LTH

Lund has had an institute of technology for 40 years – LTH – which is now part of Lund University, constituting its Faculty of Engineering. LTH has more than 5,000 undergraduates studying programmes leading to various degrees.
Among the 4 ½-year engineering programmes are subjects such as engineering physics, civil engineering, chemical engineering, electrical engineering, computer science and engineering, mechanical engineering, surveying, engineering nano-science, engineering mathematics, information and communication engineering, industrial management and engineering, environmental engineering, biotechnology and risk management.
LTH has about 540 postgraduate students whose goal is to obtain a doctoral degree in engineering after five year's study.

LTH International Office

The International Office at LTH, Kårhuset is open for students between 8.30 and 16.30. If you have any questions or problems, please feel welcome to visit. Turn to Anna Carlqvist and if you want to be sure that she is there just send an e-mail and make an appointment anna.carlqvist@kansli.lth.se

Academic Year

The academic year is divided into two terms. At LTH each term is divided into two study periods. Each study period consists of seven weeks. Usually you study at least two courses in parallel during each period.

Autumn term 2005, August 30 – January 15
Spring term 2006 (preliminary) January 17 – June 3

Christmas vacation: December 22, 2005 - - January 6, 2006
Easter vacation: April 10, 2006 - - April 17, 2006 (preliminary)

Credit System

Academic studies in Sweden are organized according to a credit system. One Swedish credit is equivalent to one week of full-time studies, and during the course of a normal academic year students should aim at obtaining 40 credits.

Degree

The international master's programmes in

- Bio- and Food Technology
- System-on-Chip
- Water Resources

all lead to the Swedish degree of "Magisterexamen" which is translated into English as "Degree of Master in...". This degree is awarded by LTH.

Degree projects in engineering programmes

Aim

In the project paper the student should display an ability to apply and compile knowledge and skills acquired on various central and qualified courses of the relevant educational programme. Through the project the student should demonstrate an ability to identify, analyse and solve a technical or scientific problem and evaluate the solution, and to present and document the result. The project should be an in-depth study of a topic, showing that the student can apply the methods of science and engineering.

The paper should be the result of independent work, carried out individually or in a group of two. If the paper is produced jointly there should be a clear statement of who contributed what. The paper should be written on one of the topics stated in the study programme syllabus unless the education committee permits an exception in individual cases.

A pass on the project is compulsory if a student it to obtain a degree in engineering.

Content

The work on the project includes:

• A written report in Swedish or English with a summary in English
• A separate summary which may be popular in character or take the form of a scientific article
• A presentation at a public seminar at LTH
• Acting as opponent at a seminar where another student's paper is presented

All of the above points must be approved if the project is to receive a pass grade.

The report should be available in a version for examination at least one week before the seminar. The department takes responsibility for producing the required number of copies of the report. It is desirable but not compulsory that the report should be scrutinized by another project candidate at the seminar. The same report can be scrutinized by more than one candidate. The seminar may be scheduled outside term time if the student, supervisor and examiner are in agreement.

The report is public and no part of it may be kept confidential. The examiner may not take into account any confidential information when assessing the report. The department must file the report.

Assessment and supervision

For each project topic the head of department appoints one or more teachers with research training at Lund University as examiner. This means, among other things, that the project is to be examined at Lund University even in the case of exchange students. The examiner decides the grade to be awarded to the paper. Before work on the project begins, the examiner must approve the choice of topic and appoint a supervisor to provide the candidate with continuous supervision. The aim of the supervision includes making it possible to complete the project within 20 weeks of full-time study. The student cannot expect supervision for more than 15 months. The examiner may appoint as supervisor anyone deemed suitable. The supervisor need not be a teacher at LTH. No one may act as examiner on a paper which he or she has supervised. The grades awarded are either pass or fail.

Scope

The degree project is worth 20 credits.

Eligibility and registration

Work on the project may begin when the student has at least 140 credits (30 credits for Master's

students) which may count towards the degree. Dispensation from this can only be granted by the education committee and only if there are special grounds.
To be allowed to start work on the project the student should also have acquired sufficient knowledge in the subject field of the project. It is up to the examiner to determine whether this requirement has been met before the work begins.

Examination

There is always one week of examinations at the end of each study period prior to the start of the next study period. It is not unusual for a course to run over two study periods and be followed by an examination at the end of the course. Written examinations at the end of a course are the most common form of evaluation, however, written reports, which may be presented orally to the lecturer or to a group, are also a common means of evaluating the performance of students.
There are always three periods of re-examination every year: in August, just prior to the start of the new academic year, in the beginning of January and just after the Easter holidays.

Grades
The grades usually awarded at LTH are:
5 - Excellent
4 - Very good
3 - Pass
Some courses are graded simply as Pass or Fail. NB! The only grade available for a Master's thesis is a Pass.
There will be no ranking of the students enrolled in the master's programmes.

Individual written exams

The length of the exam can vary from 1 to 6 hours. Normally the students should register in advance in order to participate in the exam.
The student should bring the following to an exam: Valid ID, the original "Letter of Acceptance" and permissible accessories such as pencil, ruler and eraser.
During the written exam, invigilators will answer any general questions and ensure a controlled environment. The responsible lecturer is normally available during parts of the exam to answer more specified questions. Students may bring drinks or snacks to the exam. The student should enquire as to which accessories are allowed during the exams. It is forbidden to bring accessories such as, notes, books, calculators, mobile phones, tape recorders etc., unless approved by the responsible lecturer. It is considered cheating if forbidden accessories are used or found during the exam. Communication between examining students is also considered cheating. Also note, that cheating is not socially accepted among students! Any incidence occurred where cheating is suspected will be reported to the Board of Discipline and may lead to that the student will be expelled, if he is found guilty.

Graduation Day

Graduation will be celebrated once a year by a ceremony in the University building in December.

Student Counselling

Are you having trouble concentrating on your studies, perhaps because of personal problems? Are you going through difficulties as a result of studying abroad or because of a culture change? Are you in a crisis situation and need to talk to someone or get help?

At LTH we have student councellors who are trained social workers and are there to help you. Please be assured that all your dealings with these counsellors are strictly confidential. You can call or e-mail to make an appointment at:
046-222 71 91, LTH, Kårhuset, Lund Ulla.Bergman@kansli.lth.se

Students´ Health Care

Studenthälsan/student health care centre provides care and counselling for all students at Lund University/LTH. They can help you with physical, personal or social problems, which may hamper your capacity to succeed with your studies. You may consult a general practitioner or psychiatrist, a social worker, psychologist or nurse. The centre can also provide support groups and the possibility to discuss focus issues like alcohol, eating disorders, stress reactions and examination anxiety.

Visiting address: Gerdagatan 7a, Lund
Postal address: Box 117, 221 00 Lund
Phone: 046-222 4377 (reception 222 0000)
Fax: 046-222 4386
E-mail: studhals@stu.lu.se
www.lu.se/stud/studh.htm

Time booking: Mon-Thur 9-00 - 12-00, 13.00 – 15.00, Fri 9.00 – 12.00, 13.00 – 14.00

Timetables

The schedule generator is only available in Swedish. Here is a short instruction how to generate your timetable:

1) Go to the schedule generator Http://klth4d.kansli.lth.se/start.html, and choose the appropriate study period.
2) Enter the course code in the form field and click "Sök" (Search)
3) The search has one result. Mark the box and click "Lägg till" (Add).
4) If you have successfully added a course, you will see a list of the courses that you have chosen. You can use the form field to add more courses
5) When your list is complete, click "Generera schema" (Generate schedule)

The complete course name and/or code are not mentioned in the schedule. Instead, each course is given another abbreviation in Swedish. To know what the various courses are called in Swedish you should consult the Swedish student's handbook, http://www.lth.se/for_student/studiehandbok.html , and choose "Läro- och timplan med tentaschemat".

This all may seem rather complicated, but you'll soon get the hang of it, so don't give up.

STUDY PLAN

SYSTEM-ON-CHIP

1 Aim and purpose

1.1

The programme comprises 60 credit points and leads to a master's degree with broad competence in System-on-Chip.

1.2 Overall aim

According to the Higher Education Act, a university education is supposed to give students, besides knowledge and skills, a capacity for independent and critical judgement, an ability to solve problems independently, and an ability to follow the development of knowledge in the fields covered by the education. The education should also develop the students' ability to exchange knowledge at a scientific level.

1.3 General content of the programme

The programme consists of compulsory courses, optional courses, and a degree project. Tuition is provided in different forms and with various types of examination. Students are given practice in identifying, formulating, and solving problems, and in presenting solutions. Laboratory exercises with written reports and oral presentations are a natural part of the education.

1.4 Special objective of master's education in System-on-Chip

Future silicon technologies with extremely small transistors will allow silicon designs with billions of transistors on one chip. For the silicon designer the next ten years will mean a new phase in development: the design of system-on-chip. New high-tech products like WLAN, WAP telephones, Ethernet servers, gigabit switches, set-top boxes, HD-TV, and broadband need various blocks such as signal processors, processor cores, hardware accelerators for demanding units, memory, built-in software, AD converters, analog filters, DC-DC converters, high-frequency transmitting and receiving circuits, sensors, etc.

The silicon design industry is expected to shift towards a focus on parts which are its special competence. Other parts of the chip will be purchased as intellectual properties. A new type of electronic designer is required for this work. Until today, the silicon designer has been busy designing chips with single functions. Tomorrow's designer will also combine designs to build entire systems on chips. The great challenge for tomorrow's engineers will be to fill the gap that exists between what can be achieved in today's design environment and the billions of transistors that are available.

2 The main content and arrangement of the programme

The programme comprises a compulsory set of courses worth 15 credit points, giving an orientation in modern chip design. The aim is to provide a general view of system-on-chip and a base on which to build an understanding of all types of IC design, i.e., in digital, mixed mode, analog, and radio-frequency design. An important component, also compulsory, is a large project course worth 8 credit points. The idea is to choose a number of critical components from a system, for example, a simple wireless LAN, which are implemented as real silicon, i.e., sent for manufacture and then verified. The projects may be digital, analog, mixed mode, or for radio frequencies, but above all the course is intended to show the whole, i.e., that the individual projects are part of a complete system-on-chip. Advanced study consists of two tracks with compulsory courses, one aimed at digital ASIC and built-in systems, the other at digital and analog ASIC. Apart from the compulsory courses there is an optional part with at least 17 credit points. The course part is followed by a degree project worth 20 credit points.

3 Special prior knowledge required for admission

To be accepted, applicants must have a B.Sc. in Computer Science or Electrical Engineering or equivalent, which includes courses in digital engineering, electronics, and computer science. Students must also have a good knowledge of English: TOEFL at level 550 (213 for computer-based TOEFL) or more, IELTS 6.0, or Cambridge Certificate of Proficiency.

4 Grading

Grades are awarded for whole courses and tests as stated in the respective syllabus. Whole courses are graded as good (3), very good (4) or excellent (5). Grades for tests are either fail or pass. The syllabus may, however, contain instructions that a particular whole course shall be graded as either fail or pass. For degree projects a pass is not graded. In addition, the syllabus may contain rules about different grade scales for the constituent tests. Courses and tests which a student has failed are not included in the course certificate or degree certificate. Note that, in the grade system used at LTH, grades are absolute and directly linked to the target knowledge and not based on ranking of the students.

5 Degree certificate and qualification

When the requirements for the degree are satisfied, students receive a degree certificate as Master in System-on-Chip. The certificate is accompanied by a Diploma Supplement in English, describing the content and scope of the education. This is intended to facilitate the acknowledgment of university qualifications throughout Europe and in other parts of the world.

6 Examination requirements

6.1 Required courses

The programme is divided into courses. Section 8 shows which courses must (compulsory courses) or may (optional courses) be part of the qualification if a student is to be considered to have followed and passed the programme. All the courses listed in section 8 are given in English. To obtain a degree, students, besides the basic eligibility stated in section 3, must have passed compulsory and optional courses and completed a degree project, all to a total value of at least 60 credit points. At least 45 credit points, including the degree project, must be obtained at LTH. After obtaining the approval of the education committee, students may take other optional courses than those listed in section 8 below, provided the courses are relevant for a Master's in System-on-Chip.

7 Special regulations

7.1 Laboratory exercises

All laboratory exercises are compulsory unless otherwise stated in the syllabus.

7.2 Guidelines for written assignments and laboratory exercises

Work in connection with written assignments and laboratory exercises must be done individually unless it is stated that the work should be done in groups. As regards group work, the responsible teacher decides how many students make up a group, which may not be increased without special permission. All members of the group must take part in the work on the assignment. When work is done in groups, all the members must be thoroughly familiar with all parts of the work and must also be able to report on the parts done by other members.

Cooperation between students is encouraged within specific limits. It is not permitted, however, to copy a solution from another student or group.

Compulsory courses in track 1 (Digital ASIC/Embedded Systems)

Code	Course	Credits	Study Period
ETI130	Digital IC Design	4	1 Autumn
ETI200	System-on-Chip: Low Noise Design	3	2 Autumn
ETI210	IC Project & Verification	8	2 Autumn – 2 Spring
ETI280	Intellectual Property Right Management	4	1 Spring
EDA380	Design of Embedded Systems	4	2 Spring

Compulsory courses in track 2 (Digital/Analog ASIC)

Code	Course	Credits	Study Period
ETI063	Analog IC Design	4	1 Autumn
ETI130	Digital IC Design	4	1 Autumn
ETI200	System-on-Chip: Low Noise Design	3	2 Autumn
ETI210	IC Project & Verification	8	2 Autumn – 2 Spring
ETI280	Intellectual Property Right Management	4	1 Spring

Optional courses

Code	Course	Credits	Study Period
EDA380	Design of Embedded Systems (Track 2)	4	2 Spring
EDA385	Design of Embedded Systems, Advanced course	5	1 Autumn
EEM050	Microsensors (in Swedish)	4	2 Spring
EIT120	Introduction to Structured VLSI Design	5	1 Autumn
EIT130	VLSI Architecture	8	2 Autumn – 1 Spring
ETI051	Radio Systems	4	1 Spring
ETI063	Analog IC Design (Track 1)	4	1 Autumn
ETI085	Channel Modelling for Wireless Communications	4	2 Spring
ETI121	Algorithms in Signal Processors – Project Course	4	1 Spring
ETI 135	Advanced Digital IC Design	3	1 Spring
ETI180	DSP Design	4	2 Autumn
ETI170	Integrated Radio Electronics (Track 2)	4	1 Spring
ETI220	Integrated A/D and D/A Converters	4	2 Spring
FFF021	Semiconductor Physics	4	1 Autumn
FFF041	Physics and Technology of Nanometer Structures	5	1 Spring
FFF110	Processing and Device Technology	5	1 Autumn
FFF115	High-Speed Devices	5	2 Autumn

COURSES

SYSTEM-ON-CHIP

DESIGN OF EMBEDDED SYSTEMS EDA380

Credit Points: 4. **Grading:** TH. **Lecturer:** Krzysztof Kuchcinski, Krzysztof.Kuchinski@cs.lth.se, Dept of Computer Science. **Prerequisites:** Programming, first course, Design of Digital Circuits and Computer Organisation. **Examination:** Written examination. Completed laboratory work is required. **Web page:** www.cs.lth.se/Education/Courses

Aim

The main goal of this course is to introduce embedded system design, which can be implemented using System-on-Chip technology. This kind of embedded systems contain both hardware and software components and therefore a hardware/software co-design is emphasized. The course will give a basic knowledge on specification methods, design representations (computational models) as well as related design methods. Special emphasis will be put on interface synthesis and low-power design methods.

Description

SoC development methodologies, HW/SW co-design, design specification, design representations, system partitioning, component allocation, assignment and scheduling, interface synthesis, testability, low-power design.

Literature

One of those two books:
Marwedel, P: Embedded System Design. Kluwer Academin Publisher, 2003. ISBN 1-4020-7690-8 or
Wayne Wolf: Computers as Components, Principles of Embedded computing system Design, Morgan Kaufmann Publishers, 2001. ISBN 1-55860-541-X (case), ISBN 1-55860-693-9 (paper)

DESIGN OF EMBEDDED SYSTEMS, ADVANCED COURSE EDA385

Credit Points: 5. **Grading**: UG. **Lecturer**: Flavius Gruian, flavius.gruian@cs.lth.se
Prerequisites:EDA011/EDA016 Programming, First Course and EDA380 Design of Embedded
Examination: Completed laboratory work and project. **Web page**: www.cs.lth.se.

Aim

This course intends to give hands-on experience in designing embedded systems, as a natural continuation of the first more theoretical course, EDA380. The focus is on completing a practical project of an embedded system, involving various design decisions and trade-offs. In principle, the emphasis is on choices such as software vs. hardware, distributed vs. localized implementations and trade-offs such as high-performance vs. low energy consumption, and flexibility vs. low complexity.
The students will be required to design, implement, and test a small embedded application on a predefined but highly configurable hardware architecture. During the course, a number of lectures will give more specific information on the support architecture and useful design approaches for the various parts of such an embedded application.

Description

- Introduction, from theory to practice, the available support architecture.
- Project description: Several possible projects are briefly described. New proposals are presented by the authors.
- Requirements analysis: Extracting the important information concerning performance, real-time behaviour, and non-functional requirements.

- Design decisions: Functional partitioning and assignment, Hardware/software partitioning, protocol selection, support software selection.
- Design refinement: Peripherals, interfaces, power management.
- Implementation related issues: Compiling embedded applications, Operating system's role, configuring FPGAs and other hardware devices.
- Testing and maintenance

Literature

Vahid F, Givargis T: Embedded System Design: A Unified Hardware/Software Introduction, John Wiley & Sons Inc. 2002, ISBN 0-471-38678-2.

MICRO SENSORS EEM050

Credit Points: 4. **Grading:** TH. **Lecturer:** Thomas Laurell, Dept of Electrical Measurements. **Prerequisites:** EEM022 Electrical Measurements and Instrumentation. **Recommended prerequisites:** EEM030 Transducers in Measurement Systems and basic semiconductor electronics. **Examination:** EEM022 Electrical Measurements and Instrumentation. EEM030 Transducers in Measurement Systems and basic semiconductor electronics. The results of the sensor fabrication and characterisation shall be successfully presented and defended in a poster presentation session. If the material presented at the supervisor meeting one week before the end of the course is not of sufficient quality the group will fail the course. A written examination is required to obtain grade 4 or 5. **Web page:** www.elmat.lth.se/Utbildning/Mikrosensorer/mikrosensorer.html.

Aim

The course will give a fundamental understanding of silicon as a sensor material and the techniques used for designing silicon based micro sensors. The principles for sensing parameters such as temperature, pressure, flow, acceleration, light and magnetic fields using silicon micro sensors are presented.
A large portion of experimental work will give a hands on experience in micro sensor fabrication and characterisation.

Description

Fundamental principles for the function, design and fabrication of silicon based micro sensors are given in a lecture series. Each group (2 students/group) penetrate the details of the sensor principle that they have been assigned to work with in the experimental part. This is reported in a smaller written report. The students participate in the direct fabrication of the micro sensors and follow the complete process scheme of their silicon wafer in the clean room laboratory.
The fabricated sensors are finally characterised by each group and the findings are presented and defended in an open forum in a poster format.

Literature

Recommended literature: Sze, SM: Semiconductor Sensors.

INTRODUCTION TO STRUCTURED VLSI DESIGN EIT120

Credit Points: 5. Grading: UG. **Lecturer**: Professor Lambert Spaanenburg **Prerequisites**: EIT020 Design of Digital Circuits---A Systems Approach. **Examination**: Only the grades Pass and Fail are used. For Pass a student must have completed the laboratory work and submitted a working solution to the assignment. **Web page**: http://www.it.lth.se/DSi

Aim

The goal of this course is to give an introduction to the design of application specific integrated circuits (ASIC) based on modern design tools.

Description

The course consists of the following four main parts: 1) Design flow based on modern design tools, 2) Use of VHDL as design language and input for logic synthesis, 3) Design of synchronous systems by developing clock cycle true models, 4) Use of field programmable gate arrays (FPGA) for rapid prototyping.
The course contains lectures, exercises, laboratories, and an assignment. The laboratory work is design oriented and based on the use of tools for simulation, synthesis, and optimisation with FPGA as the target technology. The assignment is a direct continuation of the laboratory work.

Literature

Douglas Perry: VHDL. McGraw-Hill, fourth edition, 2002.
Laboratory manuals and other material can be obtained from the department.

VLSI ARCHITECTURE EIT130

Credit Points: 8. **Grading**: UG. Lecturer: Professor Lambert Spaanenburg **Prerequisites**: EIT120 Introduction of Structured VLSI Design or equivalent. **Examination**: Only the grades Pass and Fail are used. For Pass a student must have completed one assignment and one project. **Web page**: http://www.it.lth.se/courses/vlsi **Comments**: Limited Admittance 20 students. Selection criteria: Interview. Ranking is established by an evaluation of the applicants' capability of accomplishing the course successfully.

Aim

The purpose of the course is, by completing a large design project, to learn how to implement a complex function in silicon with strict performance requirements.

Description

The course consists of the following four main parts: 1) Some lectures and laboratories as a deepening of the prerequisites in VHDL and logic synthesis, 2) An introductory design task with strict requirements on area and speed, 3) Some lectures and laboratories as introduction to the application area of the projects, 4) A large design project conducted in groups.

Literature

Laboratory manuals and other material can be obtained from the department. S. Malki and L. Spaanenburg: "Vision with digital CNNs"

RADIO SYSTEMS ETI051

Credit Points: 4. **Grading:** TH. **Lecturer:** Ove Edfors, Ove.Edfors@es.lth.se, Electroscience. **Recommended prerequisites:** ETI031 Radio, ETT051 Digital communications, adv. course. **Examination:** Written examination and completed laboratory work. **Web page:** www.es.lth.se/ugradcourses/radiosys/radiosystem.html.

Aim

This course aims at: (1) Combining different technologies from the field of telecommunications to a complete transmission system optimised for realistic transmission channels. (2) Discussing different design compromises, e.g. between spectrum efficiency, system performance, implementation aspects, and costs. (3) Provide models and show the combined use of theoretic analysis, simulation, and measurements, in the design of radio systems.

Description

The course will focus on the following issues; The transmission channel from transmitter to receiver, analogue/digital transmission, and radio networks. Modern radio systems will be used as examples in the course.

Literature

Compendium.

ANALOGUE IC-DESIGN ETI063

Credit Points: 4. **Grading:** TH. **Lecturer:** Henrik Sjöland, Henrik.Sjoland@es.lth.se Electroscience. **Prerequisites:** ESS020 Analogue Circuits **Examination:** To qualify for a final mark, students must have passed the written examination and the laboratory work. **Web page:** www.es.lth.se/ugradcourses/ICkonst/kurs.html.

Aim

The main goal of the course is to give a good understanding of the basic implementation techniques for analogue and mixed-mode CMOS integrated circuits.

Description

Basic analogue building blocks are treated in detail. Other important issues also covered by the course are

- the interface between IC design and IC fabrication.
- the use of sophisticated analogue simulation programs for IC design verification.

Literature

Gray, Hurst, Lewis & Meyer, "Analysis and Design of Analog Integrated Circuits, Fourth Edition, Wiley 2001.

CHANNEL MODELLING FOR WIRELESS COMMUNICATIONS ETI085

Credit Points: 4. **Grading:** TH. **Lecturer:** Prof. Andreas Molisch, Andreas.Molisch.@es.lth.se, Electroscience. **Prerequisites:** ETI051 Radio Systems. **Recommended prerequisites:** ETI031 Radio, ETT051 Digital Communications **Examination:** Written examination (5h) and completed laboratory work. **Web page:** www.es.lth.se/ugradcourses/channelmodelling.

Aim

The goal of the course is to give the students a comprehensive overview of wireless propagation channels, ranging from the underlying physical propagation phenomena to measurement techniques to ways how to model the channel. This includes physical insights for the stochastic fluctuations of typical wireless channels, mathematical methods for exact descriptions as well as the relationship between channels and wireless system design.

Description

• *Propagation Mechanisms* - Free space propagation, reflection and transmission, diffraction, scattering on rough surfaces, wave guiding
• *Statistical Description of Wireless Channels* - The time-invariant two-path model, time-variant towpath model, small-scale fading without line-of-sight, small-scale fading with line-of-sight, Doppler spectra, level crossing rate and random FM, large-scale fading
• *Wideband Channel Characterization* - Narrowband vs. wideband systems, system-theoretic description of propagation channels, the WSSUS model, description methods for time

dispersion, description methods for angular dispersion
• *Channel Models* - Narrowband models, wideband models, spatial models, deterministic models, models for ultrawideband channels
• *Channel Sounding* - Time-domain methods, frequency-domain methods, generalizations, spatially
resolved methods
• *Antennas* - Requirements for antennas in mobile radio, antennas for mobile stations, antennas for base stations

Literature

Molisch A F: Lecture notes in Channel Modelling for Wireless Communication. 2005.

ALGORITHMS IN SIGNAL PROCESSORS – PROJECT COURSE ETI121

Credit Points: 4. **Grading:** UG. **Lecturer:** Universitetslektor Bengt Mandersson, bengt.mandersson@es.lth.se, Electroscience. **Prerequisites:** ESS040 Systems and Signals or ETI265 Signal Processing in Multimedia. **Recommended prerequisites:** ETT042 Adaptive Signal Processing or ETT074 Optimum Signal Processing or both. **Examination:** Written and oral presentation of projects. **Notes:** Limited number of of participants (24). Selection criteria: 1. Credits achieved in ESS040 Systems and Signals, ETT042 Adaptive Signal Processing and ETT074 Optimum Signal Processing. 2. Marks achieved in above-mentioned courses. **Web page:** www.es.lth.se/ugradcourses/psb/projektSIG.html.

Aim

The aim of the projects is to apply the theoretical knowledge gathered from other courses in signal processing, to various topics in e.g. telecommunications, audio signal processing or biomedical signal processing.

Description

Digital Signal Processing is found in various applications, such as acoustics, audio signal processing, biomedical signal processing and telecommunications. The projects are related tothese areas.

The work is carried out in small groups (2 to 4 students). The course starts with a presentation ofthe methods and material that will be used. The students implement these methods in Matlab andDSP (Digital Signal Processor). A written presentation is an important part of the work. Teachers are available during the course for discussion and questions.

Literature

Supplementary material from the department.

DIGITAL IC-DESIGN ETI130

Credit Points: 4. **Grading:** TH. **Lecturer:** Peter Nilsson, Peter.Nilsson@es.lth.se, Electroscience. **Prerequisites:** EIT020 Design of Digital Circuits and ETI240/0101 or ETI011 Analogue Electronics. **Examination:** Laboratory work and written examination. **Web page:** www.es.lth.se/ugradcourses/digickonstr/digickonstr.html. **Remarks:** Language Swedish (All material is in English and limited teaching in English if required).

Aim

Digital IC Design is the first course out of four, in digital VLSI design, see www.tde.lth.se/ugradcourses/ugradcourses.html. The course aims to give a thorough understanding for digital integrated circuit design. Increasing complexity and high requirements on performance in form of throughput and low power consumption will increase the expectations from the hardware designer. To understand both the possibilities and the limitations is important for both full custom designers and high level designers. The course will focus on CMOS design.

Aims: Knowledge
The student shall after the course:
Have understanding for the MOS transistor, how it works and its physical properties
Understand how elementary and complex logic functions are designed
Know how wires between different blocks affect the design
Understand how arithmetic block are designed
Have knowledge about both combinatorial and sequential nets
Understand clocking and pipelining
Know about memory design

Aims: Skills
The student shall after the course:
Know about transistor sizing for performances as throughput and power consumption
Be able to optimize logical functions to a minimal transistor topology
Be able to assemble logical and arithmetic blocks to larger units
Be able to apply a clocking strategy with pipelining on a larger unit

Aims: Attitude
The student shall after the course:
Have the insight that a chip is not a chaotic collection of transistors, but is a structured hierarchical system built of modules.

Description
The course content includes the MOS-transistor, elementary logical functions, sequential circuits, arithmetic, clocking, and memories.

Literature
Rabaey J M, Chandrakasan A, Nicolic B: Digital Integrated Circuits: A Design Perspective, Prentice Hall International Editions, ISBN 0-13-120764-4.
http://infopad.eecs.berkeley.edu/~icdesign
Additional material will be found at
http://www.tde.lth.se/ugradcourses/digickonstr/digickonstr.html

ADVANCED DIGITAL IC DESIGN ETI135

Credit Points: 3. **Grading:** UG. **Lecturer:** Peter Nilsson, Peter.Nilsson@es.lth.se, Electroscience. **Prerequisites:** ETI130 Digital IC Design **Recommended prerequisites:** ESS030 Physics of Devices or FFF010 Solid State Physics, Basic Course. **Examination:** 80% attendance at lectures and seminars, homework and laboratory work. Each student shall also give a one hour lecture. **Web page:** www.es.lth.se/ugradcourses/digickonstr/digickonstr.html.

Aim

The development in digital integrated circuit design are continuously moving towards smaller and
smaller transistors at the same time as more and more components can be integrated at the same silicon die. The circuit designer is thus facing new problems when new parameters are influencing the design work. Phenomenon like leakage and short channel effects in the transistors are some examples on that. New design methods are therefore required. New technologies will also require new methodologies for test and verification.

Another important area is design of arithmetic building blocks such as adders and multipliers, which are basic operations in many designs. There are a large number of opportunities when implementing digital circuits that give different results on speed, area, and power consumption. Clocking of digital synchronous circuits is an area with increasing problems today. Efficient clocking strategies and alternatives such as asynchron design are studied.

Aims: Knowledge
The student shall after the course:
− Have got understanding for what happens when the transistors are shrinking
− Be aware of secondary effects when scaling the technologies.
− Know how to design with different arithmetic building blocks.
− Be aware of different methodologies when synchronizing circuits.
− Have knowledge in test and verification.
− Have understanding for different techniques for reducing power consumption.

Aims: Skills
The student shall after the course:
− From given criteria be able to estimate secondary effects such as leakage.
− Be able to analyse a circuit in a modern technology.
− Be able to select arithmetic building blocks from a given specification.

Aims: Attitude
The student shall after the course:
− Have an overview over modern processes for digital IC design.
− Be confident in design of arithmetic building blocks from a given specification.
− Have an overall understanding for optimizing digital circuits regarding power consumption and speed.

Description

The course has 3 main directions which of course are connected to each other:
− What effects have the shrinking technologies on the circuit design.
− Design of arithmetic building blocks.
− Synchron/Asynchron design of digital circuits.
The course will also discuss power estimation and design for testability.

Literature

Rabaey J M, Chandrakasan A, Nicolic B: Digital Integrated Circuits: A Design Perspective, Prentice Hall International Editions, ISBN 0-13-120764-4.
http://infopad.eecs.berkeley.edu/~icdesign.
Rekomended book: Parhami, B: Computer Arithmetic: Algorithms and Hardware Designs, Oxford University Press, ISBN 0-19-512583-5,
http://www.ece.ucsb.edu/Faculty/Parhami/text_comp_arit.htm. Other material will be placed on the web: www.es.lth.se/ugradcourses/a-dick.

INTEGRATED RADIO ELECTRONICS ETI170

Credit Points: 4. **Grading:** TH. **Lecturer:** Universitetslektor Henrik Sjöland, Henrik.Sjoland@es.lth.se, Electroscience. **Prerequisites:** ETI063 Analogue IC Design. **Recommended prerequisites:** ETI031 Radio. **Examination:** Written test of 5h, completed laboratory work and assignments. **Web page:** www.es.lth.se/edu/education.html.

Aim

The objective of this course is to provide fundamental and wide knowledge in design and analysis of high frequency electronics based on integrated circuit techniques. This is an expanding area as more and more applications are based on wireless communication, e.g. mobile phones, wireless multimedia terminals and computer networks, short-distance radio to connect various units to a computer etc. In all these applications, the radio is a very important part of the system.

Description

The focus is on methods for analysis and design of high frequency integrated electronics using CMOS technology. In particular, the implementation of the building blocks dealt with in the Radio course (ETI031) are discussed. Methods for design of amplifiers, mixers, oscillators etc. are treated.

Literature

Lee, T H: The Design of CMOS Radio-Frequency Integrated Circuits, Cambridge University Press, and additional material.

DSP-DESIGN ETI180

Credit Points: 4. **Grading:** TH. **Lecturer:** Viktor Öwall, viktor.owall@es.lth.se, Electroscience. **Prerequisites:** ESS040 Digital Signal Processing. **Recommended prerequisites:** ETI130 Digital IC-Design. **Examination:** Passed home-work assignments which are presented by the students during seminars, article review and passed laboratory work result in grade 3. For grades 4 or 5 a written exam is required. **Web page:** www.es.lth.se/ugradcourses/DSPDesign/DSPDesign.html.

Aim

Digital signal processing is an area becoming increasingly more important in many products and systems today. When algorithms within this area are to be implemented there is a large number of possible alternatives depending on varying requirements regarding for instance real time properties and power consumption. This course should give the students an understanding regarding how different implementation solutions affects properties like performance and flexibility and not least design time and development cost.

The overall goal of the course is to teach a systematic approach to the design process of digital signal processors. The main part of the course if focused on giving the students an understanding of the design process of application specific architectures given an algorithm specification. This process should be performed with a set of design constraints such as calculation capacity/throughput, power consumption and silicon area.

Aims: Knowledge

After completing the course the student should:

have gained an understanding for the relationship between parameters such as calculation capacity, power consumption and silicon area

be familiar with transformations that help the designer to develop different solutions for a given signal processing algorithm.

understand how different number representations affect the solution.

Aims: Skills
After completing the course the student should:
be able to suggest a processor architecture from a given set of criteria.
be able to analyse a processor architecture and suggest alternative solutions.

Aims: Attitude
After completing the course the student should:
have gained an overview of the field of implementation aspects of signal processing algorithms.
feel well equipped to design an application specific processor given a specification using the methodologies covered in the course.

Description

Digital signal processing is a highly expansive field which is a part of most modern electronic systems. Examples of such systems are mobile communication, MP3/CD/DVD-players and medical systems exemplified by pacemakers and hearing aids and examples of algorithms are different types of filtering, coding and image recognition. Often a real time requirement exists, which limits the possibilities to perform the signal processing in a standard computer. Standard processors are one alternative which are developed to cover a wide range of applications and can therefore be used in many systems and gives high flexibility. However, many applications have requirements on for instance throughput and power consumption that demands application specific architectures.
This course will give insight into how an algorithm specification can be implemented from a given set of criteria. The main part of the course will be focused on the design of application specific architectures that can be implemented on either reconfigurable hardware, e.g. FPGAs, or as a custom circuit, i.e. ASIC. Standard signal processors and their relation to other solutions will also be discussed. The content is:
1. Characterization and representation of signal processing algorithms: signal-flow, data-flow and dependence graphs and the concept of iteration bound.
2. Architectural transformations – The concepts of retiming, pipelining and parallel processing for high throughput and/or low power consumption. Different types of architectures such as timemultiplexed and hardware mapped and how transformations can be made between them using the concepts of unfolding and folding.
3. Algorithm transformations – How complexity in algorithms can be reduced and thereby reaching a more efficient implementation through the concept of strength reduction.
4. Different numbering systems, how they are used and how they affect implementation and performance.

Literature

Parhi K K: VLSI Digital Signal Processing Systems: Design and Implementation. John Wiley & Sons 1999. ISBN Number: 0-471-24186-5.

SYSTEM-ON-CHIP DESIGN — ETI200

Credit Points: 3. **Grading:** UG. **Lecturer:** Professor Jiren Yuan, Jiren.Yuan@es.lth.se, Electroscience. **Prerequisites:** EIT020 Design of Digital Circuits and ESS020 Analogue Electronics, ESS030 Physics of Devices. **Examination:** Laboratory work (4 labs) and 80% attendance at lectures. **Web page:** www.tde.lth.se/home/jry/Yuan-Course-1.htm

Aim

Higher and eventually the system-on-chip integration will greatly improve the performance of an electronic system in speed, power, synchronization, cost, reliability and portability. With the highest density and lowest cost, CMOS is considered the main stream technology for system-on-chip design. In such a single chip system, the digital part will emit strong switching noise through different paths and seriously disturb the analogue part like sensitive receiver and A/D converter as well as digital circuit itself. Within the analogue part, strong transmitter and oscillator signals will also cause problems. The performance of such a chip will to a large extent depend on the design methodology capable of de-coupling different parts on the same chip. This course is intended to characterise these problems and to introduce corresponding design techniques.

Description

- Trends of IC technology, chips and packaging
- Noise coupling in system-on-chip
- Substrate noise, characteristics and propagation
- Substrate coupling modelling
- Substrate biasing strategy
- Alternative methods for reducing substrate noise
- Techniques for experimental study of substrate noise
- Mechanisms and effects of switching noise
- Low switching noise digital design
- Alternative techniques for reducing switching noise

Literature

Aragonès, X et al: Analysis and Solutions for Switching Noise Coupling in Mixed-Signal ICs, ISBN 0-7923-8504-7, Kluwer 1999.

IC-PROJECT & VERIFICATION ETI210

Credit Points: 8. **Grading:** UG. **Lecturer:** Henrik Sjöland, Henrik.Sjoland@es.lth.se and Viktor Öwall, Viktor.Owall@es.lth.se, Electroscience. **Prerequisites:** ETI063 Analogue IC-design or ETI130 Digital IC-design. **Examination:** Passed or failed only. Passed is granted after the project has been completed and the written report has been approved and presented orally. **Comments:** Limited number of participants. Selection criteria: Average grade of prerequisite courses. **Web page:** www.es.lth.se/ugradcourses/socicproj/ic_project.htm.

Aim

The goal of the course is to provide an insight in practical design of integrated circuits with an emphasis on systems on chip. The circuits can be analogous, digital or mixed mode and the design can be performed at both transistor and block level.

Description

IC-design is a rapidly growing area with a large need for competent engineers. This is a project course in which the students in small groups apply the knowledge from previous courses to design an integrated circuit. The engineer who designs a part of a system must also understand its role in the system as a whole. The understanding of a whole system will therefore be emphasized.
This course gives the students the internationally unique possibility to design a complete chip which is sent to fabrication at the end of the project. The chips are sent in April, and will be back after the summer break. The course contains a compulsory verification part which is performed when the chips return from fabrication. The verification will take about one week, and should be

possible to perform sometimes during the fall, even if the master thesis work is performed at the same time.

Literature

Handouts.

INTEGRATED A/D AND D/A CONVERTERS ETI220

Credit Points: 4. **Grading:** TH. **Lecturer:** Professor Jiren Yuan, jry@es.lth.se, Electroscience. **Prerequisites:** EIT020 Design of Digital Circuits and ESS020 Analogue Electronics and ESS030 Physics of Devices. **Examination:** Attending at least 75% of the lectures, finishing all 4 labs and delivering all lab reports guarantee grade 3. For higher grades (4 or 5), a written examination is required. **Web page:** www.tde.lth.se/home/jry/Yuan-Course-2.htm

Aim

While digital techniques become undoubtedly efficient, most of the electronic systems still have to deal with analogue signals, e.g. the radio channel in a wireless system. High performance A/D and D/A converters are key building blocks in such a system. It is also desirable to move the analogue-digital interface towards the front-end in a software-defined radio. In designing A/D and D/A converters, there are big challenges in speed, dynamic range, area, and power consumption. Embedded A/D and D/A converters become increasingly important due to the trend of system-on-chip. This course is motivated to give the basic knowledge of A/D and D/A converters and also its state-of-the-art development.

Description

- Basics of A/D and D/A converters
- Specifications of A/D and D/A converters
- Flash and two-step A/D converters
- Folding, pipeline and successive approximation A/D converters
- High accuracy A/D converters and comparator limitations
- Sample and hold circuits
- High accuracy D/A converters (I)
- High accuracy D/A converters (II)
- Oversampling A/D and D/A converters
- Testing of A/D and D/A converters
- Components matching and on-chip reference sources
- The state-of the art CMOS Nyquist A/D and D/A converters

Literature

van de Plassche, R: Integrated Analog-to-Digital and Digital-to-Analog Converters, ISBN 0-7923-9436-4, Kluwer 1994.

INTELLECTUAL PROPERTY RIGHT MANAGEMENT (IPR) ETI280

Credit Points: 4. **Grading:** TH. **Lecturer:** Universitetslektor Peter Nilsson, Peter.Nilsson@es.lth.se, Electroscience. **Examination:** Written examination and two compulsory hand-in assignments. **Comments:** Leader of the course: Karin Lehander, Linköpings universitet, Karin.Lehander@sg.se. **Web page:** www.es.lth.se/ugradcourses/ipr

Aim

The course's main aim is to let the students learn about the kind of innovative technical work that can be protected by IPRs and how business Examinations are made by companies with respect to IPRs. After completed course, the students are supposed to have capacity to solve, on their own hand, minor juridical questions within ”Intellectual Property Rights”. They should also be able to follow and understand more complex juridical discussions and furthermore judge when juridical expertise should be asked for.

Description

The course will start with a review of fundamental Swedish and international rules of Business Right and methods to solve juridical problems.
The focus of the course is on the patent system, because it is the most important form of Intellectual Property for the SoC-design process.
Other forms of Intellectual Property, relevant for SoC-design, will also be discussed in a commercial setting: copyright, protection for integrated circuits, design rights, protection of databases and trademarks.
Some parts of the course will also deal with juridical problems related to the commercialisation of IP rights throughout license-agreements.

Literature

The main literature on the course is material on Intellectual Property Rights from WIPO that you will find on the homepage www.es.lth.se/ugradcourses/ipr. The teacher will hand other material such as legal cases or discussions on IPR-questions.

SEMICONDUCTOR PHYSICS FFF021

Credit Points: 5. **Grading:** TH. **Lecturer:** Universitetslektor Günter Grossmann, gunter.grossmann@ftf.lth.se, Solid State Physics. **Prerequisites:** Thermodynamics and Electronic Materials (FFF100) Physics of Devices (ESS030). **Examination:** Assignments and oral examination. The final grade equals the grade on the examination. **Web page:** http://www-gu.ftf.lth.se

Aim

The course connects to the course Thermodynamics and Electronic Materials - or Physics of Devices - to provide a broader and deeper understanding of fundamental aspects of Solid State Physics which are of central importance for applications. In addition, it focuses on semiconductor devices and discusses the basic physicals principles required for an in-depth understanding of devices and their operation.

Description

Crystal structure and structure determination. Binding and lattice vibrations. Electronic structure. Thermal, optical and dielectric properties.
Physics of semiconductors: intrinsic and extrinsic semiconductors, electrons an holes, charge carrier concentrations.
Generation, recombination, injection and transport of non-equilibrium carriers.
Surface states, contacts and photoconductivity.
The pn junction and bipolar transistor.
Unipolar devices: metal-semiconductor junction and contacts, MESFET, MOT diode and MOSFET. Intergrated circuits.

Literature

Sze, S.M: Semiconductor Devices, Physics and Technology, 2nd Ed., John Wiley & Sons, 2002.

PHYSICS AND TECHNOLOGY OF NANOMETER STRUCTURES FFF041

Credit Points: 5. **Grading**: TH. **Lecturer**: Professor Lars Samuelson, lars.samuelson@ftf.lth.se, Solid State Physics **Prerequisites**: Thermodynamics and Electronic Materials (FFF100) Physics of Devices (ESS030) or equivalent. **Examination**: Written examination, project dissemination, laboratory reports. **Web page**: http://www-gu.ftf.lth.se

Aim

The purpose of this course is to present the most recent advances in semiconductor technology and physics. It focuses on nm-structures and covers topics ranging from fabrication to basic physics and application in modern nanoelectronic devices.

Description

Electron-beam lithography, etching techniques and epitaxial growth. Imaging of nm structures, including scanning-probe techniques. Basic physics of quantum-dominated materials. Hetero structure physics. Quantum optics. Transport physics. QWs and QW lasers. ULSI and high-speed devices. Resonant tunnelling devices and single-electron devices.

Literature

Lecture notes: Physics and Technology of Nanometer Structures

PROCESSING AND DEVICE TECHNOLOGY FFF110

Credit Points: 5. **Grading**: TH. **Lecturer**: Professor Mats-Erik Pistol, mats-erik.pistol@ftf.lth.se; Assoc. Professor Lars-Erik Wernersson, lars-erik.wernersson@ftf.lth.se, Solid State Physics **Prerequisites**: FFF100 Thermodynamics and Electronic Materials or ESS030 Physics of Devices or FFF010 Solid State Physics, Basic Course. **Examination**: Written examination and passed laboratory exercises. **Web page**: http://www-gu.ftf.lth.se

Aim

The purpose of this course is to provide basic knowledge about fabrication and characterization of semiconductor devices on the nanometer scale. The focus is set on modern materials and processing techniques with nanotechnology as a main theme. Most of the processes are general and are applied in traditional Si based IC technology as well as in advanced III-V technology and MEMS/NEMS fabrication.

Knowledge: The student will master diffusion, deposition, and patterning and how to realize this on the nanometer scale.

Skills: After fulfillment of this course, the student will know how to work in a clean room. The student will also be able to determine the process steps needed to fabricate a specific device.

Attitude: The student will understand the relation between possibilities and limitations in processing and device performance.

Description

Materials properties of semiconductors. Device fabrication: process overview, comparison between III/V and Si. Processes: Epitaxy, doping, ion implantation, diffusion, etching, lithography. Recent methods as e.g. surface functionalization and nanoimprint lithography will also be treated. Metal-semiconductor interfaces, which are of significant importance in a number of applications will be covered. Fabrication and applications of p-n junction diodes and characterization and modeling of their electronic and optoelectronic properties. Fabrication and properties of heterostructures will be taught and exemplified by the transistors HBT and HFET. Fabrication and principles for MEMS/NEMS (micro/nano-electromechanical systems) will also be treated. In a number of laboratory exercises, some of the covered process steps will be applied in order to make working devices. Since it is highly important that semiconductor processing is carried out in a clean and dust free environment, strong emphasis will be put on clean room work methods. Finally, some advanced semiconductor structures and their properties will be demonstrated.

Literature

May, Gary S., Sze, Simon M., Fundamentals of Semiconductor Fabrication, Wiley, 2004 or Sze, S.M., Semiconductor Devices Physics and Technology, Wiley, 2002 and copied material.

HIGH SPEED DEVICES FFF115

Credit Points: 5. **Grading:** TH. **Lecturer:** Assoc. Professor Lars-Erik Wernersson, Lars-Erik.Wernersson@ftf.lth.se, Solid State Physics **Recommended prerequisites:** FFF020 Semiconductor Physics or FFF110 Processing and Device Technology **Examination:** Written examination and student paper **Web page:** http://www-gu.ftf.lth.se

Aim

Modern electronics like portable and satellite communication systems are enabled by the design of high-speed devices. This course covers the fundamentals of heterostructure design in key devices in present and future technologies. It includes a thorough modeling of the DC and AC properties of HBTs and HFETs, but also covers the use of high-speed tunnel diodes in specific circuit applications. The lecture series will be based on a mathematical description of the transport process in the devices, while the performance of state-of-the art devices (III-V and SiGe) from the literature will be used to exemplify the design. Each student will perform a simulation project (1p) where a device (HBT or FET) is simulated in a commercial simulation software. The course requirements include a written final exam, oral presentation of a recent device structure within the lecture series, and finished simulation project.

After the course the student should have acquired:

Knowledge: After the course, the student shall
- understand the physical principles behind the transistor operation in detail
- know the design principles for high-speed HBTs and HFETs/HEMTs
- be aware of the performance of state of the art three-terminal devices in III-V materials and SiGe
- know how to design elementary circuit elements using two-terminal devices with nonlinear transfer characteristics

Skills: After the course, the student shall be able to
- evaluate different technologies in terms of the performance
- run computer aided design tools to simulate the device performance

Attitude: The course aims to
- develop an understanding of the relation between materials properties and device performance
- motivate the drive for continued miniaturization as well as the need for alternative technologies

Description

Semiconductor Heterostructures: Materials properties, lateral and vertical Transport
HBTs: Repetition of basics, heterostructure design and base transport dynamics
HFETs: Repetition of basics, advanced model and physical features
CMOS: Repetition of basics, short-channel effects
Resonant Tunneling and Devices: Physics and applications

Literature

Liu, W; Fundamentals of III-V Devices: HBTs, MESFETs and HFETs/HEMTs Wiley Interscience 1999