Programme Specification for the MSc in Analogue and Digital Integrated Circuit Design

PLEASE NOTE. This specification provides a concise summary of the main features of the programme and the learning outcomes that a typical student might reasonably be expected to achieve and demonstrate if he/she takes full advantage of the learning opportunities that are provided. This specification provides a source of information for students and prospective students seeking an understanding of the nature of the programme and may be used by the College for review purposes and sent to external examiners. More detailed information on the learning outcomes, content and teaching, learning and assessment methods of each module can be found in the course handbook or on-line at http://www3.imperial.ac.uk/electricalengineering/teaching/msc/analogue.

The accuracy of the information contained in this document is reviewed by the College and may be checked by the Quality Assurance Agency.

1. Awarding Institution: Imperial College London
2. Teaching Institution: Imperial College London
3. External Accreditation by Professional / Statutory Body: IET
4. Name of Final Award: MSc
5. Programme Title: Analogue and Digital Integrated Circuit Design
7. Name of Faculty: Engineering
8. UCAS Code (or other coding system if relevant): UCAS N/A, PG code H6W8
9. Relevant QAA Subject Benchmarking Group(s) and/or other external/internal reference points
   Engineering
10. Level(s) of programme within the Framework for Higher Education Qualifications (FHEQ):
    
    Master's (MSc) | Level 7
11. Mode of Study
    Full Time
12. Language of Study: English
13. Date of production / revision of this programme specification: September 2016
14. Educational aims/objectives of the programme

The programme aims/objectives are to:

- produce graduates equipped to pursue industrial careers in electronic engineering and engineering management;
- provide the theoretical basis for analysis and synthesis of analogue and digital integrated circuits;
- provide practical experience in selected areas and with selected tools, equipment and software;
- develop problem analysis skill and create opportunities for scientific creativity in problem solving;
- provide a solid foundation in integrated circuit engineering for those who intend to go on to study for a PhD;
- provide a training in relevant laboratory and research skills;
- provide a supportive learning environment;
- attract highly motivated students, both from within the UK and from overseas;
- develop new areas of teaching in response to advances of scholarship and the needs of vocational training.

15. Programme Learning Outcomes

1. Knowledge and Understanding

Knowledge and Understanding of

1. fundamental principles of analogue circuit design;
2. fundamental principles of digital integrated circuit design
3. modern methods of analogue integrated circuit design
4. modern methods of digital integrated circuit design
5. signal processing mathematics
6. integrated circuit manufacturing technologies
7. effective use of computer aided design (CAD) tools to augment analysis and support synthesis
8. research methods:
   - literature search
   - report writing,
   - presentation skills

2. Skills and other Attributes

Intellectual Skills

- apply behavioural modelling on systems and specifications
- perform hierarchical abstractions during analysis and synthesis
- integrate and evaluate information from a variety of sources
- formulate and test hypotheses
- be creative in the solution of problems and in the development of hypotheses
- plan, conduct and write-up a programme of original research.

Practical Skills

- Design analogue circuits by hand and by using Computer Aided Design tools;
- Design digital circuits using hardware description languages;
- Use laboratory equipment to generate data;
- Analyse experimental results and determine their strength and validity;
- Prepare technical reports;
- Give Technical Presentations;
- Use the scientific literature effectively.

Transferable Skills

- communicate effectively through oral presentations, computer processing and presentations, written reports and scientific publications;
- apply modelling skills;

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• apply management skills: decision processes, objective criteria, problem definition, project design and evaluation, risk management, teamwork and coordination, extension needs;
• integrate and evaluate information from a variety of sources;
• transfer techniques and solutions from one discipline to another;
• use Information and Communications Technology;
• manage resources and time;
• learn independently with open-mindedness and critical enquiry;
• learn effectively for the purpose of continuing professional development.

16. The following reference points were used in creating this programme specification

Course Handbook

17. Programme structure and features, curriculum units (modules), ECTS assignment and award requirements

Year One:

Term one:
Compulsory Core subjects:
• Analogue Integrated Circuits and Systems
• Full-Custom Integrated Circuit Design
• Laboratories

Optional subjects (Students choose a minimum of four from the entire optional courses list during terms one and two):
• Digital Signal Processing and Digital Filters
• Optical Communications
• Microwave Technology
• High Performance Computing for Engineers

Term Two:

Compulsory Core subjects:
• Advanced Digital System Design
• Analogue Signal Processing
• Laboratories

Optional subjects
• Advanced Computer Architectures
• Radio Frequency Electronics
• MEMS and Nanotechnology
• Instrumentation
• Advanced Electronic Devices
• High Performance Analogue Electronics

Term Three: (April – September)
The individual, full-time research project, begins at the end of Term 2. Project work is interrupted for the Examinations, and recommences one week after the final examination (usually from the beginning of June until the middle of September). The projects are conducted at Imperial College’s South Kensington Campus site, or at the premises of a commercial Company when a project is industry led. The titles of the research projects, offered
by prospective supervisors are made available in term 1. On completion of the project a written report is produced and submitted for an examination late in September. A conference-style poster presentation session follows the dissertation submission and gives candidates the opportunity to present the results of their research to their colleagues, their instructors and other Department Staff.

Examination results are reviewed and Degrees are awarded at the annual Examiners meeting, usually held 1 month after the end of the Course.

**ECTS**

The Course awards 90 ECTS points as follows:

- Each of the eight taught modules attracts 5 ECTS points for a total of 40
- Laboratory work attracts 10 ECTS points
- The dissertation attracts 40 ECTS points (34 awarded for the dissertation and 6 for a related seminar presentation)

### 18. Support provided to students to assist learning (including collaborative students, where appropriate).

**Academic:**

- One week induction programme for orientation, introduction to library and computer facilities
- MSc Student Handbook, which includes lecture detailed descriptions and timetable
- Staff student ratio for teaching: 11 teaching staff for a class size that has varied recently between 15 and 45;
- Library and other learning resources and facilities at the South Kensington Campus. Opportunities for students to conduct their research projects at a wide range of internal laboratories at Imperial College, and possibly at external institutions and companies.
- Students conducting their research projects at an external site are assigned a member of Imperial College academic staff to oversee progress and advise on the project dissertation. Where practical, students will be visited by College staff during their project.
- Dedicated computing facilities in the Mahanakorn Computer Aided Design Lab.
- A comprehensive external speaker seminar programme in the Department and at the South Kensington Campus.

**Pastoral:**

- Student email and open personal access to tutorial staff including the Course Director.
- Departmental Postgraduate Tutor who has overall responsibility for student welfare and guidance
- The thesis supervisor doubles as a personal tutor; The supervisor assists students with personal problems and advises on pastoral and academic issues.
- Access to student counsellors on the South Kensington site.
- Access to Teaching and Learning Support Services, which provide assistance and guidance, e.g. on careers.

**Social:**

- A large community of postgraduate research students and postdoctoral research workers who work on integrated circuit design research in the South Kensington Campus.
- Access to student Clubs offering diverse recreational activities on the South Kensington Campus.

**Administrative:**

- A Postgraduate staff - student committee, which meets three times per year.
- A Student Representative who regularly provides feedback to the Course Director.

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Career Advice:

- Employer needs and opinions feed into the programme through frequent guest lecturers from industry and possible student placements in relevant industries and industry-based research projects.
- Course content incorporates industrial feedback through the twice annually Strategic Advisory Group meeting of research group heads and deputy heads with UK industry leaders.

19. Criteria for admission:

The minimum qualification for admission is normally a good Upper Second Class Honours degree in a Science-based subject from an UK academic institution or an equivalent overseas qualification. Where an applicant has a lesser degree qualification but has at least 2 years work experience in integrated circuit design or manufacture or as an academic member of staff of a technical university department, a special case for admission may be submitted to the College GSEPS.

20. Processes used to select students:

- Review application material, comprising personal statement, transcripts and references.
- Academic prizes and distinctions, Publications in technical journal and conferences and substantial work experience in related industrial or academic activity are considered.

21. Methods for evaluating and improving the quality and standards of teaching and learning

a) Methods for review and evaluation of teaching, learning, assessment, the curriculum and outcome standards:

The external examiner system and Boards of Examiners are central to the process by which the College monitors the reliability and validity of its assessment procedures and academic standards. Boards of Examiners comment on the assessment procedures within the College and may suggest improvements for action by relevant departmental teaching Committees.

The Faculty Studies Committees and the Graduate Schools' Postgraduate Quality Committees review and consider the reports of external examiners and accrediting bodies and conduct periodic (normally quinquennial) and internal reviews of teaching provision. Regular reviews ensure that there is opportunity to highlight examples of good practice and ensure that recommendations for improvement can be made.

At programme level, the Head of Department/Division has overall responsibility for academic standards and the quality of the educational experience delivered within the department or division.

Most of the College’s undergraduate programmes are accredited by professional engineering and science bodies or by the General Medical Council. Accreditation provides the College with additional assurance that its programmes are of an appropriate standard and relevant to the requirement of industry and the professions. Some postgraduate taught courses are also accredited.

b) Committees with responsibility for monitoring and evaluating quality and standards:

The Senate oversees the quality assurance and regulation of degrees offered by the College. It is charged with promoting the academic work of the College, both in teaching and research, and with regulating and supervising the education and discipline of the students of the College. It has responsibility for approval of changes to the Academic Regulations, major changes to degree programmes and approval of new programmes.

The Quality Assurance Advisory Committee (QAAC) is the main forum for discussion of QA policy and the regulation of degree programmes at College level. QAAC develops and advises the Senate on the implementation of codes of practice and procedures relating to quality assurance and audit of quality and arrangements necessary to ensure compliance with national and international standards. QAAC also considers amendments to the Academic Regulations before making recommendations for
change to the Senate. It also maintains an overview of the statistics on completion rates, withdrawals, examination irregularities (including cases of plagiarism), student appeals and disciplinary hearings.

The Faculty Studies Committees and Graduate School Postgraduate Quality Committees are the major vehicle for the quality assurance of undergraduate / postgraduate courses respectively. Their remit includes: setting the standards and framework, and overseeing the processes of quality assurance, for the areas within their remit; monitoring the provision and quality of e-learning; undertaking reviews of new and existing courses; noting minor changes in existing programme curricula approved by Departments; approving new modules, changes in module titles, major changes in examination structure and programme specifications for existing programmes; and reviewing proposals for new programmes, and the discontinuation of existing programmes, and making recommendations to Senate as appropriate.

The Faculty Teaching Committees maintain and develop teaching strategies and promote inter-departmental and inter-faculty teaching activities to enhance the efficiency of teaching within Faculties. They also identify and disseminate examples of good practice in teaching.

Departmental Teaching Committee have responsibility for the approval of minor changes to course curricula and examination structures and approve arrangements for course work. They also consider the details of entrance requirements and determine departmental postgraduate student numbers. The Faculty Studies Committees and the Graduate School Postgraduate Quality Committees receive regular reports from the Departmental Teaching Committees.

The departmental Student Staff Committee convenes once every term and provides a forum for students to raise concerns or provide feedback. The committee is chaired by the Director of Postgraduate studies and membership comprises the Postgraduate Tutor, Postgraduate administrator, Course Directors and student representatives one from each of the five Research Groups and one from each of the three taught MSc Courses.

c) Mechanisms for providing prompt feedback to students on their performance in course work and examinations and processes for monitoring that these named processes are effective:

- All coursework is promptly marked
- Meeting of individual students with course organisers to discuss exams, research project and career aims.
- General remarks are communicated by broadcast emails to all Course students
- More details given to representatives in the Staff – Student Committee;
- Course questionnaire evaluation of taught components;
- Anonymous Course feedback letters invited at the end of the Course;

d) Mechanisms for gaining student feedback on the quality of teaching and their learning experience and how students are provided with feedback as to actions taken as a result of their comments:

- Elected student rep has unrestricted access to course director, and participates in student-staff committee meetings held termly
- College Online lecturer’s evaluation programme (SOLE)
- Collection of optionally anonymous leavers questionnaires

e) Mechanisms for monitoring the effectiveness of the personal tutoring system:

- Student feedback
- Availability of Course Director to discuss more difficult issues

f) Mechanisms for recognising and rewarding excellence in teaching and in pastoral care:

Staff are encouraged to reflect on their teaching, in order to introduce enhancements and develop innovative teaching methods. Each year College awards are presented to academic staff for outstanding contributions to teaching, pastoral care or research supervision. A special award for
Teaching Innovation, available each year, is presented to a member of staff who has demonstrated an original and innovative approach to teaching. Nominations for these awards come from across the College and students are invited both to nominate staff and to sit on the deciding panels.

g) Staff development priorities for this programme include:

- Active research programme in analogue and digital integrated circuit design;
- Staff appraisal scheme and institutional staff development courses;
- College Teaching Development Grant Scheme to fund the development of new teaching and appraisal methods;
- Updating professional and IT/computing developments.

22. Regulation of Assessment

a) Assessment Rules and Degree Classification:

Students are assessed on 8 modules chosen from 9 examinable modules. The 4 modules out of the 9 are the core modules. The rest of the modules that will be counted in assessment are the best 4 optional modules. Students also undertake an individual project occupying 3 months part-time (January to March) and 4 months full-time (June to September).

Students are assessed in the following elements:

**Examinable Modules**
Each of the examinable modules is assessed by written examination normally held at the start of the spring and summer terms, and/or assessed by an assigned coursework.

**Laboratory**
Assessed laboratory work will be undertaken normally during the autumn and spring terms.

**Project**
The individual project will be assessed through the means of a dissertation and an assessed oral presentation. The project mark is the sum of the dissertation mark and the presentation mark weighted 85% and 15% respectively.

**Requirements for Awards**
An MSc degree will be awarded to students obtaining:
- at least 40% for each of the 8 modules counted for the computation of the examinations average
- at least 50% for the laboratory work average
- at least 50% for both the project and examinations average

MSc degree with **merit** will be awarded to students obtaining
- at least 40% for each of the 8 modules counted for the computation of the examinations average
- at least 50% for the laboratory work average
- at least 60% for both the project and examinations average

MSc degree with **distinction** will be awarded to students obtaining
- at least 40% for each of the 8 modules counted for the computation of the examinations average
- at least 50% for the laboratory work average
- at least 70% for both the project and examinations average

b) Processes for dealing with mitigating circumstances:

A candidate for a Master’s degree who is prevented owing to illness or the death of a near relative or other cause judged sufficient by the Graduate Schools from completing at the normal time the examination or Part of the examination for which he/she has entered may, at the discretion of the Examiners,
(a) Enter the examination in those elements in which he/she was not able to be examined on the next occasion when the examination is held in order to complete the examination,

or

(b) be set a special examination in those elements of the examination missed as soon as possible and/or be permitted to submit any work prescribed (e.g. report) at a date specified by the Board of Examiners concerned. The special examination shall be in the same format as specified in the course regulations for the element(s) missed.

Applications, which must be accompanied by a medical certificate or other statement of the grounds on which the application is made, shall be submitted to the Academic Registrar who will submit them to the Board of Examiners.

c) Processes for determining degree classification for borderline candidates:

Candidates should only be considered for promotion to pass, merit or distinction if their aggregate mark is within 2.5% of the relevant borderline. Nevertheless, candidates whom the Board deems to have exceptional circumstances may be considered for promotion even if their aggregate mark is more than 2.5% from the borderline. In such cases the necessary extra marks should be credited to bring the candidate’s aggregate mark into the higher range.

d) Role of external examiners:

The primary duty of external examiners is to ensure that the degrees awarded by the College are consistent with that of the national university system. External examiners are also responsible for approval of draft question papers, assessment of examination scripts, projects and coursework (where appropriate) and in some cases will attend viva voce and clinical examinations. Although external examiners do not have power of veto their views carry considerable weight and will be treated accordingly. External examiners are required to attend each meeting of the Board of Examiners where recommendations on the results of individual examinations are considered. External examiners are required to write an annual report to the Rector of Imperial College which may include observations on teaching, course structure and course content as well as the examination process as a whole. The College provides feedback to external examiners in response to recommendations made within their reports.

23. Indicators of Quality and Standards

- IET accreditation report, 2009
- Favourable comments on the MSc Course by External Examiners 1998-present.
- Research grant and publication record in Analogue and Digital Integrated Circuit Engineering.
- Internal QAA procedure within the Graduate School of Engineering and Physical Sciences, 2004 and 2008
- Independent review of the quality of the educational provision of the Electrical and Electronic Engineering Department by the Quality Assurance Agency subject review process (in 1997 the Department was awarded 24/24)

24. Key sources of information about the programme can be found in (links to course handbook, prospectus, departmental website, syllabus etc):

- The Imperial College Graduate School of Engineering and Physical Science Web page http://www3.imperial.ac.uk/graduateschools
- The Postgraduate Prospectus, Imperial College London http://www3.imperial.ac.uk/pgprospectus
- Electrical Engineering Departmental Postgraduate Courses web page, and Link to the Course page http://www3.imperial.ac.uk/electricalengineering/teaching/postgraduate

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• Course information handbook:
  http://www3.imperial.ac.uk/electricalengineering/teaching/postgraduate/analoguemsc

• Course Director’s MSc bulletin board (restricted to dept. students-staff) :
  http://www3.imperial.ac.uk/electricalengineering/teaching/postgraduate/analoguemsc

• This document
  http://www3.imperial.ac.uk/electricalengineering/teaching/postgraduate/analoguemsc