2020-2021

Master of Science in Electrical Engineering *with* ***Specialization in Integrated Circuits*** and *Gradate Diploma in* ***Integrated Circuits***

"A training from Idea to Product Design"

Salient Features and Objectives:

- First dedicated IC design program in Pakistan, supported and funded by the industrial partners.
- A hand on experience from project conception to the **working silicon microchip**.
- A bridge between the industry-and-academia in order to pave the way to FAB-less innovations resulting in commercialization IC design houses.
- To establish the VLSI Design and Training Centre at FAST-NU, Islamabad in cooperation with our Industrial Partners.

Program Objectives

This program prepares a graduate in Electrical Engineering to acquire expertise in the area of Integrated Circuits. This program is fully dedicated and focused on the IC design knowledge and skills, each student in this program will do the real world tape out from project conception to the working silicon microchip under the guidance of faculty supervisor from university and industry experts.

Eligibility

Bachelor's degree in a relevant engineering discipline (Electrical, Electronics, Telecommunications, or Computer engineering, etc.), recognized by Pakistan Engineering Council (PEC).

Minimum CGPA of 2.0 (on a scale of 4.0) or at least 60% marks.

Selection Criteria:

- Past Academic Record (Bachelor): 40%
- Performance in NU MS Admission Test: 60%
- The test will be exempted for the industrial sponsored fellows

A student has the option to pursue MS by undertaking either a 6-credit hour MS Thesis or MS Project, spread over two regular semesters.

Tentative Study Plan

Semester I		
SS 505	Core Course-I (RM)	1
EE	Core Course-II	3
EE	Core Course-III	3
EE	Elective -I	3
	Total	**10 credits**

Semester-II		
EE	Core Course-IV	3
EE	Core Course-V	3
EE	Elective -II	3
	Total	**9 credits**

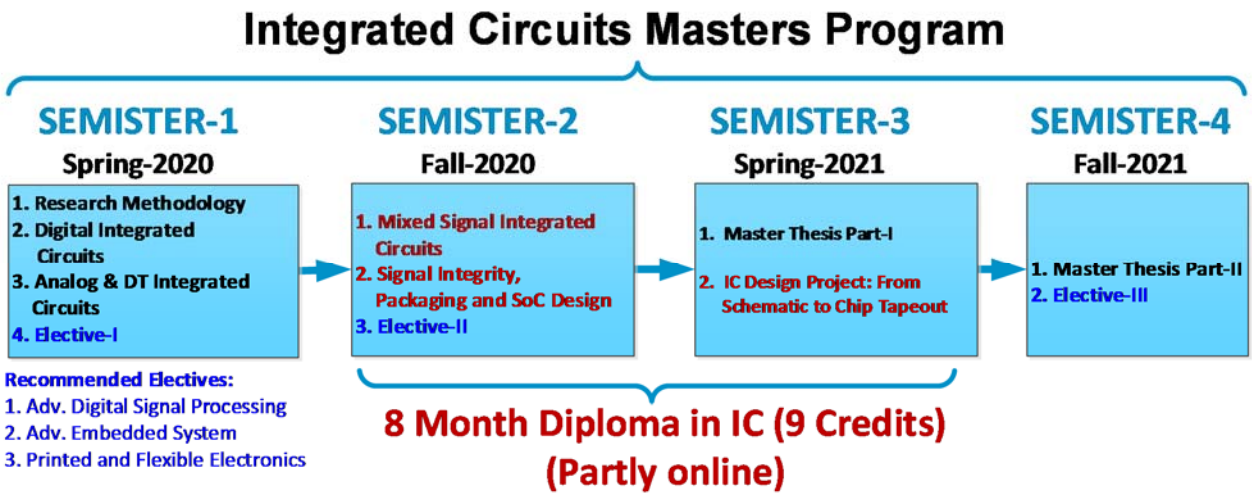
Semester-III		
EE	Core Course-VI	3
EE 591	MS Thesis-I	3
	Total	**6 credits**

Semester-IV		
EE	Elective -III	3
EE 592	MS Thesis-II	3
	Total	**6 credits**

The total credits of the MS programs are 31, which includes the 25 credits of the course work including the 01 credit Research Methodology Course and 06 credits of the MS thesis work.

Note: Registration in "Project – I" is allowed provided the student has:

- Earned at least 19 credits
- Passed the "Research Methodology" course;
- CGPA is equal to or more than 2.5



MS (Electrical Engineering – Specialization in Integrated Circuits)

Core Courses for MS-EE with Specialization in Integrated Circuits:

1. Research Methodology **01 Credits** (HEC Requirement)
2. Digital Integrated Circuits **03 Credits**
3. Analog & DT Integrated Circuits 03 **Credits**
4. Mixed Signal Integrated Circuits **03 Credits**
5. Signal Integrity, Packaging and SoC Design 03 **credits**
6. IC Design Project: From Schematic to Chip Tapeout 03 **credits**

Elective Courses (One must select minimum of 3 courses from this list of Electives)

1. RF Integrated Circuits **03 Credits**
2. Nano Electronics **03 Credits**
3. Printed and Flexible Electronics **03 Credit**
4. Advance Microwave Engineering **03 Credits**
5. Advance Embedded Systems **03 Credits**
6. Advance Digital Signal Processing **03 Credits**
7. Advanced Wireless Communication **03 Credits**
8. IC Marketing and Business Management **03 Credits**

Graduate Diploma (Electrical Engineering – Specialization in Integrated Circuits)

The student taking any three courses (9 Credits) from the core courses including the Course (IC Design Project: From Schematic to Chip Tapeout) will be given the Diploma in IC design endorsed by the FAST-NU (NUCES) EE department.

Teaching Faculty

- Prof. Dr. Rashad Ramzan
- Prof. Dr. Ata-ul-Aziz
- Prof. Dr. Mukhtar Ullaha
- Dr. Baber Minhas
- Dr. Arshad Hassan
- Dr. Shazad Saleem
- Dr. Durdana Habib
- Dr. Farhan Khalid
- *Visiting Faculty from Industry including the industrial partners*
- *New Faculty (IC Design Specialist)*

06 Compulsory Courses (16 Credit Hours):

Research Methodology: The course is mandatory for all graduate programs offered under HEC umbrella. The course covers central aspects of the research process, as well as principles and questions related to quality assessment, research planning, problem formulation, statistical data analysis, presentation of a research project, and research ethics. (01 credits; HEC requirement)

Digital Integrated Circuits: Review of integrated circuit fundamentals, CMOS devices characteristics, Design Layout rules, CMOS Inverter, Construction of multiplexers, Transmission gates, latches, flip flops, Combinational Logic, Sequential logic circuits, Adders , Multiplier , and accumulators, , Memory cells, Layout strategies, Logic synthesis and CAD tools.
Lab Tutorials: Design of logic gates, FFs, and complex circuits and layout in cell library format in Magic/LASI and Cadence tool suite (03 credits)

Analog & DT Integrated Circuits: Review of fundamentals, Analog building blocks, CMOS Device and Noise – Fundamentals , Single-stage (CS, CG, CD), Differential pair and multistage amplifiers, CMOS operational amplifier, Noise in CMOS Circuits, Feedback Principles, Current Sources and Current mirrors , Voltage comparators, Sample & Hold Circuits, Band-gap voltage references , MOS Switched-Capacitor (SC) circuits, Continuous-time Filters, OTA, and Gm cells
Lab Tutorials: Design of current sauces/sinks, current mirrors, operational amplifier and its compensation in Cadence tool suite (03 credits)

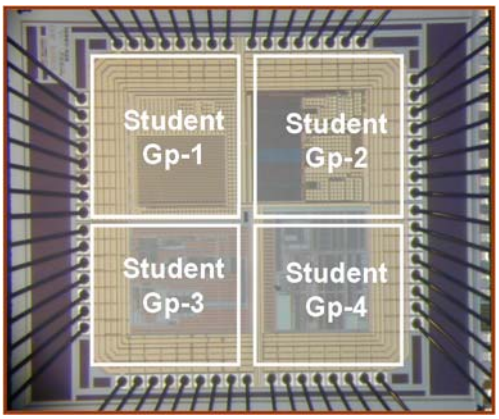
Mixed-Signal Integrated Circuits: Non-Linearity and mismatch, CMOS Processing Technology, Layout Fundamentals, Sample and hold circuits, Data converters – Fundamentals and performance metrics, Nyquist Digital-to-Analog Converters, Nyquist Analog-to-Digital Converters, Z-Transform, Oversampling ($\Sigma\Delta$) Data Converters.
Lab Tutorials: Design of Flash DAC and $\Sigma\Delta$ Analog-to-Digital Converter in Cadence tool suite (03 credits)

Signal Integrity, Packaging and Chip Design: Signal Integrity Principals, Chip interconnect and Transmission Lines, Clock Distribution, IO Pads, Pad Driver Circuits type and standards, Pad Protection and high speed characteristics, IBIS models and applications, IC Packaging types, Electrical and thermal

management. SoC Modules, multichip and 3D packaging. IC assembling, sealing and encapsulation. IC packaging failure and reliability. Microsystems packaging and applications (03 credits)

Lab Tutorials: Modeling and simulations of the chip interconnect, IO loading, and on-chip transmission lines (03 credits)

IC Design Project: From Schematic to Chip Tapeout: Project selection, Pre-study, and planning, Schematic or HDL Capture, Architectural level, Gate/Transistor level, Synthesis and simulations, Pad Frame selection and design, library mapping and optimization, Layout and DRC, Post-layout verifications, Back Annotations, Generation of mask data-base for chip-layout, Final tapeout. (03 credits) *This is self-paced lab based course. Each student will conceive a project and will pass through all the steps and do the final tapeout which will be manufactured through an external IC manufacturer.*



Elective Courses (9 Credit Hours)

RF Integrated Circuits: Basics Concepts of RF Electronics, Linearity (1dB CP and IIP3) and noise (Noise Figure) in radio circuits, High frequency model of the CMOS and BJT circuits, IC technology suitable for radio circuit design, Radio Standards, Radio Transceiver Architectures, Radio Transceiver Calculations, Transmission lines and impedance matching, Wideband and Narrow band design issues, Low Noise Amplifiers (LNAs), Active and Passive Mixers, Voltage Controlled Oscillators and Phase Lock Loops, Power Amplifiers (03 credits)

Printed and Flexible Electronics: Flexible and Printed Electronics and their Materials Systems, Thin-film Deposition and Processing Methods, Substrates for flexible electronic devices and circuits, Resistive switching devices (memristors) and their applications, OLEDs and their applications in thin-film transistor-based (OTFTs) displays, Flexible organic photovoltaics (OPVs), Thin-Film Transistors, Flexible batteries, Interfaces to Organic and Inorganic Electronic Devices, Energy harvesting technologies, flexible electronic packaging (03 credits)

Nano Electronics: Fundamentals of Quantum Mechanics, quantum wells, quantum wires and quantum dots, Electronic, optical, transport properties of nanostructures, Quantum semiconductor devices. Fabrication and characterization techniques of nanotechnology. Introduction and applications of quantum computing, Nanotechnology, Nanomaterial Fabrication Techniques, Nanomaterial Characterization, Design of basic circuit elements in the Nano domain, Nano electronics and Carbon Nanotubes (03 credits)

Advance Embedded Systems: Basics of processor architectures. Memory organization and caches. Worst-Case Execution Time (WCET) Analysis, Compositional Timing Analysis for embedded systems, Embedded software platforms, Performance analysis, memory hierarchy, buses , peripherals, Wireless Sensor Networks, Internet of Things, Embedded systems platforms: MCUs, DSPs, GPU, FPGAs, Code optimization, Factors affecting Execution time, Multi-tasking and real-time operating systems, Scheduling algorithms and their performance (03 credits)

Lab Tutorials/Class Project: Design and implementation of simple RISC processor on FPGA.

Advance Digital Signal Processing: Introduction, Discrete-time Fourier transform (DTFT), Sampling & reconstruction, Fast Fourier transform (FFT), Using z-transform to represent linear time-invariant (LTI) systems, Digital filter design fundamentals, IIR, FIR and CIC filter design and implementation, DSP algorithm implementation issues and optimization, Linear prediction and optimal linear filters, Power spectrum estimations. (03 credits)
Lab Tutorials/Class Project: Implementation of FIR, IIR or CIC comb filter on FPGA.

IC Marketing and Business Management: Trends in the IC business: Technology and manufacturing trends, Demand, applications and product trends. Market Appearances: The customers, overall Business cycles, The bull-whip effect), IC industry, supply & value chain, Geo distribution of Technology and fabrication centers, The dis-integration of the value chain, outsourcing trends, Managing the marketing function: The sources of product ideas, The role of standard and intellectual property, The strategic partnership, distributorship and matching supply with demand. (03 credits)

Advanced Microwave Engineering: Introduction to microwave engineering, microelectronics device and device models, Transmission lines theory, reflection and transmission analysis, Microwave network analysis, impedance matching networks and tuning, wideband impedance matching issues microwave resonators, Power Dividers and directional couplers, Microwave filters and their implementation, Noise in microwave circuits, Microwave amplifier design, Microwave oscillators and mixers circuits. (03 credits)

Advanced Wireless Communication: Introduction to Wireless & Mobile Communications, Propagation Models, Channel Models, Channel Sounding, Equalization, Transmission & Multiple Access techniques: OFDM/OFDMA, SC-FDMA etc., Multiantenna Systems: MISO, SIMO, MIMO, diversity, beamforming, spatial multiplexing, space-time coding (STC), BLAST architecture, massive MIMO, MIMO-OFDM transceiver design, Current Wireless Standards: IEEE 802.11n/ac WiFi, 4G mobile: 3GPP LTE, 3GPP LTE-Advanced (Emphasis on radio access network (RAN) part), 5G RAN, Satellite Communications (03 credits)