Vidyalankar Institute of Technology

An Autonomous Institute affiliated to University of Mumbai

Master of Technology

in

Electronics & Telecommunication Engineering

First Year Scheme & Syllabus

(As per AICTE guidelines, with effect from the Academic Year 2022-23)

Preamble

To meet the challenge of ensuring excellence in engineering education, the issue of quality needs to be addressed, debated, and taken forward in a systematic manner. Therefore, autonomy for Vidyalankar Institute of Technology is not merely a transition from pre-cooked syllabi to self-designed curriculum. Autonomy curriculum of the Institute offers required academic flexibility with emphasis on industry requirements and market trends, employability, problem-solving approach and research ability which leads to improving competency level of learners with diverse strengths. In line with this, the curriculum framework designed is **Choice-Based Credit and Grading System (CBCGS)**. Number of credits for courses learnt by learners, internships and dissertation is finalized considering the scope of study and the ability that a learner should gain through the programme.

The curriculum has core courses of engineering, specific to the branch. These courses are completed in first year of the engineering programme that enables learners to work on their chosen dissertation topic during their final year. The curriculum planned by the Institute offer flexibility and diversity to learners to choose any set of courses from a basket of professional electives. Learner can also choose to specialize in a domain as per their field of interest. The selection of unique specialization tracks based on recent developments and industrial requirements is a salient feature of this curricula ensuring employability. Each specialization track has mandatory courses positioned and sequenced to achieve sequential and integral learning for the required depth of the specific domain. Learner can choose to complete these courses in first year of the engineering program that enables him/her to prepare for research during their final year. Credits additional to core and professional elective courses, include dissertation, internships, advanced courses in the field of computer engineering, multi-disciplinary courses, special skill development courses and similar knowledge that make learner capable to do further research or work in industrial environment.

Thus, the academic plan of VIT envisages a shift from summative to formative and competency-based learning system which will enhance learner's ability towards higher education, employability and entrepreneurship.

Chairman, Board of Studies
Department of Electronics & Telecommunication Engineering
Vidyalankar Institute of Technology

Chairman, Academic Council
Vidyalankar Institute of Technology

First Year M. Tech. Electronics and Telecommunication Engineering **Semester: I**

Course Structure and Assessment Guidelines

Course		Head of Learning	Credits	Assessment Guidelines (Marks)				Total marks (Passing@45% of total marks)
Code	Name			ISA	MSE	ESE	Lab Work	
ET71	Advanced Optical Communication Systems	Theory+ Practical	4	40	20	40	25	125
ET72	Wireless Adhoc and Sensor Networks	Theory+ Practical	4	40	20	40	25	125
ETXX	Professional Elective-1	Theory+ Practical	4	40	20	40	25	125
ETXX	Professional Elective-2	Theory+ Practical	4	40	20	40	25	125
OEXX*	Open Elective-1	As per course						

ISA=In Semester Assessment, MSE= Mid Semester Examination, ESE= End Semester Examination
*Selection will be based on the subset of OE courses made available by the Institute for the semester.

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Refer Appendix-A for guidelines on Professional Elective Courses and Specialization Certificate

Professional Elective-1 Courses (ETXX)

Course Code	Course Name	Specialization Track Name#
ET75	OFDM and MIMO Technology	Communication
ET79	Embedded Communication Systems Design	Embedded and IoT
ET83	Sensor Technology and MEMS, NEMS	VLSI

#For details of Specialization Certificate, refer Appendix-A

Professional Elective-2 Courses (ETXX)

Course Code	Course Name	Specialization Track Name#
ET76	Smart Antennas System	Communication
ET80	Reconfigurable Computing and FPGAs	Embedded and IoT
ET84	Analog & Mixed Signal Circuit Design	VLSI

#For details of Specialization Certificate, refer Appendix-A

First Year M. Tech. Electronics and Telecommunication Engineering **Semester: II**

Course Structure and Assessment Guidelines

Course		Head of Learning	Credits	Assessment Guidelines (Marks)				Total marks (Passing@45% of total marks)
Code	Name			ISA	MSE	ESE	Lab Work	
ET73	Advanced Digital Signal Processing	Theory+ Practical	4	40	20	40	25	125
ET74	Software Defined Radio	Theory+ Practical	4	40	20	40	25	125
ETXX	Professional Elective-3	Theory+ Practical	4	40	20	40	25	125
ETXX	Professional Elective-4	Theory+ Practical	4	40	20	40	25	125
OEXX*	Open Elective-2	As per course						

ISA=In Semester Assessment, MSE= Mid Semester Examination, ESE= End Semester Examination
*Selection will be based on the subset of OE courses made available by the Institute for the semester.

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Professional Elective-3 Courses (ETXX)

Course Code	Course Name	Specialization Track Name#
ET77	Passive Optical Networks	Communication
ET81	Smart Sensors and Internet of Things	Embedded and IoT
ET85	VLSI Signal Processing	VLSI

#For details of Specialization Certificate, refer Appendix-A

Professional Elective-4 Courses (ETXX)

Course Code	Course Name	Specialization Track Name#
ET78	Space-Time Wireless Communication	Communication
ET82	High Performance Computing	Embedded and IoT
ET86	Integrated Circuits for Wireless Communication	VLSI

#For details of Specialization Certificate, refer Appendix-A

Detailed syllabus of First Year Semester-I

Course Name: Advanced Optical Communication Systems

Course Code: ET71

Category: Core

Preamble:

The objective of the course is to impart knowledge of Advanced optical system which are used in communication. This will help learners to understand the functioning and implementation of optical systems to enhance data rates and reliability of a communication system.

Pre-requisites:

Applied Physics, Applied Mathematics

Course objectives:

- The objective of this course is to introduce the learners to the fundamental basics and understanding of fiber optical communication.
- This includes the properties of optical fibers and how are they used to establish optical links for communication systems.
- Learners will be able to design an optical link by choosing various parameters and components.

Course Outcomes:

Learner will be able to:

CO1: Apply the knowledge of fundamental transmission characteristics of optical fiber.

CO2: Calculate parameters for optical link budgeting and analyse the link.

CO3: Identify working principles of various components of all optical network.

CO4: Identify issues related to signal degradation due to multiplexing.

CO5: Explore concepts of designing and operating principles of modern optical communication system and network.

Course Scheme:

Contact Hours		**Credits Assigned**	
Theory	Practical	Theory	Practical
3	-	3	1

Evaluation Scheme:

Head of learning	ISA	MSE	ESE	Total
Theory	40	20	40	100
Practical	25	-	-	25

Detailed Syllabus:

Module No.	Module Name	Content	No. of Hours
1	Transmission characteristics of optical fibre	Attenuation, absorption, linear and nonlinear scattering losses, bending losses, modal dispersion, waveguide dispersion, dispersion and pulse broadening, dispersion shifted and dispersion flattened fibers.	9
2	Optical Link	Introduction, Point to point links, system considerations, link power budget, and rise time budget. RF over fiber, key link parameters, Radio over fiber links, microwave photonics.	9
3	Nonlinear Optics	Overview of Non linearities, Stimulated Raman scattering, Stimulated Brillouin scattering, self phase and cross phase modulation, four wave mixing, Solitons, properties of solitons, optical switching, parametric amplification	9
4	Optical network components	Optical Sources (Quantum well lasers), Optical detectors (RCE and RCEPD), RCE avalanche photo diode, Optical amplifiers, WADMA, Optical cross connects.	9
5	Introduction to optical networks	Overview of generations of optical Networks, SONET& SDH: Multiplexing hierarchy, Multiplexing structure – Functional components, Problem detection, Virtual tributaries & containers Optical Transport Network: Hierarchy, Frame structure, Multiplexing	6
6	WDM Network Design	Cost Trade-offs: A detailed Ring Network example, LTD and RWA Problems, Routing and Wavelength assignment Dimensioning wavelength networks, Statistical wavelength routing networks- First passage model, Blocking model Maximum load dimensioning models- offline Lightpath request, online RWA in Rings	3
Total			**45**

Suggested list of Practicals:

1. Performance analysis of optical link in presence of group velocity dispersion
2. Performance Analysis of Optical Link with Different Sources
3. Performance Analysis of Optical Link with Different Detectors
4. Performance Analysis of Soliton Communication System
5. Effect of cross phase modulation on WDM system
6. Mitigation of Four wave mixing by NZ-DSF fiber
7. Performance Analysis of Optical Amplifier
8. Performance Analysis of DWDM System

Text Books:

1. JM Senior, "Optical fiber communication", 3rd Edition, Pearson Education 2009
2. GP Agarwal, "Nonlinear fiber optics", 2nd Edition, Pearson Education 2013

Reference Books:

1. Uyless Black, "Optical networks, third generation transport systems", 2nd Edition, Pearson,

Course Name: Wireless Adhoc and Sensor Networks

Course Code: ET72

Category: Core

Preamble:

This course aims to develop fundamental concepts of Wireless Adhoc and Sensor Networks

Pre-requisites:

Computer Communication Networks – Strongly Related

Course Objectives:

- The aim of this course is to let the learners
- To understand the Wireless adhoc and sensor Network.
- To understand the major challenges and designing issues in designing wireless sensor and adhoc networks.
- To understand various MAC and routing protocols in wireless sensor and adhoc networks.
- To Understand Heterogeneous network architecture including MANET, WLAN, Cellular Networks.

Course Outcomes:

Learner will be able to:

CO1: Understand and explain the concept of adhoc and sensor networks and their applications.
CO2: Set up and evaluate performance of various protocols in wireless sensor and adhoc networks.
CO3: Understand TCP Performance over adhoc network.
CO4: Understanding integration of MANET, Cellular network and WAN

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
3	-	3	1

Evaluation Scheme:

Head of Learning	ISA	MSE	ESE	Total
Theory	40	20	40	100
Practical	25	-	-	25

Detailed Syllabus:

Module No.	Module Name	Content	No. of Hours
1	Introduction	Challenges and Applications of MANET, Design issues and application of sensor Network, Sensing and Communication Range, Energy and Clustering of sensors, Wireless mesh Network, Architecture and Challenging technologies.	9
2	Routing in Adhoc networks	Introduction, Topology-Based versus Position-Based Approaches, Topologies-Based Routing Protocols, Position- Based Routing, Other Routing Protocols, Wireless LAN, Wireless PAN, Wireless BAN.	9
3	Broadcasting, Multicasting, Geocasting and QoS in MANET	Introduction, The Broadcast Storm, Multicasting, Geocasting, QOS requirements, objectives and Architecture	9
4	TCP over Adhoc Networks	Introduction, TCP Protocol Overview, TCP and MANETs, Solutions for TCP over Adhoc.	9
5	Design consideration in Sensor Network	Cognitive Radio based sensor Networks. Nano Sensor Networks.	5
6	Integrating MANET'S, WLAN and cellular networks	Introduction, Ingredients of a Heterogeneous Architecture, Protocol Stack, Comparison of the Integrated Architectures.	4
Total			**45**

Suggested List of Value-Added Home Assignments:

1. Reviewing Literature in the form of a technical paper on Adhoc networks

Suggested list of Practicals:

1. Study and Implementation of technical paper from the reputed Journal related to Adhoc and Wireless Sensor Networks by using any Simulator/tool. Or implementing one hardware project related to WSN.
2. Implementation /Simulation of any two Routing Protocols in Adhoc Networks.
3. Implementation /Simulation of any two Routing Protocols in Wireless Sensor Networks.
4. Implementation /Simulation of any two MAC Protocols in Wireless Sensor Networks.

Recommended Online Courses:

Coursera – https://www.coursera.org/search?query=wireless%20sensor%20network&

Reference Books:

1. Adhoc & Sensor Networks Theory and Applications by Cordeiro, Agrawal, Cambridge University Press India Pvt. Ltd, Edition 2010.
2. Adhoc Wireless Networks Architecture and Protocols by C.Siva Ram Murthy and B.S.Manoj, Pearson.
3. Adhoc & Sensor Networks by Houda Labiod, Wiley.
4. Wireless and Mobile Networks, Concepts and Protocols by Manvi, Kakkasageri, second edition, Wiley.

Course Name: OFDM and MIMO Technology

Course Code: ET75

Category: Professional Elective

Preamble:

This course introduces the fundamental issues, concepts, and design principles in "orthogonal frequency-division multiplexing" (OFDM) communications – modulation, demodulation, synchronization, peak-to-average power ratio (PAPR) reduction. This course also introduces the fundamental issues, concepts, and design principles in "multiple-input multiple-output" (MIMO) wireless communications – MIMO channel model, antenna diversity, space-time coding, MIMO detection algorithms.

Pre - requisites:

1. Digital Communications – Strongly Related
2. Digital Signal Processing- Strongly Related
3. Probability– Weakly Related
4. Linear Systems- Weakly Related

Course Objectives:

The main objective of the course is to

- To make learners familiar with fundamentals of wireless communication systems.
- To understand the diversity and spatial multiplexing phenomenon in MIMO system.
- To understand the receiver system design for MIMO.
- To become familiar with OFDM and MIMO-OFDM systems.

Course Outcomes:

Learner will be able to:

CO1: To understand OFDM's transceiver architecture.
CO2: To understand the problem of PAPR and how to reduce the PAPR.
CO3: To understand how the OFDM receiver performs synchronization and the adverse effects of mis-synchronization.
CO4: To understand MIMO channel models and space-time coding.
CO5: To understand the concept and methods of diversity reception.

Course Scheme:

Contact Hours		**Credits Assigned**	
Theory	Practical	Theory	Practical
3	2	3	1

Evaluation Scheme:

Head of Learning	ISA	MSE	ESE	Total
Theory	40	20	40	100
Practical	25	-	-	25

Detailed Syllabus:

Module No.	Module name	Content	No. of Hours
1	OFDM Basics	Multi-carrier transmission; OFDM modulation & demodulation, BER; coded-OFDM; Orthogonal frequency-division multiple-access (OFDMA).	9
2	OFDM Synchronization	Effect/estimation of symbol-time offset (STO); Effect/estimation of carrier-frequency offset (CFO); Effect/compensation of sampling clock offset (SCO).	9
3	Peak-to-Average Power Ratio Reduction (PAPRR)	Distribution of OFDM-signal amplitude; PAPR & oversampling; Mitigation methods: clipping & filtering, selective mapping (SLM), partial transmit sequence (PTS), tone reservation (TR), tone injection (TI), etc.	9
4	Multiple-Input Multiple-Output (MIMO) Channel Models	Small-scale vs. large-scale fading; time-dispersive vs. frequency-dispersive fading; Spatial correlation.	9
5	Antennas Diversity	Receive-antenna diversity; Transmit-antenna diversity.	4
6	Spatially Multiplexed MIMO Systems	Space-time Coding, Detection for Spatially Multiplexed MIMO Systems	5
Total			**45**

Suggested List of Value-Added Home Assignments:

1. Reviewing Literature in the form of a technical paper based on the capstone project.
2. Novel technical paper writing based on the capstone project.

Suggested List of Practicals:

1. Inter Carrier Interference (ICI) mitigation in OFDM system.
2. Study and analysis of peak to average power ratio (PAPR) reduction schemes in OFDM system
3. Study and analysis of peak to average power ratio (PAPR) using SC-FDMA
4. Channel estimation schemes for OFDM system

5. Study and analysis of beamforming schemes for MIMO system
6. Study and analysis of diversity schemes for MIMO system
7. Implementation of SFBC-OFDM
8. Implementation of antenna selection schemes for MIMO system
9. Study and analysis of channel estimation schemes for MIMO system
10. Estimation of angle of arrivals in MIMO system

Recommended Online Courses:

1. Principles of Modern CDMA MIMO OFDM Wireless Communications Offered by IIT Kanpur – https://onlinecourses.nptel.ac.in/noc19_ee49/preview
2. Introduction to Wireless Communications offered by Yasir Ahmed on Udemy - https://www.udemy.com/course/introduction-to-wireless-communications/
3. Matlab course for wireless communication engineering offered by Khaled Ramadan on Udemy- https://www.udemy.com/course/matlab-course-for-wireless-communication-engineering/

Reference Books:

1. MIMO-OFDM Wireless Communications with MATLAB , by Yong Soo Cho, Jaekwon Kim, Won Young Yang, Chung-Gu Kang , Wiley, 2010, ISBN: 978-0-470-82561-7
2. Mohinder Janakiram, "Space time Processing and MIMO systems", Artech House, First Edition, 2004
3. Arogyaswami Paulraj, Rohit Nabar, Dhananjay Gore, "Introduction to Space-Time Wireless Communications", Cambridge University Press, 2008.
4. Hamid Jafarkhani, "Space Time coding-Theory and Practice", Cambridge University Press, First Edition, 2005.
5. Branka Vucetic, Jinhong Yuan, "Space Time coding", John Wiley and Sons, First Edition, 2003.
6. Andrea Goldsmith, "Wireless Communication", Cambridge University Press, First Edition. 2005.
7. David Tse, Pramod Viswanath, "Fundamentals of Wireless Communication", Cambridge University Press, 2005.

Course Name: Embedded Communication Systems Design

Course Code: ET79

Category: Professional Elective

Preamble:

To understand the concepts of embedded systems and its applications in Internet of Things.

Pre-requisites:

1. Microcontrollers
2. Digital Communication protocols.

Course Objectives:

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

- Perform effectively as entry level Embedded Systems professionals.
- Develop and maintain applications written using Embedded C.
- Independently design and develop a hardware platform encompassing a microcontroller and peripherals

Course Outcomes:

Learner will be able to:

CO1: Understand the embedded concepts and design approach for embedded systems.
CO2: Understand the hardware and software trade off for design of embedded systems.
CO3: Use microcontroller boards and framework for design of embedded systems.
CO4: Apply standard communication protocols for design of embedded systems
CO5: Use muti core processor for design of embedded systems.
CO6: Design embedded system with RTOS.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
3	2	3	1

Evaluation Scheme:

Head of Learning	ISA	MSE	ESE	Total
Theory	40	20	40	100
Practical	25	-	-	25

Detailed Syllabus:

Module no.	Module Name	Content	No. of Hours
1	Overview of Product Design for Embedded Systems	Embedded systems, Need, design challenges, product survey, specifications of product need of hardware and software, partitioning of the design into its software and hardware components, iteration and refinement of the partitioning	8
2	Software and Hardware for Design	Trade-offs, custom single-purpose processors, general-purpose processors, memory, interfacing, design technology-hardware design, cost reduction, re-engineering, optimization, maintenance, validation and development, prototyping, turnkey product design	8
3	ARM Architecture and technologies for Embedded Systems	Embedded concepts, architecture of embedded systems, ARM architecture, Cortex-M3 basics, exceptions, instruction sets, NVIC, interrupt behaviour, Cortex-M3/M4 programming, memory protection unit and other Cortex-M3 features, STM32xxx ARM Cortex M3/M4 microcontroller memory and peripherals, development & debugging tools	9
4	Embedded Systems Communication and Security	Communication protocols for embedded systems, Embedded systems security and secured hardware structures, Communications security in embedded systems.	9
5	Multi core Architecture	Multi-Core architecture for embedded systems, Programming models for Multi-Core, Embedded Multi-Core processing for networking.	4
6	Open Source RTOS for System Design	Basics of RTOS: Real-time concepts, Hard Real time and Soft Real-time, differences between general purpose OS & RTOS, basic architecture of an RTOS, scheduling systems, interprocess communication, performance Matric in scheduling models, interrupt management in RTOS environment, memory management, file systems, I/O systems, advantage and disadvantage of RTOS. POSIX standards, RTOS issues – selecting a Real Time Operating System, RTOS comparative study.	7
Total			**45**

Recommended Online Courses:

1. Embedded Systems Programming on ARM Cortex-M3/M4 Processor: https://www.udemy.com/course/embedded-system-programming-on-arm-cortex-m3m4/
2. Master Microcontroller and Embedded Driver Development(MCU1): https://www.udemy.com/course/mastering-microcontroller-with-peripheral-driver-development/

Suggested List of Practicals:

1. Comparative study of customized microcontroller boards.
2. Interface output devices with ARM controller.
3. Interface input devices with ARM controller.
4. Implement serial communication using UART with ARM controller for embedded application.
5. Implement serial communication using SPI with ARM controller for embedded application.
6. Implement serial communication using I2C with ARM controller for embedded application.
7. Comparative study of security techniques for embedded application.
8. Implement security for embedded application.
9. Comparative study of RTOS for embedded application.
10. Comparative study of scheduling algorithms of RTOS.
11. Implement embedded application using RTOS.
12. Comparative study of multi core architecture and software framework
13. Mini Project based on design of embedded systems for communication based application.
14. Mini project based on design of embedded systems for Internet of Things (IoT) application.

Reference Books:

1. The Definitive Guide to the ARM Cortex-M3, Joseph Yiu, Second Edition, Elsevier Inc. 2010.
2. Andrew N Sloss, Dominic Symes, Chris Wright, "ARM System Developer's Guide - Designing and Optimizing System Software", 2006, Elsevier.
3. Communicating Embedded Systems: Networks Applications, Francine Krief (Editor) February 2010, Wiley-ISTE.
4. Frank Vahid and Tony Givargis, "Embedded System Design: A Unified Hardware/Software Introduction", John Wiley publication.
5. P Marwedel, "Embedded System Design", Springer publication.

Course Name: Sensor Technology and MEMS, NEMS

Course Code: ET83
Category: Professional Elective

Preamble:
This course Explore different MEMS Processing steps and modules. It also provides the knowledge of MEMS materials as per the application.

Pre-requisites:

1. Basic Electrical and Electronics Engineering. – Strongly Related
2. Electronic Devices and Circuits - Strongly Related.
3. Microelectronics- Strongly Related
4. Analog IC Design- Strongly Related

Course Outcomes:

Learner will be able to:
CO1: To provide knowledge of MEMS processing steps and processing modules
CO2: To provide knowledge of MEMS Materials with respect to applications.
CO3: To demonstrate the use of semiconductor based processing modules used in the fabrication of variety of sensors and actuators (e.g. pressure sensors, accelerometers, etc.) at the micro-scale
CO4: To provide an understanding of basic design and operation of MEMS sensors, actuators and structures.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
3	2	3	1

Evaluation Scheme:

Head of Learning	ISA	MSE	ESE	Total
Theory	40	20	40	100
Practical	25	-	-	25

Detailed Syllabus:

Module no.	Module Name	Content	No. of Hours
1	Introduction to MEMS	Introduction to MEMS, Comparison with Micro Electronics Technology, Real world examples (Air-Bag, DMD, Pressure Sensors), MEMS Challenges, MEMS Sensors in Internet of Things (IoT), Bio-medical applications	9
2	MEMS Materials and Their Properties	Important properties: Young modulus, Poisson's ratio, density, piezoresistive coefficients, TCR, Thermal Conductivity, Material Structure Materials (eg. Si, SiO2, SiN, SiC, Cr, Au, Al, Ti, SU8, PMMA, Pt)	9
3	MEMS Sensors, Actuators and Structures	MEMS Sensing (Capacitive, Piezo electric Piezo resistive) Micro Actuation Techniques (Thermal, Piezo electric, Electro static, Shape Memory Alloys, LORENTZ FORCE ACTUATION), Micro Grippers, Micro Gears, Micro Motors, Micro Valves, Micro Pumps	9
4	MEMS Fab Processes	MEMS Processes & Process parameters: Bulk & Surface Micromachining, High Aspect Ratio Micro Machining (LIGA, Laser), X-Ray Lithography, Photolithography, PVD techniques, Wet, Dry, Plasma etching, DRIE, Etch Stop Techniques. Die, Wire & Wafer Bonding, Dicing, Packaging(with Metal	9
5	MEMS Devices	Architecture, working and basic behaviour of Cantilevers, Micro heaters, Accelerometers, Pressure Sensor types, Micromirrors in DMD, Inkjet printer-head. Steps involved in Fabricating above devices	6
6	MEMS Device Characterization	Piezo-resistance, TCR, Stiffness, Adhesion, Vibration, Resonant frequency, & importance of these measurements in studying device behaviour .	3
Total			**45**

Text Books:

1. Tai Ran Hsu," MEMS and MICROSYSTEMS Design and Manufacture", 2nd Edition, McGraw-Hill, 2002.
2. N. Maluf, K Williams," An Introduction to Micro-electromechanical Systems Engineering", 2nd Edition, Artech House Inc, 2004.

Recommended Online Courses:

1. MEMS &MICROSYSTEM By Prof. Santiram Kal | IIT Kharagpur.

Reference Books:

1. Ville Kaajakari ," Practical MEMS ", Small Gear Publishing , 2009.

Course Name: Smart Antennas System

Course Code: ET76

Category: Professional Elective

Preamble:

This course aims to develop fundamental concepts of smart technology used in radiating systems and use of algorithms to make antennas smart.

Pre-requisites:

1. Electromagnetics and Antenna – Strongly Related
2. RF and Microwave Engineering – Strongly Related
3. Wireless Mobile Cellular Communication – Strongly Related

Course Objectives:

- To understand the fundamentals of Smart Antennas system
- Study different antenna arrays and algorithms
- Estimate the signal strength and direction

Course Outcome:

Learner will be able to:

CO1: Understand the fundamental concept of smart antenna technology
CO2: Study the operation of adaptive antenna array systems and algorithms
CO3: Analyse and estimate the direction of arrival of signal
CO4: valuate the requirement of the design and implementation of smart antenna system

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
3	2	3	1

Evaluation Scheme:

Head of Learning	ISA	MSE	ESE	Total
Theory	40	20	40	100
Practical	25	-	-	25

Detailed Syllabus:

Module No.	Module Name	Content	No. of Hours
1	Introduction	Introduction to smart antenna technology, need for smart antennas, configurations, SDMA access, architecture of smart antenna system, benefits and drawbacks, Mutual coupling effects, types of smart antennas, phased array antenna, optimal and adaptive antennas	8
2	Fixed Beam Smart Antennas	Beamforming principle: Classic beam forming, broadside and end fire arrays, significance of number of elements, Planar systems, Butler matrix, spatial filtering, switched beam system, multiple fixed beam systems, adaptive cell sectorization beam forming networks, Sidelobe effects, Minimum mean square error, direct matrix inversion techniques	8
3	Adaptive Antenna array system	Spatial processing, Adaptive arrays, Signal environment, consideration of array element spacing, performance of arrays, array effects, null limitations, broadband array processing	8
4	Adaptive Algorithms	Adaptive algorithms for beam forming – Least mean square (LMS0, Recursive Least Square (RLS), Constant modulus, Quasi Newton algorithms, Digital Software radios, Optimal spatial filtering algorithm for CDMA system, Neural network approach	8
5	Estimation of signal	DOA estimation fundamentals, array response vector, received signal model, sub space based data model, autocovariance matrices, conventional methods of estimation, source localization problem, joint angle and delay estimation	8
6	MIMO Receivers	Smart antenna applications, smart antennas for CDMA, smart antenna configurations, mobile communication with smart antennas, space time processing, space time beam forming, intersymbol and co channel suppression techniques, capacity and data rates in MIMO systems	5
Total			**45**

Recommended Online Courses:

1. Wireless Communication for Everybody – Coursera – https://www.coursera.org/learn/wireless-communications

Suggested List of Practical:

1. Study of Beam Forming Algorithm
2. Study of Received signal strength determination using single wire antenna and antenna arrays
3. Estimation of Antenna Directivity for single patch antenna and patch antenna array
4. Determination of polarization of the sample antenna
5. Study and analysis of beamforming schemes for MIMO system
6. Study and analysis of diversity schemes for MIMO system
7. Implementation of antenna selection schemes for MIMO system
8. Study and analysis of channel estimation schemes for MIMO system
9. Estimation of angle of arrivals in MIMO system

Reference Books:

1. Smart Antennas – L. C. Godara, CRC Press
2. Smart Antennas for Wireless Communication – T. S. Rappaport and J Liberti, Prentice Hall
3. Radiowave propagation and Smart antennas for wireless communication – R. Janaswamy, Kluwer, 2001
4. Smart Antennas – T. K. Sarkar, Michel Wicks, M S Palma, Robert Bonneau, Wiley Publication, 2005
5. Robust Adaptive Beamforming – Jian Li, Petre Stoica, Wiley Publication, September 2005.
6. Smart Antennas with MATLAB – 2nd Edition, Frank Gross, McGraw Hill Publication

Course Name: Reconfigurable Computing and FPGAs

Course Code: ET80

Category: Professional Elective

Preamble:

This course introduces learners about Profound understanding of Hardware Descriptive Language like VERILOG. Learners will understand the working of Complex Programmable logic devices like FPGA and will be able to design and implement various Combinational and Sequential circuits.

Pre – Requisites:

1. Basic Electrical and Electronics Engineering. – Strongly Related
2. Electronic Devices and Circuits - Strongly Related.
3. Digital System Design- Strongly Related

Course Objectives:

- Learners will gain fundamental knowledge and understanding of the principles and practice in reconfigurable architecture and computing through class lectures and discussions, reading assignments, homework, lab experiments, and a project.

Course Outcome:

Learner will be able to:
1. Understand various abstraction levels in Verilog HDL.
2. Design finite state machine using D and JK Flip Flop
3. Design the complex combinational and sequential logic circuits using various constructs in Verilog.
4. Understand programmable logic devices and various blocks exist in FPGA.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
3	2	3	1

Evaluation Scheme:

Head of Learning	ISA	MSE	ESE	Total
Theory	40	20	40	100
Practical	25	-	-	25

Detailed Syllabus:

Module No.	Module Name	Content	No. of Hours
1	Verilog HDL – Data Flow & Structural Modeling	Lexical Conventions - Ports and Modules – Operators - Gate Level Modeling - Data Flow Modeling - System Tasks & Compiler Directives - Test Bench.	8
2	State Machine Design	Definition of state machines -State machine as a sequential controller- Analysis of state machines using D and JK flip-flops - Design of state machines- State table and State assignment Transition/excitation table - excitation maps and equations - logic realization- Design examples: Sequence detector, Serial adder, Vending machine.	8
3	Verilog HDL – Behavioral Modeling	Behavioral level Modeling- Procedural Assignment Statements- Blocking and Non-Blocking Assignments - Tasks & Functions - Useful Modeling Techniques.	8
4	Verilog Modeling of Combinational	Behavioral, Data Flow and Structural Realization of Adders and Multipliers	6
5	Verilog Modeling of Sequential Circuits	Synchronous and Asynchronous FIFO – Single port and Dual port ROM and RAM - FSM Verilog modeling of Sequence detector - Serial adder - Vending machine	6
6	FPGA Architecture	Types of Programmable Logic Devices: PLA, PAL, CPLD - FPGA Architecture – Programming Technologies- Chip I/O- Programmable Logic Blocks- Fabric and Architecture of FPGA. Xilinx Virtex 5.0 Architecture - Xilinx Virtex VI Architecture – ALTERA Cyclone II Architecture - ALTERA Stratix IV Architecture.	9
Total			**45**

Recommended Online Courses:

1. Digital IC Design.IIT Madras By Jankiraman veeraghavan.
   https://nptel.ac.in/courses/108/106/108106158/

Suggested List of Mini-Project

Design and implement a circuit on the DE2-115 board that acts as a time-of day clock. It should display the hour (from 0 to 23) on the 7-segment displays HEX7−6, the minute (from 0 to 60) on HEX5−4 and the second

Text Books:

1. Samir Palnitkar, "Verilog.HDL", 2nd Edition, Pearson Publication, 2003.
2. Frank Vahid, "Digital Design with RTL design VHDL and VERILOG", Wiley, 2011.
3. Ming-Bo Lin, " Digital Systems Design and Practice: Using Verilog HDL and FPGAs", Create Space Independent Publishing Platform, 2nd Edition 2015.

Reference Books:

1. Charles H Roth Jr, Lizy Kurian John and Byeong Kil Lee, " Digital Systems Design using Verilog", 1st Edition ,Cengage Learning, 2016.

Course Name: Analog Mixed signal circuit design.

Course Code: ET84

Category: Elective

Preamble:

This course introduces students Importance of Mixed signal VLSI Design in the field of Electronics and telecommunication. Methodologies for analysis and designing of fundamental CMOS Mixed signal circuits.

Pre-requisites:

1. Basic Electrical and Electronics Engineering.
2. Electronics circuits and Devices.
3. Circuit Theory.
4. Microelectronics.
5. Digital VLSI Design.

Course Objectives:

- To understand the issues in designing and layouts of Mixed Integrated circuits.
- To understand the designing of various Integrated circuit biasing circuits.
- To understand the concept of Active load amplifier and its implementation.
- To understand the designing of two stage operational amplifier circuits.
- To understand the working concepts of various data converter circuits.

Course Outcomes:

Student will be able to:

1. Students will be able to **remember & understand** the trade-offs involved in Analog VLSI Circuits.
2. Students will be able to **analyse** building blocks of CMOS Analog VLSI circuits.
3. Students will be able to **evaluate** the values of different circuit components while design CMOS Analog VLSI circuits.
4. Students will be able to **create** a mixed signal system for a given specification.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
3	2	3	2

Assessment Guidelines:

Head of learning	ISA	MSE	ESE	Total
Theory	40	20	40	100

The assessment guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module no	Module name	Content	No of Hours
1	Active Load MOS Differential Amplifier:	Small Signal equivalent Analysis of MOS Active load Differential Amplifier. MOS Differential Amplifier with Cascode active load.	9
2	Design of MOS Operational Amplifiers	General consideration, one stage Op Amps, Two stage Op Amps, Gain Boosting, Input Range Limitation. Frequency Response and Compensation, Slew Rate	9
3	Noise:	Statistical Characteristics of Noise. Types of Noise Thermal and Flicker. Representation of Noise in circuits noise in common source amplifier stage. Noise in differential pairs. Noise Bandwidth.	9
4	Oscillators and Phase Locked Loops	General consideration, Ring oscillators,LC Oscillators,VCO,tunning range,tunning linearity. Mathematical Model of VCO. Simple PLL phase detector, Charge pump PLL'S Non ideal effects in PLL,Delay locked loops, application of PLL.Introduction to Switch capacitor circuits.	6
5	Data Converters	Analog versus digital discrete time signals, converting analog signals to data signals, sample and hold characteristics. DAC specifications, ADC specifications. Mixed signal layout issues, Floor planning, Power supply and ground issues, other interconnect consideration.	6

6	Data Converter Architectures	DAC architectures, digital input code, resistors string, R-2R ladder networks, current steering, charge scaling DACs, Cyclic DAC, pipeline DAC, ADC architectures, flash, 2-step flash ADC, pipeline ADC, integrating ADC, and successive approximation ADC	6
Total			**45**

Guidelines to conduct practical sessions:

1. Practical's will be conducted using Software tools.

Students must design the circuit for given problem and then simulate using software tools like LT-SPICE, CADENCE and verify the results.

Suggested List of Practical's.

Practical No.	Title of the Regular Experiments
1	Implementing MOSFET as a sampling switch
2	Implementing and simulating passive load differential amplifier using MOSFET.
3	Implementing and simulating ACTIVE load differential amplifier using MOSFET
4	Implementing and simulating Two stage operational amplifier using MOSFET
5	Designing and implementing MOS CS amplifier Finding its Noise Figure.
6	Designing and implementing MOS CG amplifier and Finding its Noise figure.
7	Designing and implementing differential amplifier and finding its Noise figure.

Textbooks:

1. Design of Analog CMOS Integrated Circuits,B. Razavi McGraw Hill
2. CMOS Circuit Design, Layout, Stimulation Harry W. Li and David E Boyce PHI Edn
3. CMOS Analog Circuit Design",P.E.Allen and D R Holberg Oxford University Press
4. Analysis and design of Analog Integrated Circuits Gray, Meyer, Lewis and Hurst, Willey International.

Reference Books:

1. Analysis and design of Analog Integrated Circuits, Gray, Meyer, Lewis and Hurst Willey International, 4th Edition, 2002

Detailed Syllabus of First Year Semester - II

Course Name: Advanced Digital Signal Processing

Course Code: ET73

Category: Core

Pre-requisites:

1. Signals and Systems – Strongly Related
2. Digital Signal Processing – Strongly Related
3. Mathematical Concepts like Vector Spaces, Probability, and random processes- Strongly Related
4. Linear Vector Spaces – Weakly Related

Course Objectives:

At the completion of this course, the learner should have in depth knowledge of processing digital signals.

Course Outcomes:

Learner will be able to:

CO1: Understand the basics of analysing discrete random signals and its characterization
CO2: Understand linear predictors and implementation using lattice structures
CO3: Understand Weiner filtering
CO4: Understand the working mechanism of adaptive signal processing
CO5: Understand the implementation of adaptive filtering using LMS and RLS algorithms

Course Scheme:

Contact Hours		**Credits Assigned**	
Theory	Practical	Theory	Practical
3	2	3	1

Evaluation Scheme:

Head of Learning	**ISA**	**MSE**	**ESE**	**Total**
Theory	40	20	40	100
Practical	25	-	-	25

Detailed Syllabus:

Module No.	Module Name	Content	No. of Hours
1	Introduction to Discrete random process	1. Concept of Random Process 2. Concept of Discrete random process and its characteristics 3. Characterization of white noise random process Innovation Process	4
2	Linear prediction and Optimum filtering	1. Forward and Backward linear Predictions 2. Solution of the Normal equations 3. AR, MA and ARMA models Lattice and Lattice-Ladder structures	6
3	Weiner Filtering	1. Types of Estimations 2. Optimization methods 3. FIR and IIR Weiner filters Non-Causal Wiener Filters	9
4	Adaptive systems	1. Concept of adaptive filtering 2. Linear Adaptive combiner Applications of Adaptive filters	9
5	Least Mena Square (LMS)	1. Error Criterion 2. LMS Algorithm 3. Related Stochastic Gradient Algorithm Properties of LMS	9
6	Root Least square (RLS)	1. RLS Algorithm 2. The LDU decomposition Factorization and square root Algorithm 3. Fast RLS Algorithm Properties of RLS Algorithm	8
Total			**45**

Recommended Online Courses:

1. https://nptel.ac.in/courses/117/105/117105075/
2. https://www.coursera.org/lecture/dsp2/2-3-2-a-optimal-least-squares-7FBnV

Reference Books:

1. Oppenheim A., Schafer R., Buck J., "Discrete Time Signal Processing", 2nd Edition, Pearson Education.
2. Proakis J., Manolakis D., "Digital Signal Processing", 4th Edition, Pearson Education.
3. Simon Haykin, Adaptive Filter Theory, 2nd Edition, John Wiley
4. A. H. Sayed, Adaptive filters,1st Edition, Wiley Learner.

Course Name: Software Defined Radio

Course Code: ET74

Category: Core

Preamble:

The objective of this course is to provide knowledge of fundamental and state-of the art concepts in software defined radio**.**

Pre-requisites:

1. Analog Communication– Strongly Related
2. Digital Communication– Strongly Related
3. Digital signal processing – Weakly Related

Course Objective:

The basic objective of this Software Defined Radio (SDR) training program is to equip technology professionals with —

- Thorough knowledge of the basic concepts of Software Defined Radio
- The confidence and knowledge to train team members on concepts of Software Defined Radio
- The capacity to secure a leading edge for your organisation in the Software Defined Radio market space

Course Outcomes:

Learner will be able to:

CO1: Make system-level decisions for software defined radio technology and products.
CO2: Understand analog RF components as front-end block in implementation of SDR.
CO3: Apply knowledge of digital hardware architectures and understanding of developmental methods.
CO4: Design circuits at different multirate signaling technique for frequency conversion and sampling issues.
CO5: Apply knowledge of software development methods for embedded wireless systems.
CO6: Understand ADC and DAC technology.
CO7: Implement smart antenna algorithms.
CO8: Implement modern wireless system such as systems based on OFDM.
CO9: Create an awareness of current industry trends networks.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
3	2	3	1

Evaluation Scheme:

Head of Learning	ISA	MSE	ESE	Total
Theory	40	20	40	100
Practical	25	-	-	25

Detailed Syllabus:

Module No.	Module Name	Contents	No. of Hours
1	Introduction to SDR Radio frequency implementation Issues	The Need for Software Radios, What Is a Software Radio? Characteristics and Benefits of a software radio, Design principles of software radio. The purpose of the RF Front-End, Dynamic Range, The principal challenges of receiver design, RF receiver, Front-End Topologies, Enhanced flexibility of the RF chain with software radios, Importance of the components to overall performance, Transmitter architectures and their issues, Noise and Distortion in the RF chain.	10
2	Digital generation of signals	Introduction, Comparison of Direct Digital Synthesis (DDS) with analog signal synthesis, Approaches to direct digital synthesis, Analysis of spurious signals, Spurious components due to periodic jitter, Bandpass signal generation, Performance of direct digital synthesis, Hybrid DDS-PLL systems, Applications of DDS, Generation of random sequence, ROM compression techniques	8
3	Multirate signal processing	Introduction, Sample rate conversion principles, Polyphase filters, Digital filter banks, Timing recovery in digital receivers using multirate digital filters.	8
4	Analog to Digital and Digital to Analog conversion	Parameter of ideal data converters, Parameters of practical data converters, Techniques to improve data converter performance, common ADC and DAC architectures.	5
5	Smart Antennas	Vector channel modeling, Benefits of smart antennas, Structures of beam forming systems, Smart antenna algorithms, Diversity and Space-Time adaptive signal processing (STAP), Algorithms for transmit STAP,	4

		Hardware implementation of smart antennas, Array calibration	
6	"Digital Hardware Choices Object –oriented representation of radios and network resources	Introduction, Key hardware elements, DSP Processors, FPGA, Trade-offs in using DSPs, FPGAs, and ASICs, Power management issues, Using a combination of DSPs FPGAs, and ASICs. Networks, Object-oriented programming, Object broker, Mobile application environments, Joint tactical radio system	10
Total			**45**

Suggested List of Case study:

1. Introduction and a Historical perspective
2. SPEAK easy
3. JRTS
4. Wireless information transfer system
5. SDR-3000 digital transceiver subsystem
6. Spectrum wave
7. CHARIOT

Suggested List of Value-Added Home Assignments:

2. Case Studies
3. Handwritten Assignment

Recommended Online Courses:

2. Fundamentals of SDR, Software Defined Radio -An Introduction on Udemy https://www.udemy.com/course/rahsoft-software-defined-radio-sdr-training-online-course-rahsdr480/
3. Software Defined Radio and Signal Processing with GNU Radio on Udemy - https://www.udemy.com/course/mastering-software-defined-radio-with-gnu-radio-companion/

Reference Books

1. Jeffery H.Reed, "Software Radio, (A modern approach to radio engineering)", PHI PTR, 2002.
2. John J. Rouphael, "RF and Digital Signal Processing for Software Defined Radio" Elesiver, Newness Publications.
3. B.G.Golderg, "Digital Techniques in Frequency Synthesis", McGraw-Hill, 1996.
4. N.J.Fliege, " Multirate Signal Processing", John Wiley and sons , 1994.

Course Name: Passive Optical Networks

Course Code: ET77

Category: Professional Elective

Preamble:

This course introduces the participants to understand the optical fiber communication system, issues related to signal degradation due to linear impairment, High data rate WDM optical transport networks, Link budget and optical networks, design and Management.

Pre-requisites:

Optical Fiber Communication, Electromagnetic wave propagation

Course Objectives:

- Exposure to fundamentals of Fiber Optics and fiber optic based components used in optical networks.
- Understand the technology behind long distance optical communication; light guiding mechanism and physical characteristics of light propagation in optical fibers.
- Provide a thorough understanding of the fundamental principles of Optical networks covering network architecture, network design and protection along with details of OTN and PON

Course Outcomes:

Student will be able to:

CO1: Identify the issues related to signal degradation and multiplexing.
CO2: Explore concepts of designing and operating principles of modern optical communication systems and networks.
CO3: Apply the knowledge developed in-class to contemporary optical fiber communication research and industrial areas.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
3	2	3	1

Assessment Guidelines:

Head of learning	ISA	MSE	ESE	Total
Theory	40	20	40	100
Practical	25	-	-	25

The assessment/evaluation guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to decide her/his assessment methodology based on the nature of the course. Faculty may propose the revised assessment methodology for his/her course. However, the revised assessment methodology shall be approved by a panel constituted at institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Content	No. of Hours
1	Introduction to Optical Components	Optical Components - Couplers, Isolators and Circulators, Multiplexes and Filters Optical Amplifiers. Transmitters, Detectors, Switches, Wavelength Converters, Solitions, Optical Modulators	6
2	SONET/SDH	Layered architecture for SONET/SDH & data rates, Network Survivability: Protection in SONET/SDH Point-to-Point Links, Self-Healing Rings, Unidirectional Path-Switched Rings , Bidirectional Line-Switched Rings.	10
3	WDM Network Elements	Introduction to DWDM & CWDM, Optical Line Terminals, Optical Line Amplifiers, Optical Add/Drop Multiplexers, OADM Architectures, Optical Crossconnects.	10
4	PON & Photonic Packet Switching	Passive Optical Networks, Fiber to the X. Optical Time Division Multiplexing & Demultiplexing, Bit Interleaving Packet Interleaving, Optical AND Gates, Synchronization Tuneable Delays, Optical Phase Lock Loop, Header Processing, Buffering, Burst switching, Intensity modulation and direct detection, External modulation, Radio over fiber technology	10
5	Network Reliability and Protection	Standard protection and restoration, rings, mesh topologies; SONET/SDH, Next Generation SONET, Fast reroute, Resilient Packet Rings; Generalizations: Quality of protection, network coding, protecting path segments, p-cycles	5
6	Different Optical Networks	Network Architecture Overview, Enhanced HFC, Fiber to the Curb (FTTC), Different architecture of passive optical networks, Bidirectional optical networks, PON evolution	4
Total			**45**

Reference Books:

1. Sivarajan and Rajiv Ramaswamy, Morgan Kauffman, Optical Networks: A Practical Perspective, Elsevier Publication Elsevier India Pvt. Ltd, 3rd Edition, 2010.
2. Harry G. Parros, Communication Oriented Networks, Wiley
3. G. Agrwal, Fiber Optic Communication Systems, John Wiley and Sons, 3rd Edition, New York, 2014.
4. C. Siva Ram Moorthy and Mohan Gurusamy, WDM Optical Networks: Concept, Design and Algorithms, Prentice Hall of India, 1st Edition, 2002.
5. Biswajit Mukherjee, Optical Communication Networks, TMG1998.
6. Jane M. Simoons, Optical Network Design and Planning, Second Edition, Springer
7. Ulysees Black, Optical Networks, Pearson education 2007.
8. Milorad Cvijetic, Ivan B. Djordjevic, Advanced Optical Communication Systems and Networks, Artech House Applied Photonics, 2012.

Course Name: Smart Sensors and Internet of Things

Course Code: ET81

Category: Core

Preamble:

In this course, the important sensors, associated interface electronics, signal conditioning, technology of smart sensors and IOT for the measurement and monitoring of vital environmental parameters will be studied.

Pre-requisites:

Applied Physics, Embedded System, Sensor Technology

Course objectives:

- The objective of this course is to Select the right sensor for a given application.
- To provide in depth knowledge in physical principles applied in sensing, measurement and a comprehensive understanding on how measurement systems are designed, calibrated, characterised, and analysed..
- Introduce evolution of internet technology and need for IoT.
- Discuss on IoT reference layer and various protocols and software
- Evaluate the wireless technologies used in IoT.

Course Outcomes:

Learner will be able to:

CO1: Create analytical design and development solutions for sensors

CO2: Select appropriate sensors for the given application development.

CO3: Evaluate performance characteristics of different types of sensors

CO4: Design and develop IoT based sensor systems

Course Scheme:

Contact Hours		**Credits Assigned**	
Theory	Practical	Theory	Practical
3	2	3	1

Evaluation Scheme:

Head of learning	ISA	MSE	ESE	Total
Theory	40	20	40	100
Practical	25	-	-	25

Detailed Syllabus:

Module No.	Module Name	Content	No. of Hours
1	Sensor characteristics	Definitions, terminology, classification, Static vs dynamic properties of transducers, Transfer functions, Ideal and realistic transducer models, Resolution, linearization, dynamic range, detection threshold, Selectivity & sensitivity, Calibration, Errors of the experimental measurements, Noise: electronics, environmental & internal	8
2	Physical Principle of Sensing	Capacitance, Magnetism, Induction, Resistance, Piezoelectric effect, Pyroelectric effect, Hall effect, Thermoelectric effect, Temperature and thermal properties of materials and heat transfer, Optics, Fiber optics and waveguides	8
3	Sensor Interface and Applications	Input characteristics of interface circuits, Amplifiers, Light to voltage converters, Capacitance to voltage converters, Bridge Circuits, Excitation circuits. Case Studies: Inertial Sensors (Accelerometer & gyroscope), Healthcare Sensors (Glucometer, ECG & MRI), Smart building Sensors (Smoke & occupancy sensors)	8
4	Introduction to IoT	Introduction to Internet of Things: Characteristics of IoT, Design principles of IoT, IoT Architecture and Protocols, Enabling Technologies for IoT, IoT levels and IoT vs M2M.IoT Design Methodology: Design methodology, Challenges in IoT Design, IoT SystemManagement, IoT Servers..Basics of Arduino: Introduction to Arduino, Arduino IDE, Basic Commands for Arduino, Connecting LEDs with Arduino, Connecting LCD with Arduino.	8
5	IoT point to point communication technologies	IoT Communication Pattern, IoT protocol Architecture, Selection of Wireless technologies (6LoWPAN, Zigbee, WIFI, BT, BLE,SIG,NFC, LORA,Lifi,Wifi)	7

6	IoT application and its Variants	Case studies: IoT for smart cities, health care, agriculture, smart meters.M2M, Web of things, Cellular IoT, Industrial IoT, Industry 4.0,IoT standards.	6
Total			**45**

Suggested list of Practicals:

1. Implementation of Signal Conditioning Circuits
2. Sensor interfacing using off-the-shelf components.
3. Performance Analysis of Optical Link with Different Detectors
4. Performance Analysis of Soliton Communication System
5. Effect of cross phase modulation on WDM system
6. Mitigation of Four wave mixing by NZ-DSF fiber
7. Performance Analysis of Optical Amplifier
8. Performance Analysis of DWDM System

Text Books:

1. Jacob Fraden, (2010), Handbook of Modern Sensors, 5th Edition, Springer.
2. J. W. Gardner, (1996), Microsensors, Principles and Applications, 1 st Edition, Wiley.
3. S. M. Sze, (1994), Semiconductor Sensors, 1 st Edition, Wiley.
4. Alessandro Bassi, Martin Bauer, Martin Fiedler, Thorsten Kramp, Rob van Kranenburg, Sebastian Lange, Stefan Meissner, "Enabling things to talk – Designing IoT solutions with the IoT Architecture Reference Model", Springer Open, 2016.
5. Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stamatis Karnouskos, Stefan Aves and, David Boyle, "From Machine to Machine to Internet of Things", Elsevier Publications, 2014

Reference Books:

1. Vijay Madisetti , Arshdeep Bahga, Adrian McEwen (Author), Hakim Cassimally "Internet of Things A Hands-on-Approach" Arshdeep Bahga & Vijay Madisetti, 2014.
2. LuYan, Yan Zhang, Laurence T. Yang, Huansheng Ning, The Internet of Things: From RFID to the Next-Generation Pervasive Network, Aurbach publications, March,2008.
3. John G Webster, "Measurement, Instrumentation and sensor Handbook", 2017, 2nd edition, CRC Press, Florida.

Course Name: VLSI Signal Processing.

Course Code: ET85

Category: Elective

Preamble:

This course Explore different Digital Signal Processor (DSP) architectures and to design systems using Programmable DSPs. Interface of memory and peripherals to a DSP; and acquire knowledge on different codec implemented on DSP.

Pre-requisites:

1. Basic Electrical and Electronics Engineering.
2. Electronic Devices and Circuits.
3. Digital System Design.
4. Digital VLSI Design.
5. Microcontrollers.
6. Digital Signal Processing.

Course Objectives:

- To understand the Architecture of Processors used in signal processing.
- To understand the design of various ALUS used in Digital Processors.
- To understand the concept of Memory designing and allocation for given application.
- To understand the concept of CODEC.

Course Outcomes:

Student will be able to:

1. Identify and use specific Digital Signal Processor for various applications
2. Design a system using programmable DSP.
3. Implement pipelining techniques to improve system performance.
4. Design involving memory and other interfaces to DSP.

Course Scheme:

Contact Hours		**Credits Assigned**	
Theory	Practical	Theory	Practical
3	2	3	1

Assessment Guidelines:

Head of learning	ISA	MSE	ESE	Total
Theory	40	20	40	100

The assessment guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module no	Module name	Content	No of Hours
1	DSP Integrated Circuits and VLSI Technologies	Standard digital signal processors - Application specific ICs for DSP - DSP systems - DSP system design - Integrated circuit design.	9
2	Architectures for programmable	Basic Architectural Features DSP Computational Building Blocks Bus Architecture and Memory - Data Addressing Capabilities - Address Generation Unit - Programmability and Program Execution - Features for External Interfacing	9
3	Execution Control and Pipelining	Hardware looping – Interrupts – Stacks - Relative Branch support - Pipelining and Performance - Pipeline Depth – Interlocking - Branching effects - Interrupt effects - Pipeline Programming models.	9
4	Synthesis of DSP Architectures	Top-Down approach to DSP LSI - Circuit Synthesis - High Performance Data conversion Techniques - LSI Algorithms and Architectures - Hierarchical Design of Processor Arrays - Systolic Arrays - Stack Filters - Wave-front Array Processors	6
5	Interfacing Memory and I/O to DSP Processors	External bus interfacing signals Memory interface Parallel I/O interface Programmed I/O Interrupts and I/O -Direct memory access (DMA) A Multichannel buffered serial port (McBSP) - McBSP Programming.	6
6	Interfacing CODEC	CODEC interface circuit - CODEC programming - A CODEC-DSP interface example	6
Total			**45**

Guidelines to conduct practical sessions:

2. Practical's will be conducted by giving the Mini-Project to the Students.

Deliverables of the capstone project by the student:

Sr No	Deliverables
1	A report summarizing the problem findings.
2	Analysis and designing the hardware for the given problem
3	Detailed plan for execution of the project including the objectives and the scope.
4	Final repository of the project implementation.
5	Detailed synopsis of the implemented project.

Suggested List of Mini-Projects.

1. Image Compression algorithm implementation in Programmable DSP.
2. Image processing algorithm implementations on FPGA.
3. Turbo Decoder implementation.
4. CORDIC Algorithm implementation in PDSP/FPGA/ASIC flow.
5. Improved Adaptive filters.
6. Improved Median filters.

Textbooks:

1. DSP Integrated Circuits Lars Wan hammer Academic press, New York 2011
2. DSP Processor Fundamentals, Architectures & Features, Phil Lapsley, Jeff Bier, Amit Shoham, Edward A. Lee, Wiley-IEEE Press, First Edition,2011

Reference Books:

1. Architectures for Digital signal processing,Peter Pirsch, Wiley India, 2010

Course Name: Space-Time Wireless Communication

Course Code: ET78

Category: Professional Elective

Preamble:

Space-time coding is a technique that promises greatly improved performance in wireless communication systems by using multiple antennas at the transmitter and receiver. Wireless networks are under constant pressure to provide ever higher data rates to increasing numbers of users with greater reliability. Space-time processing technology, which uses multiple antennas and sophisticated signal processing techniques, is a powerful new tool for improving system performance. The technology already features in the UMTS and CDMA2000 mobile standards. It discusses the basics of space-time propagation, space-time channels, channel capacity, spatial diversity and space-time coding. It highlights important trade-offs in the design of practical systems and cover advanced topics such as space-time OFDM and spread-spectrum modulation, co-channel interference cancellation, and multiuser MIMO.

Pre-requisites:

1. Structured Programming using C.
2. Object Oriented Programming using Java.
3. Logic Circuit.
4. Electronic Devices and Circuits

Course Objectives:

- To understand the concept of multiple antenna propagation.
- To understand the concept of capacity of frequency flat deterministic MIMO channel.
- To understand the concept of transmitter and receiver diversity technique.
- To design the coding for frequency flat channel.
- To analyze the concept of micro multi user detection

Course Outcomes:

Student will be able to:

CO1 Design and analyze the channel characterization.
CO2 Analyze the capacity of random MIMO channel.
CO3 Design and analyze the order diversity and channel variability.
CO4 Analyze the multiple antenna coding and receivers.
CO5 Analyze the MIMO multi user detection.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
3	2	3	1

Assessment Guidelines:

Head of learning	ISA	MSE	ESE	Total
Theory	40	20	40	100

The assessment guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Content	No. of Hours
1	Multiple Antenna Propagation And St Channel Characterization	Wireless channel – Scattering model in macrocells – Channel as a ST random field – Scattering functions, Polarization and field diverse channels – Antenna array topology – Degenerate channels – reciprocity and its implications – Channel definitions – Physical scattering model – Extended channel model – Channel measurements – sampled signal model – ST multiuser and ST interference channels – ST channel estimation.	09
2	Capacity Of Multiple Antenna Channels	Capacity of frequency flat deterministic MIMO channel: Channel unknown to the transmitter – Channel known to the transmitter – capacity of random MIMO channels – Influence of ricean fading – fading correlation – XPD and degeneracy on MIMO capacity – Capacity of frequency selective MIMO channels	09
3	Spatial Diversity	Diversity gain – Receive antenna diversity – Transmit antenna diversity – Diversity order and channel variability – Diversity performance in extended channels – Combined space and path diversity – Indirect transmit diversity – Diversity of a space-time – frequency selective fading channel.	09
4	Multiple Antenna Coding And Receivers	Coding and interleaving architecture – ST coding for frequency flat channels – ST coding for frequency selective channels – Receivers–SISO–SIMO–MIMO– Iterative MIMO receivers – Exploiting channel knowledge at the transmitter: linear pre-filtering – optimal pre-filtering for maximum rate – optimal pre-	09

		filtering for error rate minimization – selection at the transmitter – Exploiting imperfect channel knowledge	
5	St Ofdm, Spread Spectrum And Mimo Multiuser Detection	SISO-OFDM modulation, MIMO-OFDM modulation – Signaling and receivers for MIMO– OFDM – SISO–SS modulation – MIMO-SS modulation – Signaling and receivers for MIMO – S.MIMO – MAC – MIMO – BC – Outage performance for MIMO-MU – MIMO - MU with OFDM – CDMA and multiple antennas.	09
Total			**45**

Text Books:

1. Sergio Verdu, "Multi User Detection" , Cambridge University Press, 2011
2. A. Paulraj, Rohit Nabar, Dhananjay Gore, "Introduction to Space Time Wireless Communication Systems", Cambridge University Press , 2008

Reference Books:

1. Don Tarrieri, " Principles of Spread Spectrum Communication systems" ,Springer, Third edition, 2015

Course Name: High Performance Computing

Course Code: ET82

Category: Elective

Preamble:

High Performance Computing (HPC) is more than just for achieving high performance - it is a compelling vision for how computation can seamlessly scale from a single processor to virtually limitless computing power. The basic enabling force for HPC is the use of parallelism. The current market demands general-purpose processors that deliver high single threaded performance as well as multi-core throughput for a wide variety of workloads on client, server, and high-performance computing (HPC) systems. This course focuses on various computing technology architecture and highlights the advantage of deploying computing technology.

Pre-requisites:

1. Computer programming,
2. Data Structures.
3. Microprocessor
4. Microcontroller

Course Outcome:

Student will be able to:

1) Understand the basic knowledge of computing technology.

2) Understand architecture of computing technology.

3) Use cloud computing service models.

4) Know about emerging trends in computing technology

5) Understand basics of big data and hadoop architecture

Course Scheme:

Contact Hours		**Credits Assigned**	
Theory	Practical	Theory	Practical
3	2	3	1

Assessment Guidelines:

Head of learning	ISA	MSE	ESE	Total
Theory	40	20	40	100

Detailed Syllabus:

Module no	Module name	Content	No of Hours
1	Cluster Computing and its Architecture	Ease of Computing,Scalable Parallel Computer Architecture,Towards Low Cost Parallel Computing & Motivation,Windows opportunity,A Cluster Computer And Its Architecture,Cluster Classification,Commodity Components for Clusters,Network Services/Communication SW,Cluster Middleware and Single Systems Image,Resource management & Scheduling (RMS)	09
2	Cluster Setup and Administration	Introduction ,Setting up the cluster,Security,System Monitoring,System Tuning	09
3	Introduction to Grid and its Evolution	Beginning of the Grid,Building blocks of Grid,Grid Application and Grid Middleware,Evolution of the Grid: First, Second & Third Generation	09
4	Introduction to Cloud Computing	Defining Clouds,Cloud Providers,Consuming Cloud Services,Cloud Models – Iaas, Paas, SaaS,Inside the cloud,Administering cloud services,Technical interface,Cloud resources	09
5	Nature of Cloud	Tradition Data Centre,Cost of Cloud Data Centre,Scaling computer systems, Cloud work load, Managing data on clouds Public, private and hybrid clouds	09
6	Cloud Elements	Infrastructure as a service Platform as a service, Software as a service,	09
Total			**45**

Reference Books:

1. Ronald Krutz, Cloud Security, Wiley India.
2. Cloud Computing, A Practical Approach, Anthony Velte, Toby Velte, Robert Elsenpeter, McGrawHill.
3. High Performance Cluster Computing, Volume 1, Architecture and Systems, Rajkumar Buyya, Pearson Education.

4. Berman, Fox and Hey, Grid Computing – Making the Global Infrastructure a Reality, Wiley India.
5. Hurwitz, Bllor, Kaufman, Halper, Cloud Computing for Dummies, Wiley India.

Course Name: Integrated Circuits for Wireless Communication

Course Code: ET86

Category : Professional Elective

Preamble:

This course introduces students Importance of Radio frequency VLSI Design in the field of Eletronics and

telecommunication. Methodologies for analysis and designing of fundamental Radio

frequency signal circuits.

Pre-requisites:

Basic Electrical and Electronics Engineering. – Strongly Related

Electronics circuits and Devices. - Strongly Related.

Circuit Theory- Strongly Related

Microelectronics- Strongly Related

Digital VLSI Design with VERILOG- Strongly Related

Analog IC Design- Strongly Related

Course Outcome:

Student will be able to :

1) Understand Architecture of RF Communication
Transceiver.
2)Analyze and design Low Noise Amplifier.
3)Understand Analysis and designing of RF Mixers and Oscillator circuits.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
3	2	3	1

Assessment Guidelines:

Head of learning	ISA	MSE	ESE	Total
Theory	40	20	40	100

Detailed Syllabus:

Module no	Module name	Content	No of Hours
1	Basic Concept in RF Design :	General Consideration units in RF design. Time variance.Nonlinearity.Effects of Non linearity Sensitivity Dynamic Range.Impedance Transformation.	09
2	Architecture: Transceiver	Receiver Architecture, Modern heterodyne direct conversion, Image Rejection and low IF Receivers. Transmitter Architecture direct conversion transmission modern direct conversion transmitter heterodyne transmitter.	09
3	Low Noise Amplifier :	General Consideration, Problem of input impedance matching, various LNA topologies. High IP2 LNA	09
4	Mixer's:	General consideration, performance Parameters, Mixer noise figure. Signal balanced and Double balanced mixers passive and active down conversion mixers.	09
5	Oscillators:	Performance parameter Basic Principles, cross coupled oscillator VCO, VCO with wide turning Range.	09
Total			**45**

Text Books:

1. RF Microelectronics by B. Razavi 2nd Edition,Prentice Hall
2. Low PowRF Circuit Design in standard CMOS Technology By Aluarado U Springer Oct 2011 Edition.

Reference Books:

1. VLSI for Wireless communication by Bosco Leung Springer 2nd Edition.

Course Name: Sustainability Management

Course Code: OE04

Category: Open Elective

Preamble:
This course explores corporate sustainability from the perspective of large, multinational corporations. Focus is on the management tools available to corporations and how they can drive sustainability into a company at all levels, providing a balance between environmental stewardship, social well-being, and economic prosperity.

Objectives:
1. The importance to each individual corporate entity of corporate sustainability.
2. Key drivers and inhibitors, both external and internal to the corporation, of the natural environmental and social aspects of corporate sustainability.
3. The roles of social and natural environmental risk, and product and process innovation, in developing corporate sustainability.

Course Outcome: Student will be able to:
1. Define sustainability and identify major sustainability challenges.
2. Identify, act on, and evaluate their professional and personal actions with the knowledge and appreciation of interconnections among economic, environmental, and social perspectives.
3. Recognize the global implications of their actions.
4. Apply concepts of sustainable development to address sustainability challenges in a global context.

Course Scheme:

Contact Hours	Credits Assigned
Theory	Theory
4	4

Assessment Guidelines:

Head of learning	ISA	MSE	ESE	Total
Theory	40	20	40	100

Detailed Syllabus

Module no	Module Name	Content	No of Hours
1	Introduction to Sustainability Management	Meaning, definition, dimensions of sustainability, value of sustainability, framework for business sustainability Understanding the Sustainability Challenge- The Systemic Level and Business Level, Their Implications for business.	12

Module no	Module Name	Content	No of Hours
2	Importance of Corporate Sustainability	Assessing the Strategic Opportunity, Managing Sustainability Transitions across Business Functions, successful cases of organizations focusing on a business model designed around sustainability principles and mind-sets.	12
3	Seizing the Strategic Opportunity	Managing Sustainability Transitions across Business Functions, the challenges related to the management of the integration of sustainability-related processes in business organizations.	12
4	Stakeholder Engagement	Multilateral engagement, Government engagement, NGO's – influence and engagement, Trade associations (WBCSD), Stakeholder interests and engagement	12
5	Transitioning Organizations to Sustainable Enterprises	Developing the Road-Map, Approach the challenge of developing a roadmap to realize the stakeholder value creation potential in sustainability transitions at three different levels, initiatives related to transformational change in the organizations.	12
Total			**60**

Textbooks:

1. Corporate Sustainability in Practice: A Guide for Strategy Development and Implementation by Paolo Taticchi, Melissa Demartini
2. Corporate Sustainability, Social Responsibility and Environmental Management: An Introduction to Theory and Practice with Case Studies by Mark Anthony Camilleri.

Reference-Books:

1. How to Succeed as an Independent Consultant by Holtz, Herman.
2. Strategy for Sustainability: A Business Manifest by Adam Werbach.

E- Resources:

1. Global Journal of Management and Business Research: D Accounting and Auditing
2. Indian Journal of Finance - http://www.indianjournaloffinance.co.in/
3. IVEY Business Journal- https://iveybusinessjournal.com/publication/corporate-sustainability-what-is-it-and-where-does-it-come-from/

MOOC:

1. https://www.coursera.org/learn/corp-
2. https://www.edx.org/course/introduction-to-corporate-sustainability-social-in
3. https://www.classcentral.com/course/corp-sustainability-10667

Course Name: Operation Research

Course Code: OE05

Category: Open Elective

Pre-requisites:

- Mathematics

Course Objectives:

- Formulate a real-world problem as a mathematical programming model.
- Understand the mathematical tools that are needed to solve optimization problems.
- Use mathematical software to solve the proposed models.

Course Outcome:

- Understand the theoretical workings of the simplex method, the relationship between a linear program and its dual, including strong duality and complementary slackness.
- Perform sensitivity analysis to determine the direction and magnitude of change of a model's optimal solution as the data change.
- Solve specialized linear programming problems like the transportation and assignment problems, solve network models like the shortest path, minimum spanning tree, and maximum flow problems. Understand the applications of integer programming and a queuing model and compute important performance measures.

Course Scheme:

Contact Hours	Credits Assigned
Theory	Theory
4	4

Assessment Guidelines:

Head of learning	ISA	MSE	ESE	Total
Theory	40	20	40	100

Detailed Syllabus

Module	Detailed Content	Hours
1	**Introduction to Operations Research** • Introduction, , Structure of the Mathematical Model, Limitations of Operations Research **Linear Programming**	13

	• Introduction, Linear Programming Problem, Requirements of LPP, Mathematical Formulation of LPP, Graphical method, SimplexMethod Penalty Cost Method or Big M-method, Two Phase Method,Revised simplex method, **Duality**, Primal – Dual construction, Symmetric and Asymmetric Dual, Weak Duality Theorem, Complimentary Slackness Theorem, Main Duality Theorem, Dual Simplex Method, Sensitivity Analysis **Transportation Problem** • Formulation, solution, unbalanced Transportation problem. Finding basic feasible solutions – Northwest corner rule, least cost method and Vogel's approximation method. Optimality test: the stepping stone method and MODI method. **Assignment Problem** • Introduction, Mathematical Formulation of the Problem, Hungarian Method Algorithm, Processing of n Jobs Through Two Machines and m Machines, Graphical Method of Two Jobs m Machines	
	Problem Routing Problem, Travelling Salesman Problem **Integer Programming Problem** • Introduction, Types of Integer Programming Problems, Gomory's cutting plane Algorithm, Branch and Bound Technique. Introduction to Decomposition algorithms.	05
2	**Queuing models** • Queuing systems and structures, single server and multi-server models, Poisson input, exponential service, constant rate service, finite and infinite population	09
3	**Simulation** • Introduction, Methodology of Simulation, Basic Concepts, Simulation Procedure, Application of Simulation Monte-Carlo Method: Introduction, Monte-Carlo Simulation, Applications of Simulation, Advantages of Simulation, Limitations of Simulation	10
4	**Dynamic programming** • Characteristics of dynamic programming. Dynamic programming approach for Priority Management employment smoothening, capital budgeting, Stage Coach/Shortest Path, cargo loading and Reliability problems.	08
5	**Game Theory** • Competitive games, rectangular game, saddle point, minimax (maximin) method of optimal strategies, value of the game. Solution of games with saddle points, dominance principle. Rectangular games without saddle point – mixed strategy for 2 X 2 games.	10
6	**Inventory Models** • Classical EOQ Models, EOQ Model with Price Breaks, EOQ with Shortage, Probabilistic EOQ Model,	05
	Total	**60**

Textbooks and References:

1. Taha, H.A. "Operations Research - An Introduction", Prentice Hall, (7th Edition), 2002.
2. Ravindran, A, Phillips, D. T and Solberg, J. J. "Operations Research: Principles and Practice", John Willey and Sons, 2nd Edition, 2009.
3. Hiller, F. S. and Liebermann, G. J. "Introduction to Operations Research", Tata McGraw Hill, 2002.
4. Operations Research, S. D. Sharma, KedarNath Ram Nath-Meerut.
5. Operations Research, KantiSwarup, P. K. Gupta and Man Mohan, Sultan Chand & Sons.

Course Name: IPR and Patenting

Course Code: OE06

Category: Open Elective

Preamble:

Course Objectives:

- To understand intellectual property rights protection system
- To promote the knowledge of Intellectual Property Laws of India as well as International treaty procedures
- To get acquaintance with Patent search and patent filing procedure and applications

Course Outcome:

- Understand Intellectual Property assets
- Assist individuals and organizations in capacity building
- Work for development, promotion, protection, compliance, and enforcement of Intellectual Property and Patenting

Course Scheme:

Contact Hours	Credits Assigned
Theory	Theory
4	4

Assessment Guidelines:

Head of learning	ISA	MSE	ESE	Total
Theory	40	20	40	100

Detailed Syllabus

Module	Detailed Content	Hours
1	**Importance of IPR in Modern Global Economic Environment** • Theories of IPR, Philosophical aspects of IPR laws, Need for IPR, IPR as an instrument of development	10

2	**Enforcement of Intellectual Property Rights** • Introduction, Magnitude of problem, Factors that create and sustain counterfeiting/piracy, International agreements, International organizations (e.g. WIPO, WTO) active in IPR enforcement **Indian Scenario of IPR** • Introduction, History of IPR in India, Overview of IP laws in India, Indian IPR, Administrative Machinery, Major international treaties signed by India, Procedure for submitting patent and Enforcement of IPR at national level etc.	11
3	**Emerging Issues in IPR** • Challenges for IP in digital economy, e-commerce, human genome, biodiversity and traditional knowledge etc.	09
4	**Basics of Patents** • Definition of Patents, Conditions of patentability, Patentable and non-patentable inventions, Types of patent applications (e.g. Patent of addition etc), Process Patent and Product Patent, Precautions while patenting, Patent specification Patent claims, Disclosures and non-disclosures, Patent rights and infringement, Method of getting a patent	10
5	**Patent Rules** • Indian patent act, European scenario, US scenario, Australia scenario, Japan scenario, Chinese scenario, Multilateral treatieswhere India is a member (TRIPS agreement, Paris convention etc.)	10
6	**Procedure for Filing a Patent (National and International)** • Legislation and Salient Features, Patent Search, Drafting and Filing Patent Applications, Processing of patent, Patent Litigation, Patent Publication etc, Time frame and cost, Patent Licensing, Patent Infringement **Patent databases** • Important websites, Searching international databases	10
Total		**60**

Textbooks and References:

1. Rajkumar S. Adukia, 2007, *A Handbook on Laws Relating to Intellectual PropertyRights in India*, The Institute of Chartered Accountants of India
2. Keayla B K, *Patent system and related issues at a glance*, Published by National Working Group on Patent Laws
3. T Sengupta, 2011, *Intellectual Property Law in India*, Kluwer Law International

4. Tzen Wong and Graham Dutfield, 2010, *Intellectual Property and HumanDevelopment: Current Trends and Future Scenario*, Cambridge University Press
5. Cornish, William Rodolph & Llewelyn, David. 2010, *Intellectual Property: Patents, Copyrights, Trade Marks and Allied Right*, 7th Edition, Sweet & Maxwell
6. Lous Harns, 2012, *The enforcement of Intellactual Property Rights: A Case Book*, 3rdEdition, WIPO
7. Prabhuddha Ganguli, 2012, *Intellectual Property Rights*, 1st Edition, TMH
8. R Radha Krishnan & S Balasubramanian, 2012, *Intellectual Property Rights*, 1stEdition, Excel Books
9. M Ashok Kumar and mohd Iqbal Ali, 2-11, *Intellectual Property Rights*, 2nd Edition,Serial Publications
10. Kompal Bansal and Praishit Bansal, 2012, *Fundamentals of IPR for Engineers*, 1stEdition, BS Publications
11. Entrepreneurship Development and IPR Unit, BITS Pilani, 2007, *A Manual on Intellectual Property Rights*.
12. Mathew Y Maa, 2009, *Fundamentals of Patenting and Licensing for Scientists and Engineers*, World Scientific Publishing Company
13. N S Rathore, S M Mathur, Priti Mathur, Anshul Rathi**,** *IPR: Drafting, Interpretationof Patent Specifications and Claims***,** New India Publishing Agency
14. Vivien Irish, 2005, *Intellectual Property Rights for Engineers*, IET
15. Howard B Rockman, 2004, *Intellectual Property Law for Engineers and scientists*,Wiley-IEEE Press

Course Name: Research Methodology

Course Code: OE07

Category: Open Elective

Preamble:

This course is to make the students understand the importance of research and various methods that researcher used to investigate problems. The course will also help the students to make meaningful decisions.

Pre-requisites:

Quantitative Techniques – Strongly Related

Operations and production management - Strongly Related

Economics– Weakly Related

Course Outcome:

1. Understand the importance of research and various methods that researcher used to investigate problems.
2. Apply Modern Analytical tools for Business Management Decisions.
3. Derive strategies from the research.
4. Understand the challenges in collecting the data collection and analysis.
5. Interpret the data to make meaningful decisions.

Course Scheme:

Contact Hours	Credits Assigned
Theory	Theory
4	4

Assessment Guidelines:

Head of learning	ISA	MSE	ESE	Total
Theory	40	20	40	100

Detailed Syllabus

Module	Detailed Content	Hours
1	**Introduction and Basic Research Concepts** • Research – Definition; Concept of Construct, Postulate, Proposition, Thesis, Hypothesis, Law, Principle.Research methods vs Methodology • Need of Research in Business and Social Sciences	10

	• Objectives of Research • Issues and Problems in Research Characteristics of Research: Systematic, Valid, Verifiable, Empiricaland Critical	
2	**Types of Research** • Basic Research • Applied Research • Descriptive Research • Analytical Research • Empirical Research • Qualitative and Quantitative Approaches	10
3	**Research Design and Sample Design** • Research Design – Meaning, Types and Significance • Sample Design – Meaning and Significance Essentials of agood sampling Stages in Sample Design Sampling methods/techniques Sampling Errors	12
4	**Research Methodology** • Meaning of Research Methodology	12
	• Stages in Scientific Research Process: **a.** Identification and Selection of Research Problem **b.** Formulation of Research Problem **c.** Review of Literature **d.** Formulation of Hypothesis **e.** Formulation of research Design **f.** Sample Design **g.** Data Collection **h.** Data Analysis **i.** Hypothesis testing and Interpretation of Data Preparation of Research Report	
5	**Formulating Research Problem** • Considerations: Relevance, Interest, Data Availability, Choiceof data, Analysis of data, Generalization and Interpretation of analysis	08
6	**Outcome of Research** • Preparation of the report on conclusion reached • Validity Testing & Ethical Issues Suggestions and Recommendation	08
	Total	**60**

Textbooks and References:

1. Dawson, Catherine, 2002, Practical Research Methods, New Delhi, UBS Publishers Distributors.
2. Kothari, C.R.,1985, Research Methodology-Methods and Techniques, New Delhi, Wiley Eastern Limited.
3. Kumar, Ranjit, 2005, Research Methodology-A Step-by-Step Guide for Beginners, (2nded), Singapore, Pearson Education.

Appendix-A

Guidelines for Professional Elective Courses and Specialization Certificate

Professional Elective courses are designed to meet industrial requirements. All learners must opt for 4 professional elective courses as a part of requirement for M.Tech. degree.

Specialization Certificate is introduced in order to build competency of learners in the chosen domain. Department of Computer Engineering offers the following specialization tracks:

1. Communication
2. Embedded Systems and IoT
3. VLSI

Learners can take courses from any track. **However, if learners complete all Professional Elective Courses from the same chosen track, they will be eligible to receive a Specialization Certificate from the Institute.**

Learners who choose professional elective courses from different specialisation tracks will not be eligible for a Specialization Certificate.

It should be noted that there are no additional credit requirements for these specialisations.

Communication track: Courses to be chosen for specialization in Communication.

Preferred Semester	Course Code	Course Name
I	ET75	OFDM and MIMO Technology
I	ET76	Smart Antennas System
II	ET77	Passive Optical Networks
II	ET78	Space-Time Wireless Communication

Embedded Systems and IoT track: Courses to be chosen for specialization in Embedded Systems and IoT

Preferred Semester	Course Code	Course Name
I	ET79	Embedded Communication Systems Design
I	ET80	Reconfigurable Computing and FPGAs
II	ET81	Smart Sensors and Internet of Things
II	ET82	High Performance Computing

VLSI track: Courses to be chosen for specialization in VLSI

Preferred Semester	Course Code	Course Name
I	ET83	Sensor Technology and MEMS, NEMS
I	ET84	Analog & Mixed Signal Circuit Design
II	ET85	VLSI Signal Processing
II	ET86	Integrated Circuits for Wireless Communication

Appendix B

Courses under Open Elective (OE) Category

Sr. No.	Course Code	Course Name	Hours Per Week		Credits	Preferred Semester
			Theory	Practical		
1	OE04	Sustainability Management	4	-	4	-
2	OE05	Operation Research	4	-	4	-
3	OE06	IPR and Patenting	4	-	4	-
4	OE07	Research Methodology	4	-	4	-
5	OE13*	Online Course 1 (MOOC)	As per course		2	-
6	OE14*	Online Course 2 (MOOC)	As per course		2	-

*Online Courses (MOOC) of 2 credits is equivalent to 30 hours course.