

Programme Information		
Programme Title	Programme Code	HECoS Code
Analogue and Digital Integrated Circuit Design	H6W8	For Registry Use Only

Award	Length of Study	Mode of Study	Entry Point(s)	Total Credits	
				ECTS	CATS
MSc	1 Calendar year (12 months)	Full time	Annually in October	90	180
PG Diploma	N/A	Full time	N/A	60	120
PG Certificate	N/A	Full time	N/A	30	60

The PG Certificate and the PG Diploma are exit awards and are not available for entry. All students must apply to and join the MSc. These exit awards are not currently accredited by the Institution of Engineering and Technology.

Ownership			
Awarding Institution	Imperial College London	Faculty	Faculty of Engineering
Teaching Institution	Imperial College London	Department	Electrical and Electronic Engineering
Associateship	City and Guilds of London Institute (ACGI)	Main Location(s) of Study	South Kensington Campus

External Reference	
Relevant QAA Benchmark Statement(s) and/or other external reference points	Masters Awards in Engineering
FHEQ Level	Level 7
EHEA Level	2nd Cycle

External Accreditor(s) (if applicable)			
External Accreditor 1:	The Institution of Engineering and Technology (IET)		
Accreditation received:	2018	Accreditation renewal:	2023

Collaborative Provision			
Collaborative partner	Collaboration type	Agreement effective date	Agreement expiry date
N/A	N/A	N/A	N/A

Specification Details	
Programme Lead	Dr Pantelis Georgiou, MSc Director
Student cohorts covered by specification	2022-23 entry
Date of introduction of programme	1996/97
Date of programme specification/revision	September 22

Programme Overview
<p>This MSc programme provides essential training and skills to future integrated circuit (IC) designers with in-depth knowledge of analogue, mixed signal and digital circuits to design, implement and evaluate future integrated circuits. It will be delivered within the Department of Electrical and Electronic Engineering.</p> <p>The programme consists of compulsory taught modules that provide general background theory, practical knowledge and skills in designing integrated analogue and digital systems. The aim is to provide you with experience in both the practical issues of device-level design and system-level performance requirements. A key feature of this programme is the balanced approach to both analogue and digital IC design, and the in-depth treatment of low power circuits and embedded systems. You will gain both theoretical understanding and practical experience of CAD tools through lab exercises.</p> <p>The programme is structured in three parts. The taught component of the programme is delivered in two parts, during the Autumn and Spring Terms. In the Autumn and Spring terms you will acquire compulsory knowledge in the topics of fundamental importance to Analogue and Digital Integrated Circuit Design. You then supplement your compulsory modules with elective modules in both autumn and spring terms. During the third part of the programme, to build on your modules previously studied, you will work on your individual research project.</p> <p>During this programme you will have the opportunity to choose from elective modules which build on the fundamental importance of the compulsory modules and cover issues that are related to digital system design using modern programming languages, to embedded systems and their Operating Systems (OS), to the design of high-performance systems based on Graphic Processing Units (GPUs) and Field Programming Gateway Arrays (FPGAs), to the design of low power and high-performance analogue circuits, as well as issues related to communication systems (optical and radio frequency (RF)) and to micro-electromechanical systems (MEMS) and nanotechnology.</p> <p>A significant component of the programme is an individual project which is an opportunity to apply the knowledge and skills in a practical problem. This starts in the spring term and is full-time in the summer term.</p> <p>You will be assessed by written examination, associated coursework, and an individual research project, run as a part-time activity from January to May and then full time from May to September. It may be possible for you to undertake your MSc projects in the industry. The taught modules are confined to the autumn and spring terms, with the associated examinations are normally held during the summer term.</p> <p>The programme is normally studied by graduates in broad electrical and electronic engineering domains with substantial mathematics and engineering content that requires analogue and digital knowledge and skills. The MSc programme is delivered by research-leading academics with backgrounds in analogue, mixed signal and digital circuit design. The programme draws upon their extensive and diverse portfolio of research and their experience in providing advice and guidance to the UK and overseas governments and international agencies, and industry. The teaching is supported by guest speakers from industry to enable you to connect your learning to the ongoing developments in practice. This would also provide you the networking opportunity to enhance your career prospects in industry.</p> <p>With the knowledge and skills from this programme, our graduates typically take up a career in industries associated with Integrated Circuit Design, Complementary metal-oxide-semiconductor (CMOS) Microelectronic design, analogue systems design, digital systems design, FPGA systems, embedded systems, electronic system consulting companies or pursue PhD research in the UK and worldwide.</p>

Learning Outcomes

On completion of the MSc in Analogue and Digital IC design programme, you will be able to:

1. Demonstrate thorough conceptual understanding and knowledge of fundamental principles and methods of analogue and digital integrated circuit design and integrated circuit manufacturing technologies.
2. Formulate effective use of computer aided design (CAD) tools to augment analysis and support synthesis of analogue and digital systems.
3. Develop insight into the main considerations and constraints when designing integrated microelectronic systems.
4. Design fully integrated analogue and digital systems, microelectronic and embedded systems.
5. Design analogue circuits by hand and by using Computer Aided Design tools, digital circuits using hardware description languages.
6. Critically evaluate and analyse experimental results and determine their strength and validity, prepare technical reports.
7. Communicate effectively through oral presentations, computer processing and presentations, written reports and scientific publications.
8. Employ advanced skills to conduct a piece of independent research that demonstrates a contribution to knowledge in a research area of interest.
9. Interpret state-of-the-art technical and scientific publications related to a research topic and critically review the results of others as well as your own.
10. Approach challenges with curiosity and creativity while keeping the practical constraints in mind.
11. Innovatively apply your know-how and skills to tackle complex challenges in microelectronic systems.
12. Display a strong sense of personal and professional identity.

On completion of the PG Diploma, you will be able to cover items (1) to (6) from the above list.

On completion of the PG Certificate, you will be able to cover items (1) to (3) from the above list.

The Imperial Graduate Attributes are a set of core competencies which we expect students to achieve through completion of any Imperial College degree programme. The Graduate Attributes are available at: www.imperial.ac.uk/students/academic-support/graduate-attributes

Entry Requirements

Academic Requirement	Normally a high first class (1st) (75%+) UK Bachelor's Degree with Honours in Electrical Engineering or a related subject (or a comparable qualification recognised by the College).
Non-academic Requirements	N/A
English Language Requirement	Higher English requirement Higher Requirement: IELTS 7.0 overall (minimum 6.5 in all elements)
Admissions Test/Interview	Applications are reviewed by a selection committee consisting of the programme director and a nominated member of staff. The main criteria for selection are academic performance to date and academic potential. Applicants are not interviewed.

The programme's competency standards document can be found at: <http://www.imperial.ac.uk/electrical-engineering/study/undergraduate/applicants-with-disabilities/>

Learning & Teaching Approach

Your learning and teaching approach will include a combination of lectures, tutorials, computer and hardware laboratory work, coursework and guided reading. You will experience different learning and teaching delivery methods that most likely include:

- **Lectures:** Typically delivered to the entire cohort ranging from 1-2 hours in length as timetabled. Lectures will be delivered as traditional style lectures, flipped classroom, online learning supported through pre-recorded lectures. Most lectures involve student engagement with questions posed to the class and, in others, a lecturer may encourage you to participate in small-group exercises or discussions to reinforce learning of the recently covered material.
- **Laboratory sessions:** To train you in the use of specialist CAD software for analogue and digital design appropriate timetabled sessions will be run from our computer room facilities dedicated for the use of students in the Circuits and Systems group. You will also be given the opportunity to have hands on experience and training with hardware in small group sessions which reinforce your learning and understanding of the theoretical material of analogue and digital design systems delivered in the autumn term. These software and hardware laboratory sessions are often supported by a team of Graduate Teaching Assistants (GTAs) to assist you in your learning.
- **Individual Research Project:** You will be working on a research project of your choice, supervised by one or more members of our academic staff, who are leaders of international renown in their field of research. This will allow you to undertake in-depth research in areas of interest to you, be exposed to state-of-the-art knowledge and develop the communication skills to effectively present your research findings and deliver a research output that contributes to knowledge.

As part of the learning and teaching delivery you will be encouraged to be creative in the art of communication in both written and oral presentations, and during the programme you will be challenged to produce different types of output for assessments that rely on your communication skills. These include group/individual coursework report, programming code, lab report, an individual research dissertation and a research poster presentation.

Development of professional skills is supported by various aspects of the small group and individual research project. You will be encouraged throughout to undertake independent reading both to supplement and consolidate material relevant to the lectures and project and to broaden your individual knowledge and understanding of the analogue and digital circuit design area.

Intellectual skills are developed through the teaching and learning methods, with some experience of team work. Practical skills are developed through our teaching and learning programme. Practical computational skills are developed through coursework and project work and through interaction with research supervisor(s) and (sometimes) research students.

Overall Workload

Your overall workload consists of face-to-face sessions and independent learning. While your actual contact hours may vary according to the elective modules you choose to study, the following gives an indication of how much time you will need to allocate to different activities at each level of the programme. At Imperial College London, each ECTS credit taken equates to an expected total study time of 25 hours. Therefore, the expected total study time is 2,250 hours per year for an average student.

The Department expects you to allocate approximately 4 hours in self-study for every hour spent in lectures and tutorials for a typical lecture-based module.

The pattern of work is greatly dependent on your selected elective modules, however on average you can expect to spend about 200 hours in lectures over the autumn and spring terms, while devoting a further 800 hours to independent study. You will spend approximately 250 hours for laboratory work. You will also be expected to spend 1,000 hours on research work for your Individual Research Project, starting from the spring term but full time from May until September.

Assessment Strategy

Assessment Methods

A range of summative and formative assessment methods are utilised throughout the programme to maximise your learning. Summative assessment refers to those that will test whether you have met the intended learning outcomes of each module and contribute towards the programme-level intended learning outcomes. Formative assessments are meant for you to identify your areas of strengths and weaknesses to improve your learning.

Methods include Written Examinations, Coursework Assessment and MSc Project evaluation. Written examinations are held in December, for a limited set of subjects, and normally in May. Coursework assessment takes place continuously throughout the year. The amount of Coursework assessment you will experience varies according to your elective choice. Most subjects have a 25% Coursework component, but some are 100% Coursework based or entirely Examination based. The summer term is full-time project work and your project is submitted at the start of September. The individual research project is evaluated on the quality of the submitted report, its originality and technical contribution, and through a poster presentation.

The exact balance of the summative assessment across the programme depends upon your choice of elective modules, but an indicative breakdown is:

Coursework	50%
Exams	40%
Practical	10%

Academic Feedback Policy

The Department of Electrical and Electronic Engineering recognises that feedback is an essential part of learning and gives high priority to the timeliness and quality of feedback offered to you on all modules. The primary purpose of feedback is to assist learning and the development of skills, by highlighting strengths and weaknesses on one hand, and by identifying actions for improvement on the other. It is important to recognize that: 1) feedback comes in various forms and 2) feedback requires your active engagement.

Feedback will be provided for all assessments carried out as part of the Analogue and Digital Integrated Circuits MSc programme. For examinations, the published model answers will be annotated to highlight the common mistakes, and alternate approaches to the solutions. For coursework and the laboratory-based exercises, written feedback will normally be provided within two working weeks of submission. For the research project, feedback will be provided by the supervisor(s) on a continuous basis during the regular project supervision meetings. Oral feedback on the research project will be provided immediately by assessors during/after the poster presentation.

You should keep in mind that not all feedback is structured, and important feedback may be obtained from self-reflection on your progress to date, from peers when studying or working together in a team, in dialogue with a lecturer in or outside of a class or laboratory, or by email.

The Board of Examiners will meet to consider the results of the examinations and the research project in mid-late October and results will be released to students only via student e-service within 10 days. Students who have not managed a clear pass will be informed, setting out possible courses of action within 10 days of the examiner's board.

The College's Policy on Academic Feedback and guidance on issuing provisional marks to students is available at:

www.imperial.ac.uk/about/governance/academic-governance/academic-policy/exams-and-assessment/

Re-sit Policy

The College's Policy on Re-sits is available at: www.imperial.ac.uk/student-records-and-data/for-current-students/undergraduate-and-taught-postgraduate/exams-assessments-and-regulations/

Mitigating Circumstances Policy

The College's Policy on Mitigating Circumstances is available at: www.imperial.ac.uk/student-records-and-data/for-current-students/undergraduate-and-taught-postgraduate/exams-assessments-and-regulations/

Additional Programme Costs		
This section should outline any additional costs relevant to this programme which are not included in students' tuition fees.		
Description	Mandatory/Optional	Approximate cost
Lab equipment	Mandatory	Provided

Important notice: The Programme Specifications are the result of a large curriculum and pedagogy reform implemented by the Department and supported by the Learning and Teaching Strategy of Imperial College London. The modules, structure and assessments presented in this Programme Specification are correct at time of publication but might change as a result of student and staff feedback and the introduction of new or innovative approaches to teaching and learning. You will be consulted and notified in a timely manner of any changes to this document.

Programme Structure ¹					
Year 1 – FHEQ Level 7					
Students study all core and compulsory modules. Students must also choose 4 electives from group A. You are advised to discuss with your personal tutor about taking electives in both terms, and not to take all electives in the spring term.					
Code	Module Title	Core/ Elective/ Compulsory	Group	Term	Credits
ELEC70043	Analogue Integrated Circuits and Systems	Compulsory		Autumn	5
ELEC70012	Full-Custom Integrated Circuit Design	Compulsory		Autumn	5
ELEC70046	Advanced Digital System Design	Compulsory		Spring	5
ELEC70004	Analogue Signal Processing	Compulsory		Spring	5
ELEC70093	A1 Lab	Core		Spring	10
ELEC70094	Individual Research Project	Core		Spring	40
ELEC70077	Digital Signal Processing and Digital Filters	Elective	A	Spring	5
ELEC70050	Advanced Computer Architecture	Elective	A	Autumn	5
ELEC70013	High Performance Analogue Electronics	Elective	A	Spring	5
ELEC70051	Radio Frequency Subsystems	Elective	A	Spring	5
ELEC70079	Optical Communication	Elective	A	Autumn	5
ELEC70054	Microwave Technology	Elective	A	Autumn	5
ELEC70055	Instrumentation	Elective	A	Spring	5
ELEC70056	Hardware and Software Verification	Elective	A	Autumn	5
ELEC70057	Biomedical Electronics	Elective	A	Autumn	5
ELEC70058	Optoelectronics	Elective	A	Autumn	5
ELEC70101	Sensors	Elective	A	Spring	5
ELEC70003	Advanced Electronic Devices	Elective	A	Spring	5
ELEC70102	Microelectromechanical systems (MEMS)	Elective	A	Spring	5
Credit Total					90

¹ **Core** modules are those which serve a fundamental role within the curriculum, and for which achievement of the credits for that module is essential for the achievement of the target award. Core modules must therefore be taken and passed in order to achieve that named award. **Compulsory** modules are those which are designated as necessary to be taken as part of the programme syllabus. Compulsory modules can be compensated. **Elective** modules are those which are in the same subject area as the field of study and are offered to students in order to offer an element of choice in the curriculum and from which students are able to select. Elective modules can be compensated.

Classification of Postgraduate Taught Awards

Award of a Postgraduate Certificate (PG cert):

To qualify for the award of a Postgraduate Certificate, a student must have accumulated at least 30 ECTS credits at Level 7 or above.

Award of a Postgraduate Diploma (PG Dip):

To qualify for the award of a Postgraduate Diploma a student must have:

- a) accumulated at least 60 ECTS credits at Level 7 or above
- b) no more than 10 credits as a Compensated Pass.

Award of a Postgraduate Degree (MSc):

To qualify for the award of a postgraduate degree a student must have:

1. accumulated credit to the value of no fewer than 90 credits at level 7 or above;
2. and no more than 10 credits as a Compensated Pass as this programme is accredited by the Institution of Engineering and Technology.

Classification of Postgraduate Taught Awards

The College sets the class of Degree that may be awarded as follows:

1. Distinction: The student has achieved an overall weighted average of 70.00% or above across the programme.
2. Merit: The student has achieved an overall weighted average of above 60.00% but less than 70.00%.
3. Pass: The student has achieved an overall weighted average of 50.00% but less than 60.00%.
 - a. For a Masters, students must achieve a distinction (70.00%) mark in the dissertation or designated final major project (as designated in the programme specification) to be awarded a distinction.
 - b. For a Masters, students must achieve a minimum of a merit (60.00%) mark in the dissertation or designated final major project (as designated in the programme specification) to be awarded a merit

Programme Specific Regulations

The accreditation body (IET) requires no more than 10 ECTS credits as compensated pass

Supporting Information

The Programme Handbook is available at:

<http://www.imperial.ac.uk/electrical-engineering/study/current-students-course-handbook/#m>

The Module Handbook is available at:

http://intranet.ee.ic.ac.uk/electricalengineering/eecourses_t4/crslistpg.asp?c=A1N/A

The College's entry requirements for postgraduate programmes can be found at:

www.imperial.ac.uk/study/pg/apply/requirements

The College's Quality & Enhancement Framework is available at:

www.imperial.ac.uk/registry/proceduresandregulations/qualityassurance

The College's Academic and Examination Regulations can be found at:

www.imperial.ac.uk/about/governance/academic-governance/regulations

Imperial College is an independent corporation whose legal status derives from a Royal Charter granted under Letters Patent in 1907. In 2007 a Supplemental Charter and Statutes was granted by HM Queen Elizabeth II. This Supplemental Charter, which came into force on the date of the College's Centenary, 8th July 2007, established the College as a University with the name and style of "The Imperial College of Science, Technology and Medicine".

www.imperial.ac.uk/admin-services/secretariat/college-governance/charters/

Imperial College London is regulated by the Office for Students (OfS)

www.officeforstudents.org.uk/advice-and-guidance/the-register/

This document provides a definitive record of the main features of the programme and the learning outcomes that a typical student may reasonably be expected to achieve and demonstrate if s/he takes full advantage of the learning opportunities provided. This programme specification is primarily intended as a reference point for prospective and current students, academic and support staff involved in delivering the programme and enabling student development and achievement, for its assessment by internal and external examiners, and in subsequent monitoring and review.

Modifications

Description	Approved	Date	Paper Reference
Curriculum Review	Programmes Committee	22/03/22	PC.2021.53