COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY
DEPARTMENT OF ELECTRONICS
COCHIN – 682 022

Syllabus

M.Tech. (Electronics & Communication Engineering)

Specialisations in

VLSI and Embedded Systems
Robotics and Intelligent Systems
Microwave and Radar Engineering

2019

Course structure

Semester I

Course Code	Name of the Course	C/E	Credits
18-437-0101	Embedded Architecture and Interfacing	C	3
18-437-0102	Embedded Systems Laboratory	C	1
18-437-0103	Digital Communication	C	3
18-437-0104	Communication Laboratory	C	1
18-437-0105	Advanced Digital Signal Processing	C	3
	Elective-I (Specialization)	E	3
	Elective-II (General)	E	3
	Elective-Lab (Specialization)	E	1
Total credits			18

Specialization Electives

VLSI and Embedded Systems

18-437-0107	VLSI Technology and Design	E	3
18-437-0108	VLSI Laboratory	E	1

Microwave and Radar Engineering

18-437-0109	Microwave Devices and Circuits	E	3
18-437-0110	Microwave Laboratory	E	1

Robotics and Intelligent Systems

18-437-0111	Robotics and Automation	E	3
18-437-0112	Robotics Laboratory	E	1

General Electives

18-437-0113	Wireless Communications	E	3
18-437-0114	Wireless Communications Laboratory	E	1
18-437-0115	Neural Networks	E	3
18-437-0116	Neural Networks Laboratory	E	1

Semester II

Course Code	Name of the Course	C/E	Credits
18-437-0201	Advanced Digital System Design	C	3
18-437-0202	Digital Image Processing	C	3
18-437-0203	Signal and Image Processing Laboratory	C	1
18-437-0204	Seminar	C	1
	Elective-I (Specialization)	E	3
	Elective-II (Specialization)	E	3
	Elective –III (General)	E	3
	Elective-Lab (Specialization)	E	1
Total credits			18

Specialization Electives

VLSI and Embedded Systems

18-437-0205	Hardware Software Codesign	E	3
18-437-0206	Hardware Software Codesign Lab	E	1
18-437-0207	Real Time Operating Systems	E	3
18-437-0208	Real Time Operating Systems Lab	E	1
18-437-0209	Analog Integrated Circuit Design	E	3
18-437-0210	Analog Integrated Circuit Design Lab	E	1
18-437-0211	Design Verification and Testing	E	3
18-437-0212	Design Verification and Testing Lab	E	1

Microwave and Radar Engineering

18-437-0213	Antenna Theory	E	3
18-437-0214	Antenna Lab	E	1
18-437-0215	Radar Systems	E	3
18-437-0216	Radar Systems Lab	E	1

Robotics and Intelligent Systems

18-437-0217	Machine Learning	E	3
18-437-0218	Machine Learning Lab	E	1
18-437-0219	Mobile Robotics	E	3
18-437-0220	Mobile Robotics Lab	E	1

General Electives

18-437-0221	Broad Band Communication	E	3
18-437-0222	Spectrum Analysis	E	3
18-437-0223	Adaptive Signal Processing	E	3
18-437-0224	Underwater Communication	E	3
18-437-0225	Spread Spectrum Communication	E	3
18-437-0226	Spread Spectrum Communication Lab	E	1
18-437-0227	RF MEMS	E	3
18-437-0228	RF MEMS Lab	E	1

Semester III

18-437-0301	Project Evaluation & Viva Voce	C	18

Semester IV

18-437-0401	Project Evaluation& Viva Voce	C	18

Total credits for the course =18+18+18+18 = 72

18-437-0101 EMBEDDED ARCHITECTURE AND INTERFACING

Course Description: This course will teach the architectural optimizations of processors and embedded systems. Covers architectural optimizations and introduces new concepts such as cyber physical systems and internet of things. Low power embedded devices are reviewed and its interfacing with peripherals are discussed.

Course Objectives

- Evolution of computer architecture and optimizations
- Review of commercial computing processors and development boards.
- Interfacing of embedded devices with peripherals

1. Embedded Architecture: Evolution of microprocessors and embedded systems. General purpose computers vs Embedded system. Performance and power consumption, Moore's law, Amdahl's law. **Embedded System Architecture**: Intel x86, IBM PowerPC, ARM. Classifications: RISC, CISC, Fylnn's Classification, Big and little endian CPI. Computer Architecture: Pipelining stages, Superscalar processing, Throughput and latency.

2. Optimizations in Architecture: Pentium processor architecture, Out of order execution, micro ops and caching, branch prediction, register renaming. Pipeline conflicts and Hazards. Pipeline stalling, Delay Slot, Result forwarding, Speculative Execution. **Memory Organization:** Caches, multi-levels, placement and replacement policies, Cache hit and miss Cache performance and prediction. Address translation, base and bound registers, paging, virtual address, Translation Lookaside Buffer.

3. ARM Architecture: Evolution of ARM architecture, programming model, Cortex M3 Processor architecture, registers and flags, operation modes, memory map, Nested Vector Interrupt Controller, power management. **Graphics Processing**: Abstraction, multi-threaded programming, Hybrid processors, General Purpose-GPU, NVIDIA CUDA architecture.

4. Low power Embedded Systems: 16F87X series PIC processor organization, Instruction Set, Memory organization, Timing modes, Input-Output ports, Compare and Capture modes, Pulse Width Modulation, Interrupt Structure and handling, **Cyber Physical Systems and Internet of Things:** Client server model, Cloud computing, sensor network. Development and interfacing with evaluation boards: Arduino, Galileo, Raspberry Pi, etc.

5. Interfacing of Embedded Systems: Sensors and Transducers for interfacing. Bluetooth, Zigbee, HDMI. Interfacing standards: 1^2C, SPI, USB. Analog to Digital Convertors and properties: Parallel Comparator, Dual Slope and Successive Approximation methods. Interfacing of Real Time Clock, Pulse Width Modulation, Stepper motors, LCD.

References

1. David Patterson and John L. Hennessy, "Computer Architecture: A quantitative approach", 5th Edition, Elsevier, 2012.
2. Microarchitecture of the Pentium 4 processor, Intel Technology Journal, 2001.
3. Joseph Yiu, "The definitive guide to ARM Cortex M3", Elsevier, 2nd Edition, 2010.
4. "NVIDIA® CUDA™ Architecture: Introduction and Overview", NVIDIA, 2009.
5. Microchip PIC - Microcontroller application notes / data sheets.
6. Mazidi et. al., "The PIC microcontroller and embedded systems", Pearson, 2008.
7. Wayne Wolf, Computers as Components: Principles of Embedded Computing System Design, Elsevier Publication 2000.
8. Barry B. Brey., "The Intel Microprocessors – Architecture, programming & Interfacing", Prentice Hall.

18-437-0103 DIGITAL COMMUNICATION

Course Description: This course introduces students to the advanced concepts of digital communication. In particular, the course will review the concepts of probability and statistics and prepare a mathematical background for communication signal analysis.

Course Objectives

- To understand and analyze the signal flow in a digital communication system.
- To analyze error performance of a digital communication system in presence of noise and other interferences especially AWGN.
- To understand the importance of the concept of orthogonality in Digital Communication.
- To understand Nyquist's sampling theorem and its practical implications.
- To learn Inter symbol interference (ISI) and design Nyquist filter for avoiding ISI and practical improvisation of ideal Nyquist filter.

1. Review of Random variables. Moment generating function, Chernoff bound, Markov,s inequality, Chebyshev,s inequality, Central limit Theorem, Chi square, Rayleigh and Rician distributions, Correlation, Covariance matrix- Stationary processes, wide sense stationary processes, ergodic process, cross correlation and autocorrelation functions-Gaussian process

2. Characterization of Communication Signals and Systems- Signal space representation- Connecting Linear Vector Space to Physical Waveform Space- Scalar and Vector Communication over Memory less Channels. Optimum waveform receiver in additive white Gaussian noise (AWGN) channels - Cross correlation receiver, Matched filter receiver and error probabilities.

3. Optimum Receiver Signals with random phase in AWGN Channels- Optimum receiver for Binary Signals- Optimum receiver for M-ary orthogonal signals- Probability of error for envelope detection of M- ary Orthogonal signals. Optimum waveform receiver for coloured Gaussian noise channels- Karhunen Loeve expansion approach, whitening.

4. Carrier Recovery and Symbol Synchronization in Signal Demodulation- Carrier Phase Estimation- Effect of additive noise on the phase estimate- Maximum Likelihood phase estimation- Symbol Timing Estimation- Maximum Likelihood timing estimation- Receiver structure with phase and timing recovery-Joint Estimation of Carrier phase and Symbol Timing- Frequency offset estimation and tracking.

5. Communication over band limited Channels- Optimum pulse shaping- Nyquist criterion for zero ISI, partial response signaling- Equalization Techniques- Zero forcing linear Equalization- Decision feedback equalization- Adaptive Equalization.

References

1. J.G. Proakis and MasoudSalehi, "Digital Communication", MGH 5TH edition, 2008..
2. Edward. A. Lee and David. G. Messerschmitt, "Digital Communication", Allied Publishers (second edition).
3. J.Marvin.K.Simon, Sami. M. Hinedi and William. C. Lindsey, "Digital Communication Techniques", PHI.
4. William Feller, "An introduction to Probability Theory and its applications", Vol 11, Wiley 2000.
5. Sheldon.M.Ross, "Introduction to Probability Models", Academic Press, 7th edition.
6. Ian A Glover and Peter M Grant "Digital Communication" 2nd edition Pearson education, 2008.

18-437-0105 ADVANCED DIGITAL SIGNAL PROCESSING

Course Description: This course deals with the analysis & design of analog and digital DSP filters. It also gives an overview regarding multidimensional and multi rate signal processing. A basic understanding of DSP hardware chips.

Course Objective

- To have a basic idea of z-transform
- To understand the basic steps involved in design of IIR & FIR filters
- To have an idea about 2D- signals, systems and transforms
- To have an insight into multirate signal processing techniques
- To have a thorough undersanding of TMS 320 hardware

1. Overview of Transforms :Z – Transform, DFT, FFT, DCT, Hillbert Transform, Short-time Fourier Transom, Wavelet Transform.

2. Filter Design – LTI System as Frequency Selective Filters - FIR Filters - Characteristics of FIR Filters with Linear Phase - Fourier Series Method of FIR Filter Design – Windows - Design of FIR Filters by Frequency Sampling Technique - IIR Filters - Impulse Invariant Transformation, Bilinear Transformation - Design of Lowpass Digital Butterworth Filter, Design of Lowpass Digital Chebyshev Filter , Frequency Transformations.

3. Multidimensional Signal Processing: 2-D Signals and Systems, Multi-dimensional Sampling, Difference Equations, Convolution, Fourier representation, 2-D DFT, Multidimensional FFT, z – Transforms.

4. Multi-rate Signal Processing: Sampling and Sampling rate Conversion, Decimation and Interpolation, FIR & IIR Decimators and Interpolators.

5. Hardware: Finite word length affect in Signal Processing, Signal Processing Hardware – TMS 320 Series Chips. Real-time Implementation Considerations.

References

1. Proakis, J.G., Manolakis, D.G. “Digital Signal Processing Principle Algorithms and Applications”. PHI 1996.
2. Dudgeon, D.E., Merseraus, R.M., “Multi-Dimensional Digital Signal Processing”. Prentice-Hall, N.J., 1984.
3. Oppenheim, A.V., Schafer, R.W. , “Discrete – Times Signal Processing”. PHI, 1992
4. Crochiere, R.E., Rabiner, L.R., “Multi rate Digital Signal Processing, Prentice-Hall, N.J. 1983
5. Haddad, Richard A., Parsons, Thomas W., “Digital Signal Processing: Theory Applications & Hardware”, Computer Science Press, 1991.
6. Ahmed, N., Natarajan, T.R., “Theory and Applications of Digital Signal Processing.” Reston Publishing Co., 1983.

18-437-0107 VLSI TECHNOLOGY AND DESIGN

Course Description: This course deals with the analysis and design of MOS circuits and the various stages of the CMOS design process. It also introduces the VLSI fabrication techniques and presents the latest trends in VLSI technology.

Course Objectives:

- To refresh the basic working principles of MOS transistors and understand the short channel effects.
- To introduce digital MOS circuit design principles.
- To familiarize students with the basic VLSI design flow.
- To discuss the various stages of CMOS fabrication process.
- To introduce MOS scaling theory and expose them to the growing challenges in MOS IC design.
- To discuss with students the latest trends in nanoelectronic devices.

Course content:

1. **Introduction to CMOS VLSI:** PN Junctions, Static and Dynamic Behavior, Secondary Effects, MOS Transistor, Ideal I-V Characteristics, C-V Characteristics, Non-Ideal I-V Effects, Complementary MOS Logic - Inverter, Combinational Logic, NAND/NOR gates, Latch-up in CMOS.
2. **Combinational Circuit Design:** Static CMOS Circuits - CMOS Inverter, Static and Dynamic Behavior, Complementary CMOS, Delay models, Logical Effort, Ratioed Logic, Pass-Transistor Logic, Transmission gates, Dynamic CMOS Circuits. Sequential Circuit Design: Timing Metrics, Classification of Memory Elements, Static Latches and Registers, Dynamic Latches and Registers, Pipelining, Memory Cells.
3. **VLSI Design Flow:** Custom, Semicustom and Structured-Array Design Approaches,, Cell Based Design Methodology, Semicustom Design Flow - Design Capture, Register Transfer Logic, Functional Simulation, High Level Synthesis, Logic Synthesis, Timing Simulation, Static Timing Analysis, Power Analysis, Planning, Partitioning, Placement and Routing, Extraction, Packaging, IC testing.
4. **CMOS Fabrication and Layout** – Fabrication Process -Silicon wafer preparation, FEOL processing-Diffusion of impurities, ion implantation, annealing, oxidation, lithography, Chemical Vapour Deposition, epitaxial growth, BEOL process- metalization, patterning, wire bonding, packaging, MOS Layers, Layout Design Rules, Gate Layout, Stick Diagrams.
5. **CMOS Scaling and Sub-Micron Trends:** Propagation Delays, Logic and Interconnect delays, Scaling Factors for Device Parameters, Constant field scaling and constant voltage scaling, Challenges going to sub-100 nm MOSFETs , Multiple gate MOSFETs, FinFETs, Silicon-on-insulator, Strained Si and Si-Ge Devices, Basics of GaAs material for high frequency applications, Carbon nanotube FET, SpinFET.

References:

1. Jan M. Rabaey, Anantha Chandrakasan, Borivoje Nikolic, "Digital Integrated Circuits – A Design Perspective", Pearson Education India, 2nd edition, 2016.
2. Neil H. E. Weste & David M. Harris, "CMOS VLSI Design, - A Circuits and Systems Perspective", Pearson Education India, 4th edition, 2015.
3. Donald A. Neamen & Dhrubes Biswas, "Semiconductor Physics and Devices", McGraw Hill Education, 4th edition, 2017.
4. D. S. Pucknell & K. Eshraghian, "Basic VLSI Design", Prentice Hall, 3rd edition, 2000.
5. S. Wolf, "Silicon Processing for VLSI Era", Lattice Press, 1990.
6. S. M. **Sze, "***VLSI Technology",* McGraw Hill Education, 2nd edition, 2017.
7. J. P. Colinge (ed), FinFETs and Other Multi-Gate Transistors, Springer, 1st edition, 2008.
8. Jerry G. Fossum & Vishal P. Trivedi, "Fundamentals of Ultra-Thin-Body MOSFETs and FinFETs", Cambridge University Press, 1st edition, 2013.
9. Recent papers from IEEE Transactions on Electron Devices.

18-437-0109 MICROWAVE DEVICES AND CIRCUITS

Course Description: This course helps to learn the RF semiconductor devices, amplifiers and fabrication techniques of microwave Integrated circuits.

Course Objectives:

- To familiarize basic principles, characteristics and applications of commonly used microwave devices.
- To study about RF transistor amplifiers, RF oscillators and their matching networks.
- To provide the idea of RF IC design.

1. Planar Transmission lines. Review of Transmission lines, Smith Chart Microstrip Line, Strip line, Coplanar line. Basic theory and design of planar filters.

2. Microwave Solid state devices: BJT, IMPATT devices, Transferred Electron devices, Gunn diodes, MESFET, HEMT, control devices, Varactors, PIN diodes, switches, phase shifters, modulators and attenuators, Detectors.

3. Transistor Amplifiers: S Parameters of a network, stability consideration in active networks, Stability circles, stability criteria, matching networks, power gain concepts, unilateral transistor, gain circles, noise figure circles, bilateral design

4. RF oscillators and Mixers: Oscillation conditions, Two port and one port oscillators, Oscillator and stability conditions, tunable oscillators, mixers, mixer types, up convertors, down convertors, harmonic mixers, circuits design, conversion loss and noise figure, cascaded circuits, Inter modulation

5. RF IC design: Monolithic and hybrid MICs, Substrate and conductor materials, IC design, reproducibility and reliability issues, chip manufacturing aspects, RF MEMS

References:

1. Kai Chang, “Microwave Solid state circuits and applications”, John Wiley, 1994
2. Matthew M. Radmanesh, “Radio frequency and microwave electronics illustrated”, Pearson Education Inc, 2001.
3. Samuel Liao, “Microwave Circuit Analysis and amplifier design”, Prentice Hall, 1987
4. R Ludwig & Bretchko, “RF circuit design, Theory and applications”, Pearson Education Inc, 2000.
5. J. Michael Golio, “Microwave MESFETs and HEMTs”, Artech House, 1991.

18-437-0111 ROBOTICS AND AUTOMATION

Course Description: This course introduces robot classifications, sensors and actuators. It also provides an overview into control, dynamics of robots and its use in automation.

Course Objectives

- Discuss Robot classifications, sensors and actuators.
- Discuss kinematics, movement, joints of robots
- Discuss robot applications in automation.

1. **Introduction:** Definition, Robot Classifications – Cartesian, Cylindrical, Spherical Work Envelope, Types of joints, Prismatic, Revolute, Ball and socket, Number of Axes, Degree of freedom, Joint variables, Grippers - Mechanical Grippers, Pneumatic and Hydraulic Grippers, Magnetic Grippers, Vacuum Grippers .
2. **Sensors:** Measurement devices, Range, response time, Accuracy, Precision, Sensitivity, resolution, linearity, error, Dead band, Dead time, costs and uncertainty. Position and Odometry Sensors. Beacons and Range Sensors**:** Doppler Sensors, Haptic sensors. Touch Screen/ Touch Panel. **Actuators:** solenoids, DC motor, AC motor, Servomotors, Stepper motor, BLDC Motors, speed control, Pulse width modulation (PWM) frequency drive, vector drive, H-bridge. Pneumatics & Hydraulic Systems, directional & pressure control valves, Drive mechanisms: Lead screw, Ball screw, Chain linkage, belt drive and gear drives.
3. **Kinematics:** World frame, joint frame, end-effectors frame, Rotation Matrix, composite rotation matrix, Homogeneous Matrix, Link Coordinate, Denavit-Hartenberg representation, Arm equation, Tool Configuration. **Robot Dynamics:** Velocity Kinematics, Jacobian, Singularities, Differential motion, Euler – LaGrange Equation, Expression of Kinetic and Potential Energy, Equations of Motion.
4. **Robot Programming & Robot Controllers:** Teach-in, Teach-Through, High-Level languages –robot talk, Comparison of teaching and programming methods, Software speedup, Robot Controllers – essential components, joint actuation and Sensing, Overload, Over current and stall detection methods, Position, Speed, Direction Sensing.
5. **Automation:** Introduction**:** Definition of automation, Types of production, Functions of Manufacturing, Organization and Information Processing in Manufacturing, Production concepts and Mathematical Models, Automation Strategies, Production Economics: Methods of Evaluating Investment Alternatives, Costs in Manufacturing, Break-Even Analysis, Unit cost of production, Cost of Manufacturing Lead time and Work-in-process.

References:

1. Fu,K.S. ,et al "Robotics- Control, Sensing, Vision and Intelligence ", McGraw – Hill. Inc., Singapore,1987.
2. H.R.Everett, "Sensors for Mobile Robots – Theory and Applications", A.K.PeteresLtd. ISBN 1-56881- 048-2, 1995.
3. Kurfess, Thomas R., ed. "Robotics and automation handbook". CRC press, 2004.
4. Selig J.M, "Introductory Robotics",PHY(UK), 1992.
5. Yorem Koren, "Robotics for Engineers", McGraw-Hill Book Co., 1992.
6. Groover M.P et al., "Industrial Robotics – Technology, Programming & Applications", McGraw-Hill. 1986.
7. Derby, Stephen J. "Design of Automatic Machinery". CRC Press, 2004.
8. Groover, Mikell P. "Automation, production systems, and computer-integrated manufacturing". Pearson Education India, 2016.
9. Siciliano, Bruno, and OussamaKhatib, eds. "Springer handbook of robotics". Springer, 2016

18-437-0113 WIRELESS COMMUNICATION

Course Description: This course reviews the various communication standards in wireless domain. This course will provide students an understanding about the wireless standards, modes of communication and efficiency criteria.

Course Objective

- Study the wireless channel characteristics and performance issues.
- Discuss cellular communication and modulation schemes.
- Review next generation cellular standards.

1. Fading and Diversity: Wireless Channel Models-pathlossandshadowingmodels-statisticalfadingmodels-Narrowband and wideband Fading models-Review of performance of digital modulation schemes over wireless channels- Diversity- Repetition coding and Time Diversity- Frequency and Space Diversity- Receive Diversity- Concept of diversity branches and signal paths-Combining methods-Selective diversity combining- Switched combining-maximal ratio combining-Equal gain combining-performance analysis for Rayleigh fading channels.

2. Cellular Communication: Cellular Networks-Multiple Access: FDM/TDM/FDMA/TDMA- Spatial reuse-Co-channel interference Analysis-Handover Analysis-Erlang Capacity Analysis-Spectral efficiency and Grade of Service- Improving capacity- Cell splitting and sectorization.

3. Spread spectrum and CDMA: Motivation -Direct sequence spread spectrum-Frequency Hopping systems-Time Hopping.-Anti-jamming- Pseudo Random(PN) sequence-Maximal length sequences-Gold sequences-Generation of PN sequences.- Diversity in DSSS systems-Rake Receiver-Performance analysis. Spread Spectrum Multiple Access- CDMA Systems-Interference Analysis for Broadcast and Multiple Access Channels-Capacity of cellular CDMA networks-Reverse link power control- Hard and Soft hand off strategies.

4. Fading Channel Capacity: Capacity of Wireless Channels-Capacity of flat and frequency selective fading channels-Multiple Input Multiple output(MIMO)systems-Narrowband multiple antenna system model-Parallel Decomposition of MIMO Channels-Capacity of MIMO Channels.

5. Cellular Wireless Communication Standards: Second generation cellular systems: GSM specifications and Air Interface-specifications, IS95 CDMA-3G systems: UMTS & CDMA2000 standards and specifications

References :

1. Theodore S. Rappaport, "Wireless Communications: Principles & Practice", Second Edition, Prentice Hall of India Pvt. Ltd. (Low Priced Edition – Pearson Education Asia), 2002.
2. William C.Y. Lee, "Mobile Communication Engineering: Theory & Applications", Second Edition, McGraw Hill, 1998.
3. Gordon L. Stuber, "Principles of Mobile Communications", Kluwer Academic Press,1996.
4. John G. Proakis, "Digital Communications", Fourth Edition, McGraw Hill, 2001.
5. Jochan Schiller, "Mobile communications", Addison-Wesley (Low Priced Edition – Pearson Education Asia), 2002.
6. SimonHaykin and MichaelMoher, " Modern Wireless Communications", Pearson Education.
7. Andrea Goldsmith, "Wireless Communications",Cambridge Universitypress.
8. A.J.Viterbi,"CDMA- Principles of Spread Spectrum",AddisonWesley, 1995.

18-437-0115 NEURAL NETWORKS

Course Description: This course provides a broad introduction to Neural Networks and its design approach.

Course Objectives:

- To provide idea of neural networks
- To familiarize different architectures of Neural networks
- To understand various algorithms involved in modeling and problem solving
- To provide practical approach in various applications

1. Introduction - what is a neural network? Human Brain, Models of a Neuron, Neural networks viewed as Directed Graphs, Feedback, Network Architectures, Knowledge Representation. Learning Process–Supervised, Unsupervised and Reinforcement learning, Learning Tasks-Pattern Association, recognition, function approximation, control, beamforming

2. Perceptron –Perceptron convergence theorem, Relation between perceptron and Bayes classifier for a Gaussian Environment, **computer experiment**-pattern classification, batch perceptron algorithm. Model building through regression- linear regression model, maximum a posteriori estimation of the parameter vector. Relationship between regularized least-squares estimation and map estimation, **computer experiment:** pattern classification. Least-Mean-Square Algorithm

3. Multilayer Perceptron – Batch learning and Online learning, Back propagation algorithm, XOR problem, heuristics for making the back-propagation algorithm perform better, **computer experiment:** pattern classification.

4. Back Propagation - back propagation and differentiation, Hessian matrix, optimal annealing and adaptive control of the learning rate, Approximations of function, Generalization, Cross validation, Network pruning Techniques, Virtues and limitations of back propagation learning, Convolutional Networks

5. Kernel Methods and Radial-Basis Function networks – cover's theorem on the separability of patterns, the interpolation problem, radial-basis-function networks, k-means clustering, recursive least-squares estimation of the weight vector, hybrid learning procedure for RBF networks, **computer experiment**: pattern classification, interpretations of the Gaussian hidden units, kernel regression and its relation to RBF networks

REFERENCES:

1. Simon Haykin, "Neural Networks and Learning Machines", Pearson Education; 3rd edition 2016
2. Martin T Hagan, Howard B Demuth, Mark H Beale, Orlando De Jesús, "Neural Network Design", Cengage Learning,2nd Edition, 2014
3. S. Haykin, "*Neural* Networks: A Comprehensive Foundation", 2nd edition, (Prentice Hall, 1999)
4. Philip D. Wasserman, "Neural Computing: Theory and Practice", Coriolis Group, 1989.
5. B.Vegnanarayana, "Artificial neural networks", Prentice Hall of India, 2005
6. James. A.Freeman and David.M.Skapura, "Neural Networks Algorithms, Applications and. Programming Techniques ", Pearson Education, 2002

18-437-0201 ADVANCED DIGITAL SYSTEM DESIGN

Course Description: This course aims to provide students with knowledge about designing digital systems and realizing them using hardware description languages.

Course Objectives:

- To review digital logic design fundamentals, design of combinational and sequential circuits.
- To enable students to design and implement a complete digital system.
- To familiarize the challenges associated while designing a digital system.
- To learn Verilog HDL and use it to realize digital systems.
- To familiarize with programmable logic devices.
- To expose students to the latest trends in programmable devices.

Course content:

1. **Introduction to Digital Design:** Postulates of Boolean Algebra, Canonical and Standard Forms, logic functions and gates, Minimization of logic functions – Karnaugh Map and Quinn McClusky method, Basic combinational circuits, Sequential Logic - latches, flip flops, types, characteristic equations, Design of State machines – state table, state assignment, excitation tables, logic realization.
2. **Digital system Design:** Top down Approach to Design, Data Path, Control Path, Controller behavior and Design, Mealy & Moore Machines, Case Study of a complete system, Current trends: System on Chip, IP based Design, Hardware-Software Co-design.
3. **Design Challenges:** Timing Issues in combinational circuits – race conditions, static and dynamic hazards, Timing of sequential circuits -skew, jitter, setup and hold time, Metastability, synchronization, Pipelining, Resource sharing.
4. **System Design using Verilog HDL** – Module, compiler directives, variables, datatypes, operators and language constructs, procedural constructs, dataflow modeling, behavioral modeling, structural modeling, tasks and functions, testbench, modeling combinational and sequential circuits – arithmetic and logic circuits, registers, counters, sequential machines,
5. **Programmable Devices**: Introduction, Evolution: ROM, PROM, PLA, PAL, Applications, Design Flow, Complex PLD's - Architecture, Resources, Applications, FPGAs – Architecture, IP blocks, Memory, Design Flow, Static Timing Analysis, Programing FPGAs, Debugging , Case study of recent FPGA Architectures.

References:

1. Charles H. Roth Jr, "Fundamentals of Logic Design", CL Engineering, 7th edition, 2013.
2. John F. Wakerly, "Digital Design - Principles and Practices", Pearson, 4th edition, 2008.
3. Charles H. Roth Jr. Lizy Kurian John, Beyeong Kil Lee, "Digital Systems Design Using Verilog", CL Engineering, 1st edition, 2015.

4. W. Wolf, "FPGA- based System Design", Pearson, 1st edition, 2004.
5. Steve Kilts, "Advanced FPGA Design: Architecture, Implementation, and Optimization", Wiley-IEEE Press, 1st edition, 2007 .
6. Parag K. Lala, "Digital System Design Using: Programmable Logic Devices", BS Publications, 2003.
7. Samir Palnitkar, "Verilog HDL", Pearson Education, 2nd edition, 2004.
8. J. Bhasker, "A Verilog HDL Primer", Star Galaxy Publishing, 3rd edition, 2005.
9. PLD, FPGA data sheets.

18-437-0202 DIGITAL IMAGE PROCESSING

Course Description: This course deals with digital images and processing of digital images for various applications like Image Representation, Image Enhancement, Image Restoration, Image Compression, Image Segmentation, Morphological Image Processing, Image Recognition & Interpretation

Course Objective

- To understand the basic algorithms of image processing
- To get familiarize with 2D Systems & Transforms
- To familiarise with the image compression techniques
- To understand an overall idea regarding image segmentation, image representation and description.
- To understand the basics of pattern recognition and supervised/unsupervised learning

1. Fundamentals of Digital Image Processing: Image enhancement – Enhancement by Point Processing, Spatial Filtering, Frequency Domain Filtering, Colour Image Processing, Wavelet Transforms - 1D and 2D- fundamentals.

2. Image Restoration: Degradation Models**,** Algebraic approach to Restoration, Inverse Filtering, Wiener Filter, Constrained Least Squares and Interactive Restoration, Restoration in Spatial Domain, Geometric Transformation.

3. Image Compression: Error-Free Compression, Lossy Compression - Lossy Predictive Coding, Transform Coding, Wavelet Coding. Lossless Compression - Variable Length Coding, Arithmetic Coding, Lossless Predictive Coding.Image Compression Standards.

4. Image Segmentation, Representation and Description: Detection of Discontinuities and Boundary, Region Oriented Segmentation, Use of Motion in Segmentation. Representation Schemes; Boundary, Regional and Relational Descriptors.Morphological Operations.

5. Recognition and Interpretation : Pattern Classes, Decision-Theoretic Methods, Structural Methods; Interpretation - Knowledge types, Logical Systems, Semantic Networks, Production Systems, Statistical Pattern, Recognition, Supervised/Unsupervised learning etc.

Reference:

1. Gonzalez, Rafael.C. & Woods, Richard.E.,"Digital Image Processing" - Pearson Education Asia, 1992, 2002
2. Anil K. Jain, " Fundamentals of Digital Image Processing", PHI, 1995.
3. B.Chanda&D.DuttaMajumder, "Digital Image Processing & Analysis" , Prentice Hall of India, 2001
4. S. Jayaraman, S. Esakkirajan & T. Veerakumar," Digital Image Processing", Mcgraw Hill, 2009.

18-437-0205: HARDWARE SOFTWARE CODESIGN

Course Description: This course provides an understanding of interaction between hardware and software in electronic system design. It covers modeling of hardware and software at various levels of abstraction and interfacing between hardware and software components.

Course Objectives

- Transform software programs into cycle-based hardware descriptions.
- Partition and implement software programs into hardware and software components and design interfaces to communicate between them.
- Explain the control-flow and data-flow of a software program and cycle accurate hardware components.

1. Introduction to Hardware Software Codesign: Levels of Abstraction, Driving factors in codesign. Data flow modeling and implementation, Synchronous Data Flow Graphs, Scheduling of Data Flow, dynamic and static schedule. Pipelining, multi-rate expansion.

2. Transformation of software into hardware: Data and control flow of programs, construction of control flow graph. Design of data path and controller. Finite State Machine with Data path, FSMD modeling and implementation, Simulation and Synthesis of FSMD.

3. Design of Custom Architectures: Programming in Gezel. FSMD examples in Gezel, Verilog, VHDL. Limitations of Finite state machines, Microprogrammed architecture: control, encoding, data path. Microprogrammed Interpreters and pipelining. Picoblaze: A contemporary microprogram controller. Embedded Cores for Codesign: Processors, RISC pipeline, Control, data and structural hazards.

4. Program organization: data types, memory hierarchy, program layout, object code, compiled code. System On Chip: Design principles of SoC architecture. Data processing, Communications, Storage and Control of Heterogeneous and Distributed systems. Interfacing for Hardware Software Codesign: on-chip bus systems, bus transfers, bus priority and locking.

5. Synchronization schemes: semaphore, handshake, blocking and non-blocking data transfer. Memory-Mapped Interfaces: Register, Mailbox, FIFO, Shared memory. Coprocessor Interfacing: tight and loose coupling, Fast Simplex Link, Custom instruction interfaces, ASIP Design flow. Coprocessor design for Advanced Encryption Standard (AES): functions of coprocessor, Data and Control design, Programmers model, software design.

References

1. Patrick Schaumont, “A Practical Introduction to Hardware/Software Codesign", Springer, 2nd Edition, 2012.
2. D. D. Gajski, S. Abdi, A. Gerstlauer, G. Schirner, “Embedded System Design: Modeling, Synthesis and Verification”, Springer, 2009.
3. P. Marwedel, “Embedded System Design: Embedded systems foundations of Cyber-Physical Systems, Springer, 2011.
4. Frank Vahid, Tony Givargis, "Embedded System Design: A Unified Hardware/Software Introduction", John Wiley & Sons, 2002.
5. G. De Micheli, R. Ernst, W. Wolf, "Readings in Hardware/Software Codesign", Morgan Kaufman, 2002.
6. J. Staunstrup and Wayne Wolf, “Hardware/Software Co-design: Principles and practice”, Springer, 1997.
7. Wayne Wolf, Computers as Components: Principles of Embedded Computing System Design, Elsevier Publication, 2nd Edition, 2008.

18-437-0207 REAL TIME OPERATING SYSTEMS

Course Description: This course provides an understanding on the various aspects of real time operating systems. It covers methodologies in task scheduling and resource management.

Course Objectives

- Provide an understanding of the factors influencing embedded software.
- Discuss the various scheduling algorithms in an real time operating system
- Study the software development tools and review commercial RTOS.

1. Factors influencing Embedded system design: CPU and memory types, Direct memory access, Interrupt basics, interrupt latency, disabling and masking interrupts, Shared data problems, atomicity, critical section, multi-threaded programming, data race, IEEE POSIX standard for programming, POSIX Threads.

2. Software Architectures for RTOS: Embedded Architecture Types: Round Robin approach, Round-Robin with interrupts, Real Time Operating Systems. Soft and hard real time OS, tasks and task states, scheduler, reentrancy, semaphores, signaling, semaphore problems, POSIX semaphores, mutex locks.

3. Tasks Scheduling: Modeling of real time systems, Event triggered and Time triggered approach, interrupt driven systems, Worst case execution time, pre-emptive priority systems, hybrid systems, task control block model. The scheduling problem, schedulability test, Process scheduling, Fixed priority scheduling – Rate Monotonic approach, Dynamic priority Scheduling- Earliest Deadline First.

4. Communication and resource management: Message queue, mailbox, pipes. Inter-task communication, Blocking and non-blocking task synchronization. Nested interrupts, resource management, deadlock, starvation, pre-emption, priority inversion, priority inheritance, priority ceiling protocol.

5. Embedded software development tools: Host and target machines, cross compilers, Linker, locator, emulators, in-circuit emulators, monitors. Review of free and commercial Real Time Operating Systems- VxWorks, RTlinux, uCOS.

References

1. David E. Simon, An Embedded Software Primer - Pearson Education, 2000.
2. Abraham Silberschatz, Operating Systems Concepts, John Wiley & Sons, 2004.
3. Herman Kopetz, Real-Time systems, Design principles for distributed embedded applications, Springer 2011.
4. Philip A. Laplante, Real- Time Systems Design and Analysis, John Wiley & Sons, 2004.
5. Frank Vahid and Tony Givargis, Embedded System Design: A Unified Hardware/ Software Introduction, John Wiley & Sons, 1999.
6. Wayne Wolf, Computers as Components: Principles of Embedded Computing System Design, Elsevier 2000.
7. VxWorks, https://www.windriver.com/products/vxworks/
8. Micrium uCOS, https://www.micrium.com/rtos/kernels/.
9. Real Time Linux https://rt.wiki.kernel.org/index.php/Main_Page

18-437-0209: ANALOG INTEGRATED CIRCUIT DESIGN

Course Description: This course deals with the small signal and large signal modeling of MOS and BiCMOS circuits with a basic understanding of analog integrated circuit technology. This course also emphasise on the working, analysis and design of various analog MOS circuits.

Course Objectives

- To model and analyse analog MOS circuits.
- To have a basic idea regarding MOS and BiCMOS integrated circuit technology
- To understand the working of current mirrors, active load, voltage and current references.
- To get an insight into nonlinear analog circuits like multipliers, PLL, Function Synthesis etc.

1. Analog MOS Models for Integrated Circuit: Large-Signal Behavior of Metal-Oxide-Semiconductor Field-Effect Transistors, Small-Signal Models of MOS Transistors, Advanced MOS modeling, SPICE modeling parameters, MOS diodes, Active resistors, basics of single stage CMOS amplifiers -common Source, gate and source follower stages-frequency response

2. MOS and BiCMOS Integrated-Circuit Technology: Basic Processes in Integrated-Circuit Fabrication - Electrical Resistivity of Silicon, Solid-State Diffusion, Electrical Properties of Diffused Layers, Epitaxial Growth, Local Oxidation, Polysilicon Deposition, Passive Components in MOS Technology – Resistors and Capacitors in MOS Technology, BiCMOS Technology, Heterojunction Bipolar Transistors, Interconnect Delay, Economics of Integrated Circuit Fabrication - Yield Considerations in Integrated-Circuit Fabrication, Cost Considerations in Integrated-Circuit Fabrication

3. Current Mirrors, Active Loads, and References - Current Mirrors - General Properties, Simple Current Mirror, Simple Current Mirror with Beta Helper, Simple Current Mirror with Degeneration, Cascode Current Mirror, Wilson Current Mirror, **Active Loads** - Common-Emitter–Common-Source Amplifier with Complementary Load, Common-Emitter–Common-Source Amplifier with Depletion Load, Common-Emitter–Common-Source Amplifier with Diode-Connected Load, Differential Pair with Current-Mirror Load, **Voltage and Current References -** Low-Current Biasing, Supply-Insensitive Biasing, Temperature-Insensitive Biasing

4. **Differential Amplifiers**: Single Ended and Differential Operation, Basic Differential Pair, Common-Mode Response, **Frequency Response of Amplifiers**: General Considerations, Common Source Stage, Source Followers, Common Gate Stage, Cascode Stage, Differential Pair. **Noise**: Types of Noise, Representation of Noise in circuits, Noise in single stage amplifiers, Noise in Differential Pairs.

5. Nonlinear Analog Circuits - Analog Multipliers Employing the Bipolar Transistor, The Emitter-Coupled Pair as a Simple Multiplier, The dc Analysis of the Gilbert Multiplier Cell, The Gilbert Cell as an Analog Multiplier, A Complete Analog Multiplier, The Gilbert Multiplier Cell as a Balanced Modulator and Phase Detector, Phase-Locked Loops (PLL), PLL Concepts, The PLL in the Locked Condition, Integrated-Circuit PLL, Nonlinear Function Synthesis.

References

1. Behzad Razavi, "Design of Analog CMOS Integrated Circuits", Tata McGraw Hill, 2nd Edition, 2016.
2. Behzad Razavi, "Fundamentals of Microelectronics", Wiley, 2013.
3. R. Jacob Baker, "CMOS Circuit Design, Layout, and Simulation", Wiley, 3rd Edition, 2010.
4. Paul. R. Gray, Paul J. Hurst, Stephen H. Lewis, Robert G. Meyer, "Analysis and Design of Analog Integrated Circuits" Wiley, Fifth Edition, 2009.
5. Philip Allen & Douglas Holberg, "CMOS Analog Circuit Design", Oxford University Press, 2002.
6. D. A. John and K. Martin, "Analog Integrated Circuit Design", John Wiley, 1997.

18-437-0211 DESIGN VERIFICATION AND TESTING

Course Description: This course deals with the design verification and testing in the VLSI design process. It provides an overview of the various components involved in the process of verification of digital circuits. It also includes the different concepts and techniques in digital system testing for digital circuits.

Course Objectives:
- To differentiate between design verification and testing
- To expose the students to the basic concepts of verification and testing
- To discuss various simulator architectures and introduce the concept of testbench in verification.
- To introduce the concepts algorithm development for automatic test pattern generation for digital circuit.
- To discuss fundamentals of design for testability.

Course content:
1. Introduction - Scope of verification and testing in VLSI design processes, Basic Principle of design verification, Verification methodology, Simulation based verification versus Formal verification

2. Simulator Architectures and Operations – Compilers, Simulators – cycle based, event driven, hybrid, Hardware simulator and emulator, Simulator structures and operations, Incremental compilation

3. Test Bench organization and design – test environment, initialization, clock generation, Stimulus generation, Response assessment, Test plan, Assertions, Verification coverage

4. Fundamentals of VLSI testing – Fault modeling: Logical fault models, Fault detection, fault equivalence and fault dominance; Automatic test pattern generation – ATPG for SSF in combinational circuit, D-Algorithm, Sequential circuit test generation

5. Design for testability – Introduction – controllability and observability, Scan Design, Test interface and boundary scan, Built-in-self- test

References:

1. William K. Lam, *Hardware Design Verification: Simulation and Formal Method-Based Approaches*, Prentice Hall Modern Semiconductor Design Series, 2005.
2. Chris **Spear**, Greg **Tumbush**, *System Verilog for Verification: A Guide to Learning the Test bench Language Features,* Springer 2012.
3. Charles H. Roth Jr "Digital System Design using veriog" Cengage India, 2015.
4. M. L. Bushnell and V.D. Agrawal, *Essentials of Electronic Testing for Digital Memory and Mixed Signal VLSI Circuits*, Springer, 2005.
5. M. Abramovici, M. Breuer, and A. Friedman*, Digital System Testing and Testable Design*, IEEE Press, 1994.
6. Parag K Lala, "Fault Tolerant and Fault Testable Hardware Design", B S Publications, 2003.

18-437-0213 ANTENNA THEORY

Course Description: This is a course on the design and analysis of antenna. This course provides a comprehensive coverage of a wide variety of antennas and propagation topics related to numerous communication systems. This course presents fundamental theory together with techniques for the practical design, measurement and application of antennas over the RF (radio-frequency) to milli-meter wave frequency range.

Course Objectives

- Understand important and fundamental antenna engineering parameters and terminology,
- Learn the basic concepts of electromagnetic wave radiation and reception,
- Develop the basic skills necessary for designing a wide variety of practical antennas and antenna arrays.

1. Overview of Antennas: Types of Antennas and antenna parameters, Diploes, Horn antennas – Sectoral horns – pyramidal horns, – Helical Antennas – Yagi – Uda antenna – Reflector Antennas, Plane reflector – Corner reflector – Parabolic reflector Parabolic cylinder – Cassegrain antennas, Corrugated horn, Reflect array, Frequency independent antennas, Patch antenna.

2. Antenna arrays – Broadside array – end fire array – Array factor, directivity of the array, Non uniform arrays – Binomial array – Chebyscheff array – Planar array — Design procedure

3. Computational Electromagnetics: Different methods; Integral Equation and Moment Method, Point matching method, Basic functions, Application of point matching, Weighing function, Moment method; Finite Difference Time Domain Analysis; Numerical examples

4. Antenna Synthesis: Synthesis principles, Continuous sources, Schelkunoff Polynomial method, Fourier transform method – Woodward method – Taylor Line source method – Triangular, Cosine and Cosine squared amplitude distribution – Line source phase distribution – Continuous aperture sources.

5. Microstrip Antennas and Smart Antennas: Basic characteristics – Feeding techniques – Rectangular and circular patch antennas – Smart Antenna analogy – Cellular radio system evolution – Signal propagation – Antenna beamforming – Mobile Adhoc Networks (MANETs), System design.

References:

1. Constantine A Balanis, Antenna Theory – Analysis and design, Third Edition, John Wiley and Sons, 2005
2. John D Kraus – Antennas, Fourth Edition, Tata McGraw Hill, 2010
3. John L Volakis, Antenna Engineering Hand Book – Fourth Edition, Tata McGraw Hill Companies, 2007

18-437-0215 RADAR SYSTEMS

Course Description: The main objective of this course is to introduce the students to the basic concepts in the field of Radar communication .The students will gain knowledge on the different types of Radar Systems, different types of navigational aids used and the basic design of radar transmitter and receiver.

Course Objectives

- Learn about fundamentals of Radar
- Understand different types of radar and their working
- Study of Radar signal detection techniques
- Study of Radar navigation techniques

1. Radar fundamentals and operation: Introduction, principles, types of radar, transmitter functions, wave form spectra, receiver functions, signal processing, Radar equation, Radar cross section.
2. Radar Systems: Pulse, CW, FM-CW, MTI, Doppler Radar, Tracking Radar: Tracking system parameters, Conical Scan, amplitude comparison and phase comparison monopulse, Range and velocity tracking, Tracking accuracy.
3. Detection of Radar Signals and information extraction and estimation: Detection introduction, threshold detection, Signal integration, Binary integrators, CFAR, Theoretical accuracy of radar measurements, ambiguity function and radar waveform design, correlation detection and matched filter receiver.
4. Radar signal processing: Signal integration, spectrum analysis, windows and resolution, MTI principles and methods, De staggering and processing, Moving Radars and moving clutter, Doppler processing.
5. Radar Applications: Direction finders, instrument landing systems, Radar beacons, Electronic Warfare, ECM and ECCM, high resolution radar, range and Doppler resolution, Pulse compression (analog and digital), Synthetic aperture radar.

References:

1. Skolnik M.M., "Introduction to Radar systems", McGraw Hill, (Second Edition) 1981.
2. Byron Edde. 'Radar: principles, technology and applications", Pearson Education Inc., 1995.
3. D.CurtisScheleher, "Introduction to Electronic Warfare", Artech House Inc., 1986.
4. Wheeler G.J., "Radar Fundamentals", Prentice Hall Inc. NJ 1967.
5. LavanonNadav, "Radar Principles" john Wiley & Sons, 1988.

18-437-0217 MACHINE LEARNING

Course Description: This course provides a broad introduction to machine learning and how to apply learning algorithms.

Course Objectives

- To understand the basics of machine learning
- To familiarize with regression, classification and optimization problems
- To provide an idea about the NN Learning and SVM
- To familiarize with factors to keep in mind while systems design

1. Introduction: Introduction to learning, Supervised Learning, Unsupervised Learning, Reinforcement Learning. Linear Regression with One Variable - idea of cost function, and gradient descent method for learning, Linear Regression with Multiple Variables- Multiple Features, Gradient Descent for Multiple Variables, Feature Scaling, Learning Rate, Normal Equation Noninvertibility, Features and Polynomial Regression, Logistic Regression- classification, hypothesis representation, decision boundary, cost function, optimization, multiclass classification.

2. Neural Network learning and SVM: Non-linear hypotheses, model representation, multiclass classification. Learning-cost function, back propagation algorithm, unrolling parameters, gradient checking, random initialization. **SVM:** introduction, optimization objective, large margin classification, kernels

3. Unsupervised Learning: Introduction, k-means algorithm, optimization, random initialization, clustering. **Dimensionality Reduction**: Data compression, visualization, principal component analysis algorithm, reconstruction from compressed representation.

4. Anomaly Detection and Recommender Systems: Gaussian distribution, algorithm for anomaly detection, feature choosing, multivariate Gaussian distribution, Anomaly Detection using the Multivariate Gaussian Distribution. **Recommender Systems:** content based recommendations, collaborative filtering algorithm, vectorization and normalizations.

5. Large Scale ML and ML System Design: Learning with large datasets, stochastic gradient descent, mini-batch gradient descent, stochastic gradient descent convergence, online learning, map reduce and data parallelism. **System Design:** performance of a machine learning system, prioritizing, error analysis, error matrix for skewed classes, trading off precision and recall, data for machine learning. Evaluating a Hypothesis, Model Selection and Train/Validation/Test Sets, Diagnosing Bias vs. Variance, Regularization and Bias/Variance, Learning Curves.

REFERENCES:

1. Stuart J. Russell, "Artificial Intelligence 3e: A Modern Approach", Pearson Education India; 3rd edition 2015
2. Shai Shalev Shwartz, Shai Ben David, "Understanding Machine Learning: From Theory to Algorithms", Cambridge University Press, 2014
3. Ethem_Alpaydin, “Introduction to Machine Learning”, Second Edition, MIT Press, 2010
4. Tom_Mitchell, “Machine_Learning”, McGraw-Hill 1997
5. R.S.Michalski, J.G.Carbonell, T.M.Mitchell, “An Artificial Intelligence Approach”, Springer-Verlag, 1984
6. Mehryar Mohri, Afshin Rostamizadeh and Ameet Talwalkar, "Foundations of Machine Learning", MIT Press, 2012
7. Kevin Murphy, “Machine learning: a Probabilistic Perspective”, MIT Press, 2012.

18-437-0219 MOBILE ROBOTICS

Course Description: This course discusses robots who are mobile and communicate real time sensor data. It will discuss how these robots will make decisions for navigation using input from surroundings.

Course Objectives

- Movement and communication of mobile robots.
- Localization, navigation and control of mobile robots.

1. Mobile Robots: Introduction to Wheeled Robots, Classification of wheels, Fixed wheel, Centered Oriented Wheel, Off-centered oriented wheel, Swedish wheel, Mobile robot locomotion, Differential Wheel, Tricycle, Synchronous drive, Omni-directional, Ackerman Steering, Kinematics models of WMR.
2. Mobile Robot Kinematics: Kinematic Models and Constraints: Representing robot position, Forward kinematic models, Wheel kinematic constraints, Robot kinematic constraints. Mobile Robot Maneuverability: Degree of mobility, Degree of steerability, Robot maneuverability. Mobile Robot Workspace: Degrees of freedom, Holonomic robots, Path and trajectory considerations, Beyond Basic Kinematics, Motion Control (Kinematic Control): Open loop control (trajectory-following), Feedback control.
3. Perception: Sensors for Mobile Robots: Sensor classification, Characterizing sensor performance, Wheel/motor sensors, Heading sensors, Ground-based beacons, Active ranging, Motion/speed sensors, Vision-based sensors. Representing Uncertainty: Statistical representation, Error propagation: combining uncertain measurements, Feature Extraction: Feature extraction based on range data (laser, ultrasonic, vision-based ranging), Visual appearance based feature extraction.
4. Mobile Robot Localization: Introduction, Localization: Noise, Aliasing, Localization-Based Navigation, Programmed Solutions, Belief Representation, Map Representation: Continuous representations, Decomposition strategies, Challenges in map representation. Probabilistic Map-Based Localization: Markov localization, Kalman filter localization, Landmark-based navigation, Positioning beacon systems, Route-based localization, Autonomous Map Building, The stochastic map technique.
5. Planning and Navigation: Introduction, Competences for Navigation: Planning and Reacting: Path planning, Obstacle avoidance, Navigation Architectures: Modularity for code reuse and sharing, Control localization, Techniques for decomposition, Introduction to IoT. Case studies: ESP32 based Mobile Robot.

References

1. Siegwart, Roland, Illah Reza Nourbakhsh, and DavideScaramuzza. “Introduction to autonomous mobile robots “,MIT press, 2011.
2. H.R.Everett, “Sensors for Mobile Robots – Theory and Applications”, A.K.Peteres Ltd. ISBN 1-56881- 048-2. 1995.
3. Siegwart, Roland, Illah Reza Nourbakhsh, and DavideScaramuzza. “Introduction to autonomous mobile robots”. MIT press, 2011.
4. Kurfess, Thomas R., ed.“Robotics and automation handbook”. CRC press, 2004.
5. David Poole, Alan Mackworth “Artificial Intelligence: Foundations of Computational Agents”, Cambridge University Press, 2010.
6. “Where am I? Sensors and Methods for Mobile Robot Positioning”, J. Borenstein, et al., The University of Michigan, 1996.
7. Janakiraman P.A, “Robotics and Image Processing”, Tata McGraw-Hill, 1995.
8. Siciliano, Bruno, and OussamaKhatib, eds. “Springer handbook of robotics”. Springer, 2016.

18-437-0221 BROADBAND COMMUNICATION

Course Description: This course introduces cutting-edge technologies for broadband communication systems and to understand how ATM will interoperate with existing protocols and technologies to make networked multimedia a reality.

Course Objectives

- Discuss existing network architectures
- Discuss broadband over different technologies
- Discuss cable TV network architecture

1. Introduction: Network Architectures – Telephone Network – Internet and Intranets – Limitations of today's Network Infrastructure. Classification of Applications.Traffic Requirements and QoS Requirements.

2. Principle of ATM Network: Switched Point to Point Architecture, Packet Switching, Fast Packet Switching, Advantages of BISDN Technical & Strategic. Overview of BISDN – Basic Elements of BISDN Networks, Network Operations, Virtual Channel and Virtual Path. Traffic Management:

3. Residential Broadband Services: Connectivity and Functional Requirements. Residential Broadband Service Architecture – Residential Access Networks, CO and Headend Networks, Broadband Internet Access, In-Home Network and End-to-end Protocol/ model.

4. Broadband Over xDSL: Network Architecture – Subscriber Loop Architecture, xDSLcharacteristicsk, xDSL Technologies, HDSL, ADSL, SDSL and VDSL. ADSL based broadband service architecture – ADSL based ATM-to-the-Home Architecture – DSLAM and Broadband Internet.

5. Hybrid Fibre/ Coax Network Architecture: Legacy Cable Network Architecture – Hybrid Fibre Coax Network Architecture – Fibre Nodes – Residential Broadband Architecture – end-to-end Protocol Architecture.

References:

1. Kswok, Timothy, "ATM – The Paradigm for Internet, Intranet & Residential Broadband Services & Applications", Prentice Hall PTR, New Jersey (1998)
2. Sumit Kasera and Pankaj Sethi, "ATM Networks: Concepts and Protocols" Tata McGraw – Hill Publishing Company Limited, New Delhi (2001)
3. Introduction to Broadband Communication systems, Cajetan M. Akujuobi, Matthew N.O. Sadiku, CRC press, 2007.
4. Leon Gracia and Widjaja, "Communication Networks", Tata McGraw Hill, 2008.
5. Jean Warland and Pravin Varaiya, "High Performance Communication Networks", 2nd Edition, Harcourt and Morgan Kanffman Publishers, London, 2008

18-437-0222 SPECTRUM ANALYSIS

Course Description: This course introduces cutting-edge technologies for broadband communication systems and to understand how ATM will interoperate with existing protocols and technologies to make networked multimedia a reality.

Course Objectives

- Discuss spectral density and its properties.
- Study of algorithms used in spectrum analysis.
- Study the filtering techniques for spectrum analysis.

1. Power Spectral Density: Energy spectral density of deterministic signals, Power spectral density of random signals, Properties of PSD

2. PSD Estimation -Non-parametric methods. Estimation of PSD from finite data, Non-parametric methods: Periodogram properties, bias and variance analysis, Blackman-Tuckey method, Window design considerations, time-bandwidth product and resolution-variance trade-offs in window design, Refined periodogram methods :Bartlet method, Welch method.

3. Parametric method for rational spectra:- Covariance structure of ARMA process, AR signals, Yule- Walker method, Least square method, Levinson-Durbin Algorithm, MA signals, Modified Yule-Walker method, Two-stage least square method, Burg method for AR parameter estimation.

4. Parametric method for line spectra:- Models of sinusoidal signals in noise, Non-linear least squares method, Higher order Yule-Walker method, MUSIC and Pisayenko methods, Min-norm method, ESPIRIT method.

5. Filter bank methods: Filter bank interpretation of periodogram, Slepia base-band filters, refined filter bank method for higher resolution spectral analysis, Capon method, Introduction to higher order spectra.

References

1. Steven M. Kay, "Modern Spectral Estimation Theory & Application", Prentice-Hall Publishers, Englewood Cliffs, New Jersey USA, (1999).
2. Julius S. Bendat and Allan G. Piersol ,"Engineering Application of Correlation and Spectral Analysis", John Wiley & Sons, Inc. ,New York (1993)
3. William A. Gardner ,"Statistical Spectral Analysis", Prentice Hall Inc., New Jersey(1988)
4. Steven M .Kay and Stanley Lawrence Marple Jr., " Spectrum Analysis – A Modern Perspective", Proceedings of the IEEE , 69(11), pp.1380-1419,(1981)

18-437-0223 ADAPTIVE SIGNAL PROCESSING

Course Description: A beginner course in adaptive signal processing intended to be taught to intermediate degree qualified students. The course is aimed at providing a basic idea of adaptation that is employed in numerous adaptive systems across various domains.

Course Objective

- To introduce the practical aspect of Adaptive Signal Processing in different adaptive systems.
- Adaptive systems in the fields of communications, radar, sonar, seismology, navigation systems and biomedical engineering explored in brief.
- This course will present the basic principles of adaptation in system perspective.
- The course will cover various adaptive signal processing algorithms (e.g., the LMS algorithm) and many applications, such as adaptive noise cancellation, interference canceling, system identification, etc.

1. Introduction : Adaptive Systems - Definition and Characteristics - Open-and Closed-Loop Adaptation - Adaptive Linear Combiner - Input Signal and Weight Vectors - Desired Response and Error - Performance Function

2. Theory of Adaptation - Properties of the Quadratic Performance Surface - Normal Form of the Input Correlation Matrix - Eigenvalues and Eigenvectors of the Input - Correlation Matrix - Geometrical Significance of Eigenvectors and Eigenvalues

3. Performance Surface - Methods of Searching the Performance Surface - Basic Ideas of Gradient Search Methods - simple Gradient Search Algorithm - Gradient Estimation and its Effects on Adaptation - Gradient Component Estimation by Derivative Measurement - Derivative Measurement and Performance Penalties with Multiple Weights

4. Adaptive Algorithms - The LMS Algorithm - Derivation of the LMS Algorithm - Convergence of the Weight Vector - An Example of Convergence - Learning Curve Noise in the weight-Vector Solution.

5. Applications: Adaptive Modeling and System Identification - Adaptive Modeling of a Multipath Communication Channel. Inverse Adaptive Modeling Deconvolution and Equalization - General Description of Inverse Modeling- Adaptive Equalization of Telephone Channels - The Concept of Adaptive Noise Canceling - Stationary Noise-Canceling Solutions, Filtered-X LMS Algorithm - Adaptive Arrays - Sidelobe Cancellation - Beam forming with a Pilot Signal- Spatial Configurations, Adaptive Algorithms

References:

1. Bernad, Widrow, Stearns, .S.D, “Adaptive Signal Processing”. Prentice Hall, 2009.
2. TülayAdali, Simon Haykin, “Adaptive Signal Processing: Next Generation Solutions”, John Wiley & Sons, 2010
3. Ali H. Sayed, “Fundamentals of Adaptive Filtering”, John Wiley & Sons, 2003
4. John R. Treichler, C. Richard Johnson, Michael G. Larimore, “Theory and design of adaptive filters”, Wiley, 1987
5. Dimitris G. Manolakis, Vinay K. Ingle, Stephen M. Kogon, “Statistical and adaptive signal processing: spectral estimation, signal modeling, adaptive filtering, and array processing” McGraw-Hill, 2000
6. Jacob Benesty, Yiteng Huang, “Adaptive Signal Processing: Applications to Real-World Problems” Springer.

18-437-0224 UNDERWATER COMMUNICATION

Course Description: This course provides an outline about sonar systems, its types and their applications. The course will provide overview of signal processing and filtering options for output received from sonar systems and acoustic modems. It will discuss acoustic modems and underwater sensor networks.

Course Objectives

- Discuss the transducers and array systems used for sonar.
- Classification of sonar systems and modern versions.
- Signal processing, filtering and noise impact on sonar systems.

1. Types of sonar systems : active and passive - sonar equations - propagation characteristics of the medium - transmission loss and spreading effects - beam forming and steering - detection threshold - square law detector - cross-correlation detector. **Ambient noise :** sources of ambient noise - shallow water ambient noise - effect of depth- directional characteristics of deep water ambient noise - electrical noise, machinery noise, flow noise, propeller noise, self-noise and radiated noise.
2. Correlation receivers and matched filters: Advanced Sonar Signal Processing functions – adaptive beam forming - synthetic aperture arrays - automated decision making.
3. Orthogonal Frequency division multiplexing: Key features, characteristics and principle of operation of OFDM, Channel coding and interleaving System model, Enhancement of spectral efficiencies, Transmission/ Reception of OFTD - OFDM Simulations.
4. Acoustic Modem: Underwater Wireless Modem- Sweep spread carrier signal-transmission characteristics in shallow water channel-separation of time varying multipath arrivals-Typical acoustics modems-characteristics and specifications- Applications, Acoustic Releases-Real time wireless current monitoring system.
5. Underwater Sensor Network: Underwater Networking- Ocean Sampling Networks, Pollution Monitoring, Environmental Monitoring and Tactical surveillance systems, Major challenges in design of Underwater Sensor Networks, Factors that affect the UWSN- Sensor Node Architecture- GIBS, VRAP, DABSRAPT. etc.

References:

1. ‘Principles of Underwater Sound’ Robert J. Urick, McGraw Hill Book Company, New York (1975) Chapters: 2,3,4,5,6,7,9 and 10.
2. SONAR for Practicing Engineers, A.D. Waite John, Wiley & Sons, Ltd.,(1998).
3. Digital Spectral Analysis with applications- S. Lawrence Marple Jr. Prentice Hall. Signal Processing Series, 1987.
4. Alan. V. Oppenhein (Ed), Applications of Digital Signal Processing, Prentice Hall, Inc., Engliwood Cliffs, NJ 07632,978.
5. Andreas Antoniou, “Digital Filters, Analysis, Design & Applications”, Tata Mcgraw-Hill, 1999.
6. Richard A. Haddad and Thomas W Parsons, “Digital Signal Processing: Theory Applications and Hardware”, Computer Science Press, 1991.
7. ‘Real time Deepwater Current Profiling Systems’, Michael Uogel, etal, Marine Technology Symposium.
8. ‘Underwater Acoustics Sensor Network: Research Challenges: Ian F Akyildizetal, Elsevier, 3 (2005), pp 257-279.
9. ‘Data Collection, Storage and Retrieval with an Underwater Sensor Network, Vasilescu, etal, Sensys’ 05, Nov. 2-4, 2005, San Diego, CA.

18-437-0225 SPREAD SPECTRUM COMMUNICATION

Course Description: This course introduces students to the basic concepts of spread spectrum communications, its major applications and techniques for analyzing these systems. In particular, the course will review these concepts and emphasize the various trade-offs in the design of such systems. Students will learn to simulate spread spectrum systems in order to understand the principles upon which they are based.

Course Objectives

- To learn the principles of spread spectrum systems, including CDMA systems.
- To learn principles of finite fields, orthogonal codes & pseudorandom noise sequences.
- To understand and use generator functions to generate pseudorandom codes
- Analyze the performance and design of spread-spectrum communication systems.
- To understand the concepts of code synchronization and interference suppression.
- Examine the use of code-division multiple access in digital cellular systems.

1. Fundamentals of Spread Spectrum : Introduction to spread spectrum communication, pulse noise jamming, low probability of detection, direct sequence spread spectrum, frequency-hopping and time-hopping spread spectrum systems, correlation functions, spreading sequences-maximal-length sequences, gold codes, Walsh orthogonal codes-properties and generation of sequences , Synchronization and Tracking: delay lock and tau-dither loops, coarse synchronization- principles of serial search and match filter techniques.

2. Performance Analysis of SS system : Performance of spread spectrum system under AWGN, multi-user Interference, jamming and narrowband interferences, Low probability of intercept methods, optimum intercept receiver for direct sequence spread spectrum, Error probability of DS-CDMA system under AWGN and fading channels, RAKE receiver

3. Capacity, Coverage and Control of Spread Spectrum Multiple Access Networks . Basics of spread spectrum multiple access in cellular environments, reverse Link power control, multiple cell pilot tracking, soft and hard handoffs, cell coverage issues with hard and soft hand off, spread spectrum multiple access outage, outage with imperfect power control, Erlang capacity off or ward and reverse links.

4. Multi-user Detection-MF detector, decorrelating detector, MMSE detector. Interference Cancellation: successive, Parallel Interference Cancellation, performance analysis of multiuser detectors and interference cancellers.

5. CDMA Systems General aspects of CDMA cellular systems, IS-95 standard, Downlink and uplink, Evolution to Third Generation systems, WCDMA and CDMA-2000 standards, Principles of Multicarrier communication, MC- CDMA and MC-DS-CDMA.

References

1. R.L.Peterson,R.Ziemer and D.Borth,“Introduction to Spread Spectrum Communications,” Prentice Hall, 1995.
2. A.J. Viterbi,“CDMA- Principlesof Spread Spectrum Communications,” Addison-Wesley, 1997.
3. Vijay K. Garg, Kenneth Smolik, Joseph E. Wilkes, Applications of CDMA Wireless/ Personal Communications, Prentice Hall, 1995
4. S.Verdu, “Multiuser Detection” , Cambridge University Press-1998
5. M.K.Simon, J.K. Omura, R.A. Scholts and B.K.Levitt,“Spread Spectrum Communications Handbook”, McGraw- Hill, Newyork-1994
6. Cooper and McGillem, “Modern Communications and Spread Spectrum” TMH 1985
7. J. G. Proakis, “Digital Communications,” McGrawHill, 4th edition.
8. S.Glisic and B.Vucetic, “Spread Spectrum CDMA Systems for Wireless Communications,” Artech House, 1997.

18-437-0227 RF MEMS

Course Description: A beginner course in RF MEMS intended to be taught to intermediate degree qualified students. The course is designed to familiarize the student with the functions and applications of RF MEMS along with various design of different RF MEMS structures.

Course Objectives

- The course is designed to familiarize the student with the functions and applications of RF MEMS and other associated devices
- To familiarize with the application of RF MEMS in different fields
- To Understand the basic and complex design issues involved in RF MEMS
- Familiarize with the different type of structures used in RF MEMS such as beams, mirrors, cantilevers, comb drives, patches, coplanar waveguide etc.
- Basically, understand the concept of micromachining

1. RF MEMS relays and switches. Switch parameters. Actuation mechanisms.Bistable relays and micro actuators. Dynamics of switching operation.

2. MEMS inductors and capacitors. Micromachined inductor.Effect of inductor layout. Modeling and design issues of planar inductor. Gap tuning and area tuning capacitors.Dielectric tunable capacitors.

3. Micromachined RF filters. Modeling of mechanical filters.Electrostatic comb drive. Micromechanical filters using comb drives. Electrostatic coupled beam structures.

4. MEMS phase shifters. Types.Limitations. Switched delay lines. Micromachined transmission lines.Coplanar lines.Micromachined directional coupler and mixer.

5. Micromachined antennas.Microstrip antennas – design parameters. Micromachining to improve performance. Reconfigurable antennas.

References

1. H.J.D.Santos, RF MEMS Circuit Design for Wireless Communications, Artech House ,2002.
2. G.M.Rebeiz , RF MEMS Theory , Design and Technology, wiley , 2003.
3. Stephen D Senturia, “Microsystem Design”, Kluwer Academic Publishers, 2001.
4. Marc Madou, “Fundamentals of Microfabrication”, CRC Press, 1997.
5. V.K.Varadan, K.J Vinoy & K.A. Jose, RF MEMS and their Applications, Wiley,2003.
6. Gregory Kovacs, “Micromechanised Transducers Source Book”, WCB McGraw Hill, Boston, 1998.
7. M H Bao, “Micromechanical Transducers, Pressure Sensors, Accelerometers and Gyroscopes” Elsevier, Newyork, 2000.