**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 2: IOT & 5G**

**ECL590 Advanced Microcontrollers and Sensors**

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

Introduction to microcontrollers, difference between microprocessors and microcontrollers, classification of microcontrollers, their applications, Introduction and definition of Internet of things, IoT growth, Application areas, characteristics, IoT Stack, Baseline technologies, Communication protocols,  Overview of Atmega328P microcontroller & NodeMCU, Interfacing digital & analog sensors, display modules and actuators with Arduino Uno, posting data on cloud, creating a web server, posting data on web page, interfacing modules like GPS, GSM and Bluetooth with nodemcu, Raspberry Pi basics and programming in python, interfacing HaT, Camera module, display modules and sensors with Raspberry Pi.

**ECL591 Advanced Wireless & Mobile Communication**

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

Introduction to wireless communications: Evolution of mobile radio communications, paging system, cordless telephone system, cellular telephone system, Modern wireless communication systems: 2G networks, 3G networks, Bluetooth and personal area networks. Mobile radio propagation: large scale path loss – Free space propagation model, basic propagation mechanisms. Digital Cellular Transmission, Spread Spectrum Transmissions Local Area & Ad Hoc Networks: LAN Technologies: Evolution of Wireless LAN, IEEE802.11, Physical, Layer, MAC Sub-layer, routing algorithms. Adhoc networks: Characteristics – Performance issues. Overview to Wireless ATM, HYPERLAN, IEEE802.15 Wireless PAN, and Home RF. Bluetooth Cellular concepts: Frequency reuse, channel assignment strategies, handoff strategies, interference and system capacity, improving coverage and capacity in cellular systems, routing in mobile hosts. Mobile IP – DHCP – Mobile transport layer – Indirect TCP – Snooping TCP – Transmission / time-out freezing – Selective retransmission –Transaction oriented TCP.

**ECL592 IoT: Architecture and Protocols**

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

Introduction to IOT, Applications of IOT, Use cases of IOT, The IoT Architectural Reference Model as Enabler, IoT in Practice: Examples: IoT in Logistics and Health, IoT Reference Model: Domain, information, functional and communication models; IoT Reference Architecture: Architecture, Functional, information, deployment and operation views; SOA based Architecture, API-based Architecture, OPENIoT Architecture for IoT/Cloud Convergence. Application Protocols for IoT: UPnP, CoAP, MQTT, XMPP. SCADA, WebSocket; IP-based protocols: 6LoWPAN, RPL; Authentication Protocols; IEEE 802.15.4. Case study: Cloud-Based Smart-Facilities Management, Healthcare, Environment Monitoring System.

**ECL593 Design for IOT**

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

Design for longevity/energy efficiency needs to be highlighted. Step-by-step system design to be introduced. Security in IoT, Recognize security vulnerabilities, such as weak configurations, unpatched systems. Design of Arduino IDE libraries and functions, IoT platforms, End to End Communication, Design of circuits using heat sinks.

**ECL594 5G: Technologies, Architecture and Protocols**

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

The requirements and key drivers for 5G wireless development, 5G use cases and services, the key technologies in 5G NR (Dual Connectivity, small Cells, CRAN, Flexible Numerology, massive MIMO etc), 5G Radio Access Technology And Frame Structure, Network Virtualization and Slicing in 5G, The Key elements/Functions in 5G Core Network, UE and Network Identifiers in 5G, Procedures in 5G (UE Registration, PDU Session establishment, Paging, Tracking Area Update, Handover), Handover in 5G, Xn and X2, 5G Service Based Architecture, Network Slicing, Security in 5G Mobile Networks, Voice Over 5G, 5G UE State Management, 5G PDU Session Types, Attributes and Quality of Service (QoS), 5G Air Interface Channels, Cell Acquisition, Data Scheduling, Paging.

**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.