MTech (ESD) Semester I Courses

EC501T	**Mathematical Foundations of ESD**	**PEC**	**3 – 0 – 3**	**3 Credits**

This course will cover aspects of mathematics relevant to the design and analysis of electronic systems, communication networks/systems, real time systems, and cyber physical systems.

Objective: This course's objective is to provide a good understanding in the time complexity analysis of any arithmetic operation, Galois filed theory of any crypto operation, finding the shortest path in the computer networks, estimation theory, linear programming, and multivariate analysis.

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

CO1	Formulate and find optimal solution in the real life optimizing/allocation/assignment problems involving conditions and resource constraints.
CO2	Simulate appropriate application/distribution problems.
CO3	Obtain the value of the point estimators using the method of moments and method of maximum likelihood.
CO4	Apply the concept of various test statistics used in hypothesis testing for mean and variances of large and small samples.
CO5	Get exposure to the principal component analysis of random vectors and matrices.
CO6	Apply Graph Theory algorithms in networks.
CO7	Analyse the time complexity of the operation of the digital circuits.
CO8	Apply Galois Field theory in the cryptography applications.

Pre-requisite Courses: Random Process and Probability Theory, Discrete Mathematics

Theory Class Hours: 3 hours per week

Detailed Syllabus:

COMPLEXITY ANALYSIS: Introduction to time complexity of an algorithm or operation (worst case, average case, and best case), SAT problems, NP hard and NP complete problems.

ABSTRACT ALGEBRA: Introduction to Group, Ring, and Fields, Prime/Polynomial field representation, Irreducible polynomial, primitive polynomial, minimal polynomial, Galois field (GF) addition, GF multiplication, GF exponentiation, and GF multiplicative inverse.

GRAPH ALGORITHMS: Graphs – Sub graphs – Complements – Graph isomorphism – Eulerian graphs –Hamiltonian graphs - Planar graphs– Kruskal's algorithm – Dijkstra's shortest path algorithm, Prims algorithm– Transport Networks.

SPECIAL FUNCTIONS: Bessel's equation – Bessel function – Recurrence relations - Generating function and orthogonal property for Bessel functions of first kind – Fourier-Bessel expansion.

LINEAR PROGRAMMING: Formulation – Graphical solution – Simplex method – Two phase method –Transportation and Assignment Problems.

SIMULATION: Discrete Event Simulation – Monte – Carlo Simulation – Stochastic Simulation – Applications to real time problems.

ESTIMATION THEORY: Estimators: Unbiasedness, Consistency, Efficiency and Sufficiency – Maximum Likelihood Estimation – Method of moments.

MULTIVARIATE ANALYSIS: Random vectors and Matrices – Mean vectors and Covariance matrices – Multivariate Normal density and its properties – Principal components: Population principal components – Principal components from standardized variables.

Evaluation Process: The end-sem exam will have at least 50% of weightage. The remaining weightage comprises minor-1, minor-2, and projects (or assignments).

References:

(1) 1. Jay L. Devore, “Probability and Statistics for Engineering and the Sciences”, Cengage Learning, 9th Edition, Boston, 2016.

(2) Johnson, R.A, Irwin Miller and John Freund., “Miller and Freund’s Probability and Statistics for Engineers”, Pearson Education, 9th Edition, New York, 2016.

(3) Johnson, R.A., and Wichern, D.W., “Applied Multivariate Statistical Analysis”, Pearson Education, Sixth Edition, New Delhi, 2013.

(4) Ross. S.M., “Probability Models for Computer Science”, Academic Press, SanDiego, 2002.

(5) Taha H.A. “Operations Research: An Introduction”, Prentice Hall of India Pvt. Ltd. 10th Edition, New Delhi, 2017.

(6) Winston, W.L., “Operations Research”, Thomson – Brooks/Cole, Fourth Edition, Belmont, 2003.

(7) Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein, “Introduction to Algorithms”, MIT Press, 2009.

(8) Ralph P. Grimaldi, "Discrete and combinatorial Mathematics", Pearson Education, 5th Edition, New Jersey, 2004.

(9) Erwin Kreyszig. “Advanced Engineering Mathematics”, John Wiley & Sons, 10th Edition, New York, 2010.

DES501T	Product Design and Development	PEC	3 – 0 – 3	3 Credits

Course Aim	1. The course comprises theoretical sessions that are supplemented with practice sessions. 2. The students will be given an overview of systematic approach used during product design and development. 3. The course will highlight the methods for need identification, techniques for creative thinking, concept generation, concept selection, product architecture, aesthetics, ergonomics etc. 4. The students will realize the design through models of using suitable materials
Course Outcomes	1. The students will be able to understand the need of a customer and use the creative thinking to conceptualize designs. 2. The students will also be able to quickly visualize the concepts using models.
Contents of the course	Introduction: Importance of engineering design, types of design, total life cycle- types of products, Phases of product development process, product and process cycles. (4) Problem Definition & Need Identification: Identifying customer needs, gathering information classifying customer requirements, engineering characteristics, competitive benchmarking, QFD, product design specification. (6) Conceptual Design: Creativity in design, creativity and problem solving, creative thinking methods, conceptual decomposition morphological methods-TRIZ and contradiction, Bio and Shape mimicry techniques, Decision making and concept selection-decision theories-concept screening and scoring. (8) Embodiment Design: Product architecture, steps in developing product architecture, industrial design human factors design, Nostalgia and Design, Environment factors. (8) Design Profile Preparation (2)
Textbooks	1. K. Otto, Product Design, Pearson Education, 1st edition, 2011, ISBN: 8177588214. 2. U. Karl and S. Eppinger, Product Design and Development, McGraw-Hill Education, 6th edition, 2015, ISBN: 0078029066.
References	1. C. A. Harper, Handbook of Materials for Product Design, McGraw-Hill Professional, 1st edition, 2001, ISBN: 0071354069. 2. R. Stuer and K. Eissen, Sketching: Drawing Techniques for Product Designers, Thames & Hudson, 1st edition, 2007, ISBN: 9063691718.

	3. B. Hallgrimsson, Prototyping and Modelmaking for Product Design, Laurence King Publishing, 1st edition, 2012, ISBN: 9781856698764

DES501P	**Product Design and Development Practice**	**PEC**	**0 – 3 – 2**	**2 Credits**

Course Aim	1. The course comprises theoretical sessions that are supplemented with practice sessions. 2. The students will be given an overview of systematic approach used during product design and development. 3. The course will highlight the methods for need identification, techniques for creative thinking, concept generation, concept selection, product architecture, aesthetics, ergonomics etc. 4. The students will realize the design through models of using suitable materials
Course Outcomes	1. The students will be able to understand the need of a customer and use the creative thinking to conceptualize designs. 2. The students will also be able to quickly visualize the concepts using models.
Contents of the course	Method of Expressing and communicating and documenting technical ideas through sketches (1) Clay, Foam, Wood modelling and modern 3D printing (2) Problem Definition and Need Identification (1) Conceptual design: Morphological charts, TRIZ and Contradiction, Bio and Shape mimicry, Concept selection, Screening (5) Embodiment Design: Product Architecture, Human Factors, Aesthetics, Nostalgia and Environmental factors (4) Design Profile presentation
Textbooks	1. K. Otto, Product Design, Pearson Education, 1st edition, 2011, ISBN: 8177588214. 2. U. Karl and S. Eppinger, Product Design and Development, McGraw-Hill Education, 6th edition, 2015, ISBN: 0078029066.
References	1. C. A. Harper, Handbook of Materials for Product Design, McGraw-Hill Professional, 1st edition, 2001, ISBN: 0071354069. 2. R. Stuer and K. Eissen, Sketching: Drawing Techniques for Product Designers, Thames & Hudson, 1st edition, 2007, ISBN: 9063691718. 3. B. Hallgrimsson, Prototyping and Modelmaking for Product Design, Laurence King Publishing, 1st edition, 2012, ISBN: 9781856698764

EC502T	**Digital VLSI System Design**	**PEC**	**3– 3 – 0**	**3 Credits**

This course is to provide a good understanding in the analysis and design of RTL and CMOS logic circuits. It gives the importance of physical design and essentials of high speed logic circuits. It provides a system level perspective to the students in designing complex VLSI circuits.

Course Aim: The aim of this course is to introduce architecture and design concepts underlying the modern complex VLSI circuits/systems.

Prerequisite Courses: Digital Logic Design and Basic VLSI Design.

Theory Class Hours: 3 hours per week

Course Outcomes: At the end of the course the students will be able to:

CO1	Design digital system using HDL and CMOS transistors.
CO2	Analyse the circuit/system performance, area, and power dissipation.
CO3	Implement the low power and high throughput techniques on digital integrated circuits.
CO4	Develop the Custom IPs to integrate into Digital Systems using FPGA

Detailed syllabus

1. Introduction to Digital design: timing issues, pipelining, folding/unfolding, resource sharing, metastability, synchronization, clock skew, setup/hold time of flip-flops, synchronization between multiple clock domains using FIFO, PLL, and DLL, reset – recovery/removal time, false path. (5 hours)

2. Digital Systems Design with ASICs: PLDs, Semi/full custom ASIC designs, Emphasis on the synthesis based approach to VLSI Design. Relevant issues related to physical design automation such as partitioning, floor planning, power planning, placement & routing, Algorithms for VLSI Physical Design, IO pads, electro static discharge. (5 hours)

3. Digital Systems Design with FPGAs : Hardware-Software Co-design, Custom IP Development, High level synthesis (HLS), Efficient Coding Techniques in High Level Language for HLS. (3 hours)

4. Hardware Verification and Testing : Equivalence/model check based formal hardware verification, Binary decision/moment diagram, flexible/vector hardware designs, VLSI testing, logical fault models, fault equivalence, fault dominance, fault collapsing, double/triple modular redundancy, fault simulation, test pattern generation, Built-in-self test, Scan chain based test, fault tolerant designs. (7 hours)

5. CMOS Transistor Logic: I-V characteristics, Short channel effects, Mobility degradation & velocity saturation, channel length modulation, body effect, drain induced barrier lowering, leakage, RC delay model, logical effort, clock gating, dynamic voltage scaling, power gating, glitch free circuits, dual-edge triggering, static CMOS, ratioed circuits,

dynamic CMOS, domino logic, pass transistor logic, CMOS latches, CMOS flipflops, dual edge triggered flipflops, synchronizers, arbiters, wave pipelining. (15 hours)

6. Memory Designs: SRAM, DRAM, ROM, PROM, EPROM, EEPROM, Flash, CAM (5 hours)

Evaluation Process: The end-sem exam will have at least 50% of weightage. The remaining weightage comprises minor-1, minor-2, and projects (or assignments).

References

[1] Wakerly, J. F., Digital Design: Principles and Practices, 4th Edition, Pearson, 2008

[2] Miron Abramovici, Melvin A Breuer, and Arthur D Friedman: Digital Systems Testing and Testable Designs, Wiley-IEEE Press, 1994.

[3] N. A. Sherwani, Algorithms for VLSI Physical Design Automation, Bsp Books Pvt. Ltd., 3rd edition, 2005.

[4] Neil H.E. Westte and David Money Harris: CMOS VLSI Design : A Circuits and Systems Perspective, Addison Wesley, 4th Edn, 2011.

[5] Samir Palnitkar: Verilog HDL - Guide to Digital design and synthesis, Pearson Education, 3rd Edn, 2003.

EC502P	Digital VLSI System Design Practice	PEC	0 – 3 – 2	2 Credits

This course is to provide skills to the design of digital circuits using RTL and CMOS logic circuits. It gives the importance of physical design and essentials of high speed logic circuits. It provides a system level perspective to the students in designing complex VLSI circuits.

Course Aim: The lab course is intended to give exposure to the design of different functional components of digital integrated circuits using FPGA development boards and VLSI CAD tools respectively.

Prerequisite Courses: Digital Logic Design and Basic VLSI Design.

Lab Practice Hours: 3 hours per week

Course Outcomes: At the end of the course the students will be able to :

CO1	Design the RTL based digital circuits using HDL.
CO2	Develop the hardware-software co-design using FPGA.
CO3	Develop the custom IP using RTL design and/or high level synthesis with FPGA
CO4	Design the digital system with low power and high throughput VLSI techniques
CO5	Implement the fault tolerant hardware design and formal hardware verification using HDL
CO6	Design the digital circuits using CMOS transistor logic

Detailed syllabus

Introduction to RTL Design: Basic combinational (half adder, full adder, multiplexer, decoder, and so on) and sequential circuits design (Flip-flops and counters) using HDL.

Familiarity of Datapath elements: 32-bit Ripple carry adder, recursive doubling based carry look ahead adder, Braun multiplier, Wallace tree multiplier, non restoring based division, IEEE-754 floating point adder/Subtractor/multiplier/divider, CORDIC, modular multiplier, modular multiplicative inverse, modular exponentiator, cross-bar switch, Banyan switch, Batcher switch, digital FIR filter.

Advanced VLSI circuit design concepts: Pipelining, clock gating to reduce the switching power dissipation, hardware reuse strategy (folded hardware) to reduce the area, fault tolerant digital circuit design, formal hardware verification using equivalence check, high level synthesis, and performance analysis of RTL design & high level synthesis based digital system.

Hardware-Software Co-design: Design flow of hardware-software co-design using FPGA evaluation board, Custom IP design (arithmetic circuits as mentioned above), hardware-software partitioning, and performance analysis of various hardware-software co-design techniques.

Digital Circuits Design using CMOS: logic gates, combinational logic circuits, low power CMOS circuits using VLSI CAD tool.

Project Work (Individual) : Basic 32-bit Processor Design (Harvard Architecture with Microprogramming based Controller) that includes the functional units such as logic unit, fixed/floating point adder, multiplier, and divider. Here, two separate memories are used for data and instruction.

Evaluation Process : Both the end-sem practical exam and end-sem project will have combinely at least 50% of weightage. The remaining weightage comprises regular lab evaluations.

Text Books:

[1] Samir Palnitkar; Verilog HDL : Guide to Digital design and synthesis, 3 rd Edn, Pearson Education, 2003.

[2] Weste & Eshraghian: Principles of CMOS VLSI design, 4 th Edn, Addison Wesley 2011.

[3] Neil H.E. Westte and David Money Harris: CMOS VLSI Design : A Circuits and Systems Perspective, Addison Wesley, 4th Edn, 2011.

EC503I	Embedded System Design Practice	PEC	1 – 3 – 2	2 Credits

Since the embedded systems plays a major role in the modern real time systems and IoT, this course is designed to provide the design skills of the real time systems using a micro controller along with real time operating system.

Course Aim: To provide a hands-on introduction to design of embedded systems with hardware/software and interfacing in real-time to networked cyber-physical systems and real time systems using the microcontrollers.

Prerequisite Courses: C programming, and microprocessor/microcontrollers

Number of Hours: 4hours per week (1 hour for theory and 3 hours for lab practice)

Course Outcomes: At the end of the course the student will be able to:

CO1	Understand the basic elements of embedded systems such as I/O and interfaces
CO2	Understand embedded system design using the ARM in embedded C
CO3	Develop the rapid prototype of embedded systems using open source microcontrollers and microcomputers such as Arduino, Raspberry Pi, BeagleBone Black, and Intel Edison/Galileo.
CO4	Build wireless networked embedded systems using Arduino shields and modules (e.g., GPS, GSM/GPRS, Bluetooth, RFID, and ZigBee).
CO5	Exploit the advanced concepts such as networking and wireless communications, real-time operating systems and control, and Internet of Things in the real time embedded systems.
CO6	Develop the hardware-software co-design with parallel threads.
CO7	Conduct experiments in Internet of Things (e.g., using Arduino Yun, Intel and Microsoft Developer Kits)

Detailed Theory syllabus

1. Elements of embedded systems (such as microcontrollers, GPIO, communication, interrupts, ADC, and DAC); overview of microcontroller; Comparison between Hardware, Software, and Firmware; Comparison between Hard, Soft, Firm, and Hybrid real time systems; applications of embedded systems; classification of embedded systems; characteristics of embedded systems; hardware-software partitioning;
2. Software aspects of embedded systems; Real-time operating system (RTOS) - mutual exclusion using semaphore; deadlock; critical section; event-driven scheduling; time sharing; earliest deadline first scheduling; pre-emptive scheduling; non-pre-emptive scheduling; multi-tasking; multi-threading; inter-process communication using mboxes, and pipes; priority inversion;
3. Rapid prototyping of embedded systems with advanced microcontroller boards; Basic elements of IoT; IoT systems design using advanced microcontroller boards;

Detailed Syllabus for Lab Practice

(1) Experiments in GPIO such as switches, LEDs, LCD, Key pad, Seven Segment Display, Buzzer, and relay;
(2) Serial and parallel interfacing; data acquisition with ADC, audio, and video; timer interrupts; Various bus intereconnects such as I2C, UART, SPI, and so on;
(3) DAC Experiments in control of RC servos, stepper motors, and DC motors;
(4) Data acquisition and real-time control with ARM trainer board, FPGA evaluation boards, Arduino, Raspberry Pi, and BeagleBone Black microcontrollers;
(5) Add-on boards Experiments in wireless networked systems with GPS, GSM/GPRS, ZigBee, Bluetooth, and RFID;
(6) Hardware-software co-design experiments using FPGA boards.
(6) Experiments in IoT for smart automation using sensors, microcontrollers, and cloud.
(7) Free RTOS based applications using ARM trainer board.

Evaluation Process : Both the end-sem practical exam and end-sem project will have combinely at least 50% of weightage. The remaining weightage comprises regular lab evaluations.

References:

[1]. J. W. Valavano, Embedded Systems: Introduction to Arm Cortex-M Microcontrollers, 2nd edition, Create Space, 2012. ISBN: 978-1477508992.
[2]. J. W. Valavano, Embedded Systems (Vol-2): Real-Time Interfacing to ARM Cortex-M Microcontrollers, 2nd edition, Create Space, 2011, ISBN: 978-1463590154.
[3]. J. W. Valavano, Embedded Systems (Vol-3): Real-Time Operating Systems for Arm Cortex M Microcontrollers, 2nd edition, Create Space, 2012. ISBN: 978-1466468863.
[4]. A. McEwen and H. Cassimally, Designing the Internet of Things, 1st edition, Wiley, 2013. ISBN: 978-8126556861.
[5] D. Gajski, F. Vahid, S. Narayan, and J. Gong.*Specification and Design of Embedded Systems*,Prentice Hall.

MTech (ESD) Semester II Courses

Course Title	Circuits for Electronic System Design	**Course Number**	EC504T
Department	Electronics and Communication Engineering	**Structure (IPC)**	3-0-3
Offered to	M.Tech. ESD	**Status (Core/ Elective)**	Core
Prerequisite	Analog and Digital Electronics	**Effective from**	July 2020
Course Aim	The aim of offering this course is to provide a proficiency in designing circuits for electronics system design..		
Course Outcomes	1. Apply concepts of Analog circuits for signal conditioning, signal processing, controller circuits, and driver circuits for power electronic circuits. 2. Design transformer and different power sources for various applications 3. Understand the interface of various modules to microcontroller and learn various communication protocols 4. Perform descriptive error analysis for the circuits 5. Demonstrate key concepts in electronics circuit design, including tools, approaches, and application scenarios		
Contents of the course	1. Introduction to Op-Amps: Op-amp Characteristics, Negative feedback, Gain of the Op-Amp 2. Analog Signal conditioning circuits**:** Buffering, scaling, level translation, filtering applications, Analog math circuits - arithmetic circuits, log circuits, trigonometric circuits and applications Timer circuits, pulse width modulation circuits, P, PI and PID controller circuits, protection circuits, base and gate drive circuits for power transistors, MOSFETs and IGBTs, relay and contactor drive circuits. Design and error budget analysis of signal conditioners for low level AC and DC applications. Error Analysis. 3. Power supply circuits: Board level power supply circuits to generate +/-12V, 5V, 3.3V, 1.8V. Linear regulators, low drop out regulators, charge pumps, switched mode power converters. 4. Interfacing circuits**:** A to D, D to A, A to A and D to D interfaces, serial and parallel DACs, sampling, RS-232, USB, I2C, LCD, serial memory, SPI, CAN, wireless (RF, WiFi) Ethernet, RFID, SD card, SIM card, GPS, Touchscreen interfaces. 5. Digital circuit essentials**:**Digital filters, moving average, numeric formats, scaling, normalizing, arithmetic, log, exponential, square root, cube root, hypotenuse, sine, 3 phase waves, PWM etc.		
References	1. Franco, S., Design with operational amplifiers and analog integrated circuits. Mc. Graw Hill book Co. 1988.		

	2. Horowitz, P., and Hill, W., The art of electronics (2nd edition), Cambridge University Press. 1992. 3.Abraham Pressman, Keith Billings, Taylor Morey, Switching Power Supply Design, McGraw-Hill Education, 2009 4. Warwick A. Smith, ARM Microcontroller Interfacing: Hardware and Software, Elektor Electronics Publishing, 2010 5. Datasheets and Application notes of different Integrated circuits

Note: All students are required to use Moodle for accessing content and assignments related to theory as well as laboratory course.

Course Title	Circuits for Electronic System Design Practice	**Course Number**	EC504P
Department	Electronics and Communication Engineering	**Structure (IPC)**	0-3-2
Offered to	M.Tech. ESD	**Status (Core/ Elective)**	Core
Prerequisite	Analog and Digital Electronics	**Effective from**	July 2020
Course Aim	The aim of offering this laboratory course is to acquire knowledge and proficiency in design circuits for electronics system design.		
Course Outcomes	1. Design and build circuits using OPAMPS 2. Design and develop different power supplies 3. Design and develop signal conditioning circuits for resistive, capacitive, inductive, current current, and voltage-based sensors 4. Analysis of various communication protocols		
Contents of the course	1. Design and build circuits using OPAMPS (summer, integrator, differentiators, and Instrumentation amplifier) 2. Design and build the power supply circuits such as linear power supply, LDO, and DC-DC converter 3. Design and develop the signal conditioning circuits for resistive (RTD), capacitive, inductive (LVDT), current (Photodiode) and voltage based sensors (Thermocouple) 4. Analysis of communication protocols (SPI, CAN, I2C)		
References	1. Franco, S., Design with operational amplifiers and analog integrated circuits. Mc. Graw Hill book Co. 1988. 2. Horowitz, P., and Hill, W., The art of electronics (2nd edition), Cambridge UniversityPress. 1992. 3. Abraham Pressman, Keith Billings, Taylor Morey, Switching Power Supply Design, McGraw-Hill Education, 2009 4. Warwick A. Smith, ARM Microcontroller Interfacing: Hardware and Software, Elektor Electronics Publishing, 2010		

Course Title	Electronic Systems Packaging	**Course Number**	EC505T
Department	Electronics and Communication Engineering	**Structure (IPC)**	0-3-2
Offered to	M.Tech. ESD	**Status (Core/ Elective)**	Core
Prerequisite	Basics of Electrical & Electronics Engineering	**Effective from**	July 2020
Course Aim	The course will sensitize the participants to the fundamentals of electronics systems packaging. The course is multidisciplinary in nature. Today products in electronics industry need to be packaged to current state-of-art if it has to be in the leading edge market.		
Course Outcomes	1. Understands the electronics packaging including package styles or forms, hierarchy and methods of packaging necessary for various environments. 2. Provides industry perspective in the electronics packaging 3. Ability to distinguish between engineering performance and economic considerations to develop cost-efficient and high performance packaging approaches. 4. Predict the reliability of electronic components and structures.		
Contents of the course	Module 1: Overview of Electronic Systems Packaging: Definition of a system and history of semiconductors, Products and levels of packaging, Packaging aspects of handheld products, Definition of PWB, Basics of Semiconductor and Process flowchart, Wafer fabrication, inspection and testing, Wafer packaging; Packaging evolution; Chip connection choices, Wire bonding, TAB and flip chip. Module 2 Electronic systems and needs, physical integration of circuits, packages, boards and complete electronic systems; system applications like computer, automobile, medical and consumer electronics with case studies and packaging levels. Module 3: Electrical design considerations - power distribution, signal integrity, RF package design and Power-delivery in systems. CAD for Printed Wiring Boards (PWBs) and Design for Manufacturability (DFM). PWB Technologies, Single-chip (SCM) and Multi-chip modules (MCM), flex circuits. Recent trends in manufacturing like microvias, sequential build-up circuits and high-density interconnect structures. Module 4: Materials and processes in electronics packaging, joining methods in electronics; lead-free solders. Surface Mount Technology – design, fabrication and assembly, embedded passive components.		

	Module 5: Thermal management of IC and PWBs, Cooling Requirements, Electronic cooling methodsthermo-mechanical reliability, design for reliability, electrical test and green packaging issues, Design for Reliability – Fundamentals, Induced failures. Electrical Testing – System level electrical testing, Interconnection tests, Active Circuit Testing, Design for Testability. Trends in packaging.
References	1. Rao R. Tummala, Fundamentals of Microsystems Packaging, McGraw Hill, NY, 2001, 2. Rao R Tummala& Madhavan Swaminathan, Introduction to System-on-Package, McGraw Hill, 2008, 3. R S Khandpur, Printed Circuit Boards, McGraw Hill, 2006 4.Richard K. Ulrich &William D. Brown Advanced Electronic Packaging - 2nd Edition : IEEEPress, 2006

Course Title	Electronic Systems Packaging Practice	**Course Number**	EC505P
Department	Electronics and Communication Engineering	**Structure (IPC)**	0-3-2
Offered to	M.Tech. ESD	**Status (Core/ Elective)**	Core
Prerequisite	NIL	**Effective from**	July 2020
Course Aim	To understand the manufacturing and assembling aspects of Electronic components in systems.		
Course Outcomes	1. Expected to design optimized layout for printed circuits boards. 2. Exposed to multi-layer PCB design 3. To develop Prototype circuits		
Contents of the course	PCB design flow- Schematic -layout - PCB design using created library -PCB printing using PCB prototyping machine-Testing and debugging of PCB Familiarization of different components and chip packages PCB Design for manufacturability PCB Design consideration for special circuits Design and development of PCBs using different simulator tools and prototyping. Hands-on lab sessions for board manufacturing and assembly. Thermal and Heat Sink Design Electrical Testing and Active Circuit Testing		
References	1. Jan Axelson, Making Printed Circuit Boards, TAB/McGraw Hill, 1993 2. J. Varteresian, Fabricating Printed Circuit Boards. 3. Ronald A. Reis, Electronic project design and fabrication, 6/E, Prentice Hall, 2005. 4. Complete PCB Design Using OrCad Capture and Layout Kraig Mitzner, Elsevier		

EC506T	Digital Signal Processing and Architectures	PEC	3 – 0 – 3	3 Credits

Since the hardware for digital signal processing plays a major role in all the real time applications to enhance the performance of the system, this course is designed to provide the VLSI architectures of various digital signal processing such as discrete orthogonal transformations, digital filtering, and so on.

Course Aim: The goal of this course is to provide a good understanding of the principles and their corresponding hardware designs of various Digital Signal Processing operations.

Theory Class Hours: 3 hours per week

Prerequisite Courses: Digital logic circuits, Signals and Systems, Digital Signal Processing

Course Outcomes: At the end of the course the students will be able to:

CO1	Understand the concepts of digital signal processing : Filtering Techniques and Orthogonal Transformations
CO2	Develop the hardware designs of various Digital Filtering Techniques and Orthogonal Transformations.

Detailed syllabus

1. Arithmetic Circuits – Fixed point number representation, barrel shifter, logarithmic shifter, ripple carry adder, carry select adder, carry skip adder, carry save adder, recursive doubling based carry look ahead adder, Booth algorithm, Carry save array multiplier, Wallace tree multiplier, distributed arithmetic based multiplication, fixed point multiply accumulate circuit design, restoring/non restoring division techniques, IEEE-754 floating point representation, floating point addition/subtraction, floating point multiplication/division, floating point multiply accumulate circuit design, and CORDIC. (12 hours)

2. Digital filter design-Basics of folded/parallel design, FIR/IIR filter design, steepest-descent LMS algorithm, adaptive FIR filter design, multirate signal processing, polyphase decomposition, and filter banks. (8 hours)

3. Discrete wavelet transform-Haar wavelet, 1D/2D-Convolution based discrete wavelet transform architecture, 1D/2D- (5,3) and (9,7) lifting based discrete wavelet transform architecture. (4 hours)

4. FFT architectures – radix-2/4 SDF, MDC, parallel FFT architectures. (4 hours)

5. HEVC architectures – discrete Hadamard transform architectures and integer DCT architectures. (2 hours)

6. Hardware/software co-design analogous between ASIC/FPGA/hardware-software co-designs, need for digital signal processing accelerators (or coprocessors), and hardware/software partitioning based digital signal processing architectures, (2 hours)

7. Digital signal processor design-basics of Von-Neumann, Harvard, Modified Harvard, and super Harvard architectures, hazards, hazard resolution techniques, instruction/data level parallelism. (8 hours)

Evaluation Process : The end-sem exam will have at least 50% of weightage. The remaining weightage comprises minor-1, minor-2, and projects (or assignments).

Text Books:

(1) S. K. Mitra, *Digital Signal Processing: A computer base approach*, Third edition, Mc Graw Hill Higher Education, 2006.

(2) Y.T. Chan, *Wavelet Basics*, Kluwer Publishers, Boston, 1993.

(3) Simon Haykin, *Adaptive filter theory, Pearson Education*, Fifth edition, 2014.

(4) Carl Hamacher, Zvonko Vranesic, Safwat Zaky, and Naraig Manjikian, Computer Organization and Embedded Systems, McGraw Hill Publications, Sixth Edition, 2012.

References :

(1) A. V. Oppenheium, R. W. Schafer, *Discrete-time signal processing*, Second edition, Prentice *Hall, 1999.*

(2) Moris M. Mano, Computer System Architecture, Third Edition, Pearson Publication, 2007.

(3) John L. Hannessey and David A. Patterson, Computer Architecture: A Quantitative Approach, Fourth Edition, Elsevier, Morgan Kaufmann Publishers, 2007.

EC506P	**Digital Signal Processing and Architectures Design Practice**	**PEC**	**0 – 3 – 2**	**2 Credits**

Since the hardware for digital signal processing plays a major role in all the real time applications to enhance the performance of the system, this course is designed to provide the VLSI architectures of various digital signal processing such as discrete orthogonal transformations, digital filtering, and so on.

Course Aim: The goal of this course is to provide a good understanding of the principles and their corresponding hardware designs of various Digital Signal Processing operations.

Theory Class Hours: 3 hours per week

Prerequisite Courses: Digital logic circuits, Signals and Systems, Digital Signal Processing

Course Outcomes: At the end of the course the students will be able to:

CO1	Understand the concepts of digital signal processing : Filtering Techniques and Orthogonal Transformations
CO2	Develop the hardware designs of various Digital Filtering Techniques and Orthogonal Transformations.

Detailed syllabus

1. Design of Data path Blocks using in DSP : Adder, Multiplier, Divider, Multiply accumulate circuit, CORDIC, and so on.
2. Hardware/software co-design of signal processing operations
3. Digital Signal Co-processor design
4. Digital signal processor design-basics of Von-Neumann, Harvard, Modified Harvard, and super Harvard architectures
5. Digital Filter Designs – FIR, IIR, Adaptive filters
6. Discrete Orthogonal Transform Designs – FFT, integer DCT, DHT, DWT

Evaluation Process: The end-sem lab exam and project will have combinely at least 50% of weightage. The remaining weightage will be given to the regular lab assignments.

Text Books:

(1) S. K. Mitra, Digital Signal Processing: A computer base approach, Third edition, Mc Graw Hill Higher Education, 2006.

(2) Y.T. Chan, Wavelet Basics, Kluwer Publishers, Boston, 1993.

(3) Simon Haykin, Adaptive filter theory, Pearson Education, Fifth edition, 2014.

(4) Carl Hamacher, Zvonko Vranesic, Safwat Zaky, and Naraig Manjikian, Computer Organization and Embedded Systems, McGraw Hill Publications, Sixth Edition, 2012.

References:

(1) A. V. Oppenheium, R. W. Schafer, Discrete-time signal processing, Second edition, Prentice Hall, 1999.

(2) Moris M. Mano, Computer System Architecture, Third Edition, Pearson Publication, 2007.

(3) John L. Hannessey and David A. Patterson, Computer Architecture: A Quantitative Approach, Fourth Edition, Elsevier, Morgan Kaufmann Publishers, 2007.

FREE ELECTIVES

Course Title	Applied Game Theory	**Course Number**	FE501T
Department	Electronics and Communication Engineering	**Structure (IPC)**	3-0-3
Offered to	M.Tech. and B.Tech.	**Status (Core/ Elective)**	Elective
Prerequisite	There are no prerequisites. However, familiarity with probability, linear algebra, calculus, and algorithms are desirable	**Effective from**	July 2020
Course Aim	This course aims to introduce students to the novel concepts of Game Theory with special emphasis on its applications in engineering field.		
Course Outcomes	1. Understand the different types of games and their use in strategic thinking. 2. Identify strategic situations and represent them as games. 3. Solve simple games using game-theoretic techniques. 4. Employ game theory to model real-world scenarios in engineering and other areas. 5. Design correct and robust solutions (mechanisms, algorithms, protocols) for real-life problems		
Contents of the course	1.Introduction: Introduction, overview, uses of game theory, some applications and examples, and formal definitions of the normal form, payoffs, strategies, pure strategy, and mixed strategy Nash equilibrium, dominant strategies. 2.Alternate Solution Concepts for Games: Iterative removal of strictly dominated strategies, minimax strategies and the minimax theorem for zero-sum game, correlated equilibria. 3.Extensive-Form Games: Perfect information games: trees, players assigned to nodes, payoffs, backward Induction, subgame perfect equilibrium, introduction to imperfect-information games, mixed versus behavioural strategies. 4.Repeated Games: Repeated prisoners dilemma, finite and infinite repeated games, limited-average versus future-discounted reward, folk theorems, stochastic games, and learning. 5.Bayesian Games: General definitions, ex ante/interim Bayesian Nash equilibrium. 6.Coalitional Games: Transferable utility cooperative games, Shapley value, Core, applications.		

References	1.Martin J. Osborne, An Introduction to Game Theory, Oxford University Press, 2003. 2.Essentials of Game Theory, by Kevin Leyton-Brown and Yoav Shoham; Morgan and Claypool Publishers, 2008. Prajit Dutta, Strategies and Games, MIT Press. 3.Y. Narahari, Dinesh Garg, RamasuriNarayanam, Hastagiri Prakash, Game Theoretic Problems in Network Economics and Mechanism Design Solutions, Springer, 2009. 4.D. Fudenberg and J. Tirole, Game Theory, Indian Edition by Ane Books, 2005.

Course Title	Neural Networks and Learning Systems	**Course Number**	FE502T
Department	Electronics and Communication Engineering	**Structure (IPC)**	3-0-3
Offered to	M.Tech. and B.Tech.	**Status (Core/ Elective)**	Elective
Prerequisite	Digital signal processing and engineering mathematics at the undergraduate level.	**Effective from**	July 2020
Course Aim	To impart fundamental concepts of neural networks.		
Course Outcomes	1. To understand the fundamental theory and concepts of neural networks. 2. Identify different neural network architectures, algorithms, applications and their limitations 3. Understand appropriate learning rules for each of the architectures and learn several neuralnetwork paradigms and its applications 4. To be able to formalize the problem, to solve it by using a neural network.		
Contents of the course	**Introduction:** models of a neuron, neural networks as directed graphs, network architectures (feed-forward, feedback etc.), Learning System, processes learning tasks. **Rosenblatt's perceptron:** Perceptron, perceptron convergence theorem, relationship between perceptron and Bayes classifiers, batch perceptron algorithm. **Modeling through regression:** linear, logistic for multiple classes, Multilayer perceptron (MLP), 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, Approximations of functions: universal approximation theorem, cross-validation, network pruning and complexity regularization, convolution networks, nonlinear filtering. **Kernel method:** Cover's theorem and pattern separability, the interpolation problem, RBF networks, hybrid learning procedure for RBF networks, Kernel regression and relationship to RBFs., **Support vector machines:** optimal hyperplane for linear separability, optimal hyperplane for non-separable patterns, SVM as a kernel machine, design of SVMs, XOR problem revisited, robustness considerations for regression, representer theorem, **Regularization theory:** Hadamard's condition for well-posedness, Tikhonov regularization, regularization networks, generalized RBF networks, estimation of regularization parameter etc., L1 regularization basics, algorithms and extensions, **Principal component analysis:** Hebbian based PCA, Kernel based		

	PCA, Kernel Hebbian algorithm, deep MLPs, deep auto-encoders, stacked denoising auto-encoders.
References	1. S. Haykin, Neural Networks and Learning Machines, Pearson Press. 2. K. Murphy, Machine Learning: A Probabilistic Perspective, MIT Press. 3. NPTEL Course: Neural Network and Its Applications , Prof. Somnath Sengupta , IIT Kharagpur.

Course Title	Blockchain Design and Use Cases	**Course Number**	FE503T
Department	Electronics and Communication Engineering	**Structure (IPC)**	3-0-3
Offered to	M.Tech. and B.Tech.	**Status (Core/ Elective)**	Elective
Prerequisite	NIL	**Effective from**	July 2020
Course Aim	This course will aim to cover the conceptual and application aspects of Blockchain.		
Course Outcomes	1. Describe the working of the current financial system work? 2. Understand the structure of a Blockchain, and identify its advantages 3. Categorize the most prominent Blockchain service providers and their structure 4. Apply Blockchain in domains other than cryptocurrency. 5. Assess the new challenges that arise in monetizing businesses around Blockchains		
Contents of the course	1. Introduction: Blockchain Components and Concepts, Smart Contracts. Overview of current financial system and its drawbacks. Advantages of Blockchain as a financial system. 2.Basics of cryptocurrencies: Cryptography, Hash Functions, Public Key Cryptography, and Digital Signature. 3.Bitcoin Fundamentals: Bitcoin's block structure, Consensus, and mining processes in Bitcoin, Bitcoin Trading, Scripting language in Bitcoin. 4.Permissioned Blockchain: Permissioned Blockchain Architecture, RAFT Consensus, Byzantine General Problem, Practical Byzantine Fault Tolerance. 5.Overview of Hyperledger Fabric: Key Frameworks and Tools, Membership and Identity Management, Hyper ledger composer. 6.Application of Blockchain: Blockchain's implications on Traditional Business,Practical use-cases of Blockchain in Finance, Industry and Governance.		
References	1. Mastering Bitcoin: Unlocking Digital Cryptocurrencies, by Andreas Antonopoulos 2. Blockchain by Melanie Swa, O'Reilly 3. Hyperledger Fabric - https://www.hyperledger.org/projects/fabric 4. Zero to Blockchain - An IBM Redbooks course, by Bob Dill, David Smits https://www.redbooks.ibm.com/Redbooks.nsf/RedbookAbstracts/crse0401.html		

DEPARTMENTAL ELECTIVES

Course Title	Design of IoT Devices	**Course Number**	EC507T
Department	Electronics and Communication Engineering	**Structure (IPC)**	3-0-3
Offered to	M.Tech. ESD	**Status (Core/ Elective)**	Elective
Prerequisite	Embedded Systems, Computer Networks, C programming, and microprocessor/microcontrollers.	**Effective from**	July 2020
Course Aim	This course introduces the basic components of IoT and their interdependencies, deployment models, and fundamental concepts of IoT networking. This will be followed by more IoT network topics such as data and communication protocols. To have an in-depth understanding of data handling in IoT, this course has lectures on data handling, analytics, and data management for IoT devices.		
Course Outcomes	1. Understand the networking with IoT, its enabling technologies, and explore a young, but rich, body of exciting ideas, solutions, and paradigm shifts. 2. Understand the potential of IoT devices, support for networking according to the protocol standards, and being able to program them, would be useful for real time applications. 3. Develop the rapid prototypes of IoT based embedded systems using sensors, cloud, and open source microcontrollers such as Arduino, Raspberry Pi, BeagleBone Black, and Intel Edison/Galileo.		
Contents of the course	1. Introduction to IoT: Definition, Trend, IoT applications, Sensing and Actuation, IoT Devices and deployment models, Power awareness of IoT, LDO in IoT. 2. IoT Networking: Basic IoT Components, Interdependencies, Service Oriented Architecture. 3. IoT Data Protocols: MQTT, SMQTT, CoAP, XMPP, AMQP. 4. IoT Communication Protocols and their applications: IEEE 802.15.4, ZigBee6LoWPAN, Wireless HART, Z-Wave, ISA 100, Bluetooth, and Bluetooth low energy (BLE), NFC, RFID, WiFi for IoT communications. 5. Data Handling, Analytics, Data management for IoT: Data cleaning and processing, Data storage models, Searching in IoT, Deep Web Semantic Sensor Web, Semantic web data management, Real-time and Big data analytics for IoT, High-dimensional data processing, Parallel and Distributed data processing. 6. Interoperability in IoT: Low power Interoperability for IPV6 IoT.		

	7. Cloud-Centric IoT: Architecture, Open Challenges, Energy efficiency, QoS, QoE. 8. Industrial IoT (IIoT): Industrial IoT and its benefits, Future of IIoT, Challenges, Examples. 9. IoT System Management and Virtualization: IoT environment management over Cloud computing framework, Fog Computing paradigm for IoT with case studies, Softwarized control and virtualization technologies for IoT network and computation resource managements. 10. Case Studies: Sensor body-area-network, Smart cities and Smart homes, Agriculture. 11. IoT Network Framework: Wireless Network Fundamental for IoT communicationtutorials with demonstrations and hands-on: 802.11 and 802.15.4 MAC Fundamentals, Management Operations, Security Overview, Network Core Protocols, Tizen Network Stack Architecture, Introduction, CAPI Architecture Overview, Sync/Async Operation Sequence, Interaction of Network Core Components, P2P Core Component Overview, OEM Layer, Supplicant Plugin Architecture overview.
References	1. The Internet of Things: Enabling Technologies, Platforms, and Use Cases", by EethurumRaj and Anupama C. Raman (CRC Press). 2. Internet of Things: A Hands-on Approach, by ArshdeepBahga and Vijay Madisetti (Universities Press).

Course Title	Semiconductor Devices and Technology	**Course Number**	EC508T
Department	Electronics and Communication Engineering	**Structure (IPC)**	3-0-3
Offered to	M.Tech. and B.Tech.	**Status (Core/ Elective)**	Elective
Prerequisite	Basic Electrical & Electronics Engineering	**Effective from**	July 2020
Course Aim	This is a foundation level course in the area of electronic device technology.The course will sensitize the participants to the fundamentals of electronics systems packaging. The course is multidisciplinary in nature. Today products in electronics industry need to be packaged to current state-of-art if it has to be in the leading edge market. Hence systems packaging is essential which the course will detail.		
Course Outcomes	1. Understand the Basics of physics behind the electronics materials 2. Understand the different electronics devices characteristics. 3. Analyze the performance of different devices 4. To relate and compare the different fabrication techniques 5. To synthesize the device using technology CAD		
Contents of the course	Module 1: Introduction to semiconductor device physics: Review of quantum mechanics, electrons in periodic lattices, E-k diagrams, quasiparticles (electrons, holes and phonons) in semiconductors. Carrier statics and dynamics, carrier transport under low electric and magnetic fields: Mobility and diffusivity; Carrier statistics; Continuity equation, Poisson's equation and their solution. High field effects: Velocity saturation, hot carriers and avalanche breakdown. Module 2: Intrinsic and extrinsic semiconductor, Carrier transport, p-n junction, Metal-semiconductor junction, Bipolar Junction Transistor, Heterojunction, MOS capacitor, Capacitance-Voltage characteristics, MOSFET, JEFET, Current-Voltage characteristics, Light Emitting Diode, Photodiode, Photovoltaics, Charge Coupled Device Module 3 Integrated circuit processing, Oxidation, Ion implantation, Annealing, Diffusion, Wet etching and dry plasma etching, Physical vapour deposition, Chemical vapour deposition, Atomic layer deposition, Photolithography, Electron beam lithography, Chemical mechanical polishing, Electroplating, CMOS process integration, Moore’s law, CMOS technology scaling, Short channel effects, Module 4		

	Introduction to Technology CAD, Device and Process simulation and modeling.
References	1. Streetman and Banerjee, Solid State Electronic Devices, Prentice Hall India Learning Private Limited 6 edition (2006) 2. S. M. Sze, Physics of Semiconductor Devices, John Wiley Donald Neamen, Semiconductor Physics and Devices.

Course Title	Quality and Reliability of Electronic Systems	**Course No**	EC509T
Specialization	Electronic System Design	**Structure (IPC)**	3-0-3
Offered for	M.Tech.	**Status (Core/Elective)**	Elective
Prerequisite	Nil	**Effective from**	July 2020
Course Aim	To apply the principles of quality, reliability and asset management to Electronic System Design.		
Course Outcomes	1. Understand the concept of reliability and its significance 2. Investigate a particular failure case based on systematic procedure. 3. Plot reliability and survival graph for the given data of a product. 4. Suggest a suitable method for the availability and maintenance of equipment.		
Contents of the course	**INTRODUCTION:** Definition and Importance of Quality and Reliability **CONCEPTS OF RELIABILITY:** Causes of failure, Life characteristic pattern, Modes of failure, Measures of Reliability, Derivation of the Reliability Function, Reliability Specifications **FAILURE ANALYSIS TECHNIQUE:** Failure investigation, Data collections, Data forms, Data Sources, Reliability Analysis, Use of Probability distributions, Calculation of performance parameters, Survival curves and their Calculation, Calculation of failure rate, application of Weibull Distribution. **SYSTEM RELIABILITY & MODELING:** Types of Systems, Series, Parallel, Series-Parallel, and Parallel-Series system, Standby Systems, Types of Standby redundancy. Reliability of different systems, nature of reliability problems in electronic equipment, selection of components. **SIMULATION & RELIABILITY PREDICTION:** Generation of Random Numbers, Generation of random observations from a probability distribution, Applicability of Monte-Carlo Method, Simulation languages. **MAINTAINABILITY AND AVAILABILITY**: Objectives of maintenance, designing for optimum maintainability and measure of maintainability Availability: Uptime ratio, down time ratio and system availability **QUALITY RELIABILITY AND SAFETY:** Reliability and Quality Control, Quality Circles,Safety factor, increasing safety factors and Case Studies		
References	1. A.K.Govil, Reliability Engineering, TMH, 1983. 2. B.S.Dhillion, Reliability Engineering in Systems Design and Operation, Van No strand Reinhold Co., 1983. 3. A.E.Green and A.J.Bourne Reliability Technology, Wiley-Interscience, 1972. 4. Lecture Notes – CEDT Bangalore.		

Course Title	Advanced Sensor Systems/ Sensor System Design	**Course Number**	EC510T
Department	Electronics and Communication Engineering	**Structure (IPC)**	3-0-3
Offered to	M.Tech. ESD	**Status (Core/ Elective)**	Elective
Prerequisite	Nil	**Effective from**	July 2020
Course Aim	The aim of offering this course is to acquire knowledge about advance sensor system and its applications		
Course Outcomes	1. To gain knowledge about chemical sensors and their applications 2. To gain the basic idea of biosensor and immobilization techniques and its applications. 3. To select a suitable chemical and biosensor for a given application. 4. To develop wearable sensors for Healthcare, Wellness and Environmental Applications. 5. To understand the materials requirement and different fabrication process of MEMS devices.		
Contents of the course	Electrochemical Sensors: Galvanic Cells, Electrode – Electrolyte Interface, Fluid Electrolytes, Transduction Elements- Ion-Selective Electrodes, Nernst Equation, voltammetry, amperometry, conductivity, FET, Modified electrodes, Thin-Film Electrodes and Screen-Printed electrodes. Amperometric-bio sensors (Glucose sensor) and gas sensors (C_2H_4, CH_4, O_2, NO_x, CO_2, NH_3) Potentiometric- Ion selective electrodes- pH linked, Ammonia linked, CO_2 linked, Silver sulfide linked, Iodine selective, Lambda sensor, NO_x sensor. Conductometric-chemirsistors: Biosensor based chemiresistors- Semiconducting oxide sensor, CHEMFETs, ISFETs, FET based Biosensors. Piezoelectric effect- Gas sensor applications, Biosensor applications- Quartz crystal microbalance, surface acoustic waves, enzymatic mass sensor, Glucose thermistor, catalytic gas sensor, pellistors, Enzyme thermistor. Introduction fiber optic sensor - Industrial Applications of Fiber Optic Sensors: Temperature – Pressure – fluid level – flow – position – vibration – rotation measurements – Current -voltage measurement – Chemical analysis. Introduction to smart structures – Applications. Introduction to MEMS, Working principle of Microsystems - micro sensors – types pressure sensor- accelerometers- gyroscopes- magnetic field sensors. Introduction to nanotechnology, Future requirements and opportunities of nanotechnology in sensing, CNT based sensors,		

	Nano electronics and nano photonics. Recent trends in Smart sensor, Agriculture sensor and wearable sensor.
References	1. Loic J Blum and Coulet, “Biosensor: Principle and applications”, CRC Press, 2nd ed.2010 2. Brian R Eggins, “Chemical sensors and Biosensors”, John Wiley sons Ltd, 2004. 3. Mohamed Gad – el – Hak , MEMS Handbook , CRC Press, 2002. 4. K. T. V. Grattan, T. Sun (auth.), K. T. V. Grattan, B. T. Meggitt (eds.) Optical Fiber Sensor Technology: Fundamentals, Springer US, Year: 2000 5. Foundation of MEMS by Chang Liu. Pearson Education, 2012 6. Peter Grundler, "Chemical Sensors: Introduction for Scientists and Engineers", Springer, 2007 7. R.G.Jackson, "Novel sensors and Sensing", Philadelphia Institute of Physics, 2004 8. Guozhen Shen, Zhiyong Fan, “Flexible Electronics: From Materials to Devices”, 1st Edition, World Scientific Publishing Co, 2015. 8. Francis D'Souza, Karl M Kadish, Francis D'Souza, Karl M Kadish , “Handbook of Carbon Nano Materials: (In 2 Volumes) Volume 5: Graphene - Fundamental Properties Volume 6: Graphene - Energy and Sensor Applications” World Scientific Publishing Company, 2014

Course Title	Testing and Testability	Course Number	ECE511T
Course category	PEC	Structure (IPC)	3-0-3
Offered to	M.Tech, ESD	Status (Core/ Elective)	Elective
Prerequisite	None	Effective from	July 2019
Course Aim	The course aims to teach fundamentals of different testing mechanisms, fault models, automatic test pattern generation, and design for testability.		
Course Outcomes	1. Identify the significance of testable design 2. Understand the concept of yield and identify the parameters influencing the same 3. Specify fabrication defects, errors and faults. 4. Implement combinational and sequential circuit test generation algorithms 5. Identify techniques to improve fault coverage		
Contents of the course (With approximat e break up of hours)	Module 1: Role of testing in VLSI Design flow, Testing at different levels of abstraction, Fault error, defect, diagnosis, yield, Types of testing, Rule of Ten, Defects in VLSI chip. Modelling basic concepts, Functional modelling at logic level and register level, structure models, logic simulation, delay models (10 hours) Module 2: Various types of faults, Fault equivalence and Fault dominance in combinational sequential circuits. Fault simulation applications, General fault simulation algorithms- Serial, and parallel, Deductive fault simulation algorithms. Combinational circuit test generation, Structural Vs Functional test, ATPG, Path sensitization methods (15 hours) Module 3: Difference between combinational and sequential circuit testing, five and eight valued algebra, and Scan chain based testing method. D-algorithm procedure, Problems, PODEM Algorithm, Problems on PODEM Algorithm. FAN Algorithm, Problems on FAN algorithm, Comparison of D, FAN and PODEM Algorithms. Design for Testability, Ad-hoc design, Generic scan based design. (6 hours) Module 4: Classical scan based design, System level DFT approaches, Test pattern generation for BIST, and Circular BIST, BIST Architectures, and Testable memory design-Test algorithms-Test generation for Embedded RAMs. (8 hours) Module 5: Fault Diagnosis Logic Level Diagnosis - Diagnosis by UUT reduction - Fault Diagnosis for Combinational Circuits - Self-checking design - System Level Diagnosis (5 hours)		
References	1. 1 M. Abramovici, M. Breuer, and A. Friedman, “Digital Systems Testing and Testable Design, IEEE Press, 1990 2. Stroud, “A Designer’s Guide to Built-in Self-Test”, Kluwer Academic Publishers, 2002 3. M. Bushnell and V. Agrawal, “Essentials of Electronic Testing forDigital, Memory & Mixed-Signal VLSI Circuits”, Kluwer Academic Publishers, 2000		

	4. V. Agrawal and S.C. Seth, Test Generation for VLSI Chips, Computer Society Press.1989. 5.M. Abramovici, M.A. Breuer and A.D. Friedman, "Digital Systems and Testable Design", Jaico Publishing House. 6.M.L. Bushnell and V.D. Agrawal, "Essentials of Electronic Testing for Digital, Memory and Mixed-Signal VLSI Circuits", Kluwer Academic Publishers. 7.P.K. Lala, "Digital Circuit Testing and Testability", Academic Press, 2002. 8.A.L. Crouch, "Design Test for Digital IC's and Embedded Core Systems", Prentice Hall International.

Course Title	Electromagnetic Interference and Compatibility	Course Number	EC512T
Department	Electronics and Communication Engineering	**Structure (IPC)**	3-0-3
Offered to	M.Tech. ESD	**Status (Core/ Elective)**	Elective
Prerequisite	Electromagnetic Theory, Analog and Digital Electronics.	**Effective from**	July 2020
Course Aim	The aim of offering this course is to acquire skill EMI and EMC for electronic circuit designing		
Course Outcomes	1. Understand how electromagnetic noise is generated in large and small electrical systems 2. Interpret how electromagnetic noise is generated in large and small electrical systems. 3. Prepare the circuit design electromagnetic noise can be reduced in an electrical system using proper layout, shielding, grounding and filtering. 4. Develop circuits to solve practical problem of electromagnetic interference.		
Contents of the course	**BASIC THEORY**: Intra and inter system EMI, Elements of Interference: Conducted and Radiated EMI emission and susceptibility, EMC Engineering Application. Component Behaviour: Low frequency circuit approximations - Internal impedance of round wires - High frequency wire resistance approximation - External inductance, capacitance and conductance of parallel wires, coaxial conductors and PCB structures – Non ideal behaviour of resistors, capacitors and inductors - Noise suppression with capacitors and inductors - Common mode and differential mode currents - Ferrites and common mode chokes – Digital Circuit Devices **COUPLING MECHANISM:** Coupling paths, Coupling via the supply network, Common mode coupling, Differential mode coupling, Impedance coupling, Radiative coupling, Ground loop coupling, Cable related emissions and coupling, Transient sources, Automotive transients. Categorization of the electromagnetic interference: emission, susceptibility, transients, crosstalk, shielding and compatibility, signal integrity. **EMI MITIGATION TECHNIQUES:** Working principle of Shielding, LF Magnetic shielding, Apertures and shielding effectiveness, Choice of Materials for H, E, and free space fields, Gasketing and sealing, PCB Level shielding, Principle of		

	Grounding. **STANDARDS AND REGULATION:** Need for Standards, EMI Standardizing for different application. IEC, ANSI, FCC, AS/NZS, CISPR, BSI, CENELEC, ACEC. MIL461E **EMI TEST METHODS AND INSTRUMENTATION:** Fundamental considerations, EMI Shielding effectiveness tests, Open field test, TEM cell for immunity test, Shielded chamber, Shielded anechoic chamber, EMI test receivers, Spectrum analyser, EMI test wave simulators, EMI coupling networks, Line impedance stabilization networks, Feed through capacitors, Antennas, Current probes. **BASICS OF BIOLOGICAL EFFECTS OF EM WAVES:** Ionizing and non-ionizing radiation. Theoretic and diagnostic use of EM waves. Measurement techniques of EM radiation. Protective design techniques.
References	1. Clayton R. Paul, “Introduction to Electromagnetic Compatibility”, 2nd. Ed., John Wiley & Sons, 2006. 2. Henry W Ott, “Noise Reduction Techniques in Electronic Systems”, John Wiley & Sons, 2^{nd} Edi., 1988. 3. Bruce R Archambeault, “PCB Design for Real-World Emi Control”, Springer Science Business Media, LLC, 2002 4. Dr Kenneth L Kaiser, “The Electromagnetic Compatibility Handbook”, CRC Press 2005. 5. Paul, C.R., “Introduction to Electromagnetic Compatibility”, 2nd ed., Wiley (2010). 6. David K. Cheng, “Field and Wave Electromagnetics” 2nd ed. Pearson Education, (2009). 7. W Scott Bennett, “Control and Measurement of Unintentional Electromagnetic Radiation”, John Wiley & Sons Inc., (Wiley Interscience Series) 1997. 8. Daryl Gerke and William Kimmel, “EDN Designers Guide to Electromagnetic Compatibility”, Elsevier Science & Technology Books, 2002.

Course Title	Communication Protocols for Electronic System Design	**Course Number**	EC513T
Department	Electronics and Communication Engineering	**Structure (IPC)**	3-0-3
Offered to	M.Tech. and B.Tech.	**Status (Core/ Elective)**	Elective
Prerequisite	Nil	**Effective from**	July 2020
Course Aim	This course aims to teach fundamentals of communication protocols for designing electronic systems.		
Course Outcomes	1. Quantitative analysis of individual components of industrial data communications. 2. Analysis and specification of serial communication protocol standards. 3. Understanding the error detection, cable shielding techniques to avoid straypickups, noise. 4. Systematic understanding and development of industrial communication protocols.		
Contents of the course	**Overview:** Standards, OSI model, Protocols, Physical standards, Modern instrumentation and control systems, PLCs, Smart instrumentation systems, Communication principles and modes, error detection, Transmission, UART. **Serial communication standards:** Standards, serial data communication interface standards, EIA-RS232 interface standard, RS-449, RS-422, RS-423 and RS-485 standards, Troubleshooting and testing with RS-485, GPIB standard, USB interface. **Error Detection, Cabling and Electrical Noise:** Errors, Types of error detection, control and correction, copper and fiber cables, sources of electrical noise, shielding, cable ducting and earthling. **Modems and Multiplexers:** Synchronous and Asynchronous modes, flow control, modulation techniques, types of a modem, modem standards, terminal and statistical multiplexers. **Communication Protocols:** Flow control protocols, XON/XOFF, BSC, HDLC and File transfer protocols, OSI model and layers, ASCII protocols, Modbus protocol. **Industrial Protocols:** Introduction to HART protocol, Smart instrumentation, HART physical layer, HART data link layer, HART application layer, ASD interface, Seriplex, CANbus,		

	Devicenet, Profibus, FIP bus, Fieldbus. **Local Area Networks**: Circuitand packet switching, Network topologies, Media access control mechanisms, LAN standards, Ethernet protocol, Token ring protocol
References	1. Practical data communications for instrumentation and control, John Park, Steve Mackay, Edwin Wright, Elsevier Newness Publisher, 2008. 2. Computer Networks,Andrew Tanenbaum, Prentice Hall Professional Technical Reference, 2002.