**Brief Syllabus**

**Program Core**

**ECL507 System design & Modeling**

**3-0-2(4)**

Digital circuit design fundamentals, including Boolean algebra, logic gates, and finite state machines. MOS Transistor Theory, Register Transfer Level (RTL) design, Low-Power Design Techniques, Design of Arithmetic Building Blocks, Memory Cells Design, Physical design and layout considerations, floorplanning, routing. System-level design aspects power optimization, clock distribution, and timing closure complemented by hands-on experience with CAD tools and project work for practical application.

**ECL509 Optimization theory & Applications**

**3-0-2(4)**

Basics of optimization theory, numerical algorithms, and applications. The course is divided into three main parts: linear programming (simplex method, duality theory), unconstrained methods (optimality conditions, descent algorithms and convergence theorems), and constrained minimization (Lagrange multipliers, Karush-Kuhn-Tucker conditions, active set, penalty and interior point methods). Applications in engineering, operations, finance, statistics, etc. will be emphasized. Students will also use MATLAB’s optimization toolbox to obtain practical experience with the material.

**ECL532 Embedded System Design**

**3-0-2(4)**

Introduction to ESD, Emulator, RTOS, Task, Semaphores and Shared Data Operating system, Processor selection in Embedded System (Microprocessor V/s Microcontroller), Detailed Architecture of 8-bit Microcontroller 8051, Embedded System Development, Networks for Embedded Systems, Introduction to 32-bit controller (ARM7)

**ECL513 Machine Learning**

**2-0-2(3)**

Statistical Decision Theory - Regression, Classification, Bias Variance, Linear Regression, Multivariate Regression, Gradient Descent, Feature Scaling, Linear Classification, Logistic Regression, Decision Trees, Regression Trees, Random Forests, Multi-class Classification, Naive Bayes, K Nearest Neighbours, Perceptron, Support Vector Machines (SVM), Principal Components Analysis (PCA)

**ECC509 Seminar**

**0-0-4(2)**

Independent study on any recent research area of Electronics and Communication Engineering in the domain of Communication Engineering or VLSI Design, as per the specialization chosen by the student.

**MAL616 Research Methodology**

**2-1-0(3)**

Foundations of Research, Scientific Research, Motivation, Research Objectives, Research Designs,  Research Processes,  Design of Experiments, Understanding Feasibility of Objectives and Processes, Qualitative and Quantitative Research Methods, Data Collection Processes, Biases in Data Collection, Data Pre-processing, Sampling Distribution and Confidence Intervals, Hypothesis Testing, Interpretation of Results, Literature Review, Technical Writing, Citations, IPR, Research Ethics, Reference management software, Plagiarism, Software for Detection of Plagiarism

**ECD512 Minor Project**

**0-0-10(5)**

Hardware and software implementation of the latest research work in the domain of Communication Engineering or VLSI Design, as per the specialization chosen by the student. It has to be done under the guidance of a faculty and students are expected to complete literature survey, feasibility testing, develop or implement the research work.

**ECD605 Dissertation-I**

**0-0-12(6)**

Simulation or hardware implementation of new or recent technological research trend under the guidance of a faculty. Students are expected to complete literature survey, feasibility testing, circuit design, component arrangement, development and publications. It has to be carried out in the domain of Communication Engineering or VLSI Design, as per the specialization chosen by the student.

**ECD602 Dissertation-II**

**0-0-24(12)**

Completion of the research work and dissertation report submission, which was undertaken as ECD605. Simulation or hardware implementation of new or recent technological research trend under the guidance of a faculty, students are expected to complete literature survey, feasibility testing, circuit design, component arrangement, development and publications. It is the continuation of ECD605, and is in the domain of Communication Engineering or VLSI Design, as per the specialization chosen by the student.

**Bridge courses**

**ECV502 Skill based course (3)**

This is a bridge course to be done by students in summer, who opt for 1 year exit for PG Diploma. This will be a specialized course chosen as per the need of the industry, with more emphasis on hands-on practice.

**ECT502 Industrial Internship (7)**

This is a bridge course to be done by students in summer, who opt for 1 year exit for PG Diploma. Students need to undergo an industrial internship in the domain of their choice.

**Program Electives**

**Track 1: Semiconductor Technology**

**ECL581 Micro & Nano fabrication**

**3-0-2(4)**

Introduction and overview of micro and nano fabrication technology. Safety and contamination issues in a cleanroom. Overview of cleanroom hazards. Basic process flow structuring. Wafer type selection and cleaning methods. Additive fabrication processes. Material deposition methods. Overview of physical vapour deposition methods (thermal, e-beam, molecular beam evaporation) and chemical vapour deposition methods (PE-CVD, MOCVD, CBE, ALD). Pulsed laser deposition (PLD), pulsed electron deposition (PED). Doping: diffusion and ion implant techniques. Optical lithography fundamentals, contact lithography, stepper/scanner lithography, holographic lithography, direct-laser writing. Lithography enhancement methods and lithography modelling. Non-optical lithography; E-beam lithography, ion beam patterning, bottom-up patterning techniques. Etching process: dry and wet. Wet etch fundamentals, isotropic, directional and anisotropic processes. Dry etching process fundamentals, plasma assisted etch process, Deep Reactive Ion Etching (DRIE), Through Silicon Vias (TSV). Isotropic release etch. Chemical-mechanical polishing (CMP), lapping and polishing. Packaging and assembly, protective encapsulating materials and their deposition. Wafer dicing, scribing and cleaving. Mechanical scribing and laser scribing, Wafer bonding, die-bonding. Wire bonding, die-bonding. Chip-mounting techniques

**ECL583 Semiconductor Equipment & Technology**

**3-0-2(4)**

Semiconductor Design Equipment, Pattern Generator, Plotter, Engineering Workstation, Logic Simulator, Circuit Simulator, Design Equipment, Logic Analyzer, Photolithography Processing Equipment, Thin Film Deposition, Etching, Cleaner, & Dryer, Inspection and Metrology Equipment & Others,  Single Crystal Growing Furnace, Slicer, Lapping Equipment, Polishing Equipment, Grinding Equipment, Wafer Marking Equipment, Slicer, Lapping Equipment, Polishing Equipment, Grinding Equipment, Wafer Marking Equipment, Photoresist Processing Equipment, Surface Conditioning Equipment, Wet Etching Equipment, Dry Cleaning Equipment, Wet Cleaning Equipment, Wafer Scrubber, Drying Equipment, High Pressure Jet Cleaner, Atmospheric Pressure CVD, Subatmospheric CVD, Low Pressure CVD, Plasma Enhanced CVD, MetalCVD, ALD, Sputtering Equipment, Assembly & Packaging equipment: Molding Equipment, Deflasher, Sealing Furnace, Solder Plating Equipment, Solder Ball Mounter, Trim & Forming Equipment, Marker, Clean Room facility: Clean Bench, Clean Tunnel, Thermal Chamber, Environmental Chamber, Air Shower, Pass Box

**ECL584 Semiconductor Material Synthesis & Characterization**

**3-0-2(4)**

Elemental and compound semiconductor materials, structural, electronic and optical properties. Crystallography, surfaces and interfaces, thermodynamics, kinetics, and mechanisms of nucleation and growth of crystals. Chemical vapor deposition and physical vapor deposition, while also studying stress effects in film growth. Imaging techniques like scanning electron microscopy (SEM) and transmission electron microscopy (TEM) will be covered, alongside diffraction techniques including X-ray diffraction (XRD) and electron diffraction. Spectroscopy techniques such as X-ray photoelectron spectroscopy (XPS), X-ray absorption spectroscopy (XAS), photoluminescence, and Raman spectroscopy. Profilometry techniques like optical profilometry and ellipsometry will be discussed, along with atomic force microscopy (AFM) and its variants like conductive AFM (CAFM) and Kelvin probe force microscopy (KPFM). Basics of electrical measurements including resistivity, Hall effect, and capacitance-voltage measurements, opto-electronic measurements and basics of high-frequency measurements.

**ECL585 Semiconductor Packaging and Testing**

**3-0-2(4)**

This course will provide an overview of packaging technology. It will also provide guidance on analysis, design, assembly test and manufacturing of semiconductor, overview of IC Design, Overview of packaging, Traditional packaging, advanced packaging, OSAT Industry overview, Detailed description of semiconductor assembly & test factory, safety procedures in assembly test factories, clean room practices, supply chain logistics, basics of equipment and utility maintenance, quality and reliability basics, assembly & test line operations, PCB basics, package design basics, package design simulations.

**ECL586 ASIC’s & FPGA**

**3-0-2(4)**

Introduction to hardware description languages, types of modeling, dataflow modeling, behavioral modeling, structural modeling, use of package for structural modeling, finite state machine modeling. Introduction to ASICs: Introduction to ASICs, ASIC design flow, types of ASICs, full custom ASIC, standard cell based ASIC, Gate array based ASIC, channeled gate array, structured gate arrays, programmable logic devices, introduction to programmable logic, fixed versus programmable logic, programmable logic devices, types of programmable logic devices, PROMs, PLA, PAL, CPLD & FPGA. Introduction to FPGA, evolution of programmable devices, conceptual diagram of a typical FPGA, Logic blocks, interconnection resources, FPGA versus ASIC, applications of FPGA, FPGA design flow, and implementation process. FPGA Architecture Various classes of FPGAs, symmetrical array, row-based, hierarchical PLD, sea-of-gates. Programming technologies, static RAM programming technology, antifuse programming technology, EPROM and EEPROM programming technology, commercially available FPGAs, general architecture of Xilinx FPGAS, CLB Interconnect. Physical Design Circuit partitioning algorithm, K-L algorithm, floor planning algorithm, cluster growth roof planning, introduction to placement & routing. VLSI Testing Basic concepts to testing, yield and reject rate, ATPG, ATPG design flow, various stuck at faults BIST.

**Other Program Electives Available:**

**ECL505 Advanced Digital Communication**

**3-0-2(4)**

Random variables and Processes, Communication over additive Gaussian noise channels, Signal Space representation, Scalar and vector communication over Memory less channels, Additive white Gaussian noise, matched filter and error probabilities, AWGN Channels, M-Ary Orthogonal signals and matched filters, Carrier recovery and symbol synchronization in signal demodulation, Phase estimation, Communication over band limited channels, Nyquist criterion for zero ISI, Decision feedback.

**ECL523 Digital VLSI Design**

**3-0-2(4)**

MOS Transistor Theory, Fabrication and Modeling, MOSFET Scaling, CMOS Inverter, Transfer characteristics, Combinational MOS Logic Design, BiCMOS logic gates, Sequential MOS Logic Design,  Static and Dynamic Latches and Registers, Low-Power Design Techniques, Design of Arithmetic Building Blocks, Clock Strategies for Sequential Design, Memory Cells Design: Dynamic Random Access Memories (DRAM), Static RAM, non-volatile memories, flash memories, low-power memory; Case Study (instructor may choose any suitable digital system; in the following, an example is suggested) : A RISC Processor - Instruction Set, Pipeline Architecture, Major Logic Blocks, Layout, Functional Verification.

**ECL524 Low-Power VLSI Design**

**3-0-2(4)**

Need for low-power VLSI Chips, Sources of Power dissipation-static and dynamic, transistor sizing and technology scaling, Device & Technology Impact on Low Power, Power estimation Simulation Power analysis: SPICE level circuit simulation, gate level logic simulation, Monte Carlo System, Probabilistic power analysis, Low Power Design Circuit level, Logic level, Low power Architecture & Systems, Low power Clock Distribution Methodology; Signal Drivers and buffers, skews, clock network. Architectural level power estimation and advanced developments in low-power VLSI design.

**ECL527 Digital System Design with Verilog HDL**

**3-0-2(4)**

ASIC Design Flow, Language Constructs and Conventions in Verilog HDL, Combinational Logic Design, Sequential Logic Design, Architecture of FPGA, Behavioral Modeling, Modeling Techniques, State Machine, Moore and Mealy State Model, Usr Defined Primitives, Programming Language Interface, Current Trends.

**ECL528 Analog VLSI Design**

**3-0-2(4)**

Introduction to MOS Device Physics, Small Signal & Large Signal Models of MOS & BJT transistor. SingleStage  Amplifiers:,  Differential  Amplifiers,  Passive  and  Active  Loaded  Differential Amplifiers: Common  Emitter,  Common  base,  Common Collector,  Common  Drain,  Common  Gate  &  Common  Source  Amplifiers,  Current Mirror  Circuits,  Frequency  Response  of  Amplifiers,  CMOS  Operational Amplifiers,  Stability  and  Frequency Compensation, Design of two stage  MOS  Operational  Amplifier,  two  stage  MOS  operational  Amplifier  with  cascodes, MOS telescopic cascode  operational  amplifiers, MOS Folded‐cascode operational amplifiers

**ECL529 Linux & Scripting**

**3-0-2(4)**

Introduction to Unix and Linux, Command and Utility Syntax, Linux file and directories, Creating files, Creating directories, Disk utilization information, File and directory permission and privileges, Job and process management, Scheduling Jobs, Text editors- vi, vim editors, Editing files, Running C/C++ on Linux compiler, Tcl scripting, Commands, Data types, Variables, Operators, Arrays, Strings, Lists, Dictionary, Shell scripting, if-then scripts, loops, Aliases, User and Global Aliases.

**ECL538 Hardware Software CoDesign**

**3-0-2(4)**

Introduction to hardware & software co-design, Hardware Software back-ground and Hardware Software co-design research, Co-design concepts as functional decomposition and virtual machines, Methodology for co-design and Unified representation for Hardware & Software, Abstract Hardware & Software model, Performance Evaluation, Object oriented techniques in hardware design

**ECL540 Real Time Systems and Software**

**3-0-2(4)**

Real-time Versus Conventional Software, Computer Hardware for Monitoring and Control, Data Flow Diagrams, State machine, Software Engineering Issues. Process and State-based Systems model, Requirements and Design Specifications, Declarative Specifications & Deterministic Scheduling, Execution Time Prediction & Timer Applications, Programming Languages & Operating Systems. RISC Microcontroller, ATM Switch, etc.

**ECL578 Broadband Communication**

**3-0-2(4)**

Broadband networks and services, ISDN, broadband ISDN, B-ISDN standards and interface, B- ISDN protocol, ATM technology -VP,VC,ATM Packet, ATM Network Management, ATM digital exchange interface Management, Internet Telephony and voice over IP (VoIP)- RTP and RTCP, Next generation internet, multicasting in internet, real time communication over internet, Internet and web Traffic measurement and characterization.

**ECL587 VLSI Design Verification & Testing**

**3-0-2(4)**

Verification Guidelines: Verification Methodology, Data Types, Procedural Statements, Task and Functions, Routine Arguments, Local Data Storage, Basic OOP, Static and Global variables, Objects and Classes, Connecting the Testbench and Design, Stimulus Timing, SystemVerilog Assertation, Four-Port ATM Routers, Randomization, Constraints Details, Pre and Post Randomization, Threads and Interprocess Communication, Events, Semaphore, Mailbox, Testbench Building, Advanced OOPs and Guidelines.

**ECL588 MEMS & NEMS**

**3-0-2(4)**

Overview of MEMS and NEMS technology, applications of micro and nano electro mechanical systems, materials for mems, microsystems packaging, essential packaging technologies, design of MEMS and NEMS, mems system-level design methodology, equivalent circuit representation of mems, signal-conditioning circuits, and sensor noise calculation. MEMS sensors: design of acoustic wave sensors, resonant sensor, vibratory gyroscope, capacitive and piezo resistive pressure sensors- engineering mechanics behind these microsensors. Micro actuators: design of actuators, actuation using thermal forces, actuation using shape memory alloys, actuation using piezoelectric crystals, actuation using electrostatic forces (parallel plate, torsion bar, comb drive actuators), micromechanical motors and pumps. Comb drive actuators, nano systems and quantum mechanics: atomic structures and quantum mechanics, molecular and nanostructure dynamics: Schrodinger equation and wave function theory, density functional theory, nanostructures and molecular dynamics, electromagnetic fields and their quantization, molecular wires and molecular circuits.

**ECL589 Special Topics in Semiconductor Technologies and Applications**

**3-0-2(4)**

Latest topics on Semiconductor Technologies and Applications are selected by the concerned faculty to teach them to the students.

**ECL595 Edge and Fog Computing**

**3-0-2(4)**

Fog and Edge Computing Completing the Cloud, Advantages of FEC: SCALE, How FEC Achieves, These Advantages: SCANC, Hierarchy of Fog and Edge Computing, Addressing the Challenges in Federating Edge Resources. Optimization Problems in Fog and Edge Computing, Middleware for Fog and Edge Computing: Design Issues. Data Management in Fog Computing. Applications and Issues.

**ECL596 Network and Security in IoT**

**3-0-2(4)**

IoT and cyber-physical systems, IoT security (vulnerabilities, attacks, and countermeasures), security engineering for IoT development, IoT security lifecycle. Network Robustness of Internet of ThingsSybil Attack Detection in Vehicular Networks- Malware Propagation and Control in Internet of Things- Solution-Based Analysis of Attack Vectors on Smart HomeSystems.Block ciphers, message integrity, authenticated encryption, hash functions, Merkle trees, elliptic curves, public-key crypto (PKI), signature algorithms.Security and Impact of the Internet of Things (IoT) on Mobile Networks- Networking Function Security-IoT Networking Protocols, Secure IoT Lower Layers, Secure IoT Higher Layers, Secure Communication Links inIoTs, Back-end Security -Secure Resource Management, Secure IoT Databases, Security Products-Existing Test bed on Security and Privacy of IoTs, Commercialized Products.

**ECL597 Industrial IoT for Smart Cities**

**3-0-2(4)**

Introduction & Industry 4.0 IoT in smart city& their distinctive advantages like smart environment, smart streetlight, smart water management, Smart Road & Traffic, Smart Parking & waste management. The Fourth Revolution, LEAN Production Systems, Smart and Connected Business Perspective, Smart Factories. IoT Smart City Sensing and Power Management Smart Sensors and actuators as per requirement for Smart Cities, air quality, noise pollution measured using Electrochemical Sensors, Ultrasonic Sensors,IR, Obstacle, Proximity. IoT Data Acquisition System, Energy harvesting, Battery based systems, Power management. Interoperability for Smart City IoT systems Wireless communication modules and topology such as Zigbee, Bluetooth, GSM module, Wi-fi module & Things speak (IoT Platform) cloud, Ethernet, M2M Wireless Sensor Network (WSN). Module IV Software Defined Network Arduino Programming, Integration of Sensors and Actuators with Arduino, Raspberry Pi, Implementation of IoT with Raspberry Pi. Smart mobility Smart cities concept and services, traffic congestion, city energy consumption, IoT in carriage, solution, opportunities and threats. Application Area of Smart cities IOT Systems Working principle & Use of Geographical Information System (GIS), GPS module for vehicle speed measurement. Connected Parking - LoRaWAN private network.

**ECL598 IoT Design for Connected Health Care**

**3-0-2(4)**

Introduction to IoT based Health Care Introduction to IoT applications in smart healthcare & their distinctive advantages - Patient Health Monitoring System (PHMS), Tele-Health, TeleMedicine, Tele-Monitoring, Mobile Health Things (m-health). IoT Smart Sensing HeathCare and Power challenge Concept of Generic Biomedical sensors, Smart Sensors: Monitor health parameters, Wearable ECG sensors, IoT Data Acquisition System, Energy harvesting, Battery based systems, Power management. Interoperability in IoT IoT protocols –Interfacing of Zigbee module to create Wireless sensor network, M2M Wireless Sensor Network, MQTT, COAP, Principle of operation & Application of IoT Gateway Using Wi-Fi and Ethernet. Software Defined Network Arduino Programming, Integration of Sensors and Actuators with Arduino, Raspberry Pi, Implementation of IoT with Raspberry Pi. Internet of Medical Things Data Confidentially, Data Integrity, Data Protection, Security awareness, Emergent threats: Autonomous, IoT heterogeneity and ubiquity, Physical Environment. Emerging Technologies for Health and Medicine Virtual Reality, Augmented Reality, Artificial Intelligence, Robotics, Industry 4.0.

**ECL599 Special Topics in IOT & 5G**

**3-0-2(4)**

Latest topics on IOT & 5G are selected by the concerned faculty to teach them to the students.

**ECL601 Cloud Computing**

**3-0-2(4)**

Parallel and Distributed System Models, Cloud enabling technologies, Cloud Platform Architecture, Service Oriented Architecture, Cloud Programming and Software environments, Performance Scalability and Consistency on Cloud, Cloud Security. The course examines the most important APIs used in the Amazon and Microsoft Cloud, including the techniques for building, deploying, and maintaining machine images and applications. Students will learn how to use Cloud as the infrastructure for existing and new services.

**ECL633 Mixed Signal Design**

**3-0-2(4)**

Signals, Sampling, Aliasing and Tools: Sampling Techniques and circuits for signal sampling.  Mixed signal design challenges and issues. Analog Filters: implementation with Integrator, Analog filtering topology for LP, BP, etc., Analog filters, analog to Digital Converters Digital Filters: Digital to analog Converters, Digital Filtering topology.  SNR of data converters: Quantization, SNR Improvement. Design Basics and Noise-Shaping of Data Converters: First and Second Order Noise Shaping. Bandpass Data Converters and A High-Speed Data Converter: Continuous time BP noise shaping. Mixed signal design Applications and latest trends.

**ECL659 Global Navigation Satellite Systems and Applications**

**3-0-2(4)**

Orbit, Space Segment, Ground Segment, Link Budget, Multiple Access, Introduction to Global Navigation Satellite System (GNSS), Global Navigation Satellite System (GNSS), How position is determined by the GNSS? NAVSTAR - Global Positioning System, GLONASS, BDS, NavIC (IRNSS), GALILEO, QZSS, DGNSS, RTK, SBAS, GNSS errors, GNSS correction methods, GNSS- applications, trends and opportunities.