Master of Science
Integrated Circuit Design

At A Glance

JOINT DEGREE BY
Technical University of Munich (TUM)
Nanyang Technological University (NTU)

20 MONTHS FULL TIME
PROGRAMME
Coursework in Singapore

PRACTICAL KNOWLEDGE
Compulsory Internship & Dissertation

GLOBAL PROSPECTS
Internationally Recognized Degree

INTAKE
August Every Year

TO APPLY
Apply online from 1st November at www.tum-asia.edu.sg

1 TUM is ranked as the #1 University in Germany†
1 NTU is ranked #1 in Asia for Engineering++
1 NTU is ranked #1 in the world for industry income and innovation∗
8 TUM ranked #8 in the Global Employability Survey^*
50 Both TUM & NTU# are in the world’s Top 50 Universities

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^ NTU is ranked #1 in the world for industry income and innovation
# Both TUM & NTU are in the world’s Top 50 Universities
**Technical University of Munich (TUM)**

Technical University of Munich (TUM) is one of Europe's leading research universities, with around 500 professors, 10,000 academic and non-academic staff, and more than 37,000 students. Its focus areas are the engineering sciences, natural sciences, life sciences and medicine, reinforced by schools of management and education.

TUM acts as an entrepreneurial university that promotes talents and creates value for society. In that it profits from having strong partners in science and industry. It is represented worldwide with a campus in Singapore as well as offices in Beijing, Brussels, Cairo, Mumbai, and São Paulo.

Nobel Prize winners and inventors such as Rudolf Diesel and Carl von Linde have done research at TUM. In 2006 and 2012 it won recognition as a German “Excellence University.” In international rankings, TUM regularly places among the best universities in Germany.

**Nanyang Technological University (NTU)**

Inaugurated in 1991, Nanyang Technological University (NTU) has grown to become a full-fledged research university, and is ranked as one of the fastest-rising Asian universities in the world's top 50**. Hailing from more than 70 countries, NTU's 3,800 strong teaching and research staff contribute their dynamic perspectives and years of solid industry experience.

NTU's academic and research programmes, with real-world relevance, have reaped dividends in the form of strong support from major corporations and industry leaders, in terms of both research funding and partnerships as well as global internship opportunities for our students.

As the main Science and Technology university in Singapore, NTU has made substantial contributions to Singapore's drive for research and innovation, with the 2014 Quacquarelli Symonds (QS) ranking NTU at 10th in the World for Electrical & Electronic Engineering.

** As rated by 2013/2014 QS World University Ranking
# Master of Science Integrated Circuit Design

The joint TUM-NTU Master of Science in Integrated Circuit Design (MSc in ICD) equips students with the academic proficiency and hands-on knowledge required in the design, development, and manufacture of integrated circuit or integrated electronic products.

## JOINT DEGREE
Conferred by Technical University of Munich (Germany) and Nanyang Technological University (Singapore)

## 3 SEMESTERS
Full-time research and application focused programme, inclusive of internship experience and Master Dissertation writing

## INDUSTRY RELEVANCE
Our professors are actively involved in research and cooperation projects with leading industrial companies, allowing them to base the curriculum around the latest technological trends and knowledge

## GLOBAL OPPORTUNITIES
You are able to complete your Internship and Dissertation in Munich, Singapore, or anywhere in the world, to look for job opportunities globally

## COURSE OUTLINE

<table>
<thead>
<tr>
<th>Contact hours for every Core &amp; Elective Module</th>
<th>Technical Core Modules required to be completed by every student</th>
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<tbody>
<tr>
<td>45</td>
<td>8</td>
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The student has to complete 18 modules in 2 semesters
(8 Core Modules, 4 Elective Modules, 5 Cross Discipline Modules, 1 Business & Technical English Module)

## Duration of the Programme: 20 months

<table>
<thead>
<tr>
<th>August</th>
<th>5 Months</th>
<th>6 Months</th>
<th>3 Months</th>
<th>6 Months</th>
<th>Graduation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arrival in Singapore</td>
<td>Business &amp; Technical English</td>
<td>Core Modules</td>
<td>Internship</td>
<td>Master Thesis at a company, university or research institute (Supervised by a NTU or TUM professor)</td>
<td>End of Programme</td>
</tr>
<tr>
<td>• Business &amp; Technical English</td>
<td>• Core Modules</td>
<td>• Elective Modules</td>
<td>• Cross Discipline Modules</td>
<td></td>
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<tr>
<td>• Core Modules</td>
<td>• Lab Modules</td>
<td>• Cross Discipline Modules</td>
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Module Synopsis

Core Modules

Digital IC Design

Analog IC Design

System-on-Chip Solutions & Architecture
The course addresses application-specific digital CMOS integrated circuits (ASICs) from a system’s perspective. Covering multiple levels of abstraction from MOSFET transistor, to realization of combinational / sequential logic, finite state machines (FSM), memory (SRAM, DRAM, FLASH), to chip-level interconnect technology (busses, network-on-chip (NoC)). Furthermore, the course complements the understanding of digital integrated circuit design by investigating the architectural composition of multiple real-world case studies taken from existing SoC products in the area of Internet networking. We will investigate and compare generic RISC CPU platform architectures with network processor units (NPUs), LAN/SAN (Local area / System area network) switches and SONET/SDH transmission framers of wide area networks (WAN).

Design Methodology & Automation
Computer-aided design of integrated circuits. VLSI design flow overview: system level, algorithmic level, register transfer level, logic level, and circuit level. Detailed discussion of VLSI design methods especially for logic synthesis. Digital simulation, hardware description language, test development including design for testability. Techniques from discrete mathematics and computer science are explained and employed.

Digital Signal Processing

Mixed Signal Circuit Design

Laboratory 1 Analog IC Design
Design of a wide-band amplifier from schematic to layout verification.

Laboratory 2 Digital IC Design
Design, simulation, layout and synthesis of digital integrated circuits & systems.

Elective Modules* (Choose 4)

RF IC Design
System design considerations. CMOS RF components and devices. Low-noise amplifier (LNA), Mixers, Voltage-controlled oscillators (VCOs). RF power amplifiers. Phase-Locked Loops and Frequency Synthesizers.

IC Packaging
Packaging overview. Electrical packaging design and thermal management. Single chip, multichip and 3D packaging. IC assembling, sealing and encapsulation. IC packaging failure and reliability. Microsystems packaging and applications.

IC Marketing/ Business/ Management
Trends in the IC industry: technology and manufacturing trends, demand applications and product trends. Market characteristics: the customers, business cycles, demand lead and supply lag (the bull-whip effect), IC industry, supply and value chain, stakeholders, geographical distribution of excellence centers, technology centers, design centers, fabrication centers, the dis-integration of the value chain, outsourcing trends. Managing the marketing function: the sources of product ideas, the role of standards, formats, and intellectual property. Strategic partnership, distributorship, demand forecast, matching supply with demand.

Advanced MOSEFT & Novel Devices
Historical development of mainstream MOSFETs until today: economical, technological and physical fundamentals. Properties of long channel and short channel MOSFETs, high-field effects, scaling rules. Basics of charge carrier transport, drift-diffusion, Boltzmann-Bloch equation, hydrodynamic transport, ballistics and consequences for IV-characteristics. Advanced MOSEFTs, mobility-enhancement, metal-gate, FinFETs, MuGFETs. Hot-electron and ballistic transistors, Impact-MOSFETs, Spintronics devices. Tunneling-MOSFETs, single-electron transistors.

Nano-Electronics

Embedded Systems

Simulation and Optimization of Analog Circuits

Design for Testability of VLSI

Cross Discipline Modules

- Aspects of Asian and European Relations Today
- Cultural, Social & Economical Aspects of Globalisation
- International Intellectual Property Law
- Selected Topics in Business Administration
- Selected Topics in Business Management

*Disclaimer: Elective modules available for selection are subject to availability. Unforeseen circumstances that affect the availability of the module include an insufficient number of students taking up the module and/or the unavailability of the professor. TUM Asia reserves the right to cancel or postpone the module under such circumstances.
Admissions Information

ADMISSION CRITERIA*

- Hold a minimum 3-year Bachelor Degree in Electrical, Electronics Engineering, or equivalent degree in other relevant disciplines
- Submit one (1) notarised copy of Official or Provisional Bachelor Degree Certificate** and one (1) notarised copy of Official or Provisional Academic Transcript**
- Submit two (2) Recommendation Letters from two (2) different Professors or Employers
- Submit one (1) Letter of Motivation that indicates the reason(s) you are interested in the programme you applied for
- Submit one (1) Curriculum Vitae / Resume
- Submit one (1) Passport-sized photograph** and one (1) Passport Biodata Page photocopy (the passport page with your personal particulars)
- TOEFL / IELTS (Required for applicants whose native tongue or medium of instruction from previous studies is not in English)
- Akademische Prüfstelle (APS) certificate (Required for applicants who hold a degree from China, Vietnam, or Mongolia)

TOEFL Requirements: 100 for the Internet-Based Test (TOEFL code: 7368)
IELTS Requirements: Overall IELTS results of at least 6.5

Important: Documents that are not in English must be translated by a certified translator

*Find out about the full application process on www.tum-asia.edu.sg/application-process

**All applicants are required to submit an additional of three (3) notarised copies of Official or Provisional Bachelor Degree Certificate, three (3) notarised copies of full, Official Academic Transcript, and three (3) passport-sized photographs when you have accepted the offer of admissions and are being matriculated into our programme

TO APPLY

Applications open 15 October every year. Apply online at www.tum-asia.edu.sg

TUITION FEES

<table>
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<tr>
<th>APPLICATION FEE</th>
<th>PAYMENT OF TUITION FEES</th>
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<tr>
<td>S$79 (inclusive of GST) is payable for each application per programme</td>
<td>A Total of SGD 34,240*</td>
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</tbody>
</table>

Tuition fees includes teaching fees, laboratory expenses and cost of mandatory events. Expenses excluded from this fee and are to be borne by students include: airfare, accommodation, living expenses, and NTU miscellaneous fees (inclusive of registration, IT facilities, matriculation, examination, amenities, copy right, sports, insurance and medical). The tuition fee will be paid in 3 installments.

*Tuition fees are accurate as of 1 November 2017. Tuition fees are subject to revision due to currency fluctuations, at the discretion of TUM Asia. Fees quoted are inclusive of 7% Singapore’s Government Goods & Services Tax. Please refer to www.tum-asia.edu.sg/MScfees for the latest tuition fees.
Entrepreneurial Thinking and Engagement
Globalization is now an inevitable force that is here to stay. At TUM Asia, our classroom reflects this diversity with an enrolment of over 28 nationalities. This means that we foster a vibrant learning environment where the student learns not only from the textbook but also through the lives of their counterparts. Classroom ideas are synthesized across the diverse economic realities and students learn to see from multiple vantage points, creating a capacity to solve problems in creative ways. The unique 20 month joint degree equips the student with not only technical and scientific knowledge, but with an enriched curriculum composed of business and cultural modules.

Highest International Standards
You will be studying with the world’s best professors from TUM and NTU, as well as experts from the industry. Not only will the student benefit from professors who are actively involved in research, one will also receive a holistic learning experience with the engagement of local lecturers from academia and industry. Our TUM modules are covered by professors who fly in from Germany on an exclusive teaching basis, to ensure that students get the undivided attention of their lecturers.

Our students are not just learning about Integrated Circuit Design. The joint TUM-NTU ICD Master programme equips you to become an excellent independent engineer for the rest of your professional life. We teach you to master the challenges!

Dr. Helmut Graeb
Professor at Technical University of Munich, Institute for Electronic Design Automation
DID YOU KNOW THAT A PART OF YOUR GADGET - COMPUTER, MOBILE PHONE, TABLET OR VIDEO CONSOLE - WAS DESIGNED OR MANUFACTURED IN SINGAPORE?

Electronics: The Core of Singapore’s Progress

Since the 1960s, Singapore’s electronics industry has been a major contributing sector to the nation’s manufacturing output. Over the years, the electronics sector has continued to flourish and move up the manufacturing chain as companies started to pour into higher-end functions such as Research & Development (R&D). Singapore aims to become a world class innovation-driven electronics hub, providing technology, manufacturing and business solutions and enabling the development of new growth areas.

The Semiconductor Industry in Singapore

The global industry being dominated by USA, South Korea, Japan, Taiwan, Singapore, and European Union. Every year, chip makers and designers dramatically increase the performance of their products while decreasing prices, making high-end technology goods increasingly productive and affordable for consumers. Singapore’s semiconductor industry has the highest growth potential and is currently the fastest growing industry sector in the country.

Our Graduates

Our graduates in Integrated Circuit Design are employed all over the world, such as in Singapore (77.6%), Europe (13.8%), India (8.6%)

The most commonly accepted positions are Integrated Circuit Design Engineer, Research Associate, Engineer, and PhD Researcher

Our graduates are expected to have a high amount of job opportunities due to strong partnerships with the industry. Companies that we partner closely with include Infineon, Lantiq, and STMicroelectronics

1 Today, Singapore accounts for 1 out of 10 wafer starts in the world.

3 Three of the world’s top six outsourced semiconductor assembly and test companies are located in Singapore.

15 15 of the world’s top 25 fabless semiconductor companies, and close to 40 integrated circuit design centres are located in Singapore.

20 Today, Singapore is home to approximately 20 semiconductor assembly and test operations.

25 Electronics is the major industry underpinning Singapore’s economic growth, it contributes 25% of the total manufacturing value-add.

40 40% of the global hard disk manufactured in Singapore.

“...The programme offered a module that was related to intellectual properties and invited a German professional patent attorney to teach it. The module opened a new window for me and helped me to discover a career path that I was passionate about.

Minghui Sun Alumni, Master of Science in Integrated Circuit Design Technology Specialist, SHUSAKU·YAMAMOTO

“...When I look at the MSc in ICD interns, I see highly motivated individuals with a strong desire to learn and acquire new knowledge and skills. That mentality is very important in this dynamic industry.

STMicroelectronics Asia Pacific Pte Ltd