FINAL YEAR OPTION

~ for Academic Year 2014 Semester 2 & 2015 Semester 1

CURRICULUM STRUCTURE

All final year students will have to select one option group from the following:

Group	Option	Acronym
A	ELECTRICAL AND SYSTEMS ENGINEERING	ECAL
B	ELECTRONIC ENGINEERING	ENIC
C	INFOCOMMUNICATIONS ENGINEERING	INON

The option group selected should be the same for both semesters. The courses to be taken in each semester are as follows:

CORE	EE4080 Final Year Project
GER-CORE	EE0040 Engineers & Society HW0310 Professional Communication
DESIGN	2 Electives
TECHNICAL	3 Electives

DESIGN and TECHNICAL Elective Courses

- Students must read two (2) DESIGN elective courses and three (3) TECHNICAL elective courses from their chosen option group.
- The design elective courses and technical elective courses offered under the different option groups are given in Tables A to C below.
- Students who wish to pursue a more in-depth specialization within the three broad option groups may do so by selecting the relevant DESIGN and TECHNICAL electives courses from the eight areas of specialization under the respective option group as given in Table D below

TABLE A: ELECTRICAL AND SYSTEMS ENGINEERING

COURSE CODE AND TITLE		AVAILABILITY	
		AY2014 SEM 2	AY2015 SEM 1 (Tentative)
DESIGN ELECTIVE COURSES (Select any 2)			
EE4207	CONTROL ENGINEERING DESIGN		✓
EE4208	INTELLIGENT SYSTEM DESIGN	✓	
EE4503	POWER ENGINEERING DESIGN		✓
EE4504	DESIGN OF CLEAN ENERGY SYSTEMS	✓	
EE4901	BIOMEDICAL CONTROL SYSTEM DESIGN		✓
EE4902	DESIGN OF MEDICAL INFORMATION PROCESSING SYSTEMS	✓	
TECHNICAL ELECTIVE COURSES (Select any 3			
EE4001	SOFTWARE ENGINEERING	✓	✓
EE4265	PROCESS CONTROL SYSTEMS		✓
EE4266	COMPUTER VISION		✓
EE4268	ROBOTICS AND AUTOMATION	✓	✓
EE4273	DIGITAL CONTROL SYSTEMS	✓	
EE4285	COMPUTATIONAL INTELLIGENCE	✓	
EE4530	POWER SYSTEM ANALYSIS AND CONTROL		✓
EE4532	POWER ELECTRONICS AND DRIVES		✓
EE4534	MODERN DISTRIBUTION SYSTEMS WITH RENEWABLE RESOURCES	✓	
EE4903	PHYSIOLOGICAL SYSTEMS ANALYSIS		✓
EE4904	BIOMEDICAL INSTRUMENTATION	✓	
EE4840	BIOPHOTONICS	✓	

TABLE B: ELECTRONIC ENGINEERING

COURSE CODE AND TITLE		AVAILABILITY	
		AY2014 SEM 2	AY2015 SEM 1 (Tentative)
DESIGN ELECTIVE COURSES (Select any 2)			
EE4303	MIXED-SIGNAL IC DESIGN		✓
EE4304	RADIO FREQUENCY INTEGRATED SYSTEM DESIGN	✓	
EE4305	DIGITAL DESIGN WITH HDL		✓
EE4613	CMOS PROCESS AND DEVICE SIMULATION BY TECHNOLOGY CAD		✓
EE4614	DEVICE PARAMETER EXTRACTION AND LAYOUT IMPLEMENTATION	✓	
TECHNICAL ELECTIVE COURSES (Select any 3			
EE4001	SOFTWARE ENGINEERING	✓	✓
EE4340	VLSI SYSTEMS		✓
EE4341	ADVANCED ANALOG CIRCUITS		✓
EE4343	RADIO FREQUENCY CIRCUITS	✓	
EE4344	ANALYSIS & DESIGN OF INTEGRATED CIRCUITS	✓	
EE4645	MICROFABRICATION ENGINEERING		✓
EE4646	VLSI TECHNOLOGY	✓	
EE4647	MICROELECTRONIC DEVICES		✓
EE4648	FLAT PANEL DISPLAY TECHNOLOGIES		✓
EE4694	IC RELIABILITY AND FAILURE ANALYSIS		✓
EE4838	LASER ENGINEERING AND APPLICATIONS	✓	
EE4840	BIOPHOTONICS	✓	

TABLE C: INFOCOMMUNICATION ENGINEERING

COURSE CODE AND TITLE		AVAILABILITY	
		AY2014 SEM 2	AY2015 SEM 1 (Tentative)
DESIGN ELECTIVE COURSES (Select any 2)			
EE4105	CELLULAR COMMUNICATION SYSTEM DESIGN	✓	
EE4109	MICROWAVE CIRCUIT AND SYSTEM DESIGN	✓	
EE4110	OPTICAL COMMUNICATION SYSTEM DESIGN		✓
EE4413	DSP SYSTEM DESIGN		✓
EE4717	WEB APPLICATION DESIGN		✓
EE4718	ENTERPRISE NETWORK DESIGN	✓	
TECHNICAL ELECTIVE COURSES (Select any 3			
EE4001	SOFTWARE ENGINEERING	✓	✓
EE4151	RF AND MICROWAVE ENGINEERING		✓
EE4152	DIGITAL COMMUNICATIONS		✓
EE4153	TELECOMMUNICATION SYSTEMS	✓	
EE4188	WIRELESS COMMUNICATIONS		✓
EE4190	INTRODUCTION TO MODERN RADAR	✓	✓
EE4455	EMBEDDED SYSTEMS	✓	
EE4475	AUDIO SIGNAL PROCESSING		✓
EE4476	IMAGE PROCESSING		✓
EE4478	DIGITAL VIDEO PROCESSING	✓	
EE4483	ARTIFICIAL INTELLIGENCE AND DATA MINING		✓
EE4490	MULTIMEDIA SYSTEMS		✓
EE4756	COMPUTER ARCHITECTURE	✓	
EE4758	COMPUTER SECURITY		✓
EE4761	COMPUTER NETWORKING	✓	
EE4791	DATABASE SYSTEMS	✓	

TABLE D: SPECIALISATION

OPTION	SPECIALISATION	RECOMMENDED ELECTIVE COURSES
ECAL	INTELLIGENT SYSTEMS & CONTROL ENGINEERING	EE4207, EE4208, EE4265, EE4266, EE4268, EE4273, EE4285
	ELECTRICAL POWER AND ENERGY	EE4503, EE4504, EE4530, EE4532, EE4534, EE4265, EE4273, EE4285, EE4001
	BIOMEDICAL ELECTRONICS	EE4901, EE4902, EE4903, EE4904, EE4265, EE4266, EE4840
ENIC	INTEGRATED CIRCUIT DESIGN	EE4303, EE4304, EE4305, EE4340, EE4341, EE4343, EE4344, EE4694
	MICROELECTRONICS	EE4613, EE4614, EE4645, EE4646, EE4647, EE4648, EE4694, EE4838, EE4840
INON	COMMUNICATION ENGINEERING	EE4105, EE4109, EE4110, EE4151, EE4152, EE4153, EE4188, EE4190
	COMPUTER ENGINEERING	EE4717, EE4718, EE4756, EE4758, EE4761, EE4455, EE4483, EE4490, EE4791, EE4001
	DIGITAL MEDIA PROCESSING	EE4413, EE4105, EE4455, EE4475, EE4476, EE4478, EE4483, EE4490

THE FINAL YEAR CURRICULUM

In the new knowledge-based economy, engineering has become increasingly multi-disciplinary in nature. To better prepare you for this new environment, a new broad-based curriculum was introduced. The aim is to produce engineers who are flexible across disciplines; who are not constrained by the boundaries between traditional disciplines but are able to apply their knowledge and skills to lead multi-disciplinary teams to solve increasingly complex problems; to apply existing technologies in novel ways; and to create new technologies for the future.

In the final year curriculum, you will be given more flexibility to select your elective courses to better suit your interest and inclinations. The elective courses are now grouped under 3 broad option groups

- **ELECTRICAL AND SYSTEMS ENGINEERING** (ECAL)
- **ELECTRONIC ENGINEERING** (ENIC)
- **INFOCOMMUNICATION ENGINEERING** (INON)

Courses from related specialisations are classified under one of the 3 broad groups and you are given the flexibility to mix-and-match the Design & Technical Electives, within your selected option group. One Technical Elective course may be selected from outside your chosen option group if you wish. However, if you prefer to have a more in-depth specialisation, you may do so by selecting the recommended courses from 8 areas of specialisation

- Biomedical Electronics
- Communications
- Computer Engineering
- Digital Media Processing
- Electrical Power and Energy
- IC Design
- Intelligent Systems and Control Engineering
- Microelectronics

BIOMEDICAL ELECTRONICS

INTRODUCTION

Biomedical Engineering is a relatively new area to meet demands from the rapidly developing and growing health care services and is multidisciplinary integrating medicine, science, mathematics and engineering to provide solutions to medical and health care industries. In this area, engineers with knowledge and expertise in EEE play a critically important role in the design, manufacturing, operation and maintenance of electrical and electronic circuits, devices, processors and algorithms for medical instrumentation in industry, hospitals and laboratories. These instruments are now indispensable for medical diagnosis, therapy and life supporting. They range from large scale magnetic resonance imaging (MRI) and computed tomography (CT) imaging scanners to very small devices such as implantable pacemakers and bioelectrodes.

This final year option on biomedical electronics is to provide students a solid education and training in EEE with specialization in biomedical instrumentation, signal processing and imaging, and modelling and control of biomedical systems. While students consolidate and develop their knowledge in the conventional EEE areas of instrumentation, signal and image processing, and system modelling and control, they also study special knowledge and develop problem analysis and solving capabilities in biomedical engineering. Examples include electrocardiogram (ECG) and electroencephalogram (EEG) signal analysis and processing, magnetic resonance imaging (MRI), computed tomography (CT) and ultrasound scanning and imaging, wireless technology for telemedicine, modeling of physiological systems and control of drug delivery systems. This specialization enables students to develop their future careers in EEE, biomedical engineering industries or health care services.

CAREER OPPORTUNITIES

Biomedical engineering is a fast growing sector worldwide, including Singapore, due to the ever growing demands on health care services both qualitatively and quantitatively. In the recent five years, Singapore has invested S$2 billion in biomedical industry and institutions. This is an initiative to develop Singapore into a leading global biomedical hub. The demands on health care services and, hence, medical instruments for supporting and maintaining normal and healthy life and lifestyle are always at the top priority of our society, regardless of current and future economic situation.

In Singapore, graduates of the Biomedical Electronics Program may find opportunities to work in industrial companies, hospitals, government offices for policy making and administration, medical R &D laboratories and institutes, or to pursue postgraduate study. It is also possible for graduates to work on sale and marketing of medical instruments and products. These job and study opportunities are also widely available in USA, Asia, Europe, and Pacific countries.

COMMUNICATIONS

INTRODUCTION

Communication is a basic human need. Individuals with better communication skills are more successful than others. The same is true for business organizations and even nations. In today' s globalized economy, organizations and nations with a better communications infrastructure are better positioned to succeed and prosper. Modern communication systems include (a) mobile cellular, WiFi, Blue Tooth and other wireless communication systems that provide communication anywhere, anytime and on-the-go; (b) radio, TV, and satellite systems that serve as means of information, entertainment as well as global positioning; and (c) optical communication systems, computer networks and the Internet that enable us to access and transfer large amounts of information at high speed. The various courses in the Communication Engineering option provide a solid foundation for the undergraduate students to understand the operating and design principles of wired and wireless communications systems.

To maintain and increase the competitiveness of Singapore' s infocomm industry, many government agencies in Singapore such as iDA, EDB, Ministry of Information Communications & the Arts, and other statutory boards have invested billions of dollars in various infocomm sectors such as mobile client and services, converged network infrastructure, multimedia processing & management, web & portals services, and security & trust infrastructure.

Graduates equipped with expertise in communications technology are expected to be in high demand for the next few years. The various courses in the Communication Engineering option prepare the undergraduate students for careers in the research, design, integration, installation, operation and maintenance of wired and wireless communications systems. There are also R&D career openings in research institutes such as IME (Institute of Microelectronics), Institute of Infocomm Research (I2R), DSO National Laboratories, CSIT, and research labs of MNCs such as Panasonic, OKI, Agilent and Philips.

CAREER OPPORTUNITIES

(i) Microelectronics/Consumer Electronics Industry (a large percentage of their products are used in the communication industry):
- Thomson Multimedia, Motorola, Lucent Technologies, Siemens, NEC, HP, Agilent, OKI, Sony, Matsushita, Philips, Panasonics Audio/Video Research Labs, etc.

(ii) Communication and Broadcasting Companies:
- Singapore Telecom with its various subsidiaries such as SingTel Mobile (mobile service provider), SingNet (Internet service provider), Singtel Aeradio (facilities manager and consultant for the Civil Aviation Authority of Singapore) and joint ventures, both local and abroad.
- M1, Starhub (Including SCV), Deutsche Telecom, Telia, Telenor and Tyco Communications, etc.
- Singapore Technologies with its various companies such as Agilis Communication.
- Discovery Asia, National Geographic, etc.

(iii) Information Technology:
- Philips, NEC, Fujitsu, HP, Agilent, OKI, Unisys, IBM, Gemplus, Siemens, etc.
  (Communication and Computer companies.)

(iv) Government/Statutory Boards/Research Centres & Institutes:
- MRTC, PSA, HDB, Singapore Power, Spring, I2R, DSTA, IME, Ericsson Cyberlab, etc.

(v) MINDEF, DSO National Laboratories and Associated Companies:
- Research, development and procurement of communication and electronic systems, e.g., radar communication equipment and services.

(vi) Other Sectors:
- Petrochemical and multinational companies have their own private worldwide communication networks.
- Financial sector - banking, insurance companies, stock exchanges are leaders in the use of Information Technology, e.g., electronic fund transfer and ATMs/NETS.

COMPUTER ENGINEERING

INTRODUCTION

The emergence of internet, e-commerce, mobile phones, mp3 player, high-definition TV, telemedicine, etc., has transformed all aspects of our lives. It is computer engineers who developed the hardware, software and networking technologies that made them possible. Today, virtually all the businesses, from multinational corporations, local small and medium enterprises, government ministries, educational institutions, to service, finance, banking and manufacturing industries, heavily rely on computer systems for their day-to-day operations and business transactions. It is difficult to name a single major activity in today's society, which is not influenced by, and benefiting from, the use of computer systems. The new economy (or knowledge-based economy) is indeed powered by computer engineers.

The Computer Engineering specialisation focuses on the fundamentals of computer systems, and covers the *basics* of computer hardware, software, and networking. You will learn interesting courses like computer architecture, enterprise network design, web application design, object-oriented software engineering design, embedded systems, system software, networking, security, artificial intelligence & data mining, database systems, and multimedia systems. In particular, the specialization is designed to produce quality graduates for the networking and software development industry, one of the main engines for enhancing business advantage.

CAREER OPPORTUNITIES

There are abundant career opportunities for graduates specialised in computer engineering. Computer engineers work in every sector of society and industry, e.g., multinational corporations, banks and financial institutions, government ministries and statutory boards, manufacturing industries, telecommunication companies, defence industry, small and medium enterprises, computer hardware/software vendors and suppliers, educational institutions and service industries. You can work as a computer engineer, hardware designer, system integrator, system architect, system analyst, system administrator, or programmer. You can also choose to set up your own company as the start-up cost is relatively low.

SCHOLARSHIP

The Infocomm Development Authority of Singapore (iDA) offers partial scholarships to outstanding final-year undergraduates specializing in Computer Engineering. The scholarships are partially sponsored by companies such as IBM, Intel, Microsoft, DBS, Singtel and StarHub. The scholars are required to work for their sponsoring company for 1 year. Interested students may apply the scholarship online via the iDA's website at http://www.infocommtalent.sg/nis.aspx.

Please visit http://www.ie.eee.ntu.edu.sg/Students/Undergrad/Specialisation/Pages/ComputerEngineering.aspx for more information about the Computer Engineering specialization and the courses offered under this specialization.

DIGITAL MEDIA PROCESSING

Digital Media Processing (DMP) is concerned with the theoretical and practical aspects of representing information in digital form and using computers or special purpose digital hardware to process and display that information or to transform it into a more useful form. Today, DMP is at the heart of many consumer electronic gadgets, ranging from smart phones (such as Android phones, iPhone), VCD/DVD/Blu-ray players, tablets, iPod, digital cameras, biomedical devices, high-definition 3D TV, digital radio, mobile internet, and many more. In fact, it is the technology of choice for digital audio, image and video with applications in digital entertainment, communications, and information retrieval.

The personal computer age is moving to a new era of info-communications which is driven by both connectivity and multimedia, and digital signal processing technology is central to both. This is because DMP is the enabling technology for many complex communications systems, from satellite communications to personal wireless communications using local area networks. The result is that information transmission is more pervasive and personal. Besides the well-established PC applications for word processing, data searching, and data transfer, there are increasing demands for faster connectivity to handle interactive applications involving speech, audio, image and video. Examples include multimedia messaging, text-to-speech synthesis, and 3D multiplayer gaming with high quality audio and video. Along with the pervasiveness of info-communications comes the issue of security. DMP is also playing a very critical role in this area which includes surveillance, identification and tracking, as well as providing diagnostic tools for decision making. More recent applications include biometrics for security access, and watermarking and data hiding for digital media rights management. All of the above applications are fuelling the growth for digital media processing software and hardware. In summary, DMP is the technology that extends human capabilities and enriches the human experiences.

CAREER OPPORTUNITIES

Engineers with DMP knowledge and experience are in great demand both locally and globally. This is because DMP is the enabling technology for many applications, essentially limited by only one's imagination and creativity. In particular, many DMP engineers are in demand in the telecommunications and internet-based technology sectors, or more popularly referred to in Singapore as the infocomm technologies. With infocomm technologies becoming embedded more and more into our everyday lives, the role of DMP engineers has taken on a new dimension and the career prospects are diverse and challenging. Also, the recent initiative from the government to setup interactive digital media (IDM) as one of the three main research thrusts has spurred on many related industries to setup their bases in Singapore. DMP is the enabling technology that is central in the IDM movement and companies value talent equipped with DMP knowhow and skill sets.

DMP engineers can expect many employment opportunities in the following areas:

- Consumer electronics (e.g., Creative, Sony, LG, Phillips, Panasonic)
- Telecommunications (e.g., CSIT, Nokia, Siemens)
- Industrial electronics (e.g., Texas Instruments, Motorola, Analog Devices, Xilinx)
- Digital media related industry (e.g. Studio, Broadcasting, Media Creation, MDA)
- Defence (e.g., DSO, DSTA, Singapore Technologies)
- Entertainment industry (e.g., gaming and music recording)
- Internet-related businesses (e-commerce)
- Off-shore industries (e.g., Thales, BP, Shell)
- Automotive and avionics (e.g. Continental, Delphi Automation)
- Health and medical (e.g. hearing aids, ultrasound, NMRI)
- Research and Development (universities and research centres such as IHPC, I2R, DSO)

SCHOLARSHIP

The Infocomm Development Authority of Singapore (IDA) offers the National Infocomm Scholarships to outstanding undergraduates studying Infocomm-related courses. The scholars would pursue Infocomm at renowned local and/or overseas universities and grab the chance to gain valuable mentorship opportunities and gain experience through job attachment opportunities both locally and overseas. Detailed information and application process are available online via the IDA's website at http://www.infocommtalent.sg/nis.aspx.

Please visit http://www.eee.ntu.edu.sg/Programmes/CurrentStudents/undergraduate/undergraduatefull-time/Pages/FYOption.aspx for more information on the courses offered under the Infocommunication Engineering option group.

ELECTRICAL POWER AND ENERGY

INTRODUCTION

Over the past few decades, the demand for electrical engineers around the world has been very steady. Power and energy requirements in Asia-Pacific are growing at nearly double-digit level, which augurs well for the power industry. It can be easily appreciated that reliable and economic electricity supply is highly desirable. Electrical power supply is vital for maintaining society's high standards of living and for supporting Singapore's, as well as the Region's, expanding economy. The electric power infrastructure must be able to support the national economic advancement for generations to come. In addition, government policy to make inroads into South-East Asia and the region means that infrastructure development projects such as those related to electric power supply systems will create additional opportunities for graduates skilled in this field of engineering.

An important issue is the impact of the use of energy on climate change. Depletion and rising costs of non-renewable energy sources present both challenges and opportunities. The global community needs to step up efforts to investigate the adverse impact of climate change.

ROLE OF ELECTRICAL ENGINEERS

Power engineers are mainly concerned with the generation, transmission, distribution and utilization of electrical energy. The main tasks of power engineers are to plan, design, install, test, commission, operate and maintain power equipment and networks ranging from extra high transmission-level voltages of 500 kV to as low as the single-phase household voltage of 230 V. Reliable design and implementation of power projects, incorporating state-of-the-art technologies and engineering skills, ensure that the network and equipment are safe for operating personnel as well as for society. The electricity supply system must be of the highest quality such that the economic activities of the nation are duly supported. This applies to all major industries including manufacturing sectors, large complexes like airports, military facilities and heavy industries such as chemical plants, oil refineries and shipyards, etc. Power engineers also design and commission building services systems for commercial,

industrial, institutional and residential complexes. They use computer simulation tools for analyses, simulation, design, supervision and control of power systems. They are also actively engaged in the research, design, production, installation and maintenance of electric motors and the associated power electronic-based controllers, varying from small computer disk-drives to large machines rated for hundreds of kilowatts. The design and manufacture of electric switchgear, transformers and electrical components is also a major area of work for power engineers. Overall, electrical power engineering is a multi-billion dollar industry offering graduates challenging career prospects with excellent job satisfaction.

CAREER OPPORTUNITIES

All of NTU' s past electrical graduates from the School of EEE have obtained satisfactory employment in organizations such as Singapore Power, MINDEF, SMRT, PSA, JTC, CAAS, LTA, power equipment manufacturers, consulting firms, and various sectors for electrical services, etc. The continuing strong demand for electrical engineers by these organizations is evident from their intakes in previous years. Furthermore, deregulation of the Singapore power market, and of other utilities in the region, has opened up tremendous opportunities for electrical engineers, especially in terms of designing and operating systems that offer customers more choices at possibly lower prices.

With appropriate training and professional experience, an electrical engineering graduate can look forward to attaining the Professional Engineer (PE) status within a few years of his/her graduation.

SCHOLARSHIP

The Singapore Power (SP) offers scholarships to outstanding undergraduates in various areas. For more information, please go to http://student.brightsparks.com.sg/profile/singaporepower/index.php

INTEGRATED CIRCUIT DESIGN

INTRODUCTION

The quest for excellence in Integrated Circuit (IC) design has been geared in recent years towards developing innovative techniques and methodologies to achieve low voltage and minimum power circuits (designs). This together with the uncompromising constraint of high chip performance have shaped a new arena in which IC technology has found itself gaining growing significance and attracting keen interest.

The IC design industry has evolved and expanded into one of the critical industries with immense impact on the global economy. Moving forward, Singapore intends to go more into discovery, design and development (DDD work) to enhance future economic growth and hasten the transition into a high value-added, design-driven semiconductor industry in order to remain competitive in the global markets.

The Division of Circuits and Systems has perhaps the largest group of academic specialized in the hi-impact research area of IC design. They are the vanguard committed to provide our next generations with timely and insightful technical expertise in IC design as we strive to become a world-class varsity. Many of our professors have received various international awards and also serve as distinguished Editors and Editorial Board for internationally prominent journals and magazines.

The Division will continue to update and upgrade its IC design curriculum to address the scale and scope of the changing IC design environment. As IC design is diversified, the course offered is broad, with key fundamental concepts and technological phenomena emphasized. The curriculum is well balanced between the theoretical and practical aspects, enabling the fresh graduate to contribute immediately upon employment in industry and yet sufficiently versed in theoretical knowledge to pursue research (and development) either in industry or as a Ph.D. scholar. Students will take digital, analog and radio frequency IC design courses. They will also be given extensive IC design practice in identifying, formulating, solving problems and in presenting solutions. Laboratory exercises with written reports are a natural part of the training.

CAREER OPPORTUNITIES

Recently, there is dramatic growth in IC design activities in Singapore because of the increasing number of electronics companies migrating into product and design work here. To support the continuous growth of the electronics and semiconductor industry, an adequate supply of well-trained manpower in IC design must be ensured.

The IC design industry is becoming a major employer in Singapore, and this will likely continue in the next decade. The IC design industries include many large multi-national corporations such as Mediatek, Broadcom, Marvell, Xilinx, Altera, Microchip Technology, Renesas Technology, Philips, Silicon Labs, Infineon, STMicroelectronics, Linear Technology, O2Micro, TI and Panasonic which have design centre operation in Singapore.

A close examination of the recent statistics reveals that IC design occupies the top-end of the semiconductor value chain. It is less vulnerable to companies' relocation when compared to the chip manufacturing activities simply because of cost issues. IC design is also a high value-added activity and according to the industry estimates, each chip designer's salary doubles after a few years. This is way above the average salary for those working in other sectors and specializations.

SCHOLARSHIPS

Currently, there is a shortage of IC designer world wide, so a large number of our trained IC designers are attracted to other countries. EDB has been working with the Division on many special manpower training schemes to support our teaching and research programmes. The IC Design Specialist Manpower Programme (SMP) continues to receive excellent support from EDB and IC design companies with more than 300 undergraduate scholarships awarded since 2005. On 15 December 2009, EDB announced the setting up of VIRTUS, a new S$50 million Integrated Circuit (IC) Design Centre of Excellence (IC COE) to train 150 postgraduate students in IC design for Singapore in the next 5 years.

INTELLIGENT SYSTEMS AND CONTROL ENGINEERING

INTRODUCTION

Automation is a crucial and important technology in the land and resource scarce Singapore. With the technological advancement, manufacturing requires equipment and systems with higher intelligence and flexibility. Due to our limited natural resources, we have to constantly strife for improvement by developing and exploiting new and emerging automation technologies so that they can enhance and upgrade operations, lower production costs, overcome labour constraints, and enable the manufacturing of products previously constrained by human limitations. To improve our productivity and competitive edge, we also need to get the control and automation processes to work in the best possible ways: in performance, in robustness, in intelligence, in flexibility, and in precision.

In the Intelligent Systems and Control Engineering option, we teach future engineers to analyse the behaviour and performance of engineering systems in a systematic manner and to modify the performance of these systems by making appropriate trade-off between conflicting requirements. We offer courses in Control, Computer Vision, Robotics & Automation, Sensor Fusion and Computational Intelligence and all these are the enabling technologies that are required in automation and intelligent systems. We encourage the integration of these areas so that new innovations and applications in automation and manufacturing industries can emerge. The students can choose to specialize in Intelligent Systems and Control Engineering, or a balance of these 2 areas. The courses will provide relevant training for students who would like to work as control and/or automation engineers where they could easily fit into the wafer fabrication plants, disk drive industries, biotechnology, pharmaceutical, petrol-chemical and automation industries. Our curriculum is formulated to meet the ever-increasing demands of Intelligent Systems and Control Engineering industries.

ROLE OF INTELLIGENT SYSTEMS & CONTROL ENGINEERING ENGINEERS IN INDUSTRY

One can find an intelligent systems and control engineering engineer busy developing and implementing a sophisticated control algorithm that enables the radar to track a satellite faithfully, so that world news and beautiful images can be relayed accurately to your homes. Or one could observe him/her as he/she eagerly puts the final touches to his design of a high precision high capacity hard-disk drive that boosts the fastest access time. If you step into an air-conditioned training centre in an oil refinery or a pharmaceutical plant, you will find him/her working on a high-resolution computer system that displays the complicated plant dynamics and interlocks of the entire control process of the refinery and the plant.

In fact, the role of an intelligent systems and control engineering engineer seems boundless. He/she could be a consultant on industrial automation; a designer of products and systems; a project engineer implementing sophisticated automation systems; a sales engineer offering a wide range of controllers and instruments; a test engineer evaluating a new controller in aircraft auto-pilots; or an applied researcher investigating new control and navigation algorithms for mobile robots.

CAREER OPPORTUNITIES

In Singapore, or elsewhere in the world, an intelligent systems and control engineering engineer can find relevant employment in the following areas:

- Aerospace Industries
- Biotechnology
- Chemical Processes
- Defence Industry
- Electronic Industries
- Industrial Automation

- Instrumentation and Measurement
- Manufacturing Processes
- Medical Instrumentation
- Oil Refineries
- Pharmaceutical Processes
- Robotics
- Satellite-Tracking Stations
- Waste Water/Chemical Treatment, etc

MICROELECTRONICS

INTRODUCTION

Every advanced product nowadays, whether it is for communication, data storage and processing, household electronics appliances, flat panel displays, electronic games, biomedical devices etc., contains one or more sub-components and microsystem, e.g. integrated circuits, magnetic and optical read-write head for data storage devices, liquid crystal display TVs, movement-sensors in VR games, DNA chips, flash memory in hand phones, image sensor in digital cameras etc., that are fabricated using the microelectronic technology. In addition, microelectronics and microfabrication technology are increasingly being employed in cross-disciplinary microsystem applications like the micro-sensors and biosensors.

Singapore has made great progress in its strategic goal to be one of the few key locations for semiconductor industry in the world. In a span of 40 years, Singapore has been steadfast in nurturing the semiconductor sector into its current state. The Semiconductor cluster in Singapore employed more than 40,000 people and pumped out S$34.9 billion worth of outputs in 2006. The value-add of the corresponding operations is about S$9.3 billions. In Singapore, wafer fabrication facilities as well as assembly and test facilities have produced important components for the rest of the world. For example, US chip company Linear Technology ships about 85% of the company' s product to customers worldwide from Singapore. Currently besides Chartered Semiconductor Manufacturing, other wafer fab companies in Singapore include United Microelectronic Corp (UMC), System-on-Silicon Company (SSMC), STMicroelectronics (STM), Hitachi Nippon Steel Semiconductor Singapore Ltd, IM-Flash, Qimonda and Tech Semiconductor. Today, the city-state' s highly interconnected semiconductor domain consists of 1.) 14 wafer fabrication facilities, two of them offering 12-inch technology, which is the most sophisticated in the world today, 2.) 19 assembly test operations, which include the world' s top three subcontract and test companies, and 3.) about 40 IC design centers. In June 2005, another German company, Schott AG opened an advanced packaging facility here for mass production of wafer-level packing of image sensors and sealing computer chips with glass.

Another highly valued part of the overall value chain for semiconductor companies is HQ activities. For example, programmable logic solutions giant Xilinx, established its status in Singapore recently. German-based Infineon Technologies AG, boasted a large research facility in Singapore and opened its new Asia Pacific HQ here in May 2005. Hence from R&D, manufacturing, IC design, supply-chain management, logistics and distribution, to HQ activities, Singapore becomes a key player in the world' s vibrant semiconductor industry. As microelectronics is a very high value added industry, its contribution to and impact on the Singapore' s economy are significant and rapidly growing.

The major mission of this Final Year option in Microelectronics is to support the national manpower training programmes for the semiconductor industry. It offers graduates the unparalleled opportunities for challenging careers in the areas of advanced semiconductor technology. This Final Year option also provides the students with a unique training opportunity in semiconductor device physics, semiconductor device and circuit operation, and more importantly microfabrication technology so as to prepare them for the thriving microsystem technologies such as system-on-chips, bio-medical devices and other micro-devices.

Graduates who have taken the Final Year Microelectronics Option form a valuable manpower pool for the semiconductor industry in Singapore. Students taking this option will be well prepared to enter the semiconductor industry immediately or go on to advanced work in graduate school. This Option will prepare graduates for careers in process engineering, device design and fabrication, product engineering, R&D, customer support, process integration, failure analysis, industrial engineering, reliability and testing engineering, and equipment engineering in semiconductor and microelectronics industries.

CAREER OPPORTUNITIES

Job opportunities for graduates in Microelectronic option range from R&D, manufacturing, to IC design and semiconductor related industries in supply-chain management, logistics and distribution, and HQ activities. Currently there are about fourteen wafer fabs established in Singapore. They are the Hitachi Nippon Steel Semiconductor Singapore Ltd, STMicroelectronics, TECH Semiconductor Singapore Pte Ltd, Chartered Semiconductor Manufacturing, Silicon Manufacturing Partners, Systems on Silicon Manufacturing Company, and UMC. It is useful to note that

each fab involves an investment well above one billion dollars, and employs about 400 engineers. In addition to the wafer fabs in the silicon-based technology, there are 5 fabs focusing on III-V compounds such as Agilent Technologies and MBE etc. Numerous technical positions are also available in related microelectronics engineering and technology companies established in Singapore. These include Applied Materials Inc., LAM Research Inc., Novellous Inc., ASM Inc., Silicon Valley Group, Tokyo Electron Limited etc. It should be noted that the semiconductor industry is a truly global industry and the staff is not limited to any location. Other related industries include fabless design houses such as Broadcom and Xilinx, and wafer test and package assembly such as Cookson, UTAC and Agilent Technologies etc. In recent years, Asia Pacific such as Taiwan, Korea and the Pacific rim of China is growing to be the most important world semiconductor manufacturing base in the world. This rapid growth of the semiconductor industry in Asia gives our graduates a regional as well as global development opportunity. The potential for personal advancement and rewards for careers in advanced engineering, management and R&D is extremely high, judging from the huge demand for trained engineers in this field. Many more new high value added engineer positions are constantly being created. Due to the rapid growth and high tech nature of this industry, many companies provide parallel paths for career growth into very senior engineering positions (Principal Engineer, Consultant, Member of Technical Staff, Fellow, etc.) or into engineering and high level management.

Exciting career opportunities in microelectronics research and development are already available in a number of research organisations and fabs in Singapore. This includes Institute of Microelectronics, Chartered Semiconductor and STMicroelectronics. This option will also give new opportunities to participate in the new and important nanoelectronics and microsystem technologies that called for the good training, know-how and knowledge of semiconductor.

SCHOLARSHIP

Scholarships are available from the EDB Specialist Manpower Programme (SMP) for final-year students. Graduates will be guarantee employment in one of the Wafer Fabs or Semiconductor/wafer fab related companies upon completing his/her BEng degree. Please contact the respective staff via http://www.eee.ntu.edu.sg/Programmes/CurrentStudents/sws/Pages/Scholarships.aspx. .

FINAL YEAR COURSE DESCRIPTION

Students, may refer to the course description of each final year design and technical elective courses at http://www.eee.ntu.edu.sg/Programmes/CurrentStudents/undergraduate/undergraduatefull-time/Documents/EEE_Courses.pdf.