Institute of Microelectronics

Master's Degree Programmes

Master of Philosophy

- **Microelectronics**

		Credits
IMEL7000	Microelectronic Circuit Design	3
IMEL7990	Thesis	12
5 Required Electives chosen from the elective table		15
Total Credits:		**30**

Elective Table for MPhil in Microelectronics:

IMEL7001	Integrated Circuits Research Methodology and Applications
IMEL7002	Digital Integrated Circuits
IMEL7003	Data Converter Integrated Circuits
IMEL7004	Flexible Alternating Current Transmission System
IMEL7005	Power Management Intergrated Circuit Design
IMEL7006	Special Topics in Biomedical Engineering
IMEL7007	High-Frequency and High-Speed Wireless/Wireline Integrated Circuit
IMEL7008	Analog IC Design Methodology
IMEL7009	Machine Learning and Analog Accelerators
IMEL7010	Interface Microelectronic Circuits and Sensors Design
IMEL7011	Microelectronics for the Internet of Things

INSTITUTE OF MICROELECTRONICS

Master's Degree Programmes

Master of Science

- **Microelectronics**

Students who take Project Report are required to take 7 courses from the following Required Electives to obtain 21 credits; students who take Internship and Report are required to take 8 courses from the following Required Electives to obtain 24 credits

		Credits
IMEL7000	Microelectronic Circuit Design	3
IMEL 7998	Project Report	6
7 Required Electives chosen from the elective table		21
Total Credits:		**30**

OR

IMEL7000	Microelectronic Circuit Design	3
IMEL 7997	Internship and Report	3
8 Required Electives chosen from the elective table		24
Total Credits:		**30**

Elective Table for MSc in Microelectronics:

IMEL7001	Integrated Circuits Research Methodology and Applications
IMEL7002	Digital Integrated Circuits
IMEL7003	Data Converter Integrated Circuits
IMEL7004	Flexible Alternating Current Transmission System
IMEL7005	Power Management Intergrated Circuit Design
IMEL7006	Special Topics in Biomedical Engineering
IMEL7007	High-Frequency and High-Speed Wireless/Wireline Integrated Circuit
IMEL7008	Analog IC Design Methodology
IMEL7009	Machine Learning and Analog Accelerators
IMEL7010	Interface Microelectronic Circuits and Sensors Design
IMEL7011	Microelectronics for the Internet of Things

IMEL7000 MICROELECTRONIC CIRCUIT DESIGN

This course is designed to discuss on fundamental principles for analysis and design of analog circuits and the practical considerations in integrated circuit design. Students will learn how to design, analyze and evaluate amplifiers as an essential integrated circuit building block. Advanced amplifiers/analog circuit layout techniques with case studies will also be introduced. By providing hands-on practice with one real advanced VLSI CMOS process using industrial EDA tools, students can have a deep understanding on how to design practical integrated circuits and make real world engineering tradeoffs. This course will be assessed with assignments, presentations and projects.

This course enables students to have:

- To introduce the essential knowledge in analog circuits design.
- To introduce common analog circuit building blocks with practical considerations.
- To teach students with hands on experience on designing and simulating analog circuits using industrial simulation tools with real world CMOS process.

Pre-requisite: None

IMEL7001 INTEGRATED CIRCUITS RESEARCH METHODOLOGY AND APPLICATIONS

This is an introductory course of integrated circuits research methodology and applications. It aims to aid the students to build up an internationally competitive research goal by understanding the state-of-the-art, trends in applications and technologies, and systematically formulate a feasible schedule, with available resources, to approach the research goals. Preparation of related academic publications and system-level case studies of advanced integrated circuits and systems will be organized for the students to digest and present them. The course aims to provide the students a set of essential engineering skills for research in the integrated circuits area.

This course enables students to have:

- To introduce the essential knowledge on starting integrated circuits research.
- To introduce the trend of integrated circuits for practical applications.
- An ability to communicate effectively and understand the integrated circuits industrial trends.
- An ability to understand the impact of integrated circuit solutions in a global and societal context.
- Ability to use the computer/IT tools relevant to the discipline along with an understanding of their processes and limitations.

Pre-requisite: None

IMEL7002 DIGITAL INTEGRATED CIRCUITS

This is an introductory course in digital integrated circuits. It covers topics from MOS inverters and different logic family. The student will learn how to model interconnect wires and design optimization with respect to a number of metrics: cost, reliability, speed and power. This course also cover sequential and dynamic logic circuit design, timing considerations, and clocking approaches, as well as design of large system blocks, including memories, such as D-flip-flop and SRAM. This customized course from bottom-up based, which starts from the fundamental techniques for the design and analysis of digital circuits. Then, it provides a detailed understanding of basic logic synthesis and analysis algorithms, and to enable students to apply this knowledge in the design of digital systems and EDA tools. The course aims to give a basic idea of the digital integrated circuit design. The students will have a hands-on experience on combinational circuit optimization (two-level and multi-level synthesis), sequential circuit optimization (state encoding, retiming), timing analysis, testing, and logic verification through the lab work.

This course enables students to have:

- To introduce the essential knowledge in digital circuits design both for custom and auto generation schemes.
- To introduce common digital circuit building blocks, such as logic gates, adder and SRAM, with practical considerations.
- To teach students with hands on experience on designing and simulating digital circuits using industrial simulation tools with real world CMOS process.
- To teach students with hands on experience on the digital standard cell design with real physical layout consideration using industrial layout tools in CMOS process..

Pre-requisite: None

IMEL7003 DATA CONVERTER INTEGRATED CIRCUITS

This course will provide an introduction to the various type of Data Conversion System. The performance characterization of Data Converters will be presented, and various type of data converters (including Analog-to-Digital and Digital-to-Analog) will be discussed. This course can be served as the beginning course in the field of Data Conversion and Signal Processing in the area of Analog IC Design.

This course enables students to have:

- An ability to understand and analyze the definitions of performance parameters for data converters, in datasheet and research papers.
- An ability to design the digital-to-analog converters.
- An ability to design the analog-to-digital converters.
- An ability to design the delta-sigma modulators.
- To implement the systems above using EDA tools widely adopted in IC industries.

Pre-requisite: None

IMEL7004 FLEXIBLE ALTERNATING CURRENT TRANSMISSION SYSTEM

The Flexible Alternating Current Transmission System and Distribution Flexible AC Transmission System (FACTS/DFACTS) are a new converging technology based on the Power Electronics, Control Theory and Power System for revolution of ever more efficient control and better utilization of power and energy in the existing systems. The FACTS offers an opportunity to enhance controllability, stability and power transfer capability of AC transmission systems with fastest control speed. DFACTS is the extended modern technique of FACTS to focus on the Custom issues or power line conditioning in the distribution site as well as the Information Technology's Electricity Issues.

This course enables students to have:

- Students can understand the basic concepts, fundamental operational principles, advantages and disadvantages of different FACTS/DFACTS devices.
- Students can also understand the control strategies of some selected FACTS/DFACTS devices, in which FACTS/DFACTS devices are commonly found in nowadays power and distribution power systems.

Pre-requisite: None

IMEL7005 POWER MANAGEMENT INTEGRATED CIRCUIT DESIGN

This course starts from a single transistor, with introductions on transistor fabrication and electrical characteristics. Then, single-stage analog amplifier will be analyzed, design and analyses of two-stage amplifier will be discussed. After we know the analog integrated circuit (IC) design basics, we will learn the basic components of power management ICs: low-dropout regulators, inductor-based and switched-capacitor DC-DC converters. Last but not least, wireless power transfer circuits and systems will be briefly introduced.

This course enables students to have:

- An ability to introduce the essential knowledge in power management integrated circuits design.
- An ability to design and simulate power management ICs using EDA tools with CMOS process.
- An ability to design a low-dropout regulator to meet full design constraints.

- An ability to analyze a DC-DC converter seen for the first time.
- An ability to present design project results both orally and in IEEE-style reports.

Pre-requisite: None

IMEL7006 SPECIAL TOPICS IIN BIOMEDICAL ENGINEERING

This course is an introductory course on multidisciplinary topics covering microelectronics, biomedical engineering, and digital microfluidics. As a special topic course, it will focus on the principles and biomedical applications of digital microfluidics, which utilizes electronic signal to manipulate liquid droplets on an array of micro-electrodes. The course also covers the introduction of the fabrication technology in clean room related to MEMS and soft-lithography. The coating and etching techniques on silicon wafers or glass chips will be introduced and practiced in this course.

This course enables students to have:

- Acquire the state of the art knowledge in the development of biomedical engineering.
- Get information of new technologies in the field of biomedical engineering.
- Understand the working principles of microfluidics, including PDMS based channel microfluidics and electronic based digital microfluidics.
- Acquire the fabrication techniques of silicon- or glass-based micro-electrode fabrication and 3D pattern on-chip.
- Be aware of the various biological applications of biomedical technologies.
- Develop a self-learning capability.
- Initiate a multidisciplinary research mind.

Pre-requisite: None

IMEL7007 HIGH-FREQUENCY AND HIGH-SPEED WIRELESS/WIRELINE INTEGRATED CIRCUIT

This is an introductory course in the high-frequency and high-speed systems and circuit of both wireless and wireline tailored for ECE students. It covers topics from basic circuit techniques in the data path of both wireless and wireline, such as low-noise amplifier, mixer, linear equalizer, non-linear equalizer, automatic gain control amplifier, clock and data recovery circuit, to basic circuit techniques in the clock path, for example, PLL, VCO and divider. Also, we brief more recent techniques such as non-contact communication and RF+BB communication with special attention to hardware aspects and wireline applications. The course aims to offer students a set of modern wideband system and circuit solutions as well as the basic ideas and intuition behind, with more emphasis on hands-on experience through practical examples such as high-frequency and high-speed circuit implementation and case studies with Cadence/MATLAB.

This course enables students to have:

- To introduce the essential knowledge of high-frequency and high-speed systems and circuits in both wireless and wireline designs.
- To introduce the different aspects of wireless and wireline designs.
- To introduce the common wireless/wireline circuit building blocks with practical considerations in the data path.
- To introduce the common wireless/wireline circuit building blocks with practical considerations in the clock path.
- To teach students with hands-on experience of designing and simulating high-frequency and high-speed circuits using industrial simulation tools with real-world CMOS process.

Pre-requisite: None

IMEL7008 ANALOG IC DESIGN METHODOLOGY

This course provides the necessary systematic approach methodology in generic analog IC designs. The topics covered include the technique in systematic method in analysis and design of the amplifiers and opamps, such as using the scaled current and multiplier techniques, the impedance rules-of-thumb, and layout-oriented amplifier design techniques. Advanced layout techniques in detail, the analog IC simulations methodology, etc. will be covered. Project-based

evaluations will be the primary assessments for the students' performance.
This course enables students to have:

- Understand the systematic design approach on how to design amplifiers and opamps.
- An ability familiar with the advanced layout techniques.
- To understand the theories for simulations.
- To master the above topics through practical design projects.

Pre-requisite: None

IMEL7009 MACHINE LEARNING AND ANALOG ACCELERATORS

This is an introductory course in machine learning tailored for IME students. It covers the topics from classification, regression and statistical signal processing, to more recent techniques such as neural network and deep learning. It also covers the analog approximate computing integrated circuit design considerations for acceleration purpose. The course aims to offer students the fundamental concepts in the advanced artificial intelligence theory with emphasis on hands-on experience through practical examples such as intelligent hardware system implementation and case studies with MATLAB/Python. The verified algorithm can be further implemented on an FPGA for applications such as image/audio recognition.
This course enables students to have:

- To introduce the essential knowledge in machine learning and deep learning.
- To introduce analog accelerators with practical circuit considerations.
- To teach students with hands on experience on designing, training and verifying neural networks for image/audio classification problems using MATLAB/Python.
- To teach students with hands on experience on implementing the neural networks on an FPGA board for real-time classification.

Pre-requisite: None

IMEL7010 INTERFACE MICROELECTRONIC CIRCUITS AND SENSORS DESIGN

The sensors and their interfaces with the circuits are important part of the electronic devices. They capture vital information from the real world. This course covers the design of sensors and interfacing circuits in CMOS process. The student will learn to design the sensors for different sensing purposes and their front-end interfaces to process the acquired signals at both system- and circuit-level. Different design considerations such as noise, power consumption, distortion/nonlinearity will be discussed. Fabrication of the micro-electro-mechanical systems and their integration with the CMOS integrated circuits will also be covered.
This course enables students to have:

- To build fundamental blocks in the CMOS process for signal readout.
- To design sensing systems in CMOS process.
- To realize different sensing elements (thermal, capacitive, magnetic, optical, etc.) in the CMOS process and their potential applications.
- To understand how to interface between the sensing elements and the readout circuits.
- To understand the Micro-Electro-Mechanical Systems (MEMS) and the synergy between MEMS and CMOS process.
- To use the simulation tools to design the sensing circuits and systems in CMOS process along with an understanding of their limitations.
- To present and communicate technical ideas and concepts effectively among different fields.

Pre-requisite: None

IMEL7011 MICROELECTRONICS FOR THE INTERNET OF THINGS

As enabled by the powerful technology, mircoelectronics have become essential in our daily lives. They are also used in a wide range of fields such as healthcare, environmental monitoring, robotics or entertainment etc. This introductory course in microelectronics is tailored for the Internet of Things (IoTs), which teaches how to use mircoelectronic circuits interacting with the environment through sensors and communicate wirelessly with the other devices. It covers topics from evaluation and implementation of sensor interface, data conversion, signal

processing and device communications. This customized course from bottom-up based, which starts from introducing the fundamental building blocks in microelectronics for the IoT. Then, followed by system and architectural interface considerations. Finally, the students have chance to realize a basic IoT system based on available microelectronic module. The course aims to give a basic idea of the key microelectronic building blocks for the IoT application. The students will have a hands-on experience through practical design examples and case studies with available microelectronic module.
This course enables students to have:

- To introduce the essential knowledge in basic building blocks and system of IoT system.
- To introduce practical considerations of IoT system, especially emphasized on wireless communction and its essential chip sets.
- To teach students with hands on experience on verifying and designing IoT system with exisiting modula.

Pre-requisite: None

IMEL7990 THESIS
An independent and original research study under the supervision of a faculty staff member. An academic thesis is a scholarly written document of a piece of original research on a particular topic in consistent with every details of research methodology. In general, the study could result in a technical publication or a presentation at a professional meeting.
This course enables students to have:

- An ability to apply knowledge of mathematics, science, and engineering appropriate to the degree discipline.
- An ability to design and conduct experiments, as well as to analyze and interpret data.
- An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.
- An ability to function on multi-disciplinary teams.
- An ability to identify, formulate, and solve engineering problems.
- An understanding of professional and ethical responsibility.
- An ability to communicate effectively.
- An ability to understand the impact of engineering solutions in a global and societal context, especially the importance of health, safety and environmental considerations to both workers and the general public.
- An ability to stay abreast of contemporary issues.
- An ability to recognize the need for, and to engage in life-long learning.
- An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice appropriate to the degree discipline.
- Ability to use the computer/IT tools relevant to the discipline along with an understanding of their processes and limitations.

Pre-requisite: None

IMEL7997 INTERNSHIP AND REPORT
An independent project carried out under the supervision of a faculty staff member and a project manager in industry. Internship training will be carried out at a selected industry.
This course enables students to have:

- An ability to apply knowledge of mathematics, science, and engineering appropriate to the degree discipline.
- An ability to design and conduct experiments, as well as to analyze and interpret data.
- An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.
- An ability to identify, formulate, and solve engineering problems.
- An understanding of professional and ethical responsibility.

- An ability to communicate effectively.
- An ability to understand the impact of engineering solutions in a global and societal context, especially the importance of health, safety and environmental considerations to both workers and the general public.
- An ability to recognize the need for, and to engage in life-long learning.
- An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice appropriate to the degree discipline.
- Ability to use the computer/IT tools relevant to the discipline along with an understanding of their processes and limitations.

Pre-requisite: None

IMEL7998 PROJECT REPORT

An independent project carried out under the supervision of a faculty staff member.
This course enables students to have:

- An ability to apply knowledge of mathematics, science, and engineering appropriate to the degree discipline.
- An ability to design and conduct experiments, as well as to analyze and interpret data.
- An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.
- An ability to function on multi-disciplinary teams.
- An ability to identify, formulate, and solve engineering problems.
- An understanding of professional and ethical responsibility.
- An ability to communicate effectively.
- An ability to understand the impact of engineering solutions in a global and societal context, especially the importance of health, safety and environmental considerations to both workers and the general public.
- An ability to stay abreast of contemporary issues.
- An ability to recognize the need for, and to engage in life-long learning.
- An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice appropriate to the degree discipline.
- Ability to use the computer/IT tools relevant to the discipline along with an understanding of their processes and limitations.

Pre-requisite: None