SCHEME OF INSTRUCTION & EXAMINATION
B.E. VIII - SEMESTER
(ELECTRONICS AND COMMUNICATION ENGINEERING)

S. No.	Course Code	Course Title	Scheme of Instruction				Scheme of Examination			Credits
			L	T	P/D	Contact Hrs/Wk	CIE	SEE	Duration in Hrs	
Theory Courses										
1		Professional Elective – III	3	-	-	3	30	70	3	3
2		Professional Elective – IV	3	-	-	3	30	70	3	3
3		Professional Elective – V	3	-	-	3	30	70	3	3
Practical/ Laboratory Courses										
5	**PW961 EC**	Project Work – II	-	-	16	16	50	100	-	8
			09	**-**	**16**	**25**	**140**	**310**		**17**

Professional Elective – II			Professional Elective – III		
S. No.	Course Code	Course Title	S. No.	Course Code	Course Title
1	**PE 821 EC**	Field Programmable Gate Arrays	1	**PE 831 EC**	Wireless Sensor Networks
2	**PE 822 EC**	Internet of Things	2	**PE 832 EC**	Global Navigational Satellite Systems
3	**PE 823 EC**	Neural Networks	3	**PE 833 EC**	System Verilog
4	**PE 824 EC**	Satellite Communications	4	**PE 834 EC**	Multirate Signal Processing

Professional Elective – IV		
1	**PE 841 EC**	Real Time Operating Systems
2	**PE 842 EC**	Fuzzy Logic And Applications
3	**PE 843 EC**	Radar Systems
4	**PE 844 EC**	Design of Fault Tolerant Systems

PC: Professional Course PE: Professional Elective
L: Lectures T: Tutorials P: Practical D: Drawing
CIE: Continuous Internal Evaluation **SEE:** Semester End Examination (Univ. Exam)

Note: 1) Each contact hour is a Clock Hour
2) The duration of the practical class is two clock hours, however it can be extended wherever necessary, to enable the student to complete the experiment

Course Code	Course Title						Core / Elective
PE 821 EC	**Field Programmable Gate Arrays**						**Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
DSD PC506EC STLD PC303EC	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- Understand the ASIC design flow and Programming Technologies
- Study different Architecture of FPGAS.
- Understand the FPGA physical Design Flow of FPGA
- Learn the placement and routing algorithms
- Enlist the verification and testing methods of digital circuits

Course Outcomes

After completing this course, the student will be able to

1. Design of ASIC's using implementation tools for simulation and synthesis.
2. Describe the architecture of FPGA's.
3. Discuss physical design using FPGA's and CAD tools.
4. Describe placement & routing algorithms.
5. Analyse verification and testing of Digital circuits.

UNIT-I

Introduction to ASIC's: Types of ASIC's, ASIC design flow, Economies of ASIC's, Programmable ASIC's: CPLD and FPGA. Commercially available CPLD's and FPGA's: XILINX, ALTERA, ACTEL. FPGA Design cycle, Implementation tools: Simulation and synthesis, Programming technologies. Applications of FPGAs

UNIT-II

FPGA logic cell for XILINX, ALTERA and ACTEL ACT, Technology trends, Programmable I/O blocks, FPGA interconnect: Routing resources, Elmore's constant, RC delay and parasitic capacitance, FPGA design flow, Dedicated Specialized components of FPGAs

UNIT-III

FPGA physical design, CAD tools, Power dissipation, FPGA Partitioning, Partitioning methods. Floor planning: Goals and objectives, I/O, Power and clock planning, Low-level design entry.

UNIT-IV

Placement: Goals and objectives, Placement algorithms: Min-cut based placement, Iterative Improvement and simulated annealing.

Routing, introduction, Global routing: Goals and objectives, Global routing methods, Back-annotation. Detailed Routing: Goals and objectives, Channel density, Segmented channel routing, Maze routing, Clock and power routing, Circuit extraction and DRC.

UNIT-V

Verification and Testing: Verification: Logic simulation, Design validation, Timing verification. Testing concepts: Failures, Mechanism and faults, Fault coverage.

Testing concepts: failures, mechanisms and faults, fault coverage, ATPG methods, and programmability failures.

Suggested Readings:

1. Pak and Chan, Samiha Mourad, *Digital Design using Field Programmable Gate Arrays*, Pearson Education, 1st edition, 2009.
2. Michael John Sebastian Smith, *Application Specific Integrated Circuits*, Pearson Education Asia, 3rd edition 2001.
3. S. Trimberger, Edr, *Field Programmable Gate Array Technology*, Kluwer Academic Publications, 1994.
4. John V. Oldfield, Richard C Dore, *Field Programmable Gate Arrays*, Wiley Publications.

Course Code	Course Title						Core / Elective
PE 822 EC	**Internet of Things**						**Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
MPMC PC 603 EC	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- Discuss fundamentals of IoT and its applications and requisite infrastructure
- Describe Internet principles and communication technologies relevant to IoT
- Discuss hardware and software aspects of designing an IoT system
- Describe concepts of cloud computing and Data Analytics
- Discuss business models and manufacturing strategies of IoT products

Course Outcomes

After completing this course, the student will be able to

1. Understand the various applications of IoT and other enabling technologies.
2. Comprehend various protocols and communication technologies used in IoT
3. Design simple IoT systems with requisite hardware and C programming software
4. Understand the relevance of cloud computing and data analytics to IoT
5. Comprehend the business model of IoT from developing a prototype to launching a product.

UNIT – I

Introduction to Internet of Things: Definition and Characteristics of IoT, Physical Design of IoT: Things in IoT, IoT protocols, Logical Design of IoT: IoT functional Blocks, Communication Models, APIs, IoT enabling Technologies: Wireless Sensor Networks, Cloud Computing, Big Data Analytics (Ref 1)

IoT Applications: Smart Home, Smart Cities, Smart Environment, Smart Energy, Smart Retail and Logistics, Smart Agriculture and Industry, Smart Industry and smart Health (Ref1)

UNIT – II

Internet Principles and communication technology: Internet Communications: An Overview – IP, TCP, IP protocol Suite, UDP. IP addresses – DNS, Static and Dynamic IP addresses, MAC Addresses, TCP and UDP Ports, Application Layer Protocols – HTTP, HTTPS, Cost Vs Ease of Production, Prototypes and Production, Open Source Vs Closed Source. Prototyping Embedded Devices – Sensors, Actuators, Microcontrollers, SoC, Choosing a platform, Prototyping Hardware platforms – Arduino, Raspberry Pi. Prototyping the physical design – Laser Cutting, 3D printing, CNC Milling (Ref 2)

UNIT – III

API Development and Embedded programming: Getting started with API, writing a new API, Real time Reactions, Other Protocols, Techniques for writing embedded code: Memory management, Performance and Battery Life, Libraries, Debugging. (Ref 2)

Developing Internet of Things: IoT design Methodology, Case study on IoT System for weather monitoring (Ref 1)

UNIT – IV

IoT Systems - Logical Design using Python: Introduction to Python, Data Types and Structures, Control Flow, Functions, Modules, Packages, File Handling, Date/Time Operations., Classes, Python packages for IoT (Ref 1 and Ref 3)

IoT Physical Devices and Endpoints: Raspberry Pi, Interfaces of Pi, Programming pi with Python - Controlling LED and LDR using Pi with python programming.

UNIT – V

Cloud computing and Data analytics and IoT Product Manufacturing: Introduction to Cloud storage models and Communication APIs, Amazon web services for IoT, Skynet IoT Messaging Platform. Introduction to Data Analytics for IoT (Ref 1). Case studies illustrating IoT Design – Smart Lighting, Weather Monitoring, Smart Irrigation. (Ref 1) Business model for IoT product manufacturing, IoT Start-ups, Mass manufacturing, Ethical issues in IoT. (Ref 2)

Suggested Readings:

1. Internet of Things (A Hands-On-Approach), Vijay Madisetti, ArshdeepBahga, VPT Publisher, 1st Edition, 2014.
2. Designing the Internet of Things, Adrian McEwen (Author), Hakim Cassimally. Wiley India Publishers.
3. Fundamentals of Python, Kenneth A Lambert and B.L. Juneja, Cengage Learning
4. *Internet of Things* - Converging Technologies for smart environments and Integrated ecosystems, River Publishers.
5. *Internet of things* -A hands on Approach, Arshdeep Bahga, Universities press.

Course Code	Course Title						Core / Elective
PE 823 EC	**Neural Networks**						**Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
PTSP PC403EC DIP PE671EC	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- To understand the functioning of biological neuron and its electronic implementation using different Neuron models
- The activation & synaptic dynamics of Neural Networks & its distinction
- To understand the concepts of pattern recognition tasks as applied to Neural Networks
- The concepts of Perceptron Neural Networks & train different Feed Forward Neural Networks
- To train different Feedback Neural Networks & their applications

Course Outcomes

After completing this course, the student will be able to

1. To differentiate between Biological Neuron & Artificial Neuron and different Neuron Models
2. To analyse activation & synaptic dynamics of Neural Networks
3. To summarize the Pattern Recognition Tasks & different Neural Network memories
4. To solve Perceptron XoR problem & write different training algorithms for Feed Forward Neural Networks
5. To understand & train different Feedback Neural Networks and their applications

UNIT-I

Introduction to Neural Networks, Description of Biological Neuron, Mathematical model of Artificial Neural Network, Classification of Neural Networks, Different Neuron models: McCulloch-Pitts Neuron model, Perceptron Neuron model and ADALINE Neuron model, Basic learning laws

UNIT-II

Activation and Synaptic dynamics of Neural Networks: Additive, Shunting and Stochastic activation models, Distinction between Activation and Synaptic dynamics models, Requirements of learning laws, Recall in Neural Networks.

UNIT-III

Pattern Recognition Tasks: Pattern association, pattern storage (LTM & STM), Pattern clustering and feature mapping, Neural Network Memory: Auto Associative Memory, Hetero Associative Memory, Bidirectional Associative Memory.

UNIT-IV

Feed Forward Neural Networks: Single layer & Multi layer Neural Networks, Perceptron Neural Networks solution of XoR problem, Perceptron Convergence Theorem, Back Propagation Neural Networks, its features, limitations & extensions, Kohonen Self-Organizing Networks & its applications

UNIT-V

Feedback Neural networks: Hopfield network, capacity and energy analysis of Hopfield Neural Network & its applications, Radial Basis Function Networks, its training algorithm & applications, Boltzmann machine, Boltzman learning law.

Suggested Readings:

1. B. Yeganaranarana, *Artificial Neural Networks*, Prentice Hall, New Delhi, 2007.

2. J.A. Freeman and D.M. Skapura, *Neural Networks Algorithms, Applications and Programming Techniques*, Addison Wesley, New York, 1999.
3. Simon Haykin, *Neural Networks (A Comprehensive Foundation)*, McMillan College Publishing Company, New York, 1994.
4. S.N. Sivanandam & M. Paul Raj, *Introduction to Artificial Neural Networks*, Vikas Publishing House Pvt Limited, 2009.
5. Richard O. Duda, Peter E Heart, David G. Stork, *Pattern Classification,* John Wiley & Sons 2002

Course Code	Course Title						Core / Elective
PE 824 EC	**Satellite Communications**						**Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
DC PC601EC	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

To make the student familiar with the concepts of

- To understand basics of satellite communications
- To study various effects on satellite communications and to understand types of antennas used.
- To study various components in satellite and satellite TV systems.
- To analyse and design satellite communication link and study various access techniques.
- To study various applications of satellite communications in practical world.

Course Outcomes

After completing this course, the student will be able to

1. Explain principle, working and operation of satellite.
2. Illustrate various effects on satellite communications and its antennas.
3. Explain various components in satellite and satellite TV systems.
4. Analyse and design satellite communication link
5. Illustrate role of satellite in various applications

UNIT-I

A Brief History of Satellite Communications, Overview and Indian Scenario of Satellite Communications, Kepler's Laws, Definitions of Terms for Earth-Orbiting Satellites, Orbital Elements, Apogee and Perigee Heights, Orbit Perturbations - Effects of a non-spherical earth, Atmospheric drag

UNIT-II

Antenna Look Angles, The Polar Mount Antenna, Limits of Visibility, Near Geostationary Orbits, Earth Eclipse of Satellite, Sun Transit Outage, Launching Orbits, Atmospheric Losses, Ionospheric Effects, Rain Attenuation, Other Propagation Impairments, Antenna Polarization, Polarization of Satellite Signals, Cross-Polarization Discrimination, Ionospheric Depolarization, Rain Depolarization, Ice Depolarization, Horn Antennas, The Parabolic reflector, Offset feed, Double-reflector antennas

UNIT-III

Power Supply, Attitude Control - Spinning satellite stabilization, Momentum wheel stabilization, Station Keeping, Thermal Control, TT&C Subsystem, Transponders - The wideband receiver, the input demultiplexer, the power amplifier, The Antenna Subsystem.

Receive-Only Home TV Systems - The outdoor unit, the indoor unit for analog (FM) TV, Master Antenna TV System, Community Antenna TV System, Transmit-Receive Earth Stations

UNIT-IV

Equivalent Isotropic Radiated Power, Transmission Losses, The Link-Power Budget Equation, System Noise, Carrier-to-Noise Ratio, The Uplink - Saturation flux density, Input backoff, Downlink - Output back-off, Effects of rain – Uplink & Downlink rain-fade margin, Combined Uplink and Downlink C/N Ratio Single Access, Preassigned FDMA, Demand-Assigned FDMA, Spade System, TDMA, Preassigned TDMA, Demand-assigned TDMA, Satellite-Switched TDMA, CDMA

UNIT-V

C-Band and Ku-Band Home Satellite TV, Digital DBS TV, DBS- TV System Design, DBS-TV Link Budget, Error Control in Digital DBS-TV, Master Control Station and Uplink, Installation of DBS- TV

Antennas, Satellite Radio Broadcasting, Digital Video Broadcast(DVB) Standards, Digital Video Broadcast – Terrestrial (DVB-T) Satellite Mobile Services, VSATs, Radarsat, Global Positioning Satellite System (GPS), Orbcomm, Iridium

Suggested Readings:

1. Dennis Roddy, "Satellite Communications", 4th Edition, Tata McGraw-Hill.
2. Timothy Pratt, Charles Bostian, Jeremy Allnutt, "Satellite Communications", 2nd Edition, John Wiley & Sons.
3. Wilbur L. Pritchard, Henri G. Suyderhoud, Robert A. Nelson, "Satellite Communication Systems Engineering", 2nd Edition, Pearson
4. Tri T. Ha, Digital Satellite Communication, Tata McGraw- Hill, Special Indian Edition 2009.
5. N. Agarwal, "Design of Geosynchronous Space Craft", Prentice Hall, 1986.

Course Code	Course Title						Core / Elective
PE 831 EC	**Wireless Sensor Networks**						**Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
DCCN PE672EC	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- Determine network architecture, node discovery and localization, deployment strategies, fault tolerant and network security.
- Build foundation for WSN by presenting challenges of wireless networking at various protocol layers.
- Determine suitable protocols and radio hardware.
- Evaluate the performance of sensor network and identify bottlenecks.
- Evaluate concepts of security in sensor networks.

Course Outcomes

1. To understand network architecture, node discovery and localization, deployment strategies, fault tolerant and network security.
2. To understand foundation for WSN by presenting challenges of wireless networking at various protocol layers.
3. Study suitable protocols and radio hardware.
4. To understand the performance of sensor network and identify bottlenecks.
5. To understand concepts of security in sensor networks.

UNIT-I

Challenges for Wireless Sensor Networks-Characteristics requirements-required mechanisms, Difference between mobile ad-hoc and sensor networks, Applications of sensor networks- Enabling Technologies for Wireless Sensor Networks

UNIT-II

Single-Node Architecture - Hardware Components, Energy Consumption of Sensor Nodes, Operating Systems and Execution Environments

Network Architecture - Sensor Network Scenarios, Optimization Goals and Figures of Merit, Gateway Concepts.

UNIT-III

Physical Layer and Transceiver Design Considerations, MAC Protocols for Wireless Sensor Networks, Low Duty Cycle Protocols and Wakeup Concepts - S-MAC, Zigbee: IEEE 802.15.4 MAC Layer, The Mediation Device Protocol, Wakeup Radio Concepts, Address and Name Management, Assignment of MAC Addresses, Routing Protocols- Energy-Efficient Routing, Geographic Routing.

UNIT-IV

Topology Control, Clustering, Time Synchronization, Localization and Positioning, Sensor Tasking and Control. Operating Systems for Wireless Sensor Networks, Sensor Node Hardware – Berkeley Motes, Programming Challenges, Node-level software platforms, Node-level Simulators, State-centric programming.

UNIT-V

Security Architectures, Survey of Security protocols for Wireless Sensor Networks and their Comparisons.

Suggested Readings:

1. Holger Karl and Andreas Willig, *"Protocols and Architectures for Wireless Sensor Networks,"* John Wiley, 2005.
2. Feng Zhao and Leonidas J. Guibas, *"Wireless Sensor Networks - An Information Processing Approach,"* Elsevier, 2007.
3. FazemSohraby, Daniel Minoli, and TaiebZnati, "Wireless Sensor Networks- Technology, Protocols and Applications," John Wiley, 2007.
4. Anna Hac, "Wireless Sensor Network Designs," John Wiley, 2003.
5. Y Wang," A Survey of Security issues in Wireless Sensor Networks", IEEE Communications Survey and Tutorials, 2006.

Course Code	Course Title						Core / Elective
PE 832 EC	**Global Navigational Satellite Systems**						**Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
DC PC601EC	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- To understand fundamentals of Global Position System (GPS)
- To know the signal structures and error sources of GPS
- To study architectures of different GPS based augmentation systems.
- To learn the basic concepts of other GNSS constellations.
- To know the idea about Regional based navigation systems.

Course Outcomes

1. Familiarize with the GNSS fundamentals and GPS architecture.
2. Describe the different types of GNSS Signals and GNSS Datum.
3. Analyse the GPS errors and their modelling techniques.
4. Understanding various GPS data processing and GPS integration techniques.
5. Conceptualize the augmentation systems and regional navigation satellite systems.

UNIT-I

GPS Fundamentals: GPS Constellation, Principle of operation, GPS Orbits, Orbital mechanics and satellite position determination, Time references, Geometric Dilution of Precision: GDOP, VDOP, PDOP. Solar and Sidereal day, GPS and UTC time.

UNIT-II

GPS Signal Structure: GPS signals, C/A and P-Codes, GPS Signal generation, Spoofing and anti-spoofing. **Error sources in GPS:** Satellite and receiver clock errors, Ephemeris error, Atmospheric errors, Receiver measurement noise and UERE

UNIT-III

GPS Augmentation systems: Classification of Augmentations Systems, Relative advantages of SBAS and GBAS, Wide area augmentation system (WAAS) architecture, Local area augmentation system (LAAS) concept, GPS Aided GEO Augmented Navigation (GAGAN), European Geostationary Navigation Overlay Service (EGNOS) and MTSAT Satellite-based Augmentation System (MSAS). Differential GPS.

UNIT-IV

Other GNSSs: Architecture and features of Russian Global Navigation Satellite System (GLONASS), European Navigation System (Galileo), Chinese Global Navigation System (BieDou-2/COMPASS), GNSS Applications.

UNIT-V

Regional Navigation Satellite Systems (RNSS): Indian Regional Navigation Satellite System (IRNSS), Japan's Quasi-Zenith Satellite System (QZSS), Chinese Area Positioning System (CAPS).
GPS Integration: GPS/GIS, GPS/INS, GPS/Pseudolite, GPS/Cellular integrations.

Suggested Readings:

1. Rao G.S., "Global Navigation Satellite Systems – with Essentials of Satellite Communications", Tata McGraw Hill, 2010.
2. Sateesh Gopi, "Global Positioning System: Principles and Applications", TMH, 2005.
3. Elliot D. Kaplan, "Understanding GPS Principles and Applications", 2/e, Artech House, 2005.

4. Paul D Groves, "Principles of GNSS, Inertial, and Multi-Sensor Integrated Navigation Systems" Artech House Publishers, 2017
5. Basudeb Bhatta," Global Navigation Satellite Systems: Insights into GPS, GLONASS, Galileo, Compass", B.S. Publications, 2010

Course Code	Course Title						Core / Elective
PE 833 EC	**System Verilog**						**Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
DSD PC506EC	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- ➢ Understand about Verification and System Verilog as tool
- ➢ Gain knowledge about using the System Verilog Tool
- ➢ Learning the concept of OOP in verification
- ➢ Using the concept of OOP classes, connections and coding
- ➢ Learn verification techniques with an example

Course Outcomes

1. Understand the evolution and importance of System Verilog
2. Familiarize with the System Verilog tools
3. Apply the concepts of OOP in verification
4. Programming using the concepts of OOP classes, connections and coding.
5. Apply verification techniques

UNIT-I

System Verilog as a Verification Language, Main Benefits of Using System Verilog, Drawbacks of Using System Verilog, System Verilog Traps and Pitfalls, The Evolution of OOP and system Verilog, The Evolution of Functional Verification, The emergence of hardware verification languages, OOP and System Verilog

UNIT-II

Teal Basics: Main Components, Using Teal, simple test, Logging Output, Using Test Parameters, Accessing Memory, A memory example, Truss: A Standard Verification Framework: Overview, General Considerations, System Verilog considerations, An AHB example

UNIT-III

Overview, Sources of Complexity, Team dynamics, Creating Adaptable Code, Architectural Considerations to Maximize Adaptability. Designing with OOP: Overview, Keeping the Abstraction Level Consistent, using "Correct by Construction", The Value of Packages

UNIT-IV

OOP classes: overview, OOP Connections: Overview, How Tight a Connection, Types of Connections, Coding OOP: Overview, "If" Tests, Coding Tricks, Coding Idioms, Enumeration for Data, Integer for Code Interface.

UNIT-V

Overview, Theory of Operation, Verification environment, Verification IP, UART VIPs, Wishbone VIP, the verification dance, Running the UART Example, Configuration, VIP UART package, VIP UART configuration class, UART 16550 configuration class

Suggested Readings:

1. System Verilog for Design Stuart Sutherland, Simon Davidmann, Peter Flake, P. Moorby
2. Hardware Verification with SystemVerilog, An object-oriented Framework, Mike Mintz, Robert Ekendahl, Springer
3. J. Bhasker, "System Verilog Primer", B.S. Publication, 2013

4. Chris Spears, "SystemVerilog for Verification: A Guide to Learning the Testbench Language Features", 2006.
5. Ashok B Mehte, "SystemVerilog Assertions and Functional Coverage: Guide to Language, Methodology and Applications", Spinger, 2013

Course Code	Course Title						Core / Elective
PE 834 EC	**Multirate Signal Processing**						**Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
SATT PC304EC DSP PC503EC	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- To introduce the fundamentals of Multirate signal processing and demonstrate the ability to solve problems in sample rate conversion, filter banks
- To Create efficient realizations for up sampling and down sampling of signals using the polyphase decomposition
- To develop the ability to design digital filter banks and half-band filters based on the techniques presented
- To develop the ability to design multilevel filter banks
- To Utilize MATLAB for signal analysis, digital filter design and wavelets

Course Outcomes

1. Able to solve problems in sampling rate conversion and filter banks
2. Design and implement perfect reconstruction filter bank systems
3. Able to implement multiphase and polyphase representation.
4. Analyse the various adaptive processing algorithms
5. Able to use wavelets in signal processing applications.

UNIT-I

Review of fundamentals of Multirate systems: Decimation by an integer factor D, Interpolation by an integer factor L, Time- and frequency-domain representation and analysis of decimated and interpolated signals, Efficient structures for decimation and interpolation filters, Sampling rate conversion by a rational factor I/D, Inter connection of building blocks, polyphase representation, Multi stage implementation of sampling-rate conversion, Applications of Multirate systems.

UNIT-II

Multirate Filter banks: Digital filter banks, Uniform DFT filter banks, Polyphase implementation of Uniform filter banks.

Nyquist filters: L^{th}-band filters, half band filters, Half-band High pass filter, Window Design of Half-Band Filter, Interpolation and decimation with Low Pass Half-Band Filters**,** Design of Linear-phase L^{th} band FIR filters, Relation between Lth-Band filters and power complementary filters.

UNIT-III

Quadrature- Mirror Filter banks: The filter bank structure, Analysis of Two channel QMF bank, Errors in the QMF bank, Alias free filter banks, Alias-free realization, Alias-free FIR QMF bank, Alias-free IIR QMF bank, perfect reconstruction(PR) two-channel FIR filter bank, Alias-free L-channel filter bank and Multilevel filter banks-filter with equal and unequal pass band widths.

UNIT-IV

Adaptive Algorithms to adjust coefficients of digital filters: Least Mean Square (LMS), Recursive Least Square (RLS) and Kalman Filter Algorithms

UNIT-V

Wavelets and its applications: Introduction to wavelet Theory, wavelet transform, Definition and properties, Continuous Wavelet Transform and Discrete Wavelet Transform, Application of Wavelets in signal processing.

Suggested Readings:

1. J.G. Proakis. D.G. Manolakis. "Digital Signal Processing: Principles. Algorithms and Applications",3rd Edn. Prentice Hall India, 1999.
2. Vidyanathan PP, "Multi-rate Systems and Filter Banks," Pearson Education, 2008.
3. B. Widrow & S Stearns: Adaptive Signal Processing, PHI, 1985
4. Bruce W Suter, "Multi-rate and Wavelet Signal Processing." Volume 8, Academic Press, 1998.
5. K. P. Soman, K. I. Ramachandran, N. G. Resmi, PHI, Insight into wavelets from theory to practice

Course Code	Course Title						Core / Elective
PE 841 EC	**Real Time Operating Systems**						**Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
ES PC701EC	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- The functions performed by an Operating system
- To differentiate between real time systems and study the scheduling algorithms
- The concepts of process synchronization
- The elementary concepts of VxWorks
- The fundamental concepts of UNIX operating system

Course Outcomes

1. Classify various types of kernels and operating systems
2. Analyse various scheduling algorithms related to RTOS.
3. Summarize the Inter process communication tools.
4. Understand the elementary concepts of Vxworks
5. Enumerate the fundamental concepts of UNIX operating system

UNIT – I

Structures of Operating System (Monolithic, Microkernel, Layered, Exo-kernel and Hybrid kernel structures), Operating system objectives and functions, Virtual Computers, Interaction of OS and Hardware architecture, Evolution of operating systems, Batch, multi programming, Multitasking, Multiuser, parallel, distributed and real-time OS.

UNIT – II

Hard versus Soft Real-Time System: Jobs and Processors, release time, deadlines, and timing constraints, hard and soft timing constraints, hard real time systems, Uniprocessor Scheduling: Types of scheduling, scheduling algorithms: FCFS, SJF, Priority, Round Robin, UNIX Multi-level feedback queue scheduling, Thread scheduling, Multiprocessor scheduling concept, Real Time scheduling concept.

UNIT – III

Concurrency: Principles of Concurrency, Mutual Exclusion H/W Support, Software approaches, Semaphores and Mutex, Message passing, Monitors, Classical problems of Synchronization: Readers-Writers problem, Producer Consumer problem, Dining Philosopher problem. Deadlock: Principles of deadlock, Deadlock prevention, Deadlock Avoidance, Deadlock detection, An Integrated Deadlock Strategies.

UNIT – IV

Elementary Concepts of VxWorks: Multitasking, Task State Transition, Task Control – Task Creation and Activation, Task Stack, Task Names and IDs, Task Options, Task Information, Task Deletion and Deletion Safety. Memory Management – Virtual to Physical Address Mapping. Comparison of RTOS – VxWorks, μC/OS-II and RT Linux for Embedded Applications.

UNIT-V

UNIX Kernel: File System, Concepts of –Process, Concurrent Execution & Interrupts. Process Management – forks & execution. Basic level Programming with System calls, Shell programming and filters, UNIX Signals, POSIX Standards

Suggested Readings:

1. Andrew S. Tanenbaum, "Modern Operating Systems," 4/e, Pearson Edition,2014.
2. Jane W.S. Liu, "Real Time Systems," 1/e, Pearson Education, Asia, 2002.
3. Jean J Labrose," Embedded Systems Building Blocks Complete and Ready-to-use Modules in C", 2/e, CRC Press 1999.
4. Karim Yaghmour, Jon Masters, Gilad Ben-Yesset, Philippe Gerum", Building Embedded Linux Systems, 2/e, O' Reilly Media, 2008
5. Wind River Systems, "VxWorks Programmers Guide 5.5", Wind River Systems Inc.2002

Course Code	Course Title						Core / Elective
PE 842 EC	**Fuzzy Logic and Applications**						**Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
DCCN PE672EC	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- The concepts of regular sets and Fuzzy sets
- To gain the knowledge of Fuzzy relations
- Different Fuzzification methods & Membership function
- Different Defuzzification methods
- Fuzzy Associative Memories, FAM system Architecture & its applications

Course Outcomes

1. To distinguish crisp sets & Fuzzy sets and perform operations on Fuzzy sets
2. Define Fuzzy relations & apply operations on different Fuzzy relations
3. To convert crisp sets to Fuzzy sets using different Fuzzification methods
4. To convert Fuzzy sets to Crisp sets using different Defuzzification methods
5. To understand Fuzzy Associative Memories & FAM system Architecture

UNIT-I

Basics of Fuzzy sets: Introduction to Fuzzy sets, Operation on Fuzzy sets, Properties of Fuzzy sets, Extensions of Fuzzy set concepts, Extension principle and its applications.

UNIT-II

Fuzzy Relations: Basics of fuzzy relations, Operations on fuzzy relations, Properties of Fuzzy relations, Fuzzy Equivalence & Fuzzy Tolerance relations, Various types of Binary fuzzy relations.

UNIT-III

Membership Functions: Features of the membership function, Fuzzification, Membership value assignments: Intuition, Inference, Rank ordering, Neural Networks.

UNIT-IV

Defuzzification, Different Defuzzification methods: Max-membership principle, Central method, weighted average method, Mean-max membership, Center of sums, Center of largest area, First (or last) of maxima.

UNIT-V

Fuzzy Associative Memories: FAMs as Mappings, Fuzzy Hebb FAMS, Bi-directional FAM theorem for Correlation-Minimum Encoding, Correlation-Product Encoding, Superimposing FAM rules, FAM system Architecture, Example of Invented pendulum, Basic structure and operation of Fuzzy logic control system, Applications of Fuzzy controllers.

Suggested Readings:

1. Timothy J. Ross, “Fuzzy Logic with Engineering Applications”, McGraw Hill, 1995.
2. C.T. Lin and C.S. George Lee, "Neural Fuzzy Systems", PHI, 1996.
3. Bant A KOSKO, "Neural Networks and Fuzzy Systems", PHI, 1994.
4. Altrock, C.V., "Fuzzy Logic and Neuro Fuzzy Applications explained", PHI, 1995.
5. John Harris, "Introduction to fuzzy logic applications", Springer, 2000.

<table>
<tr><td>Course Code</td><td colspan="6">Course Title</td><td>Core / Elective</td></tr>
<tr><td>PE 843 EC</td><td colspan="6">Radar Systems</td><td>Elective</td></tr>
<tr><td rowspan="2">Prerequisite</td><td colspan="4">Contact Hours per Week</td><td rowspan="2">CIE</td><td rowspan="2">SEE</td><td rowspan="2">Credits</td></tr>
<tr><td>L</td><td>T</td><td>D</td><td>P</td></tr>
<tr><td>DC PC601EC</td><td>3</td><td>-</td><td>-</td><td>-</td><td>30</td><td>70</td><td>3</td></tr>
</table>

Course Objectives

- To understand RADAR system block diagram, applications and develop range equation.
- To study various parameters used to enhance range prediction such as receiver noise, noise temperature, integration of pulses etc.
- To understand the concept of CW radar and learn its variations, to study various types of displays in radar systems.
- To understand MTI radar and understand the limitations of MTI radar and non-coherent MTI radar.
- To understand radar tracking methods and study differences among them.
- To study and understand search radar and antennas.

Course Outcomes

1. Explain basics of RADAR system and will able to develop radar range equation. Illustrate the importance of various parameters in enhanced range estimation for accurate prediction
2. Illustrate various types of radars such as CW radar and their variations and displays in radar
3. Explain types of MTI radar and non-coherent MTI radar
4. Illustrate on radar tracking methods and differences among them
5. Explain search radars and various antennas used in radars

UNIT-I

Radar Systems: Description of basic radar system and its elements, Radar equation, Block diagram and operation of a radar, Radar frequencies, Application of Radar, Prediction of range performance, Minimum detectable signal, Receiver noise figure, Effective noise temperature, Signal to noise ratio, False alarm time and probability of false alarm, Integration of radar pulses, Radar cross-section of target, Pulse-repetition frequency and range ambiguities, System losses.

UNIT-II

CW and FMCW Radars: Doppler effects, CW Radar, FMCW Radar, Multiple frequency CW radar, Low noise front-ends, A-scope, B-scope, PPI Displays, Duplexers.

UNIT-III

MTI and Pulse Doppler Radar: MTI radar, Delay line canceller, Multiple and staggered prf, Blind speeds, Limitations to MTI performance, MTI using range gated Doppler filters, pulse Doppler radar, Non-coherent radar.

UNIT-IV

Tracking Radar: Sequential lobbing, Conical scan, Mono-pulse-amplitude comparison and phase comparison methods, Tracking in range and in Doppler, Acquisition, comparison of trackers.

UNIT-V

Search Radar: Range equation, search scans, Effect of surface reflection, Line of Sight (LOS), propagation effects, Environmental noise. Radar Antennas: Antenna parameters- Parabolic reflector antennas, Cassegrain antenna, Cosecant - squared Antenna pattern.

Suggested Readings:

1. Skolnik, Merrill I, Introduction to Radar Systems, 3/e, MGH, 2002.
2. Barton. David K, Modern Radar System Analysis, 1/e, Aretech House, 2004.
3. Peebles PZ, 'Radar Principles', John – Willey, 2004.
4. Paul A Lynn, "Radar Systems" Springer, 1987
5. Harold Roy Reamer, "Radar Systems Principles", Springer, 1997

Course Code	Course Title						Core / Elective
PE 844 EC	**Design of Fault Tolerant Systems**						**Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
STLD PC303EC	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- Gain the basic concepts and metrics of reliable systems.
- To be able to comprehend the methods involved in testing of circuits.
- Appreciating the techniques involved in developing reliable and fault tolerant modules using redundancy.
- Gain insight into practical applications of reliable systems.
- Study testability, built–in-test & self-test concepts.

Course Outcomes

1. To understand the basic concepts and metrics of reliable systems.
2. To understand the methods involved in testing of circuits.
3. Study the techniques involved in developing reliable and fault tolerant modules using redundancy.
4. Study practical applications of reliable systems.
5. To understand testability, built–in-test & self-test concepts.

UNIT-I

Failures and faults, Reliability and failure rate, Relation between reliability & mean time between failure, Maintainability & Availability, reliability of series and parallel systems. Modelling of faults. Test generation for combinational logic Circuits: conventional methods-path sensitization & Boolean difference. Random testing- transition count testing and signature analysis.

UNIT-II

Basic concepts, static, (NMR and use of error correcting codes), dynamic, hybrid and self-purging redundancy, Sift-out Modular Redundancy (SMR), triple modular redundancy, SMR reconfiguration.3

UNIT-III

Time redundancy, software redundancy, fail-soft operation, examples of practical fault tolerant systems, introduction to fault tolerant design of VLSI chips.

UNIT-IV

Design of totally self-checking checkers, checkers using m-out of a codes, Berger codes and low cost residue code, self-checking sequential machines, partially self-checking circuits. Fail safe Design: Strongly fault secure circuits, fail-safe design of sequential circuits using partition theory and Berger codes, totally self-checking PLA design.

UNIT-V

Basic concepts of testability, controllability and observability. The Reed-Muller expansion technique, level OR-AND-OR design, use of control and syndrome-testing design.

Built-in-test, built-in-test of VLSI chips, design for autonomous self-test, design in testability into logic boards.

Suggested Readings:

1. Parag K. Lala, "Fault Tolerant & Fault Testable Hardware Design", PHI, 1985
2. Parag K. Lala, "Digital systems Design using PLD's", PHI 1990.
3. N.N. Biswas, "Logic Design Theory", PHI 1990.

4. Konad Chakraborthy & Pinaki Mazumdar, Fault tolerance and Reliability Techniques for high – density random – access memories Reason, 2002.
5. Rolf Isermann "Fault Diagnosis Applications", Springer 2011.

Course Code	Course Title						Core / Elective
PW 961 EC	**Project Work - II**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**-**	**-**	**-**	**16**	**50**	**100**	**8**

Course Objectives

- To enhance practical and professional skills.
- To familiarize tools and techniques of systematic literature survey and documentation
- To expose the students to industry practices and team work.
- To encourage students to work with innovative and entrepreneurial ideas

Course Outcomes

1. Demonstrate the ability to synthesize and apply the knowledge and skills acquired in the academic program to the real-world problems.
2. Evaluate different solutions based on economic and technical feasibility
3. Effectively plan a project and confidently perform all aspects of project management
4. Demonstrate effective written and oral communication skills

The aim of Project work –II is to implement and evaluate the proposal made as part of Project Work - I. Students can also be encouraged to do full time internship as part of project work-II based on the common guidelines for all the departments. The students placed in internships need to write the new proposal in consultation with industry coordinator and project guide within two weeks from the commencement of instruction.

The department will appoint a project coordinator who will coordinate the following:

1. Re-grouping of students - deletion of internship candidates from groups made as part of project Work-I
2. Re-Allotment of internship students to project guides
3. Project monitoring at regular intervals

All re-grouping/re-allotment has to be completed by the 1st week of VIII semester so that students get sufficient time for completion of the project.

All projects (internship and departmental) will be monitored at least twice in a semester through student presentation for the award of sessional marks. Sessional marks are awarded by a monitoring committee comprising of faculty members as well as by the supervisor. The first review of projects for25 marks can be conducted after completion of five weeks. The second review for another 25 marks can be conducted after 12 weeks of instruction.

Common norms will be established for the final documentation of the project report by the respective departments. The students are required to submit draft copies of their project report within one week after completion of instruction.

Note: Three periods of contact load will be assigned to each project guide.