



ELEC4602

Microelectronics

Design and Technology

COURSE INTRODUCTION — session 2, 2008

Course Staff

Course convener: Dr. T. Lehmann, room EE208, tlehmann@unsw.edu.au
Laboratory demonstrator: Kushal Das

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, 3pm–4pm, room EE231A/EE208
Wednesdays, 10am–11am, room EE231A/EE208

Course details

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

Contact hours: The course consist of 2 hours of lectures per week, and 2 hours of laboratory sessions per week:

Lectures: Tuesdays, 5pm–6pm, room EE418
Wednesdays, 12pm–1pm, room EE418
Lab sessions: Wednesdays, 1pm–3pm, room EE214, or
Wednesdays, 3pm–5pm, room EE214

Laboratory sessions start in week 2.

Course Information

Context and aims

Microelectronics or integrated electronics is 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. *Microelectronics Design and Technology* is a broad based, introductory IC design course, which takes the student through all the necessary

steps in order to complete (ready-to-manufacture) a basic mixed-signal front-end in a typical integrated system.

Aims: The course aims to make the student familiar with CMOS microelectronics technologies, and enable the student to do analysis and design of circuits implemented in these technologies.

Relation to other courses

The course is a fourth year professional elective offered to students following a BEE course at the University of New South Wales. The course gives the foundations for microelectronic circuit design and technology; as such, the course would normally be taken concurrently with thesis work in the microelectronic circuit design area.

Pre-requisites: The pre-requisites for the course is ELEC3106, Electronics. 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 and ELEC2132.

Assumed knowledge: It is further assumed that the students are familiar with SPICE-like circuit simulators, and have a good computer literacy.

Following courses: The course is a co-requisite for the post-graduate course ELEC9701, Mixed Signal Microelectronics Design, which is a core course in the microelectronics post-graduate program offered by the school.

Old courses: The course replaces previous courses ELEC4522 and ELEC4532.

Learning outcomes

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

1. appreciate capabilities and limitations of current microelectronic (or IC) technologies,
2. use modern CAD design tools to design ICs,
3. create IC layouts,
4. understand and use circuit models of IC components,
5. analyse simple analogue and digital microelectronic circuits, and
6. design simple analogue, digital and mixed microelectronic circuits.

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.

3. The skills of effective communication, which are addressed by the reports.
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, laboratory work, 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.

Laboratory work

The laboratory work provides the student with hands-on design experience and exposure to state-of-the-art CAD tools. The laboratory work thus enables the students to use these tools for IC circuit design, analysis and lay-out. Students must come prepared for the laboratory sessions; the laboratory sessions are short, so this is only possible way to complete the given tasks.

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 laboratory exercises provides the student with quantitative understanding of IC circuit analysis. 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 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 the CAD tools to verify the circuit operation and write a report 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, computer simulations and layout of a microelectronic circuit is to be carried out in groups of two students. Students may use the CAD tools in room EEG16/EEG20 for this task. (Students are not to use the scheduled laboratory time for the design task).

Assessment

There are four components of the assessment in this course:

Laboratory work:	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.

Laboratory work: The laboratory work is assessed in order to ensure that the students understand the material in this essential course component; thus, this assessment test that the student can use the CAD tools, understand circuit models and circuits, and can create IC layouts. Laboratory work must be documented in brief reports which are due on the due date by 5pm. 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. The reports should be dropped into the school assignment box next to room G12A. Assessment is grade-only marks based on lab work and reports (a HD mark is given only for exceptional performance; a serious attempt at completing the problems 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 simple integrated circuit, thus also demonstrating the students appreciation of the technology, and ability to use appropriate models and conduct suitable analysis to aid the design. A report on the design 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 (a HD mark is given only for exceptional performance; a serious attempt at completing the problems 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 tests 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 Schedule

1:	Topic: CMOS processing technology and components: lithography, oxidation, diffusion, implantation, film deposition, etching, metallisation; MOS transistors, resistors, capacitors, inductors. Text: Baker ch. 7, web; Baker ch. 5.
2:	Topic: IC layout: active, poly, contact, metal and other layers; design rules. Text: Baker ch. 3, 4, web. Tasks: Lab 1, layout with Cadence.
3:	Topic: Design, synthesis and verification tools. Layout editor, p-cells, cell libraries, P&R, VHDL compilers, process scaling, spice simulator, extraction, LVS. Tasks: Lab 1 continued.
4:	Topic: MOS models; device noise: NMOS and PMOS devices, operating regions, current equations, large/small signal models, analogue/digital models; noise. Text: Baker ch. 9, 10; Baker ch. 8. Tasks: Lab 2, circuit simulation with Cadence; Lab 1 report due.
5:	Topic: Single-stage amplifiers: current mirrors, common-source, common-drain, cascodes, differential pairs. Text: Baker ch. 20, 21, 22. Tasks: Lab 2 continued. QUIZ 1.
6:	Topic: Operational amplifiers: two-stage amplifiers, compensation, slew-rate, bandwidth, output stages. Text: Baker ch. 24. Tasks: Lab 3, op-amp design; Lab 2 report due.
7:	Topic: Samplers; comparators: capacitive sampling, charge-injection; continuous and latched comparators. Text: Baker ch. 25; Baker ch. 27. Tasks: Lab 3 continued.
8:	Topic: D/A and A/D converters: data converter fundamentals, current-steering, charge scaling DACs, flash and successive approximation ADCs. Text: Baker ch. 28, ch. 29. Tasks: Lab 4, combinational logic; Lab 3 report due.
9:	Topic: CMOS inverters and logic: noise margins, voltage transfer characteristics, switching, gate delay, inverter sizing, fan-out, power dissipation. Text: Baker ch. 11. Tasks: Lab 4 continued. Design project released. QUIZ 2.
10:	Topic: CMOS logic: static logic, complex gate synthesis, gate layout, gate sizing, special functions. Text: Baker ch. 12. Tasks: Lab 5 sequential logic; Lab 4 report due.
11:	Topic: Sequential logic: transmission gates, multiplexers, latches and flip-flops, transistor sizing, set-up and hold times, dynamic registers. Text: Baker ch. 13, 14. Tasks: Lab 5 continued.
12:	Topic: Memory: ROM, SRAM and DRAM cell design, organisation and performance, sense amplifiers, floating-gate memory. Text: Baker ch. 16. Tasks: Lab 5 report due. Design project due.

Resources for Students

Textbooks

Prescribed textbook

The following textbook is prescribed for the course:

R. J. Baker, *CMOS Circuit Design, Layout, and Simulation*. Wiley Interscience, 2nd ed., 2005.

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.

Reference books

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

D. A. Johns and K. Martin, *Analog Integrated Circuit Design*. Wiley and Sons Inc., 1997.

B. Razavi, *Design of Analog CMOS Integrated Circuits*. Electrical Engineering, McGraw-Hill International, 2001.

P. R. Gray, P. J. Hurst, S. H. Lewis, and R. G. Meyer, *Analysis and Design of Analog Integrated Circuits*. Wiley and Sons Inc., 4th ed., 2001.

K. R. Laker and W. M. C. Sansen, *Design of Analog Integrated Circuits and Systems*. Electrical Engineering, McGraw-Hill International, 1994.

R. L. Geiger, P. E. Allen, and N. R. Strader, *VLSI Design Techniques for Analog and Digital Circuits*. McGraw-Hill Publishing Company, 1990.

T. H. Lee, *The Design of CMOS Radio-Frequency Integrated Circuits*. Cambridge University Press, 1998.

N. Weste and D. Harris, *CMOS VLSI Design: a Circuits and Systems Perspective*. Addison-Wesley, 3rd ed., 2005.

J. M. Rabaey, A. Chandrakasan, and B. Nikolic, *Digital Integrated Circuits: a Design Perspective*. Prentice-Hall, 2nd ed., 2003.

R. S. Muller and T. I. Kamins, *Device Electronics for Integrated Circuits*. Wiley, 3rd ed., 2003.

S. M. Sze, *Semiconductor Devices: Physics and Technology*. Wiley, 1985.

M. Ohring, *Reliability and Failure of Electronic Materials and Devices*. Academic Press, 1998.

Books covering assumed knowledge

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

R. C. Dorf and J. A. Svoboda, *Introduction to Electric Circuits*. Wiley, 6th ed., 2004.

A. S. Sedra and K. C. Smith, *Microelectronic Circuits*. Oxford University Press, 4th ed., 1998.

J. F. Wakerly, *Digital Design Principles and Practises*. Prentice-Hall, 3rd ed., 2001.

A. V. Oppenheim and A. S. Willsky, *Signals and Systems*. Prentice-Hall, 2nd ed., 1997.

On-line resources

Some additional on-line resources relevant to the course:

Resource:	course website	http://subjects.ee.unsw.edu.au/elec4602
	mosis website	http://www.mosis.com
	book website	http://www.cmosedu.com
	library resources	http://info.library.unsw.edu.au/web/ services/teaching.html

CAD resources

Students will use the PCs in the CAD Laboratory (room 214) for all laboratory works. The CAD tools used in this course is the industry standard Cadence design suite which run under the Linux system on the dual boot PCs. For specific details on how to log on, see the course web page. Students can access the CAD tools after hours on the dual boot PCs in the School computer laboratory located in room EEG16/EEG20.

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.

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/>.