DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

Master of Technology in Electronics & Communication Engineering
Effective from Academic Session – 2021-22

Detailed Course Structure & Curriculum

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY

Approved in Academic Council Meeting held on 28 July, 2021

SEMESTER - I								
S. No.	**Course Code**	**Name of the Subjects**		**Course Hours**			**Total**	**Credits**
			C/E	L	T	P		
1	21M11EC112	Embedded Systems and Applications	C	3	0	0	3	3
2	21M11EC111	Sensor and Smart Instrumentation	C	3	0	0	3	3
3	21M11EC113	Object Oriented Programming	C	3	0	0	3	3
4		Departmental Elective - I	E	3	0	0	3	3
5		Departmental Elective - II	E	3	0	0	3	3
6		Departmental Elective - III	E	3	0	0	3	3
7	21M11EC172	Advanced Communication Lab	C	0	0	6	6	3
						Total	**24**	**21**
SEMESTER - II								
S.No.	**Course Code**	**Subject Names**		**Course Hours**			**Total**	**Credits**
			C/E	**L**	**T**	**P**		
1	21M11EC211	Digital System design using verilog HDL	C	3	0	0	3	3
2	21M11EC212	Artificial Intelligence and Expert Systems	C	3	0	0	3	3
3	21M11EC213	Network Security Protocols	C	3	0	0	3	3
4		Departmental Elective - IV	E	3	0	0	3	3
5		Departmental Elective - V	E	3	0	0	3	3
6		Open Elective	E	3	0	0	3	3
7	21M11EC272	Advanced Signal Processing Lab	C	0	0	6	6	3
						Total	**24**	**21**
SEMESTER - III								
S. No.	**Course Code**	**Name of the Subjects**		**Course Hours**			**Total**	**Credits**
			C/E	**L**	**T**	**P**		
1	21M19EC391	Literature Review / Seminar	C	0	0	6	6	3
2	21M19EC392	Dissertation Part - I	C	0	0	28	28	14
						Total	**34**	**17**
SEMESTER - IV								
S.No.	**Course Code**	**Subject Names**		**Course Hours**			**Total**	**Credits**
			C/E	**L**	**T**	**P**		
1	21M19EC491	Seminar	C	0	0	6	6	3
2	21M19EC492	Dissertation Part - II	C	0	0	28	28	14
						Total	**34**	**17**

LIST OF ELECTIVES FOR M. TECH ECE								
ELECTIVE – I								
S.No.	**Course Code**	**Subject Names**		**Course Hours**			**Total**	**Credits**
			C/E	**L**	**T**	**P**		
1	21M1WEC137	Advanced Cognitive Radio	E	3	0	0	3	3
2	21M1WEC138	Advanced Software Defined Radio	E	3	0	0	3	3
3	21M1WEC139	Fault Tolerant Communication Networks	E	3	0	0	3	3
4	21M1WEC140	Advanced Next Generation Communication	E	3	0	0	3	3
Elective - II								
1	21M1WEC141	Advanced Control Systems	E	3	0	0	3	3
2	21M1WEC142	Networked Distributed Control	E	3	0	0	3	3
3	21M1WEC143	Fundamentals of MIMO Systems	E	3	0	0	3	3
4	21M1WEC144	Mobile Adhoc and Sensor Network	E	3	0	0	3	3
Elective - III								
1	21M1WEC145	Architecture and Algorithms for DSP Systems	E	3	0	0	3	3
2	21M1WEC146	Statistical & Adaptive Signal Processing	E	3	0	0	3	3
3	21M1WEC147	Statistical Signal Processing	E	3	0	0	3	3
4	21M1WEC148	Radar and Sonar Signal Processing	E	3	0	0	3	3
5	21M1WEC149	Computational Intelligence and Applications	E	3	0	0	3	3
Elective - IV								
1	21M1WEC237	Biomedical signal and Image Processing	E	3	0	0	3	3
2	21M1WEC238	Advanced Digital Image Processing	E	3	0	0	3	3
3	21M1WEC239	CMOS Digital Design Techniques	E	3	0	0	3	3
4	21M1WEC240	Real Time Embedded System	E	3	0	0	3	3
5	21M1WEC241	VLSI in Biomedical Processing System	E	3	0	0	3	3
Elective - V								
1	21M1WEC242	Anteena and Radio Wave Propagation	E	3	0	0	3	3
2	21M1WEC243	Antenna Theory and Techniques	E	3	0	0	3	3
3	21M1WEC244	RF IC Design	E	3	0	0	3	3
4	21M1WEC245	Analog IC Design	E	3	0	0	3	3

M. TECH.

ELECTRONICS & COMMUNICATION ENGINEERING

COURSE CONTENTS

Approved in Academic Council Meeting held on 28 July, 2021

Embedded Systems and Applications

COURSE CODE: 21M11EC112

COURSE CREDITS: 3

CORE/ELECTIVE: CORE

L-T-P: 3-0-0

Prerequisite: None

Course Objectives:

To learn about the embedded system application areas, design challenges, embedded system processors and tools used for embedded system design.

Course Outcomes:

Sl. No.	Course Outcomes	Level of Attainment
1	Understand various components of embedded system, design challenges	Familiarity
2	Comprehend RISC architecture, programming of ARM and PIC microcontrollers	Usage
3	Know about embedded system design and development methodology, tools and languages used for embedded system design	Usage
4	Learn about Devices and Communication interface used in embedded system	Usage
5	Learn about Real Time Operating System used for embedded system application	Usage

Course Contents:

Unit	Contents	Lectures required
1	Introduction: Characteristics of Embedded System Computing, Concept of Real time Systems, Classification, Application areas, Design challenges – real-time execution, physical size, power consumption, multirate operation	6
2	Embedded system processors: ARM Processor Fundamentals and Architectures, ARM Instruction Set, PIC Microcontroller and its Architecture, Instruction Set	8
3	Embedded hardware units and devices in a System, Embedded software in a system, Embedded system-on-chip (SOC), Embedded system-on-module (SOM)	6
4	Devices and Communication interface: Serial communication devices, Parallel communication, Wireless Devices, Timer and Counting Devices, Watchdog timer, Real time clock, Parallel communication network using ISA, PCI, Serial bus	8

	communication protocols, SCI, CAN, I2C, USB	
5	Real Time Operating System: Real-time Kernels, Polled Loops System, Co-routines, Interrupt-driven System, Multi-rate System, Processes and Threads, Context Switching, Scheduling, Inter-process Communication, Real-time Memory Management, I/O, VxWorks, RT-Linux	8
6	Case Study: ARM Cortex-A5 Processor-based SOM, ATSAMA5D27-SOM1, Use of SAMA5D2 GPIO under Linux	6
Total lectures		**42**

Suggested Text Book(s):

1. Frank Vahid and Tony Givargis, "Embedded system design: A unified Hardware/Software introduction,"3rd Ed., Wiley 2014

2. Shibu K. V, "Introduction to Embedded Systems," 2nd Ed., McGraw Hill 2017

3. Embedded System: Architecture, Programming and Design by Rajkamal,2nd Ed., 2010, Tata McGraw Hill

Suggested Reference Book(s):

1. Steve Furber, "ARM System-on-Chip Architecture," 2nd Ed., Pearson, 2012

2. Tim Wilmshurst, "Designing Embedded Systems with PIC Microcontrollers: Principles and Applications," 2nd Ed., Newnes, 2009

3. Steven F Barrett and Daniel J Pack, "Embedded Systems Design and Applications with the 68HC12 and HCS12," 1st Ed., Pearson 2012

4. Kenneth Ayala, "The 8051 microcontroller," 3rd Ed., Thomson,2005

Other useful resource(s):

https://www.microchip.com/wwwproducts/en/ATSAMA5D27-SOM1

https://www.microchip.com/wwwappnotes/appnotes.aspx?appnote=en1000789

NPTEL ONLINE COURSES

1. Embedded Systems: https://nptel.ac.in/courses/108105057/
2. Embedded Systems: https://nptel.ac.in/courses/108102045/
3. Embedded Systems Design: https://nptel.ac.in/courses/106105159/

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1.	T-1	15	1 Hour.	Syllabus covered up to T-1
2.	T-2	25	1.5 Hours	Syllabus covered up to T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

Sensors and Smart Instrumentation

COURSE CODE:21M11EC111
COURSE CREDITS: 3
CORE/ELECTIVE: CORE
L-T-P: 3-0-0

Prerequisite: None

Course Objectives:

To learn about various sensors and transducers and their integration in a smart instrumentation system

Course Outcomes:

Sl. No.	Course Outcomes	Level of Attainment
1	Knowledge of characteristics of sensors and measurement system, criteria for transducer selection	Familiarity
2	Learn about data acquisition systems, signal conditioners and signal converters	Usage
3	Knowledge about different basic sensors and transducers used for measurement of physical quantities	Usage
4	Knowledge about different measurement systems used in industry	Usage
5	Learn about characteristics and working of smart sensors and instruments	Assessment

Course Contents:

Unit	Contents	Lectures required
1	Introduction: Basics of measurement systems, sensors and transducers, General transducers characteristics, static and dynamic characteristics, Criteria for transducer selection, Calibration techniques, Classification of errors	6
2	Data acquisition system and its uses in intelligent Instrumentation systems, Signal conditioners, signal converters, sample and hold. Instrumentation amplifiers, Interference, grounding and shielding	8
3	Resistive Transducers: Potentiometers, strain gauges, Resistance Thermometer, Thermistors. Inductive Transducers, Capacitive Transducers: Principles of operation, construction, Piezoelectric transducer, fibre optic transducers for the measurement of force, temperature, flow and pressure, Elastic Transducers: Spring bellows, diaphragm, bourdon tube.	10
4	Pressure sensor, temperature measurement, flow measurement, level measurement, displacement, force, velocity, acceleration and torque measurement. Telemetry, multiplexing, modulation of data, transmission channels.	8

5	Smart instruments - comparison with conventional transducers - self diagnosis and remote calibration features - smart transmitter with HART communicator - Micro Electro Mechanical Systems - sensors, actuators - principles and applications, nonlinearity compensation. Cogent sensors, Soft sensors, self-validating sensors, temperature-compensating sensors, ANN-based sensors, ANN techniques for fault detection, linearization, and calibration	10
Total lectures		**42**

Suggested Text Book(s):

1. Doebelin EO, "Measurement Systems: Application and Design," Tata McGraw Hill, 7th Ed., 2019
2. Patranabis D, "Sensors and Transducers," Prentice Hall of India, 2nd Ed., 2003
3. Manabendra Bhuyan, "Intelligent Instrumentation: Principles and Applications", CRC Press, 2017

Suggested Reference Book(s):

1. Subhas Chandra Mukhopadhyay, "Intelligent Sensing, Instrumentation and Measurements (Smart Sensors, Measurement and Instrumentation Book 5)," Springer, 2013.
2. Bela G. Liptak, "Instrument Engineers' Handbook, Volume One: Process Measurement and Analysis," 4th Ed., CRC Press, 2003

Other useful resource(s):

NPTEL Course: https://nptel.ac.in/courses/108/105/108105064/ Evaluation

Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1.	T-1	15	1 Hour.	Syllabus covered up to T-1
2.	T-2	25	1.5 Hours	Syllabus covered up to T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

Object Oriented Programming

COURSE CODE: 21M11EC113

COURSE CREDITS: 3

CORE/ELECTIVE: CORE

L-T-P: 3-0-0

Prerequisite: None

Course Objectives:

To learn the concept of object oriented programming and to acquire object oriented programming skills in Python, C++ and JAVA

Course Outcomes:

Sl. No.	Course Outcomes	Level of Attainment
1	Learn about object-oriented approach to programming and advantages of Object-oriented programming over other approaches	Familiarity
2	Understand the concepts of data abstraction, encapsulation, inheritance and polymorphism	Familiarity
3	Analyze and decompose problem specifications from Object Oriented Perspectives and represent the solution, using UML notation	Usage
4	Learn to do object oriented programming using Python	Usage
5	Learn to do object oriented programming using C++ and JAVA	Usage

Course Contents:

Unit	Contents	Lectures required
1	Introduction: procedural programming, structured programming, abstract data types, data encapsulation, object oriented programming paradigm	6
2	Abstract Data Types, Classes and Objects, Inheritance (Single, Multilevel, Multiple, Hierarchical, Hybrid). Super-classes (base classes) and sub-classes (derived classes). Specialisation vs. Generalisation. Abstract and Concrete Classes and Methods. Inheritance for Specialisation vs. Specification. Inter-class Relationships (isa, has-a, part-of, association, aggregation, composition). Class members: fields (data members, variables, attributes), and methods (member functions, procedures). Messages. Object State. Constructors (parameterised, copy, conversion, default) and destructors. Object and member scope. Polymorphism.	10

3	Unified Modelling Language (UML). Use case diagrams: actors, system boundary, <<uses>> and <<extends>>. Class diagrams: associations, aggregation, dependency, and inheritance. Object interaction diagrams, object state transition diagrams.	8
4	Object oriented programming using Python: Builtin classes in Python - data types. User defined class, Object, Method, Inheritance, Encapsulation, Polymorphism, Data Abstraction in Python. Exception handling.	8
5	Object oriented programming using C++ and JAVA: Objects, Classes, Methods, Constructors and destructors. Friend Functions, Static member functions, Inheritance, Multiple Inheritance, Polymorphism and Virtual Functions, Function and Operator overloading, Namespace and Templates in C++. Packages, Class path, Interfaces in JAVA. Exception Handling in C++ and JAVA	10
Total lectures		**42**

Suggested Text Book(s):

1. Robert Lafore, "Object-Oriented Programming in C++," 4th Ed., Sams, 2001
2. Herbert Schildt, "Java The Complete Reference - 11th Ed. McGraw Hill, 2020
3. Martin C. Brown, "Python: The Complete Reference", 4th Ed. McGraw Hill, 2018

Suggested Reference Book(s):

1. A Downey, "Learning with Python", Dreamtech Press, 2015
2. Bjarne Stroustrup, "The C++ Programming Language," 3rd Ed., Pearson, 2002
3. Matha, "Object - Oriented Analysis and Design Using UML: Introduction to Unified Process and Design Patterns", PHI, 2008

Other useful resource(s):

NPTEL Course: https://nptel.ac.in/courses/106/105/106105153/

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1.	T-1	15	1 Hour.	Syllabus covered up to T-1
2.	T-2	25	1.5 Hours	Syllabus covered up to T-2
3.	T-3	35	2 Hours	Entire Syllabus

4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

Advanced Cognitive Radio

COURSE CODE:21M11WC137

COURSE CREDITS: 3

CORE/ELECTIVE:

: 3-0-0

Pre-requisite: None

Course Objectives:

1. To understand the fundamentals of cognitive radio networks.
2. To understand the need of cognitive radio networks for next generation communication
3. Analyze the design of wireless networks based on cognitive radio technology

Course Outcomes:

S. No.	Course Outcomes	Level of Attainment
CO-1	To understand the fundamentals of cognitive radio networks	Familiarity
CO-2	Knowledge of spectrum sensing and spectrum sharing models in the Cognitive Radio Network	Assessment
CO-3	To understand the need of cognitive radio networks for next generation communication	Assessment
CO-4	Analyze the emerging issues in cognitive radio network	Usage

Course Contents:

Unit	Contents	Lectures required
1	CRN Basics: Cognitive cycle, Hypothesis model, Spectrum sensing and sharing overview, challenges in spectrum sensing and sharing	**11**
2	Multiuser and Multi-antenna Environment in CRN, Performance Parameters and their optimization in CRN	**11**
3	Clustering in CRN, Primary User Emulation Attack , Full Duplex CRN, NOMA in CRN	**10**
4	CRN in the context of Industry 4.0, Recent Advancements in CRN	**10**
Total lectures		**42**

Suggested Text Book(s):

1. Ekram Hossain, Dusit Niyato and Zhu Han: Dynamic Spectrum Access and Spectrum Management in Cognitive Radio Networks, 1st Edition, Cambridge University Press, 2009.

2. Huseyin Arslan: Cognitive Radio, Software Defined Radio, and Adaptive Wireless Systems, 1st Edition, Springer, 2007.

Suggested Reference Book(s):

1. Linda E. Doyle: Essentials of Cognitive Radio, 1st Edition, Cambridge University Press, 2009Fundamentals of Wireless Communication by Tse David and Viswanath Pramod, Cambridge University press, Cambridge
2. Yang Xiao and Fei Hu: Cognitive Radio Networks, 1st Edition, CRC Press, 2008

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

Course Outcomes (COs) contribution to the Programmed Outcomes (POs)

Course outcomes (Advanced Cognitive Radio Network)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	1	2	2	2	3	1	1	1	1	2	2	3	**1.75**
CO-2	3	3	2	2	2	2	2	1	2	2	1	2	**2**
CO-3	3	1	2	1	2	2	2	2	2	3	1	1	**1.83**
CO-4	3	3	2	2	2	2	1	2	1	2	2	1	**1.91**
Average	**2.5**	**2.25**	**2**	**1.75**	**2.25**	**1.75**	**1.5**	**1.5**	**1.5**	**2.25**	**1.5**	**1.75**	

FAULT-TOLERANT COMMUNICATION NETWORKS

(Elective Subject)

Course Code:	14M1WEC331	**Semester:**	**M.Tech. 3rd Sem.**
Credits:	3	**Contact Hours:**	L-3, T-0, P-0

Course Objectives

The objectives are to study

1. Define common terms such as availability, reliability, dependability etc.
2. Induction with the service-based network design approach.
3. Terminology related to network pathology.
4. Role of reliability engineering in fault-tolerant network design.
5. Methodology of protection and restoration.
6. Implementation of fault-tolerant scheme for: (i) optical networks, (ii) SONET/SDH network, (iii) MPLS based network, (iv) adhoc networks
7. Planning for mission-critical networks.

Course Outcomes

After studying this course the students would gain enough knowledge

1. Apply the concepts of reliability and fault-tolerance for the network design.
2. Grade the network services on the basis of predictable.
3. Apply the knowledge for various networks viz. (i) optical networks, (ii) SONET/SDH network, (iii) MPLS based network, (iv) adhoc networks
4. Extend the knowledge for the mission-critical networks.

Course Contents

Unit	Topics	References (chapter number, page no. etc)	Lectures
1.	**Background of Fault-tolerance in Communication Network:** Historical perspective of fault-tolerance in communication, performance predictability, best-effort service, guaranteed service, QoS Fault, Failure and Error: reliability engineering in network design, causes of network failure, uncertainty in network, Imperfections in network design, performance failure, breakdown failure, reliability evaluation, failure distribution, MTTR, MTTF. Concepts of reliability, survivability, dependability, resiliency, recovery, continuity and performability	[1,2,3,7,8]	9
2.	**Network Availability, Protection & Restoration** Continuity and availability in communication network, transition from acceptable to unacceptable service state and Vice-Versa, Concepts and methodology of protection and restoration. [1,2,5]	Kang : Chapter 3	8
3	Fault-tolerant schemes for Optical networks, [2,4]	Kang : Chapter 5 Pucknell : Chapter 2	5
4	Fault-tolerant schemes for SONET/SDH network, [2]	Kang : Chapter 7 Uymera : Chapter 10	5
5		Pucknell : Chapter 3	5

	Fault-tolerant schemes for MPLS based network, [2]	Kang : Chapter 2 (Fabricarion)	
6	Fault-tolerant schemes for adhoc networks [6]		5
7	Mission-critical network planning [5]		5
		Total Lectures	**42**

Evaluation Scheme

1. Test 1 :15 marks
2. Test 2 : 25 marks
3. Test 3 : 35 marks
4. **Internal Assessment** : 25 marks
    - 10 Marks : Class performance, Tutorials & Assignments
    - 10 Marks : Quizzes
    - 5 marks : Attendance

Text Books

1. Martin L. Shooman, Reliability of Computer Systems and Networks: Fault Tolerance, Analysis, and Design, John Wiley & Sons.
2. Jean-Philippe Vasseur, Mario Pickavet, Piet Demeester Network Recovery: Protection andRestoration of Optical, SONET-SDH, IP, and MPLS, Elsevier.
3. James D. McCabe, Network Analysis, Architecture, and Design, Elsevier
4. Arun K. Somani, Survivability and Traffic Grooming in WDM Optical Networks,Cambridge University Press.
5. Mathew Liotine, Mission-Critical Network Planning, Artech House.

Reference Articles:

1. Xing, Liudong, Haoli Li, and Howard E. Michel. "Fault-tolerance and reliability analysis for wireless sensor networks." International Journal of Performability Engineering 5.5 (2009): 419.
2. Malec, Henry A. "Communications reliability: a historical perspective."Reliability,IEEE Transactions on 47, no. 3 (1998): SP333-SP345.
3. Bjarne E. Helvik, Perspectives on the Dependability of Networks and Services, Telektronikk (100th Anniversary Issue: Perspectives in telecommunications), (3):27 – 44, 2004.

Advanced Next Generation Communication

COURSE CODE:

COURSE CREDITS: 3

CORE/ELECTIVE:

: 3-0-0

Pre-requisite: Wireless Communication

Course Objectives:

1. To understand the fundamentals of wireless channels.
2. To understand the various technologies employed in next generation communication.
3. To study recent advancement in next generation communication.

Course Outcomes:

S. No.	Course Outcomes	Level of Attainment
CO-1	Understanding the evolution of various generation of wireless communication	Familiarity
CO-2	Analyze the behavior of wireless channel	Assessment
CO-3	Knowledge of various technologies of wireless communication	Assessment
CO-4	Design and development of various applications of technologies in next generation communication	Usage

Course Contents:

Unit	Contents	Lectures required
1	Evolution of different generation of wireless communication, Basic of wireless communication, Baseband and pass band representation of signal, Effect of wireless channel on transmitted signal.	**7**
2	Fading concept, Multipath fading and shadowing, Channel characteristics and QoS parameters	**7**
3	Basic technologies used in wireless communication**:** Diversity, Equalization, MIMO, OFDM,SVD	**10**
4	Advanced Technologies used in wireless communication**:** NOMA, CRN, Machine Learning, Half duplex and Full duplex wireless communication	**10**
5	Application of Machine learning and NOMA in next generation communication	**8**
Total lectures		**42**

Suggested Text Book(s):

1. Wireless Communications – Principles and Practice; by Theodore S Rappaport, Pearson Education Pte. Ltd., Delhi
2. Andrea Goldsmith, "Wireless Communications," Cambridge University Press, 2005

Suggested Reference Book(s):

1. Fundamentals of Wireless Communication by Tse David and Viswanath Pramod, Cambridge University press, Cambridge
2. Mobile Communications; By: Schiller, Jochen H; Addison Wesley Longman Pte Ltd., Delhi

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

Course Outcomes (COs) contribution to the Programmed Outcomes (POs)

Course outcomes (Advanced Next Generation Communication)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	1	2	2	2	3	1	1	1	1	2	2	3	**1.75**
CO-2	3	3	2	2	2	2	2	1	2	2	1	2	**2**
CO-3	3	1	2	1	2	2	2	2	2	3	1	1	**1.83**
CO-4	3	3	2	2	2	2	1	2	1	2	2	1	**1.91**
Average	**2.5**	**2.25**	**2**	**1.75**	**2.25**	**1.75**	**1.5**	**1.5**	**1.5**	**2.25**	**1.5**	**1.75**	

Fundamentals of MIMO Systems

(Core Subject)

Course Code:	12M1WEC432	Semester:	4th Sem. M. Tech (ECE)/DD
Credits:	3	Contact Hours:	L-3, T-0, P-0

Course Objectives

The main objective of the course is to

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

Course Outcomes

After studying this course the students would gain enough knowledge of

1. Emerging issues for implementing MIMO wireless channels.
2. Different fading channel distributions in multipath wireless channel.
3. OSTBC design for multiple antenna system.
4. Computation of performance parameters of MIMO wireless system.

Course Contents

Unit	Topics	References (chapter number, page no. etc)	Lectures
1.	Overview of Probability and Stochastic Processes: Probability distributions, Statistical averages and Random variables, Binomial distribution, Chi-square distribution, Rayleigh distribution, Rice distribution, Nakagami m-distribution, Central limit theorem, etc.	Haykin: Chapter 8	2
2.	Overview of Wireless Channel and Fading: Multi-path and Time-varying channel impulse response, Inter-Symbol-Interference, Narrowband fading, Envelope and power distribution, Level-crossing Rate and Average fading duration, Wideband fading, slow and fast-fading, Delay Spread and Coherence Bandwidth, Doppler Spread and Channel Coherence Time, Rayleigh fading, Rician fading, m-Nakagami fading	Goldsmith: Chapter 3	5
3	MIMO-I: Diversity: Temporal diversity, Frequency diversity, Spatial diversity, Multiplexing gain, Diversity gain, Analysis of receiver diversity, Combining schemes :	Goldsmith: Chapter 7, Kshetrimayum: Chapter 1	8
	Selection, Threshold, Maximal ratio, Equal gain, Transmitter diversity: with and without channel state information, Alamouti scheme, Diversity Analysis		
4	MIMO-II: Principles: Multi-antenna system and its advantages, MIMO channel and signal model, MIMO channel capacity, MIMO system model, Analysis of BER of multiple antenna system with diversity, Zero-forcing receiver; drawbacks, MIMO-MMSE receiver; properties and advantages	Goldsmith: Chapter 7, 10, Kshetrimayum: Chapter 3,5	8

5	MIMO-III: Multiplexing Architectures: Decomposition of MIMO channel; Singular value decomposition (SVD), Optimal MIMO power allocation, MIMO system capacity, Transmit beamforming, Orthogonal space-time code (OSTBC), Alamouti code, Non-linear MIMO receiver; V-BLAST; SIC, MIMO beamforming; maximal ratio transmission.	Kshetrimayum: Chapter 7,8, 9, 10	9
6	Orthogonal Frequency Division Multiplexing (OFDM): Multicarrier modulation (MCM); schematic; detection, Comparison of single carrier and multicarrier transmission, bottleneck in MCM, OFDM schematic and cyclic prefix, Loss in efficiency, Frequency offset in OFDM; ICI, Peak to average power ratio (PAPR) in ODFM, Single-carrier (SC)- FDMA; schematic, subcarrier mapping, BER performance of OFDM. MIMO-ODFM; schematic.	Goldsmith: Chapter 12	5
7	Applications of MIMO and OFDM: Long term evolution (LTE) and WiMAX; features, OFDMA, Channel dependent scheduling, Resource allocation, Puncturing, H-ARQ, Frequency shift transmit diversity, Network architecture, frame structure, Protocol stack	Kshetrimayum: Chapter 4, 12	5
		Total Number of Lectures	42

Evaluation Scheme

1. Test 1 :15 marks
2. Test 2 : 25 marks
3. Test 3 : 35 marks
4. **Internal Assessment** : 25 marks
    - 10 Marks : Class performance, Tutorials & Assignments
    - 10 Marks : Quizzes
    - 5 marks : Attendance

Text Books

1. Goldsmith, Andrea, “Wireless Communications”, Cambridge University press (2005).
2. Rakhesh. S. Kshetrimayum: “Fundamentals of MIMO Wireless Communications”, Cambridge University press, 2017
3. Haykin, Simon, “An introduction to analog and digital communications” John Wiley & Sons.

Reference Books

1. Space-Time coding: theory and Practice, Hamid Jafarkhani, Cambridge University Press, 2005.
2. MIMO: From Theory to Implementation, ALain Sibille, Claude Oestges, and Alberto Zanella, Academic Press, 2013.
3. Fundamentals of Wireless Communication, David Tse and Pramod Viswanath, Cambridge University Press, 2005.
4. MIMO Wireless Communications, Ezio Biglieri, Robert Calderbank, Anthony Constantinides, Andrea Goldsmith, Arogyaswami Paulraj, and H. Vincent Poor, Cambridge University Press, 2007.

Web resources

1. nptel lecture on MIMO, OFDM and wireless.

Mobile Adhoc and Sensor Networks

COURSE CODE:21M1WEC144

COURSE CREDITS: 3

CORE/ELECTIVE:

: 3-0-0

Pre-requisite: None

Course Objectives:

1. To understand the basics of mobile adhoc and sensor networks and the protocol design for these networks;
2. To learn about the challenges in the design of mobile ad hoc and sensor networks.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Understand the fundamental concepts and applications of mobile ad hoc and sensor networks	Familiarity
CO-2	Describe the MAC protocol design for mobile ad hoc and sensor networks.	Assessment
CO-3	Describe the routing protocol for mobile ad hoc and sensor networks.	Assessment
CO-4	Identifying the issues and challenges in providing QoS.	Usage
CO-5	Familiarity with the various security attacks in network.	Familarity

Course Contents:

Unit	Contents	Lectures required
1	**Introduction:** Mobile Adhoc Networks (MANETs), Wireless Sensor Networks, Concepts and architectures, Applications of Ad Hoc and Sensor Networks, Design Challenges in Ad hoc and Sensor Networks.	5
2	**MAC Protocols for Mobile Adhoc Network:** Design Goals of a MAC Protocol for Mobile Ad Hoc Networks, Challenges in designing a MAC Protocol for Mobile Ad Hoc Networks, Classification of MAC Protocols- Contention based protocols - Contention based protocols with Reservation Mechanisms - Contention based protocols with Scheduling Mechanisms - Multi channel MAC - IEEE 802.11.	8

3	**Routing Protocols and Transport Layer in Mobile Ad Hoc Networks:** Routing Protocol: Design Goals of a Routing Protocol for Mobile Ad Hoc Networks, Challenges in designing a routing protocol for Mobile Ad hoc Networks, Classification: proactive routing, reactive routing (on-demand), hybrid routing, Transport Layer protocol for Ad hoc networks.	**8**
4	**MAC protocols for Wireless Sensor Network:** Data Dissemination, Data Gathering, MAC Protocols for wireless sensor networks- Low duty cycle protocols and wakeup concepts, Contention Based protocols, Schedule-Based protocols, IEEE 802.15.4 Zigbee .	**8**
5	**WSN Routing, Localization & QoS**: Issues in WSN routing , OLSR - Localization –Indoor and Sensor Network Localization - absolute and relative localization - triangulation , QOS in WSN	**8**
6	**Security in Mobile Ad Hoc and Sensor Networks:** Network Security, Security in Ad Hoc Wireless Networks, Network Security Requirements, Security Attacks.	**5**
Total lectures		**42**

Suggested Text Book(s):

1. C. Siva Ram Murthy, and B. S. Manoj, "Ad Hoc Wireless Networks: Architectures and Protocols ", Pearson Education, 2008.
2. Labiod. H, "Wireless Adhoc and Sensor Networks", Wiley, 2008.
3. Li, X, "Wireless ad -hoc and sensor Networks: theory and applications", Cambridge University Press, 2008.

Suggested Reference Book(s):

1. Holger Karl and Andreas Willig "Protocols and Architectures for Wireless Sensor Networks", Wiley, 2005.
2. Carlos De Morais Cordeiro, Dharma Prakash Agrawal "Ad Hoc & Sensor Networks: Theory and Applications", World Scientific Publishing Company, 2nd edition, 2011.

EvaluationScheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (3) - 10 Quizzes(3) -10 Attendance - 5

Approved in Academic Council Meeting held on 28 July, 2021

Course Outcomes (COs) contribution to the Programme Outcomes (POs)

Course outcomes (Mobile Adhoc and Sensor Networks)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	3	3	2	2	2	2	2	1	1	2	3	3	**2.17**
CO-2	3	3	3	3	3	3	3	1	3	3	3	3	**2.83**
CO-3	3	3	3	3	3	3	3	1	3	3	3	3	**2.83**
CO-4	3	3	3	2	3	2	2	1	1	2	3	3	**2.33**
CO-5	3	3	3	3	3	3	3	1	3	3	3	3	**2.83**
Average	**3.00**	**3.00**	**2.80**	**2.60**	**2.80**	**2.60**	**2.60**	**1.00**	**2.20**	**2.60**	**3.00**	**3.00**	

Architecture and Algorithms for DSP Systems

COURSE CODE: 21M1WEC144

COURSE CREDITS:3

CORE/ELECTIVE:

L-T-P:3-0-0

Pre-requisite: Basic course in Digital Signal Processing Course Objectives:

1. To introduce to various DSP algorithms
2. Mapping of DSP algorithms to application specific DSP architecture
3. Understanding underlying algorithms for various DSP applications
4. Learn to reduce algorithmic complexity of filter algorithms

Course Outcomes:

Sl. No.	Course Outcomes	Level of Attainment
1	Students shall be able to understand various DSP algorithms	Familiarity
2	Knowing the target application he/she shall be able to Map the required algorithm to a suitable architecture and choose the efficient architecture	Usage
3	Knowing various available algorithms and be able to tweak that to match a target architecture and also choose the best architecture for an algorithm	Usage
4	Learn to reduce algorithm complexity as well as architectural complexity for low power application algorithms	Assessment

Course Contents:

Unit	Contents	Lectures required
1	Introduction for DSP algorithms: VLSI Design flow, Mapping algorithms into Architectures: Graphical representation of DSP algorithms – signal flow graph (SFG), data flow graph (DFG), critical path, dependence graph (DG). Data path synthesis, control structures, Optimization at Logic Level and architectural Design, Loop bound and iteration bound, Algorithms for computing iteration bound, Iteration bound of Multirate data-flow graphs.	8
2	Parallel and pipeline of signal processing application : Architecture for real time systems, latency and throughput related issues, clocking strategy, power conscious structures, array architectures; Pipelining processing of Digital filter, Parallel processing, Parallel and pipelining for Low power design, Optimization with regard to speed, area and power, asynchronous and low power system design, ASIC (application specific integrated circuits) and ASISP application specific instruction set processors) design;	9
3	Retiming, Unfolding, and Folding:	5
4	Systolic Array Architecture: Methodology of systolic array architecture, FIR based Systolic Array, Selection of Scheduling Vector, Matrix multiplication of systolic array	5
5	Fast Convolution: Cook-Toom algorithm, Winograd Algorithm, Iterated convolution, Design of Fast convolution algorithm by Convolution, Cyclic inspection	6
6	Algorithmic Strength reduction in Filters and Transforms: Parallel FIR filters, Discrete Cosine Transform and Inverse DCT, Parallel Architectures for Rank Order Filters	6
7	Low power Design :Theoretical background , Scaling v/s power consumption, power analysis, Power reduction techniques, Power estimation approach	3
Total lectures		42

Suggested Text Book(s):

1. VLSI Digital Signal Processing Systems: Design and Implementation By K.K. Parhi , John Wiley & Sons, 1999
2. M.A. Bayoumi, VLSI Design Methodology for DSP Architectures, Kluwer, 1994 Suggested

Reference Book(s):

1. Richard J, Higgins, Digital Signal Processing in VLSI, Prentice Hall, 1991
2. U. Meyer – Baese , Digital Signal Processing with FPGAs, Springer, 2004

Other useful resource(s):

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered up to T-1
2	T-2	25	1.5 Hours	Syllabus covered up to T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

Course outcomes (Architecture and Algorithms for DSP Systems)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	3	3	3	3	2	2	3	3	2	3	3	3	2.75
CO-2	3	3	2	2	2	1	2	2	3	3	2	3	2.4
CO-3	3	3	3	2	2	1	2	3	2	3	3	3	2.5
CO-4	2	3	3	3	2	3	2	2	3	3	2	3	2.5
Average	3	3	2.75	2.5	2	1.75	2.25	2.5	2.5	3	2.5	3	

STATISTICAL SIGNAL PROCESSING

(Elective Subject)

Course Code:	**13M1WEC431**	**Semester:**	**4th Semester, M. Tech. (ECE)**
Credits:	**3**	**Contact Hours:**	**L-3, T-0,P-0**

Pre-requisites: Signals & Systems, Digital Signal Processing

Course Objectives:

The objective of this course to provides well understanding of

1. The random signals, random process and their statistical properties
2. Spectral methods signal analysis
3. Weiner filtering and adaptive filetring of the signals

Course Outcomes

At the end of the Statistical Signal Processing course, a student should be able to:

1. Comprehend the random variable random process and statistical feature ofrandom signals.
2. Analyze and understand the modeling styles or methods of the random signals.
3. Analyze and understand the FIR , IIR Wiener filtering, and Kalman filtering.
4. Analyze and understand the various power spectral estimation methods of thestatistical signals.
5. Understand the least mean square (LMS), Recursive least square, and others adaptive filtering methods.

Course Contents :

Unit	Topics	Text book	Lectures
1	**DISCRETE-TIME RANDOM PROCESSES** **Random Variables**: Ensemble Averages , Jointly Distributed Random Variables, Joint Moments, Independent, Uncorrelated and Orthogonal Random Variables, Linear Mean Square Estimation, Gaussian Random Variables, Parameter Estimation: Bias and Consistency, **Random Processes:** Ensemble Averages, Gaussian Processes, Stationary Processes, The Autocovariance and Autocorrelation Matrices, Ergodicity White Noise, The Power Spectrum **Filtering Random Processes**: Spectral Factorization, Special Types of Random Processes , Autoregressive Moving Average Processes ,Autoregressive Processes, Moving Average Processes, sHarmonic Processes	[1]	**10**
2	**SIGNAL MODELING** The Least Squares (Direct) Method, The Pade Approximation, **Prony's Method:** Pole-Zero Modeling , Shanks' Method, All-Pole Modeling, Linear Prediction, Application: FIR Least Squares Inverse Filters Iterative Prefiltering, **Finite Data Records**: The Autocorrelation Method,The Covariance Method, **Stochastic Models:** Autoregressive Moving Average Models, Autoregressive Models, Moving Average Models, Application : Power Spectrum Estimation	[1]	**06**
3	**WIENER FILTERING** The FIR Wiener Filter: Filtering, Linear Prediction, Noise Cancellation, Lattice Representation for the FIR Wiener Filter The IIR Wiener Filter: Noncausal IIR Wiener Filter , The Causal IIR Wiener Filter, Causal Wiener Filtering , Causal Linear Prediction, Wiener Deconvolution , Discrete Kalman Filter	[1] & [2]	**08**
4	**SPECTRUM ESTIMATION** **Nonparametric Methods:** The Periodogram, Performance of the Periodogram, The Modified Periodogram, Bartlett's Method Welch's Method, Blackman-Tukey Approach Performance Comparisons	[1],& [2]	**10**

	Minimum Variance Spectrum Estimation, **The Maximum Entropy Method,** **Parametric Methods**: Autoregressive Spectrum Estimation, Moving Average Spectrum Estimation, Autoregressive Moving Average Spectrum Estimation: **Frequency Estimation**: Eigendecomposition of the Autocorrelation Matrix, Pisarenko Harmonic Decomposition MUSIC, Other Eigenvector Methods **Principal Components Spectrum Estimation**: Bartlett Frequency Estimation, Minimum Variance Frequency Estimation, Autoregressive Frequency Estimation		
5.	**ADAPTIVE FILTERING** **FIR Adaptive Filters** :The Steepest Descent Adaptive Filter, The LMS Algorithm, Convergence of the LMS Algorithm , Normalized LMS, Application : Noise Cancellation, Other LMS-Based Adaptive Filters, Gradient Adaptive Lattice Filter, Joint Process Estimator, Application : Channel Equalization , **Adaptive Recursive Filters** ,**Recursive Least Squares**: Exponentially Weighted RLS, Sliding Window RLS ,	[2], & [1]	**08**
	Total Lecture Hours		**42**

Evaluation Scheme

Text Books

1. Test 1 : 15 marks
2. Test 2 : 25 marks
3. Test 3 : 35 marks
4. **Internal Assessment** : 25 marks
    1. 10 Marks : Class performance, Tutorials & Assignments
    2. 10 Marks : Quizzes
    3. 5 marks : Attendance

1. Hayes, M.H.,"Statistical digital signal processing and modeling" Willey publishers
2. Proakis, John G. Digital signal processing: principles algorithms and applications. Pearson Education India.
3. P.Stoica,and Randolph Moses "Spectral analysis of signals " PHI, Publishers

Reference Book

1. Oppenheim, Alan V., Ronald W. Schafer, and John R. Buck. Discrete-time signal processing, 2nd edition, Pearson Education.
2. Mitra, Sanjit Kumar, and Yonghong Kuo. Digital signal processing: a computer-based approach, 2nd edition, Tata McGraw-Hill.
3. Mitra, Sanjit Kumar, and Yonghong Kuo. Digital signal processing, 3rd edition, Tata McGraw-Hill.

RADAR AND SONAR SIGNAL PROCESSING

(Elective Subject)

Course Code:	13M1WEC432	**Semester:**	4th Semester, M. Tech (ECE)
Credits:	3	**Contact Hours:**	L-3, T-0, P-0

Course Objectives

The objectives are to study the basics of a radar systems and its components and to aanalyse of radar systems..

Course Outcomes

After the successful completion of the course student should be able to:

1. Know the basic building blocks of a radar system.
2. Have an in-depth knowledge on different types of signals that are used.
3. Know about the ambiguity function and its significance in radar signal processing.
4. To know the principle of operation of sonar and sound propagation in water.
5. Apply the knowledge acquired in this course in real time applications.

Course Contents

Unit	Topics	References (chapter number, page no. etc)	Lectures
1.	Introduction to radar and radar equation, radar wave propagation. Radar block diagram, resolutions in range velocity, radar equation, types of radars. Atmospheric effects on radar wave propagation. Radar cross section, radar displays.	Peebles	6
2.	CW and FM radar and MTI radar: Doppler radar, CW radar, FMCW radar, multiple frequencies CW radar, MTI radar, delay line cancellers, staggered pulse repetitive frequencies, pulse Doppler radar, limitations of MTI radar.	Skolnik	8
3	Radar waveforms: Matched filter, Pulse compression, ambiguity function, LFMCW, HFM waveforms, Doppler invariant waveforms.	Peebles	8
4	Radar antennas and radar tracking: Radar antennas and radar tracking Antenna basics, antenna arrays, analysis and synthesis of antenna arrays. Buttler's matrix, tracking of radar. Synthetic aperture radar.	Elliot	9
5	Radar transmitters and receivers: Noise figure, amplifiers, mixers, power dividers and phase shifters.	Pozar	8
6	Introduction to sonar: Under water propagation, types of sonar, sonar transducers.	Hansen	3
Total Number of Lectures			42

Evaluation Scheme

1. Test 1 :15 marks
2. Test 2 : 25 marks
3. Test 3 : 35 marks
4. **Internal Assessment** : 25 marks
   - 10 Marks : Class performance, Tutorials & Assignments
   - 10 Marks : Quizzes
   - 5 marks : Attendance

Text Books

1. Peebles, Peyton Z. *Radar principles*. John Wiley & Sons, 2007.
2. Skolnik, Merrill I. "Introduction to radar." *Radar Handbook* 2 (1962).
3. Elliot, Robert S. *Antenna theory and design*. John Wiley & Sons, 2006.
4. Pozar, David M. *Microwave engineering*. John Wiley & Sons, 2009.
5. Hansen, Roy Edgar. "Introduction to sonar." *Course Material to INF-GEO4310, University of Oslo,(Oct. 7, 2009)* (2009).

Reference Books

1. Stutzman, Warren L., and Gary A. Thiele. *Antenna theory and design*. John Wiley & Sons, 2012. Cheng, David Keun. *Field and wave electromagnetics*. Pearson Education India, 1989.
2. Hodges, Rich`ard P. "Introduction to Sonar." *Underwater Acoustics: Analysis, Design and Performance of Sonar*: 1-15.
3. Navigation, Guidance and control, NPTEL lectures by Debasish Ghose.

COMPUTATIONAL INTELLIGENCE AND APPLICATIONS

(Elective Subject)

Course Code:	17M1WEC332	**Semester:**	3rd Semester, M. Tech (CSE/IT)
Credits:	3	**Contact Hours:**	L-3

Course Objectives

1. Fundamentals of key intelligent systems technologies including knowledge-based systems, neural networks, fuzzy systems, and evolutionary computation, and
2. Practice in integration of intelligent systems technologies for engineering applications.

Course Outcomes

This course provides the knowledge of analog and digital communication system analysis and design. After study through lectures and assignments, students will be able to

1. Gain a working knowledge of knowledge-based systems neural networks, fuzzy systems, and evolutionary computation;
2. Apply intelligent systems technologies in a variety of engineering applications;
3. Implement typical computational intelligence algorithms in MATLAB;
4. Present ideas and findings effectively; and
5. Think critically and learn independently

Course Contents

Unit	Topics	References (chapter number, page no. etc)	Lectures
1.	Introduction: Intelligence machines, Computational intelligence, paradigms Short history	Eberhart& Shi S. Haykin N. Sivanandam, S. N. Deepa	5
2.	Fuzzy Expert Systems: Rule-based expert system. Uncertainty management. Fuzzy Logic and Fuzzy Relationships. Fuzzy sets and operations of fuzzy sets. Fuzzy rules and fuzzy inference. Fuzzy expert systems. Adaptation of fuzzy systems. Case Studies	Eberhart& Shi S. Haykin N. Sivanandam, S. N. Deepa	7
3	Artificial Neural Networks: Fundamental neuro computing concepts: artificial neurons, activation functions, neural network architectures, learning rules. Supervised learning neural networks: multi-layer feed forward neural networks, simple recurrent neural networks, time-delay neural networks, supervised learning algorithms. Unsupervised learning neural networks: self-organizing feature maps. Radial basis function networks. Deep neural networks and learning algorithms. Case studies	Eberhart& Shi S. Haykin N. Sivanandam, S. N. Deepa	9
4	Evolutionary computation: Chromosomes, fitness functions, and selection mechanisms. Genetic algorithms: crossover and mutation, Genetic programming. Evolution strategies. Case studies	Eberhart& Shi S. Haykin N. Sivanandam, S. N. Deepa	7
5	Swarm Intelligence: Foundations. cAnts, Termites, Gnats, Birds. Applications. Case Studies.	Eberhart& Shi S. Haykin N. Sivanandam, S. N. Deepa	7
6	Hybrid Intelligent Systems: Neural expert systems. Neuro-fuzzy systems. Evolutionary neural networks.	Eberhart& Shi S. Haykin N. Sivanandam, S. N. Deepa	7

Total Number of Lectures	**42**

Evaluation Scheme

1. Test 1 : 15 marks
2. Test 2 : 25 marks
3. Test 3 : 35 marks
4. **Internal Assessment** : 25 marks
   - 10 Marks : Class performance, Tutorials & Assignments
   - 10 Marks : Quizzes
   - 5 marks : Attendance

Text Books

1. 1 Computational Intelligence - Concepts to Implementations by Eberhart& Shi
2. S. Haykin, Neural Networks – A Comprehensive Foundation, Prentice Hall, 1999
3. N. Sivanandam, S. N. Deepa," Principals of soft Computing", Wiley India

Reference Books

1. Introduction to Genetic Algorithms by Melanie Mitchell
2. S. Russell and P. Norvig. Artificial Intelligence – A Modern Approach, Prentice Hall, 2010
3. A.P. Engelbrecht, Computational Intelligence: An Introduction, 2nd Edition, John Wiley & Sons, 2012.
4. H.K. Lam, S.S.H. Ling, and H.T. Nguyen, Computational Intelligence and Its Applications: Evolutionary Computation, Fuzzy Logic, Neural Network and Support Vector Machine, Imperial College Press, 2011.

Digital System Design Using Verilog HDL

COURSE CODE: 21M11EC211
COURSE CREDITS: 3
CORE/ELECTIVE: CORE
L-T-P: 3-0-0

Pre-requisite: Basic course in Digital Electronics & Logic Design Course

Objectives:

1. Designing digital circuits, behaviour and RTL modeling of digital circuits using verilog HDL, verifying these Models and synthesizing RTLmodels to standard cell libraries and FPGAs.

2. Students gain practical experience by designing, modeling, implementing and verifying several digital circuits.

Course Outcomes:

Sl. No.	Course Outcomes	Level of Attainment
1	To understand the constructs and conventions of the Verilog HDLprogramming.	Familiarity
2	To understand the structural, register-transfer level (RTL), and algorithmic levels of abstraction for modelling digital hardwaresystems.	Usage
3	To design and modelling of combinational and sequential digital systems (FiniteState Machines).	Usage, Assessment
4	To understand and apply the concept of test-benches to create testing behavioural environments for simulation based verification	Usage, Assessment

Course Contents:

Unit	Contents	Lectures required
1	Introduction to Logic circuits and implementation technology: Logic gates, Boolean algebra, design examples, CAD tools, introduction to verilog, Programmable Logic devices and types, Optimized implementation of Logic Functions	3
2	Verilog as HDL, Levels of design Description, Concurrency, Simulation and Synthesis, Functional verification, System Tasks, Programming Language Interface (PLI), Module, Simulation and Synthesis Tools, Test Benches	4
	Introduction, Keywords, Identifiers, White Space Characters, Comments, Numbers, Strings, Logic Values,Strengths, Data Types, Scalars and Vectors, Parameters, Operators, AND Gate Primitive,Module Structure, Other Gate Primitives,	

3	Illustrative Examples, Tri-State gates, Array of Instances of Primitives, Design of Flip –Flops with gate primitives, Delays, Strengths and contention Resolution, Net Types, Design of BasicCircuits.MODELING AT DATA FLOW LEVEL: Introduction, Continuous Assignment Structures, Delays and Continuous Assignments, Assignment to vectors, Operators	7
4	BEHAVIORAL MODELING: Introduction, Operations and Assignments, Functional Bifurcation, Initial Construct, Always Construct, assignments with Delays, Wait Construct, Multiple Always Blocks, Designs at Behavioural Level, Blocking and Non-Blocking Assignments, The case statement, Simulation Flow if and if-else constructs, assign–design construct, repeat construct, for loop, the disable construct, while loop, forever loop, parallel blocks, force-release construct, Event.	4
5	Arithmetic circuits: number representation review, arithmetic circuits (adders and multipliers using CAD, Combinational circuit building blocks: Multiplexers, decoders, encoders, using verilog HDL.	4
6	Flip-Flops, Registers, Counters and Simple Processor: Latches, Flip-flops. Registers, counters and types, Reset Synchronization, Using Storage Elements in verilog HDL, Design Examples and timing concepts	6
7	Synchronous Sequential Circuits with verilog: BasicDesign Steps, One hot encoding, Mealy State Model, Moore tupe FSM Design of FSM using verilog, Design Examples, FSM as arbitrator circuit, ASM	6
8	Asynchronous sequential circuits: Behaviour, Analysis and synthesis, State Reduction, State assignment, Hazards, a complete design example	4
9	Digital System Design: Building Block circuits, clock synchronization concepts, various design examples, Testing of Logic Circuits: Fault models, path sensitizing, testing of sequential circuits, Built in self test: boundary scan	4
Total lectures		42

Suggested Text Book(s):

1. Fundamentals of Digital Logic design with Verilog Design –Stephen Brown and Zvonko Vranesic, TMH, 2ndEdition,2010.

2. Advanced Digital Design with Verilog HDL –Michael D. Ciletti, PHI, 2005.

Suggested Reference Book(s):

Other useful resource(s):

1. T. R. Padmanabhan and B. Bala Tripura Sundari, Design through Verilog HDL – Wiley,2009.(T1) .Zainalabdien Navabi, Verilog Digital System Design, TMH, 2ndEdition

2. Verilog HDL –Samir Palnitkar, 2ndEdition, Pearson Education, 2009.

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered up to T-1
2	T-2	25	1.5 Hours	Syllabus covered up to T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

Course outcomes (Digital System Design Using Verilog HDL)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	3	3	3	3	2	2	3	3	2	3	3	3	2.75
CO-2	3	3	2	2	2	1	2	2	2	3	3	3	2.4
CO-3	3	3	3	2	2	1	2	3	2	3	3	3	2.5
CO-4	3	3	3	3	2	3	2	3	2	2	3	3	2.6
Average	3	3	2.75	2.5	2	1.75	2.25	2.75	2	2.75	3	3	

Artificial Intelligence and Expert Systems

COURSE CODE21M11EC212

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: Prerequisites are good programming skills, basic data structures and algorithms, and some university level mathematics.

Course Objectives:

1. To understand the concept of designing expert systems which exhibit intelligent behavior.
2. To study and create expert systems which exhibit the capability to learn, demonstrate, explain and advise its users.
3. To learn artificial intelligent systems finding solutions to complex problems.
4. To design human-like machines in a computer friendly manner.
5. To study State of the Art algorithms with engineering applications.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	To analyze the need and foundation of Artificial Intelligence and expert systems	Familiarity
CO-2	Study the various types of expert systems that receive precepts from the environment and perform actions	Assessment
CO-3	Analysis of problem solving, knowledge and reasoning	Assessment
CO-4	Study of application domains of Artificial Intelligence	Usage

Course Contents:

Unit	Contents	Lectures required
1	**Introduction to Artificial Intelligence:** What is Artificial Intelligence (AI), The foundations of AI, The birth of AI, Knowledge based Systems, The State of the Art techniques.	7
2	**Intelligent Agents:** Agents and Environments, The concept of Rationality, Performance Measures, The structure of Agents, Agent Programs, Simple reflex Agents, Model based reflex Agents, Goal based Agents, Utility based Agents, Learning Agents.	7
3	**Problem Solving:** Problem solving Agents, Formulating Problems, Searching for Solutions, Uninformed Search Strategies, Breadth first search, Depth first search, Depth limited Search, Bidirectional search,	7

	Informed Search Exploration, Constraint Satisfaction Problems	
4	**Knowledge and Reasoning:** Knowledge based agents, Reasoning Patterns in Propositional Logic, Forward and Backward Chaining, Backtracking Algorithm, First Order Logic, Knowledge Representation, Uncertain Knowledge and Reasoning	**7**
5	**Learning:** Laning from Observations, Forms of Learning, Inductive Learning, Learning Decision Trees, Ensemble Learning, Knowledge in Learning, Statistical Learning, Reinforcement Learning	**7**
6	**Perception and Action:** Communication as Action, Fundamental of Language, Syntactic Analysis, Semantic Interpretation, Probabilistic Language Processing, Perceptual analysis, Robotic Hardware and software Architectures.	**7**
Total lectures		**42**

Suggested Text Book(s):

1. Stuart J. Russel and Peter Norvig, "Artificial Intelligence: A Modern Approach" SecondEdition, Pearson Prentice Hall.
2. E. rich and K. Knight, "Artificial Intelligence and Applications" Third Edition, Tata McgrawHill.

Suggested Reference Book(s):

1. P. Kulkarni and P. Joshi, "Artificial Intelligence", PHI Learning Private Limited,2015.
2. P. H. Winston, Artificial Intelligence and Applications", PHI Learning Private Limited,2017.

Other useful resource(s):

Link to topics related to course:

i. https://nptel.ac.in/courses/106105077/
ii. https://www.tutorialspoint.com/artificial_intelligence/

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

Course Outcomes (COs) contribution to the Programme Outcomes(POs)

Course outcomes (Artificial Intelligence and Expert Systems)													A
CO-1	2	2	3	3	2	1	1	1	2	2	2	2	**2**
CO-2	2	3	3	3	2	1	1	1	2	2	1	2	**2**
CO-3	2	3	3	3	2	1	1	1	2	2	1	2	**2**
CO-4	2	3	3	3	2	1	1	1	2	3	2	2	**2**
Average	**2**	**3**	**3**	**3**	**2**	**1**	**1**	**1**	**2**	**2**	**3**	**2**	

Network Security Protocols

COURSE CODE: 21M11EC213

COURSE CREDITS: 3

CORE/ELECTIVE: CORE L-T-P: 3-0-0

Pre-requisite: None

Course Objectives:

1. To understand the concept of network security.
2. Familiarization of various security protocols implemented at different layers.

Course Outcomes:

Sl. No.	Course Outcomes	Level of Attainment
CO-1	Understand the threats posed to network security and the more common attacks associated with those threats	Familiarity
CO-2	Understand the threats present in computer networks and counter measures for the same	Usage
CO-3	Analyzing the security protocols at different layers of the OSI model.	Usage
CO-4	Gain knowledge of authentication processes and security in the wireless networks.	Assessment

Course Contents:

Unit	Contents	Lectures required
1.	Introduction: Computer security concepts; OSI security architecture, Security attacks, Security mechanisms, A model for network security, Standards	5
2.	Understanding network security: Network security: Physical security, Pseudo security, Hardware security, Software security; Security services: Access control, Authentication, Confidentiality, Integrity, Non-repudiation; Security standards, Elements of security. DoS Attacks, Firewall and Intrusion prevention systems	8
3.	Security threats to Computer Networks: Introduction; Sources of security threats; Security threat motives; Security threat management; Security threat correlation; Security threat awareness.	6

4.	Security protocols in network layer: Security at different layers: pros and cons; Internet protocol security (IPSec): IPSec security associations, IPSec protocols: AH and ESP, Tunnel versus transport mode, Incompatibility with NAT, Internet key exchange protocol.	6
5.	Security protocols in transport layer: Secure socket layer (SSL) handshake protocol: Steps in handshake, Key design ideas; SSL record layer protocol, OpenSSL, Transport layer security (TLS).	6
6.	Security protocols in application layer: Pretty good privacy (PGP), Secure/multipurpose internet mail extension (S/MIME), Secure-HTTP (S-HTTP), Hypertext transfer protocol over secure socket layer (HTTPS), Secure electronic transactions (SET), Kerberos.	6
7	Security in wireless networks and devices: GSM (2G) security, Security in UMTS (3G), Wireless LAN security: authentication, confidentiality and integrity.	5
Total lectures		42

Suggested Text Book(s):

1. Cryptography and Network Security: principle and practices Wiliam Stallings.
2. Computer Network Security, Joseph Migga Kizza.
3. Cryptography, Network Security, and Cyber Laws / Bernard L. Menezes.

Suggested Reference Book(s):

Other useful resource(s):

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered up to T-1
2	T-2	25	1.5 Hours	Syllabus covered up to T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

Course Outcomes (COs) contribution to the Programmed Outcomes (POs)

Course outcomes (Network security protocols)													
CO-1	1	2	2	2	3	1	1	1	1	2	2	3	**1.75**
CO-2	3	3	2	2	2	2	2	1	2	2	1	2	**2**
CO-3	3	1	2	1	2	2	2	2	2	3	1	1	**1.83**
CO-4	3	3	2	2	2	2	1	2	1	2	2	1	**1.91**
Average	**2.5**	**2.25**	**2**	**1.75**	**2.25**	**1.75**	**1.5**	**1.5**	**1.5**	**2.25**	**1.5**	**1.75**	

Approved in Academic Council Meeting held on 28 July, 2021

BIOMEDICAL SIGNAL AND IMAGE PROCESSING

(Core Subject)

Course Code:	15M1WEC231	**Semester:**	2th Semester, M. Tech (ECE)
Credits:	3	**Contact Hours:**	L-3, T-0, P-0

Course Objectives

The objectives are to:

1. Introduce various bioelectric signals and medical imaging modalities.
2. Implementation of different signal and image processing techniques on the acquired biomedical signals and images.

Course Outcomes

After studying this course the students would gain enough knowledge

1. Able to understand different types of bioelectric signals and their acquisition from human body.
2. Able to understand different types of medical imaging modalities and would be able to differentiate them with respect to their advantages and limitations.
3. Acquire an ability to analyze and process bioelectric signals.
4. Acquire an ability to analyze and process medical images.
5. Understand different feature extraction techniques and classifiers used for image classification.

Course Contents

Unit	Topics	References (chapter number, page no. etc)	Lectures
1.	Bioelectric signals: Electrical activities of the cell and propagation of electric potential as a wave, Acquisition of bioelectric signals, Electrocardiogram (ECG), Electroencephalogram (EEG), Electromyogram (EMG), other biomedical signals: blood pressure, blood flow, Electrooculogram, respiratory signals, and ERG.	Kayvan: Chapter 8-12	12
2.	Medical Imaging modalities: Working principle, application and limitation of Computed tomography (CT), X-ray, Magnetic resonance imaging (MRI) , Ultrasound imaging, and Positron emission tomography (PET).	Kayvan: Chapter 13-17	8
3	Digital Signal Processing: Introduction to processing and transformation of signals, Data Acquisition: Sampling in time, aliasing, interpolation, and quantization, Difference equations, FIR and IIR filters, basic properties of discrete-time systems, convolution, Discrete-time Fourier transform and its properties. FIR filter design using windows, discrete Fourier transform and its properties, fast Fourier transform (FFT), Sampling and aliasing in time and frequency, spectral analysis.	Kayvan: Chapter 1-2 Tamal: Chapter 1-2	10
4	Image Processing I: Extension of filtering and Fourier methods to 2-D signals and systems, Image enhancement and restoration, Edge Detection and Image Segmentation Techniques.	Kayvan: Chapter 3-4	10

5	Image Processing II: Introduction to feature extraction techniques, Clustering and classification of images.	Kayvan: Chapter 7	5
		Total Number of Lectures	45

Evaluation Scheme

1. Test 1 :15 marks
2. Test 2 : 25 marks
3. Test 3 : 35 marks
4. **Internal Assessment** : 25 marks
    - 10 Marks : Class performance, Tutorials & Assignments
    - 10 Marks : Quizzes
    - 5 marks : Attendance

Text Books

1. Kayvan Najarian, Robert Splinter: Biomedical Signal and Image Processing. CRC Press, 2012
2. Tamal Bose: Digital Signal and Image Processing. John Wiley & Sons, 2004

Reference Books

1. Biomedical Image Analysis, Rangaraj M. Rangayyan, CRC Press, New York
2. Digital Image Processing, RC Gonzalez & RE Woods, Pearson Publishers, Third Edition

ADVANCED DIGITAL IMAGE PROCESSING

(Elective Subject)

Course Code:	16M1WEC231	**Semester:**	8th Semester, B. Tech (ECE)/ 2nd semester M. Tech
Credits:	3	**Contact Hours:**	L-3, T-0, P-0

Course Objectives

Major Learning Objectives are:

1. Describe and explain basic principles of digital image processing;
2. Design and implement algorithms that perform basic image processing (e.g., noise removal and image enhancement);
3. Design and implement algorithms for advanced image analysis (e.g., image compression, image segmentation)
4. Assess the performance of image processing algorithms and systems.

Course Outcomes

After Completing this course students will be able to:

1. Analyze general terminology of digital image processing.
2. Examine various types of images, intensity transformations and spatial filtering.
3. Develop Fourier transform for image processing in frequency domain.
4. Evaluate the methodologies for image segmentation, restoration etc.
5. Implement image process and analysis algorithms.
6. Apply image processing algorithms in practical applications.

Course Content

Unit	**Topics**	**References (chapter number, page no. etc)**	**Lectures**
1	Digital image fundamentals Fundamental steps in DIP, Components of digital image processing system, elements of visual perception, Structure of the human eye, Image formation in the eye, Brightness adaptation and discrimination, light, Image sensing and acquisition, Image formation model, definition and some properties of two dimensional system, Discrete 2D convolution, 2D discrete Fourier transform and its properties, optical and modulation transfer function, Spectral density function. Sampling and quantization of images, Two dimensional	Gonzalez and Woods Chapter -1 Pg 1 - 29 Chapter -2 Pg 34 - 70	**7**
	sampling theory, representation of digital image, Spatial and gray level resolution, Zooming and shrinking, some basic relationships between pixels.	Chapter -4 Pg 149 - 166	
2	Image Enhancement in spatial domain Gray level transformations, Piecewise linear transformation, Histogram processing, enhancement using Arithmetic/ logic operations, Basics of spatial filtering, Smoothing and sharpening spatial filters, Use of first order and second order derivative in	Gonzalez and Woods Chapter -3 Pg 76 - 130	**7**

	enhancement.		
3	Image Enhancement in frequency domain Two dimensional Fourier transform, properties of frequency domain, correspondence between filtering in spatial and frequency domain, Smoothing and Sharpening frequency domain filters, Homomorphic filtering	Gonzalez and Woods Chapter -4 Pg 148 - 193	**6**
4	Image Restoration Model of image degradation/ Restoration process, Noise models, Noise reduction in spatial domain and frequency domain, Inverse filtering, Wiener filtering.	Gonzalez and Woods Chapter -5 Pg 221 - 261	**7**
5	Image compression Fundamentals of Image compression, Types of redundancy. Image compression model, concepts of information theory, Fundamental coding theorems, Estimation of entropy, Variable length coding, Huffman coding, Near optimal variable length coding, Arithmetic coding, LWZ coding, Bit plane coding , constant area coding, run length coding, Lossless predictive coding, image compression standards (JPEG, JPEG2000)	Gonzalez and Woods Chapter -8 Pg 411 - 456	**7**
6	Image Segmentation Detection of discontinuities (point, line edge), Edge linking and boundary detection, Thresholding, Basic global thresholding, Adaptive thresholding, Region based segmentation, region growing, splitting and merging.	Gonzalez and Woods Chapter-10 Pg 568 - 615	**6**

Evaluation Scheme

1. Test 1 :15 marks
2. Test 2 : 25 marks
3. Test 3 : 35 marks
4. **Internal Assessment** : 25 marks
    - 10 Marks : Class performance, Tutorials & Assignments
    - 10 Marks : Quizzes
    - 5 marks : Attendance

Text Books

1. R.C.Gonzalas and R.E.Woods: Digital Image Processing, Prentice Hall, 3rd Ed

Reference Books

1. A.K.Jain, Fundamentals of Digital Image Processing, Prentice Hall.
2. S.Sridhar, Digital Image Processing, Oxford University Press.

ADVANCED CMOS DIGITAL DESIGN TECHNIQUES

(Core/ Elective Subject)

Course Code:	14M1WEC231	**Semester:**	2nd Semester, M.Tech (ECE) and 8th Semester, B. Tech (ECE)
Credits:	3	**Contact Hours:**	L-3, T-0, P-0

Course Objectives

1. To study advanced concepts of CMOS Digital Design. It will be helpful for the students when they work in VLSI industries or in R&D's.
2. To cover crucial real world system design issues such as signal integrity, power dissipation, interconnect packaging, timing and synchronization.
3. To provide unique coverage of the latest design methodologies and tools.
4. To learn Low-power design concepts and voltage-frequency scaling.

Course Outcomes

This course provides the knowledge of Advanced CMOS Digital Design Techniques. After study through lectures and assignments, students will be able to do the

1. Modeling and estimation of R, C, and L parasitics, effect of technology scaling, sheet resistance, techniques to cope with ohmic drop and capacitive cross talk, estimating RC delay, and inductive effects.
2. Several lab team assignments to design actual VLSI subsystems from high level specifications, culminating in a course project involving the software design of a modest complexity chip.
3. Several homework assignments based on core concepts and reinforcing analytical skills learned in class.

Course Contents

Unit	Topics	References (chapter number, page no. etc)	Lectures
1.	Introduction, The Wire, Coping with Interconnect: Impact of Interconnect Parasitic, Impact of Resistance, Impact of Capacitance, Cross-talk, Reducing RC-delay, Dealing with inductance.	Rabaey (Page 135-148, 445- 475)	5
2.	Designing Sequential Logic Circuits: Self Timed Circuit Design, Self Timed Signaling, Muller-C Element, Two Phase Handshake Protocol, Self Resetting CMOS, Synchronizer, Designing Latch and Edge triggered Register using different approach, Clock Overlaps, C2MOS Logic, TSPC Logic, Specialized edge triggered TSPCR, Pulse Registers, Pipelining, Designing Schmitt Trigger and multi-vibrators, Design Techniques for large Fan in, Sizing combinational circuits for minimum delay, Ratioed Logic: DCVSL, Pass transistor Logic, Differential Pass transistor Logic.	Rabaey (Chapter 10.4, 10.5, Chapter 7) Rabaey Page (261-273)	16
3	Arithmetic Circuits: Adders (Ripple-Carry Adder, Complimentary Static CMOS FullAdder, Mirror Adder, Transmission Gate Full Adder, Carry-Bypass Adder, Carry-Select Adder, Logarithmic Look-Ahead Adder, Tree Adders). Multipliers (Array Multiplier, Wallace-Tree Multiplier, Booths Multiplier Algo), Shifters (Barrel Shifter, Logarithmic Shifter).	Rabaey (Chapter 11) Uyemura (Chapter 12)	11

4	Semiconductor Memories: Memory Timing, Memory Architecture, Read-Only Memory Cells, MOS OR ROM, MOS NOR ROM, MOS NAND ROM, Dual Data rate Synchronous Dynamic RAM, DRAM Timing, Sources of Power Dissipation in Memories, Data Retention in SRAM, Suppressing Leakage in SRAM, Data Retention in DRAM.	Rabaey (Chapter 12)	9
		Total Number of Lectures	**41**

Evaluation Scheme

1. Test 1 : 15 marks
2. Test 2 : 25 marks
3. Test 3 : 35 marks
4. **Internal Assessment** : 25 marks
   - 10 Marks : Class performance, Tutorials & Assignments
   - 10 Marks : Quizzes
   - 5 marks : Attendance

Text Books

1. J. Rabaey, A. Chandrakasan; “Digital Integrated Circuits: A Design Perspective”, 3rd and B. Nikolic Edition 2003.
2. John P. Uyemura;”Introduction to VLSI Circuits and Systems”, John Wiley & Sons, Inc, 2002.

Reference Books

1. Sung-Mo Kang, Yusuf Leblebici,: CMOS Digital Integrated Circuits Analysis and Design”,Tata McGraw-Hill Edition 2003

Web Resources

1. URL1:- http://nptel.ac.in/courses/117106092/
2. URL2:- http://nptel.ac.in/courses/117106093/

REAL-TIME EMBEDDED SYSTEM

(Elective Subject)

Course Code:	12M1WEC232	**Semester:**	B.Tech.(8th Sem.), M.Tech. (2nd Sem.)
Credits:	3	**Contact Hours:**	L-3, T-0, P-0

Course Objectives

The objectives are to study

1. Introduction of the real-time systems.
2. Computing required for the real-time embedded systems.
3. Communication required for the real-time embedded systems.

Course Outcomes

After studying this course the students would gain enough knowledge

1. To present the mathematical model of the system.
2. To develop real-time algorithm for task scheduling.
3. To understand the working of real-time operating systems and real-time database.
4. To work on design and development of protocols related to real-time communication.

Course Contents

Unit	Topics	References (chapter number, page no. etc)	Lectures
1.	**Introduction:** Applications of real-time systems, basic model and characteristics of a real-time system, safety and reliability, types of real-time tasks.	[1,chapter 1(1-22)], [2,3]	3
2.	**Modeling Timing constraints:** Timing constraints, events, classifications, modeling timing constraints.	[1,chapter 1(23-40)], [2,3]	3
3	**Scheduling Real-Time Tasks:** Task scheduling types, Types of Schedulers, clock driven, table-driven, Cyclic, EDF, RMA	[1,chapter 2(41-73)], [2,3]	5
4	**Handling Resource sharing among real-time tasks:** Resource sharing among real-time tasks, inversion, HLP,PCP	[1,chapter 3(74-97)], [2,3]	5
5	**Scheduling Real-Time Tasks in Multiprocessor and Distributed systems:** Multiprocessor task allocation, dynamic allocation of tasks, fault-tolerant scheduling of tasks, clocks in distributed real-time systems	[1,chapter 4(98-104)], [2,3]	5
6	**Real-time operating systems:** Features of real-time operating systems, time services	[1,chapter 5(1-40)], [2,3]	4
7	**Real-Time Communication:** Types of networks, QoS, traffic categorization, LAN architecture, soft and hard real-time	[1,chapter 7(139-177)], [2,3]	5
	communication, QoS framework, routing, resource reservation, rate control, QoS models.		
8	**Real-Time Databases:** Review, design issues, consistency, concurrency control, commercial real-time databases.	[1,chapter 8(178-190)], [2,3]	4
9	**Study of Practical Systems:** Networked control systems, cyber-physical system, controller area network.	[1,chapter 8], [2,3]	3
		Total Lecture	**42**

Evaluation Scheme

1. Test 1 :15 marks
2. Test 2 : 25 marks
3. Test 3 : 35 marks
4. **Internal Assessment** : 25 marks
    - 10 Marks : Class performance, Tutorials & Assignments
    - 10 Marks : Quizzes
    - 5 marks : Attendance

Text Books

1. Rajib Mall, Real-Time Systems: Theory and Practice, Pearson Education, 2007.

Reference Books

1. C. Siva Ram Murthy and G. Manimaran, 'Resource Management in Real Time Systems and Networks', the MIT Press, 2001.

VLSI IN BIOMEDICAL SIGNAL PROCESSING

(Elective Subject)

Course Code:	17M1WEC331	**Semester:**	3rd Semester, M. Tech (ECE) PhD
Credits:	3	**Contact Hours:**	L-3, T-0,P-0

Course Objectives

The objective of the VLSI in Biomedical Signal Processing is to address the research, development and design problems and advance their solutions in VLSI circuits for embedded system and ubiquitous computing applications. The areas are Embedded System design, Power Electronics, Wireless networks; Signal processing, Biomedical Electronics, Electronic Instrumentation, and Audio and Speech Processing.

Course Outcomes

After studying this course the students would gain enough knowledge

1. Basic concepts in Digital CMOS circuit design.
2. To make an in depth study of DSP structures amenable to VLSI implementation.
3. To enable students to design VLSI system with high speed and low power.
4. Improve the speed of digital system through transformation techniques.
5. Perform pipelining and parallel processing in FIR/IIR systems to achieve high speed and low power.
6. Have knowledge of the principle operation and design and the background knowledge of biomedical instruments and specific applications of Biomedical engineering.

Course Contents

Unit	Topics	References (chapter number, page no. etc)	Lectures
1.	**INTRODUCTION TO COMPUTERS IN MEDICINE** : Characteristics of medical data**,** What is a medical instrument? Iterative definition of medicine, Evolution of microprocessor-based systems, The microcomputer-based medical instrument, Generalised Instrumentation system, The Biopotential Amplifier, The Instrumentation Amplifier, Characteristics of bio medical signal, Circuit Enhancements, Electrical Interference Reduction, Filtering, Artifact Reduction	Veeramachaneni : Chapter 1	2
2.	**ADDERS :** Review of Existing Adder Designs : Ripple Carry Adder (RCA), Carry Select Adder (CSA), Carry Look-Ahead Adder (CLA), Parallel Prefix- based Adder (PPA); Design and Implementation of Efficient Sum Computation Block for Higher Bit Sparse Adders; Design and Implementation of Higher Bit Sparse Adder	Veeramachaneni : Chapter 2	6
3	**COMPRESSORS AND COUNTERS :** Existing Compressor Designs : 3-2 Compressor , 4-2 Compressor , 5-2 Compressor; Efficient Compressor Designs using CMOS ; Designs of Counters : (3, 2) Counter, (7, 3) Counter , (15, 4) Counter , (31, 5) Counter; Design and Implementation of Efficient Parallel Counters	Veeramachaneni : Chapter 3	8
4	**SIGNAL PRE-PROCESSING** *SIGNAL CONVERSION* : Sampling basics, Simple signal conversion systems, Conversion requirements for biomedical signals, Signal conversion circuits, Lab: Signal conversion *SIGNAL AVERAGING* : Basics of signal averaging , Signal averaging as a digital filter, A typical averager , Software for signal averaging , Limitations of signal averaging . *SIGNAL COMPRESSOR/ DECOMPRESSOR*	TOMPKINS : Chapter 3, 4	7

	DATA REDUCTION TECHNIQUES : Turning point algorithm, AZTEC algorithm , Fan algorithm , Huffman coding *OTHER TIME- AND FREQUENCY-DOMAIN TECHNIQUES* **:** The Fourier transform , Correlation, Convolution , Power spectrum estimation		
5	**BASICS OF FILTERING** : Digital filters, The *z* transform, Elements of a digital filter, Types of digital filters, Transfer function of a difference equation, The *z*-plane pole-zero plot, The rubber membrane concept *FINITE IMPULSE RESPONSE FILTERS* : Characteristics of FIR filters, Smoothing filters, Notch filters, Derivatives, Window design, Frequency sampling, Min-max design , Lab: FIR filter design *INFINITE IMPULSE RESPONSE FILTERS* **:** Generic equations of IIR filters , Simple one-pole example, Integrators , Design methods for two-pole filters, Lab: IIR digital filters for ECG analysis *INTEGER FILTERS* **:** Basic design concept, Low-pass integer filters, High-pass integer filters, Bandpass and band-reject integer filters, The effect of filter cascades, Other fast-operating design techniques, Design examples and tools, Lab: Integer filters for ECG analysis *ADAPTIVE FILTERS***:** Principal noise canceller model, 60-Hz adaptive cancelling using a sine wave model , Other applications of adaptive filtering	TOMPKINS : Chapter 5, 6, 7, 8	12
6	**VLSI IN BSP** : Digital signal processors, High-performance VLSI signal processing, VLSI applications in medicine , VLSI sensors for biomedical signals, VLSI tools, Choice of custom, ASIC, or off-the-shelf components		**7**
		Total Number of Lectures	42

Evaluation Scheme

1. Test 1 :15 marks
2. Test 2 : 25 marks
3. Test 3 : 35 marks
4. **Internal Assessment** : 25 marks
   - 10 Marks : Class performance & Assignments
   - 10 Marks : Quizzes
   - 5 marks : Attendance

Text Books

1. W.J. TOMPKINS , "BIOMEDICAL DIGITAL SIGNAL PROCESSING : C-Language Examples and Laboratory Experiments for the IBM® PC", 2000.

Reference Books

1. Sreehari Veeramachaneni , "Design of Efficient VLSI Arithmetic Circuits", PhD Thesis, International Institute of Information Technology, Hyderabad
2. K.K.Parhi, "VLSI Digital Signal Processing Systems", John-Wiley, 2007
3. U. Meyer -Baese," Digital Signal Processing with FPGAs", Springer, 2004
4. W.Burleson, K. Konstantinides, T.H. Meng," VLSI Signal Processing"",1996.
5. R.J. Higgins, "Digital signal processing in VLSI", 1990.
6. S.Y.Kung, H.J. Whitehouse, "VLSI and modern signal processing", 1985
7. Carr and Brown, Biomedical Instrumentation.
8. Cromwell, Biomedical Instrumentation and Measurement, PHI.
9. Neil Weste and David Harris, "CMOS VLSI Design", 4th Ed., Addison Wesley, 2011.
10. Douglas A Pucknell et al, "Basic VLSI Design", 3rd Ed., Prenctice Hall, 2004

11. Sung-Mo Kang, Yusuf Leblebici : CMOS Digital Integrated Circuits Analysis and Design",Tata McGraw-Hill Edition 2003

ANTENNA AND RADIO WAVE PROPAGATION

(Elective Subject)

Course Code:	12M1WEC231	Semester:	7th Semester, B. Tech (ECE)
Credits:	3	Contact Hours:	L-3, T-0,P-0

Course Objectives

At the completion of this course, the student should have in depth knowledge antennas and radio wave propagation.

Course Outcomes

After the successful completion of the course, student should be able to:

1. Know the analysis of simple antenna structures.
2. Design different types of antennas.
3. Have an in-depth knowledge of antenna arrays and applications.
4. Apply the knowledge for wide area of recent applications.

Course Contents

Unit	Topics	References (chapter number, page no. etc)	Lectures
1.	Fundamental concepts: Types of antennas, radiation mechanism, antenna parameters.	Ballanis	8
2.	Radiation from wires and loops: Dipole, finite length dipole, half-wave dipole and its properties, loop antennas.	Ballanis	9
3	Aperture antennas: Field equivalence principle, radiation between wire and aperture antennas, horn antenna design principles.	Elliot	5
4	Broadband antennas: Principle of frequency dependent antennas, log periodic antennas	Elliot	4
5	Antenna arrays: Broadside, end-fire phased arrays. Dolph-Tchebyshev antenna arrays. Planar arrays.	Elliot	8
6	Radio-wave propagation: antenna located over a flat earth, over a spherical earth. Surface wave propagation, scattering by rain, propagation into sea water, atmospheric ducts and nonstandard refraction.	Collins	8
		Total Number of Lectures	42

Evaluation Scheme

1. Test 1 :15 marks
2. Test 2 : 25 marks
3. Test 3 : 35 marks
4. **Internal Assessment** : 25 marks
   - 10 Marks : Class performance, Tutorials & Assignments
   - 10 Marks : Quizzes
   - 5 marks : Attendance

Text Books

1. Elliot, Robert S. *Antenna theory and design*. John Wiley & Sons, 2006.
2. Ballanis, Constantine A. "Antenna theory analysis and design." *John Willey and Son's Inc., New York* (1997).
3. Collin, Robert E. *Antennas and radiowave propagation*. McGraw-Hill, 1985.

Reference Books

1. Jordan, E. C., and K. G. Balmain. *Electromagnetic Waves and Radiating Systems*, Prentice Hall." *Englewood Cliffs, New Jersey* (1968).
2. Robert E.Colin. *Foundations for Microwave Engineering*, McGraw Hill, 2nd Edition, 2001.
3. John D. Kraus & R.J Marhefka, *Antennas for all appl*ications, The McGraw-Hill Companies, 2nd/3rd edition, 2006
4. C.A. Balanis*, Antenna Theory, Analysis and Design*. NY: John Wiley and Sons, 2nd edition, 2002
5. WL Stutzman & GA Thiele, Antenna Theory and Design , John Wiley and Sons, 2nd edition,1997

ANTENNA THEORY AND TECHNIQUES

(Elective Subject)

Course Code:	13M1WEC334	**Semester:**	3rd Semester, M. Tech (ECE)
Credits:	3	**Contact Hours:**	L-3

Course Objectives

1. Understanding of antenna fundamentals
2. Ability to design, synthesize and analyze the performance of various antenna types.

Course Outcomes

1. The ability to understand important and fundamental antenna engineering parameters and terminology.
2. To learn the basic concepts of electromagnetic wave radiation and reception.
3. Be familiar with important classes of antennas and their properties and to gain the ability to pick a particular class of antenna for given specifications.
4. To develop the basic skills necessary for designing a wide variety of practical antennas and antenna arrays.
5. Be familiar with techniques for estimating the propagation performance of a communication channel.
6. Be able to define specifications for a communications system based on a set of requirements.

Course Contents

Unit	Topics	References (chapter number, page no. etc)	Lectures
1.	Electromagnetic Radiation: Radiation phenomenon from an oscillation dipole in free space, induction and radiation fields, Retarded potentials, Radiated power and radiation resistance from a short dipole , half wave dipole and quarter wave monopole.	C. A. Balanis J. D. Kraus and R. J. Marhefka	
2.	Antenna Basics: Directional properties of antennas, Radiation patterns, antenna gain and aperture, antenna terminal impedance, self and mutual impedance, front to back ratio, antenna beam width and bandwidth, antenna efficiency, antenna beam area, polarization linear polarization, circular and elliptic polarization, antenna temperature and Reciprocity properties of antennas, Friss equation.	C. A. Balanis J. D. Kraus and R. J. Marhefka	
3	Auxilliary Potentials Functions and Linear Wire Antennas: Vector potential A and F, Electric and Magnetic Fields for Electric and Magnetic Current sources, Duality Theorem, Reciprocity and Reaction Theorem, Infinitesimal Dipole, Finite length dipole, Half wave dipoles.	C. A. Balanis J. D. Kraus and R. J. Marhefka	
4	Antenna Arrays: Classification of arrays, linear arrays of two point sources, linear arrays of n-point sources, pattern multiplication, array factor, linear arrays of equal amplitude and spacing (Broadside and end fire arrays) of n-point sources, directivity and beam width.	C. A. Balanis J. D. Kraus and R. J. Marhefka	
5	Antenna Arrays: Analysis and Synthesis: Linear arrays, circular array, planar (2D) arrays, sum and difference patterns, Effect of mutual couplings, Phased array antennas, scan	C. A. Balanis J. D. Kraus and R. J. Marhefka	

	principles, Non-uniform arrays, Dolph-Chebyshev Arrays, Binomial Arrays.		
6	Analysis and Design of Anteena: Resonant Antennas: Wires and Patches, Yagi - Uda Antennas, Micro strip Antenna, horn antennas, Parabolic reflector antenna principles, offset parabolic reflectors, dual reflector antennas, Gain calculations for reflector antennas, feed antennas for reflectors, field representations, matching the feed to the reflector, general feed model, feed antennas used in practice. Broad band Antennas: Traveling - wave antennas, helical antennas, Biconical antennas, sleave antennas, and Principles of frequency - independent Antennas, spiral antennas, Log – Periodic antenna, fractal antenna.	C. A. Balanis J. D. Kraus and R. J. Marhefka	
		Total Number of Lectures	

Evaluation Scheme

1. Test 1 : 15 marks
2. Test 2 : 25 marks
3. Test 3 : 35 marks
4. **Internal Assessment** : 25 marks
   - 10 Marks : Class performance, Tutorials & Assignments
   - 10 Marks : Quizzes
   - 5 marks : Attendance

Text Book

1. Antenna Theory Analysis and Design, C. A. Balanis, 3rd Ed, 2005, John Wiley & Sons Inc.
2. Antennas for All Applications, J. D. Kraus and R. J. Marhefka, 3rd Ed., 2002, McGraw-Hill, Inc.

Reference Books

1. Antennas and Radio wave Propagation, R. E. Collin, 1985, McGraw-Hill, Inc.
2. Antenna Theory and Microstrip Antennas, D. G. Fang, 2010, CRC Press.
3. Electromagnetic waves and Radiating Systems, E. C. Jordan and Balmain, Pearson Education.

Analog IC Design

COURSE CODE:21M1WEC245

COURSE CREDITS: 3

CORE/ELECTIVE: CORE

L-T-P: 3-0-0

Pre-requisite:

Student must have a very good understanding of circuit analysis, electronics, electronic devices and models, and analog circuit design.

Course Objectives:

This course deals with design of analog integrated circuits with emphasis on the design of feedback circuits at the transistor level. The objective of this course is to provide in-depth understanding of the analog integrated circuit and building blocks

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Able to carry out research and development in the area of analog IC design.	Familiarity
CO-2	Able to analyze and design analog circuits such as Differential Amplifier, OP-AMP, Current mirrors, Biasing circuits.	Assessment
CO-3	Able to analyze and design mixed mode circuits such as Comparator, ADCs, DACs, PLL.	Assessment
CO-4	Solve practical and state of the art analog IC design problems to serve VLSI industries.	Usage

Course Contents:

S. No.	Contents	Contact Hours
1.	**Negative feedback systems and stability** Negative feedback amplifier using an integrator; Frequency and time domain behavior; Loop gain and its implications; Negative feedback amplifier realization; Finite DC gain; Increasing DC gain; Effect of multiple poles; Negative feedback systems with multiple poles and zeros in the forward path; Stability analysis using Nyquist criterion; Nyquist criterion; Loop gain-Bode plot and time domain interpretation; Significance of 60 degree phase margin	8

2.	**Op-amp at the block level; Frequency compensation** Concept of the op-amp for realizing negative feedback circuits; Realizing a multi stage op-amp-frequency compensation-miller op-amp; Realizing a multi stage op-amp; feed forward compensated op-amp; Op-amp as a general block; unity gain compensation; non-idealities swing limits, slew rate, offset; dc negative feedback around op-amps	6
3.	**Op-amp amplifiers** Amplifier using Miller compensated op-amp; Effect of input capacitance; gain bandwidth product; Trans-impedance amplifier; lead-lag compensation; Inverting and non-inverting amplifiers-CMRR and its importance	4
4.	**Components available on an IC** IC components and their models; Mismatch; Layout considerations	3
5.	**Single ended op-amp design** Realizing a single stage op-amp-diff pair; small signal ac analysis; Single stage op-amp-mismatch and noise;-Single stage op-amp-telescopic cascode; Replica biasing a cascode;-Single stage op-amp-folded cascode; Two stage miller compensated op-amp; Three stage op-amp; CMRR of an op-amp and op-amp circuits	8
6.	**Fully differential op-amp design** Fully differential op-amps; Differential and common mode half circuits; common mode feedback; Fully differential miller compensated op-amp-common mode feedback loop and its stability; Fully differential single stage opamp; Fully differential telescopic cascode op-amp; Fully differential feed-forward compensated op-amp	5
7.	**Phase locked loop** Frequency multiplier-Phase locked loop; Lock range limitations; type II loop; Jitter & Phase noise; Continuous time approximation; PLL transfer functions; Reference feed through spurs; LC oscillators	8
	Total	**42**

Suggested Text Book(s):

1. Behzad Razavi, "Design of Analog CMOS Integrated Circuits", Tata McGraw-Hill Edition 2006
2. Gray & Meyer, "Analysis & Design of Analog Integrated Circuits", Wiley 4th edition, ,2001.

Suggested Reference Book(s):

1. Jacob Baker, "CMOS Mixed Signal Circuit Design", John Wiley.
2. Gray, Wooley, Brodersen, " Analog MOS Integrated Circuits ", IEEE Press, 1989.
3. Kenneth R. Laker, Willy M.C. Sansen, William M.C.Sansen, "Design of Analog Integrated Circuits and Systems ", McGraw Hill.

Other useful resource (s):

https://nptel.ac.in/courses/117/106/117106030/
(Dr. Nagendra krishnapura, IIT Madras)

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

Course Outcomes (COs) contribution to the Program Outcomes (POs)

Course outcomes (Analog IC Design)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	3	3	3	3	3	1	1	2	2	2	1	1	2.1
CO-2	2	2	2	2	1	1	2	2	2	2	1	2	1.8
CO-3	3	3	3	3	2	1	1	3	2	3	3	2	2.4
CO-4	3	2	3	3	1	1	2	1	1	3	2	1	1.9
Average	2.75	2.5	2.75	2.75	1.75	1.0	1.5	2.0	1.75	2.5	1.75	1.5	