M Tech in Electronics Design & Technology

Semester I

Course Code	Course Name	Type	L	T	P	CR
EL523	Advanced Programming Language	C	3	0	2	5
EL533	Data Communication and Networks (3-0-2)	C	3	0	1	4
EL521	Design and Technology of Electronic Devices	C	3	0	1	4
EL531	Design of Digital Systems	C	3	0	1	4
EL517	Physical and Industrial Design of Electronics Systems	C	3	0	1	4
	Open Elective - I	OE				

Semester II

Course Code	Course Name	Type	L	T	P	CR
EL538	Advanced Electronic Devices	C	2	0	1	3
EL516	Design of Fine Mechanics and Power Devices	C	3	0	1	4
BE528	MEMS and Nanotechnology	C	3	0	0	3
EL540	Sensors and Sensor Intelligence	C	3	0	1	4
EL530	VLSI Design	C	3	0	1	4
EL546	Modelling and Simulation of Digital System	E	3	0	1	4
EL544	CMOS Analog Circuits		3	0	1	4
	Open Elective - II	OE				

Semester III and IV

Course Code	Course Name	Type	L	T	P	CR
EL601	M. Tech. Dissertation	C				24

EL523: Advanced Programming Language

Syllabus

Introduction to Object Oriented Programming (OOP) & its applications, Differences between OOP and Procedure-Oriented Programming (POP), System Input/Output streams, Functions, Defining Classes and Objects, Constructors and Destructors, Operator Overloading, Function overloading, Inheritance, Pointers, Virtual functions, Polymorphism, Templates and exception handling, Managing console I/O operations, Working with files, Graphics Programming. Introduction to MATLAB, and its Applications, Executable C code in MATLAB Programming (Laboratory will be based on C++ and MATLAB)

Course Outcomes (COs)

1. After completion of this course, students will have basic knowledge of the Object oriented programming (OOP).
2. After completion of this course, students will have basic knowledge of the MATLAB
3. Students can utilize the knowledge of OOP & MATLAB in engineering problem solving.
4. Students are expected to do their final year project work using the C++ compiler and/or MATLAB

EL533: Data Communication & Networks

Syllabus

Data Transmission:
Analog and Digital transmission, Transmission Impairments, Wireless Transmission Media – microwave and satellite, Guided transmission media – twisted wire, coaxial cable and optical fiber.

Data Signaling:
Encoding of Digital Data to Digital signal, Digital Data to Analog Signal, Analog Data to Analog signal and Analog Data to Digital Signal. Spread Spectrum Signaling, Data Communication Interface, Data Link control-stop & wait protocol, sliding window protocol, select & reject ARQ etc., Multiplexing – FDM, TDM, WDM.

Data Communication Networks:
Circuit Switched Networks (CSN)– switching concept, routing in CSN, control signaling, Network Security. Packet Switched Networks (PCN) – principles routing in PCN, congestion control, X.25. Asynchronous Transfer Mode (ATM) Networks – Protocol architecture, ATM logical connections, ATM cells, Transmission of ATM cells, Traffic and congestion control. Local Area Networks – architecture Bus, Star, ring and tree LANS, Medium excess control, CSMA/CD, Token ring, wireless LANS etc.

Protocol and Architecture:
OSI model, TCP/IP Protocol, IPv4, IPv6, Connectionless internetworking, Routing Network, Wide Area Networks, Fiber Optic Networks, ISDN - ISDN Channels & Interface, All Optical Networks-WDM Optical Networks, Photonic Switch Networks, Wavelength routing networks.

Course Outcomes (COs)

At the end of this course students will demonstrate the ability to
1. Apply data transmissions in the design of computer networks
2. Apply data signaling for making design of MODEM for WAN, Nation wide network
3. Apply circuit switched and packet switched networks in LAN
4. Apply data communication protocols in internet
5. Apply high bandwidth protocols in high speed communication networks such as WDM, Photonic switched networks

EL521: Design & Technology of Electronic Devices

Syllabus

Theory:

Unit 1: Review of microelectronic devices (10 lectures)

Introduction to MOS technology and related devices. MOS transistor theory.

Unit 2: Scaling theory (7 lectures)

Scaling theory related to MOS circuits, short channel effect and its consequences, narrow widtheffect, FN tunneling.

Unit 3: Multi-gate Transistor(5 lectures)

Double gate MOSFET, Cylindrical MOSFET

Unit 4: CMOS circuits and logic design (6 lectures)

Basic concept of CMOS circuits and logic design. Circuit characterization and performance estimation, important issues in real devices. PE logic, Domino logic, Pseudo N-MOS logic- dynamic CMOS and Clocking, layout design and stick diagram, CMOS analog circuit design, CMOS design methods.

Unit 4: SOI Technology (5 lectures)

Introduction to SOI, Multi layer circuit design and 3D integration.

Unit 4: Fabrication Steps of a MOSFET (7 lectures)

CMOS processing technology: Crystal grown and Epitaxy, Film formation, Lithography and Etching, Impurity doping, Integrated Devices.

Total: 40 lectures for theory

Practical:

Experiment 1: Study the diode characteristics using Matlab

Experiment 2: Simulate the diode structure with Sentaurus device Simulator and compare with experiment-1

Experiment 3: Study the BJT characteristics using Matlab

Experiment 4: Simulate the BJT structure with Sentaurus device Simulator and compare with experiment-3

Experiment 5: Study the MOSFET characteristics using Matlab

Experiment 6: Simulate the MOSFET structure with Sentaurus device Simulator and compare with experiment-5

Experiment 7: Study the Short channel characteristics of a MOSFET using Matlab

Experiment 8: Simulate the Short channel characteristics of a MOSFET with Sentaurus device Simulator and compare with experiment-7.

Total: 16 hours for practical

Course Outcomes (COs)

1. Understand the fundamental principles of electronic devices
2. Understanding of need of a new device for higher performance and low power
3. Designing circuits with MOSFETs
4. Understanding the fabrication steps of a MOSFET.

EL531: Design of Digital Systems

Syllabus

IEEE logic Notation, Polarised Mnemonic Convention & Dependency Notation, Designing Combinational Circuits, MSI & LSI Circuits & their applications, Multiplexers & Demultiplexers, State equation & other diagram representation of sequential circuits, Realisation of sequential functions using Gates/Flip-Flop, counters & Registers, Structure of General Digital Systems, System Controls, Timing & Frequency considerations, Design Phases & System Documentation, Programmable Logic Device, Classification (PAL, PLA, & EPLD) , Design with PLD's the associated development tools, Case Studies, Microprocessor Architectural Concepts, Microprocessor instructions & Communication, Micro-controller, Motorola 68xxx family microprocessors, Architecture & Instruction Set, Microprocessor Input Output Interface, Design of Microprocessor based Systems & Testing, Design Tools for Microprocessor based System Design.

Course Outcomes (COs)

At the end of this course students will be:

1. able to design the combinational circuits
2. able to design the sequential circuits
3. able to understand the concepts of design with PLDs, Architecture of Microprocessor and Microcontrollers
4. able to design and analyse Microprocessor and Microcontroller based Systems

EL517: Physical and Industrial Design of Electronics Systems

Syllabus

Translation of Product concepts to manufacturable designs, Product Design Methodology, Product Planning and Data Collection, Sources for New Ideas, Creativity Technique, Elements of Aesthetic, Ergonomics of Electronic Equipment, Control panel Layouts, Computer Aided Physical Design, Structuring, Layers, Structural Design, Layout of Components, Product detailing and Value Engineering, Packaging, Thermal Management of Electronic Equipment, System operating Characteristic.

Course Outcomes (COs)

At the end of this course students will demonstrate the ability to:

1. Analyse functional and design aspects of existing products for identifying opportunities for improvement and modification
2. Generate creative product development ideas
3. Apply elements of aesthetics in the design of products
4. Design user-machine interfaces using the concepts of ergonomics
5. Communicate design solutions using dummy, semi functional and fully functional models or prototypes
6. Apply the concepts of product management and design in assessment and intervention of product life cycle
7. Formulate product level thermal management strategies

EL538: Advanced Electronic Devices

Syllabus

Theory:

Unit 1: MOSFET Devices (3 lectures)
Introduction to Long Channel devices and their mathematical modeling. Introduction to Short Channel devices.

Unit 2: Short channel Devices (7 lectures)
Introduction to Short Channel devices and their mathematical modeling. Different short channel effects: drain-induced barrier lowering and punch through, surface scattering, velocity saturation, impact ionization, hot electrons.

Unit 3: Nano scale MOSFETs: (9 lectures)
Quantum effects and Single-electron charging effects in nano scale Si- MOSFETs. Double gate and all around MOSFETs, Nano-wire MOSFETs.

Unit 4: Hybrid Electronic Devices (12 lectures)
Introduction to Hybrid Electronic Devices , Electrolyte-Insulator-Semiconductor (EIS) structure, Site binding Theory. MOSFET based Bioelectronic Devices: Ion sensitive Field Effect Transistor (ISFET), Reference Field Effect Transistor (REFET), Measurement with ISFETs. Interfacing of Biological molecules with Electronic elements: Enzyme kinetics, Enzyme Field Effect Transistor (ENFET), Biological Field Effect transistor (BIOFET).

Unit 5: Modeling of FETs (6 Lectures)
Modeling for short channel effects, Nano scale devices, ISFET, ENFET and BIOFET.

Total: 37 lectures for theory

Practical:

1. Modeling of potential and threshold voltage of long channel MOSFET (MATLAB)
2. Modeling of drain current of long channel devices (MATLAB)
3. Modeling of potential of short channel MOSFET (MATLAB)
4. Modeling of drain current short channel MOSFET(MATLAB)
5. Repeat exp.1 with TCAD simulation and compare with MATLAB results and analyze
6. Repeat exp.2 with TCAD simulation and compare with MATLAB results and analyze
7. Repeat exp.3 with TCAD simulation and compare with MATLAB results and analyze
8. Repeat exp.4 with TCAD simulation and compare with MATLAB results and analyze
9. Potential model of ISFET
10. Potential model for enzyme FET

Total: 20 hours for practical

Course Outcomes (COs)

1. Basis understanding of electronics devices.
2. Connect the understanding of electronic devices to understand bioelectronics devices
3. Design bioelectronics devices for real life applications say, for medical applications.

EL516: Design of Fine Mechanics and Power Devices

Syllabus

Survey of Mechanical Components assembly & Systems for Fine Mechanics Applications. Basic Mechanical Laws & Analysis of Load Characteristics for actuator selection & coupling. Measurement of mechanical Parameters.Introduction to various incremental motion systems. Principle of operation & classification of various types of stepper motors. Controls & drive circuits. Improved control & drive techniques in open & closed loop. Use of DC motor in incremental motion systems & related control techniques.Use of permanent magnets.Design of sensors.(Optical Encoders etc.)Design of Actuators (Electromagnets, Step motors etc.)Design & Fabrication of Pulse & Rectifier Transformers. Operation & Characteristics of power semiconductor devices like Thyristors, MCTs, SITHS, RCTs, GTCs, IGBTs etc. Drive & Protection of PSDs. Cooling of PSDs. PCB design aspects of power circuits. Linear & Power switching converters.

Course Outcomes (COs)

At the end of this course students will demonstrate the ability to:

1. Apply concepts of incremental motion controls in real life applications
2. Choose type of stepper motors for specific applications
3. Design drive circuits for stepper motors to suit particular applications
4. Apply the principles of PCB layout specific to power electronics
5. Evaluate, compare and choose the type of PSD appropriate for specific applications
6. Apply the knowledge on PSD drive design for device safety and efficiency

BE528: MEMS and Nanotechnology

Syllabus

Introduction to MEMS: Micro and Nano-scale size domains; Evolution of MEMS Technology in Early Days, Moore's Law in MEMS, Prospects and Challenges in Commercialization of MEMS Technology Scaling laws in Miniaturization, MEMS materials and Processes; MEMS devices and Applications

(3 Lectures)

Introduction to Submicron Technology: Semiconductor materials; Photolithography; Doping; Thin film growth and Deposition; CVD and Ion Implantation, Metallization; Wet and Dry Etching; Silicon Micromachining; Metal MEMS Processes; Submicron Optical Lithography; Electron Beam Lithography; Soft Lithography and Printing.

(3 Lectures)

Mechanics of beam and diaphragm: Elasticity, Stress-Strain Relation, Bending Moment, Beam Bending Theory, Micro-cantilever Beam, Analysis of Deformation of Membranes.

(4 Lectures)

Sensing and actuation principles: Sensing Principles in MEMS: Piezoresistive, Capacitive, Thermoelectric, Thermoresistive etc. Actuation Principles in MEMS: Electrostatic, Thermal, Piezoelectric etc. Microactuators based on various principles: electrostatic, electromagnetic, piezoelectric, Capacitive and SMA; Pull in Effect, Actuator applications: Inkjet, Electrical and Optical Switching, Micropump.

(8 Lectures)

Case Studies: Physical sensor like pressure, chemical, flow sensor, accelerometer and gyroscope, inkjet nozzle, electrical and optical switching, micropumps etc.

(3 Lectures)

BioMEMS: Introduction, Chemical and Biomedical Sensing Mechanisms and Principles, Chem-Lab on a Chip, Chemoresistors, Chemocapacitors, Chemotransistors, DNA sensors.

(4 Lectures)

Microfluidics: transport in micro-channels; microfluidic components (filters, mixers, valves, and pumps)

(3 Lectures)

Nanotechnology: Nanomaterials: Quantum wire, quantum well, quantum dots, fullerenes, graphene, carbon nanotube; Synthesis of Nanomaterials: Physical methods (electrodeposition, sputtering, molecular beam epitaxy, spary pyrolysis), chemical methods (CVD, solvothermal etc) Top down and bottom up approach for nanofabrication: electron beam lithography, FIB lithography, soft lithography, nanoimprint, nanosphere, Dip-pen nanolithography, self assembly and chemical synthesis.

(4 Lectures)

Characterization Technique: scanning electron microscopy, scanning tunnelling microscopy, X-ray photoelectron spectroscopy, Surface enhanced Raman spectroscopy etc.

(2 Lectures)

Medical Application of Nanotechnology: Nano-biosensor, Nanotechnology in drug delivery

(2 Lectures)

Course Outcomes (COs):

1. Elucidate the principles of different types of MEMS sensors and actuators.

2. Explain the concept of MEMS design, and fabrication technology.
3. Acquire and apply new knowledge as needed to work in the area of microelectromechanical systems.
4. Apply the contemporary knowledge into the area of Biomedical Engineering.

EL540: Sensors and Sensor Intelligence

Syllabus
Theory:

Unit 1: Classical sensors and transducers (10 hours):
Definition and classifications ; Working principle, materials and types of-Resistive sensors-potentiometer, strain gauge, RTD, thermistor; Capacitive- capacitive moisture, density and level measurement ; Inductive- RPM, flow measurement; Thermocouple; MEMS; Gas sensors ; Electrochemical sensors; ISFETs-glucose sensors; pulse, blood pressure and oxymeter

Unit 2: Intelligent Sensors (10 hours): Definition; Classifications- based on functions and techniques; Smart sensors- monolithic and hybrid; Soft sensors- modelling techniques, time sharing; Cogent sensors-monotype and multitype, classification, semantic transformation and decision making; Self adaptive sensors- adaptation to accuracy, time, power consumption and linearity;

Unit 3: Intelligent signal processing (10 hours): Metrological intelligence; Linearization techniques-circuit based linearization- OPAMP based, nonliner ADC; Look-up table; Piece-wise linearization; Interpolation; Error and drift compensation; Circuit based compensation-dummy circuit; Temperature compensation; Frequency based sensor- sensitivity control;

Unit 4: Artificial intelligence (10 hours): Human intelligence and machine learning; Biological and artificial neuron; Hardware realization of Neuron; Array based sensors; ANN based classification and discrimination, Recurrent ANN; E-tongue and E-Nose; Prognostic, diagnostic and predictive techniques in medical science, Fuzzy logic based techniques

Total: 40 lectures

Course Outcomes (COs)

Towards the end of the course the student will be expected to –

1. explain and differential classical and intelligent sensors
2. illustrate sensor and its intelligence
3. explain various Intelligent Sensor Standards and Protocols
4. illustrate artificial and adaptive intelligence
5. apply various intelligent signal processing techniques
6. develop basic artificial and adaptive neural networks for signal processing

EL530: VLSI Design

Syllabus

Basic VLSI Design: Fundamentals of CMOS &BiCMOS, Scaling of CMOS Devices, CMOS, Digital Circuit Design, CMOS Analog Circuit Design, VLSI Design Methodology, Scaling of MOS Circuit, Stick Diagram & Lay out – λ-rules, System Design – FSM – Model, ASM Chart.

VLSI Physical Design: ASIC Design Flow, Top Down Approach, Bottom up approach, Partitioning – Approximation of Hyper graphs with graphs, Kernighan – LIN, heuristic, Ratio cut partitioning, Genetic Algorithms Based portioning, F. M. partitioning, Floor Planning – rectangular dual graph approach to floor planning, hierarchical approach simulated annealing, Floor plan sizing, Placement – Cost function, force directed approach, placement by simulated annealing, regular placement, partitioning placement, Routing – Line Searching, Steiner Trees, Maze Running, Global Routing – sequential approaches, hierarchical approach randomized routing, linear programming etc., Detail Routing – channel routing, switch box routing, routing in Field Programmable Gate Arrays (FPGA), array based and row based. Lay out Methodologies, Packaging.

Course Outcomes (COs)

At the end of this course students will demonstrate the ability to

1. Apply CMOS digital circuit in preliminary design of digital IC and processor
2. Apply CMOS analog circuit in preliminary design of analog IC
3. Apply CMOS analog and digital circuit in mixed circuit design of IC
4. Apply computer aided tools such as partitioning, floor planning, placement and routing in ASIC design of high held processor design
5. Apply Layout design and packaging design for the fabrication of ASIC

EL546: Modelling and Simulation of Digital System

Syllabus

Introduction: Modeling digital systems, Design Methodology, Hardware modeling languages.

Introduction to Hardware description languages (HDL): *Introduction to VHDL*- Entity, Architecture, Modeling styles, Data Types and Operators, Flow controls, Generics and Configurations, Subprograms, Attributes, Packages and Libraries, Model simulation and interface with example code. *Introduction to Verilog Language Constructs*: Modules, programs, subroutines, package, Data Types and Operators, Loops and Flow control- for Loop, While Loop, The Case Statement, Simulation Flow if an if-Else Constructs, Tasks and Functions, Timing and delays, Simulation and Synthesis tools.

Combinational Circuits: HDL modeling of combinational Circuits, Combinational Components and Circuits, Decoders and encoders, Multiplexers and Demultiplexers, Priority encoder, Priority decoder, Comparators, Adders.

Sequential Circuits: HDL modeling of Sequential Circuits, Counters, Registers, State machine design, Sequential Data paths and Control, Clocked Synchronous Timing Methodology.

Programmable logic devices: programmable logic design techniques, modular designs and hierarchy, Read Only Memory (ROM), Programmable Read Only Memory (PROM), Programmable Logic Array (PLA), Programmable Array Logic (PAL), field programmable gate arrays (FPGAs) and complex programmable logic devices (CPLDs).

Laboratory:
Introduction to hardware Modeling and Simulation in VHDL and Verilog, Implementations of digital systems on FPGA platforms, Design and implementation of Registers, Counters, State Machines, Traffic light Controller, Arithmetic Logic Unit Modeling , Design and implementation of a Simple Central Processing Unit

Course Outcomes (COs)

Upon completion of the course, the student will be able to
1. Understand various constructs and conventions of VHDL and Verilog.
2. Analyse and design combinational and sequential digital systems using VHDL and Verilog.
3. Simulate various digital system in VHDL and Verilog and implement the system in FPGA.
4. Work in teams in the design and implementation of an application of digital system using VHDL and Verilog.

EL-544 CMOS Analog Circuits

Credit Structure				Contact Hour
L	T	P	CR	CH
3	0	1	4	5

Objective: This course will inculcate basic understanding of analog integrated circuit and enhance understanding the trade-off involved in analog circuit design. The primary objectives are

a. To understand the building blocks of analog circuits
b. To design analog circuits based on certain specifications.
c. To optimize the design of analog circuits based on application specific requirements.
d. To tune the design of circuits based on constraints imposed by fab lab technology.

Prerequisite: Introductory course in electronic circuits, Basic understanding of semiconductor device operation.

Introduction: Analog integrated circuit design, Circuit design consideration for MOS challenges in analog circuit design

Review of MOS transistor: Device characteristics, second order effects, large and small signal models, MOS capacitance

Fabrication of MOSFET, isolation technique in MOS, CMOS Technology, Layout and Design Rules, SPICE simulations

Analog Sub Circuits: MOS Diode/Active resistor, Simple current source and sink, current mirror, Current and Voltage references, Bandgap references.

Single Stage CMOS Amplifiers: Common Source Amplifiers, Source followers, Source Degeneration, Common gate amplifier, Cascode amplifier, folded cascode amplifiers, Frequency response of amplifiers and stability of amplifier

CMOS Differential amplifier: Source coupled pairs, Current Mirrors, Differential Pairs, Differential Amplifiers, Frequency Response, Noise, Feedback, Nonlinearities

Operational Amplifier: Ideal characteristics of Op-Amplifier, Operational Amplifiers, Stability and Compensation, Design of two stage Op-Amplifier, Compensation of Op-Amplifier, Frequency response of Op-Amplifier, Operational Transconductance Amplifier (OTA). Bandgap References, chopper stabilized amplifiers, analog filter, oscillator and mixer design.

CMOS Comparator: Characteristic of a comparator, Two stage open loop comparator, Special purpose comparator, Regenerative comparator, High output current amplifier, High speed comparator.

Introduction to Switched Capacitor Circuits: Switched capacitor circuits, Switched capacitor amplifiers, Switch capacitor integrators.

Design of ADC and DAC: sigma delta modulators and pipelined ADC etc.

Text Book:

1. Razavi, *"Design of analog CMOS integrated circuits",* McGraw Hill, Edition 2002.

Reference Books:

2. 2. Gray, Meyer, Lewis, Hurst, *"Analysis and design of Analog Integrated Circuits",* Willey International, 4th Edition, 2002.
3. 3. Allen, Holberg, *"CMOS analog circuit design",* Oxford University Press, 2nd Edition, 2012.
4. 4. Analog Integrated Circuit Design, D.A. Johns and K. Martin