KAMARAJ COLLEGE OF ENGINEERING & TECHNOLOGY

(An Autonomous Institution - AFFILIATED TO ANNA UNIVERSITY, CHENNAI)

S.P.G.Chidambara Nadar - C.Nagammal Campus

S.P.G.C. Nagar, K.Vellakulam – 625 701 (Near VIRUDHUNAGAR).

B.E. ELECTRONICS AND COMMUNICATION ENGINEERING

REGULATIONS – 2021

AUTONOMOUS SYLLABUS

CHOICE BASED CREDIT SYSTEM

V TO VI SEMESTER CURRICULUM AND SYLLABI

VISION:

To make the Department of Electronics and Communication Engineering of this Institution the unique of its kind in the field of Research and Development activities in this part of world.

MISSION:

To impart highly innovative and technical knowledge in the field of Electronics and Communication Engineering to the urban and unreachable rural student folks through Total Quality Education.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

PEO 1: To establish a strong foundation in Electronics and Communication Engineering necessary to formulate, model, analyze and solve real time problems.

PEO 2: To inculcate professional skills and life skills for placement or to pursue higher studies in the relevant fields.

PEO 3: To promote research and development activities and solve industrial problems with creative ideas.

PROGRAM OUTCOMES:

After going through the four years of study, the Electronics and Communication Engineering graduates will have the ability to

POs	Graduate Attribute	Programme Outcome
1	Engineering knowledge	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
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.
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.
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
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
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
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.

8	Ethics	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9	Individual and team work	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10	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.
11	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.
12	Life-long learning	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAMME SPECIFIC OUTCOMES (PSOs):

PSO1 : Ability to make use of attained technical knowledge in the field of Electronics and Communication Engineering for successful career and qualifying in competitive examinations at the national level.

PSO2 : Ability to develop workable solutions for real time challenges in Electronics and Communication Engineering.

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B.E. ELECTRONICS AND COMMUNICATION ENGINEERING

CURRICULUM AND SYLLABI FOR SEMESTER V TO VI

SEMESTER V

S.NO.	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
THEORY								
1	EC2301	Electromagnetic Fields & Transmission Lines	PC	3	3	0	0	3
2	EC2302	VLSI Design and Technology	PC	3	3	0	0	3
3	EC2303	Wireless Communication	PC	3	3	0	0	3
4		Professional Elective I	PE	3	3	0	0	3
5		Professional Elective II	PE	3	3	0	0	3
6		Professional Elective III	PE	3	3	0	0	3
PRACTICALS								
7	EC2304	Advanced Communication Laboratory	PC	4	0	0	4	2
8	EC2305	VLSI Design Laboratory	PC	4	0	0	4	2
9	EM2301	Internship **	EM	0	0	0	0	1
			TOTAL	**26**	**18**	**0**	**8**	**23**

**** Credits earned by the student through internship will be given in the final consolidated mark statement.**

SEMESTER VI

S.NO.	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
THEORY								
1	EC2351	Introduction to Artificial Intelligence and Machine Learning	PC	3	3	0	0	3
2	EC2352	Statistical Theory of Communication	PC	3	3	0	0	3
3		Open Elective I*	OE	3	3	0	0	3
4		Professional Elective IV	PE	3	3	0	0	3
5		Professional Elective V	PE	3	3	0	0	3
6		Professional Elective VI	PE	3	3	0	0	3
PRACTICALS								
7	EC2353	Mini Project	EM	4	0	0	4	2
8	EM2252	An Introduction to Advanced Reading and Writing	EM	2	0	0	2	1
			TOTAL	**24**	**18**	**0**	**6**	**21**

***Open Elective – I shall be chosFen from the list of open electives offered by other Programmes**

ECE PROFESSIONAL ELECTIVE COURSES: VERTICALS

Vertical I Semiconductor Chip Design and Testing	**Vertical II Signal Processing**	**Vertical III RF and Wireless Technologies**	**Vertical IV Sensor Technologies and IoT**
Digital VLSI Design and Technology	Acoustics & Speech Processing	Antenna Design #	MEMS & Nanoelectronics
Analog VLSI Design	Advanced Digital Signal Processing	Radio Frequency Integrated Circuits	Sensors and Control Systems
Low power VLSI design	Introduction to Deep Learning#	Microwave Engineering#	Internet of Things#
VLSI Architecture for Signal Processing and Machine Learning	Digital Image Processing#	Electromagnetic Interference and Compatibility	Data Analytics and Visualization
IC Manufacturing and Packaging	Computer Vision	Optical Communication	Security in Internet of Things
SoC Design and Verification#	Pattern recognition and Computational Intelligence	Cognitive Radio	Wireless Technologies#
Semiconductor Test Engineering#	RADAR & SONAR Signal Processing	Ad hoc and Wireless Sensor Networks	Industrial IoT

Theory Cum Lab

VERTICAL I: SEMICONDUCTOR CHIP DESIGN AND TESTING

S.NO.	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
THEORY								
1	VEC311	Digital VLSI Design and Technology	PE	3	3	0	0	3
2	VEC312	Analog VLSI Design	PE	3	3	0	0	3
3	VEC313	Low power VLSI design	PE	3	3	0	0	3
4	VEC314	VLSI Architecture for Signal Processing and Machine Learning	PE	3	3	0	0	3
5	VEC315	IC Manufacturing and Packaging	PE	3	3	0	0	3
6	VEC316	SoC Design and Verification[#]	PE	4	2	0	2	3
7	VEC317	Semiconductor Test Engineering[#]	PE	4	2	0	2	3

VERTICAL II: SIGNAL PROCESSING

S.NO.	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
THEORY								
1	VEC321	Acoustics & Speech Processing	PE	3	3	0	0	3
2	VEC322	Advanced Digital Signal Processing	PE	3	3	0	0	3
3	VEC323	RADAR & SONAR Signal Processing	PE	3	3	0	0	3
4	VEC324	Digital Image Processing[#]	PE	4	2	0	2	3
5	VEC325	Computer Vision	PE	3	3	0	0	3
6	VEC326	Pattern recognition and Computational Intelligence	PE	3	3	0	0	3
7	VEC327	Introduction to Deep Learning[#]	PE	4	2	0	2	3

[#] Theory Cum Lab

VERTICAL III: RF AND WIRELESS TECHNOLOGIES

S.NO.	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
THEORY								
1	VEC331	Antenna Design #	PE	4	2	0	2	3
2	VEC332	Radio Frequency Integrated Circuits	PE	3	3	0	0	3
3	VEC333	Microwave Engineering#	PE	4	2	0	2	3
4	VEC334	Electromagnetic Interference and Compatibility	PE	3	3	0	0	3
5	VEC335	Optical Communication	PE	3	3	0	0	3
6	VEC336	Cognitive Radio	PE	3	3	0	0	3
7	VEC337	Ad hoc and Wireless Sensor Networks	PE	3	3	0	0	3

VERTICAL IV: SENSOR TECHNOLOGIES AND IOT

S.NO.	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
THEORY								
1	VEC341	Sensors and Control Systems	PE	3	3	0	0	3
2	VEC342	MEMS & Nanoelectronics	PE	3	3	0	0	3
3	VEC343	Internet of Things#	PE	4	2	0	2	3
4	VEC344	Data Analytics and Visualization	PE	3	3	0	0	3
5	VEC345	Wireless Technologies#	PE	4	2	0	2	3
6	VEC346	Security in Internet of Things	PE	3	3	0	0	3
7	VEC347	Industrial IoT	PE	3	3	0	0	3

Theory Cum Lab

MINOR DEGREE IN ECE

S.NO.	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
THEORY								
1	MEC101	Analog Devices and Circuits	OE	3	3	0	0	3
2	MEC102	Digital Logic Design[#]	OE	4	2	0	2	3
3	MEC103	Principles of Communication	OE	3	3	0	0	3
4	MEC104	Introduction to Machine Learning	OE	3	3	0	0	3
5	MEC105	Sensors and IoT	OE	3	3	0	0	3
6	MEC106	Electronic System Design[#]	OE	4	2	0	2	3

[#] Theory Cum Lab

OPEN ELECTIVES

OPEN ELECTIVES I (Offered to EEE, Mechanical, Civil, Mechatronics and Bio-Technology)

S.NO.	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
1	OEC781	IoT Concepts and Applications	OE	3	2	0	2	3

Course Code	Course Name	L	T	P	C
EC2301	ELECTROMAGNETIC FIELDS & TRANSMISSION LINES	3	0	0	3

Category: Professional Core

a. Preamble

The purpose of the course is to familiarize the students with the fundamentals of electrostatics, magnetostatics, time-varying fields and electromagnetic waves. To introduce various types of transmission lines and to discuss the losses associated and also to provide understanding about impedance transformation and matching.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Apply electromagnetic laws to static fields.	K3
CO2	Infer about the fundamental concepts and laws of static magnetic field.	K2
CO3	Apply EM laws for electromagnetic fields.	K3
CO4	Discuss the characteristics of signal propagation through transmission lines and its losses.	K2
CO5	Analyze impedance matching by stubs using smith charts.	K3

c. Course Syllabus **Total : 45 Periods**

STATIC ELECTRIC FIELDS **9**

Introduction to Coordinate System – Rectangular – Cylindrical and Spherical Coordinate System –Definition of Gradient- Coulomb's Law in Vector Form – Definition of Electric Field Intensity – Principle of Superposition – Electric Field and Electric Scalar Potential due to point charges –continuous charge distribution –charges distributed uniformly on an infinite and finite line –a uniformly charged circular disc/ring – an infinite uniformly charged sheet – Electric Dipole – Definition of Divergence and Divergence theorem – Electric Flux Density – Gauss Law – Applications – Electrostatic energy and energy density.

STATIC MAGNETIC FIELDS **9**

The Biot–Savart Law in vector form – Magnetic Field intensity due to a finite and infinite wire carrying a current I – Definition of Curl and Stokes theorem – Magnetic field intensity on the axis of a circular and rectangular loop carrying a current I – Ampere's circuital law and simple applications – Magnetic flux density – Magnetic Potentials – The Lorentz force equation for a moving charge and applications – Force on a wire carrying a current I placed in a magnetic field – Torque on a loop carrying a current I.

TIME VARYING ELECTRIC AND MAGNETIC FIELDS **9**

Time varying fields – emf and mmf – Faraday's law – Lenz's law – Maxwell's Second Equation in integral form from Faraday's Law – Displacement current – Modified form of Ampere's circuital law – Maxwell's four equations in integral form and differential form – Poynting Vector and the flow of power.

TRANSMISSION LINE THEORY **9**

General theory of Transmission lines - the transmission line - general solution - The infinite line - Wavelength, velocity of propagation - Waveform distortion - the distortion-less line - Loading and different methods of loading - Line not terminated in Zo - Input and transfer impedance - reflection factor, reflection loss, insertion loss.

LINE AT RADIO FREQUENCY AND IMPEDANCE MATCHING **9**

Transmission line equations at radio frequencies – Input impedance of the dissipation-less line - Open and short circuited lines – Reflection Phenomena – Standing waves – $\lambda/8$, $\lambda/4$ & $\lambda/2$ lines – $\lambda/4$ Impedance transformers, Stub Matching – Single and Double Stub – Smith Chart and Applications.

d. Activities

Students shall be exposed to EM Simulation tools such as ADS and HFSS.

e. Learning Resources

Text Books

1. W H. Hayt& J A Buck, 2010. *Engineering Electromagnetics*, TATA McGraw–Hill, 8th Edition.
2. John D Ryder, 2005. *Networks Lines and Fields*, Prentice Hall of India.
3. E.C.Jordan and K.G. Balmain, 2011. *Electromagnetic Waves and Radiating Systems*, Prentice Hall of India.

References

1. Sadiku, M.N., 2007. *Elements of Electromagnetics*, Oxford University Press, USA.
2. Cheng, D.K., 1989. *Field and Wave Electromagnetics*, Pearson Education India.
3. Pozar, D.M., 2011. *Microwave Engineering*, John Wiley & Sons.

Course Code	Course Name	L	T	P	C
EC2302	VLSI DESIGN AND TECHNOLOGY	3	0	0	3

Category: Professional Core

a. Preamble

Deals about the principles of VLSI System Design and construction of CMOS Combinational & Sequential Logic Circuits and Subsystem Design.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Generalize the design techniques and analyze the characteristics of VLSI circuits such as area, speed and power dissipation.	K2
CO2	Synthesize the combinational and sequential circuits.	K2
CO3	Explain and compare the architectures of adders and multipliers and evaluate their characteristics such as area, power dissipation.	K2
CO4	Synthesize the memory array systems in CMOS circuits.	K2
CO5	Describe the techniques used for VLSI fabrication, design of CMOS logic circuits.	K2

c. Course Syllabus **Total :45 Periods**

INTRODUCTION TO MOS TRANSISTORS **9**

VLSI design Flow -MOS transistor, Ideal I–V characteristics, C–V characteristics, Non ideal I–V effects – CMOS Inverter and Pass transistor- DC transfer characteristics - Delay estimation – Logical effort and Transistor sizing – Power dissipation.

CMOS LOGIC CIRCUITS **9**

Combinational Logic Circuits: Static CMOS Design – Dynamic CMOS Design – Transmission Gates – Design Examples: Basic Gates, Complex Logic Circuits. Sequential Logic Circuits: Static Latches and Registers, Dynamic Latches & Registers, Transmission Gate Based Registers, C2MOS Registers, True Single-Phase Clocked Register (TSPCR), Register Pipelining, Latch vs Register Based Pipelines, NORA – CMOS.

9

SUBSYSTEM DESIGN

Design of adders-Static adder, Carry Look Ahead adder, Binary adder – Multipliers -Array multiplier, Carry Save multiplier, Booths and Modified Booths multiplier - Barrel shifter, Logarithmic shifter.

MEMORY DESIGN **9**

CAM memory,4x4 -OR ROM, NOR ROM, NAND ROM cell array,6-T SRAM cell,3-T DRAM cell, Memory peripheral circuitry-Address Decoders-Sense amplifiers-Power dissipation in memories.

VLSI LAYOUT DESIGN AND FABRICATION TECHNIQUES **9**

Layout styles – Full custom and Semi custom approaches -Layout Design Rules – CMOS nwell process rules - Stick diagram - Layout examples – Fabrication techniques – Wafer processing - Oxidation - Patterning - Diffusion - Ion implantation - Deposition - CMOS processes : nWell, Twin tub, Silicon on Insulator.

d. Activities

Students shall be exposed to IC design and its steps through EDA tools.

e. Learning Resources

Text Books

1. Weste, N.H. and Eshraghian, K., 1985. *Principles of CMOS VLSI Design: A Systems Perspective*. Addison-Wesley Longman Publishing Co., Inc..
2. Jan, M.R., Anantha, C. and Borivoje, N., 2003. *Digital Integrated Circuits: A Design Perspective*. Pearson.

References

1. Mead, C. and Conway, L., 1980. *Introduction to VLSI Systems*.
2. Pucknell, D.A. and Eshraghian, K., 1985. *Basic VLSI design Principles & Applications*. Prentice-Hall, Inc..
3. Mukherjee, A. ed., 1986. *Introduction to n MOS & VLSI Systems Design*. Prentice-Hall, Inc..

Course Code	Course Name	L	T	P	C
EC2303	WIRELESS COMMUNICATION	3	0	0	3

Category: Professional Core

a. Preamble

Wireless communication is a broad term that incorporates all procedures and forms of connecting and communicating between two or more devices using a wireless signal through wireless communication technologies and devices. The cellular ideas, multiple modulation systems and multipath mitigation strategies are all exposed in this course.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Characterize a wireless channel and evolve the system design specifications.	K2
CO2	Explain a cellular system based on resource availability and traffic demands.	K2
CO3	Identify suitable signaling schemes for fading channels.	K2
CO4	Identify suitable multipath mitigation techniques for the wireless channel.	K2
CO5	Illustrate the multi antenna techniques in fading and nonfading channels.	K2

c. Course Syllabus **Total : 45 Periods**

WIRELESS CHANNELS **9**

Large scale path loss – Path loss models: Free Space and Two-Ray models -Link Budget design – Small scale fading- Parameters of mobile multipath channels – Time dispersion parameters-Coherence bandwidth – Doppler spread & Coherence time, fading due to Multipath time delay spread – flat fading – frequency selective fading – Fading due to Doppler spread – fast fading – slow fading.

CELLULAR ARCHITECTURE **9**

Multiple Access techniques - FDMA, TDMA, CDMA – Capacity calculations–Cellular concept- Frequency reuse - Channel assignment- Hand off- Interference & system capacity- trunking & grade of service – Coverage and capacity improvement.

DIGITAL SIGNALING FOR FADING CHANNELS **9**

Structure of a wireless communication link, Principles of Offset-QPSK, Pi/4-DQPSK, Minimum Shift Keying, Gaussian Minimum Shift Keying, Error performance in fading channels, OFDM principle – Cyclic prefix, Windowing, PAPR.

MULTIPATH MITIGATION TECHNIQUES **9**

Equalisation – Adaptive equalization, Linear and Non-Linear equalization, Zero forcing and LMS Algorithms. Diversity – Micro and Macro diversity, Diversity combining techniques, Error probability in fading channels with diversity reception, Rake receiver.

MULTIPLE ANTENNA TECHNIQUES **9**

MIMO systems – Spatial multiplexing -System model - Pre-coding - Beam forming - Transmitter diversity, Receiver diversity- Channel state information - Capacity in fading and non-fading channels.

d. Activities

Students shall be exposed to design embedded system architecture for wireless communication systems and applications and fundamentals of wireless radio communications and signal analysis.

e. Learning Resources

Text Books

1. Rappaport, T.S., 2010. *Wireless Communications: Principles and Practice,* 2/E. Pearson Education India.
2. Molisch, A.F., 2012. *Wireless Communications*, John Wiley & Sons.

References

1. Goldsmith, A., 2005. *Wireless Communications*. Cambridge university press.
2. Nee, R.V. and Prasad, R., 2000. *OFDM for Wireless Multimedia Communications*, Artech House, Inc..
3. Tse, D. and Viswanath, P., 2005. *Fundamentals of Wireless Communication*, Cambridge university press.
4. Dalal, U., 2010. *Wireless Communication,* Oxford University Press, Inc..

Course Code	Course Name	L	T	P	C
EC2304	ADVANCED COMMUNICATION LABORATORY	0	0	4	2

Category: Professional Core

a. Preamble

This course promotes the students to understand the working principle of optical and microwave sources, detector, fibers and thereby measure the numerical aperture and analyze the mode characteristics. Also this course makes the students understand and capture an experimental approach to digital wireless communication.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Examine the performance of simple optical link by measurement of losses and Analyzing the mode characteristics of fiber.	K3
CO2	Analyze the eye pattern, pulse broadening of optical fiber and the impact on BER.	K4
CO3	Simulate the wireless channel characteristics and its impairments.	K3
CO4	Analyze the transmission and reception of wireless system using SDR.	K4
CO5	Demonstrate the intricacies in Microwave System design.	K3

c. Course Syllabus **Total : 60 Periods**

I. List of Optical Experiments

1. Measurement of connector, bending and Fiber attenuation losses
2. Numerical Aperture measurement of Fibers
3. DC Characteristics of LED and PIN Photo diode
4. Fiber optic Analog and Digital Link Characterization - frequency response (analog), eye diagram and BER (digital)

II. List of Wireless Communication Experiments

1. Wireless Channel Simulation including fading and Doppler effects
2. Simulation of Channel Estimation, Synchronization & Equalization techniques
3. Modeling and simulation of TDMA, FDMA and CDMA for Wireless Communication
4. Transmission and reception of Single tone signal using Software Defined Radio
5. Analysing Impact of Pulse Shaping and Matched Filtering using Software Defined Radios
6. OFDM Signal Transmission and Reception using Software Defined Radios
7. Node creation, Packets transmission using NS3

III. List of Microwave Experiments

1. Characteristics of Reflex Klystron
2. Measurement of VSWR and unknown impedance
3. Characterization of Directional Couplers, Isolators and Circulators
4. Gunn Diode Characteristics

d. Activities

Students shall be given exposure to measure the different kind of losses of fiber optics and to analyse the characteristics of different microwave devices and gain knowledge on MATLAB/LabVIEW software for doing high end projects in software defined radio.

e. Learning Resources

Text Books

1. Pozar, D.M., 2011. *Microwave Engineering,* John Wiley & Sons.
2. Chakrabarti, P., 2015. *Optical Fiber Communication*, McGraw-Hill Education.
3. Rappaport, T.S., 2010. *Wireless Communications: Principles and Practice,* 2/E. Pearson Education India.

References

1. Collin, R.E., 2007. *Foundations for Microwave Engineering*. John Wiley & Sons.
2. Keiser, G., 2013. *Optical Fiber Communications* (Vol. 2). New York: McGraw-Hill.
3. Nee, R.V. and Prasad, R., 2000. *OFDM for Wireless Multimedia Communications*, Artech House, Inc.

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS:

S.No.	Description of Equipment	Quantity Required
1.	Trainer kit for carrying out LED and PIN diode characteristics, Digital multimeter, Optical power meter.	2 Nos
2.	Trainer kit for determining the mode characteristics, losses in optical fiber, Numerical aperture and Attenuation of fiber.	2 Nos
3.	Trainer kit for analyzing Analog and Digital link performance, 2 Mbps PRBS Data source, 10 MHz signal generator, 20 MHz Digital storage Oscilloscope.	2 Nos
4.	Advanced Optical fiber trainer kit for PC to PC communication, BER Measurement, Pulse broadening.	2 Nos
5.	MM/SM Glass and plastic fiber patch chords with ST/SC/E2000 connectors.	2 sets
6.	Digital Communications Teaching Bundle (LabVIEW/MATLAB/Equivalent software tools)	10 Users
7.	Transmit / receive pair of NI USRP–2920 transceivers (50 MHz to 2.2 GHz).	2 Nos
8.	Klystron power supply, Reflex klystron Mount, Isolator, Frequency meter, Variable attenuator, Slotted section, VSWR meter, Detector mount & CRO	2 sets
9.	Gunn power supply, Gunn oscillator, pin Modulator, Isolator, Frequency meter, attenuator, Slotted section with probe carriage, Detector mount & VSWR meter	1 set

Course Code	Course Name	L	T	P	C
EC2305	VLSI DESIGN LABORATORY	0	0	4	2

Category: Professional Core

a. Preamble

Exposure to various stages of a typical state of the CAD VLSI tool be provided by various experiments designed to bring out the key aspects of simulation, and power and clock routing modules.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Apply CAD tools to draw/edit, and analyze the Digital circuits.	K3
CO2	Design and simulate the combinational circuits in Verilog HDL.	K3
CO3	Design and simulate the sequential circuits in Verilog HDL.	K3
CO4	Execute various logic modules on FPGA.	K3
CO5	Analyze the characteristics of Layout in Digital Circuits.	K3

c. Course Syllabus **Total : 60 Periods**

I. Digital System Design using HDL & FPGA

1. EDA tool Demo & Hands on Schematic
2. Design of 4bit / 8bit Adders using Verilog HDL and implement in FPGA.
3. Design of Multiplier 4 x 4 array multiplier and Booth multiplier using Verilog HDL
4. Design of ALU and implement in FPGA.
5. Design of Finite State Machine (Moore/Mealy)
6. Design of Memory (SRAM / DRAM)

II. Digital Circuit Design

7. Design and Analysis of CMOS circuit
8. Design Combinational Logic Circuit
9. Design Sequential Circuit

III. Layout Design

10. Layout of CMOS basic gates

11. Layout & Post Layout Simulation

d. Activities

Students shall be exposed to do mini project on VLSI design.

e. Learning Resources

Text Books

1. Eshraghian, K. and Weste, N.H., 1993. *Principles of CMOS VLSI Design*. Addiso-Wesley Pub. Company.
2. Baker, R.J. and Harry, W., LI., David E. Boyee, 2005. *CMOS Circuit Design, Layout and Simulation*, Prentice Hall of India.

References

1. Palnitkar, S., 2003. *Verilog HDL: A guide to Dgital Design and Synthesis* (Vol. 1), Prentice Hall Professional.
2. Micahel, D.C., 2010. *Advanced Digital Design with the Verilog HDL*, Pearson Education India.

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS:

S.No.	Description of Equipment	Quantity Required
1.	Xilinx ISE/Altera Quartus/ equivalent EDA Tools	10 User License
2.	Xilinx/Altera/equivalent FPGA Boards	10 Nos
3.	Cadence/Synopsis/ Mentor Graphics/Tanner/Microwind/ equivalent EDA Tools	10 User License
4.	Personal Computer	30 Nos

Course Code	Course Name	L	T	P	C
EM2301	INTERNSHIP	0	0	0	1

Category: Employability Enhancement Course

a. Preamble

To enable the students to

- Get connected with industry/ laboratory/research institute.
- Get practical knowledge on production process in the industry and develop skills to solve industry related problems.
- Develop skills to carry out research in the research institutes/laboratories.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Validate system-level processes, techniques, manufacturing and production processes in the industry/research facilities of the laboratory/research institute.	K5
CO2	Analyse the solutions of industry/research problems.	K4
CO3	Document system specifications, design methodologies, process parameters, testing parameters and results.	K2
CO4	Comprehend the process followed in the industry/research institute in the form of presentation .	K2
CO5	Demonstrate the technical knowledge observed in the industry/research institute with the courses studied.	K2

c. Course Instruction

The students individually undergo training in reputed industry/ research institutes/ laboratories for the specified duration. After completion of the training, a detailed report should be submitted within ten days from the commencement of next semester. The evaluation will be done as per the Regulations. Credits shall be awarded to the students who satisfy the clauses for industrial training/ internship of the Regulation concerned.

Course Code	Course Name	L	T	P	C
EC2351	INTRODUCTION TO ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING	3	0	0	3

Category: Professional Core

a. Preamble

This course promotes the students to get the knowledge on uninformed and Heuristic search techniques. It makes the students to learn techniques for reasoning under uncertainty. Also, this course promotes the study of supervised, unsupervised and reinforcement machine learning algorithms. This course also provides the basics concepts of Neural Networks.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Explain the appropriate search algorithms for problem solving in AI.	K2
CO2	Discuss supervised learning models using different algorithms.	K2
CO3	Infer about the unsupervised learning and ensemble learning for different algorithms.	K2
CO4	Explore various Reinforcement learning algorithms.	K2
CO5	Elucidate the basic concepts of neural networks for learning linear & non-linear activation function.	K2

c. Course Syllabus **Total : 45 Periods**

PROBLEM SOLVING & PROBABILISTIC REASONING **9**

Introduction to AI - AI Applications - Problem solving agents – search algorithms – uninformed search strategies – Heuristic search strategies – Local search and optimization problems – constraint satisfaction problems (CSP), Acting under uncertainty – Bayesian inference – naïve bayes models. Probabilistic reasoning – Bayesian networks – exact inference in BN – approximate inference in BN.

SUPERVISED LEARNING **9**

Introduction to machine learning – Linear Regression Models: Least squares, single & multiple variables, Bayesian linear regression, gradient descent, Linear Classification

Models: Discriminant function – Probabilistic discriminative model - Logistic regression, Probabilistic generative model – Naive Bayes, Maximum margin classifier – Support vector machine, Decision Tree, Random forests.

ENSEMBLE TECHNIQUES AND UNSUPERVISED LEARNING **9**

Combining multiple learners: Model combination schemes, Voting, Ensemble Learning - bagging, boosting, stacking, Unsupervised learning: K-means, Instance Based Learning: KNN, Gaussian mixture models and Expectation maximization.

REINFORCEMENT LEARNING **9**

Introduction to reinforcement learning – Passive reinforcement learning – Active reinforcement learning - Generalization in reinforcement learning – Policy search – Applications of reinforcement learning.

NEURAL NETWORKS **9**

Introduction to neural networks - Perceptron - Multilayer perceptron – gradient descent optimization – stochastic gradient descent - backpropagation algorithm -Training Procedures – Tuning the network size – Bayesian View of Learning – Dimensionality Reduction – Learning Time.

d. Activities

Students shall be exposed to model supervised, unsupervised and reinforcement learning.

e. Learning Resources

Text Books

1. Russell, S.J., 2010. *Artificial intelligence a modern approach*. Pearson Education, Inc..
2. Alpaydin, E., 2020. *Introduction to machine learning*. MIT press.

References

1. Patterson, D., 1990. *Introduction to artificial intelligence and expert systems*. Prentice-Hall, Inc..
2. Rich, E., Knight, K. and Nair, S.B., 2018. Artificial intelligence, McGraw Hill, 2008.
3. Winston, P.H., 1992. *Artificial intelligence*. Addison-Wesley Longman Publishing Co., Inc..
4. Deepak Khemani., 2013. *Artificial Intelligence*, Tata McGraw Hill Education, (http://nptel.ac.in/).

5. Bishop, C.M. and Nasrabadi, N.M., 2006. *Pattern recognition and machine learning* (Vol. 4, No. 4, p. 738). New York: springer.
6. Mitchell, T.M., 1997. Machine Learning McGraw-Hill International

7. Aggarwa, C.C., 2015. Data Classification: Algorithms and Applications. *Data Mining and Knowledge Discovery Series*.
8. Chen, L.P, Mehryar Mohri, Afshin Rostamizadeh and Ameet Talwalkar., 2019. Foundations of machine learning: The MIT Press, Cambridge, MA, 2018, 504 pp., CDN $96.53 (hardback), ISBN 9780262039406.
9. Goodfellow, I., Bengio, Y. and Courville, A., 2016. *Deep learning*. MIT press.

Course Code	Course Name	L	T	P	C
EC2352	STATISTICAL THEORY OF COMMUNICATION	3	0	0	3

Category: Professional Core Course

a. Preamble

This course enables the students to understand the fundamental principles that govern entropy, which measures the uncertainty or randomness of information; channel capacity, which quantifies the maximum rate of error-free information transmission and security needed for communication.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Discuss the basic random signals and processes.	K2
CO2	Explain various discrete memoryless sources and channels.	K2
CO3	Describe the signal detection and estimation algorithms.	K2
CO4	Elucidate linear filtering and Wiener filtering.	K2
CO5	Summarize the symmetric and asymmetric cryptographic algorithms for secure communication.	K2

c. Course Syllabus **Total : 45 Periods**

RANDOM SIGNAL THEORY **9**

Random variables, Random Process, Stationary Processes, Mean, Correlation & Covariance functions, Central limit Theorem, Power Spectral Density, Ergodic Processes, Gaussian Process.

INFORMATION SOURCES AND CHANNELS **9**

Discrete Memoryless source, Information, Entropy, Mutual Information and channel capacity, Shannon's fundamental theorem - Discrete Memoryless channels – Binary Symmetric Channel, Binary Erasure channel.

SIGNAL DETECTION AND ESTIMATION **9**

Hypothesis Testing and the MAP Criterion, Bayes Criterion, Minimax Criterion, Neyman-Pearson Criterion, Sequential Detection, Random parameter estimation-MMSE, Nonrandom parameters – ML estimation.

LINEAR FILTERING **9**

Discrete optimum linear filtering. Orthogonality principle. Spectral factorization. FIR and IIR Wiener filters.

SECURITY FOR COMMUNICATION **9**

Introduction to cryptography, Symmetric Key Cryptography – Data Encryption Standards, Asymmetric Key Algorithms – RSA Algorithm, One way Hashing.

d. Activities

Students shall be given exposure on MATLAB programs on Information channel generation, MMSE and ML estimation.

e. Learning Resources

Text Books

1. Srinath, M.D., Rajasekaran, P.K. and Viswanathan, R., 1995. Introduction to statistical signal processing with applications. Prentice-Hall, Inc..
2. Ash, R.B., 2012. Information theory. Courier Corporation.

References

1. Tanenbaum, A.S., 2003. Computer networks. Pearson Education India.
2. Poor, H.V., 1998. An introduction to signal detection and estimation. Springer Science & Business Media.
3. Proakis, J.G., 2008. Digital communications. McGraw-Hill, Higher Education.
4. Haykin, S., 2014. Digital Communication systems. John Wiley & Sons.

Course Code	Course Name	L	T	P	C
EC2353	MINI PROJECT	0	0	4	2

Category: Employability and Enhancement courses

a. Objectives

- To impart required knowledge related to the project.
- To analyse the realtime problem with an indepth study from available literature in the selected domain.
- To understand the methodology used to solve the problem.
- To apply the engineering knowledge in the project domain.
- To discuss results with experimental outputs of hardware/ software implementation.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Identify a potential problem based on literature survey and real time needs.	K2
CO2	Categorize various solution methodologies to solve problem taken for study.	K4
CO3	Design and develop solution for the proposed problem.	K4
CO4	Infer the experimental results based on hardware & software implementation.	K4
CO5	Analyse the results with the existing solutions.	K4

Total : 60 Periods

The Students in a group of 3 or 4 works on a topic approved by the Head of the Department under the guidance of a faculty member and prepares a comprehensive project report after completing the work to the satisfaction of the supervisor. The review progress of the project is evaluated based on a minimum of three reviews. The review committee may be constituted by the Head of the Department. A project report is required at the end of the semester. The project work is evaluated based on oral presentation and the project report by the examiners constituted by the Head of the Department.

Course Code	Course Name	L	T	P	C
EM2252	AN INTRODUCTION TO ADVANCED READING AND WRITING	0	0	2	1

Category: Employability Enhancement Course

a. Preamble

The course will enable learners to

- Strengthen the reading skills of students of engineering.
- Enhance their writing skills with specific reference to technical writing
- Develop their critical thinking skills.
- Provide more opportunities to develop their project and proposal writing skills

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Understand how the text positions the reader.	K3
CO2	Develop critical thinking while reading a text.	K3
CO3	Develop a descriptive paragraph.	K3
CO4	Make use of sentence structures effectively when creating an essay.	K3
CO5	Demonstrate proper usage of grammar in writing E-Mails, Job application and project.	K3

c. Course Syllabus **Total : 30 Periods**

EFFECTIVE READING **6**

Reading – Strategies for effective reading-Use glosses and footnotes to aid reading comprehension- Read and recognize different text types-Predicting content using photos and title. Reading-Read for details-Use of graphic organizers to review and aid comprehension.

CRITICAL READING **6**

Reading– Understanding pronoun reference and use of connectors in a passage- speed reading techniques. Reading– Genre and Organization of Ideas- Reading– Critical reading and thinking- understanding how the text positions the reader

PARAGRAPH WRITING **6**

Writing-Plan before writing- Develop a paragraph: topic sentence, supporting sentences, concluding sentence.-Write a descriptive paragraph Writing-State reasons and examples to support ideas in writing– Write a paragraph with reasons and examples- Write an opinion paragraph

ESSAY WRITING **6**

Writing– Elements of a good essay - Types of essays- descriptive-narrative- issue-based argumentative-analytical

EFFECTIVE WRITING **6**

Writing– Email writing- visumes – Job application- Report Writing - Project writing-Writing convincing proposals

d. Activities

Students shall be exposed to various passages for reading and trained to write in different forms.

e. Learning Resources

Text Books

1. Gramer, M.F. and Ward, C.S., 2011. Q: Skills for Success: Reading and Writing. Level 3, Oxford University Press, Oxford.
2. Debra Daise, Charl Norloff, and Paul Carne., 2011, *Reading and Writing (Level 4)*, Oxford University Press: Oxford

References

1. Davis, J. and Liss, R., 2006. *Effective academic writing 3*. Oxford: Oxford University Press.
2. Kumar, E.S., 2012. Enriching Speaking and Writing Skills, Second Edition, Orient Black swan: Hyderabad
3. Withrow, Jeans and et al. 2004, *Inspired to Write. Readings and Tasks to develop writing skills*, Cambridge University Press: Cambridge.
4. Goatly, A., 2013. *Critical reading and writing: An introductory coursebook*. Routledge, United States of America.
5. Petelin, R. and Durham, M., 2004. The Professional Writing Guide: Knowing Well and Knowing Why. *Business & Professional Publishing: Australia*.

Course Code	Course Name	L	T	P	C
VEC311	DIGITAL VLSI DESIGN AND TECHNOLOGY	3	0	0	3

Category: Professional Elective

a. Preamble

This course promotes students to apply the knowledge of digital logic design into real time application in synchronous and asynchronous circuit and also diagnosis and test the fault in the circuit. This course also enhances the knowledge in Verilog program for Digital system to meet the industry expectations.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Construct the synchronous sequential circuits.	K3
CO2	Solve hazards and design asynchronous sequential circuits.	K3
CO3	Relate the testing procedure for combinational circuit and PLA.	K2
CO4	Make use of PLD to construct the synchronous circuit design.	K3
CO5	Design and use programming tools for implementing digital circuits of industry standards.	K3

c. Course Syllabus **Total : 45 Periods**

SEQUENTIAL CIRCUIT DESIGN **9**

Analysis of clocked synchronous sequential circuits and modelling - State diagram, state table, state table assignment and reduction - Design of synchronous sequential circuits design of iterative circuits - ASM chart and realization using ASM.

ASYNCHRONOUS SEQUENTIAL CIRCUIT DESIGN **9**

Analysis of asynchronous sequential circuit – Flow table reduction – Races - State assignment transition table and problems in transition table - Design of asynchronous sequential circuit static, dynamic and essential hazards – Mixed operating mode asynchronous circuits – Designing vending machine controller.

FAULT DIAGNOSIS AND TESTABILITY ALGORITHMS **9**

Fault table method-path sensitization method – Boolean difference method - D algorithm – Kohavi algorithm – Tolerance techniques – The compact algorithm – Fault in PLA – Test generation – DFT schemes – Built in self test.

SYNCHRONOUS DESIGN USING PROGRAMMABLE DEVICES 9

Programming logic device families – Designing a synchronous sequential circuit using PLA/PAL – Designing ROM with PLA – Realization of finite state machine using PLD – FPGA – Xilinx FPGA – Xilinx 4000.

SYSTEM DESIGN USING VERILOG 9

Pipelined Adder, Pipelined FIR Filter – Circular buffers – FIFOs and Synchronization across clock domains – Functional units for addition, subtraction, multiplication and division – Multiplication of signed binary numbers and fractions - Barrel Shifter - Simple Floating–Point Encoder – Design of Real Time Clock - Design of UART - Design of simple microprocessor.

d. Activities

Students shall be exposed to Verilog programming to Design of Real Time Clock, UART and Simple Microprocessor.

e. Learning Resources

Text Books

1. Ciletti, M.D., 2001. *Advanced digital design with the Verilog HDL*. Pearson Education.
2. Roth Jr, C.H., Kinney, L.L. and John, E.B., 2020. *Fundamentals of logic design*. Cengage Learning..

References

1. Ciletti, M.D., 1999. *Modeling, synthesis, and rapid prototyping with the Verilog HDL*. Prentice-Hall, Inc..
2. M.G.Arnold, 1999. *Verilog Digital – Computer Design*, Prentice Hall (PTR).
3. Nripendra N Biswas, 2001. *Logic Design Theory,* Prentice Hall of India.
4. ParagK.Lala, 2002. *Fault Tolerant and Fault Testable Hardware Design,* B S Publications.
5. Samir Palnitkar, 2003. *Verilog HDL*, 2nd Edition, Pearson Education.
6. Stephenbrown, 2007. *Fundamentals of Digital Logic with Verilog*, McGraw-Hill.

Course Code	Course Name	L	T	P	C
VEC312	ANALOG VLSI DESIGN	3	0	0	3

Category: Professional Elective

a. Preamble

The course aims to teach basic concepts along with advanced design techniques for CMOS amplifiers and to design and implement the product level IC based VLSI applications.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Understand the fundamentals of analog IC design.	K2
CO2	Design of CMOS single stage amplifiers.	K3
CO3	Design of differential amplifiers for the desired specifications.	K3
CO4	Analyze various performance of operational amplifiers.	K3
CO5	Understand the fundamentals and architectures of CMOS data converters.	K2

c. Course Syllabus **Total : 45 Periods**

CMOS ANALOG SUBCIRCUITS **9**

Introduction to Analog Integrated Circuit Design – Analog Switches - Active Resistors - Current Sources & Sinks – Passive and Active Current Mirrors: Basic Current Mirrors, Cascode Current Mirrors and Active Current Mirrors – Voltage & Current References – Bandgap References: General Considerations, Supply Independent Biasing, Temperature Independent, PTAT Current Generation, Constant Gm Boosting, Speed and Noise issues.

SINGLE STAGE AMPLIFIERS **9**

Basic Concepts - Common Source Stage - Common Gate Stage - Source Follower - Cascode & Folded Cascode Stages. Frequency Response & Noise Analysis.

DIFFERENTIAL AMPLIFIERS **9**

Single Ended & Differential Operation - Basic Differential Pair – Qualitative & Quantitative Analysis - Common Mode Response, Differential Pair with MOS Loads - Gilbert Cell. Frequency Response & Noise Analysis.

OPERATIONAL AMPLIFIERS **9**

General Considerations - One Stage Op Amps - Two Stage Op Amps – Gain Boosting – Common Mode Feedback- Input Range Limitations – Slew Rate – Power Supple Rejection – Frequency Response of One Stage and Two Stage Op Amps - Noise in Op Amps.

DATA CONVERTERS **9**

Data Converter Fundamentals: Characterization of ADC & DAC – Specifications of ADC & DAC – DAC Architectures: Digital Input Code, Resistor String, R-2R Ladder Networks, Current Steering, Charge Scaling DACs, Cyclic DACs & Pipeline DAC – ADC Architectures: Flash, 92 Two Step Flash ADC, Pipeline ADC, Integrating ADC, Successive Approximation ADC, Oversampling ADC.

d. Activities

Understand the techniques, skills, and modern programming tools such as Cadence, Tanner necessary for engineering practice.

e. Learning Resources

Text Books

1. Behzad Razavi, 2016. *Design of CMOS Analog Integrated Circuits*, McGraw Hill Publications, Second Edition.
2. Baker, R.J., 2019. *CMOS: circuit design, layout, and simulation*. John Wiley & Sons.
3. Johns, D.A. and Martin, K., 2008. *Analog integrated circuit design*. John Wiley & Sons.

References

1. Allen, P.E. and Holberg, D.R., 2011. *CMOS analog circuit design*. Elsevier.
2. Hurst, Gray and Lewis Meyer, 2014. *Analysis and Design of Analog Integrated Circuits*, Wiley Publications, Fifth Edition.
3. Randall L. Geiger, Philip E.Allen and Noel R. Strader, 2012. *VLSI Design Techniques for Analog and Digital Circuits*, Tata McGraw-Hill Education

Course Code	Course Name	L	T	P	C
VEC313	LOW POWER VLSI DESIGN	3	0	0	3

Category: Professional Elective

a. Preamble

Low power has emerged as a principal theme in today's electronics industry. This course reviews various strategies and methodologies for designing low power circuits and systems. This course aims to identify the suitable techniques to reduce power dissipation in combinational and sequential circuits.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Explain the fundamentals of low power design and different sources of power dissipation.	K2
CO2	Illustrate various low power design approaches and techniques.	K2
CO3	Acquire the knowledge in designing of various types of low power adders and multipliers.	K2
CO4	Discuss the different low power techniques for designing memory circuits.	K2
CO5	Explain the various power estimation techniques.	K2

c. Course Syllabus **Total : 45 Periods**

FUNDAMENTALS OF LOW POWER VLSI DESIGN **9**

Need for Low Power Circuit Design - Hierarchy of limits of power -Sources of power dissipation -Static Power Dissipation, Active Power Dissipation - Designing for Low Power, Circuit Techniques for Leakage Power Reduction - Basic principle of low power design.

LOW POWER DESIGN APPROACHES **9**

Low-Power Design through Voltage Scaling – VTCMOS circuits, MTCMOS circuits, Architectural Level Approach – Pipelining and Parallel Processing Approaches. Switched Capacitance Minimization Approaches, System Level Measures, Circuit Level Measures, Mask level Measures.

LOW-POWER ADDERS AND MULTIPLIERS **9**

Standard Adder Cells, Review of CMOS Adders, Architectures and performance Comparison-Review of Multiplier Architectures, Braun, Booth and Wallace Tree Multipliers and their performance comparison.

LOW-POWER MEMORIES **9**

Basics of ROM, Sources of power dissipation in SRAMs, Low power SRAM circuit techniques, Sources of power dissipation in DRAMs, Low power DRAM circuit techniques.

POWER ESTIMATION-SIMULATION AND SYNTHESIS **9**

Power Estimation techniques – Logic power estimation – Simulation power analysis-Synthesis for low power.

d. Activities

Students shall be exposed to Verilog and VHDL programming to get the power analysis of combinational circuits.

e. Learning Resources

Text Books

1. P. Rashinkar, Paterson and L. Singh, 2002. *Low Power Design Methodologies*, Kluwer Academic.
2. Yeo, K.S. and Roy, K., 2004. *Low voltage, low power VLSI subsystems*. McGraw-Hill, Inc..
3. Pal, Ajit, 2015. *Low-Power VLSI Circuits and Systems*, Springer.

References

1. Anantha Chandrakasan, 1998. *Low Power CMOS Design*, IEEE Press/Wiley International.
2. Kaushik Roy, Sharat C. Prasad, 2000. *Low Power CMOS VLSI Circuit Design*, John Wiley & Sons.
3. Gary K. Yeap, 2002. *Practical Low Power Digital VLSI Design*, Kluwer Academic Press.
4. A. Bellamour, M. I. Elamasri, 1995. *Low Power CMOS VLSI Circuit Design*, Kluwer Academic Press.

Course Code	Course Name	L	T	P	C
VEC314	VLSI ARCHITECTURE FOR SIGNAL PROCESSING AND MACHINE LEARNING	3	0	0	3

Category: Professional Elective

a. Preamble

VLSI (Very Large-Scale Integration) for Machine Learning is an emerging field that aims to design and implement specialized hardware architectures for machine learning algorithms. The goal of this course is to introduce students to the principles and techniques of VLSI design for machine learning applications. The course will cover a range of topics including digital signal processing, neural network architectures, hardware acceleration techniques.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Outline the basic principles of Digital Signal Processing.	K2
CO2	Infer the principles and applications of unfolding and folding transformations in digital signal processing and machine learning algorithms.	K2
CO3	Summarize the advantages and limitations of different fast convolution algorithms.	K2
CO4	Relate the different type of neural network architectures used in machine learning algorithms.	K2
CO5	Illustrate the principles and techniques of hardware acceleration for machine learning.	K2

c. Course Syllabus **Total : 45 Periods**

INTRODUCTION TO DIGITAL SIGNAL PROCESSING SYSTEMS 9

Introduction to DSP Systems, Typical DSP algorithms, Data flow graph representations, Loop bound and Iteration bound, Longest Path Matrix algorithm; Pipelining and Parallel processing of FIR digital filters, Pipelining and Parallel processing for low power.

UNFOLDING, FOLDING AND SYSTOLIC ARCHITECTURES 9

Unfolding Algorithm - Properties and Applications of Unfolding - Folding Transformation - Systolic Array design - FIR systolic arrays - Selection of Scheduling Vectors - Matrix multiplication and 2D systolic array design.

FAST CONVOLUTION AND ALGORITHMIC STRENGTH REDUCTION 9

Cook-Toom Algorithm - Inefficient/Efficient Single Channel Interleaving - Cyclic convolution – Algorithmic strength reduction in FIR filters and DCT - Look-Ahead pipelining in first-order IIR filters - Parallel processing of IIR filters - Combined pipelining and parallel processing for IIR filters - Pipelined adaptive digital filters.

NEURAL NETWORK ARCHITECTURES 9

Overview of neural networks - Feedforward Neural Networks : Feedforward neural network basics and their learning algorithms, Backpropagation algorithm - Convolutional Neural Networks : Convolutional neural network basics and their learning algorithms, Convolutional and pooling layers and their VLSI implementation - Recurrent Neural Networks : Recurrent neural network basics and their learning algorithms, Long Short-Term Memory (LSTM) and Gated Recurrent Unit (GRU) cells - Customizing neural network architecture for hardware implementation.

HARDWARE ACCELERATION TECHNIQUES 9

Hardware acceleration techniques and their applications in machine learning - Field Programmable Gate Arrays (FPGAs) and their use for accelerating machine learning algorithms - Graphics Processing Units (GPUs) and their use for accelerating machine learning algorithms – Application Specific Integrated Circuits (ASICs) and their use for accelerating machine learning algorithms.

d. Activities

A group project in which students will design and implement a VLSI architecture for a specific machine learning algorithm. The project will include simulation, design, and verification steps.

e. Learning Resources

Text Books

1. Parhi, K.K., 2007. *VLSI digital signal processing systems: design and implementation*. John Wiley & Sons.
2. Saini, S., Lata, K. and Sinha, G.R. eds., 2021. *VLSI and Hardware Implementations Using Modern Machine Learning Methods*. CRC Press.

References

1. Meyer-Baese, U. and Meyer-Baese, U., 2007. *Digital signal processing with field programmable gate arrays* (Vol. 65). Berlin: springer.
2. Ismail, M. and Fiez, T., 1994. *Analog VLSI: signal and information processing* (Vol. 166). New York: McGraw-Hill.
3. Kung, S.Y., Whitehouse, H.J. and Kailath, T., 1985. VLSI and modern signal processing: Prentice-Hall Inc., Information and System Sciences Series, Englewood Cliffs, NJ 07632, USA, 1985, xiii+ 481 pp., ISBN 0-13-942699-X.
4. Moore, W.R. and Delgado-Frias, J.G. eds., 1989. *VLSI For Artificial Intelligence*. Kluwer Academic Publishers.

Course Code	Course Name	L	T	P	C
VEC315	IC MANUFACTURING AND PACKAGING	3	0	0	3

Category: Professional Elective

a. Preamble

This course will discuss all the important facts of manufacturing and packaging at three major levels namely, chip level, board level and system level. The entire spectrum of microelectronic systems packaging from design to fabrication; assembly and test will be covered. Current trends in packaging of electronic systems will be covered.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Explain the concept of fabrication process of Microsystems.	K2
CO2	Outline Placement and partitioning.	K2
CO3	Explain floor planning and routing.	K2
CO4	Knowledge on the appropriate packaging styles and design procedures.	K2
CO5	Exposure on IC packaging with associated issues like thermal speed signal and integrity power.	K2

c. Course Syllabus **Total : 45 Periods**

FABRICATION TECHNOLOGIES **9**

Microsystem fabrication processes: Photolithography, Ion Implantation, Diffusion, Oxidation. Thin film depositions: LPCVD, Sputtering, Evaporation, Electroplating; Etching techniques: Dry and wet etching, electrochemical etching; Micromachining: Bulk Micromachining, Surface Micromachining, High Aspect- Ratio (LIGA and LIGA-like) Technology; Packaging: Microsystems packaging, Essential packaging technologies, Selection of packaging materials.

LAYOUT, PLACEMENT AND PARTITIONING **9**

Layout Compaction, Design rules, Problem formulation, Algorithms for constraint graph compaction, Placement and partitioning, Circuit representation, Placement algorithms, Partitioning.

FLOOR PLANNING AND ROUTING **9**

Floor planning concepts, Shape functions and floorplan sizing, Types of local routing problems, Area routing, Channel routing, Global routing, Algorithms for global routing.

OVERVIEW OF ELECTRONICS SYSTEMS PACKAGING

Introduction of an electronic system and history of semiconductors- Products and levels of packaging - Packaging aspects of hand-held products - Definitions of PWB - Basics of semiconductor and process flow chart - Wafer fabrication inspection and testing - Wafer packaging - Packaging evolution: Chip connection choices, wire bonding- TAB and flip chip.

SEMICONDUCTOR PACKAGES **9**

Single chip packages or modules (SCM) - Commonly used packages and advanced packages -Materials in packages; Thermal mismatch in packages; Multi chip modules (MCM) types System in package (SIP)- Packaging road map; hybrid circuits; Electrical design considerations in system packaging resistor, capacitor and inductive parasitic - Layout guidelines and the refraction problem –Interconnection.

d. Activities

Students shall be exposed to EDA tools to design IC for given specification.

e. Learning Resources

Text Books

1. Marc Madou., 1997. *Fundamentals of Microfabrication,* CRC Press.
2. Sherwani, N.A., 2012. *Algorithms for VLSI physical design automation*. Springer Science & Business Media.
3. Tummala, R.R., 2001. *Fundamentals of microsystems packaging*. McGraw-Hill Education.

References

1. Sait, S.M. and Youssef, H., 1999. *VLSI physical design automation: theory and practice* (Vol. 6). World Scientific.
2. Gerez, S.H., 1998. *Algorithms for VLSI design automation*. Wiley.
3. Ulrich, R.K. and Brown, W.D. eds., 2006. *Advanced electronic packaging* (Vol. 9). John Wiley & Sons.

Course Code	Course Name	L	T	P	C
VEC316	SoC DESIGN AND VERIFICATION	2	0	2	3

Category: Professional Elective

a. Preamble

This course promotes students to gain the fundamentals of SoC Design and verification to obtain knowledge to model, design, simulate, test and implement electronic systems.

b. Course Outcome (for Theory)

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

CO. No.	Course Outcome	Knowledge Level
CO1	Explore the use of System Verilog to create correct, efficient, and re-usable models for digital designs.	K2
CO2	Construct system Verilog to create testbenches for digital designs.	K2
CO3	Interpret new constructs in System Verilog for verification.	K2
CO4	Illustrate the communication between modules.	K2
CO5	Realize a complete system model using Verilog.	K3

Course Outcome (for Laboratory)

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

CO. No.	Course Outcome	Knowledge Level
CO1	Design and verify various digital logic modules.	K3
CO2	Construct and implement mailbox by allocating memory.	K3
CO3	Make use of Coverage & Assertion techniques for Verification of DUT.	K3
CO4	Create testbenches for digital device under test.	K3
CO5	Design a complete system model using System Verilog.	K3

c. Course Syllabus (for Theory) **Total : 30 Periods**

SoC & VERIFICATION METHODOLOGY **6**

System on Chip (SoC) – Architecture – Design Flow and Methodologies - Verification Guidelines: Introduction, Verification Process, Verification Plan, Verification Methodology Manual, Basic Testbench Functionality, Directed Testing, Methodology Basics, Constrained - Random Stimulus, Functional Coverage, Testbench Components, Layered Testbench.

SYSTEM VERILOG BASICS AND CONCEPTS **6**

Data Types: Built-in Data Types, Fixed-Size Arrays, Dynamic Arrays, Queues, Creating New Types with Typedef, Creating User-Defined Structures, Enumerated Types, Constants, Strings. Procedural Statements and Routines: Procedural Statements, Tasks, Functions, and Void Functions.

OBJECT ORIENTED PROGRAMMING (OOPS) IN SYSTEMVERILOG **6**

Introduction - Where to Define a Class - OOPS Terminology - Creating New Objects - Object Deallocation - Using Objects - Static Variables Vs. Global Variables - Class Routines - Defining Routines Outside of The Class - Scoping Rules - Using One Class Inside Another - Understanding Dynamic Objects -Copying Objects -Public Vs. Private -Straying Off Course - Building a Testbench.

THREADS AND INTER-PROCESS COMMUNICATION AND FUNCTIONAL COVERAGE **6**

Working with Threads, Inter-Process Communication, Events, Semaphores, Mailboxes, Building a Test bench with Threads and IPC. Coverage Types, Functional Coverage Strategies, Simple Functional Coverage Example, Coverage Options, Parameterized Cover Groups, Analysing Coverage Data, Measuring Coverage Statistics.

COMPLETE DESIGN MODEL USING SYSTEM VERILOG - CASE STUDY **6**

System Verilog ATM Example, Data Abstraction, Interface Encapsulation, Receivers and Transmitters, Test Bench for ATM.

Course Syllabus (for Laboratory) **Total : 30 Periods**

LIST OF EXPERIMENTS

1. Design a Testbench for 2x1 Mux Using Gates
2. Implementation of a Mailbox by Allocating Memory
3. Implementation and Testing of Semaphore for a Simple DUT
4. Implementation of Scoreboard for a Simple DUT

d. Activities

Students shall be given mini project on Complete design model using System Verilog.

e. Learning Resources (for both Theory and Laboratory)

Text Books

1. Chris Spears., 2006. *System Verilog for Verification - a Guide to Learning The Testbench Language Features*, 2nd Edition, Springer.
2. Bergeron, J., 2012. *Writing testbenches: functional verification of HDL models*. Springer Science & Business Media.

References

1. Vijayaraghavan, S. and Ramanathan, M., 2005. *A practical guide for SystemVerilog assertions*. Springer Science & Business Media.
2. Bergeron, J., 2007. *Writing testbenches using SystemVerilog*. Springer Science & Business Media.
3. Stojcev, M., 2006. System Verilog for Design: A Guide to Using System Verilog for Hardware Design and Modeling Hardcover, S. Sutherland, S. Davidman, P. Flake, Kluwer Academic Publishers, Norwell, MA (2004), pp. 374, plus XXVIII, euro 119, ISBN: 1-4020-7530-8.

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS:

S.No.	Description of Equipment	Quantity Required
1.	PCs with Icarus Verilog / Verilator / Xilinx Vivado or any other Equivalent software	15 Nos

Course Code	Course Name	L	T	P	C
VEC317	SEMICONDUCTOR TEST ENGINEERING	2	0	2	3

Category: Professional Elective

a. Preamble

This course promotes students to understand basic concepts of various devices, their characteristics and applications to impart knowledge on usage of devices in circuits. It also enables the students to have knowledge in Integrated Circuits (IC) Test Engineering such as Functional test and Parametric test.

b. Course Outcome (for Theory)

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

CO. No.	Course Outcome	Knowledge Level
CO1	Explain the need for Integrated Circuits (IC) testing.	K2
CO2	Describe the architecture of ATE.	K2
CO3	Make use of IC testing principles to analyze the performance of ICs.	K3
CO4	Explain the various features of CAD tools used for IC testing.	K2
CO5	Explain the concept of DFT.	K2

Course Outcome (for Laboratory)

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

CO. No.	Course Outcome	Knowledge Level
CO1	Examine the Functional test of IC.	K3
CO2	Examine the Parametric Test of IC.	K3
CO3	Experiment with Communication protocol.	K3
CO4	Make use of biasing techniques to plot I-V characteristics of semiconductor devices.	K3
CO5	Demonstrate line and load regulation of Semiconductor devices.	K3

c. Course Syllabus (for Theory) **Total : 30 Periods**

INTRODUCTION TO SEMICONDUCTOR IC TESTING **6**

Design and manufacturing cycle of an IC –Logic Verification – Manufacturing defects in an IC – Manufacturing test – Need for CHIP testing – Types of CHIP testing – Engineering testing, production testing, QA testing, Customer inspection testing. Automated Test Equipment (ATE) – Types of ATE-ATE subsystems – Test head, Main frame, Test computer, Manipulator. Common accessories of an ATE – Load boards, Probe cards.

AUTOMATIC TEST EQUIPMENT ARCHITECTURE **6**

Architecture of a mixed signal ATE – Digital subsystem, Pogo blocks, digitizers– Drivers, Comparators, PMU, Timing and formatting units, Sequence controller, Digital source memory, digital capture memory, ATE Pin Electronics. Analog source and Capture memory. Types of ATE- Digital ATE and Mixed Signal ATE.

TESTING – CONCEPTS AND METHODS **6**

Introduction to testing in digital domains – Data sheet of typical IC – DC Parametric test, continuity test, leakage test, IDD static test – VIL/VIH, VOL/VOH, IIL, IIH, IOL, IOH IDD dynamic test – AC Parameters Test – AC Timing Tests – Setup Time, Hold Time, Propagation Delay, ATE Time Measurement subsystem. Digital Functional Test – Pattern, Timing, Levels. Test plan and Test Programs

TEST DATA ANALYSIS USING CAD TOOLS AND ESD PROTECTION **6**

Introduction to data analysis– Data visualization tools – Data logs – Lot summaries –Wafer map – shmoo plots – Histograms – Statistical process control – Standard deviation– Mean – Process capability Index – Six sigma quality – Reproducibility – Introduction to ESD – Sources of ESD – ESD models – ESD protection circuits –Latch up test.

FAULT MODELS AND PRINCIPLES OF DESIGN FOR TESTABILITY **6**

Fault models – Simple examples with stuck at and bridging faults – Controllability and observability – Principles of DFT – Scan based Techniques – Boundary scan test – JTAG-Built in self-test.

Course Syllabus (for Laboratory) **Total : 30 Periods**

LIST OF EXPERIMENTS

1. Functional Test of Integrated Circuits
2. Continuity Test
3. Leakage Current Test

4. Functional test in I^2C bus
5. I-V Characteristics of diode
6. Line and Load regulation in Voltage regulator

d. Activities

Students shall be given exposure to understand the Devices characteristics and to test the ICs' working condition.

e. Learning Resources (for both Theory and Laboratory)

Text Books

1. Bell, D.A., 2010. Electric Circuits and Electronic Devices. Oxford University Press..
2. Salivahanan, A.S., 2009. Digital Circuits And Design, 3E. Vikas Publishing House Pvt Ltd.

References

1. Sudhakar. A & Shyam Mohan, SP 2015. *Circuits and Networks-Analysis and Synthesis*, McGraw Hill.
2. Charles K. Alexander, Mathew N.O. Sadiku, 2015. *Fundamentals of Electric Circuits*, Fifth Edition, McGraw Hill, 9th Reprint.

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS:

S.No.	Description of Equipment	Quantity Required
1.	LGLite ATE KIT with Load board	5 Nos
2.	Moku:GO	2 Nos
3.	IC7404,7408,7432,I2C and 4148	Each 10 Nos

Course Code	Course Name	L	T	P	C
VEC321	ACOUSTICS & SPEECH PROCESSING	3	0	0	3

Category: Professional Elective

a. Preamble

This course promotes students to have analytical knowledge in Acoustics & speech signal transmission and reception techniques. It helps to analyze the performance of Acoustics & speech analysis techniques.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Interpret the different acoustic signals and its analysis.	K2
CO2	Illustrate auditory system and its functions.	K2
CO3	Infer the speech production mechanism and different speech compression techniques.	K2
CO4	Outline the performance and the need for speech recognition techniques.	K2
CO5	Explain the speaker recognition systems with the various features and various text to speech synthesis systems.	K2

c. Course Syllabus **Total: 45 Periods**

ACOUSTIC SIGNALS AND SYSTEMS **9**

Acoustic Data Acquisition- Spectral Analysis and Correlation- The FFT and Tone Identification- Measuring Transfer-Functions and Impulse Responses- Digital Sequences- Filters- Adaptive Processing- Beamforming and Wavenumber Processing.

AUDITORY SYSTEM AND HEARING **9**

Anatomy, Physiology and Function of the Auditory System- Physiological Measures of Auditory Function- Auditory Processing Models- Speech Intelligibility- Signal Processing in Hearing Aids.

SPEECH SIGNAL CHARACTERISTICS & COMPRESSION **9**

Speech production process - speech sounds and features - Phonetic Representation of Speech – representing - speech in time and frequency domains - Sampling and Quantization of Speech

(PCM) - Adaptive differential PCM - Delta Modulation - Vector Quantization- Linear predictive coding (LPC) - Code excited Linear predictive Coding (CELP).

SPEECH RECOGNITION **9**

LPC for speech recognition- Hidden Markov Model (HMM)- training procedure for HMM-subword unit model based on HMM- language models for large vocabulary speech recognition - Overall recognition system based on subword units - Context dependent subword units- Semantic post processor for speech recognition.

SPEAKER RECOGNITION **9**

Acoustic parameters for speaker verification- Feature space for speaker recognition-similarity measures- Text dependent speaker verification-Text independent speaker verification techniques - Text to speech synthesis (TTS).

d. Activities

Students shall be given exposure in simulation software like LABVIEW or MATLAB to understand the performance of various speech signal.

e. Learning Resources

Text Books

1. Havelock, D., Kuwano, S. and Vorländer, M. eds., 2008. *Handbook of signal processing in acoustics* (Vol. 1). New York: Springer.
2. Rabiner, L.R. and Schafer, R.W., 2007. Introduction to digital speech processing. *Foundations and Trends® in Signal Processing*, *1*(1–2), pp.1-194.
3. Gold, B., Morgan, N. and Ellis, D., 2011. *Speech and audio signal processing: processing and perception of speech and music*. John Wiley & Sons.

References

1. Rabiner, L. Juang, B.H. and Yegnanarayana, B., 2009. *Fundamentals of Speech Recognition*, Pearson Education.
2. Becchetti, C. and Ricotti, L.P., 1999. *Speech Recognition*, John Wiley and Sons.
3. O'shaughnessy, D., 2001. *Speech Communication: Human and Machine* , 2nd Ed. University press.

Course Code	Course Name	L	T	P	C
VEC322	ADVANCED DIGITAL SIGNAL PROCESSING	3	0	0	3

Category: Professional Elective

a. Preamble

This course promotes the students to have in-depth knowledge on the processing of random signals.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Outline the time domain and frequency domain description of Wide Sense Stationary process in terms of matrix algebra.	K3
CO2	Explain power spectrum estimation using parametric and non-parametric methods.	K3
CO3	Summarize various linear estimation and prediction models.	K3
CO4	Interpret recursive estimation algorithms for adaptive filters.	K3
CO5	Elucidate multirate digital signal processing with its applications in FIR adaptive filters.	K3

c. Course Syllabus **Total : 45 Periods**

DISCRETE RANDOM SIGNAL PROCESSING **9**

Wide sense stationary process – Ergodic process – Mean – Variance - Auto-correlation and Auto-correlation matrix - Properties - Weiner Khitchine relation - Power spectral density – filtering random process, Spectral Factorization Theorem–Finite Data records, Simulation of uniformly distributed/Gaussian distributed white noise – Simulation of Sine wave mixed with Additive White Gaussian Noise.

SPECTRUM ESTIMATION **9**

Bias and Consistency of estimators - Non-Parametric methods - Correlation method - Co-variance estimator - Performance analysis of estimators – Unbiased consistent estimators - Periodogram estimator - Barlett spectrum estimation - Welch estimation.

LINEAR ESTIMATION AND PREDICTION **9**

Model based approach - AR, MA, ARMA Signal modeling - Parameter estimation using Yule-Walker method - Maximum likelihood criterion - Efficiency of estimator - Least mean squared error criterion – Wiener filter - Discrete Wiener Hoff equations – Mean square error.

ADAPTIVE FILTERS **9**

Recursive estimators - Kalman filter - Linear prediction – Forward prediction and Backward prediction, Prediction error - Whitening filter, Inverse filter - Levinson recursion, Lattice realization, Levinson recursion algorithm for solving Toeplitz system of equations.

MULTIRATE DIGITAL SIGNAL PROCESSING **9**

FIR Adaptive filters - Newton's steepest descent method - Adaptive filters based on steepest descent method - Widrow Hoff LMS Adaptive algorithm - Adaptive channel equalization - Adaptive echo canceller - Adaptive noise cancellation - RLS Adaptive filters - Exponentially weighted RLS – Sliding window RLS - Simplified IIR LMS Adaptive filter.

d. Activities

Students shall be exposed to MATLAB programming to find the Digtal signal proceesing applications.

e. Learning Resources

Text Books

1. Hayes, M.H., 2006. Statistical Digital Signal Processing and Modeling. John Wiley&Sons. *New York*.
2. Proakis, J.G., 2005. *Digital signal processing: principles, algorithms, and applications, 4/E*. Pearson Education India.

References

1. Vaidyanathan, P.P., 2006. *Multirate systems and filter banks*. Pearson Education India.
2. Orfanidis, S.J., 332: 525–Optimum Signal Processing–Spring 2011.
3. Haykin, S.S., 2002. *Adaptive filter theory*. Pearson Education India.
4. S. Kay, 1998. *Modern Spectrum Estimation Theory and Application*, Prentice Hall, EnglehoodCliffs, NJ.

Course Code	Course Name	L	T	P	C
VEC323	RADAR & SONAR SIGNAL PROCESSING	3	0	0	3

Category: Professional Elective

a. Preamble

This course promotes students to learn Radar Signal acquisition and sampling in multiple domains, radar DSP basics. Students can improve their skills needed in design and analysis of radar algorithms. This course also provides the insight on the basics of synthetic aperture imaging and adaptive array processing. This course provides the knowledge on the basic principles of SONAR.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Explain the basics of Radar and Radar signal processing.	K2
CO2	Compare the various signal models of Radar systems.	K2
CO3	Describe the sampling and quantization of pulsed Radar signals.	K2
CO4	Illustrate the different kinds of Radar wavefoms.	K2
CO5	Elucidate the basics of SONAR and its beamforming concepts.	K2

c. Course Syllabus **Total : 45 Periods**

INTRODUCTION TO RADAR SYSTEMS **9**

History and application of radar, basic radar function, elements of pulsed radar, review of signal processing concepts and operations, A preview of basic radar signal processing.

SIGNAL MODELS **9**

Components of a radar signal, amplitude models, types of clutters, noise model and signal-to noise ratio, jamming, frequency models: the doppler shift, spatial models, spectral model.

SAMPLING AND QUANTIZATION OF PULSED RADAR SIGNALS **9**

Domains and criteria for sampling radar signals, Sampling in the fast time dimension, Sampling in slow time: selecting the pulse repetition interval, sampling the doppler spectrum, Sampling in the spatial and angle dimension, Quantization, I/Q Imbalance and Digital I/Q.

RADAR WAVEFORMS **9**

Introduction, The waveform matched filter, Matched filtering of moving targets, The pulse burst waveform, frequency-modulated pulse compression waveforms, Range sidelobe control for FM waveforms.

SONAR **9**

Basics of SONAR- correlation and ambiguities-Wideband Synthetic Aperture SONAR processing-Discrete Spatial arrays-Beam stearing- Target Angle Estimation –Array Shading.

d. Activities

Students shall be given to get exposure in RADAR and SONAR signal processing in MATLAB.

e. Learning Resources

Text Books

1. Kolawole, M., 2003. *Radar systems, peak detection and tracking*. Elsevier.
2. Istepanian, R.S. and Stojanovic, M. eds., 2002. *Underwater acoustic digital signal processing and communication systems* (pp. 37-75). Boston: Kluwer Academic Publishers.

References

1. Peebles, P.Z., 2007. *Radar principles*. John Wiley & Sons.
2. Nathanson, F.E., Reilly, J.P. and Cohen, M.N., 1991. *Radar design principles-Signal processing and the Environment.* NASA STI/Recon Technical Report A, 91, p.46747.
3. Skolnik, M.I., 1980. *Introduction to radar systems*. New York.
4. Burdic, W.S., 2002. *Underwater acoustic system analysis*. Peninsula Pub.

Course Code	Course Name	L	T	P	C
VEC324	DIGITAL IMAGE PROCESSING	2	0	2	3

Category: Professional Core

a. Preamble

To learn fundamentals of image processing and various transformations applied in an image. To reconstruct a degraded image using image reconstruction techniques. To apply the image compression techniques and image segmentation techniques in real world problems.

b. Course Outcome (for Theory)

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

CO. No.	Course Outcome	Knowledge Level
CO1	Understand the basics and fundamentals of digital image processing, such as digitization, sampling, quantization, and 2D-transforms.	K2
CO2	Differentiate and interpret various image enhancement techniques.	K3
CO3	Reconstruct the image from the degraded image.	K3
CO4	Analyze and use appropriate image compression techniques.	K3
CO5	Apply image segmentation concepts to solve real world problems.	K3

Course Outcome (for Laboratory)

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

CO. No.	Course Outcome	Knowledge Level
CO1	Perform enhancing operations on the image using spatial filters and frequency domain filters	K3
CO2	Use transforms and analyse the characteristics of the image	K3
CO3	Perform segmentation operations in the images.	K3
CO4	Estimate theefficiency of the compression technique on the images	K3
CO5	Apply image processing technique to solve real health care problems	K3

c. Course Syllabus (for Theory) **Total : 30 Periods**

INTRODUCTION **6**

Introduction to Digital Image Processing - Characteristics of Digital Image - Basic relationship between pixels - Image sampling and quantization - Color models - Basic Geometric Transformations - Fourier Transform - Cosine-Sine and Hartley Transform - Hadamard-Haar-Slant Transform - Discrete Fourier Transform.

IMAGE ENHANCEMENT TECHNIQUES **6**

Spatial Domain Methods - Basic Grey Level Transformation - Histogram Processing - Image subtraction - Image averaging - Spatial filtering - Smoothing - Sharpening filters - Laplacian filters - Frequency domain filters - Smoothing - Sharpening filters - Homomorphic filtering.

IMAGE RESTORATION **6**

Model of Image Degradation/restoration process - Noise models - Spatial and Frequency Filters - Inverse filtering & Wiener Filtering - Least mean square filtering - Constrained least mean square filtering.

IMAGE COMPRESSION FUNDAMENTALS **6**

Image Compression Models - Lossless compression: Variable length coding - LZW coding - Bit plane coding - predictive coding - DPCM - Lossy Compression: Lossy Predictive Coding - Transform coding - Wavelet coding.

IMAGE SEGMENTATION & ANALYSIS **6**

Image Segmentation techniques - Edge detection - Thresholding - Region - Boundary Extraction & Representation - Region - Moment representation - chain codes - Polygonal approximation - Texture - Pattern Recognition. Applications - Finger print/iris recognition - Remote sensing - Automatic character recognition - Medical image processing.

Course Syllabus (for Laboratory) **Total : 30 Periods**

LIST OF EXPERIMENTS

MATLAB / EQUIVALENT SOFTWARE PACKAGE

1. Image sampling and quantization
2. Analysis of spatial and intensity resolution of images.
3. Intensity transformation of images.
4. DFT analysis of images
5. Transforms (Walsh, Hadamard, DCT, Haar)

6. Histogram Processing and Basic Thresholding functions
7. Image Enhancement-Spatial filtering
8. Image Enhancement- Filtering in frequency domain
9. Image segmentation – Edge detection, line detection and point detection.
10. Image compression techniques
11. Study of DICOM standards

d. Activities

Students shall be given mini project on image processing in MATLAB.

e. Learning Resources (for both Theory and Laboratory)

Text Books

1. Gonzalez, R.C. and Woods, R.E., 2018. *Digital Image Processing*, Hoboken. *NJ: Pearson*.
2. Jain, A.K., 1989. *Fundamentals of digital image processing*. Prentice-Hall, Inc..

References

1. Pratt, W.K., 2007. *Digital image processing: PIKS Scientific inside* (Vol. 4). Hoboken, New Jersey: Wiley-interscience.
2. Umbaugh, S.E., 2017. *Digital image processing and analysis: applications with MATLAB and CVIPtools*. CRC press.
3. Shih, F.Y., 2010. *Image processing and pattern recognition: fundamentals and techniques*. John Wiley & Sons.

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS:

S.No.	Description of Equipment	Quantity Required
1.	PCs with MATLAB or equivalent software package	30

Course Code	Course Name	L	T	P	C
VEC325	COMPUTER VISION	3	0	0	3

Category: Professional Elective

a. Preamble

This course promotes students to have theoretical knowledge in computer vision. It helps to know the performance of image processing and analysis.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Infer the fundamentals of computer vision.	K2
CO2	Interpret the various methods for shapes and regions identification.	K2
CO3	Outline the various 3D vision techniques for image analysis.	K2
CO4	Illustrate the basics and various methods of 3D motion for image analysis.	K2
CO5	Make use of various applications in computer vision to solve real time problems.	K3

c. Course Syllabus **Total: 45 Periods**

INTRODUCTION **9**

Computer Vision and Computer Graphics, Computer Vision - Low-level, Mid-level, High-level, Image Processing techniques – classical filtering operations – thresholding techniques – edge detection techniques – corner and interest point detection – mathematical morphology – texture.

SHAPES AND REGIONS **9**

Binary shape analysis – connectedness – object labeling and counting – size filtering – distance functions – skeletons and thinning – deformable shape analysis – boundary tracking procedures – active contours – shape models and shape recognition – centroidal profiles – handling occlusion – boundary length measures – boundary descriptors – chain codes – Fourier descriptors – region descriptors – moments, Hough Transform.

3D VISION **9**

Methods for 3D vision – projection schemes – shape from shading – photometric stereo – shape from texture – shape from focus – active range finding – surface representations – point-based representation – volumetric representations – 3D object recognition – 3D reconstruction.

3D MOTION **9**

Introduction to motion – triangulation – bundle adjustment – translational alignment – parametric motion – spline-based motion – optical flow – layered motion.

APPLICATIONS **9**

Application: In-vehicle vision system: locating roadway – road markings – identifying road signs – locating pedestrians. Application: Face detection – Face recognition – Eigen faces, Application: Surveillance – foreground-background separation – particle filters – Chamfer matching, tracking, and occlusion – combining views from multiple cameras – human gait analysis

d. Activities

Students shall be given exposure to simulation software like MATLAB to understand the performance of image processing.

e. Learning Resources

Text Books

1. E. R. Davies, 2012, *Computer & Machine Vision*, Fourth Edition, Academic Press.

2 D. L. Baggio, 2012, *Mastering OpenCV with Practical Computer Vision Projects*, Packt Publishing.

References

1. Richard Hartley and Andrew Zisserman, 2004, *Multiple View Geometry in Computer Vision*, Cambridge University Press, Second Edition.
2. Morgan Kaufmann and K. Fukunaga, 1990, *Introduction to Statistical Pattern Recognition*, Academic Press, Second Edition.
3. Richard Szeliski, 2011, *Computer Vision: Algorithms and Applications*, Springer-Verlag London Limited.
4. D. A. Forsyth, J. Ponce, 2003, *Computer Vision: A Modern Approach*, Pearson Education,

5. Jan Erik Solem, 2012, *Programming Computer Vision with Python: Tools and algorithms for analyzing images*, O'Reilly Media.
6. Mark Nixon and Alberto S. Aquado, 2012, *Feature Extraction & Image Processing for Computer Vision*, Third Edition, Academic Press.
7. R. Szeliski, 2011, *Computer Vision: Algorithms and Applications*, Springer.

Course Code	Course Name	L	T	P	C
VEC326	PATTERN RECOGNITION AND COMPUTATIONAL INTELLIGENCE	3	0	0	3

Category: Professional Elective

a. Preamble

This course promotes students to have theoretical knowledge in pattern recognition. It helps to know the performance of image processing and analysis.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Infer about the various techniques involved in pattern recognition.	K2
CO2	Identify the suitable pattern recognition techniques for the particular applications.	K2
CO3	Interpret the various pattern recognition techniques into supervised and unsupervised.	K2
CO4	Illustrate the mixture models based pattern recognition techniques.	K2
CO5	Explain the various computational intelligence techniques for pattern recognition.	K2

c. Course Syllabus **Total: 45 Periods**

PATTERN RECOGNITION **9**

Polynomial curve fitting – The curse of dimensionality - Decision theory - Information theory - The beta distribution - Dirichlet distribution-Gaussian distribution-The exponent family: Maximum likelihood and sufficient statistics -Non-parametric method: kernel-density estimators - Nearest neighbour methods.

LINEAR MODELS FOR REGRESSION **9**

Linear models for regression and classification: Linear basis function models for regression - Bias variance decomposition-Bayesian linear regression-Discriminant functions - Fisher's linear discriminant analysis (LDA) - Principal Component Analysis (PCA) - Probabilistic generative model - Probabilistic discriminative model- Independent Component Analysis (ICA).

KERNEL METHODS **9**

Kernel methods: Dual Representations-Constructing kernels-Radial basis function networks-Gaussian process-Maximum margin classifier (Support Vector Machine) – Relevance Vector Machines-Kernel-PCA, Kernel-LDA.

MIXTURE MODELS **9**

Mixture models: K-means clustering - Mixtures of Gaussian - Expectation-Maximization algorithm-Sequential models: Markov model, Hidden-Markov Model (HMM) - Linear Dynamical S.

NEURAL NETWORKS **9**

Feed- forward network functions-Network training - Error Back propagation - The Hessian Matrix - Regularization in Neural Network - Mixture density networks – Bayesian Neural Networks - Particle swarm optimization-Genetic algorithm-Ant colony optimization-Bacterial foroging-Simulated annealing – Fuzzy logic systems.

d. Activities

Students shall be given exposure in simulation software like MATLAB to understand the performance of pattern recognition.

e. Learning Resources

Text Books

1. Bishop, C.M. and Nasrabadi, N.M., 2006. *Pattern recognition and machine learning* (Vol. 4, No. 4, p. 738). New York: springer.
2. Devijver, P.A. and Kittler, J., 1982. *Pattern recognition: A statistical approach*. Prentice hall.

References

1. Schalkoff, R.J., 1992. *Pattern recognition: statistical, structural and neural approaches*.
2. Tou.J.I and Gonzalez R.C., 1977, *Pattern recognition and Machine learning*, Addition-Wesley.

Course Code	Course Name	L	T	P	C
VEC327	INTRODUCTION TO DEEP LEARNING	2	0	2	3

Category: Professional Elective

a. Preamble

Deep learning is a subfield of machine learning that focuses on building and training artificial neural networks with multiple layers of interconnected nodes, also known as deep neural networks. Deep learning has revolutionized the field of artificial intelligence in recent years, enabling breakthroughs in various domains and applications.

b. Course Outcome (for Theory)

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

CO. No.	Course Outcome	Knowledge Level
CO1	Summarize the basic ideas and principles of Neural Networks.	K2
CO2	Infer the role and steps involved in deep learning algorithms.	K2
CO3	Explain Convolutional Neural Networks algorithm.	K2
CO4	Summarize the different architectures of deep learning algorithms.	K2
CO5	Apply computer vision related applications using Deep Learning.	K3

Course Outcome (for Laboratory)

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

CO. No.	Course Outcome	Knowledge Level
CO1	Apply the use of TensorFlow/Keras in Deep Learning Applications.	K3
CO2	Build a model for Image Processing applications using Tensorflow / Keras.	K3
CO3	Experiment the applications of Deep Learning using Transfer learning	K3
CO4	Develop a simple LSTM network using Tensor flow / Keras.	K3
CO5	Model a CNN for object detection applications.	K3

c. Course Syllabus (for Theory) **Total: 30 Periods**

BASICS OF NEURAL NETWORK **6**

Biological Neuron – Idea of computational units – McCulloch–Pitts unit and Thresholding logic – Linear Perceptron – Perceptron Learning Algorithm – Linear separability – Convergence theorem for Perceptron Learning Algorithm – Feed Forward and Back Propagation Networks.

INTRODUCTION TO DEEP NEURAL NETWORKS **6**

Feed Forward Neural Networks – Gradient Descent – Back Propagation Algorithm – Vanishing Gradient problem – Mitigation – ReLU Heuristics for Avoiding Bad Local Minima – Heuristics for Faster Training – Nestors Accelerated Gradient Descent – Regularization – Dropout

CONVOLUTIONAL NEURAL NETWORKS **6**

CNN Architectures – Convolution – Pooling Layers – Transfer Learning – Image Classification

DEEP LEARNING ARCHITECTURES **6**

LSTM, GRU, Encoder/Decoder Architectures – Autoencoders – Standard- Sparse – Denoising – Contractive- Variational Autoencoders – Adversarial Generative Networks – Autoencoder and DBM

APPLICATION OF DEEP LEARNING **6**

Image Segmentation – Object Detection – Automatic Image Captioning – Image generation with Generative Adversarial Networks – Video to Text with LSTM Models – Attention Models for Computer Vision – Case Study: Named Entity Recognition – Opinion Mining using Recurrent Neural Networks – Parsing and Sentiment Analysis using Recursive Neural Networks – Sentence Classification using Convolutional Neural Networks – Dialogue Generation with LSTMs.

Course Syllabus (for Laboratory) **Total: 30 Periods**

LIST OF EXPERIMENTS

1. Implement Simple Programs like vector addition in TensorFlow
2. Implement a simple problem like regression model in Keras
3. Implement an Image Classifier using CNN in TensorFlow/Keras

4. Implement a Transfer Learning concept in Image Classification
5. Implement a Simple LSTM using TensorFlow/Keras
6. Implement an Opinion Mining in Recurrent Neural network
7. Implement an Object Detection using CNN
8. Mini Project

d. Activities

Deep learning is a powerful subset of machine learning that has revolutionized many industries, including healthcare, finance, manufacturing, and entertainment. Students shall be given mini project in any one application using python such as Image and video recognition, Natural language processing, Predictive analytics, Speech recognition and Recommender systems.

e. Learning Resources (for both Theory and Laboratory)

Text Book

1. Goodfellow, I., Bengio, Y. and Courville, A., 2016. *Deep learning*. MIT press.
2. Rojas, R., 1996. Neural Networks: A systematic introduction.

References

1. Bishop, C., 2007. *Pattern Recognition and Machine Learning,* Springer-Verlag New York Inc.
2. Francois, C., 2018. *Deep Learning with Python*, Manning Publications.
3. Kim, P., 2017. *Matlab deep learning with machine learning, neural networks and artificial intelligence*. by Phil Kim.
4. Venkatesan, R. and Li, B., 2017. *Convolutional neural networks in visual computing: a concise guide*. CRC Press.
5. Manaswi, N.K., Manaswi, N.K. and John, S., 2018. *Deep learning with applications using python* (pp. 31-43). Berkeley, CA, USA: Apress.
6. Wiley, J.F., 2016. *R deep learning essentials*. Packt Publishing.

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS:

S.No.	Description of Equipment	Quantity Required
1.	PC with Anaconda software	30

Course Code	Course Name	L	T	P	C
VEC331	ANTENNA DESIGN	2	0	2	3

Category: Professional Elective

a. Preamble

From holistic point of view communication is classified into wired and wireless types. In the era of multimedia, Internet, Web-world, Mobile and Bluetooth communication is becoming wireless. Antennas are important component in making wireless communication a reality. This course also give understanding about types of antennas.

b. Course Outcome (for Theory)

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

CO. No.	Course Outcome	Knowledge Level
CO1	Outline the radiation characteristics and antenna basic parameters.	K2
CO2	Understand the behavior of an antenna array and its applications	K2
CO3	Make use of different aperture types of antenna which will operate at microwave frequency band.	K3
CO4	Make use of the principle of special antenna at VHF & UHF band, the concept of frequency independent antenna and the antenna measurements.	K3
CO5	Discuss the Structure of atmosphere based on the Wave propagation and atmospheric parameters.	K2

Course Outcome (for Laboratory)

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

CO. No.	Course Outcome	Knowledge Level
CO1	Measure the radiation characteristics of Half Wave Dipole & Monopole.	K3
CO2	Measure the radiation characteristics of VSAT Antenna.	K4
CO3	Measure the radiation characteristics of Helical antenna.	K4
CO4	Measure the radiation characteristics of Yagiuda antenna.	K2
CO5	Measure the radiation characteristics of Loop antenna.	K3

c. Course Syllabus (for Theory) **Total : 30 Periods**

ELECTROMAGNETIC RADIATION AND ANTENNA FUNDAMENTALS **6**

Antenna characteristics: Radiation pattern, Beam solid angle, Directivity, Gain, Input impedance, Polarization, Bandwidth, Reciprocity, Equivalence of Radiation patterns, Equivalence of Impedances, Effective aperture, Vector effective length, Antenna temperature.

WIRE ANTENNAS AND ANTENNA ARRAYS **6**

Short dipole – Radiation resistance and Directivity – Half wave Dipole – Monopole – Small loop antennas – Antenna Arrays – Linear Array and Pattern Multiplication, Two–element Array, Uniform Array – Array with non–uniform Excitation

APERTURE ANTENNAS **6**

Aperture Antennas: Magnetic Current and its fields, Uniqueness theorem, Field equivalence principle, Duality principle, Method of Images, Pattern properties, Horn Antenna, Pyramidal Horn Antenna, Reflector Antenna.

SPECIAL ANTENNAS AND ANTENNA MEASUREMENTS **6**

YagiUda Antenna – Helical Antenna – Axial mode helix, Normal mode helix, Log periodic Dipole Array –Microstrip Patch Antennas – Design of Microstrip. Antenna Measurements – Radiation Pattern measurement, Gain and Directivity Measurements.

RADIO WAVE PROPAGATION **6**

Free–space Propagation – Ground Wave Propagation, Ground Reflection, Surface waves, space waves – Diffraction –Tropospheric Propagation – Tropospheric Scatter – Ionospheric propagation – Structure of ionosphere, Sky waves,skip distance, Virtual height, Critical frequency, MUF.

Course Syllabus (for Laboratory) **Total : 30 Periods**

LIST OF EXPERIMENTS

1. Measurement of Radiation pattern of Half wave dipole and Monopole Antenna.
2. Measurement of Radiation pattern of Horn antenna
3. Measurement of Radiation pattern of VSAT antenna
4. Measurement of Radiation pattern of Helical antenna
5. Measurement of Radiation pattern of Yagiuda antenna
6. Measurement of Radiation pattern of various loop antennas

d. Activities

Students shall be given mini project on simulation of radiation pattern using MATLAB

e. Learning Resources (for both Theory and Laboratory)

Text Books

1. Kraus, J.D., Marhefka, R.J. and Khan, A.S., 2006. *Antennas and wave propagation*. Tata McGraw-Hill Education.
2. Prasad, K.D., 2003. *Antenna & wave Propagation*, Fourth Edition, Tech India Publications,New Delhi-110005.

References

1. Jordan, E.C. and Balmain, K.G., 2006. *Electromagnetic Waves and Radiating Systems* Prentice Hall of India.
2. Collin, R.E., 1985. *Antennas and radiowave propagation*. McGraw-Hill College.
3. Balanis, C.A., 2016. *Antenna theory: analysis and design*. John wiley & sons.

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS:

S.No.	Description of Equipment	Quantity Required
1.	Antenna Training System (Transmitter & Receiver)	4
2.	RF signal Source	6
3.	Antenna Stepper Motor Controller	4
4.	Antenna Digital RF Transmitter	2
5.	Antenna Digital RF Receiver	2
6.	Half wave dipole and Monopole Antenna.	7
7.	Horn antenna	2
8.	VSAT antenna	2
9.	Helical antenna	2
10.	Yagiuda antenna	2
11.	loop antennas	2
12.	BNC Sockets	12
13.	Antenna Tripod	12

Course Code	Course Name	L	T	P	C
VEC332	RADIO FREQUENCY INTEGRATED CIRCUITS	3	0	0	3

Category: Professional Elective

a. Preamble

The course covers design aspects of RF IC circuits and systems. Fundamental RF circuit theory (matching, noise and distortion) and design and analysis of CMOS RF circuits like amplifiers (LNA, PA), mixers, voltage controlled oscillators as well as phase-locked loops (PLLs) will be covered in depth.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Understand the fundamentals of RF circuit theory and design.	K2
CO2	Understand the principles of operation of an RF receiver front end.	K2
CO3	Comprehend the various types and design procedure of microwave mixers.	K2
CO4	Explain oscillator and sources of noise.	K2
CO5	Illustrate PLL and Frequency Synthesizers.	K2

c. Course Syllabus **Total : 45 Periods**

IMPEDANCE MATCHING IN AMPLIFIERS **9**

Definition of Q, Series parallel transformations of lossy circuits, Impedance matching using ‘L’, ‘PI’ and ‘T’ networks, Integrated inductors, Resistors, Capacitors, Tunable inductors, Transformers.

AMPLIFIER DESIGN **9**

Noise characteristics of MOS devices, Design of CG LNA and inductor degenerated LNAs. Principles of RF Power Amplifiers design.

ACTIVE AND PASSIVE MIXERS **9**

Qualitative Description of the Gilbert Mixer - Conversion Gain, and distortion and noise , analysis of Gilbert Mixer – Switching Mixer - Distortion in Unbalanced Switching Mixer - Conversion Gain in Unbalanced Switching Mixer - Noise in Unbalanced Switching Mixer -

A Practical Unbalanced Switching Mixer. Sampling Mixer - Conversion Gain in Single Ended Sampling Mixer - Distortion in Single Ended Sampling Mixer - Intrinsic Noise in Single Ended Sampling Mixer - Extrinsic Noise in Single Ended Sampling Mixer.

OSCILLATORS **9**

LC Oscillators, Voltage Controlled Oscillators, Ring oscillators, Delay Cells, Tuning range in ring oscillators, Tuning in LC oscillators, Tuning sensitivity, Phase Noise in oscillators, Sources of phase noise.

PLL AND FREQUENCY SYNTHESIZERS **9**

Phase Detector/Charge Pump, Analog Phase Detectors, Digital Phase Detectors, Frequency Dividers, Loop Filter Design, Phase Locked Loops, Phase noise in PLL, Loop Bandwidth, Basic Integer-N frequency synthesizer, Basic Fractional-N frequency synthesizer.

d. Activities

Students shall be exposed to simulate and model RF circuits using advanced tools as Cadence and ADS.

e. Learning Resources

Text Books

1. Razavi, B. and Microelectronics, R.F., 1998. Prentice Hall. *Upper Saddle River, NJ, 7458*.
2. Leung, B., 2011. *VLSI for wireless communication*. Springer Science & Business Media.

References

1. Razavi, B., 1999. CMOS technology characterization for analog and RF design. *IEEE journal of solid-state circuits*, *34*(3), pp.268-276.
2. Hong, J.S.G. and Lancaster, M.J., 2004. *Microstrip filters for RF/microwave applications*. John Wiley & Sons.
3. Lee, T.H., 2003. *The design of CMOS radio-frequency integrated circuits*. Cambridge university press.

Course Code	Course Name	L	T	P	C
VEC333	MICROWAVE ENGINEERING	2	0	2	3

Category: Professional Elective

a. Preamble

This subject delivers basic concepts of Microwave signal, S matrix and Passive components those supporting for microwave passing. It enables students to know about microwave signal source and measuring instruments.

b. Course Outcome (for Theory)

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

CO. No.	Course Outcome	Knowledge Level
CO1	Derive impedance and admittance of low frequency circuits.	K2
CO2	Derive S matrix parameter for High frequency circuits.	K2
CO3	Design passive microwave components.	K3
CO4	Explain the operation of Microwave Semiconductor Devices and Microwave tubes and design the basic MIC Filters.	K3
CO5	Measure microwave power, wavelength, impedance, SWR, attenuation, Q and Phase shift.	K3

Course Outcome (for Laboratory)

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

CO. No.	Course Outcome	Knowledge Level
CO1	Experiment with microwave setup to plot the characteristics of microwave sources.	K3
CO2	Derive the S parameters for microwave passive components.	K2
CO3	Calculate the unknown Impedance for Materials.	K2
CO4	Examine the radiation pattern of horn antenna using microwave setup.	K3
CO5	Demonstrate the frequency and wavelength measurement setup.	K2

c. Course Syllabus (for Theory) **Total : 30 Periods**

TWO PORT NETWORK THEORY **6**

Review of Low frequency parameters: Impedance, Admittance, Hybrid and ABCD parameters, High Frequency parameters, Formulation of S parameters, Properties of S parameters, Reciprocal and lossless Network, Transmission matrix.

MICROWAVE PASSIVE COMPONENTS **6**

Microwave junctions – Tee junctions – Magic Tee – Directional couplers – two hole directional couplers – Ferrites – Termination – Gyrator – Isolator – Circulator – Attenuator – Phase changer – S Matrix for microwave components.

MICROWAVE SEMICONDUCTOR DEVICES **6**

Microwave semiconductor devices – operation, characteristics and application of BJTs and FETs – Transferred Electron Devices – Gunn diode – Avalanche Transit time devices – Reed diode, IMPATT and TRAPATT devices.

MICROWAVE SOURCES **6**

Microwave tubes – High frequency limitations – Principle of operation of Multi cavity Klystron, Reflex Klystron, Traveling Wave Tube and Magnetron.

MICROWAVE MEASUREMENTS **6**

Microwave measurements – power, wavelength, impedance, SWR, attenuation, Q and Phase shift measurements.

Course Syllabus (for Laboratory) **Total : 30 Periods**

LIST OF EXPERIMENTS

1. Microwave Source – Mode characteristics
2. Directional Coupler characteristics
3. Unknown Impedance Measurement
4. Radiation pattern of Horn Antenna
5. Frequency and wavelength measurement

d. Activities

Students shall be exposed to work on Microwave lab to find the S matrix for passive device and characteristics of microwave sources.

e. Learning Resources (for both Theory and Laboratory)

Text Books

1. Liao, S.Y., 1990. *Microwave devices and circuits*. Pearson Education India.
2. Annapurna Das and Sisir K Das., 2017. *Microwave Engineering,* 3rd edition,Tata McGraw Hill Inc.

Reference

1. Pozar, D.M., 2011. *Microwave engineering*. John wiley & sons.

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS:

S.No.	Description of Equipment	Quantity Required
1.	Microwave Setup (Klystron / Gunn Diode , Isolator, Attenuator, Frequency Meter, Slotted line section, detector)	10 Nos
2.	VSWR Meter	5 Nos
3.	Tee Junctions	5 Nos
4.	Directional Coupler	5 Nos
5.	DSO / CRO	10 Nos
6.	Microwave Setup (Klystron / Gunn Diode , Isolator, Attenuator, Frequency Meter, Slotted line section, detector)	10 Nos

Course Code	Course Name	L	T	P	C
VEC334	ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY	3	0	0	3

Category: Professional Elective

a. Preamble

This course delivers generation of various electrical noise and interferences by systems or Equipments during their operation. It also enable the students to know various measurement methods and their operation.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Interpret the basics theories of EMI and EMC.	K2
CO2	Identify the different coupling mechanism used in EMI and EMC.	K2
CO3	Identify the type of EMI and Choose appropriate mitigation techniques.	K2
CO4	Explain the different standards and regulation.	K2
CO5	Illustrate the EMI testing methods and its instrumentation.	K2

c. Course Syllabus **Total : 45 Periods**

EMI/EMC CONCEPTS **9**

EMI-EMC definitions, Sources and Victims of EMI, ESD and Transient EMI phenomena, Conducted and Radiated EMI Emission and Susceptibility with examples, Case Histories and Applications of EMI, Radiation Hazards to humans.

EMI COUPLING PRINCIPLES **9**

Conducted, radiated and transient coupling, Common ground impedance coupling and ground loop coupling, Common mode, and Differential mode coupling, Near field cable to cable coupling, Field to cable coupling, Power mains and Power supply coupling.

EMI CONTROL **9**

Shielding, EMI Filters, Grounding, Bonding, Isolation transformer, Transient suppressors, EMI Suppression Cables and EMI Gaskets.

EMC DESIGN FOR CIRCUITS AND PCBs **9**

Noise from Relays and Switches, Nonlinearities in Circuits, Cross talk in transmission line and cross talk control, Component selection and mounting, PCB trace impedance, Routing, Power distribution decoupling, Zoning; Grounding; VIAs; Terminations.

EMI MEASUREMENTS AND STANDARDS **9**

Open area test site, TEM cell, EMI test shielded chamber and shielded ferrite lined anechoic chamber, Conducted EMI measurements: LISN (Line Impedance Stabilization Network), Current probe, Voltage probe and Power probe, EMI Rx and spectrum analyzer, Civilian standards - CISPR, FCC, IEC, EN; Military standards MIL461E/462.

d. Activities

Students shall be exposed to Microwave lab to find the Electromagnetic interference of the given systems.

e. Learning Resources

Text Books

1. Kodali, V.P, 1996. *Engineering EMC Principles, Measurements and Technologies*, IEEE Press.
2. Ott, H.W, 1988. *Noise reduction techniques in electronic systems*, (Vol. 442, pp. p-4), Wiley, New York.

References

1. Paul, C.R, 1992. *Introduction to electromagnetic compatibility* (Vol. 184). John Wiley & Sons.
2. Bemhard Keiser, 1986. *Principles of Electromagnetic Compatibility*, 3rd Ed, Artech house, Norwood.
3. Don R. J, 1988. *Handbook of EMI/EMC*, Vol I-V, White Consultant Incorporate.

Course Code	Course Name	L	T	P	C
VEC335	OPTICAL COMMUNICATION	3	0	0	3

Category: Professional Core

a. Preamble

This course promotes students to have theoretical knowledge in optical communication. It helps to know the performance of optical devices and system transmission.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Illustrate the various elements of fiber optics transmission link.	K2
CO2	Interpret and calculate various losses and signal distortion.	K2
CO3	Outline the fiber optics sources and various coupling techniques.	K2
CO4	Infer the concept of working of optical receivers and identify the type of receiver for different links.	K2
CO5	Explain the concepts of WDM, optical amplifiers and Soliton Propagation.	K2

c. Course Syllabus **Total: 45 Periods**

INTRODUCTION TO OPTICAL FIBERS **9**

Element of an Optical Fiber Transmission link - Optical Fibers: Structure, Wave guiding - Step index and Graded index optical fiber - Modal analysis - Classification of modes - Single Mode Fibers.

SIGNAL DEGRADATION IN OPTICAL FIBERS **9**

Attenuation - Absorption, Scattering and Bending losses. Dispersion - Material and Waveguide dispersion - Polarization Mode Dispersion - Dispersion Shifted Fibers - Dispersion Compensating Fibers.

OPTICAL SOURCES **9**

Optical sources: LEDs and Laser Diodes. Optical Power Launching and Coupling: Source to Fiber coupling - Schemes for coupling improvement - Fiber to Fiber joints - Fiber Splicing.

OPTICAL DETECTORS **9**

Optical detectors: PIN and Avalanche photodiodes, Photo detector noise, Optical receivers. Digital link design: Power budget and Rise time budget.

OPTICAL COMMUNICATION SYSTEMS **9**

WDM Concepts - Optical Amplifiers: EDFA - Nonlinear effects: Self Phase Modulation, Nonlinear Schrodinger Equation - Optical Soliton.

d. Activities

Students shall be given exposure in simulation software like OPTISYSTEM to understand the performance of optical fiber.

e. Learning Resources

Text Books

1. Keiser, G., 2010. *Optical Fiber Communication*, Mc Graw -Hill International, 4th Edition.
2. Senior, J.M. and Jamro, M.Y., 2009. *Optical fiber communications: principles and practice*. Pearson Education.

References

1. Chakrabarti, P., 2015. Optical Fiber Communication. *McGraw-Hill Education*.
2. Ramaswami, R., Sivarajan, K. and Sasaki, G., 2009. *Optical networks: a practical perspective*. Morgan Kaufmann.
3. Gowar, J., 2001. *Optical communication systems*. Prentice-Hall, Inc..
4 Agrawal, G.P., 2012. *Fiber-optic communication systems*. John Wiley & Sons.

Course Code	Course Name	L	T	P	C
VEC336	COGNITIVE RADIO	3	0	0	3

Category: Professional Elective

a. Preamble

This course promotes students to learn the evolving software defined radio and cognitive radio techniques and their essential functionalities. This course enables the students about the physical, MAC and Network layer design of cognitive radio. Students can have the knowledge in the recent technologies in Cognitive Radio.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Interpret the architecture, design issues & Challenges of software defined radio & cognitive radio.	K2
CO2	Illustrate the theoretical aspects of cognitive radio.	K2
CO3	Summarize the different types of spectrum sensing & spectrum access of cognitive radio.	K2
CO4	Compare MAC and network layer design for cognitive radio.	K2
CO5	Infer about the advanced technologies in cognitive radio.	K2

c. Course Syllabus **Total : 45 Periods**

INTRODUCTION TO SOFTWARE DEFINED RADIO AND COGNITIVE RADIO **9**

Evolution of Software Defined Radio and Cognitive radio: goals, benefits, definitions, architectures, relations with other radios, issues, enabling technologies, radio frequency spectrum and regulations.

COGNITIVE RADIO ARCHITECTURE **9**

Cognitive Radio – functions, components and design rules, Cognition cycle – orient, plan, decide and act phases, Inference Hierarchy, Architecture maps, Building the Cognitive Radio Architecture on Software defined Radio Architecture, Overview of IEEE 802.22 standard for broadband wireless access in TV bands.

SPECTRUM SENSING AND DYNAMIC SPECTRUM ACCESS **9**

Introduction – Primary user detection techniques – energy detection, feature detection, matched filtering, cooperative detection, Bayesian Approach, Neyman Pearson fusion rule for spectrum sensing, Optimum spectrum sensing – Kullback Leibler Divergence and other approaches, Fundamental Tradeoffs in spectrum sensing, Spectrum Sharing Models of Dynamic Spectrum Access – Unlicensed and Licensed Spectrum Sharing, Fundamental Limits of Cognitive Radio.

MAC AND NETWORK LAYER DESIGN FOR COGNITIVE RADIO **9**

MAC for cognitive radios – Multichannel MAC – slotted ALOHA – CSMA, Network layer design – routing in cognitive radios, flow control and error control techniques.

ADVANCED TOPICS IN COGNITIVE RADIO **9**

Cognitive radio for Internet of Things – Features and applications – Enabling Technologies and Protocols – M2M technologies – Data storage and analysis techniques – Requirements and Challenges of IoT – Energy efficiency – MIMO Cognitive Radio – Power allocation algorithms.

d. Activities

Students shall be given to get exposure in spectrum sensing and layerwise design in Cognitive Radio.

e. Learning Resources

Text Books

1. Wyglinski, A.M., Nekovee, M. and Hou, T. eds., 2009. *Cognitive radio communications and networks: principles and practice*. Academic Press.
2. Arslan, H. ed., 2007. *Cognitive radio, software defined radio, and adaptive wireless systems*. Springer Science & Business Media.

References

1. Fette, B.A. ed., 2006. *Cognitive radio technology*. Elsevier.
2. Kwang–Cheng Chen & Ramjee Prasad., 2009. *Cognitive Radio Networks*, John Wiley and Sons.

Course Code	Course Name	L	T	P	C
VEC337	AD HOC AND WIRELESS SENSOR NETWORKS	3	0	0	3

Category: Professional Elective

a. Preamble

This course promotes students to learn Ad hoc network and Sensor Network fundamentals and different routing protocols. Students can have in-depth knowledge on sensor network architecture and design issues and security issues. This course also promotes the students to have an exposure on mote programming platforms and tools.

b. Course Outcome

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

CO.No.	Course Outcome	Knowledge Level
CO1	Explain the basics concepts of Ad hoc networks and the routing protocols.	K2
CO2	Interpret the challenges in Wireless Sensor Networks with its single node and network architectures.	K2
CO3	Compare various MAC layer protocols and Transport layer protocols.	K2
CO4	Describe the security issues and challenges possible in wireless sensor networks.	K2
CO5	Elucidate the OS used in Wireless Sensor Networks and build basic modules.	K2

c. Course Syllabus **Total : 45 Periods**

AD HOC NETWORKS – INTRODUCTION AND ROUTING PROTOCOLS 9

Elements of Ad hoc Wireless Networks, Issues in Ad hoc wireless networks, Example commercial applications of Ad hoc networking, Ad hoc wireless Internet, Issues in Designing a Routing Protocol for Ad Hoc Wireless Networks, Classifications of Routing Protocols, Table Driven Routing Protocols - Destination Sequenced Distance Vector (DSDV), On–Demand Routing protocols – Ad hoc On–Demand Distance Vector Routing (AODV).

SENSOR NETWORKS – INTRODUCTION & ARCHITECTURES **9**

Challenges for Wireless Sensor Networks, Enabling Technologies for Wireless Sensor Networks, WSN application examples, Single-Node Architecture - Hardware Components, Energy Consumption of Sensor Nodes, Network Architecture - Sensor Network Scenarios, Transceiver Design Considerations, Optimization Goals and Figures of Merit.

WSN NETWORKING CONCEPTS AND PROTOCOLS **9**

MAC Protocols for Wireless Sensor Networks, Low Duty Cycle Protocols And Wakeup Concepts - S-MAC, The Mediation Device Protocol, Contention based protocols - PAMAS, Schedule based protocols – LEACH, IEEE 802.15.4 MAC protocol, Routing Protocols-Energy Efficient Routing, Challenges and Issues in Transport layer protocol.

SENSOR NETWORK SECURITY **9**

Network Security Requirements, Issues and Challenges in Security Provisioning, Network Security Attacks, Layer wise attacks in wireless sensor networks, possible solutions for jamming, tampering, black hole attack, flooding attack. Key Distribution and Management, Secure Routing – SPINS, reliability requirements in sensor networks.

SENSOR NETWORK PLATFORMS AND TOOLS **9**

Sensor Node Hardware – Berkeley Motes, Programming Challenges, Node-level software platforms – TinyOS, nesC, CONTIKI OS, Node-level Simulators – NS2 and its extension to sensor networks, COOJA, TOSSIM, Programming beyond individual nodes – State centric programming.

d. Activities

Students shall be given exposure in simulation in different sensor network simulators.

e. Learning Resources

Text Books

1. Murthy, C.S.R. and Manoj, B.S., 2004. *Ad hoc wireless networks: Architectures and protocols, portable documents*. Pearson education.
2. Karl, H. and Willig, A., 2007. *Protocols and architectures for wireless sensor networks*. John Wiley & Sons.

References

1. Zhao, F., Guibas, L.J. and Guibas, L., 2004. *Wireless sensor networks: an information processing approach*. Morgan Kaufmann.
2. Charles E. Perkins, 2000. *Ad Hoc Networking*, Addison Wesley.
3. Akyildiz, I.F., Su, W., Sankarasubramaniam, Y. and Cayirci, E., 2002. Wireless sensor networks: a survey. *Computer networks*, *38*(4), pp.393-422.

Course Code	Course Name	L	T	P	C
VEC341	SENSORS AND CONTROL SYSTEMS	3	0	0	3

Category: Professional Elective

a. Preamble

This course promotes students to learn the various sensors used to measure various physical parameters. To analyze the stability and state variable of a control system.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Study the basic principles of various smart sensors.	K2
CO2	Select sensors for the measurement of physical variables for real time applications.	K2
CO3	An ability to compute differential equation and tranfer function of a given control system.	K2
CO4	An ability to analyze the stability and state variable of a control system.	K2
CO5	Knowledge on the concepts of time response and frequency response analysis.	K2

c. Course Syllabus **Total : 45 Periods**

MOTION, PROXIMITY AND RANGING SENSORS **9**

Motion Sensors – Potentiometers, Resolver, Encoders – Optical, Magnetic, Inductive, Capacitive, LVDT – RVDT – Synchro – Microsyn, Accelerometer.,- GPS, Bluetooth, Range Sensors – RF beacons, Ultrasonic Ranging, Reflective beacons, Laser Range Sensor (LIDAR).

FORCE, MAGNETIC AND TEMPERATURE SENSORS **9**

Strain Gage, Load Cell, Magnetic Sensors -types, principle, requirement and advantages: Magneto resistive – Hall Effect – Current sensor Heading Sensors – Compass, Gyroscope, Inclinometers – RTD.

CONTROL SYSTEM MODELING **9**

Basic Elements of Control System - Open loop and Closed loop systems - Differential equation – Transfer function, Modeling of Electric systems, Translational and rotational mechanical systems - Block diagram reduction Techniques - Signal flow graph.

STABILITY ANALYSIS **9**

Stability - Routh-Hurwitz Criterion, Root Locus Technique- Construction of Root Locus - Dominant Poles, Application of Root Locus Diagram - Nyquist Stability Criterion - Relative Stability.

FREQUENCY RESPONSE ANALYSIS **9**

Frequency Response - Bode Plot, Polar Plot, Nyquist Plot - Frequency Domain specifications from the plots - Constant M and N Circles - Nichol's Chart - Use of Nichol's Chart in Control System Analysis-Series, Parallel, series-parallel Compensators - Lead, Lag, and Lead Lag Compensators.

d. Activities

Using MATLAB software analyze the stability and state variable of a control system and plot frequency response of various syatems.

e. Learning Resources

Text Books

1. Nagrath, I.J. and Gopal, M., 2008. *Textbook of control systems engineering (Vtu)*. New Age International.
2. Doebelin, E.O. and Manik, D.N., 2007. Measurement systems: application and design, Mc-Graw Hill.

References

1. Patranabi, D., 2010. *Sensors and Tranducers*. PHI Learning Pvt. Ltd..
2. Gopal, M., 2008. *Control systems: principles and design*. McGraw-Hill Science Engineering.
3. Turner, J.D. and Hill, M., 1999. *Instrumentation for engineers and scientists*. Oxford University Press.
4. Ogata, K., 2010. *Modern control engineering* (Vol. 5). Upper Saddle River, NJ: Prentice hall.

Course Code	Course Name	L	T	P	C
VEC342	MEMS AND NANOELECTRONICS	3	0	0	3

Category: Professional Core

a. Preamble

The course aims at studying micro and nano electromechanical devices, micro sensors,actuators and nanosystems.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Summarize the Concept of miniaturization and need for MEMS in various applications.	K2
CO2	Generalize Micro fabrication techniques.	K2
CO3	Design and analyze various sensors..	K3
CO4	Explain the concepts of various actuation mechanisms of MEMS components.	K2
CO5	Explain about various nano devices.	K2

c. Course Syllabus **Total : 45 Periods**

INTRODUCTION TO MEMS AND NEMS **9**

Introduction to Design of MEMS and NEMS, Overview of Nano and Microelectromechanical Systems, Applications of Micro and Nanoelectromechanical systems, Materials for MEMS and NEMS: Silicon, silicon compounds, polymers, metals.

MEMS FABRICATION TECHNOLOGIES **9**

Photolithography, Ion Implantation, Diffusion, Oxidation, CVD, Sputtering Etching techniques, Micromachining: Bulk Micromachining, Surface Micromachining, LIGA.

MICRO SENSORS **9**

MEMS Sensors: Design of Acoustic wave sensors, Vibratory gyroscope, Capacitive Pressure sensors, Case study: Piezoelectric energy harvester.

MICRO ACTUATORS **9**

Design of Actuators: Actuation using thermal forces, Actuation using shape memory Alloys, Actuation using piezoelectric crystals, Actuation using Electrostatic forces,

RF MEMS Components: Case study 1:MEMS Switch, Example of RF MEMS switches and applications, Mechanical design , Electromagnetic modeling (Capacitance, Loss, Isolation), Current research Case Study 2: Tunable Capacitors and Inductors, Example of tunable capacitors and inductors and their applications in circuits, Effect of inductor layout, reduction of stray capacitance of planar inductor.

NANO DEVICES **9**

Atomic Structures and Quantum Mechanics, Shrodinger Equation, ZnO nano rods based NEMS device: Gas sensor.

d. Activities

Industrial Visit to Indian Institute of Science (CeNSE Lab).

e. Learning Resources

Text Books

1. Madou, M.J., 2002. *Fundamentals of microfabrication: the science of miniaturization*. CRC press.
2. Varadan, V.K., Vinoy, K.J. and Jose, K.A., 2003. *RF MEMS and their applications*. John Wiley & Sons.
3. Poole, C.P. and Owens, F.J., 2003. Introduction to nanotechnology, Wiley student Edition.

References

1. Tai-Ran, H., 2002. MEMS & MICROSYSTEMS. *Design and Manufacture*, pp.112-116.
2. Liu, C., 2012. *Foundations of MEMS*. Pearson Education India.
3. Lyshevski, S.E., 2018. *MEMS and NEMS: systems, devices, and structures*. CRC press.

Course Code	Course Name	L	T	P	C
VEC343	INTERNET OF THINGS	2	0	2	3

Category: Professional Elective

a. Preamble

Internet of Things, refers to the collective network of connected devices and the technology that facilitates communication between devices and the cloud, as well as between the devices themselves. The objective of this course is to introduce the students to some of these constituent technologies and provide them hands-on experience in designing simple IoT systems. While the emphasis is given on the implementation aspects, the students will be briefed about the underlying theoretical concepts. They will be also introduced to several performance metrics that can be used to evaluate different IoT systems.

b. Course Outcome (for Theory)

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

CO. No.	Course Outcome	Knowledge Level
CO1	Describe the concepts of IoT along with its applications.	K2
CO2	Identify different types of sensors, actuators and communication Protocols.	K2
CO3	Build a prototype using Arduino Uno.	K2
CO4	Design IoT application using Raspberry pi.	K3
CO5	Understand the various cloud platform for IoT.	K2

Course Outcome (for Laboratory)

CO. No.	Course Outcome	Knowledge Level
CO1	Make use Arduino board to monitoring sensor values in real time.	K3
CO2	Build the simple IoT system to transfer the data in the cloud.	K3
CO3	Develop the web Application to control the IoT devices.	K3
CO4	Determine appropriate components to make IoT system.	K3
CO5	Build society relevant mini projects in IoT.	K3

c. Course Syllabus (for Theory) **Total : 30 Periods**

INTRODUCTION TO INTERNET OF THINGS **6**

Introduction – Physical Design of IoT – Logical Design of IoT – IoT Enabling Technologies – IoT Levels & Deployment Templates - Domain Specific IoT - Home, City, Environment, Energy, Agriculture and Industry.

SENSORS **6**

Light sensor - Temperature sensor with Thermistor & LM35 – Proximity Sensor - Humidity Sensor - Motion Detection Sensors – Gas & Smoke Sensors - Accelerometer Sensor – Gyroscope Sensor - Distance Measurement with Ultrasound sensor.

IoT WITH ARDUINO **6**

Introduction to the Arduino - Creating an Arduino programming Environment - Using the Arduino IDE - Creating an Arduino program - Using Libraries - Working with Digital Interfaces - Interfacing with Analog devices - Adding Interrupts - Communicating with devices - Using sensors - Working with Motors - Using an LCD.

IoT WITH RASPBERRY PI **6**

Raspberry Pi - About the Board - Linux on Raspberry Pi - Raspberry Pi Interfaces – Serial, I2C, SPI - Programming Raspberry Pi with Python -Controlling LED with Raspberry Pi - Interfacing an LED and Switch with Raspberry Pi - Interfacing a Light Sensor (LDR) with Raspberry Pi.

IoT PHYSICAL SERVERS AND CLOUD OFFERINGS **6**

Introduction to Cloud Storage models and communication APIs Web Server - Xively Cloud for IoT - Python web application framework - Django– Amazon Web Services (AWS) for IoT.

Course Syllabus (for Laboratory) **Total : 30 Periods**

LIST OF EXPERIMENTS

1. Working with Digital I/O:

Implement the following experiments using Arduino IDE

a. LED Blinking
b. Multiple LED’s Blinking
c. Two-way switch logic using Push buttons and LED

2. Working with Analog Inputs:

Write Program for monitoring sensor values in real time using Arduino.

a. Temperature sensor
b. Automatic Street Light ON/OFF Control
c. Fire alarm indication using Buzzer

3. Write program to transfer the data in the cloud using ESP8266 WIFI module / NodeMCU

a. Light Control Monitoring
b. Soil Condition Monitoring
b. Smart Intrusion detection – PIR Sensor
c. Water Level Indicator

4. Mini Projects in IoT:

a. Smart Home/City
b. Smart health monitoring
c. Smart agriculture
d. Environmental Monitoring

d. Activities

Students shall be development the mini Project in real time smart IoT Applications.

e. Learning Resources

Text Books

1. Bahga, A. and Madisetti, V., 2014. *Internet of Things: A hands-on approach*. Vpt., Universities Press.
2. Blum, R., 2014. *Arduino Programming in 24 Hours, Sams Teach Yourself*. Sams Publishing.

References

1. Ida, N., 2013. *Sensors, actuators, and their interfaces: a multidisciplinary introduction* (No. 11040). SciTech Publishing Inc.
2. Hanes, D., Salgueiro, G., Grossetete, P., Barton, R. and Henry, J., 2017. *IoT fundamentals: Networking technologies, protocols, and use cases for the internet of things*. Cisco Press.
3. Minoli, D., 2013. *Building the internet of things with IPv6 and MIPv6: The evolving world of M2M communications*. John Wiley & Sons.
5. Waher, P., 2015. *Learning Internet of Things: Explore and learn about Internet of Things with the help of engaging and enlightening tutorials designed for Raspberry Pi*. Packt publishing.

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS:

S.No.	Description of Equipment	Quantity Required
1.	PCs with Arduino IDE Software (open source)	15 Nos
2.	Arduino Uno / NodeMCU / ESP32 / Raspberry Pi or any other Equivalent Controller with Wi-Fi / Bluetooth with power cable	15 Nos
3.	Module Kit – LM 35 Temperature Sensor, Thermocouple/Thermistor, Soil Moisture Sensor, PIR Sensor, IR Sensor, Photoresistor (LDR), Ultrasonic Sensor, MQ2 Gas Sensor / MQ7 / MQ135 Air Quality Sensor, DHT 11 Sensor, MAX30100 Pulse Oximeter Sensor, 0.96" I2C OLED Display / 16x2 LCD with I2C Module, DC Motor, Servo Motor.	15 Nos
4.	Small Size Breadboard, 10x LED's, Bulb Holder and Plug, Blub, RGB LED, 2x Push buttons, Buzzer, 5v one Channel Relay model, 2N2222 transistor, Diode 1N4148, 10x 330Ω Resistor, 2x 10k Resistors, 2x1k Resistors, 10x Jumper Wires	15 Nos

Course Code	Course Name	L	T	P	C
VEC344	DATA ANALYTICS AND VISUALIZATION	3	0	0	3

Category: Professional Elective

a. Preamble

This course is about data analytics used to develop sound hypotheses, collect and analyze appropriate data and to Sketch it using visualization techniques.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Explain various Data Visualization methods.	K2
CO2	Can handle data using primary tools used for data science in Python.	K2
CO3	Evaluate the use of data from acquisition through cleaning, warehousing, analytics, and visualization to the ultimate business decision.	K3
CO4	Mine data and carry out predictive modeling and analytics to support business decision-making.	K3
CO5	Suggest prescriptive modeling techniques for real-world problems.	K3

c. Course Syllabus **Total : 45 Periods**

BASICS OF DATA VISUALIZATION **9**

The Seven Stages of Visualizing Data - Getting Started with Processing - Mapping - Time Series - Connections and Correlations - Scatterplot Maps - Trees, Hierarchies, and Recursion - Networks and Graphs – Acquiring Data – Parsing Data.

VISUALIZING USING MATPLOTLIB **9**

Importing Matplotlib – Simple line plots – Simple scatter plots – visualizing errors – density and contour plots – Histograms – legends – colors – subplots – text and annotation – customization – three dimensional plotting - Geographic Data with Basemap - Visualization with Seaborn.

IoT FUNDAMENTALS , DESIGN AND DEVELOPMENT **9**

Introduction to Data Analytics - Types of Data Analytics - Predictive Analytics - Simple linear regression - Multiple linear regression - Auto regression - Moving Average - Autoregressive Integrated Moving Average - Data Preprocessing - Data Cleaning - Data Integration and Transformation - Data Reduction - Descriptive data analytics - measures of central tendency - measures of location of dispersions.

DATA ANALYTICS AND SUPPORTING SERVICES **9**

Association Rule Mining: Efficient and Scalable Frequent Item set Mining Methods - Mining Various Kinds of Association Rules - Association Mining to Correlation Analysis - Constraint Based Association Mining - Cluster Analysis: Types of Data in Cluster Analysis - A Categorization of Major Clustering Methods - Partitioning Methods - Hierarchical methods.

CASE STUDIES/INDUSTRIAL APPLICATIONS **9**

Introduction to Streams Concepts - Stream data model and architecture - Stream Computing - Sampling data in a stream - Filtering streams - Counting distinct elements in a stream - Estimating moments - Counting oneness in a window - Decaying window - Real Time Analytics Platform (RTAP) applications - case studies - real time sentiment analysis - stock market predictions.

d. Activities

Students shall be exposed to Python programming for various IoT applications.

e. Learning Resources

Text Books

1. Han, J., Pei, J. and Tong, H., 2022. *Data mining: concepts and techniques*. Morgan kaufmann.
2. Leskovec, J., Rajaraman, A. and Ullman, J.D., 2020. *Mining of massive data sets*. Cambridge university press.
3. Catherine Marsh, Jane Elliott, 2008. *Exploring Data: An Introduction to Data Analysis for Social Scientists*, Wiley Publications, 2nd Edition.

References

1. Fry, B., 2007. *Visualizing Data: Exploring and Explaining Data with the processing Environment*, O Reily Publications.
2. Loshin, D., 2013. *Big data analytics: from strategic planning to enterprise integration with tools, techniques, NoSQL, and graph*. Elsevier.

Course Code	Course Name	L	T	P	C
VEC345	WIRELESS TECHNOLOGIES	2	0	2	3

Category: Professional Elective

a. Preamble

This course promotes students to understand basic concepts of wireless networks, their characteristics and applications to impart knowledge on usage in wireless communication. It also enables the students to have knowledge in Bluetooth, wi fi and zigbee.

b. Course Outcome (for Theory)

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

CO. No.	Course Outcome	Knowledge Level
CO1	Identify suitable wireless technologies for wireless communication.	K2
CO2	Explain the working principle of Bluetooth technologies.	K2
CO3	Illustrate the working principle of Zigbee network.	K2
CO4	Outline the working principle of cellular technologies.	K2
CO5	Outline the recent wireless technologies application.	K2

Course Outcome (for Laboratory)

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

CO. No.	Course Outcome	Knowledge Level
CO1	Build the network for wireless communication using Wi – Fi.	K3
CO2	Implementation of data transmission using Zigbee.	K3
CO3	Implement data transmission in wireless communication.	K3
CO4	Demonstrate the mobile ad hoc network for data transmission.	K2
CO5	Experiment with wireless communication using wireless protocol.	K3

c. Course Syllabus (for Theory) **Total : 30 Periods**

INTRODUCTION TO WIRELESS COMMUNICATION **6**

Introduction to Wireless Technologies - Wireless LAN - IEEE 802.11 standards - Frequency bands - Sub Standards (a,b,g,n) - Network Topology - Terminology, Client Server Network Management for WLAN.

FUNDAMENTALS OF BLUETOOTH **6**

Bluetooth Basics, Classic Bluetooth Profiles - L2CAP, RFCOMM, Bluetooth Smart/Low Energy, BLE Profiles-GATT, GAP, BLE Motes, Beacons- Protocols.

STUDY AND DEPLOYMENT OF IEEE 802.15.4 STANDARDS **6**

Wireless PAN - IEEE 802.15.4 standards - Implementation of Zigbee - Thread etc., Linux support for WPAN, 6, 6LowPAN standard, Ipv6 Routing Protocol for Low-Power (RPL) and Lossy Networks.

CELLULAR TECHNOLOGIES **6**

Introduction to Cellular Technologies, Frequency Reuse Concepts Global System for Mobile Communications (GSM), General Radio Packet Radio Services (GPRS), G/UMTS, 4G/LTE.

OVERVIEW OF RECENT IoT WIRELESS TECHNOLOGIES **6**

Introduction to Short range communication, RFID, IrDA, NFC, GPS, Sigfox, NB-IoT, LoRA-WAN Protocol.

Course Syllabus (for Laboratory) **Total : 30 Periods**

LIST OF EXPERIMENTS

1. Wireless communication using Wi Fi Network
2. Personal Area Network Implementation using Zigbee
3. Simulating a mobile ad hoc network
4. Implementation of wireless communication using wireless protocol
5. Implement packet data protocol
6. Simulating a wireless sensor network
7. Implement IP network
8. Implement transport control

d. Activities

Students shall be exposed to work on Microwave lab to find the S matrix for passive device and characteristics of microwave sources.

e. Learning Resources (for both Theory and Laboratory)

Text Book

1. Zheng, J. and Jamalipour, A., 2009. *Wireless sensor networks: a networking perspective*. John Wiley & Sons.
2. Dargie, W. and Poellabauer, C., 2010. Fundamentals of wireless sensor networks: theory and practice. John Wiley & Sons.

References

1. Edgar H. Callaway, *Wireless Sensor Networks: Architectures and Protocols*, CRC Press, 1st Edition, August 2003.
2. Gutierrez, J.A., Winkel, L., Callaway Jr, E.H. and Barrett Jr, R.L., 2011. *Low-rate wireless personal area networks: enabling wireless sensors with IEEE 802.15. 4*. John Wiley & Sons.
3. Sohraby, K., Minoli, D. and Znati, T., 2007. *Wireless sensor networks: technology, protocols, and applications*. John wiley & sons.

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS:

S.No.	Description of Equipment	Quantity Required
1.	Wi-Fi module	10
2.	Node MCU	10
3.	Network Simualtor	2
4.	Personal Computer	10
5.	5V Adaptor	10

Course Code	Course Name	L	T	P	C
VEC346	SECURITY IN INTERNET OF THINGS	3	0	0	3

Category: Professional Elective

a. Preamble

This course is designed to provide an overview of the importance of IoT security and the measures that can be taken to secure IoT devices and networks. As the number of IoT devices continues to grow, the need for cybersecurity measures has become increasingly important. In this course, we will explore the potential risks associated with using IoT devices and the consequences of security breaches. We will also discuss the best practices for securing IoT devices and networks, including firmware updates, password protection, and network security.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Illustrate the Security Requirements in IoT.	K2
CO2	Explain the Cryptography fundamentals for IoT.	K2
CO3	Explain the authentication credentials and access control.	K2
CO4	Summarize the various types Trust models.	K2
CO5	Outline the types and architecture for Cloud security for IoT.	K2

c. Course Syllabus **Total : 45 Periods**

INTRODUCTION: SECURING THE INTERNET OF THINGS **9**

Security Requirements in IoT Architecture - Security in Enabling Technologies - Security Concerns in IoT Applications – Security Architecture in the Internet of Things - Security Requirements in IoT - Insufficient Authentication/Authorization – Insecure Access Control - Threats to Access Control, Privacy, and Availability - Attacks Specific to IoT– Vulnerabilities – Secrecy and Secret-Key Capacity – Authentication / Authorization for Smart Devices - Transport Encryption – Attack & Fault trees.

CRYPTOGRAPHIC FUNDAMENTALS FOR IoT **9**

Cryptographic primitives and its role in IoT – Encryption and Decryption – Hashes – Digital Signatures – Random number generation – Cipher suites – Key management fundamentals – Cryptographic controls built into IoT messaging and communication protocols – IoT Node Authentication.

IDENTITY & ACCESS MANAGEMENT SOLUTIONS FOR IoT 9

Identity lifecycle – Authentication credentials – IoT IAM infrastructure – Authorization with Publish / Subscribe schemes – access control.

PRIVACY PRESERVATION AND TRUST MODELS FOR IoT 9

Concerns in data dissemination – Lightweight and robust schemes for Privacy protection – Trust and Trust models for IoT – Self-organizing Things - Preventing unauthorized access.

CLOUD SECURITY FOR IoT 9

Cloud services and IoT – Offerings related to IoT from cloud service providers – Cloud IoT security controls – An enterprise IoT cloud security architecture – New directions in cloud enabled IoT computing.

d. Activities

Ask each group to research the specific security measures that should be taken to secure their assigned device. Encourage the students to consider factors such as firmware updates, password protection, and network security.

e. Learning Resources

Text Books

1. Russell, B. and Van Duren, D., 2016. *Practical internet of things security*. Packt Publishing Ltd.
2. Li, S. and Da Xu, L., 2017. *Securing the internet of things*. Syngress.

References

1. Hu, F., 2016. *Security and privacy in Internet of things (IoTs): Models, Algorithms, and Implementations*. CRC Press.
2. Whitehouse, O., 2014. Security of things: An implementers' guide to cyber-security for internet of things devices and beyond. *NCC Group*.
3. Stallings, W., 2006. *Cryptography and network security, 4/E*. Pearson Education India.
4. Gilchrist, A., 2017. IoT security issues. In *IoT Security Issues*. De| G Press.

Course Code	Course Name	L	T	P	C
VEC347	INDUSTRIAL IoT	3	0	0	3

Category: Professional Elective

a. Preamble

The Industrial Internet of Things (IIoT) is transforming the way we live and work, revolutionizing industries ranging from manufacturing to healthcare. This course provides an in-depth exploration of the principles and technologies that underpin the IIoT, and prepares students to design and implement IIoT systems in a variety of industrial settings.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Illustrate the smartness in Smart Factories, Smart cities, smart products and smart Services.	K2
CO2	Identify the implementation systems for the Industrial IoT.	K3
CO3	Utilize the different system and technologies to enabling the Industrial 4.0.	K3
CO4	Interpret data collected from IIoT devices using Data Analytics and Data Management.	K3
CO5	Develop project management skills to plan and execute IIoT projects.	K3

c. Course Syllabus **Total : 45 Periods**

INTRODUCTION TO INDUSTRIAL IoT (IIoT) SYSTEMS 9

The Various Industrial Revolutions, Role of Internet of Things (IoT) & Industrial Internet of Things (IIoT) in Industry, Industry 4.0 revolutions, Support System for Industry 4.0, Internet of Services – Smart Manufacturing - Advantages of smart manufacturing companies – Smart Factories- Real-World Smart Factories: GE's Brilliant Factory - Siemens' Amberg Electronics Plant (EWA) – Smart Devices and Products- Smart Logistics - Smart Cities - Predictive Analytics.

IMPLEMENTATION SYSTEMS FOR IIoT 9

Sensors and Actuators for Industrial Processes, Sensor networks, Process automation and Data Acquisitions on IoT Platform, Microcontrollers and Embedded PC roles in IIoT, Wireless Sensor nodes with Bluetooth, Wi-Fi, and LoRa Protocols and IoT Hub systems.

SYSTEM, TECHNOLOGIES FOR ENABLING INDUSTRY 4.0 **9**

Cyber physical Security in Industry 4.0 - Secure Manufacturing Information Architecture - Robotic Automation and Collaborative Robots - Support System for Industry 4.0 – Mobile Computing - Cyber Security.

IIoT ANALYTICS AND DATA MANAGEMENT **9**

Introduction – IIoT Analytics – Types - Machine Learning and Data Science - Cloud Computing In IIoT – Cloud Platform for Device Management – Fog Computing – Data Management with Hadoop – Data Center Network.

APPLICATIONS, AND CASE STUDIES **9**

Smart Factory and Assembly Line – Food Industry – IIoT in Healthcare – Plant Security and Safety (Including AR and VR safety applications) – Facility Management - Oil, Chemical and Pharmaceutical Industry - UAVS in Industries, Case Study : IIoT application development with Embedded PC based development boards.

d. Activities

Students shall be development the mini Project on new version of Operating systems and Edge development board. That project should also address to the current societal needs.

e. Learning Resources

Text Books

1. Gilchrist, A., 2016. *Industry 4.0: the industrial internet of things*. Apress.
2. Ustundag, A. and Cevikcan, E., 2018. *Industry 4.0: managing the digital transformation*, Springer Nature.

References

1. Vermesan, O. and Friess, P. eds., 2013. *Internet of things: converging technologies for smart environments and integrated ecosystems*. River publishers.
2. Thames, L. and Schaefer, D., 2017. *Cybersecurity for industry 4.0* (pp. 1-33). Heidelberg: Springer.
3. Kagermann, H., Wahlster, W. and Helbig, J., 2013. Acatech "Recommendations for implementing the strategic initiative INDUSTRIE 4.0. *Final report of the Industrie, 4*.

4. Evans, P.C. and Annunziata, M., 2012. Industrial internet: Pushing the boundaries. *General Electric Reports*, pp.488-508.

Course Code	Course Name	L	T	P	C
MEC101	ANALOG DEVICES AND CIRCUITS	3	0	0	3

Category: Open Elective (Minor Degree)

a. Preamble

This course promotes students to understand basic concepts of circuit theory and semiconductor devices, their characteristics and applications to impart knowledge on usage of devices in circuits. It also enables the students to have knowledge in DC power supplies.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Derive the voltage and current in circuits.	K2
CO2	Derive the voltage and current in networks.	K2
CO3	Explain the working principle of Semiconductor devices.	K2
CO4	Outline the working principle of Transistors and various configuration and models.	K2
CO5	Explain the linear mode power supply and voltage regulators.	K2

c. Course Syllabus **Total: 45 Periods**

BASIC CIRCUITS ANALYSIS **9**

Resistive Elements - Ohm’s Law - Kirchhoff's Voltage Law, Kirchhoff's Current Law - Series and Parallel Resistance, Equivalent Resistance -Voltage Divider Law, Current Divider Law.

MESH, NODAL ANALYSIS AND NETWORK THEOEMS **9**

Currents and Voltages in Circuits - Mesh Analysis, Node Analysis – Source Transformation, Thevenin’s theorem - Norton’s theorem – Superposition Theorem – Maximum Power Transfer Theorem.

SEMICONDUCTOR DEVICES **9**

PN junction Diodes - working principle, VI characteristics - PN diode currents - diode current equation - Varactor diode - Tunnel diode - LED - Photo Diode - LDR, Opto Coupler, Solar Cell. SCR.

TRANSISTORS **9**

Principle and Operation of PNP and NPN transistors, Input and Output Characteristics of CE, CB, CC, Principle and Operation of JFET and MOSFET.

DC POWER SUPPLIES **9**

HWR, FWR, full-wave bridge rectifier- ripple factor, efficiency analysis. Voltage regulation, Zener diode shunt regulator, transistor series regulator, transistor shunt regulator, design of complete DC power supply circuit.

d. Activities

Students shall be given exposure to understand the devices characteristics and measure the electrical parameters in circuits and networks.

e. Learning Resources

Text Books

1. Floyd, L Thomas., 2012. Electronic Devices, 9th edition, Pearson Education.
2. Neamen, D.A., 1992. S*emiconductor Physics and Devices Basic Principles*, Tata McGraw Hill Publishing.
3. Alexander, C.K. and Sadiku, M.N., 2007. O. Fundamentals of electric circuits, Boston: McGraw-Hill Higher Education.

References

1. Sudhakar. A and Shyam Mohan, SP., 2015. *Circuits and Networks-Analysis and Synthesis*, McGraw Hill.
2. Streetman, B.G. and Banerjee, S., 2000. *Solid state electronic devices* (Vol. 4). New Jersey: Prentice hall.
3. Boylestad, R. and Nashelsky, L., 2008. Electron Devices and Circuit Theory‖ Pearson Prentice Hall.
4. Yang., 1978. *Fundamentals of Semiconductor devices,* McGraw Hill International Edition.
5. Adel S. Sedra and Kenneth C. Smith., 2017. *Microelectronic Circuits: Theory and Applications,* 7th Edition, Oxford University Press.

Course Code	Course Name	L	T	P	C
MEC102	DIGITAL LOGIC DESIGN	2	0	2	3

Category: Open Elective (Minor Degree)

a. Preamble

This course promotes students to learn combinational circuits, sequential circuits and Memory devices.

b. Course Outcome (for Theory)

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

CO. No.	Course Outcome	Knowledge Level
CO1	Explain the basic concepts of digital circuitry and techniques for simplification.	K2
CO2	Make use of logic gates to create a variety of adders / subtractor circuit using combinational digital circuits.	K3
CO3	Design various combinational digital circuits using logic gates.	K3
CO4	Apply the synchronous and asynchronous sequential circuit analysis and design processes.	K3
CO5	Explain integrated circuit families and memory devices.	K2

Course Outcome (for Laboratory)

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

CO. No.	Course Outcome	Knowledge Level
CO1	Use simplification techniques and Boolean algebra to design digital logic.	K3
CO2	Design various combinational digital circuits for adder/subtractor circuit using logic gates.	K3
CO3	Design combinational circuits for magnitude comparator and seven segment display decoders.	K3
CO4	Design sequential circuits and analyze the design procedures.	K3
CO5	Build logic gates for shift registers.	K3

c. Course Syllabus (for Theory) **Total: 30 Periods**

BASICS OF DIGITAL ELECTRONICS **6**

Introduction, Binary number system, Number base conversion, Octal and hexadecimal numbers, compliments, Signed Binary numbers, Decimal codes (BCD, 8 4 -2 -1, Excess 3, Gray Code), Binary logic gates, truth-tables and designing circuits, Boolean Algebra, Karnaugh maps (K-maps), realization of AND/OR gates, Don't Care conditions.

COMBINATIONAL CIRCUITS I **6**

Problem formulation and design of combinational circuits, Design of some basic building blocks: half-adder, full-adder, half subtractor, full subtractor, Encoder & Decoders, Multiplexers / demultiplexer, Code-Converters, Binary to Gray, BCD to Excess 3.

COMBINATIONAL CIRCUITS II **6**

n-bit ripple-carry adder, Discussion of nominal delays through ripple carry adder, Design of n-bit Carry Lookahead Adders and nominal delay analysis, Design of n-bit comparators - Parity Generator/Checker, Seven Segment display decoder.

SEQUENTIAL CIRCUITS **6**

Introduction to Sequential Circuits – Flip-Flops – operation and excitation table, Analysis and design of clocked synchronous sequential circuits – state minimization, state assignment -circuit implementation, Shift Registers - SISO, SIPO, PISO, PIPO, Counters – Mod N counters.

PROGRAMMABLE LOGIC DEVICES **6**

Programmable logic devices – Types – Programmable Array Logic, Programmable Logic Array, Implementation of Combinational logic circuits using PLA, PAL, basic memory – RAM – static & dynamic RAM, ROM - PROM, EPROM, EEPROM.

Course Syllabus (for Laboratory) **Total: 30 Periods**

LIST OF EXPERIMENTS

COMBINATIONAL & SEQUENTIAL CIRCUITS

1. Verification of Boolean theorems using logic gates
2. Design of adders and subtractors
3. Design of code converters.
4. Design of Multiplexers & Demultiplexers.

5. Design of Encoders and Decoders.
6. Design of Magnitude Comparators.
7. Design and implementation of counters using flip-flops
8. Design and implementation of shift registers

d. Activities

Students shall be given mini project in combinational circuits or sequential circuits.

e. Learning Resources (for both Theory and Laboratory)

Text Books

1. M Morris, M. and Michael, D., 2013. *Digital Design With an Introduction to the Verilog HDL*, Fifth Edition, Pearson Education.

References

1. Thomas L. Floyd, 2017. *Digital Fundamentals*, 11th Edition, Pearson Education.
2. Roth Jr, C.H., Kinney, L.L. and John, E.B., 2020. *Fundamentals of logic design*. Cengage Learning.
3. Fletcher, W.I., 1997. *An engineering approach to digital design*. Prentice Hall PTR.
4. John. F. Wakerly, 2007. *Digital Design Principles and Practices*, Pearson Education, 4th Edition.

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS:

S.No.	Description of Equipment	Quantity Required
1.	IC Trainer Kit	10 Nos
2.	Bread Boards	10 Nos
3.	Seven segment display	10 Nos
4.	IC 7400/ 7402 / 7404 / 7486 / 7408 / 7432 / 7483 / 74150 / 74151 / 74147 / 7445 / 7476/7491/ 555 / 7494 / 7447 / 74180 / 7485 / 7473 / 74138 / 7411 / 7474	each 15 Nos

Course Code	Course Name	L	T	P	C
MEC103	PRINCIPLES OF COMMUNICATION	3	0	0	3

Category: Open Elective (Minor Degree)

a. Preamble

This course promotes students to have analytical knowledge in analog & digital transmission and reception techniques. It helps to analyze the performance of various detection techniques.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Explain the generation and detection methods of analog modulation schemes with its spectral characteristics.	K2
CO2	Interpret different waveform coding techniques to model the pulse coding systems.	K2
CO3	Elucidate the pass band modulation techniques with its performance and the need for equalization.	K2
CO4	Identify problems based on Information theory and Error control coding.	K2
CO5	Illustrate various spread spectrum & multiple access techniques.	K2

c. Course Syllabus **Total: 45 Periods**

ANALOG MODULATION **9**

Amplitude Modulation - DSBFC, DSBSC, SSBSC, VSB-SC - Generation & Detection, Mathematical expression PSD, modulators and demodulators - Angle modulation - PM and FM - PSD, modulators and demodulators - Superheterodyne receivers.

WAVEFORM CODING & REPRESENTATION **9**

Low pass sampling -Aliasing, Signal Reconstruction - Quantization -Uniform & non-uniform quantization, Quantization noise -Line coding -PAM, PCM, DPCM, DM, ADM.

DIGITAL MODULATION AND TRANSMISSION **9**

Geometric Representation of signals - Gram Schmitt Orthogonalization Procedure - Generation, detection, PSD & BER of Coherent BPSK, BFSK, QPSK & QAM -ISI - Pulse shaping - Eye pattern.

INFORMATION THEORY AND CODING **9**

Measure of information - Entropy - Source coding theorem - Shannon-Fano coding, Huffman Coding - Channel capacity - Error control codes - Cyclic codes, Syndrome calculation - Convolution Coding, Viterbi decoding.

SPREAD SPECTRUM AND MULTIPLE ACCESS **9**

PN sequences - properties - DSSS - Processing gain, Jamming - FHSS - Synchronization and tracking - Multiple Access - TDMA, FDMA, CDMA

d. Activities

Students shall be given exposure in simulation software like LABVIEW or MATLAB to understand the performance of various analog & digital modulation techniques.

e. Learning Resources

Text Books

1. Haykin, S., 2008. *Communication systems*. John Wiley & Sons.
2. J.G.Proakis and M.Salehi., 2014. *Fundamentals of Communication Systems*, Pearson Education.
3. Sastry, S. S., 2015, *Introductory Methods of Numerical Analysis*, PHI Learning, Fifth Edition.

References

1. Lathi, B.P., 1995. *Modern digital and analog communication systems*. Oxford University Press, Inc..
2. D.Roody, J.Coolen, 2006. *Electronic Communications*, 4th edition PHI.
3. Sklar, B., 2001. *Digital communications* (Vol. 2, p. 1011). Upper Saddle River, NJ, USA:: Prentice hall.

Course Code	Course Name	L	T	P	C
MEC104	INTRODUCTION TO MACHINE LEARNING	3	0	0	3

Category: Open Elective (Minor Degree)

a. Preamble

This subject focuses on basic and advanced algorithms and approaches present in Machine Learning.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Explain the basic concepts of Machine Learning algorithm process.	K2
CO2	Apply supervised learning techniques to machine learning concepts.	K3
CO3	Make use of unsupervised learning techniques for machine learning applications.	K3
CO4	Infer the instant based learning in machine learning.	K2
CO5	Choose appropriate machine learning approaches for various types of problems.	K3

c. Course Syllabus **Total : 45 Periods**

INTRODUCTION **9**

Machine Learning–Types of Machine Learning –Machine Learning process- preliminaries, testing Machine Learning algorithms – turning data into Probabilities, and Statistics for Machine Learning- Probability theory – Probability Distributions – Decision Theory.

SUPERVISED LEARNING **9**

Linear Models for Regression – Linear Models for Classification- Discriminant Functions – Probabilistic Generative Models – Probabilistic Discriminative Models – Decision Tree Learning – Bayesian Learning – Naïve Bayes – Ensemble Methods – Bagging – Boosting – Neural Networks– Multi-layer Perceptron– Feed- forward Network, Error Back propagation - Support Vector Machines.

UNSUPERVISED LEARNING **9**

Clustering- K-means – EM Algorithm- Mixtures of Gaussians –Dimensionality Reduction, Linear Discriminant Analysis, Factor Analysis, Principal Components Analysis, Independent Components Analysis.

INSTANT BASED LEARNING **9**

K- Nearest Neighbour Learning – Locally weighted Regression – Radial Basis Functions – Case Based Learning.

ADVANCED LEARNING **9**

Learning Sets of Rules – Sequential Covering Algorithm – Learning Rule Set – First Order Rules – Sets of First Order Rules – Induction on Inverted Deduction – Inverting Resolution – Analytical Learning – Perfect Domain Theories – Explanation Base Learning.

d. Activities

Students shall be exposed to different algorithms and approaches in Machine Learning.

e. Learning Resources

Text Book

1. Mitchell, T.M., 2007. *Machine learning* (Vol. 1). New York: McGraw-hill.

References

1. Bishop, C.M. and Nasrabadi, N.M., 2006. *Pattern recognition and machine learning* (Vol. 4, No. 4, p. 738). New York: springer.
2. Marsland, S., 2015. *Machine learning: an algorithmic perspective*. CRC press.
3. Murphy, K.P., 2012. *Machine learning: a probabilistic perspective*. MIT press.
4. Ethem Alpaydin, 2004. *Introduction to Machine Learning (Adaptive Computation and Machine Learning)*, MIT Press.

Course Code	Course Name	L	T	P	C
MEC105	SENSORS AND IoT	3	0	0	3

Category: Open Elective (Minor Degree)

a. Preamble

Internet of Things refers to the collective network of connected devices and the technology that facilitates communication between devices and the cloud, as well as between the devices themselves. Sensors refer to measures a physical property and records, indicates, and responds to it. These devices measure and transmit the data to remote cloud using IoT technology.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Describe the concepts of IoT along with its applications.	K2
CO2	Identify different types of sensors, actuators and communication Protocols.	K2
CO3	Build a prototype using Arduino Uno.	K2
CO4	Design IoT application using Raspberry pi.	K3
CO5	Build applications of IoT in real time scenario.	K3

c. Course Syllabus **Total : 45 Periods**

INTRODUCTION TO INTERNET OF THINGS **9**

Introduction – Physical Design of IoT – Logical Design of IoT – IoT Enabling Technologies – IoT Levels & Deployment Templates.

SENSORS **9**

Light sensor - Temperature sensor with Thermistor & LM35 – Proximity Sensor - Humidity Sensor - Motion Detection Sensors – Gas & Smoke Sensors - Accelerometer Sensor – Gyroscope Sensor - Distance Measurement with Ultrasound sensor.

IoT WITH ARDUINO **9**

Introduction to the Arduino - Creating an Arduino programming Environment - Using the Arduino IDE - Creating an Arduino program - Using Libraries - Working with Digital

Interfaces - Interfacing with Analog devices - Adding Interrupts - Communicating with devices - Using sensors - Working with Motors - Using an LCD.

IoT WITH RASPBERRY PI **9**

Raspberry Pi - About the Board - Linux on Raspberry Pi - Raspberry Pi Interfaces - Programming Raspberry Pi with Python -Controlling LED with Raspberry Pi - Interfacing an LED and Switch with Raspberry Pi - Interfacing a Light Sensor (LDR) with Raspberry Pi.

DOMAIN SPECIFIC APPLICATIONS **9**

Home Automation – Cities – Environment – Energy - Agriculture – Industry – Logistics – Health & Lifestyle.

d. Activities

Students shall be exposed to do mini project on IoT.

e. Learning Resources

Text Books

1. Bahga, A. and Madisetti, V., 2014. *Internet of Things: A hands-on approach*. Vpt.
2. Blum, R., 2014. *Arduino Programming in 24 Hours, Sams Teach Yourself*. Sams Publishing.

References

1. Nathan Ida, 2014, *Sensors, Actuators and Their Interfaces*, SciTech Publishers.
2. Dieter Uckelmann, Mark Harrison, Michahelles & Florian (Eds), 2011, *Architecting the Internet of Things*, Springer.
3. Zhou, H., 2012. *The internet of things in the cloud: A middleware perspective*. CRC press.
4. Holler, J., Tsiatsis, V., Mulligan, C., Karnouskos, S., Avesand, S. and Boyle, D., 2014. *Internet of things*. Academic Press.

Course Code	Course Name	L	T	P	C
MEC106	ELECTRONIC SYSTEM DESIGN	2	0	2	3

Category: Open Elective (Minor Degree)

a. Preamble

This course promotes students to gain the fundamentals of PCB and to obtain knowledge to model, design, simulate, test and implement electronic applications in PCB.

b. Course Outcome (for Theory)

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

CO. No.	Course Outcome	Knowledge Level
CO1	Explain the necessity and evolution of PCB, types and classes of PCB.	K2
CO2	Explore the steps involved in schematic, layout, fabrication and assembly process of PCB design.	K2
CO3	Illustrate the basic electronic components used in product design.	K2
CO4	Identify different types of sensors & actuators used in real time applications.	K2
CO5	Build simple applications used in daily life.	K2

Course Outcome (for Laboratory)

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

CO. No.	Course Outcome	Knowledge Level
CO1	Determine appropriate components to make circuits.	K3
CO2	Interpret test results and measurements on electric circuits.	K3
CO3	Analyze the fabrication processes of printed circuit boards.	K4
CO4	Apply the software and hardware for PCB Design.	K3
CO5	Evaluate an electronic printed circuit board for a specific application using industry standard software.	K5

c. Course Syllabus (for Theory) **Total : 30 Periods**

INTRODUCTION TO PCB **6**

Definition and Need of PCB - Background and History of PCB - Types of PCB - Classes of PCB Design - Terminology in PCB Design - Different Electronic design automation (EDA) tools and comparison.

PCB DESIGN AND FABRICATION **6**

Introduction to PCB design software - PCB layout and routing techniques - PCB fabrication and assembly - Overview of product testing and troubleshooting techniques – Design failure analysis.

COMPONENT INTRODUCTION AND CATEGORIES **6**

Types of components - Active Components - Diode, Transistor – BJT & MOSFET - LED, Integrated Circuits (ICs) – 555 Timer, Comparator, Logic Gates - Passive Components – Resistor, Capacitor, Inductor, Transformer, Switches, Relays.

SENSORS & ACTUATORS **6**

Sensors - Light sensor (LDR), Temperature sensor, Phototransistors, Optoisolators – Actuators – DC Motors, RC Servos and Stepper Motors.

APPLICATIONS **6**

DC Power Supply (5V or 12V) – Automatic Street Light Control – Water Level Indicator – Intrusion Detection System – Components Used – Schematic Diagram – Working with Features & Applications.

Course Syllabus (for Laboratory) **Total : 30 Periods**

LIST OF EXPERIMENTS

Design, Simulation and Development of:

1. PCB Board for 5V DC Power Supply - using Manual method / PCB Machine
2. Realization of EXOR Gate using 5v Power supply
3. Product for Water Level Indication
4. Product for Analog to Digital Converter circuit for Sensor applications – Mini project

d. Activities

Students shall be given mini project on real time applications of Product development.

e. Learning Resources (for both Theory and Laboratory)

Text Books

1. Mehta SD, 2011, *Electronic Product Design (Volume- I) Basics of PCB Design*, S.Chand & Company Ltd.
2. Scherz, P. and Monk, S., 2013. *Practical electronics for inventors*. McGraw-Hill Education.

References

1. Nathan Ida, 2014, *Sensors, Actuators and their Interfaces*, SciTech Publishers.
2. Khandpur, R.S., 2006. Printed Circuit Boards Design, Fabrication, and Assembly.
3. Coombs Jr, C.F., 2008. *Printed circuits handbook*. McGraw-Hill Education.

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS:

S.No.	Description of Equipment	Quantity Required
1.	PCs with KiCAD / Eagle / Easy EDA or any other Equivalent software	15 Nos
2.	Ferric Chloride, Driller	1 Nos
3.	**Consumables:** 7805 voltage regulator (5V), 0.1uF Capacitors (2nos), 470uF Capacitor (1 no), Diode 1N4007 (4 nos), Step Down Transformer [230/110V – 9V], LM358 OP – Amp IC. Small LDR., 10 KΩ Resistor, 10 KΩ Potentiometer, White LED, 220 Ω Resistor, Connecting wires, Power supply (9V Battery), IC 7826 – XOR, Soldering iron, Copper Board	15 Nos

Course Code	Course Name	L	T	P	C
OEC781	IoT CONCEPTS AND APPLICATIONS	2	0	2	3

Category: Open Elective

a. Preamble

Internet of Things, refers to the collective network of connected devices and the technology that facilitates communication between devices and the cloud, as well as between the devices themselves. The objective of this course is to introduce the students to some of these constituent technologies and provide them hands-on experience in designing simple IoT systems. While the emphasis is given on the implementation aspects, the students will be briefed about the underlying theoretical concepts. They will be also introduced to several performance metrics that can be used to evaluate different IoT systems.

b. Course Outcome (for Theory)

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

CO. No.	Course Outcome	Knowledge Level
CO1	Describe the basic concepts of Internet of Things and its levels.	K2
CO2	Identify different types of sensors, actuators and communication Protocols.	K2
CO3	Build a prototype using Arduino Uno.	K2
CO4	Design IoT application using Raspberry pi.	K3
CO5	Discuss the various domain specific IoT applications.	K2

Course Outcome (for Laboratory)

CO. No.	Course Outcome	Knowledge Level
CO1	Make use Arduino board to monitoring sensor values in real time.	K3
CO2	Build the simple IoT system to transfer the data in the cloud.	K3
CO3	Develop the web Application to control the IoT devices.	K3
CO4	Determine appropriate components to make IoT system.	K3
CO5	Build society relevant mini projects in IoT.	K3

c. Course Syllabus (for Theory) **Total : 30 Periods**

INTRODUCTION TO INTERNET OF THINGS **6**

Introduction – Physical Design of IoT – Logical Design of IoT – IoT Enabling Technologies – IoT Levels & Deployment Templates.

SENSORS **6**

Light sensor - Temperature sensor with Thermistor & LM35 – Proximity Sensor - Humidity Sensor - Motion Detection Sensors – Gas & Smoke Sensors - Accelerometer Sensor – Gyroscope Sensor - Distance Measurement with Ultrasound sensor.

IoT WITH ARDUINO **6**

Introduction to the Arduino - Creating an Arduino programming Environment - Using the Arduino IDE - Creating an Arduino program - Using Libraries - Working with Digital Interfaces - Interfacing with Analog devices - Adding Interrupts - Communicating with devices - Using sensors - Working with Motors - Using an LCD.

IoT WITH RASPBERRY PI **6**

Raspberry Pi - About the Board - Linux on Raspberry Pi - Raspberry Pi Interfaces – Serial, I2C, SPI - Programming Raspberry Pi with Python -Controlling LED with Raspberry Pi - Interfacing an LED and Switch with Raspberry Pi - Interfacing a Light Sensor (LDR) with Raspberry Pi.

DOMAIN SPECIFIC IOT APPLICATIONS **6**

Domain Specific IoT - Home, City, Environment, Energy, Agriculture, Logistics and Industry.

Course Syllabus (for Laboratory) **Total : 30 Periods**

LIST OF EXPERIMENTS

1. Working with Digital I/O:

Implement the following experiments using Arduino IDE

a. LED Blinking
b. Multiple LED’s Blinking
c. Two-way switch logic using Push buttons and LED

2. Working with Analog Inputs:

Write Program for monitoring sensor values in real time using Arduino.

d. Temperature sensor
e. Automatic Street Light ON/OFF Control

3. Write program to transfer the data in the cloud using ESP8266 WIFI module / NodeMCU

f. Light Control Monitoring
g. Soil Condition Monitoring
h. Smart Intrusion detection

4. Mini Projects in IoT:
   i. Smart Home/City
   j. Smart health monitoring
   k. Smart agriculture
   l. Environmental Monitoring

d. Activities

Students shall be development the mini Project in real time smart IoT Applications.

e. Learning Resources

Text Books

1. Bahga, A. and Madisetti, V., 2014. *Internet of Things: A hands-on approach*. Vpt.
2. Blum, R., 2014. *Arduino Programming in 24 Hours, Sams Teach Yourself*. Sams Publishing.

References

1. Nathan Ida, 2014, *Sensors, Actuators and Their Interfaces,* SciTech Publishers.
2. Hanes, D., Salgueiro, G., Grossetete, P., Barton, R. and Henry, J., 2017. *IoT fundamentals: Networking technologies, protocols, and use cases for the internet of things*. Cisco Press.
3. Minoli, D., 2013. *Building the internet of things with IPv6 and MIPv6: The evolving world of M2M communications*. John Wiley & Sons.
4. Waher, P., 2015. *Learning Internet of Things: Explore and learn about Internet of Things with the help of engaging and enlightening tutorials designed for Raspberry Pi*. Packt publishing.

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS:

S.No.	Description of Equipment	Quantity Required
1.	PCs with Arduino IDE Software (open source)	15 Nos
2.	Arduino Uno / NodeMCU / ESP32 / Raspberry Pi or any other Equivalent Controller with Wi-Fi / Bluetooth with power cable	15 Nos
3.	Module Kit – LM 35 Temperature Sensor, Thermocouple/Thermistor, Soil Moisture Sensor, PIR Sensor, IR Sensor, Photoresistor (LDR), Ultrasonic Sensor, MQ2 Gas Sensor / MQ7 / MQ135 Air Quality Sensor, DHT 11 Sensor, MAX30100 Pulse Oximeter Sensor, 0.96" I2C OLED Display / 16x2 LCD with I2C Module, DC Motor, Servo Motor.	15 Nos
4.	Small Size Breadboard, 10x LED's, Bulb Holder and Plug, Blub, RGB LED, 2x Push buttons, Buzzer, 5v one Channel Relay model, 2N2222 transistor, Diode 1N4148, 10x 330Ω Resistor, 2x 10k Resistors, 2x1k Resistors, 10x Jumper Wires	15 Nos