ELEC9701
Mixed Signal Microelectronics Design

COURSE INTRODUCTION — session 2, 2009

Course Staff
Course convener: Dr. T. Lehmann, room EE208, tlehmann@unsw.edu.au

Consultations: Students are encouraged to use the open consultation hour rather than contact by email; students may seek consultation with the course convener at other times by appointment.
Consultations: Tuesdays, 1pm–2pm, room EE231A/EE208
Wednesdays, 1pm–2pm, room EE231A/EE208

Course details
Credits: The course is a 6 UoC course; expected workload is 10–12 hours per week throughout the 13 week session.

Contact hours: The course consist of 2 hours of lectures per week, and 1 hour of discussion classes per week:
Lectures: Thursdays, 6pm–8pm, room QG032
Discussion classes: Thursdays, 8pm–9pm, room QG032
Discussion classes start in week 2.

Course Information

Context and aims
Microelectronics or integrated electronics are the miniaturised electronic circuits that make up Integrated Circuits (ICs) such as microprocessors, Field-Programmable Gate Arrays, Flash-memories, operational amplifier, analogue-to-digital converters and many other functions. Most ICs today are implemented in various flavours of CMOS technology which is the focus of this course. The ability to use large number of components at relative low cost and the ability to match components accurately on-chip makes the design of integrated circuits and systems different from a similar design using discrete components. Mixed Signal Microelectronics Design is a broad based, more advanced IC design course, which present the students with analogue and digital circuits and design techniques required to implement mixed-signal integrated circuits with good performance.
Aims: The course aims to enable the student to do analysis and design of integrated circuits of good performance, and to equip the student to do self-guided, continuing learning in the advancing field of microelectronics.

Relation to other courses

The course is a graduate level course offered to students following a post-graduate program at the University of New South Wales. The course is a core course in the microelectronics post-graduate program offered by the school, and is a requirement for post-graduate work in microelectronics circuit design.

Pre-requisites: The course build on the microelectronics foundations given in the undergraduate course ELEC4602, Microelectronics Design and Technology. ELEC4602 is a pre-requisite for this course, but the two courses can be followed concurrently.

Assumed knowledge: It is essential that the students are familiar with circuit theory and basic analogue and digital electronics as well as basic signal analysis as covered in the courses ELEC1111, ELEC2133, ELEC2141, ELEC2132 and ELEC3106 which is the pre-requisite course for ELEC4602. It is further assumed that the students are familiar with SPICE-like circuit simulators, and have a good computer literacy.

Old courses: The course replaces previous courses ELEC4532 and ELEC9503.

Learning outcomes

After the successful completion of the course, the student will be able to

1. appreciate capabilities and limitations of advanced microelectronic (or IC) technologies,
2. understand and use advanced circuit models of IC components,
3. analyse analogue and digital microelectronic circuits,
4. design analogue, digital and mixed microelectronic circuits,
5. critically read and present papers from technical journals, and
6. keep up-to-date with future technological development in the field.

The course delivery methods and course content address a number of core UNSW graduate attributes; these include:

1. The capacity for analytical and critical thinking and for creative problem-solving, which is addressed by the design task and tutorial exercises.
2. The ability to engage in independent and reflective learning, which is addressed by the design task and the discussion classes.
3. The skills of effective communication, which are addressed by the report and the discussion classes.
4. Information literacy, which is addressed by the homework.

Please refer to http://www.ltu.unsw.edu.au/content/userDocs/GradAttrEng.pdf for more information about graduate attributes.
Teaching strategies

The course consists of the following elements: lectures, discussion classes, home work, self-guided tutorials and a design task:

Lectures

During the lectures technology capabilities and design issues are discussed and theoretical aspects of IC design and technology are presented. The lectures provide the students with a focus on the core material in the course, and a qualitative, alternative explanations. Numerous examples of analogue and digital integrated circuits are discussed in order to convey a qualitative understanding of circuit operations. The lectures aim to support students in analysing circuits and appreciate the capabilities of IC technologies. Students are expected to attend the lectures and prepare themselves for them.

Discussion classes

Technical papers are the researcher’s and practicing design engineer’s primary source of knowledge for keeping abreast a rapidly developing field. During the discussion classes, students and lecturer will discuss papers from technical journals; from week 3 onwards, students will take turns to lead these discussions. The discussion classes thus provide the students with exercises in critically analysing and reflective learning from technical papers; they also provide the students with exercise in oral communication and with advanced, contemporary discipline knowledge. The discussion classes aim to prepare the students for future self-guided learning.

Home work

The lectures can only cover the course material to a certain depth; students must read the textbook and reflect on its content as preparation for the lectures to fully appreciate the course material. Home preparation for the discussion classes provides the student with in-depth qualitative understanding of IC circuit design. The home work aim to provide in-depth quantitative and qualitative understanding of IC circuits and technologies. Note that no lecture notes will be handed out. The ability to read papers and the recommended text book and identify critical parts with the aid of the lectures is regarded as an essential component of this course.

Self-guided tutorials

The self-guided tutorials provides the student with in-depth quantitative understanding of IC circuit analysis. The tutorials take the student through all critical course topics and aim to exercise the students IC circuit analysis skills. The students are strongly encouraged to complete all the tutorials; the problems may be discussed in the consultation hours.

A design task

The design task aims to draw together theoretical and practical design aspects in an open-ended realistic design problem. Students design an IC circuit meeting given specifications, use CAD tools to verify the circuit operation and write a technical paper documenting their design. The design task provide and test engineering creativity, open-ended problem solving skills, communication skills and general understanding of the course content. The design task involves design,
theoretical analysis and computer simulations of a microelectronic circuit is to be carried out in groups of one or two students. Students may use the CAD tools in room EEG16/EEG20 for this task.

Assessment

There are four components of the assessment in this course:

Discussion classes: 10% overall weight
Quizzes: 10% overall weight
Design task: 15% overall weight
Final examination: 65% overall weight

Assessment task due dates are given in the course schedule.

Discussion classes: Participation in the discussion classes is assessed in order to ensure that the students are able to critically read and learn from technical papers, and communicate their findings to the class. Assessment is grade-only marks and are given on basis on activeness of participation and on the ability to learn from the papers and to lead the discussions (a HD mark is given only for exceptional performance; active participation is required for a PS mark).

Quizzes: There are two quizzes held during the lecture time through the semester, which are provided in order to give early feed-back on student performance. The quizzes test the students general understanding of the course material; assessment is a graded mark according to the correct fraction of the answers to the quiz questions.

Design task: The design task is assessed to test the students ability to design a microelectronic circuit and communicate its key features in a professional manner, thus also demonstrating the students appreciation of the technology, and ability to use appropriate models and conduct suitable analysis and simulations to aid the design. A report on the design, taken the form of a four page technical paper (IEEE format), must be written which is to be placed in the School assignment box next to room G12A by 5pm Friday the due week. Late submissions carry a 50% penalty for the first week and will not be accepted beyond one week delay. Delays on medical grounds are accepted. Assessment is grade-only marks and are given on basis of the quality and innovativeness of the design and the quality of the report (a HD mark is given only for exceptional performance; a serious attempt at completing the design is required for a PS mark).

Final examination: The exam in this course is a standard closed-book 3 hours written examination; University approved calculators are allowed. The examination test analytical and critical thinking and general understanding of the course material in a controlled fashion. Assessment is a graded mark according to the correct fraction of the answers to the exam questions.

Course contents

Handbook entry: The aim of the course is to enable the student to design advanced analogue, digital and mixed signal microelectronic circuits and to enable self-guided continuing learning in the advancing field of microelectronics. Topics covered include: special IC processes, scaling, matching, parasitics, wires, advanced transistor modelling, frequency analysis, cascode OTAs,
fully-differential circuits, filters, sigma-delta converters, logic effort, advanced logic families, TSP registers, arithmetic circuits, timing, clock distribution, self-timed systems, mixed analogue-digital design, current research.

## Course Schedule

<table>
<thead>
<tr>
<th>Week</th>
<th>Topic</th>
<th>Text</th>
<th>Tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Topic: Advanced CMOS technologies and components: high-voltage, silicon-on-sapphire, nano, MEMS.</td>
<td>Notes.</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Topic: Advanced MOS models: sub-threshold, velocity saturation, corner and Monte-Carlo models, matching models.</td>
<td>Baker ch. 9, 10; notes.</td>
<td>Discussion topic 3.</td>
</tr>
<tr>
<td>7</td>
<td>Topic: Switched Capacitor circuits, (G_m)-C filters, transconductors, non-linear circuits.</td>
<td>Baker ch. 25; Baker ch. 27; notes.</td>
<td>Discussion topic 6.</td>
</tr>
<tr>
<td>9</td>
<td>Topic: Logic effort, sizing, power dissipation.</td>
<td>Baker ch. 11; notes.</td>
<td>Discussion topic 8. QUIZ 2.</td>
</tr>
<tr>
<td>13</td>
<td>Tasks: Design project due.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Resources for Students

Textbooks

Prescribed textbook

The following textbook, also used in ELEC4602, is prescribed for the course:

Students are strongly encouraged to purchase a copy of this book as it provides the most coverage of the topics in the syllabus. Lecture notes will not be handed out.

In addition to the textbook, numerous technical papers will be used as reading material; these will be handed out during the course.

Reference books

The following books are good additional resources for topics on analogue integrated circuit design, digital integrated circuit design and semiconductor device physics:


Books covering assumed knowledge

The following books cover material which is assumed knowledge for the course:


On-line resources

Some additional on-line resources relevant to the course:

- mosis website  http://www.mosis.com
- book website  http://www.cmosedu.com
- library resources  http://info.library.unsw.edu.au/web/services/services.html

CAD resources

Students can access the industry standard Cadence design suite for the work in this course. The CAD tools are located in the computer laboratories EEG16/EEG20 and students should have after hours access here. Students must remember to copy their work on to their own storage device before they logout as all data will otherwise be lost. The CAD tools run under the Linux system on the dual boot PCs. For specific details on how to log on, see the course web page. Students who have not followed ELEC4602 is encouraged to go through the ELEC4602 laboratory exercises in order to familiarise themselves with the CAD tools.

Other Matters

Academic Honesty and Plagiarism

Plagiarism is the unacknowledged use of other peoples work, including the copying of assignment works and laboratory results from other students. Plagiarism is considered a serious offence by the University and severe penalties may apply. For more information about plagiarism, please refer to http://www.lc.unsw.edu.au/plagiarism

Continual Course Improvement

Students are advised that the course is under constant revision in order to improve the learning outcomes of its students. Please forward any feedback (positive or negative) on the course to the course convener or via the Course and Teaching Evaluation and Improvement Process. Previous feedback have led to inclusion of self-guided tutorials.

Administrative Matters

On issues and procedures regarding such matters as special needs, equity and diversity, occupational health and safety, enrolment, rights, and general expectations of students, please refer to the School policies, see http://scoff.ee.unsw.edu.au/.