BVM Engineering College (An Autonomous Institution)
Electronics Engineering Department
B. Tech. (Electronics Engineering) Honours Degree*

Sr. No.	Course Code & Course Title	L	T	P	H	C
1	Program Elective I	3	0	0	3	3
2	**HEL93: EMBEDDED DESIGN AND IOT LABORATORY**	0	0	2	2	1
3	Program Elective II	4	0	0	4	4
4	Program Elective III	3	0	0	3	3
5	**HEL92: RF MEASUREMENT LABORATORY**	0	0	2	2	1
6	Program Elective IV	4	0	0	4	4
7	**HEL91: HONOR DEGREE PROJECT**	0	0	8	8	4
	Total	**14**	**0**	**12**	**26**	**20**
	Program Elective - I					
1	**HEL11: DESIGN FOR INTERNET OF THINGS**	3	0	0	3	3
2	**HEL12: VLSI SIGNAL PROCESSING**	3	0	0	3	3
3	**HEL13: WIRELESS AD HOC AND SENSOR NETWORKS**	3	0	0	3	3
	Program Elective - II					
1	**HEL14: EMBEDDED SYSTEMS-DESIGN VERIFICATION AND TEST**	4	0	0	4	4
2	**HEL15: DEEP LEARNING**	4	0	0	4	4
3	**HEL16: VLSI PHYSICAL DESIGN**	4	0	0	4	4
	Program Elective - III					
1	**HEL17: MILLIMETER WAVE TECHNOLOGY**	3	0	0	3	3
2	**HEL18: OPTIMIZATION FOR COMMUNICATION AND MACHINE LEARNING**	3	0	0	3	3
3	**HEL19: ADVANCED IOT APPLICATIONS**	3	0	0	3	3
	Program Elective - IV					
1	**HEL20: OPTIMIZATION FOR COMMUNICATION AND MACHINE LEARNING**	4	0	0	4	4
2	**HEL21: DIGITAL VLSI TESTING**	4	0	0	4	4
3	**HEL22: NEURAL NETWORKS FOR SIGNAL PROCESSING**	4	0	0	4	4

*A student of B. Tech. Electronics will be eligible to get B. Tech. Degree with Honours, if he/she gets additional Credits as per above structure.

L=Lecture Hrs./wk; T=Tutorial Hrs./wk; P=Practical Hrs./wk; H=Total Contact Hrs./wk; C=Credits of Course

HEL93: EMBEDDED DESIGN AND IOT LABORATORY
CREDITS - 1 (LTP : 0,0,2)

Course Objective:

Design and Development of Hardware and Software Design for Embedded and IOT Systems.

Teaching and Assessment Scheme:

Teaching Scheme (Hours per Week)			Credits	Assessment Scheme				
L	T	P	C	Theory Marks		Practical Marks		Total Marks
				ESE	CE	ESE	CE	
0	0	2	1	00	00	40	60	**100**

Course Contents:

Sr. No.	Suggested List of Experiments
1.	Study of Open source operating system used in Embedded Design.
2.	ARM based Embedded System Programming using Embedded C.
3.	LED Interfacing program for ARM based Embedded System
4.	Interfacing Push button Switch interfacing with ARM based Embedded System
5.	External Peripheral Interfacing with ARM based Embedded System.
6.	On Chip peripheral programming with ARM based Embedded System
7.	Serial Communication Protocol programming with ARM based Embedded Systems.
8.	Wireless Bluetooth communications with Embedded IOT Platform.
9.	WiFi communication interfacing with Embedded IOT Board.
10.	Embedded Systems design with IOT capability.
11.	IOT based Temperature monitoring embedded system with open source cloud tools.
12.	Introduction to RTOS installation on Embedded Boards.
13.	RTOS based programming for LED blinking project.

List of References:

1. Freescale ARM Cortex-M Embedded Programming Using C Language, 1st Edition By Muhammad Ali Mazidi,Shujen Chen, SepehrNaimi,SarmadNaimi.
2. ARM System on Chipby Steve Ferbur, Embedded System: Architecture, Programming and Design by Rajkamal, TMH3.
3. Dr. OvidiuVermesan, Dr. Peter Friess, "*Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems*", River Publishers

Course Outcomes:

At the end of this course, students will be able to:

1. Analyze the Hardware design techniques and development of software codes for Embedded Systems.
2. Use software tools to simulate and analyze the performance of Embedded Systems and development of prototypes for real time Application.

HEL92: RF MEASUREMENT LABORATORY
CREDITS - 1 (LTP : 0,0,1)

Course Objective:
The goal of this course is to introduce students to the concepts and principles of the RF and optical fiber communication engineering.

Teaching and Assessment Scheme:

Teaching Scheme (Hours per Week)			Credits	Assessment Scheme				
L	T	P	C	Theory Marks		Practical Marks		Total Marks
				ESE	CE	ESE	CE	
0	0	2	1	00	00	40	60	**100**

Course Contents:

Sr. No.	Suggested List of Experiments
1.	Basic Antenna parameters measurement techniques. 1. Demonstration of gain measurement of various antenna 2. Demonstration of E field and H- field pattern of various antenna 3. Demonstration of S – Parameter of various antenna 4. Demonstration of bandwidth measurement of various antenna 5. Demonstration of spectrum Analyzer 6. Demonstration of Vector Network Analyzer
2.	Basic experiment of Optical fiber laboratory. 1. Demonstration of Eye pattern diagram 2. Demonstration of dispersion compensation of fiber pre/post/symmetrical analysis 3. Demonstration of laser frequency response 4. Demonstration of PAM fiber link 5. Demonstration of BER calculation 6. Demonstration of Manchester coding – decoding 7. Demonstration of Rayleigh backscattering time domain representation

List of References:

1. David M. Pozar, '*Microwave Engineering*,' 3rd. Ed., John Wiley & Sons, 2005.
2. Guillermo Gonzalez, *Microwave Transistor Amplifiers*, 2nd. ed., Prentice-Hall, 1997.
3. Thomas H. Lee, Planar Microwave Engineering: A Practical Guide to Theory, Measurement, and Circuits, 1st Edition, Cambridge University Press, 2004.
4. Gerd Keiser, "*Optical Fiber Communication*", Mc Graw Hill
5. G. Agrawal,"*Fiber optic Communication Systems*", John Wiley and sons.
6. Djafar Mymbaev& Lowell L, Scheiner, "*Fiber optical communication Technology*", Pearson.

Course Outcomes:
At the end of this course, students will be able to:
1. Experiment and analyze the operation of different types of antenna parameters measurement techniques.
2. Analyze various optical fiber communication link setup, measurement techniques.
3. Experiment on various RF measurement equipment used for measurement.

HEL91: HONOR DEGREE PROJECT
CREDITS - 4 (LTP : 0,0,4)

Course Objective:

The goal of this course is to apply and implement the concept of electronics circuit design, circuit simulation, Software program development, etc. The individual's project should involve analysis, design, and implementation and testing of substantial hardware, software or any combination thereof in the field of study in the electronics and communication engineering.

Teaching and Assessment Scheme:

Teaching Scheme (Hours per Week)			Credits	Assessment Scheme				
L	T	P	C	Theory Marks		Practical Marks		Total Marks
				ESE	CE	ESE	CE	
0	0	8	4	00	00	40	60	**100**

Course Contents:

Unit No.	Topics
1.	The individual's project should involve analysis, design, implementation and testing of substantial hardware, software or any combination thereof in the field of electronics engineering.
2.	The topic must be related to any application in the field of Electronics. The investigation of practical problem in the manufacture and/or testing of electronics communication equipment, the Microprocessor/Microcontroller based projects, VLSI, Communication, Instrumentation, Signal Processing, Image Processing, Remote sensing, RF applications, etc. The Industry Project can be encouraged.
3.	Periodical monitoring and assessment will be done by the internal guides.
4.	A project report will be prepared and submitted for a viva – voice examination at the end.
5.	A good quality research paper should be drafted based on their project.
6.	The tile and topic of the project should be different from any project taken as B.Tech degree project.

Course Outcomes:

At the end of this course, students will be able to:

1. Review research literature, analyze complex engineering problems, reaching substantiated conclusions and apply appropriate techniques & modern engineering tools to design electronics project using relevant software and hardware.
2. Understand the impact of the electronics engineering solutions to societal and environmental contexts, ethical and function effectively as an individual, and as a member or leader in diverse teams to manage projects, and communicate effectively.

HEL11: DESIGN FOR INTERNET OF THINGS
CREDITS - 3 (LTP : 3,0,0)

Course Objective:

The goal of this course is to give an overview of IOTs, design of smart objects that provide collaboration and ubiquitous services. The students will learn design for longevity/energy efficiency and hence step by step system design will be introduced.

Teaching and Assessment Scheme:

Teaching Scheme (Hours per Week)			Credits	Assessment Scheme				
L	T	P	C	Theory Marks		Practical Marks		Total Marks
				ESE	CE	ESE	CE	
3	0	0	3	60	40	-	-	100

Course Contents:

Unit No.	Topics	Teaching Hours
1.	Introduction to IoT: Definition, Applications, Challenges – Unique ID, Power, Security, Location.	8
2.	Addressing the Power challenge:RFID, Energy harvesting, Battery based systems, Power management systems.	8
3.	System design for low power: LDO, DC-DC converters, low power software.	7
4.	Sensors and actuators: Temperature sensor, Air quality, Solenoid valves, Power management algorithms.	7
5.	IoT protocols: MQTT, COAP, and Websockets with associated applications.	7
6.	Wireless technologies:BLE, IEEE 802.15.4e, Wi-Fi. Wide area technologies: NBIoT, CAT – LTE-M1, LORA.	8
	Total Hrs.	**45**

List of References:

1. Dr. Guillaume Girardin , Antoine Bonnabel, Dr. Eric Mounier, *'Technologies Sensors for the Internet of Things Businesses & Market Trends 2014 -2024'*,Yole Development Copyrights 2014.
2. Peter Waher, *'Learning Internet of Things'*, Packt Publishing, 2015.
3. Editors Ovidiu Vermesan Peter Friess,*'Internet of Things – From Research and Innovation to Market"*
4. N. Ida, Sensors, Actuators and Their Interfaces, Scitech Publishers, 2014.

Course Outcomes:

At the end of this course, students will be able to:

1. Understand the right choice of hardware, software, and protocols for the proposed application.
2. Design prototype of the application.
3. Analyze the problem and can make a robust IoT solution

HEL12: VLSI SIGNAL PROCESSING
CREDITS - 3 (LTP : 3,0,0)

Course Objective:

This course aims at providing comprehensive coverage of some of the important techniques for designing efficient VLSI architectures for DSP. Towards this, architectural optimization at various levels will be considered.

Teaching and Assessment Scheme:

Teaching Scheme (Hours per Week)			Credits	Assessment Scheme				
L	T	P	C	Theory Marks		Practical Marks		Total Marks
				ESE	CE	ESE	CE	
3	0	0	3	60	40	-	-	100

Course Contents:

Unit No.	Topics	Teaching Hours
1.	Graphical Representation of Signals, Signal Flow Graph, Data Flow Graph, Critical Path, Dependence Graph, Basics of Retiming, Retiming Theorem.	8
2.	Forward Path and Loop Retiming, Loop Bound and Iteration Bound, Cutset Retiming, Retiming IIR Filters, Adaptive Filter Basics (LMS Algorithm).	7
3.	Retiming LMS, Retiming Delayed LMS, Parallel Processing in DSP by Unfolding, Basic Unfolding Relation, Retiming for Unfolding, Loop Unfolding, Iteration bound for Loops, Bitserial, Digit serial and Word serial Structures, Unfolding a Switch, Unfolding Bit Serial Systems.	8
4.	Folding of DFG, Folding Examples - IIR Filter, Retiming for Folding, Introduction to Delay Optimization by Folding, Life Time Analysis of Storage Variables.	7
5.	Foward Backward Data Allocation, Life Time Analysis of Storage Variables in a Digital Filter, Delay Folded Realization of a Digital Filter, Polyphase Decomposition of Sequences, Hardware Efficient 2-Parallel FIR Filters.	7
6.	Hardware Efficient 3-Parallel FIR Filters, Introduction to First Level Architectures, 2's Complement Number Systems, Multiplication of Two Binary Numbers, Carry Ripple and Carry Save Array, Bit Serial Multipliers, Bit Serial Digital Filters, Baugh Wooley Multiplier, Distributed Arithmetic.	8
	Total Hrs.	**45**

List of References:

1. K.K. Parhi : VLSI Digital Signal Processing systems, John Wiley, 1999.
2. Proakis, Digital Signal Processing, PHI, Second edition.
3. Lars Wanhammar, DSP Integrated Circuits, Academic Press, First edition, 1999
4. K KParhi, VLSI Digital Signal Processing Systems: Design and Implementation, John Wiely, 2007

Course Outcomes:

At the end of this course, students will be able to:

1. Understand Hardware minimization techniques.
2. Analyze various types of digital filters.
3. Understand the graphical representation of DSP algorithms and transfer functions of various architectures.

HEL13: WIRELESS AD HOC AND SENSOR NETWORKS
CREDITS - 3 (LTP : 3,0,0)

Course Objective:

This course aims to focus on the attractiveness of ad hoc networks, in general, is attributed to their characteristics/features such as the ability for infrastructure-less setup, minimal or no reliance on network planning, and the ability of the nodes to self-organize and self-configure without the involvement of a centralized network manager, router, access point, or a switch.

Teaching and Assessment Scheme:

Teaching Scheme (Hours per Week)			Credits	Assessment Scheme				
L	T	P	C	Theory Marks		Practical Marks		Total Marks
				ESE	CE	ESE	CE	
3	0	0	3	60	40	-	-	100

Course Contents:

Unit No.	Topics	Teaching Hours
1.	Introduction: Wireless Ad Hoc Networks-, Self-organizing Behavior of Wireless Ad Hoc Networks, Cooperation in Mobile Ad Hoc Networks,	6
2.	Cooperation in Mobile Ad Hoc Networks- Part- II, MAC Protocols in MANETs, Routing in MANETs	6
3.	Multicasting in MANETs, Mobility Models for MANETs, Transport Protocols for MANETs, Opportunistic Mobile Networks , UAV Networks	8
4.	Introduction: Wireless Sensor Networks, WSN Coverage & Placement-Topology Management in Wireless Sensor Network, Mobile Wireless Sensor Networks.	8
5.	Mobile Wireless Sensor Networks, Medium Access Control in Wireless Networks, Routing in Wireless Sensor Networks	8
6.	Congestion and Flow Control, Underwater Sensor Networks, Underwater Sensor Networks and Security of Wireless Sensor Networks, Hardware Design of Sensor Node, Real Life Deployment of WSN.	9
	Total Hrs.	**45**

List of References:

1. Kazem Sohraby, Daniel Minoli, Taieb Znati, "*Wireless Sensor Networks'*, John Wiley & Sons Inc. Publication, 2007(8).
2. Holger Karl, and Andreas Willig, "*Protocols and Architectures for Wireless Sensor Networks*" John Wiley & Sons Inc. Publication.
3. XiangYang Li, "*Wireless Adhoc and Sensor Networks: Theory and Applications*", Cambridge university press, USA, 2008.

Course Outcomes:

At the end of this course, students will be able to:

1. Understand the various wireless Ad-hoc Networks.
2. Understand the mobile wireless sensor networks.
3. Analyze real-life deployment of WSN.

HEL14: EMBEDDED SYSTEMS-DESIGN VERIFICATION AND TEST
CREDITS - 4 (LTP : 4,0,0)

Course Objective:
The goal of this course is to introduce an embedded system with a verification concept. The proposed course will systematically cover all these topics so that the student gains an end-to-end understanding of the overall ES design process.

Teaching and Assessment Scheme:

Teaching Scheme			Credits	Assessment Scheme				
L	T	P	C	Theory		Practical		Total Marks
				ESE	CE	ESE	CE	
4	0	0	4	60	40	-	-	100

Course Contents:

Unit No.	Topics	Teaching Hours
1.	Introduction and Modeling Techniques: Introduction, Modeling Techniques, Modeling and synthesis issues, Hardware/Software Partitioning, Introduction to Hardware Design	8
2.	Architectural Synthesis of Hardware: Hardware Architectural Synthesis System-Level Analysis: System-Level Analysis, Uniprocessor Scheduling, Multiprocessor Scheduling	8
3.	Temporal Logic: Introduction and Basic Operators of Temporal Logic, Syntax, and Semantics of CTL, Model Checking: Equivalence between CTL formulas, Model Checking Algorithm	10
4.	BDD and Symbolic Model Checking :Binary Decision Diagram, Use of OBDDs for State Transition System, Symbolic Model Checking, Introduction to Digital Testing: Introduction to Digital VLSI Testing, Automatic Test Pattern Generation (ATPG)	10
5.	Introduction to Digital Testing & Embedded Systems hardware Testing: Scan Chain based Sequential Circuit Testing, "Software-Hardware Co-validation Fault Models and High-Level Testing for Complex Embedded Systems, Embedded System hardware Testing: Testing for embedded cores, Bus and Memory Testing	12
6.	Advanced in Embedded System hardware Testing: Testing for advanced faults in Real-time Embedded Systems, Advanced in Embedded System hardware Testing & Testing for Embedded Software Systems: Concurrent Testing for Fault-tolerant Embedded Systems – 1, Concurrent Testing for Fault-tolerant Embedded Systems – 2, Testing for Re-programmable hardware, Interaction Testing between Hardware and Software	12
	Total Hrs.	**60**

List of References:

1. Peter Marwedel, P. Marwedel, â€œEmbedded System Designâ€•, Springer, 2011 Wayne Wolf, Components
2. Kaufmann Computers as Edition, Morgan
3. AbhikRoychoudhury, Embedded Systems, and Software Validation, 1 st Edition, Morgan Kaufmann.
4. M. Huth and M. Ryan, Logic in Computer Science modeling and reasoning about systems, Cambridge University Press, 2nd Edition, 2004

5. Bushnell and Agrawal, Essentials of Electronic Testing for Digital, Memory & Mixed-Signal Circuits, Kluwer Academic Publishers, 2000

Course Outcomes:

At the end of this course, students will be able to:

1. Understand the embedded systems and various stages of design verification.
2. Analyze verification and validation of the correctness and performance-related properties that the designed system should satisfy.
3. Design of appropriate structural representations and implementation methodologies, corresponding to the specified behavior.

HEL15: DEEP LEARNING
CREDITS - 4 (LTP : 4,0,0)

Course Objective:

This course highlights traditional Machine Learning approaches and focuses on modern Deep Learning architectures**.**

Teaching and Assessment Scheme:

Teaching Scheme (Hours per Week)			Credits	Assessment Scheme				
L	T	P	C	Theory Marks		Practical Marks		Total Marks
				ESE	CE	ESE	CE	
4	0	0	4	60	40	-	-	100

Course Contents:

Unit No.	Topics	Teaching Hours
1.	Introduction to Deep Learning, Bayesian Learning, Decision Surfaces. Linear Classifiers, Linear Machines with Hinge Loss, Optimization Techniques, Gradient Descent, Batch Optimization	10
2.	Introduction to Neural Network, Multilayer Perceptron, Back Propagation Learning, Unsupervised Learning with Deep Network, Autoencoders, Convolution Neural Network, Building blocks of CNN, Transfer Learning	10
3.	Revisiting Gradient Descent, Momentum Optimizer, RMSProp, Adam, Effective training in Deep Net- early stopping, Dropout, Batch Normalization, Instance Normalization, Group Normalization Recent Trends in Deep Learning Architectures, Residual Network, Skip Connection Network, Fully Connected CNN etc.	10
4.	Classical Supervised Tasks with Deep Learning, Image Denoising, Semantic Segmentation, Object Detection etc. LSTM Networks	10
5.	Generative Modeling with DL, Variational Auto encoder, Generative Adversarial Network Revisiting Gradient Descent, Momentum Optimizer, RMSProp, Adam.	8
6.	Examples on Duality: Min-Max problem, Analytic Centering, Semi Definite Program (SDP) and its application:MIMO symbol vector decoding, Application: SDP for MIMO Maximum Likelihood(ML) Detection, Introduction to big Data: Online Recommender System(Netflix), Matrix	12

Unit No.	Topics	Teaching Hours
	Completion Problem in Big Data: Netflix-I, Matrix Completion Problem in Big Data: Netflix-II.	
	Total Hrs.	**60**

List of References:

1. Deep Learning- Ian Goodfelllow, YoshuaBenjio, Aaron Courville, The MIT Press
2. Pattern Classification- Richard O. Duda, Peter E. Hart, David G. Stork, John Wiley & Sons Inc.

Course Outcomes:

At the end of this course, students will be able to:

1. Understand the various machine learning algorithms.
2. Analyze the several deep learning algorithms.
3. Implement an appropriate deep learning algorithm to solve real-life problems.

HEL16: VLSI PHYSICAL DESIGN
CREDITS - 4 (LTP : 4,0,0)

Course Objective:

The course will introduce the students to the basic design flow in VLSI physical design automation, the basic data structures, and algorithms used for implementing the same.

Teaching and Assessment Scheme:

Teaching Scheme (Hours per Week)			Credits	Assessment Scheme				
L	T	P	C	Theory Marks		Practical Marks		Total Marks
				ESE	CE	ESE	CE	
4	0	0	4	60	40	-	-	100

Course Contents:

Unit No.	Topics	Teaching Hours
1.	Introduction, Design Representation, VLSI Design Styles, VLSI Physical Design Automation, Partitioning, Floor planning, Floor planning Algorithms, Pin Assignment, Placements	12
2.	Grid Routings I to IV, Detailed Routings ,Clock Designs, Clock Network Synthesis and Power And Ground Routing.	12
3.	Time Closure and Timing Driven Placement, Timing Driven Routing, Physical Synthesis Performance-Driven Design Flow, Miscellaneous Approaches to Timing Optimization.	12
4.	Interconnect Modeling’s, Design Rule Check, Layout Compactions Test Pattern Generation, Design for Testability, Boundary Scan Standard, Built-in Self-Tests	12
5.	Low Power VLSI Design, Techniques to Reduce Power, Gate Level Design for Low Power , Other Low Power Design Techniques, Algorithmic Level Techniques for Low Power Design	12
	Total Hrs.	**60**

List of References:
1. S. Kang & Y. Leblebici "*CMOS Digital IC Circuit Analysis & Design*"- McGraw Hill, 2003.
2. J. Rabaey, "*Digital Integrated Circuits Design*", Pearson Education, Second Edition, 2003.
3. Neil Weste and David Harris :" *CMOS VLSI design*" Pearson Education 2009.

Course Outcomes:
At the end of this course, students will be able to:
1. Understand the physical design flow in VLSI.
2. Understand the basic data structures and algorithms for the physical design.
3. Design low power VLSI circuits.

HEL17: MILLIMETER WAVE TECHNOLOGY
CREDITS - 3 (LTP : 3,0,0)

Course Objective:
The primary focus of this course is to discuss the design issues at millimeter-wave frequencies. Further, to explain how the various devices of a microwave/millimeter-wave circuit operate and how they are assembled into a system. To explain how microwave/millimeter-wave devices and circuits are characterized in terms of their scattering parameters. To describe the new devices that is extending this technology to sub-millimeter wavelengths (terahertz frequencies).

Teaching and Assessment Scheme:

Teaching Scheme (Hours per Week)			**Credits**	**Assessment Scheme**				
L	**T**	**P**	**C**	**Theory Marks**		**Practical Marks**		**Total Marks**
				ESE	**CE**	**ESE**	**CE**	
3	0	0	3	60	40	-	-	100

Course Contents:

Unit No.	**Topics**	**Teaching Hours**
1.	Introduction to Millimeter-Wave Technology I to V, Guiding Structures for Millimeter wave technology	12
2.	Antennas at MM-Wave Frequencies	8
3.	Passive components for Millimeter wave technology, Active devices for Millimeter wave technology	10
4.	Noise and Link budged gets for Millimeter wave technology	8
5.	Millimeter wave systems	7
	Total Hrs.	**45**

List of References:
1. RajeshwariChatterji, "*Microwave, Millimeter wave and sub-millimeter wave vacuum electron devices*", Affiliated East - West Press
2. Kao-Cheng Huang, Zhoacheng Wang, "*Millimeter Wave Communication Systems*", Wiley IEEE press, 2011.
3. John S. Seybold "*Introduction to RF propagation*,"John Wiley and Sons, 2005.
4. Chia-Chin Chong, Kiyoshi Hamaguchi, Peter F. M. Smulders and Su-Khiong, "*Millimeter - Wave Wireless Communication Systems: Theory and Applications,"* Hindawi Publishing Corporation, 2007.

Course Outcomes:

At the end of this course, students will be able to:

1. Understand guiding structures at Millimeter Wave Frequency.
2. Understand Millimeter Wave Antennas and Components.
3. Understand Millimeter-Wave Devices and Propagation.

HEL18: OPTIMIZATION FOR COMMUNICATION AND MACHINE LEARNING CREDITS - 3 (LTP: 3,0,0)

Course Objective:

This course will focus on comprehensive several applications of maximum likelihood (ML) estimation theory in wireless communications. Further, it will also cover the recent research developments in areas such as Wireless Sensor Networks (WSNs).

Teaching and Assessment Scheme:

Teaching Scheme (Hours per Week)			Credits	Assessment Scheme				
L	T	P	C	Theory Marks		Practical Marks		Total Marks
				ESE	CE	ESE	CE	
3	0	0	3	60	40	-	-	100

Course Contents:

Unit No.	Topics	Teaching Hours
1.	Basics - Sensor Network and Noisy Observation Model, Likelihood Function and Maximum Likelihood (ML) Estimate, Properties of Maximum Likelihood (ML) Estimate – Mean and Unbiasedness, Properties of Maximum Likelihood (ML) Estimate – Variance and Spread Around Mean, Reliability of the Maximum Likelihood (ML) Estimate – Number of Samples Required	6
2.	Estimation of Complex Parameters – Symmetric Zero Mean Complex Gaussian Noise, Wireless Fading Channel Estimation – Pilot Symbols and Likelihood Function, Wireless Fading Channel Estimation – Pilot Training based Maximum Likelihood ML Estimate, Wireless Fading Channel Estimation – Mean and Variance of Pilot Training Based Maximum Likelihood, Example – Wireless Fading Channel Estimation for Downlink Mobile Communication.	6
3.	Cramer Rao Bound (CRB) for Parameter Estimation, Cramer Rao Bound CRB Example – Wireless Sensor Network, Vector Parameter Estimation – System Model for Multi Antenna Downlink Channel Estimation, Likelihood Function and Least Squares Cost Function for Vector Parameter Estimation, Least Squares Cost Function for Vector Parameter Estimation Vector Derivative Gradient.	6
4.	Least Squares Solution Maximum Likelihood ML Estimate Pseudo Inverse, Properties of Least Squares Estimate – Mean Covariance and Distribution, Least Squares Multi Antenna Downlink Maximum Likelihood Channel Estimation, Multiple Input Multiple Output MIMO Channel Estimation – Least Squares Maximum Likelihood ML, Example – Least Squares Multiple Input Multiple Output MIMO Channel Estimation.	6
5.	Channel Equalization and Inter Symbol Interference ISI Model, Least Squares based Zero Forcing Channel Equalizer, Example of ISI Channel and Least Squares based Zero Forcing, Equalization and Approximation	11

Unit No.	Topics	Teaching Hours
6.	Error for Zero Forcing Channel Equalizer, Example Equalization and Approximation Error for Zero Forcing Channel Equalizer, Introduction to Orthogonal Frequency Division Multiplexing OFDM – Cyclic Prefix CP and Circular Convolution, Introduction to Orthogonal Frequency Division Multiplexing OFDM – FFT at Receiver and Flat Fading, Channel Estimation Across Each Subcarrier in Orthogonal Frequency Division Multiplexing OFDM, Example Orthogonal Frequency Division Mulltiplexing OFDM – Transmission of Samples with Cyclic Prefix, Example Orthogonal Frequency Division Mulltiplexing OFDM – FFT at Receiver and Channel Estimation. Comb Type Pilot CTP Based Orthogonal Frequency Division Multiplexing OFDM Channel Estimation, Comb Type Pilot CTP Based Orthogonal Frequency Division Multiplexing OFDM Channel Estimation, Example Comb Type Pilot CTP Based Orthogonal Frequency Division Multiplexing OFDM Channel, Frequency Domain Equalization FDE for Inter Symbol Interference ISI Removal in Wireless System, Example Frequency Domain Equalization FDE for Inter Symbol Interference ISI Removal in Wireless Channels. Example Frequency Domain Equalization FDE for Inter Symbol Interference ISI Removal in Wireless Channels, Introduction to Sequential Estimation – Application in Wireless Channel Estimation, Sequential Estimation of Wireless Channel Coefficient – Estimate and Variance Update Equation, Example Sequential Estimation of Wireless Channel Coefficient.	10
	Total Hrs.	**45**

List of References:

1. Paulraj, R. Nabar and D Gore, "*Introduction to Space-Time Wireless Communications*", Cambridge University Press, First Edition, 2008.
2. D.Tse and P.Viswanath, "*Fundamentals of Wireless Communications",* Cambridge University Press, First Asian Edition, 2006.
3. Stefania Sesia, IssamToufik, Matthew Baker, *"LTE - The UMTS Long Term Evolution: From Theory to Practice*", Wiley, 2nd Edition,2011.
4. Y.S.Cho,J.Kim,Won Young Yang, Chung G. Kang, *"MIMO OFDM Wireless Communications with MATLAB"* John Wiley & sons(Asia) private Ltd, First Edition, 2010.
5. L. Hanzo, Y.A. Li Wang, M. Jiang "*MIMO-OFDM for LTE, Wi-Fi and WiMAX* ", John Wiley & Sons Ltd, First Edition,2010.

Course Outcomes:

At the end of this course, students will be able to:

1. Understand the basic concepts of maximum likelihood (ML) and Least Squares Estimation (LS).
2. Analyze the capacity and BER performance to various MIMO OFDM systems
3. Understand the basic principles of estimation.
4. Understand the deeper insights into various techniques in signal processing and communication.

HEL19: ADVANCED IOT APPLICATIONS
CREDITS - 3 (LTP : 3,0,0)

Course Objective:

This course focuses on the selected set of applications for the IoT world. The students will be able to understand various sensors and use of their in real life.

Teaching and Assessment Scheme:

Teaching Scheme			Credits	Assessment Scheme				
L	T	P	C	Theory		Practical		Total Marks
				ESE	CE	ESE	CE	
3	0	0	3	60	40	-	-	100

Course Contents:

Unit No.	Topics	Teaching Hours
1.	Localization in IoT – Part 1: Overview of localization using IoT sensors, Outdoor localization without GPS, Outdoor localization using elevation - pressure mapping, Localization in IoT – Part 2: Localization using IMU sensors, RFID based localization	6
2.	Sensors and protocols for next-generation automobiles: Simulation of simple algorithms for object detection, Building smart vehicle for collision avoidance, Basic computer vision algorithms Part -1, Basic computer vision algorithms Part -2, Code walkthrough of computer vision algorithm, Introduction to LiDAR, Range estimation & Obstacle avoidance, Introduction to vehicle platooning	6
3.	Automotive IoT: Building blocks for autonomous vehicles – 1, Building blocks for autonomous vehicles – 2, On-Board Diagnostics and protocols, Diagnostic services and fuel-injection ratio control unit, Real-time event processing and Anomaly detection, OBD - II and stream processing demonstration	6
4.	Speech to text processing: Speech recognition , Device Security	10
5.	Air quality monitoring: Need for air quality monitoring, Air quality: pollutants and standards, Introduction to air quality sensors, Calibration techniques for IoT air quality sensors, Sensor types: semiconductor and electrochemical, Air quality : Overview of system design, Air quality : System design - part 1, Air quality : System design - part 2, Air quality: Real time measurement for a drive cycle.	11
6.	Case Studies: Introduction to First Responder networks, First Responders – Applications, Cargo monitoring for tamper detection	6
	Total Hrs.	**45**

List of References:

1. Vijay Madisetti and ArshdeepBahga, "*Internet of Things (A Hands-on-Approach)",* 1 st Edition, VPT, 2014
2. Francis daCosta, "*Rethinking the Internet of Things: A Scalable Approach to Connecting Everything",* 1 st Edition, Apress Publications, 2013
3. CunoPfister, Getting Started with the Internet of Things, O"Reilly Media, 2011, ISBN: 978-1-4493- 9357-1

Course Outcomes:
At the end of this course, students will be able to:
1. Understand and analyze IoT networks.
2. Understand sensors and network for next-generation automobiles.
3. Design indoor localization applications, and other battery less applications.

HEL20: OPTIMIZATION FOR COMMUNICATION AND MACHINE LEARNING
CREDITS - 4 (LTP : 4,0,0)

Course Objective:
This course is focused on developing the fundamental tools/ techniques in modern optimization as well as illustrating their applications in diverse fields such as Wireless Communication, Signal Processing, Machine Learning, Big-Data, and Finance.

Teaching and Assessment Scheme:

Teaching Scheme			Credits	Assessment Scheme				
L	T	P	C	Theory		Practical		Total Marks
				ESE	CE	ESE	CE	
4	0	0	4	60	40	-	-	100

Course Contents:

Unit No.	Topics	Teaching Hours
1.	Vectors and Matrices- Linear Independence and Rank, Eigenvectors and Eigenvalues of Matrices and their Properties, Positive Semidefinite (PSD) and Postive Definite (PD) Matrices and their Properties, Inner Product Space and it's Properties: Linearity, Symmetry and Positive Semi-definite, Inner Product Space and its Properties: Cauchy Schwarz Inequality, Inner Product Space and its Properties: Cauchy Schwarz Inequality. Gram Schmidt Orthogonalization Procedure, Null Space and Trace of Matrices, Eigenvalue Decomposition of Hermitian Matrices and Properties, Matrix Inversion Lemma (Woodbury identity), Introduction to Convex Sets and Properties, Affine Set Examples and Application.	10
2.	Norm Ball and its Practical Applications, Ellipsoid and its Practical Applications, Norm Cone,Polyhedron and its Applications, Applications: Cooperative Cellular Transmission, Positive Semi Definite Cone And Positive Semi Definite (PSD) Matrices, Introduction to Affine functions and examples, Norm balls and Matrix properties: Trace,Determinant, Inverse of a Positive Definite Matrix, Example Problems: Property of Norms, Problems on Convex Sets, Problems on Convex Sets(contd.), Introduction to Convex and Concave Functions, Properties of Convex Functions with examples, Test for Convexity: Positive Semidefinite Hessian Matrix, Application: MIMO Receiver Design as a Least Squares Problem.	10
3.	Jensen's Inequality and Practical Application, Jensen's Inequality application, Properties of Convex Functions, Conjugate Function and Examples to prove Convexity of various Functions, Example Problems: Property of Norms,Problems on Convex Sets, Problems on Convex	10

Unit No.	Topics	Teaching Hours
	Sets(contd.), -Introduction to Convex and Concave Functions, Properties of Convex Functions with examples, Test for Convexity: Positive Semidefinite Hessian Matrix, Application: MIMO Receiver Design as a Least Squares Problem, Jensen's Inequality application, Properties of Convex Functions, Conjugate Function and Examples to prove Convexity of various Functions, Example problems: Operations preserving Convexity(log-sum, average) and Quasi Convexity, Example Problems: Verify Convexity, Quasi -Convexity and Quasi- Concavity of functions, Example Problems:Perspective function, Product of Convex functions and Pointwise Maximum is Convex.	
4.	Practical Application: Beamforming in Multi-antenna Wireless Communication, Practical Application: Maximal Ratio Combiner for Wireless Systems, Practical Application: Multi-antenna Beamforming with Interfering User, Practical Application: Zero-Forcing (ZF) Beamforming with Interfering User, Practical Application: Robust Beamforming With Channel Uncertainity for Wireless Systems, Practical Application: Robust Beamformer Design for Wireless Systems, Practical Application: Detailed Solution for Robust Beamformer Computation in Wireless Systems Tex, Linear modeling and Approximation Problems: Least Squares, Geometric Intuition for Least Squares, Practical Application: Multi antenna channel estimation, Practical Application:Imagedeblurring, Least Norm Signal Estimation, Regularization: Least Squares + Least Norm, Convex Optimization Problem representation: Canonical form, Epigraph form.	10
5.	Linear Program Practical Application: Base Station Co-operation, Stochastic Linear Program,Gaussian Uncertainty, Practical Application: Multiple Input Multiple Output (MIMO) Beamforming, Practical Application: Multiple Input Multiple Output (MIMO) Beamformer Design, Practical Application: Co-operative Communication, Overview and various Protocols used, Practical Application: Probability of Error Computation for Co-operative Communication, Practical Application:Optimal power allocation factor determination for Co-operative Communication,Practical Application: Compressive Sensing, Practical Application, Practical Application- Orthogonal Matching Pursuit (OMP) algorithm for Compressive Sensing, Example Problem: Orthogonal Matching Pursuit (OMP) algorithm, Practical Application : L1 norm minimization and regularization approach for Compressive Sensing Optimization problem, Practical Application of Machine Learning and Artificial Intelligence:Linear Classification, Overview and Motivation, Practical Application: Linear Classifier (Support Vector Machine) Design.	10
6.	Practical Application: Approximate Classifier Design, Concept of Duality, Relation between optimal value of Primal & Dual Problems, concepts of Duality gap and Strong Duality, Example problem on Strong Duality, Karush-Kuhn-Tucker(KKT) conditions, Application of KKT condition:Optimal MIMO power allocation(Waterfilling), Optimal MIMO Power allocation(Waterfilling)-II, Example problem on Optimal MIMO Power allocation(Waterfilling), Linear objective with box constraints, Linear Programming, Example Problems II, Examples on Quadratic Optimization, Examples on Duality: Dual Norm, Dual of Linear Program(LP), Examples on Duality: Min-Max problem, Analytic Centering, Semi Definite Program(SDP) and its application: MIMO symbol vector decoding, Application: SDP for MIMO Maximum	10

Unit No.	Topics	Teaching Hours
	Likelihood(ML) Detection, Introduction to big Data: Online Recommender System(Netflix), Matrix Completion Problem in Big Data: Netflix-I, Matrix Completion Problem in Big Data: Netflix-II.	
	Total Hrs.	**60**

List of References:

1. Leskovec, Jure, Anand Rajaraman, and Jeffrey David Ullman. Mining of massive data sets. Cambridge university press, 2020.
2. Bekkerman, Ron, Mikhail Bilenko, and John Langford, eds. Scaling up machine learning: Parallel and distributed approaches. Cambridge University Press, 2011.
3. Max A. Little, Machine Learning for Signal Processing: Data Science, Algorithms, and Computational Statistics, Oxford Publisher, 2019 .
4. Paolo Prandoni , Martin Vetterli, Signal Processing for Communications (Communication and Information Sciences), CRC Press, 2008.
5. Stephen Boyd, Lieven Vandenberghe, Convex Optimization ,Cambridge University Press, 2004.

Course Outcomes:

At the end of this course, students will be able to:

1. Understand the Wireless: MIMO/ OFDM systems, Beam forming, Cognitive Radio, and Cooperative Communication.
2. Understand the Signal Processing concepts: Signal Estimation, Regularization, Image Reconstruction; Compressive Sensing: Sparse estimation, OMP, LASSO techniques.
3. Understand the Machine Learning concepts: Principal Component Analysis (PCA), Support Vector Machines (SVM); Big-Data: Recommender systems, User-rating prediction, Latent Factor Method; Finance: Financial models, Portfolio Optimization.

HEL21: DIGITAL VLSI TESTING
CREDITS - 4 (LTP : 4,0,0)

Course Objective:

The main objective of the course is to expose the students and practitioners to the most recent, yet fundamental, VLSI test principles and DFT(Design for Testability)architectures in an effort to help them design better quality products that can be reliably manufactured in large quantity.

Teaching and Assessment Scheme:

Teaching Scheme (Hours per Week)			Credits	Assessment Scheme				
L	T	P	C	Theory Marks		Practical Marks		Total Marks
				ESE	CE	ESE	CE	
4	0	0	4	60	40	-	-	100

Course Contents:

Unit No.	Topics	Teaching Hours
1.	Introduction: Importance, Challenges, Levels of abstraction, Fault Models, Advanced issues.	10

Unit No.	Topics	Teaching Hours
2.	Design for Testability: Introduction, Testability Analysis, DFT Basics, Scan cell design, Scan Architecture.Scan design rules, Scan design flow Fault Simulation: Introduction, Simulation models.Fault Simulation: Logic simulation, Fault simulation.	10
3.	Test Generation: Introduction, Exhaustive testing, Boolean difference, Basic ATPG algorithms. ATPG for non stuck-at faults, Other issues in test generation Built-In-Self-Test: Introduction, BIST design rules.Built-In-Self-Test: Test pattern generation, Output response analysis, Logic BIST architectures	10
4.	Test Compression: Introduction, Stimulus compression.Stimulus compression, Response compression.	10
5.	Memory Testing: Introduction, RAM fault models, RAM test generation,BIST Power and Thermal Aware Test: Importance, Power models, Low power ATPG.	10
6.	Power and Thermal Aware Test: Low power BIST, Thermal aware techniques	10
	Total Hrs.	**60**

List of References:

1. N. Jha & S.D. Gupta, "*Testing of Digital Systems*", Cambridge, 2003.
2. W. W. Wen, "*VLSI Test Principles and Architectures Design for Testability",* Morgan KaufmannPublishers. 2006
3. Michael L. Bushnell & Vishwani D. Agrawal," *Essentials of Electronic Testing for Digital,memory& Mixed signal VLSI Circuits*", Kluwar Academic Publishers. 2000.

Course Outcomes:

At the end of this course, students will be able to:

1. Understand fundamental VLSI test principles.
2. Understand DFT architectures.
3. Know the simulation techniques and different testing operation for designing.

HEL22: NEURAL NETWORKS FOR SIGNAL PROCESSING

CREDITS - 4 (LTP : 4,0,0)

Course Objective:

This course highlights different neural networks and optimization techniques.

Teaching and Assessment Scheme:

Teaching Scheme (Hours per Week)			Credits	Assessment Scheme				
L	T	P	C	Theory Marks		Practical Marks		Total Marks
				ESE	CE	ESE	CE	
4	0	0	4	60	40	-	-	100

Course Contents:

Unit No.	Topics	Teaching Hours
1.	Introduction, human brain, models of a neuron, neural communication, neural networks as directed graphs, network architectures (feed-forward, feedback etc.), knowledge representation, Learning processes, learning tasks, Perceptron, perceptron convergence theorem, relationship between perceptron and Bayes classifiers, batch perceptron algorithm.	10
2.	Modeling through regression, linear and logistic regression for multiple classes. Multilayer perceptron, batch and online learning, derivation of the back propagation algorithm, XOR problem, Role of Hessian in online learning, annealing and optimal control of learning rate.	10
3.	Approximations of functions, cross-validation, network pruning and complexity regularization, convolution networks, non-linear filtering. Cover's theorem and pattern separability, the interpolation problem, RBF networks, hybrid learning procedure for RBF networks, Kernel regression and relationship to RBFs.	10
4.	Support vector machines, optimal hyperplane for linear separability, optimal hyperplane for nonseparable patterns, SVM as a kernel machine,design of SVMs, XOR problem revisited, and robustness considerations for regression. SVMs contd. optimal solution of the linear regression problem, representor theorem and related discussions. Introduction to regularization theory.	10
5.	Hadamard's condition for well-posedness, Tikhonov regularization, regularization networks, generalized RBF networks, estimation of regularization parameter etc, L1 regularization basics, algorithms and extensions.	10
6.	Principal component analysis: Hebbian based PCA, Kernel based PCA, Kernel Hebbian algorithm, Deep multi-layer perceptron, deep autoencoders and stacked denoising auto-encoders.	10
	Total Hrs.	**60**

List of References:

1. S. Haykin, Neural Networks and Learning Machines, Pearson Press, 2009.
2. K. Murphy, Machine Learning: A Probabilistic Perspective, MIT Press, 2012.
3. G. James, D. Witten, T. Hastie and R. Tibshirani, An Introduction to Statistical Learning, Springer, 2013.
4. Y. S. Abu-Mostafa, M. Magdon-Ismail and H. Lin, Learning from Data, AMLBook, 2012.
5. J. Nocedal and S. J. Wright, Numerical Optimization, Springer, 2006.

Course Outcomes:

At the end of this course, students will be able to:

1. Understand basics of optimization and soft computing algorithms.
2. Understand artificial neural network and its training.
3. Implement various signals on different neural networks.