	Topics	Hrs	CO
Module 1:	in class	Realization of Band pass filter using Op-AMP Realization of wide Band reject filter using Op-AMP Realization of Notch filter using Op-AMP		1
Module 2:	in class	Study of Continuous Time Domain signal spectrum using FOURIER spectrum trainer/ Simulation Amplitude Modulation & Demodulation Simulation (Time Domain/Spectral Characteristics of AM) Hardware Experiment Frequency Modulation & Demodulation Simulation(Time Domain/Spectral Characteristics of FM) Hardware Experiment Pulse Amplitude Modulation & Demodulation Simulation Hardware Experiment		2
Module 3:	in class	Pulse Width Modulation Simulation Hardware Experiment Pulse Position Modulation & Demodulation Simulation Hardware Experiment Frequency Division Multiplexing & Demultiplexing Simulation Hardware Experiment Time Division Multiplexing & Demultiplexing Simulation		3

		Hardware Experiment	
Module 4:	in class	Signal Sampling and reconstruction Simulation Hardware Experiment Experiments on line coding and decoding of signal. Study of Pulse Code Modulation and Demodulation	4
Module 5:	in class	Delta modulation Adaptive delta Modulation Study of Delta Pulse Code Modulation and Demodulation. FSK, PSK, DPSK and QAM Modulation through simulation Study of QAM through hardware kits.	5



ECVT304A4 **Credit: 1 (L-0, T-0, P-2)**

ARM based SOC Design Lab

Minimum number of experiments to be completed: 12 (covering all the modules)

Course Objective: To develop Arm Cortex-M0 based SoCs, from creating high-level functional specifications to design, implementation and testing on FPGA platforms using standard hardware description and software programming languages.

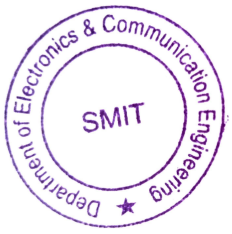
Pre-requisites:

- Basics of hardware description language (Verilog or VHDL)
- Basic C and assembly programming

Course Outcomes (CO): After the completion of this course, the students should be able to:

CO6. Know about Verilog HDL and hierarchical modelling concept.
CO7. Know about ARM cortex architecture.
CO8. Understand AMBA protocol.
CO9. Understand AHB protocol.
CO10. Program an SoC using C language.

Topics to be covered	Topics	Hrs	CO
Experiment 1	Introduction to Verilog HDL & Hierarchical Modelling Concepts	2	1
Experiment 2	AHB Light bus architecture	2	
Experiment 3	Building a System on Chip- Integrating AHB peripherals to ARM	2	
Experiment 4	UART, Timer, MEMORY, GPIO etc.	2	2
Experiment 5	Introduction to Arm-based System on Chip Design	2	
Experiment 6	The Arm Cortex-M0 Processor Architecture: Part 1	2	
Experiment 7	The Arm Cortex-M0 Processor Architecture: Part 2	2	3
Experiment 8	AMBA 3 AHB-Lite Bus Architecture	2	
Experiment 9	AHB SRAM Memory Controller	2	
Experiment 10	AHB VGA Peripheral	2	4
Experiment 11	AHB UART Peripheral	2	
Experiment 12	Timer, GPIO and 7-Segment Peripherals	2	
Experiment 13	Interrupt Mechanisms	2	5
Experiment 14	Programming an SoC Using C Language	2	
Experiment 15	Application Programming Interface and Final Application	2	



Program Elective-1

VT201A3 **Credit: 4 (L-3, T-1, P-0)**

Electromagnetic Theory

Questions to be set: 05 (All Compulsory)

Course Objective: To serve as a beginner course in acquiring knowledge in Electromagnetic waves. This course describes fundamentals of Coordinate systems, Vector Calculus, Static Electric Fields, Electric and Magnetic flux, Electric Current density, Magnetic fields, Maxwell's equations, Solution of Maxwell's equation in different medium conditions.

Pre-requisites: Differential and Integral Calculus, concept of vectors, coordinate geometry, Basic idea on electric and magnetic field.

Course Outcomes (CO): On Successful Completion of the course

CO	STATEMENT	BL
CO1	Students should be able to comprehend the concepts of electrostatics, and apply the knowledge in solving the relevant problems.	**2,3**
CO2	Students should be able to comprehend the concepts of magnetostatics, and apply the knowledge in solving the relevant problems.	**2,3**
CO3	Students should be able to apply the Maxwell equations in steady and time-varying conditions.	**3,4**
CO4	Students should be able to analyze the electromagnetic wave propagation through different media and power measurement using Poynting vector theorem.	**3,4**
CO5	Student should be able to explain the characteristics of transmission line.	**3,4**

** not more than 20% of total topics to be allotted for assignment

Module	Topics to be covered	Topics	Hrs	CO
Module 1; Revision of Vector algebra , Coordinate system and Vector calculus	**In class**	Revision of formulas related to vector algebra, Coordinate geometry (cartesian, Cylindrical and spherical) and Vector calculus (Gradient, Divergence, curl, laplacian)	**10**	**1**
	****Assignment Topics**	Gauss theorem, Stokes theorem		
Module 2: **Electrostatics Fields and Electric Fields in Material Space**	in class	Coulomb's law and field intensity, Electric fields due to continuous charge distribution, Electric Flux density, Gauss's Law – Maxwell's Equation, Application of Gauss's law, Electric potential, Relation between electric field and electric potential. Properties of materials, Convection and conduction current, Current density, Types of dielectric medium: Linear, Isotropic and Homogeneous dielectrics, Boundary conditions.	14	2

	****Assignment Topics**	Poisson's and Laplace equation, Energy density in electrostatic fields. Continuity equation and Relaxation time		
Module 3: **Magnetostatic Fields:**	in class	Biot – Savart's law, Applications of Biot- Savart's law, Ampere's Circuit law – Maxwell's equation, Application of Ampere's law, Magnetic flux density – Maxwell's equation, Maxwell's equation for static EM fields, Magnetic scalar and vector potential	10	3
	****Assignment Topics**	Coulomb gauge condition, vector Poisson's equation.		
Module 4: **Maxwell's Equation in Time varying condition**	In Class	Faraday's law, Lenz's law, Trans former and Motional EMFs, Displacement current and modification of Maxwell's equation, Displacement current through capacitor, Final form of Maxwell's equation	6	4
	****Assignment Topics**	Time-Harmonic electric and magnetic fields, Time-Harmonic Maxwell's equation		
Module 5: **Electromagnetic Wave Propagation**	In Class	Wave propagation in Lossy Dielectrics, Plane wave in Lossless Dielectrics, Plane wave in free space, Intrinsic impedance of free space, Plane wave in good conductor, Skin effect and skin depth, Related problems	8	5
	****Assignment Topics**	Power and Poynting vector,		

Text Books:

1. Matthew N.O. Sadiku., Principles of Electromagnetics, 4th Edition, Oxford University Press , 2009

2. Liao S., Microwave Devices and Circuit, 3e, Prentice Hall, 2013.

Reference Books:

1. Jordan Edward, C Balmain Keith G., Electromagnetic wave and Radiating System, 2e, Prentice Hall, 2013.

2. M.L.Sisodia and Vijaylaxmi Gupta, Microwaves, Introduction to Circuits, devices

VT202A3 **Credit:4 (L-3, T-1, P-0)**

Network Analysis and Synthesis

Questions to be set: 05 (All Compulsory)

Course Objectives: To enrich the knowledge of the students with a sound understanding of various techniques of network analysis and synthesis.

Pre-requisites: Basics of circuit theory, Laplace Transform, Integration, first and second order
homogenous and non-homogeneous solution.

Course Outcomes (COs):

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

CO1: Apply the network theorems of electrical networks and initial conditions in electrical circuits.

CO2: Use Laplace transform to solve differential equations for electrical networks.

CO3: Determine the network function and two port network parameters of an electrical network.

CO4: Apply graph theory for solving electrical network problems.

CO5: Synthesize passive networks and design of filters.

Module	Topics to be covered	Topics	Hrs	CO
Module 1: **Basics of Network and Theorems**	in class	Circuit Elements (R, L, C**,** Mutual Inductance, Independent and Dependent Current and Voltage Sources), Classification of Networks (Passive and Active N/W, Lumped and Distributed N/W, Linear and Non-Linear N/W), RC integrator (LPF), RC differentiator (HPF) and response studies, Thevenin's theorem, Norton's theorem,	8	1
	****Assignment Topics**	Star-Delta Transformation, Superposition theorem, Maximum Power Transfer theorem.		1
Module 2: **Steady state and transient analysis.**	in class	Initial conditions in elements, Procedure for evaluating initial conditions, Steady state and transient analysis, Application of Laplace transform in network analysis.	10	2
	****Assignment Topics**	Practice problems		2
Module 3: **Network Functions and Two Port Parameters**	in class	1 port and 2 port Network functions, Poles and zeroes of network functions, 2 port variables, short circuit and open circuit parameters, transmission and hybrid parameters.	10	3
	****Assignment Topics**	Transmission and hybrid parameters.		3
Module 4: **Graph Theory**	in class	Graph of a network, Concepts of tree and links, Incidence matrix, Tie- set and cut-test schedules, Solution of Networks.	10	4

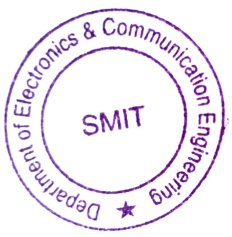
	****Assignment Topics**	Principles of duality.		4
Module 5: **Passive network synthesis and Filter Design**	in class	Positive real functions, synthesis of R-L, R-C and L-C network, Characteristic impedance, propagation constant, Constant K-Type filter Design (Low pass, High pass), Drawbacks & remedies of K filters.	10	5
	****Assignment Topics**	Synthesis of R-C and L-C network.		5

Text Books:

1. M.E. Van Valkenburg, *Network Analysis*, PHI, 3rd edition, 2014.
2. D. Roy Choudhury, *Networks and Systems*, 2e, New Age international Publisher,2011.

Reference Books:

1. Franklin.F.Kuo, *Network Analysis and Synthesis*, Wiley Edition, 2e, 2012.
2. Ravish R Singh, *Network Analysis and Synthesis* , McGraw Hill Education, 2013.
3. A. Sudhakar, SS Palli, *Circuits and Networks Analysis and Synthesis*, McGraw Hill, 5e,2015.



VT203A3 **Credit: 4 (L-3, T-1, P-0)**

Object Oriented Programming using C++

Questions to be set: 05 (All Compulsory)

Course Objectives: This course is designed so that thestudent should be able to define the objects and classes.. This course contains the basic features of Object Oriented Progamming using C++. This course is aimed for providing a complete knowledge of different functions, techniques and algorithms used in C++ to address different practical problems. This definitely creates interests and motivations in students and in other way, this course will fetch a large scope of job and research opportunities in India as well abroad.

Pre-requisites: C programming, Object Oriented Programming.

Course Outcomes (CO):

1. The students should be able to understand the basic concept of Object oriented programming
2. The students should be able to understand the basic features and syntaxes of C++.
3. The students should be able to write programs using the different concepts of object oriented programming.
4. The students should be able to understand file handling and input output operation
5. The students should be able to apply the concept of OOPs to solve some practical problems

Module	Topics	Hrs	CO
Module 1: **Overview of OOP a using C++ Syntaxes of C++ and Basic Procedure-Oriented program using C++**	Procedure-Oriented programming, Object-oriented programming, benefits, features and Application of OOP. Simple C++ program, Tokens, Keywords, constants, Basic data types, User defined data types and Derived data types, Function prototyping, Call by reference, analyzing simple programs.	10	1
Module 2: **Concepts of OOP in C++**	Classes, Class scope, Nested classes,Member functions, Nesting of member functions and basic Object-Oriented features (encapsulation), overloading, namespace and using structure and union, Array of objects, Member functions, Friend function, Pointers to members, Constructors, Copy Constructors, Destructors.	11	2
Module 3: **Inheritance**	Generalization / Specialization of Object Modeling in C++ Pointer, Virtual Functions, Static and Dynamic Binding, pointers to objects, this pointer, pointers to derived class, Abstract class, Friend function, Virtual functions, Method Overloading, Method Overriding	9	3

Polymorphism			
Module 4: **Type Casting, Exceptions, Templates&STL**	C++ cast operators; C++ Exceptions & standard exception classes, Function and Class templates and using STL like containers.	9	4
Module 5: Files handling	Classes for file stream operations, Accessing files, Sequential I/O operations, Random access, Command- line arguments, Exception handling (throw, try, and catch).	9	5

Text Books:

1. Robert Lafore, *Object-oriented programming in C++*, 4e ,Sams Publishing, 2001.
2. Bjarne Stroustrup, The C++ Programming Language, 4e, Pearson education, edition,2013.

Reference Books:

1. Cay Horstmann, *Computing Concepts with C++ Essentials*, 2e, John Wiley & Sons, 1997.
2. John Hubband, *Programming with C++*,2e., Schaum's outline series, McGraw Hill, 2017

VT204A3 **Credit: 4 (L-3, T-1, P-0)**

Internet of Things

Questions to be set: 05 (All Compulsory)

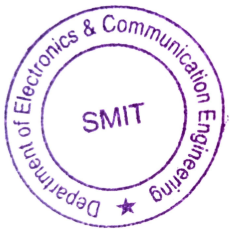
Course Objectives: The course is focused to give a vision and introduction to IoT Technology. This course will provide the knowledge of IoT Gateway, Cloud and its access. It also highlights the basic architecture of BIG DATA solution, Radio Frequency Identification system, Near-field Communication system in relevance to the IoT market perspective. The students will be able to grow the expertise in data and knowledge management methodologies after pursuing this course. The course is dedicated towards the realization of 'Connected Society': Smart Cities and Smart World. The future Industry trends is highly inclined with the aspect of the outcomes of this course. So, after completion of this course, the students will be able to get a huge scope of jobs in this domain.

Pre-requisites: Knowledge of basic signals and communication.

Course Outcomes(CO):

CO1: The students should be able to explain the basic features and requirements of IoT.
CO2: The students should be able to establish the need of Big Data solution strategy in corporate.
CO3: The students should be able to explain various short range communication protocols used for different IoT applications.
CO4: The students should be able to explain various long and medium range communication protocols used for different IoT applications.
CO5: The students should be able to elucidate how IoT can be deployed in different application scenarios.
** not more than 20% of total topics to be allotted for assignment

Module	Topics to be covered	Topics	Hrs	CO
Module 1: **IoT basics**	in class	Introduction to Internet of Things, Physical Design of IOT, Logical Design of IOT, IOT Enabling Technologies, IOT Levels. IoT system components, IoT Devices, IoT Gateways, Cloud Access, Cloud Components.	10	1
Module 2: **Big Data**	in class	What is Big Data (BD). Modern Corporate's need of BD Strategy. Main components of Big Data Solution. Basic Architecture of BD Solution. Introducing Hadoop.	8	2
	****Assignment Topics**	Case study		2
Module 3: **Short-Range Wireless Communication**	in class	Introduction to: Near-field communication (NFC); Radiofrequency identification (RFID) Thread – Network protocol based on the IEEE 802.15.4 standard, similar to ZigBee, Bluetooth low energy (BLE); Z-Wave; Body area Networks – BAN, Light-Fidelity (Li-Fi);	12	3
	****Assignment Topics**	Use cases		3



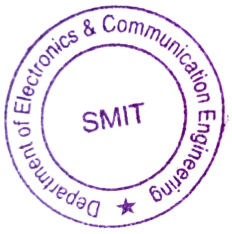
Module 4: **5G based IoT Under Medium and LongRange Wireless**	in class	Overview on 6LoWPAN, Low Power Wide Area Networks (LPWANS), Overview On 5G IOT, Low-power Consumption, Enhanced Coverage, Ultra-reliable Low-latency Communications, Massive Number of Devices. IoT Networking Protocols: MQTT, CoAP	10	4
	****Assignment Topics**	AMQP, XMPP		4
Module 5: **Towards 'connected Society': Smart Cities and Smart World**	in class	Smart Home, Connected Vehicle, Smart Agriculture, Smart Healthcare, Smart Grid	8	5
	****Assignment Topics**	Case study		5

Text Books:

1. Pethuru Raj and Anupama C. Raman, The Internet of Things: Enabling Technologies, Platforms, and Use Cases, 1/e, CRC Press, Taylor & Francis Group, 2017.
2. Vijay Madisetti, ArshdeepBahga, Internet of Things A Hands-On- Approach,2014, ISBN:9780996025515.
3. Hongjian Sun, Chao Wang, Bashar I. Ahmad, From Internet of Things to Smart Cities: Enabling Technologies, CRC Press, Taylor & Francis Group, 2018.

Reference Books:

1. Adrian McEwen, Designing the Internet of Things, Wiley Publishers, 2013, ISBN: 978-1-118-43062-0.
2. Daniel Kellmereit, The Silent Intelligence: The Internet of Things. 2013, ISBN 0989973700.
3. NB-IoT : Enabling New Business Opportunities- Building A Better Connected World, Huawei.
4. http://bookgedebook.tk/downloads/nb-iot-enabling-new-business-opportunities-huawei.pdf.
5. Mishra S., Bhutia S.D., Akhtar N., Dhar S., "Cloud-Based Multilayer Telemedicine Architecture: A Case Study" in: Advances in Communication, Devices and Networking. Lecture Notes in Electrical Engineering, vol 537. Springer, Singapore, Bera R., Sarkar S., Singh O., Saikia H. (eds) (2019)



VT205A3 **Credit: 4 (L-3, T-1, P-0)**

COMPUTER ORGANIZATION AND ARCHITECTURE

Questions to be set: 05 (All Compulsory)

Course Outcomes: After Completion of the course, students will be able:

1. To demonstrate an understanding of the organization of a computer system.
2. To identify instruction sets, processor structure and its functions.
3. To have knowledge on memory system and I/O organization.
4. To explain the working of a control unit and its operations.
5. To discover parallelism and features of parallel processing and superscalar operations.

Pre-requisites: Basic of Digital Systems.

Module	Topics	Hrs	CO
Module 1: **Introduction: Overview of Computers**	Historical background, Classification of computers. Basic Structure, Fundamental Units, Basic Operational Concepts, Bus Structure, RISC and CISC processors, Introduction to RISC V processor, SHAKTI Processor, VIKRAM Processor, ARM Processors.	10	1
Module 2: **Computer Arithmetic and Processor Basics**	Addition and Subtraction, Multiplication Algorithms (Booth's Algorithm), Division Algorithms, Floating point number representation, Floating point arithmetic and unit operations, Pipelined ALU. Processor architecture and organization, Processor operation, Register set, Stack organization, Interrupts and subroutine.	10	2
Module 3: **Memory System and I/O Organization**	Memory classification, memory characteristics and hierarchy, Cache memory, main memory Secondary memory, Virtual memory. Basic I/O structure of computers, Asynchronous data communication, Serial and parallel communication, Programmed I/O Interrupt driven I/O, Interrupt controller, DMA controller, Device drivers, Standard I/O buses (USB, SCSI, IEEE488), Bus arbitration, I/O processor.	10	3
Module 4: **Microprogramming and Micro Architecture Control Unit Operation**	Need of data flow control, data paths, control signal requirements, microinstructions, instruction cycles, hardwired control, programmed control, sequencing and execution of microinstructions, utilizing system clock. Control Unit, Micro-operations, control of the processor, hardware implementation.	10	4
Module 5: **Pipelining, Parallel Processing and Superscalar Operation**	Pipeline strategy, pipeline performance, Pipeline Hazards, Data hazards, Control hazards, Structural hazards, Control and data paths. Flynn's classification, Network topologies, Program parallelism, shared variables and critical section, cache coherence, superscalar operation.	8	5

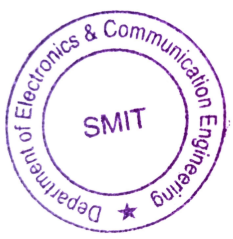
Text Books:

1. Computer Architecture & Organization, William Stallings, 2008, Pearson Education.

Reference Books:

1. Computer Architecture & Organization, Nicholas Carter & Raj Kamal, 2009, McGraw Hill.
2. Computer Organization, Carl Hamacher, Zvonko Vranesic, Safwat Zaky, 1996, McGraw Hill.

Program Elective-2



VT206A3 **Credit: 4 (L-3, T-1, P-0)**

Computer Networks

Questions to be set: 05 (All Compulsory)

Course Objectives:

1. Identify the different approaches towards computer networking
2. Compare and contrast the underlying technologies and
3. Problem solving based on case studies.

Pre-requisites: Probability

Course Outcomes:

Students can be able to:

1. Analyze different types of network topologies.
2. Inspect error detection and correction in data link layer and analyze the working of protocols involved in this layer.
3. Build the skills in classless and classful addressing and sub-netting.
4. Identify the Client/Server Paradigm and the protocols involved in this layer.
5. Analyze the applications protocols and know the actual application implementation in the areas such as security, banking sector and novel area of interest.

Module	Topics to be covered	Topics	Hrs	CO
Module 1: Introduction to computer networks and layered architecture	**In class Topics**	Network Topology, The Layered Architecture (OSI, TCP/IP), Peer-to-Peer Processes, Physical Addresses, Logical Addresses, Port Addresses, Basics of Internet, Switching circuits.	10	1
	Assignment Topics	Compare the OSI and TCP/IP architectures.		1
Module 2: Data Link Layer	**In class Topics**	Error Detection and Correction: Checksum-One's Complement, Internet Checksum. Data Link Control-Framing: Fixed-Size Framing, Variable-Size Framing. Flow Control, Error Control, Private addressing. Data Link Control: Noiseless channels: Simplest Protocol, Stop-and-Wait Protocol.	10	2

		Noisy channels: Stop-and-Wait ARQ, Go-Back- N ARQ, Selective Repeat ARQ, Piggybacking. Multiple Access: Random access-ALOHA, slotted ALOHA, CSMA, CSMA/CD and CSMA/CA.		
	Assignment Topics	Problems related to Go-back-N ARQ and Selective repeat ARQ		2
Module 3: Network Layer	**In class Topics**	Logical Addressing: IPv4 addresses, Address Space, Notations, Classful Addressing, Classless Addressing, IPv6 addresses Structure, Address Space, Subnets. Internet Protocol: Internetworking. Address Mapping, Error Reporting and Multicasting: Mapping Logical to Physical Address, ARP, ICMP, IGMP. Delivery, Forwarding and Routing: Unicast routing protocols, Intra and Inter-domain Routing, Distance Vector Routing, Dijkstra's Algorithm, Shortest Path Algorithm, Link State Routing-OSPF, Path Vector Routing.	11	3
	Assignment Topics	Problems related to Sub-netting. Explain the Dijkstra's algorithm		3
Module 4: Transport Layer	**In class Topics**	Process to process delivery: Client/Server Paradigm, Multiplexing and Demultiplexing, Connectionless Versus Connection-Oriented Service, Reliable Versus Unreliable. UDP: Well-Known Ports for UDP, User Datagram, Checksum, UDP Operation, Use of UDP. TCP: TCP Services, TCP Features, Segment, ATCP Connection, Flow Control, Error Control, Congestion Control,	9	4

3

		Process-to-Process Delivery: UDP, TCP. Congestion Control: Open-Loop Congestion Control, Closed-Loop Congestion Control, Three-way-Handshake.		
	Assignment Topics	Explain the concept of UDP and TCP		4
Module 5: Application	**In class Topics**	Protocols SMTP, POP, FTP, HTTP. Recent Trends in Protocols, Introduction to mobile IP, Basics of Wi-Fi, Basics of Network Security Authentication, firewalls, digital signatures, and certificates	8	5
	Assignment Topics	Study the application in Network Security Authentication		5

Text Books:

1. Andrew S. Tanenbaum, David J. Wetherall. Computer Networks, 5e, Pearson 2014

2. Forouzan, A. Behrouz. Data communications & networking, 2e, Tata McGraw-Hill Education 2006.

Reference Books:

1. Stallings, William. Local Networks, 3e, Prentice Hall PTR, 1990.

2. James F. Kurose and Keith W. Ross. Computer Networking: A Top-Down Approach, 6e, Pearson, 2012.

VT207A3 **Credit: 4(L-3, T-1, P-0)**

ELECTRONIC INSTRUMENTATION AND MEASUREMENTS

Questions to be set: 05 (All Compulsory)

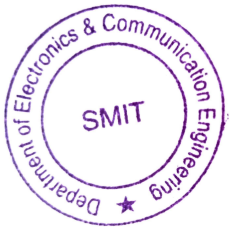
Course Objectives: To understand the basic concept of measurement and various bridges and their applications. To gather concept on various measuring instruments. To learn various display devices and recorders. To acquire the concepts of transducer for the application of various non electrical quantities. To learn the concept of data transmission and telemetry.
Pre-requisites: Knowledge in statistics, basic of DC bridges, electronic devices and mathematics.

Course Outcomes(CO):
After successful completion of this course, students will be able to:

CO1 Summarize the basic measurement concepts
CO2 Analyze the concept of various bridges and their applications
CO3 Describe various electronic measuring instrument, display devices and recorders
CO4 Explain the knowledge of sensors and transducers
CO5 Discuss on telemetry and tele-control

** not more than 20% of total topics to be allotted for assignment

Module	Topics to be covered	Topics	Hrs	CO
Module 1: <**Art of Measurement**>	in class	Static and Dynamic Characteristics of Measuring Devices, Measurement Errors: types and Statistical Analysis.	7	1
	****Assignment Topics**	Numerical on Static Characteristics and Statistical Analysis.		1
Module 2: **<Bridges and Their Applications>**	in class	Difference between DC and AC bridge, Wheatstone Bridge, Maxwell Bridge, Maxwell Wein Bridge, Andersons Bridge, Schering Bridge, De-Sauty's Bridge, Applications of AC bridges.	9	2
	****Assignment Topics**	Numerical on various AC bridges		2
Module 3: **<Electronic Measuring Instruments and Display Devices>**	in class	Multimeter, Digital Voltmeter (DVM), Cathode Ray Oscilloscopes, Digital Storage Oscilloscopes and Spectrum Analyzer, Light Emitting Diode, Liquid Crystal Devices, Data Acquisition System and Recorders.	10	3
	****Assignment Topics**	Numerical on CRT, DVM and LED		3
Module 4: **<Sensors and Measurement of Non-electrical Quantities Using Transducers>**	in class	Definition of sensors and Electrical transducer, Basic requirements of a transducer, Classifications of transducers, Strain: Strain Gauge & Piezo-electric Transducers, Temperature: Thermocouple & RTD, Pressure: Bourden Tube & Diaphragm, Flow: Rotameter &Orifice, Liquid Level: Capacitive and Ultrasonic Level Detector, LVDT	12	4



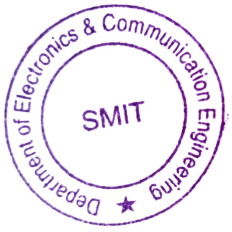
	****Assignment Topics**	Numerical on various Transducers		4
Module 5: **<Data Transmission and Telemetry>**	in class	Method of data transmission, general telemetry system, types of telemetry system, Land line telemetry, voltage T.S., current T.S., Position T.S., land line telemetry, Feedback system, R.F. telemetry, recent telemetry systems.	10	5
	****Assignment Topics**	Recent study on telemetry systems		5

Text Books:

1. *A.* K. Sawhney, *A course in Electrical and Electronic Measurements and Instrumentation*, 19e, Dhanpat Rai and Co.(P) Ltd.,2011.
2. Helfrick & Cooper, *Modern Electronic Instrumentation & Measurement Techniques*,1e, Prentice Hall of India, 2008.

Reference Books:

1. P. H. Mansfield, *Electrical Transducers & Industrial measurements*,1e, Butterworth-Heinemann, 1973.
2. H. S. Kalsi, *Electronic Instrumentation*, Tata McGraw-Hill, 2002



VT208A3 **Credit: 4 (L-3, T-1, P-0)**

Data Structure

Questions to be set: 05 (All Compulsory)

Course Objectives: To provide the knowledge of basic data structures and their implementations. To understand importance of data structures in context of writing efficient programs. To develop skills to apply appropriate data structures in problem solving.

Pre-requisites: Basic knowledge on C programing.

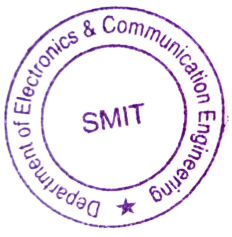
Course Outcomes (CO):

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

CO1 Explain the basic concepts of data structures and algorithms.
CO2 Apply basic techniques of stacks and queues
CO3 Describe implementation of linear data structures such as linked lists
CO4 Summarize non-linear data structures such as trees and graph
CO5 Extract concepts about searching and sorting techniques.

** not more than 20% of total topics to be allotted for assignment

Module	Topics to be covered	Topics	Hrs	CO
Module 1: **Introduction to Data Structure**	in class	Data and data structure concept; Different Data Type; Algorithms and programs. Algorithm efficiency and analysis, time and space analysis of algorithms – order notations.	9	1
	****Assignment Topics**	Basic C programs using Arrays		1
Module 2: <**Stack**>	in class	Stack and its implementations using array, Concept of queue, circular queue and de-queue. Implementation of linear and circular queue using array, Applications of stack and queue.	10	2
	****Assignment Topics**	Push, Pop, Enqueue and Dequeue programs using C		2
Module 3: <**Queue**>	in class	Singly circular and doubly linked list, operations using single linked list, linked list representation of polynomial and applications.	9	3
	****Assignment Topics**	Insertion and Deletion in Singly linked list programs using C		3
Module 4: <**Tree and Graph**>	in class	Tree representation using array and linked list. Binary trees - binary tree traversal, Creation, insertion, deletion and searching operation of binary search tree. Insertion, deletion with examples of Height balanced binary tree – AVL tree. Terminology and representations: Introduction, Definition and terminology, Graph representations, Traversals, Connected components and spanning trees, Shortest path problem, Dijkstra's algorithm.	10	4
	****Assignment Topics**	Creation, insertion, deletion and searching operation of binary search tree programs using C		4



Module 5: <**Searching and Sorting**>	in class	Sorting: Bubble, Insertion, merge, Heap sort and quick sort, Radix sort. Searching: Linear, Binary search, Comparison of different methods. Hashing technique: Hash tables, Different hashing functions, Overflow handling, Methods for collision handling, Theoretical evaluation.	10	5
	****Assignment Topics**	Different sorting and searching programs using C		5

Text Books:

(i) S. Lipschutz , “Data Structures” Revised 1st edition, Mcgraw Hill, February, 2018.

(ii) Debasis Samanta, “Classic Data Structures”, 2nd edition, PHI Learning Private Limited, 2012.

Reference Books:

(i) Ellis Horowitz, Sartaj Sahni, Susan Anderson-freed, “Fundamentals of Data Structures of C”, 2nd edition, Orient black swan, 2008.

(ii) Robert L. Kruse, Bruce P. Leung, “Data Structures and Program Design in C”, 1st edition, Pearson, 1990.

VT209A3 **Credit: 4 (L-3, T-1, P-0)**

Advanced Electronic Devices

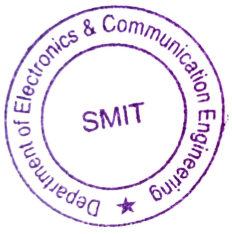
Questions to be set: 05 (All Compulsory)

Course Objectives: The course is designed to teach the physical principles and operational characteristics of advanced semiconductor electronic devices with emphasis on metal-oxide systems, high-electron mobility, and field-effect transistors. Topics also include quantum point contact and tunneling devices.

Pre-requisites: Electronic Devices and components.

Course Outcomes(CO): Students should be able to
CO1: analyze the issues in scaling MOS transistor.
CO2: explain the controlling mechanism of short channel effect.
CO3: explain the working principle of advanced junction diode.
CO4: analyze and design high speed devices.
CO5: explain and design of low dimensional structure devices.

Module	Topics to be covered	Topics	Hrs	CO
Module 1: **MOS Scaling theory**	in class	Issues in scaling MOS transistors, Channel length modulation, mobility variation, velocity saturation, Punch through, Hot carrier effect, drain induced barrier lowering (DIBL),	10	1
	****Assignment Topics**	Gate induced drain leakage (GIDL)		1
Module 2: **Controlling of short channel effect**	in class	Mobility booster-strained silicon technology, Gate leakage reduction, High-k dielectric.	10	2
	****Assignment Topics**	Poly depletion elimination- Metal gate.		2
Module 3: **Advanced Junction Diodes**	in class	Resonant tunneling diode (RTD).	8	3
	****Assignment Topics**	None		3
Module 4: **High Speed Devices**	in class	Metal-semiconductor field effect transistors (MESFET), Modulation doped heterostructures MODFET, High Electron Mobility Transistor (HEMT), Multi gate transistor: double gate transistors.	10	4
	****Assignment Topics**	FinFET and Surround gate FET.		4
Module 5: **Low dimensional structure devices**	in class	Homo-structure, Hetero-structure, Quantum tunnelling, Density of states in 2D, 1D, 0D structure, Quantum well, Quantum electron transport through nanostructure devices: Coulomb Blockade.	10	5
	****Assignment Topics**	Single Electron transistor.		5



Text Books:

1. Streetman and Banerjee, Solid State Electronic Devices, Paperback – 2015.
2. Donald Neamen and Dhrubes Biswas, Semiconductor Physics and Devices, Paperback – 1 Jul 2017.
3. S. M. Sze and K.K. Ng, Physics of Semiconductor Devices, 3ed Paperback – 2008.

Reference Books:

1. Charles Kittel, Introduction to Solid State Physics, Wiley; Eighth edition (2012).

Program Elective-3

VT301A3 **Credit: 3 (L-3, T-0, P-0)**

FPGA ARCHITECTURE

Questions to be set: 05 (All Compulsory)

Course objectives:

The course will introduce the participants to understand the architecture of FGPA.

Prerequisite: Basic of memory and processors.

Course outcomes

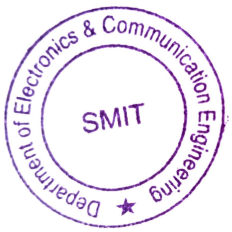
On completion of the course, the student will be able to:
1. comprehend low and programmable devices
2. understand Spartan 6 basics
3. use Virtex 5 clock sources and FIFO. Comprehend various I/O standards.
4. use memory, and DSP blocks in complex. Comprehend SerDes.
5. comprehend JTAG. Distinguish RISC-based soft processors from Xilinx, and Altera.

Module	Topics to be covered	Topics	Hrs	CO
1	In Class	**Designing with programmable logic devices:** Read only memories, programmable logic array (PLA), programmable array logic (PAL), programmable logic devices (PLD), Skew, setup time, hold time. **Designing with FPGA** Xilinx 3000 series FPGAs, programmable interconnects, Xilinx 4000 series FPGAs. Altera Flex 8000 FPGAs	8	1
	Assignment Topics:			
2	In Class	**Spartan6 architecture** Spartan 6 device features- 6 input LUT, slice, single port RAM, Dual port RAM, ROM, Distributed RAM, 32 × 6, 64 × 1, 128 × 1, distributed RAM timings, shift registers, multiplexers, interconnect, PLL, DCM, DSP slice.	8	2
	Assignment Topics:			
3	In Class	**Virtex 5 architecture**	8	3

		Clock resources- global clocks, regional clocks, clock buffer, clock gating, clock tree, clock De-skew, True Dual port RAM, Write modes, FIFO architecture, empty flag, almost empty flag, almost full flag, cascading FIFOS, connecting FIFOs in parallel, designing large multiplexer 4 × 1, 8 × 1, 16 × 1. Control impedance, I/O primitives, I/O supported standards, LVDS.		
	Assignment			
	Topics:			
4	In Class	**Staratix V architecture**	8	4
		ALM block diagram, ALM operating modes, ALM in arithmetic mode, types of embedded memory, control clocking, memory features, memory modes, DSP block features, optional modes, DSP block architecture in 27 × 27 mode, independent complex multiplier mode, I/O features mixing voltage referenced and non voltage referenced standard I/O standards. Dynamic OCT, LVDS Serdes block diagram and features, Differential receiver block diagram and features.		
	Assignment			
	Topics:			
5	In Class	**SOFT PROCESSORS**	4	5
		JTAG, programming through JTAG, IEEE 1149.1 boundary scan testing, programmable power technology, features of soft processors NIOS-II, Microblaze		
	Assignment			
	Topics:			

Books

1. Charles H Roth Jr “Digital systems design using VHDL”, second edition, 2008.
2. Spartan 6 family overview.
3. Virtex 5- User guide.
4. Stratix V device handbook.
5. NIOS-II, Microblaze features-Altera, Xilinx.



VT302A3 **Credit: 3(L-3, T-0, P-0)**

DIGITAL SIGNAL PROCESSING

Questions to be set: 05 (All Compulsory)

Course Objectives: To make students familiar with the most important methods in DSP, including digital filter design, transform-domain processing and importance of Signal Processors. To make students aware about the meaning and implications of the properties of systems and signals.

Pre-requisites: Mathematics, Signals and Systems.

Course Outcomes(CO):

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

CO1 Analyze basic signals, systems, sampling and DTFT

CO2 Analyze the frequency response of discrete time domain signals using DFT and FFT

CO3 Design analog and digital IIR filters for given specifications

CO4 Design FIR filters for given specifications

CO5 Realize digital systems based on IIR and FIR filter structures

** not more than 20% of total topics to be allotted for assignment

Module	Topics to be covered	Topics	Hrs	CO
Review of signals and systems	in class	Basic signals, Importance of impulse response, Types of systems, Sampling, Discrete Time Fourier Transform(DTFT) and its properties.	6	1
	****Assignment Topics**	Practice Numerical based on DTFT		1
Discrete Fourier Transform(DFT) and Fast Fourier Transform(FFT)	in class	Definition of DFT, Properties of DFT: Linearity, Circular shift of a sequence, Symmetry properties, Circular convolution, Linear Convolution using DFT, Relation among Z-Transform, Computation of DFT, FFT algorithms-Divide and conquer approach, Decimation in time and Decimation in frequency (radix-2 only), Computation of FFT, Signal Flow Graph.	8	2
	****Assignment Topics**	Practice Numerical based on DFT, IDFT, FFT		2
Analog and Digital IIR filters	in class	Butterworth, Chebyshev (T-I and T-II) and Frequency transformation, Mapping from analog domain to digital domain using Impulse invariance method, Bilinear transformations and Approximation of derivative; Design of IIR filters from analog filters.	8	3
	****Assignment Topics**	Practice Numerical based on IIR filter designing		3
Digital FIR filters	in class	Comparison between IIR and FIR filter; Different types of windows: Rectangular, Bartlett, Hanning, Hamming and Blackman windows; Design of FIR filters using windows;	8	4

		Design of FIR filters using Frequency sampling method; Linear phase FIR filter		
	****Assignment Topics**	Practice Numerical based on FIR filter designing		4
Realization of Digital Filter	in class	Comparison between analog and digital filter; Basic IIR filter structures: Direct forms (I&II), Cascade and parallel realizations. Basic FIR filter structures: Direct form FIR structures	6	5
	****Assignment Topics**	Practice Numerical based on digital filter designing		5

Text Books:

1. John G. Proakis and Dimitris G. Manolakis, Digital Signal Processing, 4e, Pearson,2007.

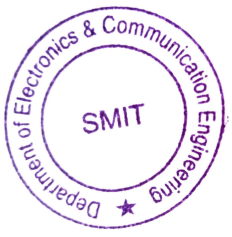
2. A V Oppenheim and R.W Schafer, Digital Signal Processing, 1e, Pearson Education, 2015.

3. P. Ramesh Babu, Digital Signal Processing, 4e, Scitech, 2010.

Reference Books:

1. Sanjit K Mitra, Digital Signal Processing:A Computer based Approach, 4e, Mcgraw Hill Education, 2013.

2. Tarun Kumar Rawat, Digital Signal Processing, 2e, Oxford University Press, 2015.



VT303A3 **Credit: 3(L-3, T-0, P-0)**

VLSI PHYSICAL DESIGN

No. of questions to be set: 1 from each CO
No. of questions to be answered: Five

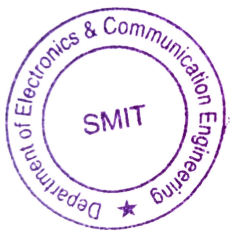
Objectives: The course will introduce the participants to the basic design flow in VLSI physical design automation, and the basic data structures and algorithms used for implementing the same. The course will also provide examples and assignments to help the participants understand the concepts involved and appreciate the main challenges therein.

Pre-requisites: Digital electronics, VLSI

Course outcomes:

On completion of the course, the student will be able to:

1. understand partitioning, floor planning, and placement.
2. familiar with the routing and clock design.
3. interpret statistic timing analysis and timing closure.
4. realize the concept of physical synthesis.
5. understand the low-power design.



Module	Topic	Hrs	CO	PO
1	**Introduction** Introduction to physical design automation, VLSI design styles, partitioning, floor planning, floor planning algorithms, pin assignment, placement	8	1	1,2
2	**Routing** Grid routing, global routing, detailed routing, clock designing, clock network synthesis, power, and ground routing.	8	2	1,2
3	**Static timing analysis and timing closure** Time closure, timing-driven placement, timing-driven routing, physical synthesis, performance-driven design flow, and timing optimization.	8	3	1,2
4	**Interconnect modelling and layout compaction** Interconnect modelling, design rule check, layout compaction.	8	4	1,2
5	**Low power design technique** Technique to reduce power, gate-level design for low power, other low-power design techniques, algorithmic level techniques for low power design	4	5	1,2

Books:

1. K. Golshan, *Physical design essentials: An ASIC design implementation perspective*. New York, NY: Springer, 2010.
2. S. M. Sait and H. Youssef, *Vlsi Physical Design Automation: Theory And Practice: Theory and Practice*. Singapore, Singapore: World Scientific Publishing, 1999.
3. J. Bhasker and R. Chadha, *Static timing analysis for nanometer designs: A practical approach*, 2009th ed. New York, NY: Springer, 2011.

VT304A3 **Credit: 3 (L-3, T-0, P-0)**

Java Programming

Questions to be set: 05 (All Compulsory)

Course Objectives: The Java Programming Language course provides students with a solid foundation for programming with JAVA. It also highlights the creation of graphical user interfaces (GUIs), exceptions, file input/output (I/O), and threads; and network programming.

Pre-requisites: Object Oriented Programming.

Course Outcomes (CO):

1. Use the syntax and semantics of java programming language and basic concepts of OOP.
2. Develop reusable programs using the concepts of inheritance, polymorphism and interfaces.
3. Transfer reusable programs using the concepts Strings handling, Interfaces and Packages.
4. Apply the concepts of Multithreading and Exception handling to develop efficient and error free codes.
5. Design event driven GUI and web related applications which mimic the real word scenarios.

Module	Topics	Hrs	CO
Module 1: Introduction to Java	Evolution and features of java, Overview of java, Two control statements, Lexical issues, Data types, Variables and arrays, Literals, Variables, Type conversion and casting, Type promotion in expression, arrays, Operators, Bitwise operators, Relational operators, Boolean and logical operators, Assignment Operators, The '?' operator, Operator precedence, JAVA statements.	8	1
Module 2: Introducing classes and Methods	Class fundamentals, Declaring objects, Assigning object reference Variables, Introducing methods, Constructors, 'this' keyword, Garbage collection, The finalize() method, stack class. Overloading methods and constructors, using object as parameters, Argument passing, Returning objects, Recursion, Access control, Static methods, Nested and inner classes, Command line argument.	8	2
Module 3: **Strings handling, Interfaces and Packages**	String constructors, String length, Special string operators, Character extraction, String comparison, String searching, String modification, Changing case of characters within a string, Compression and String buffer, String builder. Inheritance, Basics of inheritance, Types of inheritance,	8	3

	Using super keyword, method overriding, Dynamic method dispatch, Abstract class, Using final with inheritance, The object class, Defining and implementing interface, Extending interfaces, Nested interfaces, Applying interfaces, Defining and creating packages, Access protection, Importing packages. Exception Handling ,Fundamentals, Exception types, Uncaught exceptions, Using try and catch, Multiple catch clauses, Nested try statements, Throws, Finally, Java's built in exceptions, Creating own exception classes.		
Module 4: Input/Output, file handling and Multithreaded programming	Java I/O classes and interfaces, The stream classes, Byte streams, The character streams, The console class, File class, Byte-stream class, Random access files. Thread basics, Java's thread model, Thread priorities, Synchronization, Messaging, Thread class and runnable interface. The main thread, Creating a thread, Creating multiple threads, Interthread communication, Suspending/resuming and stopping threads.	8	4
Module 5: Network programming and Event Based Programming	Networking basics, The networking classes and interfaces, The InetAddress class, Inet4Address, TCP socket, URL, URLConnection, HTTP/URL Connection, TCP/IP server sockets, Datagram socket and Datagram Packet. The applet class, Repaint(), The HTML applet tag, Passing Parameter to applet, Event handling, Using delegation event model, Abstract Window program, Displaying information within a window, AWT controls.	4	5

Textbooks:

1. Programming With JAVA, 2nd Edition, E. Balaguruswami and TMH Publication.
2. Java: The Complete Reference, 7th Edition, Herbert Scheldt, TMH Publication.

Reference Books:

1. The Java Programming Language: K.Arnold and J. Gosling.
2. Professional java Server Programming: Allamaraju.
3. JAVA2: The Complete Reference, 3rd Edition, Patrick Naughton and HarbertSchildt, TMH Publication.
4. Internet & Java Program: R.Krishnamoorthy& S. Prabhu, New Age Internet Publisher.

VT305A3 **Credit: 3 (L-3, T-0, P-0)**

Database Management Systems

Questions to be set: 05 (All Compulsory)

Course objectives

To provide an introduction of DBMS and their use, be familiar with the basic DBMS architecture, components, and interfaces, have experience using at least one modern Database Management System.

Pre-requisites

Basic knowledge of mathematics.

Course outcomes

On completion of the course the student will be able to:

1. Define fundamental elements of a relational database management system

2. Describe entity-relationship diagrams to represent simple database application scenarios.

3. Interpret the basic concepts of relational data model, and Map Entity-relationship model, Relational database design, relational algebra, and database language SQL

4. Connect database using SQL

5. Relate database using NoSQL

Module	Topics to be covered	Topics	Hrs	CO
Module 1: Introduction to Database Management Systems	**In class Topics** **Assignment Topics**	DBMS: Characteristics, Advantages, Architecture. Database concept and architecture, Data models, Instances and schema, Database languages, Database manager, Database administrator, Database users, Concept of centralized database management and distributed database system.	8	1
Module 2: Data modelling	**In class Topics** **Assignment Topics**	Entity sets, attributes types and keys, Entity Relationship (ER) diagram, Type role and structural constraints, Enhanced entity-relationship (EER), Object modelling, Specialization and generalization, Modelling of union types, Data models: Definition, Purpose and Types, Hierarchical models, Network model, Relational model	8	2
Module 3:	**In class Topics**	Database design process, Relational database design, Relation schema, Functional dependencies, minimal covers, Normal forms, Multivalued dependencies, Converting EER diagrams to relations, Effect of de-normalization on database performance.	8	3

Database design	**Assignment Topics**			
Module 4: Database query languages (SQL)	**In class Topics**	Query-by-example (QBE), Introduction to SQL, Use of some special data types, Overview of SQL 92, Basic queries in SQL, Advanced queries in SQL, Functions in SQL, Basic data retrieval, Aggregation, Categorization, Updates in SQL, Embedded SQL and 4GLs, Procedural extension to SQL: PL/SQL. Introduction to SQLite-Android Database.	8	4
	Assignment Topics			
Module 5: Database query languages (NoSQL)	**In class Topics**	API-connection and operations APK. An overview of NoSQL, Characteristics of NoSQL, Advantages and challenges of NoSQL, NoSQL storage types, Case study of MongoDB.	4	5
	Assignment Topics			

Books

Text Books:

a) Elmasri and Navathe: "Fundamentals of Database Systems" Addison Wesley, 5th Edition.
b) Silberschatz, Korth, Sudarshan, "Database System Concepts" McGraw-Hill, 4th Edition.

Reference Books:

a) Thomas Connolly, Carolyn Begg, "Database Systems – A Practical Approach to Design, Implementation and Management", Pearson Education.
b) Jefrey D. Ullman, Jenifer Widom, "A First Course in Database Systems", Pearson Education.
c) Bipin C Desai, "An Introduction to Database Systems", Galgotia.
d) Atul Kahate, "Introduction to Database Management Systems", Pearson.
e) Ian Robinson, Jim Webber, Emil Eifrem,"Graph Databases",O'Reilly Media.
f) Gaurav Vaish, "Getting started with NoSQL", Packt.

Program Elective-4

VT306A3 **Credit: 4 (L-3, T-1, P-0)**

ADVANCED SEMICONDUCTOR DEVICES AND FLEXIBLE ELECTRONICS

Questions to be set: 05 (All Compulsory)

Course objectives:

The course will introduce the participants to the operation and application of various advanced semiconductor devices and flexible electronics.

Prerequisite: Basic semiconductor physics and devices.

Course outcomes

On completion of the course, the student will be able to:

1. understand the operation of PN junction, bipolar transistor, and related devices.
2. understand the operation of MOSFET and related devices.
3. use microwave diodes, quantum effect devices, and hot-electron devices.
4. understand the photonic devices.
5. have an idea of flexible electronics.

Module	Topics to be covered	Topics	Hrs	CO
1	In Class	**PN junction, Bipolar transistor, and related devices** PN junction: Thermal equilibrium condition, depletion region, depletion capacitance, IV characteristics, charge storage and transient behaviour, junction breakdown, Heterojunction Bipolar transistor and related devices: The transistor action, static characteristics of bipolar transistor, frequency response and switching of bipolar transistor, the heterojunction bipolar transistor, the thyristor and related power devices	9	1
	Assignment Topics:			
2	In Class	MOSFET and related devices The MOS diode, MOSFET fundamentials, MOSFET scaling, CMOS and BiCMOS, MOSFET on insulator, MOS memory structure, The power MOSFET, Metal-semiconductor contact, MESFET, MODFET.	9	2
	Assignment Topics:			

3	In Class	**Microwave diodes, quantum effect, and hot-electron devices** Basic microwave technology, Tunnel diode, IMPATT diode, transferred electron devices, quantum effect devices, Hot electron devices.	10	3
	Assignment			
	Topics:			
4	In Class	**Photonic devices** Radiative transitions and optical absorption, light emitting diode, semiconductor laser, photodetector, Solar cell	10	4
	Assignment			
	Topics:			
5	In Class	**Flexible electronics** Materials for Flexible Electronics, Fabrication Technology for Flexible Electronics, Mechanical Theory of Film on Substrate Foil Structure, Materials and Novel Patterning Methods for Flexible Electronics. Low Temperature Amorphous and Nano-crystalline Silicon Materials, Low-Temperature Dielectrics, Low Temperature Thin Film Transistor Devices, Flexible Transition Metal Oxide Electronics.	10	5
	Assignment			
	Topics:			

Books

1. Donald A Neamen, Semiconductor Physics and Devices: Basic Principles, McGraw-Hill (1997) ISBN 0-256-24214-3.
2. Yuan Taur & Tak H Ning, Fundamentals of Modern VLSI Devices, Cambridge University Press, 1998.
3. Robert F. Pierret, Semiconductor Device Fundamentals, Addison-Wesley (1995), ISBN 020154393-1.
4. E. H. Nicollian and J. R. Brews, MOS Physics and Technology, John Wiley, 1982.
5. K. K. Ng, Complete Guide to Semiconductor Devices, McGraw Hill, 1995.
6. Flexible Electronics Fabrication and Ubiquitous Integration, Ramses V. Martinez, Mdpi AG

VT307A3 **Credit: 4 (L-3, T-1, P-0)**

Linear and Digital Control Systems

Questions to be set: 05 (All Compulsory)

Course objectives

1. To give a vision and introduction to how the input affects the output (or, vice-versa, what inputs should be given to generate a desired output).

2. To provide the knowledge of the response of control systems to various standard test inputs.

3. To highlight the basic architecture of analog controllers under various control actions.

4. To understand the utility of frequency domain and time domain analysis for stability.

5. To understand the design of control systems using compensation circuits.

6. To analyze the use of digital control systems using state space technique.

Prerequisite

Knowledge of Engineering mathematics and basic electronics

Course outcomes

On completion of the course the student should be able to:

1. Describe the mathematical model of electrical and mechanical systems

2. Explain the stability in the time domain and the calculation of steady-state error.

3. Illustrate the stability in frequency domain

4. Explain Digital Control Systems using state space representation.

5. Summarize the various type of controller operation.

Module	Topics to be covered	Topics	Hrs	CO
Module 1: Introduction to Control systems and system modeling	**In class Topics**	Classification, comparison of open-loop and closed-loop systems, Representation of control systems by block diagrams, Mathematical models of electrical, mechanical and electromechanical systems. Block diagram reduction, signal flow graphs, Masons gain formula, limitations of mathematical models	9	1
Module 2:	**In class Topics**	Step response of first - and second - order systems, under damped system response, over damped, critically damped system – time domain specifications, Concept of order of system, type of systems. Steady state errors, Error ratio, Static error	9	2

Time-domain analysis		Constants, Generalized error series. dynamic error coefficients, steady state errors due to Impulse, step and ramp inputs.		
Module 3: Stability analysis	**In class Topics**	The concept of stability – Routh's stability criterion – qualitative stability and conditional stability – limitations of Routh's stability. Root-locus technique— properties and rules for construction, numerical examples. Nyquist stability criterion, construction of Nyquist-plot, stability assessment from the plot. Bodeplot—Gain Margin and Phase margin calculations and corresponding stability assessment.	10	3
Module 4: State space analysis	**In class Topics**	Concepts of state, state variables and state model, derivation of state models from block diagrams, Diagonalization- Solving the Time invariant state Equations, State Transition Matrix and it's Properties – Concepts of Controllability and Observability.	10	4
Module 5: Analog controller	**In class Topics**	Proportional control, proportional-plus integral control, proportional-plus-derivative control. Proportional-plus-integral-plus derivative control, their realization. Tuning the controllers - ziegler and Nicholas methods	10	5

Test books

ii) Automatic Control System By S. Hasan Saeed

iii) Linear Control Systems By B. S. Manke

Reference books

i) Control System Engineering By Norman S. Nise

ii) Modern Control Engineering By Katsuhiko Ogata

VT308A3 **Credit: 4 (L-3, T-1, P-0)**

Information Theory and Coding

Questions to be set: 05 (All Compulsory)

Course Objectives: The course is intended to give students a basic idea of information theory and coding. The course offers different types of source and channel coding technique, channel capacity and bounds, probability of error calculation for different channels.

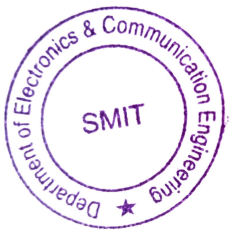
Pre-requisites: Random variable and Process and, Probability, Linear Algebra

Course Outcomes (CO): Students should be able to

1. Calculate information, entropy and kraft's inequality.
2. Identify the concept of Shannon's theorem.
3. Analyze the concept of mutual information and channel capacity.
4. Inspect error detection and correction in linear block codes.
5. Construct convolutional codes and turbo codes.

Module	Topics to be covered	Topics	Hrs	CO
Module 1: INFORMATION SOURCES AND PROPERTIES OF A CODES:	**In class Topics**	Definition of Information, Properties of Information, Entropy, Information rate, Zero memory information source, Entropy, Properties of Entropy**,** Markov information source**,** Adjoint Source**,** Extensions of a Markov source. source coding: Uniquely decodable codes, Instantaneous cods, Construction of Instantaneous cods, Kraft's Inequality, McMillan's Inequality	10	1
	Assignment Topics	Tutorial problems on entropy, classification of codes based on kraft's Inequality		1
Module 2: INFORMATION CODES	**In class Topics**	The average length of a code, Encoding for the special sources, Shannon's First Theorems, Shannon Fano algorithm, Huffman's Codes, r-array compact cods, code efficiency and redundancy. Shannon- Hartley law, Trade-off between bandwidth and SNR.	8	2

	Assignment Topics	Tutorial problems on source coding		2
Module 3: CHANNEL AND MUTUAL INFORMATION	**In class Topics**	Information Channels, probability relation in a channel, apriori and posteriori entropies, A generalization of Shannon's first theorem, Mutual information, properties of mutual information, noiseless and deterministic channels, cascaded channels, channel capacity, conditional mutual information.	12	3
	Assignment Topics	Tutorial problems on mutual information and channel capacity		3
Module 4: RELIABLE MESSAGES THROUGH NON-RELIABLE CHANNELS USING ERROR CORRECTING CODES	**In class Topics**	Error probability and decision rules, The Fano bound, Reliable messages and unreliable channels, An example of coding to correct errors, Hamming distance, Shannon's Second theorem for binary symmetric channel (BSC)-The First step, Random coding-Second Step. Linear Coding linear block codes for error detection and correction. codes) Linear block codes and their properties, syndromes, weight distribution. BCH Codes: Binary and Nonbinary BCH codes (Reed Solomon) BCH codes for Channel performance improvement against burst errors.	10	4
	Assignment Topics	Tutorial problems on linear block codes		4
Module 5: CONVOLUTION CODES, LDPC CODES AND TURBO CODING	**In class Topics**	Convolutional codes: Convolutional encoders and decoding convolution codes for performance analysis & cyclic codes for error detection and correction. trellis diagrams, Viterbi algorithm. Turbo codes: Turbo encoders and Iterative turbo decoding LDPC Codes: Encoding and decoding	8	5
	Assignment Topics	Tutorial problems on Convolutional codes codes		5

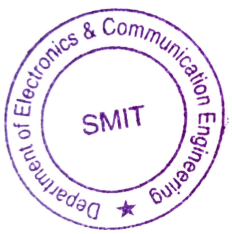


Text Books:

1. N. Abrahamson, Information Theory, and coding. 2e, McGraw Hill, 1963
2. Thomos M.Cover et.al, Elements of Information Theory. 2e, Wiley Series in Telecommunication, 2004.
3. Sarah J Johnson, Iterative error correction. Cambridge University Press, 2010.

Reference Books:

1. R.G. Gallager, "Information Theory and reliable communication" , Wiley Newyork,1e, 1968
2. Richard E. Blahut, "Principles and practices of information Theory" –, Addison Wesley,1e 1987.
3. David Slapian, "Key papers in the development of information theory" , IEEE press, 1e, 1973.
4. Shu Lin et.al, Error Control coding. 2e, Pearson, 2011.



VT309A3 **Credit: 4 (L-3, T-1, P-0)**

MEMS & NEMS

Questions to be set: 05 (All Compulsory)

Course Objectives: The main aim of the course is to teach basic knowledge in MEMS & NEMS and apply them to design different real-time products and to impart a solid understanding of the role of micro and Nano-systems and their design and development.

Pre-requisites: Basic knowledge in Analog & digital electronics, VLSI design, and fabrication technique.

Course Outcomes (CO): Students can be able to

1. explain the basics of the Micro Electronic Mechanical System.
2. design different MEMS devices.
3. manufacture different MEMS devices.
4. design different MEMS devices used in medical Science.
5. design different NEMS devices.

Module	Topics to be covered	Topics	Hrs	CO
Module 1: **Introduction to micro-systems**	**In class Topics**	Overview of microelectronics manufacture and Microsystems technology. Definition - MEMS materials. Laws of scaling. The multidisciplinary nature of MEMS. Materials for MEMS manufacturing, Applications of MEMS in various industries.	7	1
	Assignment Topics	Recent trends in MEMS		1
Module 2: **MEMS Devices**	**In class Topics**	Working principle of Microsystems, micro-actuation techniques, micro sensors, Definition, Constructional description, Classification, Working principle, and applications of MEMS Accelerometers and MEMS gyroscopes, RF MEMS, Optical MEMS	12	2
	Assignment Topics	Industrial Details of MEMS device design company and its scope.		2

Module 3: **MEMS manufacturing technologies**	**In class Topics**	Bulk Micro manufacturing, surface micro machining, LIGA, SLIGA, High aspect ratio (HAR) silicon micromachining, Micro system packaging materials, surface bonding, wire bonding, sealing	9	3
	Assignment Topics	Industrial Details of MEMS fabrication company and its scope.		3
Module 4: **MEMS devices for biomedical applications**	**In class Topics**	MEMS Pressure Sensors, MEMS Hearing-Aid Transducer , Micro fluidics for diagnostics, Micro fluidics for drug delivery, Micro machined needles, Microsurgical tools. Modern trends in MEMS	9	4
	Assignment Topics	Current trends in MEMS based bio medical instruments.		4
Module 5: **Nano-systems Design**	**In class Topics**	Overview of microelectronics manufacture and Nano-systems technology. SOI MOSFET, multi-gate transistors – single gate – double gate – triple gate, Carbon nanotube, Carbon nanotube FETs – Carbon nanotube MOSFETs, General model for ballistic nano transistors – MOSFETs with 0D, 1D, and 2D channels – Molecular transistors – Single electron charging – Single electron transistor	11	5
	Assignment Topics	Recent trends in MEMS		5

Text Books:

(i) Tai-Ran Hsu, MEMS and Microsystems Design and Manufacture, Tata McGraw-Hill Publishing Company Ltd, 2012.

(ii) Mark Lundstrom, Jing Guo, "Nanoscale Transistors: Device Physics, Modeling and Simulation", Springer, 2006

Reference Books:

(i) Francis E.H. Tay and Choong .W.O, Micro fluidics and Bio MEMS application, IEEE Press New York, 1997.

(ii) M S Lundstorm, "Fundamentals of Carrier Transport", 2nd Ed., Cambridge University Press, Cambridge UK, 2000.

Program Elective-5

VT310A3 **Credit: 4 (L-3, T-1, P-0)**

ADVANCE VLSI AND SOC DESIGN

Questions to be set: 05 (All Compulsory)

Course objectives:

Historical Perspective of VLSI, CMOS VLSI Design for Power and Speed consideration, Logical Efforts: Designing Fast CMOS Circuits; Datapath Design, Interconnect aware design, Hardware Description Languages for VLSI Design, FSM Controller/Datapath and Processor Design, VLSI Design Automation, and VLSI Design Test and Verification.

Prerequisite: Knowledge of basic VLSI circuit and technology.

Course outcomes

On completion of the course, the student will be able to:

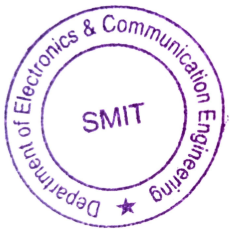
1. Introduction to different VLSI design and performance parameters.
2. Familiarization to data path & Interconnect aware design
3. Skill development inHardware Description Languages for VLSIDesign.
4. Introduction to processor design.
5. Familiar with different Automation and testing tools in VLSI design.

Module	Topics to be covered	Topics	Hrs	CO
1	In Class	**CMOS VLSI Designfor Power and Speed consideration** Historical Perspective and Future Trends in CMOS VLSI Circuit and System Design- Part-I,Historical Perspective and Future Trends in CMOS VLSI Circuit and System Design - Part II, Logical Effort - A way of Designing Fast CMOS Circuits Logical Effort - A way of Designing Fast CMOS Circuits - Part II, Logical Effort - A way of Designing Fast CMOS Circuits - Part III, Power Estimation and Control in CMOS VLSI circuits Power Estimation and Control in CMOS VLSI circuits -Part II Low Power Design Techniques- Part-I,Low Power DesignTechniques - Part II	10	1
	Assignment Topics:			
2	In Class	**Datapath Design & Interconnect aware design:** Arithmetic Implementation Strategies for VLSI, Impact of scaling, buffer insertion and Inductive peaking, Low swing and Current mode signalling, Capacitively coupled interconnects.	9	2

	Assignment			
	Topics:			
3	In Class	**Hardware Description Languages for VLSI Design** Managing concurrency and time in Hardware Description Languages. Introduction to VHDL. Basic Components in VHDL. Structural Description in VHDL. Behavioral Description in VHDL. Introduction to Verilog.	10	3
	Assignment			
	Topics:			
4	In Class	**Controller/Datapath and Processor Design** FSM + datapath (GCD example) , Single Cycle MMIPS, Multicycle MMIPS , Multicycle MMIPS – FSM	4	4
	Assignment			
	Topics:			
5	In Class	**VLSI Design Automation, Test and Verification** Brief Overview of Basic VLSI Design Automation Concepts , Netlist and System Partitioning , Timing Analysis in the context of Physical Design Automation, Placement algorithm, Introduction to VLSI Testing , VLSI Test Basics - I , VLSI Test Basics - II , VLSI Testing:Automatic Test Pattern Generation , VLSI Testing: Design for Test (DFT) , VLSI Testing:Built-In SelfTest (BIST) , VLSI Design Verification: An Introduction 40. VLSI Design Verification: Equivalence Checking , VLSI Design Verification: Equivalence/Model Checking , VLSI Design Verification: Model Checking	15	5
	Assignment			
	Topics:			

Books

1. Rao R. Tummala, Fundamentals of Microsystems Packaging, McGraw Hill, NY, 2001.
2. William D. Brown, Advanced Electronic Packaging, IEEE Press, 1999.
3. Bosshart, Printed Circuit Boards Design and Technology, TataMcGraw Hill, 1988.
4. Blackwell (Ed), The electronic packaging handbook, CRC Press, 2000.



VT311A3 **Credit: 4 (L-3, T-1, P-0)**

SEMICONDUCTOR DEVICE MODELLING

Questions to be set: 05 (All Compulsory)

Course objectives:

This course is a foundation-level course on semiconductor devices. The course consists of three broad topics (1) Semiconductors properties, (2) Devices and (3) governing equations along with their boundary conditions. The course objective is to develop a sound physical and intuitive understanding of semiconductor devices and achieve the ability to make some key decisions while designing application-specific semiconductor devices.

Prerequisite: Basic semiconductor physics and mathematics

Course outcomes

On completion of the course, the student will be able to:

1. understand the advanced semiconductor physics.
2. familiar with semiclassical transport theory.
3. interpret drift-diffusion model.
4. realize the hydrodynamic modeling.
5. understand the quantum transport model.

Module	Topics to be covered	Topics	Hrs	CO
1	In Class	**Introduction to semiconductor physics** Crystal structure-Unit cell and Miller Indices, Reciprocal Space, Doping, Band Structure, Effective Mass, Density of states, Electron Mobility, Semiconductor Statistics- Fermi-Dirac function and carrier concentration calculation, p-n junction under equilibrium, derivation of I-V relation, Minority carrier diffusion equation, non-idealities in the p-n junction diode (Breakdown and Generation-Recombination currents).	10	1
	Assignment Topics:			
2	In Class	**Semiclassical Transport Theory** Distribution Function, Boltzmann Transport Equation (BTE), Relaxation-Time Approximation (RTA), Scattering and Mobility.	6	2

	Assignment			
	Topics:			
3	In Class	**Drift-Diffusion (DD) model** Drift-diffusion model Derivation and dielectric relaxation time, Taylor series expansion and Finite Difference method, Normalization, Scaling and Linearization of Poisson's Equation and Scharfetter–Gummel Discretization of the Continuity Equation, Generation and Recombination models, Derivation of SRH model, Boundary conditions, Gummel's Iteration Method and Newton's Method, Drift-Diffusion Application example.	12	3
	Assignment			
	Topics:			
4	In Class	**Hydrodynamic Modeling** As an extension of the DD model, Carrier Balance, Energy balance, and momentum balance Equations, Direct solution scheme through Monte Carlo simulations.	10	4
	Assignment			
	Topics:			
5	In Class	**Quantum Transport models** Tunneling, Schrodinger equation and free particle, potential step, potential barrier, Transfer Matrix Approach, Quantum Mechanical corrections to standard approach.	10	5
	Assignment			
	Topics:			

Books

1. G. Streetman, and S. K. Banerjee, "Solid State Electronic Devices," 7th edition, Pearson,2014.
2. S. M. Sze and K. N. Kwok, "Physics of Semiconductor Devices," 3rd edition, John Wiley&Sons, 2006.
3. D Vasileska, SM. Goodnick, G Klimeck, "Computational Electronics: Semiclassical and Quantum Device Modeling and Simulation," CRC Press 2010.
4. Selberherr Siegfried, "Analysis and Simulation of Semiconductor Devices", 1984

VT312A3 **Credit: 4 (L-3, T-1, P-0)**

MACHINE LEARNING

Questions to be set: 05 (All Compulsory)

Course Objectives: The objective of this course is to provide a concise introduction to the fundamental concepts in machine learning and popular machine learning algorithms. The standard and most popular supervised learning algorithms including linear regression, logistic regression, assembling and boosting algorithms and neural networks with an introduction to Artificial Neural Networks.

Pre-requisites: Basics of Probability and Linear Algebra

Course Outcomes (CO): After Successful completion of this course, students should be able to

CO-1: Apply the knowledge of linear regression and logistic regression for prediction and classification problems.

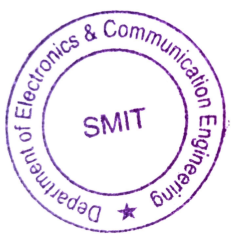
CO-2: Use supervised learning algorithms to solve classification problems.

CO-3: Explain the theoretical framework for analyzing the generalization error of a learning algorithm.

CO-4: Apply unsupervised learning algorithms for dimensionality reduction and clustering techniques to real world problems.

CO-5: Explain the basic concept of Artificial Neural Network.

Module	Topics	Hrs	CO
Module 1: **Basics of ML and Regression**	Basic Definition, Types of Learning: Supervised Learning, Unsupervised Learning, semi-supervised Learning and Reinforcement Learning, Examples of Machine Learning Applications., hypothesis space and inductive bias, evaluation, cross-validation. Linear Regression: Linear Regression with Single Variables- Model Representation and Cost Function. Parameter Learning: Gradient Descent, Gradient Descent Intuition, Gradient Descent for Linear Regression, Linear Regression with Multiple Variables Multiple Features, Gradient Descent for Multiple Variables, Gradient Descent in Practice: Feature Scaling and Learning Rate; Features and Polynomial Regression. Logistic Regression: Classification and Representation. Classification, Hypothesis Representation and Decision Boundary, Logistic Regression Model - Cost Function, Simplified Cost Function and Gradient Descent Multiclass Classification- One-vs-all, Regularization: Overfitting problems, Regularized Linear Regression, Regularized Logistic Regression.	10	1
Module 2: **Supervised Learning**	Nearest neighbor (NN), Linear Discriminant Analysis, Support vector machines, Decision Trees, Generative classifiers like naïve Bayes.	10	2
Module 3: **Computational learning theory**	PAC learning model, Sample complexity, VC Dimension, Ensemble learning: Bagging, Boosting, Stacking	10	3



Module 4: **Unsupervised Learning**	Principle component Analysis, Factor Analysis, Nonnegative matrix factorization, Rate-Distortion Theory, Kmeans, hierarchical clustering, Gaussian mixture model, Expectation-Maximization Algorithm	10	4
Module 5: **Neural Networks**	Overview of neural networks, perceptron's, Activation functions, Multilayer network, backpropagation Algorithm	8	5

Text Books:

1. Ethem Alpaydın, "Introduction to Machine Learning", 2nd Edition, MIT Press, 2010. 2. Tom M. Mitchell, "Machine Learning ", McGraw-Hill Science, 1997.
2. Trevor Hastie, Robert Tibshirani and Jerome Friedman.. The Elements of Statistical Learning. Second Edition, Springer, 2009

Reference Books:

1. Christopher M. Bishop, "Pattern Recognition and Machine Learning", Springer 2006
2. Stephen Marsland, "Machine Learning: An Algorithmic Perspective", 2nd Edition, CRC Press, 2015.
3. R. O. Duda, P. E. Hart, and D. G. Stork, "Pattern classification". John Wiley & Sons, 2012.
4. Shai Shalev-Shwartz and Shai Ben-David, Understanding Machine Learning.. Cambridge University Press. 2017.
5. Tom Mitchell, Machine Learning, McGraw Hill, 1997

Open Elective-1

VT201A2 **Credit: 4 (L-3, T-1, P-0)**

Introduction to Complex Variables

Questions to be set: 05 (All Compulsory)

Course objectives:

Complex numbers, the topology of the complex plane, the extended complex plane and its representation using the sphere. Complex functions and their mapping properties, their limits, continuity and differentiability, analytic functions, analytic branches of a multiplevalued function. Complex integration, Cauchy's theorems, Cauchy's integral formulae. Power series, Taylor's series, zeroes of analytic functions, Rouche's theorem, open mapping theorem Isolated singularities and their classification, Laurent's series, Cauchy's residue theorem, the argument principle.

Prerequisite:

Single and multi-variable real analysis

Course outcomes

On completion of the course the student should be able to:

1. Understand the concept of the Algebra Geometry and Topology of the Complex Plane

2. Understand the concept of the Complex Functions and associated concept of Limits, Continuity and Differentiation

3. Exploit Complex Integration methods

4. Understand the Properties of Analytic Functions

5. Understand the concept of Isolated Singularities and Residue Theorem

Module	Topics to be covered	Topics	Hrs	CO	PO	PSO
1: Introduction: The Algebra Geometry and Topology of the Complex Plane	In Class	Introduction and overview of the course, Complex numbers, conjugation, modulus, argument and inequalities, Powers and roots of complex numbers, geometry in the complex plane, the extended complex plane, Topology of the complex plane: Open sets, closed sets, limit points, isolated points, interior points, boundary points, exterior points, compact sets, connected sets, sequences and series of complex numbers and convergence.	8	1	1,2	1
	Assignment Topics:	Numerical Problem				
2:	In Class	Introduction to complex functions, Limits and continuity, Differentiation and the Cauchy-Riemann	10	2	1,2	1

Complex Functions: Limits, Continuity and Differentiation		equations, analytic functions, elementary functions and their mapping properties, harmoni , properties, harmonic functions				
	Assignment Topics:	Numerical Problem				
3. Complex Integration Theory	In Class	Introducing curves, paths and contours, contour integrals and their properties, fundamental theorem of calculus, Cauchy's theorem as a version of Green's theorem, Cauchy-Goursat theorem for a rectangle, The antiderivative theorem, Cauchy Goursat theorem for a disc, the deformation theorem. Cauchy's integral formula, Cauchy's estimate, Liouville's theorem, the fundamental theorem of algebra, higher derivatives of analytic functions, Morera's theorem	12	3	1,2	1
	Assignment Topics:	Numerical Problem				
4. Properties of Analytic Functions	In Class	Power series, their analyticity, Taylor's theorem, Zeroes of analytic functions, Rouche's theorem, Open mapping theorem, maximum modulus theorem	9	4	1,2	1
	Assignment Topics:	Numerical Problem				
5. Isolated Singularities and Residue Theorem	In Class	Isolated singularities, removable singularities, Poles, classification of isolated singularities, Casoratti-Weierstrass theorem, Laurent's theorem, Residue theorem, the argument principle.	9	5	1,2	1
	Assignment Topics:	Numerical Problem				

Test books

1. H. A. Priestley, Introduction to Complex Analysis, 2nd edition (Indian), Oxford, 2006.

2. L. V.Ahlfors, Complex Analysis, 3rd edition, McGraw Hill, 2000.

Reference books

1. J. E. Marsden and M. J. Hoffman, Basic Complex Analysis, 3rd edition, W.H. Freeman,1999.
2. J. W. Brown and R. V. Churchill, Complex Variables and Applications, 7th edition,McGraw Hill, 2003

VT202A2 **Credit:4 (L-3, T-1, P-0)**

SEMICONDUCTOR PHYSICS

Questions to be set: 05 (All Compulsory)

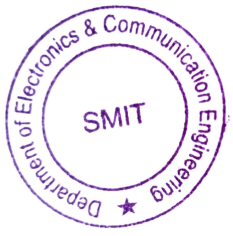
Course Objectives:

Semiconductor physics. Explain and apply basic concepts of semiconductor physics and semiconductor devices. Describe, explain, and analyze the operation of important semiconductor devices in terms of their physical structure. Physics-based models. Explain, describe, and use physicsbased device and circuit models for semiconductor devices of varying levels of complexity, select models appropriate to a specific need, and apply those models to analyze multi-component circuits.

Pre-requisites: Students should be able to,

CO1: Demonstarte a clear understanding of concepts of semiconductor materials and the physics of the materials and devices.
CO2: Demonstarte an understanding of Quantum Theory of Semiconductors.
CO3: Build a clear knowledge and exhibit the understanding of various carrier statistics in semiconductors.
CO4: Apply various models for the current transport for different conditions in a semiconductor.
CO5: Exhibit a clear understanding of various carrier dymanics and matehmnatical derivations for continuity and concentrations in semiconductors.** not more than 20% of total topics to be allotted for assignment

Module	Topics to be covered	Topics	Hrs	CO
Module 1: QUANTUM THEORY OF SEMICONDUCTORS	in class	Type of solids, Bravais lattices, Lattice with basis, Point defects, Dislocation, Bulk crystal growth, Epitaxy, Energy levels of atoms and molecules, Energy bands of solids, Energy bands in real space, Energy bands in reciprocal lattice, Energy band structures of metal and insulator, Kronig-Penny Model, Definition of semiconductor, Electrons and holes, and Effective mass.	10	1
	**Assignment Topics	Kronig-Penny Model, Definition of semiconductor, Electrons and holes, and Effective mass		1
Module 2: CARRIER STATISTICS	in class	Currents in semiconductors, Density of states, Fermi-Dirac probability function, Equilibrium carrier concentrations, Non-degenerate semiconductors, Intrinsic carrier concentration, Intrinsic Fermi level, Donor and acceptor impurities, Impurity energy levels, Carrier concentration in extrinsic semiconductor, and Fermi level of extrinsic semiconductors, Position of Fermi Energy Level: Mathematical Derivation , Variation of E, with Doping Concentration and Temperature, Relevance of the Fermi Energy, Statistics of Donors and Acceptors:	10	2



		Probability Function , Complete Ionization and Freeze-Out ,Compensated Semiconductors		
	**Assignment Topics	Position of Fermi Energy Level		2
Module 3: CURRENTS IN SEMICONDUCTOR	in class	Thermal motion of carriers, Carrier motion under electric field, Drift current, Mobility and conductivity, Velocity saturation, Diffusion of carriers, General expression for currents in semiconductor, Carrier concentration and mobility, and the Van der Pauw technique. Graded Impurity Distribution: Induced Electric Field, The Einstein Relation	10	3
	**Assignment Topics	Graded Impurity Distribution: Induced Electric Field, The Einstein Relation		3
Module 4: ELECTRON TRANSPORT	in class	Electronic transitions in semiconductor, Radiative transition, Direct and indirect bandgap semiconductors, Roosbroeck-Shockley relationship, Radiative transition rate at nonequilibrium, Minority carrier lifetime, Localized states, Recombination center and trap.	10	4
	**Assignment Topics	Direct and indirect bandgap semiconductors		4
Module 5: CARRIER DYNAMICS	in class	Shockley-Hall-Reed recombination, Surface recombination, Auger recombination, Derivation of continuity equation, Non-equilibrium carrier concentration, Quasi-Fermi level, Current and quasi-Fermi level, Non-uniform doping, and Non-uniform bandgap.	8	5
	**Assignment Topics	Fermi level, Non-uniform doping, and Non-uniform bandgap.		5

Textbooks:

1. G. Streetman, and S. K. Banerjee, “Solid State Electronic Devices,” 7th edition, Pearson,2014.
2. D. Neamen , D. Biswas "Semiconductor Physics and Devices," McGraw-Hill Education.
3. S. M. Sze and K. N. Kwok, “Physics of Semiconductor Devices,” 3rd edition, John Wiley & Sons, 2006. 4. C.T. Sah, “Fundamentals of solid-state electronics,” World Scientific Publishing Co. Inc, 1991.

Reference Books:

1. Y. Tsividis and M. Colin, “Operation and Modeling of the MOS Transistor,” Oxford Univ.Press, 2011.

VT203A2 **Credit: 4 (L-3, T-1, P-0)**

PYTHON PROGRAMMING

Questions to be set: 05 (All Compulsory)

Course Objectives: This course covers the fundamentals of Python programming. This course covers everything from the fundamental concepts of Python such as variables, operators, lists, tuples, and objects to topics like files and exception handling. The completion of this course will enable the students to write programs in Python language to solve their problems of interest.

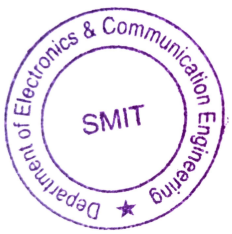
Pre-requisites: Knowledge of basics programming.

Course Outcomes (CO):

After studying this course, students will be able to:
1. Understand the concept of structure, data types and variables using Python Programming Language
2. Apply the concept of list, tuples, functions and dictionaries in Python Programs
3. Understand and use classes and objects in Python.
4. Read and write files in Python.
5. Use exception handling in Python applications for error handling.

** not more than 20% of total topics to be allotted for assignment

Module	Topics to be covered	Topics	Hrs	CO
1. **Overview & Introduction**	In class	Introduction, Features, Lexical Structure, Data Type, Variables, Numbers, Strings, Expression and Operators, Numeric Operations, Conditional Statements, Looping, Control flow Statements.	10	1
2. **List, Tuples, Functions & Dictionaries**	In Class	Introduction to List and Tuple, Accessing List and Tuple, Operations, working with List and Tuple Build-in Function and Methods, optional arguments, default values, Passing functions as arguments, Working with dictionaries, properties and Methods.	10	2
3. **Classes and Objects in Python**	In Class	Defining Class, Creating Object, Built-in class Attributes, Inheritance, Overloading and Overriding, Data Hiding	8	3
4. **Read and Write Files**	In Class	File Objects, File Built-in Function, File Built-in Methods, File Built-in Attributes, Standard Files, Command-line Arguments, File System, File Execution, Persistent Storage Modules.	10	4
5. **Error and Exception Handling**	In Class	Exceptions in Python, Detecting and Handling Exceptions, Exceptions as Strings, Raising Exceptions, Assertions, Standard Exceptions	10	5



Text Book

1. Lutz, Mark, Learning Python, O Rielly.

2. Chun, J Welsey, Core Python Programming, Pearson.

Reference Books:

1. Ljubomir Perkovic, Introduction to Computing Using Python: An Application Development Focus, John Wiley & Sons.

2. Barry, Paul, Head First Python, O Rielly.

3. Guttag John V, Introduction to Computation and Programming Using Python with Application to Understand Data, PHI.

4. Taneja Sheetal, Python Programming : A modular approach, Pearson.

VT204A2 **Credit: 4 (L-3, T-1, P-0)**

MATHEMATICS FOR COMMUNICATION ENGINEERING

Questions to be set: 05 (All Compulsory)

Course Objectives:

iv. To build the strong foundation in Mathematics in students needed for the field of Communication Engineering.
v. To provide the mathematics fundamentals necessary to formulate, solve and analyse complex engineering problems.
vi. To apply reasoning by the contextual knowledge to engineering practice.
vii. To work as teams on multi-disciplinary projects.

Pre-requisites: Linear algebra

Course Outcomes (CO): Students should be able to

1. Apply matrix theory in Communication Engineering problems.
2. Calculate gradients, derivatives and its applications
3. Apply the constrained optimization for approximate solutions.
4. Do statistical modelling and analysis of Communication Systems
5. Apply Markovian process and distinguish the utility of queuing models.

** not more than 20% of total topics to be allotted for assignment

Module	Topics to be covered	Topics	Hrs	CO
Module 1: **Basic Matrix Concepts**	in class	Linear equations and matrix representations, Determinants. Vector spaces- Basis and dimension, Norms and inner-products, The Cauchy- Schwarz inequality, Direction of vectors, weighted inner products, Expectation as an inner product, Hilbert and Banach spaces, orthogonal subspaces, null space, column space, row space. Projection matrices.	9	1
	****Assignment Topics**	Numerical Problems		1
Module 2: **Matrix Factorizations and applications**	in class	The LU factorization-Methods of Crout and Cholesky factorization, unitary matrices and the QR factorization, Eigen values, Eigen vectors, EVD, whitening, Pseudo inverses and the SVD, numerically sensitive problems, Rank-reducing approximations.	9	2
	****Assignment Topics**	Numerical Problems		2
Module 3: **Theory of Constrained optimization**	in class	Basic definitions, definitions of constrained optimization, equality constraints: Lagrange multipliers.	8	3
	****Assignment Topics**	Numerical Problems		3
Module 4: **Probability and random processes**	in class	Random vectors, transformations, joint moments, joint characteristic function, correlation, covariance matrices - properties. Vector Gaussian, Q-function, Circular complex Gaussian,	10	4

		various transformations, Gaussian random vectors, Rayleigh, Rician, Nagakami distributions, probability of error upper bounds for M-ary modulations.		
	****Assignment Topics**	Numerical Problems		4
Module 5: **Markov Chains Queuing theory**	in class	Markov Process, Markov chains, Birth Death process- Characteristics of queuing models –Kendall's otation - Transient and Steady States and Difference equations related to Poisson Queue systems – Single server and Multiple Server Poisson queue Models with Finite and Infinite capacity.	12	5
	****Assignment Topics**	Numerical Problems		5

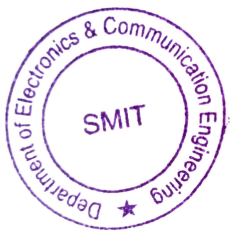
Text-Books:

1. Todd.K. Moon and Wynne Stirling, Mathematical methods and algorithms for signal processing, 2000, Prentice Hall, 2000. New York.
2. John G. Proakis, Masoud Salehi, Digital Communications, 2008, 5th edition, McGrawHill.
3. T.Veerarajan, Probability, Statistics and Random Processes, 2009, 3rd edition, McGrawHill.

Reference Books:

4. Gilbert Strang, Introduction to Linear Algebra, 2009, 4th edition, Wellesley-Cambridge press.
5. E. Larsson, P. Stoica, Space time block coding for wireless communications, 2003, Cambridge University press.
6. P.P. Vaidyanadhan, Multirate systems and filter banks, 1993, Pearson India. Dimitris G. Manolakis, Vinay K. Ingle, Stephen M. Kogon, Statistical and adaptive signal processing: Spectral estimation, signal modelling, adaptive filtering and array processing, 2005, Artech House.
7. Athanasios Papoulis, S Pillai , Probability, Random Variables and Stochastic Processes, 2014 (reprint), 4th Edition, McGraw-Hill.
8. Kishor S. Trivedi, Probability and Statistics with Reliability, Queuing, and Computer Science Applications, 2016, 2nd Edition, John-Wiley & Sons.

Open Elective-2



VT205A2 **Credit: 4 (L-3, T-1, P-0)**

Signal Processing for Communication

Questions to be set: 05 (All Compulsory)

Course Objective : The student should be able to understand different Signal processing techniques used in Analog, Digital and Wireless Communication.

Pre-requisites: Thorough knowledge of Differential and Integral Calculus, Probability and Linear Algebra are expected

Course Outcomes(CO):

COs	**At the end of the course, the students should be able to**
CO1	gain insight of Signals and its different forms.
CO2	gain idea about signal processing
CO3	gain insight of Communication systems and channels
CO4	also learn about different type of signal processing techniques required in wireless communication system.
CO5	Design a basic communication system.

** not more than 20% of total topics to be allotted for assignment

Module	Topics to be covered	Topics	Hrs	CO
Module 1: Introduction to Signals and Hilbert Space	in class	Basic Signals: Type of basic signals , Energy, Power, digital frequency, Finite Length and Infinite Length Signals, Elementary Operations: Shifting, Scaling and Folding, Basic communication System Model, Review of Euclidean Geometry, Vector Space, Hilbert Space, Example of Hilbert Space, Inner Product and Distances, Subspace, Bases and Projections, Signal Space, Gram-Schmidt Process.	10	1
	****Assignment Topics**	Numericals on Signal operations and gram-Schmidt Process.		
Module 2: **Stochastic Signal Processing**	in class	Random Variables, Random Vectors, Random Processes, Power Spectral Density (PSD), PSD of stationary Process, White Noise, Stochastic Signal Processing. Sampling Theorem, Aliasing: Non bandlimited signals, Discrete time processing of analog signals, proof and example, Interpolation: Local, Polynomial and Sinc.	10	2
	****Assignment Topics**	Guassian Distribution, Anti-aliasing Filter		

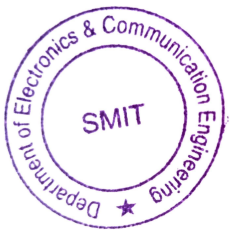
Module 3: **A/D and D/A conversion**	in class	Quantization: Uniform and Non-uniform, Advanced Quantizer, Quantization Error, A/D conversion, D/A conversion.	10	3
	****Assignment Topics**	Quantizing for aperiodic signals.		
Module 4: **Multirate Signal Processing**	in class	Downsampling: Properties of Downsampling operator, Frequency Domain representation, Downsampling and Filtering, Upsampling and Interpolation, Rational Sampling Rate Change, Oversampling: Oversampled A/D conversion, Oversampled D/A Conversion.	10	4
	****Assignment Topics**	Make a chart of five recent DSP processor and compare them based on their performance, efficiency,power consumption		
Module 5: **Design of Digital Communication System**	in class	Communication Channel: AM radio channel and Telephone channel, Transmitter Design: Digital Modulation, Bandwidth and Power Constraint, Receiver Design: Hilbert Demodulation and Channel Effect, Signaling alphabets and power constraints, Adaptive Synchronization: Timing Recovery and Carrier Recovery	8	5
	****Assignment Topics**	Design a digital communication system using Matlab.		

Text Book

1. Paolo Prandoni and Martin Vitterli, “Signal Processing for Communications”, EPFL Press, 2008, 1st ed.

Reference Books:

2. Marvin E. Frerking “Digital Signal Processing in Communication Systems”, Springer, 1994.



VT206A2 **Credit: 4 (L-3, T-1, P-0)**

Semiconductor Devices and Circuits

Questions to be set: 05 (All Compulsory)

Course objectives:

This course is intended to equip any students interested in electronic materials and devices with the fundamentals of semiconductor devices. The materials covered in the course begin with fundamentals and accelerate to advanced topics in semiconductor physics. The course connects circuit performance to material and device behavior.

Prerequisite:

A background in electrical engineering helps to some extent, but this is not required.

Course outcomes

On completion of the course the student should be able to:

1. learn the important concepts related to semiconductor technology.
2. understand the basic concepts of carrier transport.
3. know the basic characteristics of MS contact, PN junctions, BJT.
4. explore all concepts related to MOSFET.
5. design an optimized CMOS inverter.

Module	Topics to be covered	Topics	Hrs	CO
1 Introduction to quantum mechanics and solid-state physics	In Class Assignment Topics:	Concept of wave-particle duality, schrodinger equations, particle in a box, particle in a periodic potential, harmonic oscillator, formation of bands, Kronig-Penny Model, electrons and holes, crystals.	10	1
2 Carrier statistics and carrier transport	In Class Assignment Topics:	Density of states, Fermi function, carrier concentration, doping, recombination, generation, charge transport, continuity equation.	10	2
3	In Class	Junctions, Metal semiconductor junctions, Schottky contact: electrostatics and current-voltage characteristics, PN junctions: electrostatics and current-voltage	10	3

Metal-semiconductor junction, P-N junction, and Bipolar junction transistor	Assignment Topics:	characteristics, BJT: current-voltage characteristics, non-idealities and equivalent circuit modeling.		
4 MOSCAP, and MOSFET	In Class	Metal Oxide Semiconductor Capacitor: CV characteristics, MOSFET: Introduction, I-V characteristics, Subthreshold Swing, additional concepts, trapped charge, Body-bias, scaling of MOSFET, leakage current in MOSFET, MOSFET characterization: parameter extraction, trapped charges, contact resistance.	10	4
	Assignment Topics:			
5 CMOS circuit design	In Class	Static CMOS Inverter, Switching Threshold, Noise Margins, Computing the Capacitances of CMOS inverter, Propagation Delay: First-Order Analysis, Propagation Delay from a Design Perspective, Dynamic Power Consumption, Static Consumption, Technology Scaling and its Impact on the Inverter Metrics	8	5
	Assignment Topics:			

Books

Test books

1. B. G. Streetman, Solid State Electronic Devices: Global Edition. 2015. Available: https://www.amazon.com/Solid-State-Electronic-Devices-Global/dp/1292060557
2. Donald A Neaman, Semiconductor Physics and Devices, 4th ed, ISBN 978-0-07-352958-5, 2011

3. Digital Integrated Circuits: A Design Perspective, Anantha P. Chandrakasan, Borivoje

Nikolic, and Jan M. Rabaey, 2002

VT207A2 **Credit: 4 (L-3, T-1, P-0)**

SENSORS AND ACTUATORS FOR IoT

Questions to be set: 05 (All Compulsory)

Course Objectives: To make students familiar with the constructions and working principle of different types of sensors and transducers. To make students aware about the measuring instruments and the methods of measurement and the use of different transducers.

Pre-requisites: Basic Electronics.

Course Outcomes (CO):

CO1: The students should be able to identify the components required for IoT system.

CO2: The students should be able to solve problems of amplifiers and converters.

CO3: The students should be able to explain the working of different sensors used in IoT.

CO4: The students should be able to explain the working of different actuators used in IoT.

CO5: The students should be able to integrate sensors and actuators in a single system.

** not more than 20% of total topics to be allotted for assignment

Module	Topics to be covered	Topics	Hrs	CO
Module 1: **Introduction to Hardware used for IoT**	in class	Introduction to IOT, Microcontrollers, Microprocessors, SoC. Applications of IOT, Reference Architecture of IOT, IOT Functional Blocks, Need of Sensors in IOT, Selection Parameters of Sensors and Actuator for IOT, Introduction to Arduino, Pi, Spark, Intel Galileo.	10	1
	**Assignment Topics			1
Module 2: **Sensor Signal Conditioning And Interfacing**	in class	Amplifier, Driver Circuit, V-I converter, R-V converter, etc.	10	2
	**Assignment Topics	Numerical problems.		2
Module 3: **Sensor for IoT**	in class	Different type of Sensors used in IOT- PIR Motion Sensor, Rain Drop Sensor, Moisture Sensor, Temperature Sensor, Touch Sensor, Infrared Sensor, Camera Sensor, RFID System, Bluetooth Module and Wi-Fi Module.	10	3
	**Assignment Topics	Use cases		3
Module 4: **Actuators for IoT**	in class	Introduction, Actuator Definition, Classification of Actuators, Need for Actuators in IOT enabled system;	10	4

		Working Principle and Applications in IOT – Pneumatic actuators, Hydraulic actuators, Electric actuators, Thermal actuators and Mechanical actuators		
	**Assignment Topics	Use cases		4
Module 5: **Interfacing of sensors and actuators**	in class	Introduction to interfacing real-world sensors and actuators to embedded computing systems, real-time operation and user interaction, such as digital input/outputs, interrupt service routines and serial communications.	8	5
	**Assignment Topics	Examples of integrated systems of sensors and actuators.		5

Text Books:

1. Kamal Kishore Jha “Getting Started with IoT: A Hands-on Approach ”, Evincepub Publishing, 1/e , 2019

2. Al-Turjman Fadi, “Multimedia-enabled Sensors in IoT: Data Delivery and Traffic Modelling”, CRC Press Inc., 1/e, 2018

VT208A2 **Credit: 4 (L-3, T-1, P-0)**

ADVANCED ANTENNA DESIGN

Questions to be set: 05 (All Compulsory)

Course Objectives:

i. To provide the essential knowledge of the antenna parameters and measurements.
ii. To design antenna array using synthesize techniques.
iii. To design the single element microstrip antenna and array with feeder network
iv. To introduce the types of high impedance surface antennas for various applications.

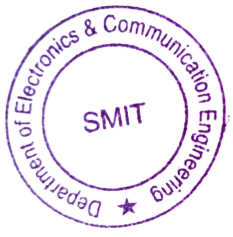
Pre-requisites: Linear algebra

Course Outcomes (CO): Students should be able to

1. Understand the radiation mechanism of antenna and to solve the numerical problems related to antenna parameters.
2. Design and interpret non uniform excitation coefficients using array synthesis techniques for minimum side lobe level.
3. Design and analyze rectangular and circular microstrip antenna with power divider network.
4. Understand the importance of defected ground structures and metamaterial surfaces and design high impedance surfaces.
5. Exploit the antennas for wireless communication, radar applications, Software defined and cognitive radio.

** not more than 20% of total topics to be allotted for assignment

Module	Topics to be covered	Topics	Hrs	CO
Module 1: **Antenna Fundamentals**	in class	Radiation Mechanism, antennas used in various applications and selection criteria, Antenna measurements using anechoic chamber - Radiation pattern, Radiation Intensity, Power gain, Directivity, impedance, Radiation efficiency, Polarization	10	1
	****Assignment Topics**	Numerical Problems		1
Module 2: **Antenna Array Synthesis**	in class	Fourier Transform - Woodward-Lawson Sampling Schelkunoff Method- Dolph-Tchebyscheff - Taylor Line Source Method	8	2
	****Assignment Topics**	Numerical Problems		2
Module 3: **Microstrip Antennas**	in class	Basic characteristics, feeding methods, Methods of analysis – Transmission line model and cavity model - Design of Rectangular patch, Circular patch –Microstrip antenna array and feed network.	10	3
	****Assignment Topics**	Numerical Problems		3
Module 4: **Antenna Design Techniques**	in class	Antenna Design using Artificial Impedance Surface Metamaterial- Electromagnetic Band Gap- Defective Ground Structure - High Impedance Surface	10	4



	****Assignment Topics**	Numerical Problems		4
Module 5: **Antenna Applications**	in class	Integrated Antenna for wireless personal communication, mobile communication- Antenna design consideration for MIMO diversity systems - medical therapy, Antenna for Software Defined Radio – Cognitive Radio- Electronic Warfare- Ground penetrating Radar	10	5
	****Assignment Topics**	Numerical Problems		5

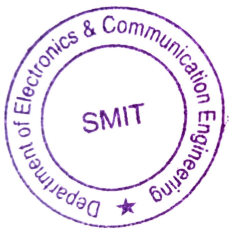
Text-Books:

1. C.A. Balanis, Antenna Theory: Analysis and Design, 2016, 4th edition, Wiley, India
2. C.A. Balanis, Modern Antenna Handbook, 2012, 1st Edition, Wiley, India

Reference Books:

1. W.L. Stutzman and G.A. Thiele, Antenna Theory and design, 2012, 3rd Edition, Wiley, India
2. J. D. Kraus, Antennas and Wave propagation, 2012, 4th Edition, McGraw Hill, India.
3. Sanjay Kumar,Saurabh Shukla, Wave Propagation and Antenna Engineering, 2016, 1st Edition PHI, India

Open Elective-3



VT301A2 **Credit:4 (L-3, T-1, P-0)**

Optimization Techniques

Questions to be set: 05 (All Compulsory)

Course Objectives: The student should be able to understand different Linear and Non-Linear Optimization techniques.

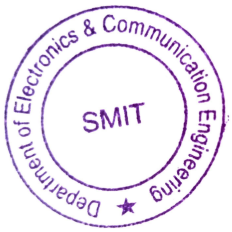
Pre-requisites: Thorough knowledge of Differential Calculus, Probability, Linear Algebra and Matrix Theory are expected.

Course Outcomes (CO): After successful completion of this course, students will be able to:

CO	STATEMENT
CO1	Apply linear algebra, vector space and probability theories for solving practical problems.
CO2	Analyze the optimization problem and function.
CO3	Analyze the linear/ non-linear programming model.
CO4	Evaluate the Unconstrained optimization techniques
CO5	Evaluate the constrained optimization techniques

** not more than 20% of total topics to be allotted for assignment

Module	Topics to be covered	Topics	Hrs	CO
Module 1: Mathematical preliminaries	in class	Linear algebra and matrices, Vector space, eigen analysis, Elements of probability theory, Elementary multivariable calculus.	8	1
	**Assignment Topics	Practice Problems		1
Module 2: Introduction and Optimization using Calculus	in class	Objective function; Constraints and Constraint surface; Formulation of design problems as mathematical programming problems; Classification of optimization problems; Stationary points; Functions of single and two variables; Global Optimum Convexity and concavity of functions of one and two variables; Optimization of function of one variable and multiple variables; Gradient vectors; Optimization of function of multiple variables subject to equality constraints; Lagrangian function Hessian matrix formulation; Eigen values.	10	2
	**Assignment Topics	Practice Problems		2
Module 3: Linear/Non-Linear Programming	in class	Introduction to linear programming model, Standard form of linear programming (LP) problem; Canonical form of LP problem; Assumptions in LP Models; Elementary operations; Graphical method for two variable optimization problem; Simplex method, Duality, Karmarkar's method.	10	3



	**Assignment Topics	Practice Problems		3
Module 4: Unconstrained optimization	in class	General properties of minimization algorithms, One-dimensional search methods, Gradient-based methods, Newton's method, Conjugate direction and quasi-Newton methods.	10	4
	**Assignment Topics	Practice Problems		4
Module 5: Constrained Optimization	in class	Lagrange theorem, Method of Lagrange multipliers, FONC (First Order Necessary Conditions), SONC (Second Order Necessary Conditions), and SOSC (Second Order Sufficient Conditions).	10	5
	**Assignment Topics	Practice Problems		5

Text Books: Edwin P K Chong, Stainslaw Zak, "An introduction to Optimization", Wiley India, 2017, 4th ed

Reference Books: Stephen Boyd, Lieven Vandenberghe "Convex Optimization", Cambridge University Press, 2004.

VT302A2 **Credit: 4 (L-3, T-1, P-0)**

Solid State Devices

Questions to be set: 05 (All Compulsory)

Course Objectives:

i. To provide an insight into the basic semiconductor concepts
ii. To provide a sound understanding of current semiconductor devices and technology to appreciate its applications to electronics circuits and systems

Pre-requisites: Basic Electronics, Electronic Devices & Components

Course Outcomes (CO): Students should be able to

1. Learn the basic and fundamental concepts of Semiconductor Physics.
2. Gain the knowledge and idea behind the concept of PN Junction and its related topics.
3. Analyze the relevant concepts of MOSFET and its different types.
4. Understand the concept behind the operating principle of various Opto-electronic devices.
5. Recognize the importance of IC Fabrication for industrial applications.

** not more than 20% of total topics to be allotted for assignment

Module	Topics to be covered	Topics	Hrs	CO
Module 1: **Basic Semiconductor Physics**	in class	Elemental and compound semiconductors, Fermi-Dirac distribution, Equilibrium and steady state conditions, Equilibrium concentration of electrons and holes, Temperature dependence of carrier concentration	8	1
	****Assignment Topics**	Numericals on Mass-Action Law, Work-function Equilibrium.		1
Module 2: **PN Junctions & Semiconductor Contacts**	in class	Contact potential, Electrical Field, Potential and Charge density at the junction, Energy band diagram, Minority carrier distribution, Ideal diode equation, Electron and hole component of current in forward biased p-n junction, piecewise linear model of a diode effect of temperature on V-I characteristics. Diode capacitances, switching transients, Electrical Breakdown in PN junctions, Zener and avalanche break down (abrupt PN junctions only), Tunnel Diode basics only. Ohmic and Rectifying Contacts.	12	2
	****Assignment Topics**	Numericals on Diode Equation, Zener Diode Voltage Regulation.		2
Module 3: **Metal Oxide Semiconductor Devices**	in class	The ideal MOS capacitor, band diagrams at equilibrium, accumulation, depletion and inversion, surface potential, CV characteristics, effects of real surfaces, work function difference, interface charge, threshold voltage MOSFET: Output characteristics, transfer characteristics, sub	10	3

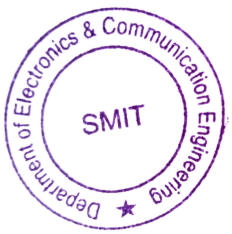
		threshold characteristics, MOSFET scaling. Fin FET structure and operation		
	****Assignment Topics**	Numericals on Work-function Equilibrium, Transconductance Expression.		3
Module 4: **Opto-Electronics & Its Devices**	in class	Optical absorption in semiconductors, Photovoltaic Effects, Solar Cells (PN Junction), Photoconductors, Photodiode, PIN photodiode, Avalanche Photodiode, Phototransistor, LED, Semiconductor Laser (PN Junction)	10	4
	****Assignment Topics**	Experimental Observation of LED, Solar Cell Efficiency Measurement, Laser Operation, Photodiode Luminescence Characteristics.		4
Module 5: **Integrated Circuit Technology**	in class	Fabrication Process: Oxidation, Diffusion, Ion Implantation, Photolithography, Etching, Chemical Vapor Deposition, Sputtering, Twin-Tub CMOS Process.	8	5
	****Assignment Topics**	Observation of PCB Designing Techniques.		5

Text-Books:

4. Ben Streetman and Sanjay Banerjee, Solid State Electronic Devices, 7e, Prentice-Hall, 2015.
5. Donald A. Neamen, Semiconductor Physics And Devices: Basic Principles, 4e, Tata McGraw-Hill Pvt. Ltd., 2012.
6. Millman J and Halkias, Integrated Electronics, 2e, McGraw Hill Education (India) Pvt.Ltd, 2009.

Reference Books:

9. D Chattopadhyay and P.C. Rakshit, Electronics Fundamentals and Applications, 1e, New Age International Publications, 2008.
10. Boylestead and Nashelsky, Electronic Devices and Circuits Theory: 11e, Prentice-Hall, India, 2012.
11. J. Milman and A. Grabel, Microelectronics, 1e, Tata McGraw-Hill Education, 2001.
12. S. M. Sze and K. N. Kwok, "Physics of Semiconductor Devices," 3rd edition, John Wiley & Sons, 2006. 4. C.T. Sah, "Fundamentals of solid-state electronics," World Scientific Publishing
Co. Inc, 1991.
13. Y. Tsividis and M. Colin, "Operation and Modeling of the MOS Transistor," Oxford Univ.Press, 2011.



VT303A2 **Credit: 4 (L-3, T-1, P-0)**

IoT Gateways and Edge Computing

Questions to be set: 05 (All Compulsory)

Course Objectives: Integrated Smart Gateways with Edge computing are becoming essential ingredients for the smart proliferation of IoT services. Students will be able to design such Smart Gateway system with the completion of this course.

Pre-requisites: Knowledge of Sensors, actuators and IoT physical layer.

Course Outcomes(CO):

CO1: The students should be able to explain different IoT networking protocols.

CO2: The students should be able to explain Gateways for IoT networking.

CO3: The students should be able to explain different IoT short and long range communication protocols.

CO4: The students should be able to explain the edge and fog computing paradigms.

CO5: The students should be able to explain how the concept of edge and fog computing is applied in different IoT applications.

** not more than 20% of total topics to be allotted for assignment

Module	Topics to be covered	Topics	Hrs	CO
Module 1: **Overview of Computer Networking**	in class ****Assignment Topics**	TCP/IP protocol, CoAP, XMPP, Web Socket, AMQP, MQTT, WebRTC, PuSH. in IoT networking, Routers, Switches and Hubs in IoT networking, Architectural Considerations in Smart Object Networking.	8	1 1
Module 2: **Introduction to Gateways**	in class	Home Media Gateway and Companion Devices, Architecture of 4K TV Hybrid Set Top Box with case study of Airtel 4K TV STB. Light Gateway and HUB with case study of Philips Hue smart lighting system. Smart IoT Gateways: Processor, Operating System, Memory, Hard Drive, Antennas, Power supply, Wireless LAN Card, LTE/5G Mobile broadband Card .	10	2
Module 3: **Short Range and Long Range Wireless Communication**	in class	Bluetooth, 802.15.4, ZigBee, Wireless Hart, Thread, Z-Wave Unlicensed spectrum offerings: LoRa, SigFox; Licensed spectrum specialties: NB-IoT, CAT-M1, Hybrid networks.	10	3
Module 4:	in class	Addressing the Challenges in Federating Edge Resources, Integrating IoT-Fog-Cloud Infrastructures,	10	4

New Computing Paradigms	****Assignment Topics**	System Management and Orchestration of Network Slices in 5G, Fog, Edge, and Clouds.		4
Module 5: **Applications**	in class	Exploiting Fog Computing in Health Monitoring , Smart Surveillance Video Stream Processing at the Edge for Real-Time Human Objects Tracking,	10	5
	****Assignment Topics**	Fog Computing Model for Evolving Smart Transportation Applications.		5

Text Books:

1. Gerardus Blokdyk, “IoT Gateways The Ultimate Step-By-Step Guide”, 5STARCooks , 2018.

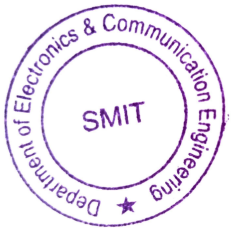
Reference Books:

1. James F. Kurose, Keith W. Ross, “Computer Networking”, Pearson, Seventh Edition, 2017.

2.https://www.dell.com/en-us/work/shop/gateways-embedded-computing/dell-edge-gateway-5100/spd/dell-edge-gateway-5100/xctoi5100us

3. Keysight TechnologiesThe Menu at the IoT Café: A Guide to IoT Wireless Technologies. http://literature.cdn.keysight.com/litweb/pdf/5992-2412EN.pdf

4. Rajkumar Buyya and Satish Narayana Srirama, “Fog and Edge Computing Principles and Paradigms”, Wiley Series On Parallel and Distributed Computing, John Wiley & Sons, Inc, 2019.



VT304A2 **Credit: 4 (L-3, T-1, P-0)**

ADVANCED DIGITAL COMMUNICATION

Questions to be set: 05 (All Compulsory)

Course Objectives:

I. To introduce the concept of digital base-band data transmission through a band limited channel.
II. To familiarize the student with concept of binary and M-ary band-pass modulation schemes.
III. To introduce the advanced channel coding techniques to minimize the probability of error.
IV. To acquaint with the emerging trends in digital communication field.

Pre-requisites: Digital Communication.

Course Outcomes (CO): Students should be able to

1. Design matched filter for detection of digital signals in the presence of white Gaussian noise.
2. Design waveforms to overcome ISI in band-limited channels.
3. Design equalization circuits to overcome the effect of channel distortion.
4. Understand the binary digital modulation schemes and M-ary modulation schemes.
5. Design turbo and LDPC codes to overcome the effect of noise in the channel.

** not more than 20% of total topics to be allotted for assignment

Module	Topics to be covered	Topics	Hrs	CO
Module 1: **Introduction to Detection and Estimation Theory**	in class	Detection of known signals in noise, Correlation receiver, Matched filter receiver, Detection of signals with unknown phase in noise. Minimum mean square error estimator, Maximum a posteriori estimator, Maximum likelihood estimation, Cramer Rao bound (CRB) for parameter estimation.	9	1
	****Assignment Topics**	Numerical Problems		1
Module 2: **Baseband Transmission Techniques**	in class	Digital transmission through band limited channels, Power spectrum of digitally modulated signals, Signal design for band limited channels, Band limited signal design for zero ISI, Band limited signal design for controlled ISI.	7	2
	****Assignment Topics**	Numerical Problems		2
Module 3: **Baseband Reception Techniques**	in class	Probability of error in detection of digital PAM, Eye pattern, Channel equalization, Linear Equalizers, Adaptive equalizers, Decision feedback equalizers, Fractionally spaced equalizers.	10	3
	****Assignment Topics**	Numerical Problems		3
Module 4: **Modulation Schemes**	in class	Binary modulation schemes, Coherent and non-coherent detection of binary modulation schemes, Performance analysis of binary modulation schemes under AWGN channel, Minimum Shift Keying (MSK), Gaussian Minimum Shift Keying (GMSK).	12	4

		M-ary Phase Shift Keying, M-ary Quadrature Amplitude Modulation, M-ary Frequency Shift Keying, Performance analysis of M-ary modulation schemes under AWGN channel, Non-coherent detection of M-ary orthogonal signals, Carrier and timing recovery, Synchronization, Applications.		
	****Assignment Topics**	Use Cases OFDM		4
Module 5: **Trellis and Turbo Codes**	in class	Convolutional codes, Viterbi Decoder for convolutional codes, Set partitioning, Trellis codes, Turbo encoders, Turbo decoders, MAP decoder and Max-Log-Map decoder, Irregular and Asymmetric turbo codes.Regular LDPC codes, Gallager construction of LDPC codes, Gallager based decoding algorithm for LDPC codes and its analysis, LDPC threshold, Irregular LDPC codes.	10	5
	****Assignment Topics**	Application of MIMO		5

Text-Books:

1. Aditya K. Jagannatham, Principles of Modern Wireless Communications Systems, 2015, 1st Edition, McGraw-Hill Education, India.

Reference Books:

1. Simon Haykin, Michael Moher, Modern Wireless Communications, 2011, 1st Edition,
Pearson Education, India.

Open Elective-4

VT305A2 **Credit: 4(L-3, T-1, P-0)**

Pattern Recognition

Questions to be set: 05 (All Compulsory)

Course Objectives: In this course, students will learn the fundamentals of pattern recognition and its relevance problems. Students will be able to identify where, when and how pattern recognition can be applied. Several applications of pattern recognition will show the student how to use pattern recognition in real settings. The student will also be introduced to more recent applications of pattern recognition.

Pre-requisites: Basic knowledge of Signals and Systems, Digital Signal Processing

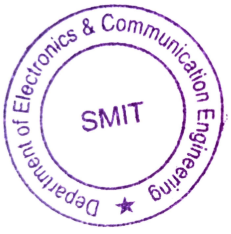
Course Outcomes (CO):

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

1. Explain and compare a variety of pattern classification, structural pattern recognition, and pattern classifier combination techniques
2. Understand the major approaches in statistical and syntactic pattern recognition
3. Implement simple pattern classifiers, classifier combinations, and structural pattern recognizers
4. Summarize, analyze, and relate research in the pattern recognition area
5. Apply pattern recognition techniques to real-world problems

** not more than 20% of total topics to be allotted for assignment

Module	Topics to be covered	Topics	Hrs	CO
Module 1: Bayes Decision Theory	in class	Discriminant Functions and Services, the Normal Distribution, Bayesian Classification, Estimating Probability Density Functions, Nearest Neighbour Rules, Bayesian Networks	**8**	1
	****Assignment Topics**			1
Module 2: Linear and Nonlinear Classifiers	in class	Perceptron Algorithm, Least-Squares Methods Multilayer Perceptron's, Back Propagation Algorithm, Decision Trees - CART, C4.5, ID3, Random Forests, Boosting	10	2
	****Assignment Topics**	Combinations of Classifiers		2
Module 3: Classifier Ensembles and Feature Selection	in class	Bagging, Boosting / AdaBoost Data Preprocessing, ROC Curves, Class Separability Measures, Feature Subset Selection, Bayesian Information Criterion	10	3
	****Assignment Topics**			3



Module 4: Dimensionality Reduction and Additional Features & Template Matching	in class	Basis Vectors, Singular Value Decomposition, Independent Component Analysis, Kernel PCA, Wavelets	10	4
		Texture, Shape and Size Characterization, Fractals, Features for Audio,		
	****Assignment Topics**	Template Matching Using Dynamic Time Warping and Edit Distance		4
Module 5: Clustering	in class	Sequential Algorithms, Hierarchical Algorithms, Functional Optimization-Based Clustering, Graph Clustering, Learning Clustering, Clustering High Dimensional Data, Subspace Clustering, Cluster Validity Measures, Expectation Maximization, Mean Shift.	10	5
	****Assignment Topics**			5

Textbooks:

1. Duda, R.O., Hart, P.E., and Stork, D.G. Pattern Classification. Wiley-Interscience. 2nd Edition. 2001

2. Bishop, C. M. Pattern Recognition and Machine Learning. Springer. 2007

3. Marsland, S. Machine Learning: An Algorithmic Perspective. CRC Press. 2009

4. Theodoridis, S. and Koutroumbas, K. Pattern Recognition. Edition 4. Academic Press, 2008

Reference Books:

1. Russell, S. and Norvig, N. Artificial Intelligence: A Modern Approach. Prentice Hall Series in Artificial Intelligence. 2003

2. Bishop, C. M. Neural Networks for Pattern Recognition. Oxford University Press. 1995

3. Hastie, T., Tibshirani, R. and Friedman, J. The Elements of Statistical Learning. Springer. 2001

4. Koller, D. and Friedman, N. Probabilistic Graphical Models. MIT Press. 2009

VT306A2 **Credit: 4(L-3, T-1, P-0)**

Nano electronic Devices and Materials

Questions to be set: 05 (All Compulsory)

Course Objectives:

i. To introduce Nanotechnology to the students and to provide basic concepts of the Nanomaterials, Nanoelectronic Devices.
ii. To introduce the tools used for Nanoscale Engineering.
iii. To introduce the IC fabrication and characterization techniques.

Course Outcomes (CO):

On successful completion of this course, students will be able to:

CO1: The students should be able to understand concepts of historical perspective of Nanotechnology with reference to different devices.

CO2: The students should be able to understand crystallography concepts and quantum mechanical aspects of nanomaterials.

CO3: The students should be able to different nanoelectronics and quantum electronic devices concepts.

CO4: The students should be able to have insights and have insights of IC fabrication and characterization processes.

CO5: The students should be able to understand and know the various applications of nanoelectronics and societal impacts.

** not more than 20% of total topics to be allotted for assignment

Module	Topics to be covered	Topics	Hrs	CO
Module 1: PHYSICS APPLIED TO NANOSTRUCTURES	in class	Introduction; Historical Perspectives; Vacuum Electron Tube; Quantum Theory; Invention of Transistor; Integrated Circuit Era; Physical Size Scales; Nanomaterials Used Prior to 1990s; Prospects and Potential of Nanotechnology. Crystal Structures - Crystallography-Historical Perspectives; Size Dependence of Material Properties. Quantum Mechanical Aspects of Nanomaterials – Introduction;	8	1
	****Assignment Topics**	Crystal Structures - Crystallography		1
Module 2: NANOMATERIALS AND DEVICES	in class	Bohr's Theory of Hydrogen Atom. Energy Bands in Solids – Introduction; Band Theory of Solids-Historical Perspectives; Bonding in Hydrogen Molecule. Carbon Nanoclusters - Nature of Carbon Bonds; Allotropes of Carbon; Graphene; Carbon Fullerenes-Buckyballs; Nanodiamonds; Diamond-like carbon Nanotubes. Historical Background of CNT; Physical Structure of CNT; Types of Nanotubes; Synthesis of CNT.	10	2

		Properties of Nanomaterials - Why Nanomaterials Show Unique Properties; Structural Properties; Electronic Properties; Magnetic Properties; Electrical Properties; Optical Properties; Mechanical Properties.		
	**Assignment Topics	Unique Properties; Structural Properties; Electronic Properties; Magnetic Properties; Electrical Properties; Optical Properties; Mechanical Properties		2
Module 3: QUANTUM ELECTRONICS AND DEVICES	in class	Tunnel Diodes; Single Electron Devices; Quantum Well Devices; Superconducting Devices; Photonic Crystals. Physical Methods of Nanostructure Fabrication; Chemical Synthesis of Nanomaterials;	10	3
	**Assignment Topics	Chemical Synthesis of Nanomaterials		3
Module 4: METHODS OF GROWTH AND SYNTHESIS OF NANOMATERIALS	in class	Biological Synthesis of Nanomaterials. Particle Size Determination; Surface Layer Structural Determination; Electron Microscopy; Scanning Probe Microscopy; Field Ion Microscopy; Spectroscopy; Mass Spectrometry.	10	4
	**Assignment Topics	Spectroscopy; Mass Spectrometry		4
Module 5: APPLICATIONS OF NANOELECTRONICS AND ITS SOCIETAL IMPACT	in class	Applications of Nanotechnology – Energy; Information Technology; Displays; Computers; Defence; Nanomedicines; Consumer Goods Societal Impact of Nanotechnology Uniqueness of Nanomaterials. Implications of Nanotechnology; Health Issues; Environmental and Energy Issues; Basic Necessities-Safe Drinking Water and Food Security; Other Societal Implications.	10	5
	**Assignment Topics	Implications of Nanotechnology; Health Issues; Environmental and Energy Issues; Basic Necessities-Safe Drinking Water and Food Security; Other Societal Implications.		5

Text Books:

1. Donald A. Neamen, Semiconductor Physics and Devices: Basic Principles, 4e, Tata McGraw-Hill Pvt. Ltd., 2012.
2. Singh R., Gupta S. P., Introduction to Nanotechnology, 1e, Oxford University Press, 2016

Reference Books:

1. G. W. Hanson, “Fundamentals of nanoelectronics”, Pearson, 2009.
2. Ben Streetman and Sanjay Banerjee, Solid State Electronic Devices, 7e, Prentice-Hall, 2015

VT307A2 **Credit: 4 (L-3, T-1, P-0)**

Communication Pathways between Cloud and IoT

Questions to be set: 05 (All Compulsory)

Course Objectives: This course is designed to teach the different use cases of IoT Communication System including Fibre, Satellite, 4G-5G wireless wide area network and WiFi wireless LAN. This course contains latest case studies of Advanced Communication System where majority of the Electronics & Communication Engineering core subjects are involved and aimed for broadband and Machine to Machine communications to realize a Smart Home, Smart City and others. This definitely creates interests and motivations in students and in other way, this course will fetch a large scope of job and research opportunities in India as well abroad.

Pre-requisites: IoT Gateways, Edge computing.

Course Outcomes (CO):

CO1: The students should be able to explain the gateways and pathways connection to cloud.

CO2: The students should be able to explain uses of fibre optic communication for IoT networking.

CO3: The students should be able to explain underlying technologies for IoT communication protocols.

CO4: The students should be able to explain the role of WiFi technology in detail for IoT deployment.

CO5: The students should be able to explain the role of satellite communication technology in detail for IoT deployment.

** not more than 20% of total topics to be allotted for assignment

Module	Topics to be covered	Topics	Hrs	CO
Module 1: **Overview of IoT Devices [2Hrs]**	in class	Gateways, Pathways and their connection to Cloud towards SMARTER WORLD **.**	8	1
	****Assignment Topics**			1
Module 2: **FTTH Passive Optical Networks [7 Hrs]**	in class	WDM – Passive Optical Network, Geographical, Optical and Virtual Topologies: Star, Tree, Bus, Ring and Combined Components for Future Access Networks: Tunable Optical Network Unit, Fast-Tunable Laser at the Optical Line Terminal, Arrayed Waveguide Gratings, Reflective Receivers and Modulators **Enhanced Transmission Techniques:** Advanced Functionalities in PONs, Bidirectional Single Fiber	10	2

		Transmission with Colourless Optical Network Unit, Spectral Slicing, Active and Remotely-Pumped Optical Amplification.		
	****Assignment Topics**	G/E-PON international standards**,** fiber-to-the home (FTTH), Case Study : Jio Giga Fiber system for Smart Home.		2
Module 3: **Introduction to 4G/5G Heterogeneous Communication System [9 hrs]**	in class	Introduction M2M, difference between IOT and M2M, ETSI M2M Architecture, system architecture. SDN/NFV Architecture for IoT Networks Overview of 4G based LTE /LTE A communication system. DSP used in 5G for Enhanced Mobile Broadband (eMBB) Use Cases- Orthogonal Frequency Division Multiplexing, Generalized Frequency Division Multiplexing (GFDM), Universal Filtered OFDM, Filter Bank Multi Carrier (FBMC), Antennas and Electromagnetic Waves For 5G - Smart Antenna Beamformation Techniques in 5G Enhanced Machine Type Communication Use Cases - 5G IoT Evolution, Millimeter Wave Communication for 5G IoT Applications, Implementing 5G IoT Using Cognitive Radio, Energy Harvesting and Sustainable Machine To Machine (M2M) Communication In 5G Mobile Technologies 4G-5G Hetnet with Dual Connectivity :- Case study Samsung 4G-5G Integrated Radio	10	3
	****Assignment Topics**			3
Module 4: **WiFi Communication Systems [9 hrs]**	in class	WiFi Evoluation wifi b/g/a/ac/ax/ay and others. Understanding current Wi-Fi network challenges: Looking ahead to the next Wi-Fi standard, Considering current and future Wi-Fi use cases. Understanding Key 802.11ax Technologies: Multi-User (MU) defined, MU-OFDMA, MU-MIMO, Spatial reuse (BSS Coloring). Looking at Other 802.11ax Enhancements and Design Considerations: Target Wake Time (TWT), 1024 QAM, New PHY Headers, Design Considerations.	10	4
	****Assignment Topics**	Exploring the Aerohive 802.11ax Family: AP 630, AP650; Things You Need to Know about 802.11ax		4
Module 5: **Satellite based IoT [9 Hrs]**	in class	Mobile Satellite Communications: Communications satellites, Preliminary issues, History of communications satellites, Mobile satellite	10	5

	communications systems, Orbit selection, Mobile satellite systems. Communications with LEO Satellites : Preliminary issues in LEO satellite systems, Required number of LEO satellites and orbits, Hand-off, Inter satellite links, Spot beams, Doppler shift effect , Specific issues in LEO satellite systems, Selection of a multiple-access scheme, Traffic considerations, Modeling the LEO satellite systems Application of CDMA in LEO Satellite Systems : Performance evaluation of analog systems, Traffic modeling, SIR: The measure of performance, Traffic assignment control, Performance of integrated voice/data systems, System considerations, Extension of the traffic model, Simulation environment, Performance measurement, Dynamic non uniform traffic concepts. Spread-Slotted Aloha for LEO Satellite Systems : Spread-slotted Aloha, Low Earth Orbital Satellites for Personal Communication Networks, The Aloha multiple-access scheme , Spreading the Aloha packets, Employing spread-slotted Aloha in a LEO satellite system, Distribution of users, Throughput analysis, Probability of packet success	
****Assignment Topics**	Case Study: LEO satellite (Example Iridium satellite) for IoT Use cases	5

Text Books:

1. Josep Prat, “Next-Generation FTTH Passive Optical Networks”, Springer Science, 2008.
2. Hossam Fattah, “5G LTE Narrowband Internet of Things (NB-IoT)”, CRC Press, 2019.
3. David Coleman, Lawrence C. Miller, “802.11ax For Dummies” , John Wiley & Sons, Inc.2018.
4. Abbas Jamalipour, “Low Earth Orbital Satellites for Personal Communication Networks” , ARTECH HOUSE, INC 1998.

Reference Books:

1.https://literature.cdn.keysight.com/litweb/pdf/5992-1217EN.pdf?id=2788751
2.https://news.samsung.com/global/sk-telecom-and-samsung-completed-4g-5g-network-dual-connectivity-test-achieving-2-7gbps

EC308A2 **Credit: 4 (L-3, T-1, P-0)**

MODERN WIRELESS COMMUNICATION SYSTEMS

Questions to be set: 05 (All Compulsory)

Course Objectives:

V. To introduce the fundamentals and limitations of wireless channels imposed on communication systems.
VI. To understand the principles and importance of spread spectrum and multicarrier communication in the context of wireless communication.
VII. To identify the role of diversity and MIMO techniques in combating the effect of fading and maximizing the capacity.
VIII. To cognize the most recent trends in the broad area of wireless communication.

Pre-requisites: Digital Communication.

Course Outcomes (CO): Students should be able to

6. Describe the effect of small scale and large scale fading on signal transmission.
7. Design and implement diversity coding techniques to overcome the effect of fading.
8. Apply the theory of probability and random processes in the design of baseband CDMA system.
9. Design the transmitter and receiver blocks of OFDM for better transmission through multipath channel.
10. Design and solve specific problems in advanced technologies like massive MIMO.

** not more than 20% of total topics to be allotted for assignment

Module	Topics to be covered	Topics	Hrs	CO
Module 1: **Large-Scale Path Loss And Small-Scale Fading and Multipath**	in class	Propagation of EM signals in wireless channel, Reflection, Diffraction and scattering, Free space propagation model, Two ray ground reflection model, Log-distance path loss model, Log-normal shadowing, Outdoor propagation models, Longley-Rice model, Okumura model, Hata model, COST-231, Link power budget analysis. Parameters of mobile multipath channels, Types of small scale fading, Rayleigh and Rician distributions, Jakes Doppler spectrum.	9	1
	****Assignment Topics**	Numerical Problems		1
Module 2: **Diversity Techniques**	in class	Condition for deep fading, Probability of error analysis under fading channel, Time diversity, Repetition codes, Frequency diversity, Spatial diversity techniques, Analysis of BER of multiantenna system, Diversity order.	7	2
	****Assignment Topics**	Numerical Problems		2
Module 3:	in class	Introduction to spread spectrum, Orthogonal spreading codes, Benefits of spreading (Jamming Margin, Graceful degradation, Universal frequency reuse, Multipath diversity), Multi user CDMA, Performance analysis of CDMA	10	3

Spread Spectrum Techniques		downlink with multiple users, Performance analysis of CDMA uplink with multiple users, Asynchronous CDMA, Near far problem, Power control, CDMA receiver synchronization, Introduction to MC-CDMA.		
	****Assignment Topics**	Numerical Problems		3
Module 4: **OFDM**	in class	Introduction to multicarrier modulation, Importance of cyclic prefix, Adaptive modulation and coding techniques. OFDM issues, PAPR, Frequency and timing offset, ICI mitigation techniques, Introduction to SC-FDMA-PAPR analysis with localized and interleaved schemes.	10	4
	****Assignment Topics**	Use Cases OFDM		4
Module 5: **MIMO and Recent Trends**	in class	Spatial multiplexing, Decomposition of MIMO channel, Pre-coding, Optimal MIMO power allocation, MIMO beamforming, Nonlinear MIMO receivers-V-BLAST, D-BLAST, Requirements of 5G, Drawbacks of OFDM, Introduction to Filter Bank Multicarrier System (FBMC), Massive MIMO, Millimeter wave technology, Dense network, Cognitive radio technology, Smart antennas, Multi-hop relay networks.	12	5
	****Assignment Topics**	Application of MIMO		5

Text-Books:

2. Aditya K. Jagannatham, Principles of Modern Wireless Communications Systems, 2015, 1st Edition, McGraw-Hill Education, India.

Reference Books:

2. Simon Haykin, Michael Moher, Modern Wireless Communications, 2011, 1st Edition, Pearson Education, India.

Open Elective-5

VT401A2 **Credit:4 (L-3, T-1, P-0)**

Time Frequency Analysis

Questions to be set: 05 (All Compulsory)

Course Objectives: The student should be able to understand the requirement of Time frequency analysis and its practical applications. Students will also know different high end signal processing technology like Short Time Fourier Transform, Wavelet Transform and Wigner-Ville Distribution.

Pre-requisites: Thorough knowledge of Signal and Systems, DSP, Probability and Matrix Theory are expected.

Course Outcomes (CO):

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

CO	STATEMENT
CO1	Apply CTFT, DTFT and DFT for analyzing the signal and system
CO2	Analyze the time – frequency nature of the signal
CO3	Apply STFT for signal analysis
CO4	Evaluate Wigner-Ville Distribution for signal analysis
CO5	Evaluate Wavelet Transform (WT) for signal analysis

** not more than 20% of total topics to be allotted for assignment

Module	Topics to be covered	Topics	Hrs	CO
Module 1: Introduction	in class	Review of Signals and Systems, Review of CTFT, DTFT, DFT and their properties.	8	1
	****Assignment Topics**	Numerical Problems		1
Module 2: Time and Frequency Analysis techniques	in class	Introduction of duration and bandwidth, Bandwidth equation and instantaneous frequency, duration-bandwidth principle, requirement of time-frequency analysis techniques, Uncertainty principles.	10	2
	****Assignment Topics**	Numerical Problems		2
Module 3: Short Time Fourier Transform (STFT)	in class	Introduction to STFT, Properties of STFT, Practical aspects of STFT	10	3
	****Assignment Topics**	Numerical Problems		3
Module 4: Wigner-Ville Distribution (WVD)	in class	Wigner-Ville distribution, Properties of WVD, Discrete WVD, Pseudo and Smoothed WVD, Cohen class and Smoothed WVD, Ambiguity function, Affine class.	10	4

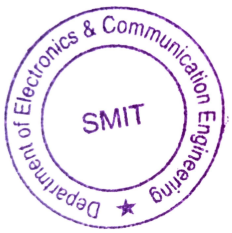
	****Assignment Topics**	Numerical Problems		4
Module 5: Wavelet Transform (WT)	in class	Introduction to CWT, computational aspects of CWT, Scaling function, Applicationsof CWT. Introduction to DWT, Orthogonal Scaling function bases and Multiresolution Analysis (MRA), Wavelet filters and Fast DWT Algorithm, Wavelets for DWT, DWT Computation.	10	5
	****Assignment Topics**	Numerical Problems		5

Text Books:

i. Leon Cohen, "Time-Frequency Analysis", Prentice Hall, 1995.
ii. Karlheinz Grochenig, "Foundations of Time-Frequency Analysis", SpringerScience+Business Media, LLC, 2001.

Reference Books:

i. Franz Hlawatsch, François Auger, "Time-Frequency Analysis – Concepts and Methods", Willey, 2005



VT402A2 **Credit: 4 (L-3, T-1, P-0)**

ADVANCE VLSI DESIGN AND APPLICATION

Questions to be set: 05 (All Compulsory)

Course objectives:

Historical Perspective of VLSI, CMOS VLSI Design for Power and Speed consideration, Logical Efforts: Designing Fast CMOS Circuits; Datapath Design, Interconnect aware design, Hardware Description Languages for VLSI Design, FSM Controller/Datapath and Processor Design, VLSI Design Automation, and VLSI Design Test and Verification.

Prerequisite: Knowledge of basic VLSI circuit and technology.

Course outcomes

On completion of the course, the student will be able to:

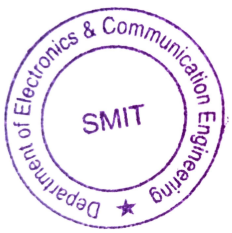
1. Introduction to different VLSI design and performance parameters.
2. Familiarization to data path & Interconnect aware design
3. Skill development inHardware Description Languages for VLSIDesign.
4. Introduction to processor design.
5. Familiar with different Automation and testing tools in VLSI design.

Module	Topics to be covered	Topics	Hrs	CO
1	In Class	**CMOS VLSI Designfor Power and Speed consideration** Historical Perspective and Future Trends in CMOS VLSI Circuit and System Design- Part-I,Historical Perspective and Future Trends in CMOS VLSI Circuit and System Design - Part II, Logical Effort - A way of Designing Fast CMOS Circuits Logical Effort - A way of Designing Fast CMOS Circuits - Part II, Logical Effort - A way of Designing Fast CMOS Circuits - Part III, Power Estimation and Control in CMOS VLSI circuits Power Estimation and Control in CMOS VLSI circuits -Part II Low Power Design Techniques- Part-I,Low Power DesignTechniques - Part II	10	1
	Assignment Topics:			
2	In Class	**Datapath Design & Interconnect aware design:** Arithmetic Implementation Strategies for VLSI, Impact of scaling, buffer insertion and Inductive peaking, Low swing and Current mode signalling, Capacitively coupled	9	2

		interconnects.		
	Assignment			
	Topics:			
3	In Class	**Hardware Description Languages for VLSI Design** Managing concurrency and time in Hardware Description Languages. Introduction to VHDL. Basic Components in VHDL. Structural Description in VHDL. Behavioral Description in VHDL. Introduction to Verilog.	10	3
	Assignment			
	Topics:			
4	In Class	**Controller/Datapath and Processor Design** FSM + datapath (GCD example) , Single Cycle MMIPS, Multicycle MMIPS , Multicycle MMIPS – FSM	4	4
	Assignment			
	Topics:			
5	In Class	**VLSI Design Automation, Test and Verification** Brief Overview of Basic VLSI Design Automation Concepts , Netlist and System Partitioning , Timing Analysis in the context of Physical Design Automation, Placement algorithm, Introduction to VLSI Testing , VLSI Test Basics - I , VLSI Test Basics - II , VLSI Testing:Automatic Test Pattern Generation , VLSI Testing: Design for Test (DFT) , VLSI Testing:Built-In SelfTest (BIST) , VLSI Design Verification: An Introduction 40. VLSI Design Verification: Equivalence Checking , VLSI Design Verification: Equivalence/Model Checking , VLSI Design Verification: Model Checking	15	5
	Assignment			
	Topics:			

Books

1. Rao R. Tummala, Fundamentals of Microsystems Packaging, McGraw Hill, NY, 2001.
2. William D. Brown, Advanced Electronic Packaging, IEEE Press, 1999.
3. Bosshart, Printed Circuit Boards Design and Technology, TataMcGraw Hill, 1988.
4. Blackwell (Ed), The electronic packaging handbook, CRC Press, 2000.



VT403A2 **Credit: 4 (L-3, T-1, P-0)**

Artificial Intelligence and machine learning

Questions to be set: 05 (All Compulsory)

Course Objectives: To develop semantic-based and context-aware systems to acquire, organize process, share and use the knowledge embedded in multimedia content. Research will aim to maximize automation of the complete knowledge lifecycle and achieve semantic interoperability between Web resources and services.

Pre-requisites: Statistics, linear algebra, matrix, calculus, probability, programming languages and data modelling.

Course Outcomes (CO): After Completion of the Course, students will be able to:

CO1: Explain basic concept of Artificial Intelligence.
CO2: Explain the search algorithm in Artificial Intelligence.
CO3: Develop the concept about the logic and object
CO4: Explain the concept of agent
CO5: Explain and examine different AI based applications.

** not more than 20% of total topics to be allotted for assignment

Module	Topics to be covered	Topics	Hrs	CO
Module 1: **Introduction to AI**	in class	AI problems, foundation of AI and history of AI intelligent agents: Agents and Environments, the concept of rationality, the nature of environments, structure of agents, problem solving agents, problem formulation	10	1
Module 2: **Search Algorithm**	in class	Searching- Searching for solutions, uniformed search strategies – Breadth first search, depth first Search. Search with partial information (Heuristic search) Hill climbing, A* ,AO* Algorithms, Problem reduction, Game Playing-Adversial search, Games, mini-max algorithm, optimal decisions in multiplayer games, Problem in Game playing, Alpha-Beta pruning, Evaluation functions	8	2
	****Assignment Topics**	Case study		2
Module 3: **Introduction to logic and object**	in class	Knowledge Representation First Order Predicate Logic – Prolog Programming Unification – Forward Chaining-Backward Chaining – Resolution – Knowledge Representation – Ontological Engineering-Categories and Objects – Events – Mental Events and Mental Objects – Reasoning Systems for Categories –Reasoning with Default Information	10	3
	****Assignment Topics**	Use cases		3
Module 4:	in class	Software Agents Architecture for Intelligent Agents – Agent communication–Negotiation and Bargaining –	10	4

Introduction to Agent		Argumentation among Agents – Trust and Reputation in Multi-agent systems.		
	****Assignment Topics**	Case study		4
Module 5: **AI Application**	in class	Applications AI applications – Language Models – Information Retrieval-Information Extraction – Natural Language Processing – Machine Translation – Speech Recognition – Robot – Hardware –Perception – Planning – Moving	10	5
	****Assignment Topics**	Case study		5

Text Books:

1. S. Russell and P. Norvig, "Artificial Intelligence: A Modern Approach, Prentice Hall, Third Edition, 2009.
2. Artificial Intelligence: A Modern Approach, 4th Edition, Stuart Russell, Peter Norvig University of California at Berkeley, Pearson education, 2020.

Reference Books:

1. I. Bratko, ―Prolog: Programming for Artificial Intelligence, Fourth Edition, Addison-Wesley Educational Publishers Inc., 2011.

VT404A2 **Credit: 4 (L-3, T-1, P-0)**

CODING FOR MIMO COMMUNICATION

Questions to be set: 05 (All Compulsory)

Course Objectives:

I. To cognize the most recent trends in the broad area of wireless communication.
II. To understand the importance of MIMO for next generation networks.
III. To identify the role of different diversity formats and spatial multiplexing in combating the effect of fading and maximizing transmission capacity.
IV. To provide an introduction to advanced MIMO concepts like multi-user MIMO, massive MIMO and SM-MIMO for next generation communication.

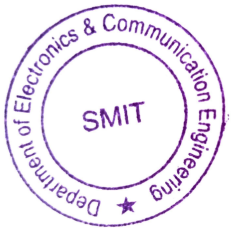
Pre-requisites: Mobile Communiaction.

Course Outcomes (CO): Students should be able to

1. Characterize and model the MIMO wireless channel
2. Design and implement diversity coding techniques to overcome the effect of fading And Design optimal power allocation algorithms to maximize the system capacity
3. Assemble different forms of diversity to improve the error performance
4. Design low-complexity, linear and non-linear receivers
5. Evaluate the performance of concatenated codes for MIMO communication

** not more than 20% of total topics to be allotted for assignment

Module	Topics to be covered	Topics	Hrs	CO
Module 1: **Introduction to MIMO and Wireless Channel**	in class	Introduction, Multi antenna systems, Array gain, Diversity gain, Data pipes, Spatial multiplexing, Wireless channel, MIMO system model.	8	1
	****Assignment Topics**	Numerical Problems		1
Module 2: **Diversity Techniques And Capacity of MIMO Channel**	in class	Diversity, Types, Selection diversity, Scanning diversity, Maximum ratio combining, Equal gain combining, Calculation of SNR.MIMO system capacity, Channel unknown to the transmitter, Channel known to the transmitter, Water pouring principle, Capacity when channel is known to the transmitter, Deterministic channels.	12	2
	****Assignment Topics**	Numerical Problems		2
Module 3: **Space Time Block Coding**	in class	Space Time Coded system, Design of space time trellis coded on slow fading channel, Error probability of slow fading channel, Design of space time trellis codes on fast fading channels, Error probability of fast fading channels, Comparison of STBC and STTC.	8	3
	****Assignment Topics**	Numerical Problems		3



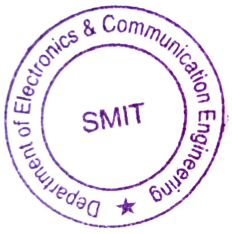
Module 4: **Layered Space Time Codes**	in class	LST transmitters: Types of encoding, Horizontal encoding, Vertical encoding, Diagonal encoding, Layered Space-Time coding design criteria, Performance analysis of HLST, VLST and DLST systems, Code design criteria, Receivers for LST systems, Iterative receivers.	12	4
	****Assignment Topics**	Use Cases OFDM		4
Module 5: **Concatenated Codes and Iterative Decoding**	in class	Development of concatenated codes, Concatenated codes for AWGN and MIMO channels, Turbo coded modulation for MIMO channels, Concatenated space-time block coding.	8	5
	****Assignment Topics**	Application of MIMO		5

Text-Books:

1. Aditya K. Jagannatham, Principles of Modern Wireless Communications Systems, 2015, 1st Edition, McGraw-Hill Education, India.

Reference Books:

1. B. Gershman, N. D. Sidiropoulus, Space-time Processing for MIMO Communications, 2011, 1st Edition, Wiley, NJ, USA.
2. A. Paulraj, R. Nabar, D Gore, Introduction to Space-Time Wireless Communications, 2013, 1st Edition, Cambridge University Press, UK.



Open Elective-6

VT405A2 **Credit: 4 (L-3, T-1, P-0)**

Advance Digital Signal Processing

Questions to be set: 05 (All Compulsory)

Course Objectives: The course is intended to give students a clear idea of signal processing methodologies in modern digital devices. The course is divided into two units. In unit I, the topics like Multirate signal processing and Hilbert Transform are elaborated. In unit II, cepstral analysis and Homomorphic deconvolution, power spectral estimation and optimal and adaptive filters are introduced.

Pre-requisites: Signals & Systems, Digital Signal Processing.

Course Outcomes(CO):

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

CO	STATEMENT
CO1	Explain the basics of signal and system, DFT, Filters
CO2	Analyze and application of Multirate DSP and Discrete Hilbert transforms
CO3	Examine the Cepstrum & Homomorphic Deconvolution
CO4	Evaluate the Power Spectral Estimation
CO5	Analysis of Parametric Method Of Power Spectrum Estimation

** not more than 20% of total topics to be allotted for assignment

Module	Topics to be covered	Topics	Hrs	CO
Module 1: **Introduction**	in class	Discrete-Time Signals & Systems, Sampling, DFT, Z-transform, Filter design techniques- FIR, IIR, The basic sample rate Alteration device, Filters in sampler rate Alteration System, Multistage Design of Decimator & interpolator. The polyphase Decomposition, Arbitrary rate sampler rate converter	8	1
	****Assignment Topics**	Numerical Problems		1
Module 2: **Multirate DSP and Discrete Hilbert transforms**	in class	Digital filter banks, Nyquist filters, two channel quadrature mirror filter bank, L channel QMF banks, Cosine modulated L- channel filter banks, Multilevel filter bank, STFT, DCT. Real & Imaginary Part, sufficiency of the FT for causal Sequences, Sufficiency Theorems for Finite length Sequences, Relationship between Magnitude & Phase, HT Relation for complex sequences.	10	2
	****Assignment Topics**	Numerical Problems		2
Module 3: **Cepstrum analysis &**	in class	Definition of complex Cepstrum, Homomorphic Deconvolution, Properties of complex Logarithm, Alternative expression for complex cepstrum, The complex cepstrum of exponential sequences,	10	3

Homomorphic Deconvolution		Realization of the Characteristic system, Examples of Homomorphic Filtering.		
	****Assignment Topics**	Numerical Problems		3
Module 4: **Introduction to Power Spectral Estimation**	in class	Estimation of Spectra from Finite Duration Observations of a signal, the Periodogram, Use DFT in power Spectral Estimation, Bartlett, Welch and Blackman, Tukey methods, Comparison of performance of Non-Parametric Power Spectrum Estimation Methods	10	4
	****Assignment Topics**	Numerical Problems		4
Module 5: **Parametric Method Of Power Spectrum Estimation**	in class	Parametric Methods for power spectrum estimation, Relationship between Auto-Correlation and Model Parameters, AR (Auto-Regressive) Process and Linear Prediction, Yule-Walker, Burg and Unconstrained Least Squares Methods, Sequential Estimation, Moving Average(MA) and ARMA Models Minimum Variance Method, Piscaranko's Harmonic Decomposition Methods, MUSIC Method.	10	5
	****Assignment Topics**	Numerical Problems		5

Text Books:

1. A.V. Oppenheim and R.W. Schaffer, "*Discrete-Time Signal Processing*", 3/e, Pearson, 2014.

2. J.G. Proakis and D. Manolakis, "*Digital Signal Processing*", 4/e, Pearson, 2007.

References:

1. S.K. Mitra, "*Digital Signal Processing-A Computer based approach*", 3/e, McGraw-Hill Education (Asia), 2006.

2. Simon Haykin, "*Adaptive Filter Theory*", 4/e, Pearson, 2012.

3.Samuel D Stearns, "Digital Signal Processing with examples in Matlab. " CRC Press.

VT406A2 **Credit: 4 (L-3, T-1, P-0)**

ASIC Design

Questions to be set: 05 (All Compulsory)

Course objectives:

- To prepare the student to be an entry-level industrial standard ASIC or FPGA designer.
- To give the student an understanding of issues and tools related to ASIC/FPGA design and implementation.
- To give the student an understanding of basics of System on Chip and platform-based design.

Prerequisite:

Fundamentals of VLSI Design and Analog Circuits

Course outcomes

On completion of the course the student should be able to:

CO1: Demonstrate VLSI tool-flow and appreciate FPG Architecture.

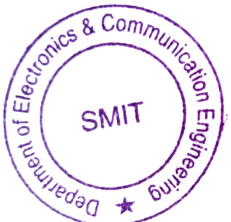
CO2: Understand the issues involved in ASIC design, including technology choice, design management, tool-flow, verification, debug and test, as well as the impact of technology scaling on ASIC design.

CO3: Understand the algorithms used for ASIC construction.

CO4: Understand the basics of System on Chip, on chip communication architectures like AMBA, AXI and utilizing Platform based design.

CO5: Appreciate high performance algorithms available for ASICs IC.

Module	Topics to be covered	Topics	Hrs	CO
1	In Class	Types of ASICs, VLSI Design flow, Programmable ASICs - Antifuse, SRAM, EPROM, EEPROM based ASICs. Programmable ASIC logic cells and I/O cells. Programmable interconnects.	8	1
	Assignment Topics:	Latest Version - FPGAs and CPLDs and Soft-core processors.		1
2	In Class	Trade off issues at System Level: Optimization with regard to speed, area and power, asynchronous and low power system design. ASIC physical design issues, System Partitioning, Power Dissipation, Partitioning Methods.	10	2
	Assignment Topics:			
3	In Class	ASIC floor planning, Placement and Routing.	10	3



	Assignment			
	Topics:			
4	In Class	System-On-Chip Design - SoC Design Flow, Platform-based and IP based SoC Designs, Basic Concepts of Bus-Based Communication Architectures, On-Chip Communication Architecture Standards	10	4
	Assignment	Low-Power SoC Design		4
	Topics:			
5	In Class	High performance algorithms for ASICS/ SoCs as case studies – Canonic Signed Digit Arithmetic, KCM, Distributed Arithmetic	10	5
	Assignment	High performance digital filters for sigma-delta ADC, USB		5
	Topics:	controllers, OMAP		

TEXTBOOKS:

1. M.J.S. Smith,"Application Specific Integrated Circuits", Pearson, 2003

2. H.Gerez, "Algorithms for VLSI Design Automation", John Wiley,1999.

REFERENCE BOOKS:

1. J..M.Rabaey, A. Chandrakasan, and B.Nikolic, "Digital Integrated Circuit Design Perspective (2/e)", PHI2003.

2. D.A.Hodges,"AnalysisandDesignofDigitalIntegratedCircuits(3/e)",MGH2004.

3. Hoi-Jun Yoo, Kangmin LeeandJun Kyong Kim, "Low-Power NoC for High-Performance SoC Design", CRC Press,2008.

4. S. Pasricha and N. Dutt," On Chip Communication Architectures System on Chip Interconnect, Elsveir",2008.

VT407A2 **Credit: 4 (L-3, T-1, P-0)**

Data Centre and Cloud Computing

Questions to be set: 05 (All Compulsory)

Course Objectives: In near future, all the activities of the 'Things' will be monitored and controlled from the cloud and data center. Students will be able to learn and use the knowledge from this course, in designing such computational algorithm and system.

Pre-requisites: Basic knowledge of cloud and gateways.

Course Outcomes (CO):

CO1: The students should be able to explain the cloud computing requirements and challenges.

CO2: The students should be able to explain Cloud based IoT platform design methodology.

CO3: The students should be able to explain storage hierarchy for cloud computing.

CO4: The students should be able to explain the role of Data centre cloud computing.

CO5: The students should be able to explain the basic concept of cloud server.

** not more than 20% of total topics to be allotted for assignment

Module	Topics to be covered	Topics	Hrs	CO
Module 1: **Introduction to Cloud Computing**	in class	Cloud Computing in a Nutshell , Roots of Cloud Computing , Layers and Types of Clouds, Desired Features of a Cloud , Cloud Infrastructure Management. Infrastructure as a Service Providers , Platform as a Service Providers , Challenges and Risks	8	1
	****Assignment Topics**			1
Module 2: **Migrating into a Cloud**	in class	Introduction, Broad Approaches to Migrating into the Cloud, The Seven-Step Model of Migration into a Cloud , IoT platforms design methodology, IoT Physical devices and endpoints. IoT Systems: Logical design using Python, IoT physical servers and cloud offerings (Cloud computing for IoT), Conclusions	10	2
	****Assignment Topics**			2
Module 3:	in class	Storage hierarchy. Hard disk drive (HDD) fundamentals, HDD evolution, storage SLA and RAID architecture,	10	3

Cloud storage basics		RAID techniques, RAID configurations, storage LUN, LUN capacity expansion, Storage topologies and connections, direct attached storage (DAS), storage area network (SAN), storage protocols.		
	****Assignment Topics**	**Applications:** Massively Multiplayer Online Game Hosting on Cloud Resources Building Content Delivery Networks Using Clouds		3
Module 4: **Introduction to Data Centre network (DCN)**	in class	Basic understanding of a data center, DATA CENTER ARCHITECTURE, DATA CENTER PERFORMANCE , Scalability, Latency and throughput, data center capacity planning, data center space, how to estimate cost of space	10	4
	****Assignment Topics**	key network terms and components, network hardware, Hub, Switch, Bridge, Router, Gateway, Data center network topology.		4
Module 5: **Cloud infrastructure servers**	in class	**CISC, RISC, Rack-mounted, and Blade servers** Cloud servers, a client/server architecture, X86 SERVER, Core, multicore, processor, and CPU, N-way servers, Multithreading and processes, Hyperthreading, server pci cards, server storage, server network, server motherboard, Rack-mounted servers and vendors,	10	5
	****Assignment Topics**	Blade servers, rack vs. Blade server, RISC server, CISC vs. RISC, ORACLE/SUN SPARC servers, ORACLE/SUN m-series RISC servers, ORACLE/SUN t-series RISC servers, SPARC logical domain and virtual machine (VM).		5

Text Books:

1.Rajkumar Buyya, James Broberg, Andrzej Goscinski , “CLOUD COMPUTING Principles and Paradigms” , John Wiley & Sons, Inc, 2011.

Reference Books:

1. Caesar Wu, Rajkumar Buyya , “ Cloud Data Centers and Cost Modeling”, Elsevier Inc.,2015.
2. Kai Hwang, Min Chen, “Big-Data Analytics for Cloud, IoT and Cognitive Computing”, John Wiley & Sons Ltd, 2017.

VT408A2 **Credit: 4 (L-3, T-1, P-0)**

5G MOBILE COMMUNICATION

Questions to be set: 05 (All Compulsory)

Course Objectives:

I. To cognize the most recent trends 5G wireless communication.
II. To understand the current research avenues in 5G domain.

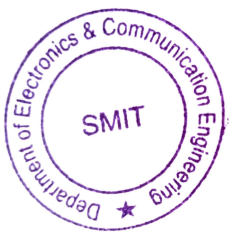
Pre-requisites: Mobile Communiaction.

Course Outcomes (CO): Students should be able to

1. Understand 5G spectrum requirement, its channel model and use cases
2. Familiarize with 5G architecture options and physical layer concepts
3. Examine the multicarrier techniques and new waveform options for 5G communication
4. Illustrate the concept of network slicing and V2V Communication
5. Interpret the Interference and Mobility management in 5G networks

** not more than 20% of total topics to be allotted for assignment

Module	Topics to be covered	Topics	Hrs	CO
Module 1: **Introduction to 5G**	in class	5G RADIO SPECTRUM: 5G spectrum landscape and requirements, Spectrum access modes and sharing scenarios, 5G spectrum technologies. 5G CHANNEL MODEL: The 5G wireless Propagation Channels: Channel modeling requirements, propagation scenarios and challenges in the 5G modeling. 5G USE CASES AND SYSTEM CONCEPT: Use cases and requirements, 5G system concept.	12	1
	****Assignment Topics**			1
Module 2: **5G Radio Interface architecture and Physical Layer**	in class	RADIO INTERFACE ARCHITECTURE: 5G architecture options, core network architecture, RAN architecture. 5G PHYSICAL LAYER: Physical channels and signals, 5G frame structure, physical layer procedures (MIMO, Power control, link adaptation, beam forming).	10	2
	****Assignment Topics**			2
Module 3: **5G Radio Access Technology**	in class	Access design principles for multi-user communications, multi-carrier with filtering: a new waveform, non-orthogonal schemes for efficient multiple access	10	3
	****Assignment Topics**			3



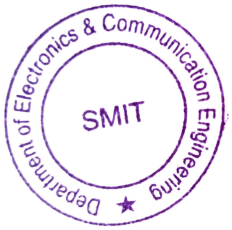
Module 4:	in class	Network Slicing, E2E Slicing, SDN and NFV Slicing	8	4
Introduction To 5G Network Slicing:	****Assignment Topics**	Use Cases OFDM		4
Module 5: **Mobility And Handoff Management In 5G**	in class	Network deployment types, Interference management in 5G, Mobility management in 5G, Dynamic network reconfiguration in 5G.	8	5
	****Assignment Topics**			5

TEXTBOOKS:

1. Afif Osseiran, Jose F Monserrat, Patrick Marsch, "5G Mobile and Wireless Communications
Technology", Cambridge University Press, 2016
2. Saad Z. Asif, "5G Mobile Communications Concepts and Technologies", CRC Press, Taylor
& Francis Group, First Edition, 2018
3. Harri Holma, Antti Toskala, Takehiro Nakamura, "5G Technology 3GPP NEW RADIO", John Wiley & Sons First Edition,2020

REFERENCES:

1. Gordon L. Stuber, "Principles of Mobile Communication", KLUWER ACADEMIC PUBLISHERS, 2nd Edition, 2002
2. Joseph C. Liberti, Theodore S. Rappaport, "Smart Antennas for Wireless Communications",
Prentice Hall PTR, 1999
3. Ying Zhang, "Network Function Virtualization Concepts and Applicability in 5G Networks", John Wiley & Sons, 2018



Choice Based Electives

The consent of Department's Internal Board of Studies (BoS) are as:

1. Dr. Bikash Sharma, Chairman, HoD, Dept. of ECE
2. Prof.(Dr.) P.C.Pradhan, Member, Dept. of ECE
3. Prof.(Dr.) Sourav Dhar, Member, Dept. of ECE
4. Dr.Hemanta Saikia, Member, Dept. of ECE
5. Dr.Tanushree Bose, Member , Dept. of ECE
6. Dr. S.N. Sur , Member, Dept. of ECE
7. Dr. O. P. Singh, Member, Dept. of CSE (DS)
8. Dr. Arun Kumar Singh, Dept. of ECE
9. Mr. Suman Das, Dept. of ECE (Invited member)