Graduate School in Information Engineering: Ph.D. program
Department of Information Engineering
University of Padova

Course Catalogue

2006

Requirements for Ph.D. Students in the Graduate School of Information Engineering:

1. Students are expected to take for credit, during the first two years of the Ph.D. program, courses for *a minimum* 120 hours. Course hours outside the present catalogue will be appropriately weighted. In particular, each course hour of the "Laurea specialistica" program will be normally rated as 1/2 hour.
2. Students are expected to take for credit the basic courses "Applied Functional Analysis", "Applied Linear Algebra". Moreover, the course "Statistical Methods" is *strongly recommended* to all the students.

Students are expected to enroll in the courses they intend to take at least one month before the first course lesson. To enroll it is sufficient to send an e-mail message to the secretariat of the school at the address `calore@dei.unipd.it`

Contents

1 Applied Functional Analysis

Instructor: Prof. Paolo Ciatti, Dept. Metodi e modelli matematici per le scienze applicate, University of Padova, e-mail: `ciatti@dmsa.unipd.it`

Aim: The course is intended to give a survey of the basic aspects of functional analysis and operator theory in Hilbert spaces. First elements of Fourier analysis are also discussed.

Topics:

1. *Review of some notions on metric spaces and Lebesgue integration:* Metric spaces. Open sets, closed sets, neighborhoods. Convergence, Cauchy sequences, completeness. Completion of metric spaces. Review of the Lebesgue integration theory. Lebesgue spaces.

2. *Normed spaces and Banach spaces:* Normed spaces and Banach spaces. Finite dimensional normed spaces and subspaces. Compactness and finite dimension. Bounded linear operators. Linear functionals. The finite dimensional case. Normed spaces of operators and the dual space. Weak topologies.

3. *Inner product spaces and Hilbert spaces:* Inner product spaces and Hilbert spaces. Orthogonal complements and direct sums. Orthonormal sets and sequences. Fourier series. Representation of functionals on Hilbert spaces. Hilbert adjoint operator. Self-adjoint operators, unitary operators.

4. *Fourier transform and convolution:* The convolution product and its properties. The basic L^1 theory of the Fourier transform. The inversion theorem. The L^2 theory and the Plancherel theorem.

5. *Compact linear operators on normed spaces and their spectrum:* Spectral theory in finite dimensional spaces. Spectral properties of bounded linear operators. Compact linear operators on normed spaces. Spectral properties of compact linear operators. Operator equations involving compact linear operators. Fredholm alternative.

6. *Spectral theory of bounded self-adjoint operators and their spectrum:* Spectral properties of bounded self-adjoint operators. Positive operators. Square roots of a positive operator. Projection operators. Spectral measures. Spectral representation of a bounded self-adjoint operator. Extension of the spectral theorem to continuous functions.

References:

[1] E. Kreyszig, *Introductory Functional Analysis with Applications*, John Wiley and Sons , 1978.

[2] M. Reed and B. Simon, *Methods of Modern Mathematical Physics, vol. I, Functional Analysis*, Academic Press, 1980.

Time table: Course of 28 hours (2 two-hours lectures per week): Classes on Tuesday 10:30 – 12:30 A.M. and Thursday 2:30 – 4:30 P.M.. First lecture on Tuesday October 24, 2006. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Course requirements:

1. The classical theory of functions of real variable: limits and continuity, differentiation and Riemann integration, infinite series, uniform convergence, and the notion of a metric space. Moreover, one needs to know a bit of Lebesgue integration theory - actually, not much more than the definitions and the statements of the two main convergence results: the monotone convergence theorem and the Lebesgue dominated convergence theorem.

2. The arithmetic of complex numbers and the basic properties of the complex exponential function.

3. Some elementary set theory.

4. A bit of linear algebra.

All the necessary material can be found in W. Rudin's book *Principles of Mathematical Analysis* (3rd ed., McGraw-Hill, 1976).
A summary of the relevant facts will be given in the first lecture.

Examination and grading: HW and final written examination.

2 Applied Linear Algebra

Course co-sponsored by the Graduate School in Mathematics

Instructor: Tobias Damm, TU Braunschweig, Germany, e-mail: `t.damm@tu-bs.de`

Aim: Concepts and techniques of linear algebra will be studied, which are important for applications and computational issues. A wide range of exercises and problems will be presented such that a practical knowledge of tools and methods of linear algebra can be acquired.

Topics:

- *Singular values and generalized inverse:*
  Polar form, singular value decomposition, generalized inverse, least squares problem, norms, low-rank approximation.
- *Krylov subspaces:*
  cyclic subspaces and Jordanblocks, matrix polynomials, projections, numerical methods.
- *Matrix equations and inequalities:*
  Lyapunov and Riccati equations, stability and inertia, matrix functions.
- *Positive matrices and positive operators:*
  Perron Frobenius theory and generalization, stochastic matrices, M-matrices and positive evolutions.

References:

[1] A. Berman and R. J. Plemmons. *Nonnegative Matrices in the Mathematical Sciences.* Classics in Applied Mathematics. SIAM, 1994.

[2] R. Bhatia. *Matrix Analysis* Springer, New York, 1997.

[3] J. W. Demmel. *Applied Numerical Linear Algebra.* SIAM, Philadelphia, 1997.

[4] E. Gregorio and L. Salce. *Algebra Lineare.* Edizioni Libreria Progretto, Padova, 2005.

[5] R. A. Horn and C. R. Johnson. *Matrix Analysis.* Cambridge University Press, Cambridge, Massachusetts, 1985.

[6] R. A. Horn and C. R. Johnson. *Topics in Matrix Analysis.* Cambridge University Press, Cambridge, 1991.

[7] P. Lancaster and L. Rodman. *Algebraic Riccati Equations.* Oxford, 1995.

Course requirements: A good working knowledge of basic notions of linear algebra, as e.g. presented in [4].

Time table: 16 hours. Lectures (2 hours) on Tuesday and Thursday, 10:30-12:30 A.M. First lecture on Tuesday, February 21, 2006. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Examination and grading: Grading will be based on homeworks or a written examination or both.

3 Data Structures, Analysis of Algorithms and Data Compression

Instructor: Prof. Raffaele Giancarlo, Dipartimento di Matematica ed Applicazioni, Università di Palermo, e-mail: `raffaele@math.unipa.it`

Aim: Nowadays it is cheaper to keep information in compressed form, yet we would like fast access to it. Half a century ago, only fast access was required. That lead to the birth of many Data Structures and Algorithms for storage and retrieval. Starting from the foundations laid by Sleator and Tarjan, we will present issues in Algorithm and Data Structures design, now classics, to conclude with an apparently unrelated topic of Compression Boosting. *De facto*, the course will follow a very subtle thread highlighting the duality of several notions that have been used and investigated both in Data Structures and Compression. The subtle thread will naturally lead to some recent major ground breaking advances: compression boosting techniques and its data structural counterpart of compressed full text Indexes.

Topics:

1. BASICS: Amortized Analysis of Algorithms: Credits/debits, potential functions. Examples. Empirical Entropies and related compression measures.

2. ADVANCED DATA STRUCTURES: Data Structures for List update and Paging, i.e., Move to Front, self- adjusting trees, linking and cutting of trees. Relation to compression: MTF and splay compression.

3. SORTING AND SEARCHING: Unbounded searching, sorting strings. Relation to compression: Universal codes of the integers, the Burrows-Wheeler transform.

4. ADVANCED TOPICS:Compression Boosters, Table Compressors, Wavelet Trees, Compressed Full Text Indexes.

References: The main references are listed below. Additional material will be distributed during class.

[1] Any advanced book on algorithms and data structures.

[2] J. Bentley, D. Sleator, R. Tarjan, and V. Wei. A locally adaptive data compression scheme. *Comm. of ACM*, 29:320–330, 1986.

[3] A.L. Buchsbaum and G.L. Flowler and R. Giancarlo. Improving Table Compression with Combinatorial Optimization *J. of ACM* , 50:825-851, 2003.

[4] M. Burrows and D. Wheeler. A block sorting lossless data compression algorithm. Technical Report 124, Digital Equipment Corporation, 1994.

[5] T. M. Cover and J. A. Thomas. *Elements of Information Theory.* Wiley Interscience, 1990.

[6] P. Elias. Universal codeword sets and representations of the integers. *IEEE Transactions on Information Theory*, 21(2):194–203, 1975.

[7] P.Ferragina and G. Manzini. On Compressing and Indexing Text. *J. of ACM*, 2005.

[8] P. Ferragina and R. Giancarlo and G. Manzini and M. Sciortino. Boosting Textual Data Compression in Optimal Linear Time. *J. of ACM, to appear.*

[9] P. Fenwick. The Burrows-Wheeler transform for block sorting text compression: principles and improvements. *The Computer Journal*, 39(9):731–740, 1996.

[10] V.I. Levenshtein. On the redundancy and delay of decodable coding of natural numbers. *(Translation from) Problems in Cybernetics, Nauka, Mscow*, 20:173–179, 1968.

[11] G. Manzini. An analysis of the Burrows-Wheeler transform. *Journal of the ACM*, 48(3):407–430, 2001.

[12] E. M. McCreight. A space-economical suffix tree construction algorithm. *Journal of the ACM*, 23(2):262–272, 1976.

[13] M. Schindler. A fast block-sorting algorithm for lossless data compression. In *Proc. of IEEE Data Compression Conference*, 1997. `http://eiunix.tuwien.ac.at/~michael/st/`.

[14] J. Seward. The BZIP2 home page, 1997. `http://sources.redhat.com/bzip2`.

[15] R.E. Tarjan. Data Structures and Network Algorithms. AMS-SIAM 1984.

Time table: Course of 16 hours. Lectures (2 hours) on Tuesday 2:30–4:30 P.M. and Thursday, 10:30–12:30 A.M. First lecture on Tuesday, Oct. 3, 2006. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Course requirements: Any elementary course in Probability and Statistics, Algorithms and Data Structures, Programming. It is desirable to have basic notions of Coding and Information Theory.

Examination and grading: Take Home Written Exam.

4 Dose, effect, threshold

Instructor: Prof. Andrea Trevisan, Dipartimento di Medicina Ambientale e Sanità Pubblica, Univ. di Padova, e-mail: `andrea.trevisan@unipd.it`

Aim: understanding of biological mechanisms that are the basis of the effect of chemical, physical and biological agents in humans. To supply a critical evaluation of the reference data on biological effects of electromagnetic fields.

Topics: General introduction to cell biology and mechanisms of pharmacokinetics. The dose and the significance of threshold. The effect (response) of the dose. Methods to define the threshold. The significance of cancer and the threshold problem. Electromagnetic fields and general aspects related to the dose and the effect.

References: Handouts provided by the instructor.

Time table: 10 hours. Lectures (2 hours) on May 15, May 22, May 29, June 12 and June 20, 2:30–4:30 P.M.. First lecture on Monday, May 15, 2006. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Course requirements: None.

Examination and grading: Oral exam.

5 Digital Processing of Measurement Information

Instructor: Prof. Claudio Narduzzi, Dept. Ingegneria dell'Informazione (DEI), University of Padova, e-mail: `narduzzi@dei.unipd.it`

Aim: Whenever reasearch involves experimental activities, there is a need to characterise measuring equipment, assess the accuracy of data and, most often, process raw data to extract relevant information. The course introduces essential measurement algorithms, together with the conceptual tools that allow their characterisation in a probabilistic framework. This should provide the student with the basic skills required to formulate a measurement problem and correctly approach the analysis of uncertainty. More precisely, the course will provide basic tools and methods for processing information obtained from experimental data and assessing its accuracy.

Topics:

1. Evaluation of measurement uncertainty: the probability-based approach and the guidelines of the ISO "Guide to the evaluation of uncertainty in measurement".
2. Quantisation and the additive noise stochastic model.
3. Characterisation of waveform digitisers.
4. Analysis of a signal processing algorithm: statistical properties of discrete Fourier transform-based spectral estimators, least squares regression and the Cramér-Rao bound.
5. Resolution in model-based measurements.
6. Compensation of measurement system dynamics: inverse problems and ill-posedness.

References: Lecture notes and selected reference material will be handed out during the course.

Time table: Course of 18 hours (two two-hours lectures per week): Classes on Tuesday and Thursday, 2:30 – 4:30 P.M., first lecture on May 2nd, 2006. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Examination and grading: Final project assignment.

6 Effects of Ionizing Radiation on Electronic Components: From Space Applications to Sea Level Effects

Instructor: Prof. Alessandro Paccagnella, Dipartimento di Ingegneria dell'Informazione (DEI), Università di Padova e-mail: `paccag@dei.unipd.it`

Aim: Aim of the course is to illustrate the wide interdisciplinary field of ionizing radiation effects on electronic components, involving issues proper of radiation physics, electronic devices and circuits, reliability. This course will not explore only the classical problems arising in space or high energy physics applications, but also at sea level in commercial devices.

Topics:

1. Interaction between particles and matter: energy deposition, charge recombination and collection in semiconductors and insulators. The concept of Linear Energy Transfer. Displacement damage on the lattice of crystalline and amorphous materials. Different types of radiation damage in electronic components: total dose, displacement, single ion effects. (4 hours)

2. Radiation effects: solar radiation and cosmic rays for space environments. Atmospheric neutrons for avionic applications. Ground level sources: from natural radioactive contaminants to radiogenic machines. The High Energy Physics experiments. (2 hours)

3. Total dose effects: MOS components; recovery mechanisms and the temperature role; the ELDR case on bipolar components; test methodologies and qualification procedures. (2 hours)

4. Single event effects on components and circuits: soft error; bit-flip and stuck bit in DRAM and SRAM; Soft Error Rate in digital components; non-volatile memories; catastrophic phenomena; latch-up; gate oxide breakdown. (8 hours)

5. Technologic evolution of CMOS circuits and techniques to reduce and mitigate radiation damage. (2 hours)

References: Slides from the teacher.

Time table: 20 hours. Lectures (2 hours) on Wednesday and Friday, 10:30–12:30 A.M. First lecture on Wednesday, February 15, 2006. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Course requirements: Basic courses of Electronics, including Electronic devices.

Examination and grading: oral examination

7 Electrostatic Discharge in Integrated Circuits

Instructor: Prof. Gaudenzio Meneghesso, Dept. Ingegneria dell'Informazione (DEI), University of Padova, e-mail: `gaudenzio.meneghesso@unipd.it`

Aim: This course is intended to provide an introduction coverage of the Electrostatic Discharge (ESD) problem in modern Integrated Circuits (ICs). There are several reason that indicate the ESD problem as one of the most critical issue in modern ICs to be faced, among others: a) with the continuous technology scaling down, in the deca-nanometer dimension, devices can not sustain voltages larger than 1 V, hence these devices are extremely sensitive to electrostatic discharge and an adequate ESD protection become quite difficult to provide; b) very high speed RF circuits needs ESD protection devices that do not affect their RF performances by altering the input/output matching, so suitable ESD protection elements must be developed; c) automotive industry is making very comfortable and secure cars by filling them with as much electronics as possible working in a very hostile ambient, a suitable ESD protection of these devices is not trivial. These are only few examples that however give an impression of how much critical will be the ESD aspect in the future ICs.

Topics:

1. Basics of the Electrostatic Discharge phenomena.
2. Test Methods.
3. Active and passive ESD protection.
4. Device Physics of the most common ESD protection elements.
5. Characterization of ESD protection elements.
6. Failure Modes, Reliability Issues and Case Studies.
7. Circuit Simulation basics: approaches and applications.

References:

[1] Amerasekera, C. Duvvury, ESD in Silicon Integrated Circuits, Wiley 2002 (Second Edition).
[2] Z. H. Wang, On Chip ESD Protection for Integrated Circuits, Kluwer Academic Publisher, 2002.
[3] S. Dabral, T. J. Maloney, Basic ESD and I/O Design, Wiley Interscience, 1998.

Time table: Course of 20 hours (2 two-hours lectures per week): Classes on Monday 2:30 – 4:30 P.M. and Friday, 10:30 – 12:30 A.M.. First lecture on November 13 (there will be no classes on December 4 and December 8). Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Course requirements: Introductory course of device physics: "Microelectronics"

Examination and grading: Design and SPICE verification of an ESD protection network.

8 Innovative Device Concepts in Electronics

Instructor: Andrea Cester, Dept. Ingegneria dell'Informazione (DEI), University of Padova, e-mail: `andrea.cester@dei.unipd.it`

Aim: Aim of the course is to illustrate the innovations and the new concepts which permit the CMOS technology to continue the Moore's Law, addressing issues proper of device physics, technology, and circuits. This course cover different aspects of the Silicon On Insulator (SOI) technology, materials, fabbrication and characterisation techniques. The physics of the SOI MOSFETs receive an in-depth analysis, from the conventional SOI structures to the most innovative double gate and multiple gate SOI devices.

Topics:

1. SOI Materials and SOI wafer fabbrication techniques. Standard SIMOX process and related techniques. Wafer Bonding and Etch back (BESOI), SmartCut Process, Transfer layer technique (ELTRAN). Device isolation tecniques: LOCOS, STI, and MESA isolation. Channel doping profile, source and drain engineering, gate stack, and silicide.
2. The SOI Partially Depleted (PD) MOSFET: Source, Drain and Gate Capacitance. Floating Body Effects and Short Channel Effects. Current-Voltage characteristics, transconductance, mobility, subthreshold behaviour. Impact Ionization and High field effects: kink effect, parasitic BJT and Single Transistor Latchup.
3. The SOI Fully Depleted (FD) MOSFET: Electrostatics and device physics, threshold voltage and subthreshold behaviour. Scaling issues and natural lenght of scaling. Drain current of the FD-SOI MOSFET.
4. The Double Gate (DG) SOI MOSFET. Device physics, threshold voltage, subthreshold behaviour. DG SOI MOSFET with lightly doped or intrinsic substrate. Volume Inversion.
5. Other SOI structures. Multiple gate MOSFET: Triple gate, surronding gate, triple plus gate.

References:

[1] Slides from the teacher.

[2] J.P. Colinge, Silicon On Insulator technology: materials to VLSI, 3rd Edition.

[3] H.-S. P. Wong, Beyond the conventional transistor, IBM J. RES. DEV. VOL. 46 NO. 2/3 MARCH/MAY 2002.

[4] Jean-Pierre Colinge, Multiple-gate SOI MOSFETs, Solid-State Electronics 48 (2004) 897–905.

[5] S.-H. Lo, D. A. Buchanan, Y. Taur, Modeling and characterization of quantization, polysilicon depletion, and direct tunneling effects in MOSFETs with ultrathin oxides, IBM J. RES. DEVELOP. VOL. 43 NO. 3 MAY 1999.

[6] Yuan Taur, Xiaoping Liang, Wei Wang, and Huaxin Lu, A Continuous, Analytic Drain-Current Model for DG MOSFETs, IEEE ELECTRON DEVICE LETTERS, VOL. 25, NO. 2, FEBRUARY 2004.

[7] Pascale Francis, Akira Terao, Denis Flandre, Fernand Van de Wiele, Modeling of Ultrathin Double-Gate nMOS/SOI Transistors, IEEE TRANSACTIONS ON ELECTRON DEVICES, VOL. 41, NO. 5, MAY 1994.

Time table: 20 hours. Lectures (2 hours) on Wednesday and Friday, 2:30 – 4:30 P.M.. First lecture on Wednesday, May 3, 2006. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Course requirements: Basic courses of Electronics, including Microelectronics.

Examination and grading: oral examination

9 Introduction to Computer Graphics

Instructor: Andrea Fusiello, University of Vertona, e-mail: `andrea.fusiello@univr.it`

Aim: The course is an introduction to the rendering techniques upon which many interactive graphical applications are based. The emphasis will be on the phisical approximations and computational tricks that make interactive visualization feasible.

Topics:

1. Rendering as solution of the radiance equation. BRDF. Ray casting. Overview of approximate solutions.
2. Illumination models. Local (Phong) and global (ray tracing, radiosity).
3. Pipeline rendering. Geometric transformations, clipping, visible surfade determination, scan conversion, shading.
4. Texture mapping.
5. Increasing realism: reflection maps, light maps, shadows, transparency.
6. Visibility processing.

References:

[1] R. Scateni, P. Cignoni, C. Montani, R. Scopigno. Fondamenti di grafica tridimensionale interattiva. McGraw-Hill, 2005

[2] S. R. Buss. 3-D computer Graphics. A Mathematical Introduction with OpenGL. Cambridge University Press, 2003.

[3] E. Angel. Interactive Computer Graphics with OpenGL, third edition, Addison Wesley, 2003.

[4] A. Watt. 3D Computer Graphics, 3rd edition, Addison-Wesley 2000.

Time table: 12 hours. Lectures on Monday (2:30–4:30 P.M.) and Thursday (4:00–6:00 P.M.). First lecture on Monday, June 19, 2006. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Course requirements: Basic knowledge of Linear Algebra. Some familiarity with Computational Geometry might be helpful.

Examination and grading: HW assignment.

10 Isotopic Tracers in Kinetic Studies

Instructor: Prof. Gianna Toffolo, Dept. Information Engineering, University of Padova, e-mail: toffolo@dei.unipd.it

Aim: Tracers are widely used in biomedical research, to gain kinetic information on physiological systems. The course is intended to provide a description of the process involved in designing and analysing tracer kinetic studies, starting from the steps involved in choosing an isotope for a tracer through formulating simple models to analyse the kinetic data resulting from a tracer experiment.

Topics:

1. Fundamentals of tracer kinetics: the tracer-tracee system, ideal vs real tracers, radioactive and stable isotope tracers.
2. Measurement techniques: scintillation counting and mass spectrometry.
3. Measurement variables, i.e. specific activity, isotope ratio, molar ratio, enrichment vs kinetic variables, i.e. tracer to tracee ratio, for single and multiple tracer experiments.
4. Experiment design in tracer kinetic studies: accessible and non accessible pools, input format, steady state and non steady state conditions, tracer perturbation and how to test it.
5. Simple models that can be used to interpret tracer kinetic studies: A-V difference models, non compartmental models, Steeles equation, precursor-product model.

References:

[1] R.J. Slater Radiosotopes in Biology : a Practical Approach, Oxford University Press, 2002.

[2] E. de Hoffmann Mass Spectrometry : Principles and Applications, Wiley, 2001.

[3] C. Cobelli, D. Foster, G.Toffolo Tracer Kinetics in Biomedical Research, Kluwer Academics, 2000.

[4] R. R. Wolfe, D. L. Chinkes Isotope Tracers in Metabolic Research. Principles and Practice of Kinetic Analysis, John Wiley & Sons, 2004.

Time table: Course of 12 hours (one two-hours lecture per week, for 6 weeks) Classes on Wednesday 10:30–12:30. First lecture on Wednesday, April 5, 2006. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Course requirements: Basics of mathematical analysis.

Examination and grading: Final project assignment.

11 Numerical Models for Fields Analysis in Biological Beings

Instructor: Prof. Fabrizio Dughiero, Dept. Ingegneria Elettrica, University of Padova, e-mail: `fabrizio.dughiero@unipd.it`

Aim: The course will deal with the main analytical and numerical methods for the evaluation of electromagnetic and thermal fields in biological beings from the macroscopic point of view.

Topics: Electromagnetic and thermal characteristics of biological tissues with particular reference to human body. Outline about measurements methods for evaluation of tissues characteristics. Blood perfusion: behaviour and modelling. Outline about the main procedures for 2D and 3D domains acquisition from diagnostic images (CT, PET, NMR). Analytical and numerical methods for fields analysis. Main numerical methods for the evaluation of electromagnetic and thermal fields in human body: FEM, FDTD, MoM, Cells method. Examples of application: Ablation therapy (Hyperthermia); evaluation of SAR in a human body in a 27,12 MHz Electromagnetic field.

References: Lectures notes prepared by the teacher and a list of reference books and papers will be available at the beginning of the course.

Time table: Course of 20 hours (two 2-hours lectures per week): Classes on Monday and Friday, 10:30 to 12:30, first lecture on April 3 (there will be no class on April 28 and May 1). Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Course requirements: Electrotechnics, Electromagnetism, Numerical Methods.

Examination and grading: Final project assignment.

12 Power Supplies for Microprocessors: the Voltage-Regulation Module (VRM) Approach and Integration of Digital and Mixed-Signal Controllers

Instructor: Prof. Paolo Mattavelli, Dept. of Technology and Management of Industrial Systems, University of Padova, e-mail: `mattavelli@ieee.org`

Aim: The course presents the state-of-the-art technologies of dc-dc converters for powering the actual and future generation of microprocessor. The material discussed includes: multi-phase Voltage Regulator Module, transient modeling and analysis, control and design with adaptive voltage positioning and applications to laptop computers. The course then focuses at the controller aspects, including the use of integrated digital or mixed-signal controllers. Starting from standard analog controller architectures and design principles, the basics issues on digital control in high-frequency Switched-Mode Power Supplies are discussed, including Digital-Pulse-Width Modulation Architectures, A/D converters, and implementation of controller algorithms. Quantization effects and limit-cycling issues are also discussed. Some complete design examples are used to present practical design and implementation options, CAD tools, simulation techniques, and experiments on VRM prototypes with FPGA control.

Topics:

1. Power Trend for low-voltage high-current digital devices.
2. Synchronous rectification, multi-phase interleaved dc-dc converters, current sensing.
3. Transient modeling and analysis.
4. Control and design with Adaptive voltage positioning.
5. Two-stage solutions and applications to laptop computers.
6. Integrated digital and mixed signal controller for high-frequency dc-dc converters.
7. Digital Pulse Width Modulation architectures.
8. Design examples used to present practical design and implementation options, CAD tools, simulation techniques for high-frequency dc-dc converters.
9. Rapid prototyping of digital and mixed-signal controller with FPGAs.

References:

[1] R. W. Erickson, D. Maksimovic, "Fundamentals of Power Electronics", Kluwer Academic Press, 1999.

[2] B.J. Patella, A. Prodic, A. Zirger, D. Maksimovic, "High-frequency Digital Controller IC for dc/dc Converters", *IEEE Transactions on Power Electronics*, Vol. 18, No. 1, January 2003, pp. 438-446.

[3] J. Xiao, A.V. Peterchev, S.R. Sanders, "Architecture and IC implementation of a digital VRM controller", *IEEE Trans. on Power Electronics*, Vol. 18, No. 1, January 2003, pp. 356-364.

[4] Kaiwei Yao, Ming Xu, Yu Meng, F.C. Lee, "Design considerations for VRM transient response based on the output impedance", *IEEE Transactions on Power Electronics*, Vol. 18, no. 6, Nov. 2003, pp. 1270-1277.

[5] Mobile Intel® Pentium® 4 Processor Supporting Hyper-Threading Technology on 90-nm Process Technology Datasheet.

[6] M.T. Zhang, M.M. Jovanovic, F.C.Lee, "Design Considerations for Low-Voltage On-Board DC/DC Modules for Next Generations of Data Processing Circuits", *IEEE Trans. on Power Electronics*, Vol. 11 No. 2, March 1996, pp. 328-337.

Time table: Course of 12 hours (two two-hours lectures per week). Lectures (2 hours) on Monday and Wednesday, 10:30–12:30 A.M. First lecture on Monday, September 11, 2006. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Course requirements: Undergraduate knowledge of electronics, control theory and industrial electronics

Examination and grading: Final assignment.

13 Renewal and Semi-Markov Random Processes and their Application to Network Protocol Analysis

Instructor: Prof. Michele Zorzi, DEI, e-mail: `zorzi@dei.unipd.it`

Aim: The course presents a quick overview of Poisson processes and their main properties. It deals in some detail with renewal processes and their applications. Finally, it presents some results on renewal reward and semi-Marov processes and their application to protocol analysis.

Topics:

1. Poisson processes, interarrival times and relevant statistics.
2. Renewal processes, definitions and main concepts.
3. The Poisson process as a renewal process.
4. Asymptotic behavior of renewal processes, main results.
5. Elementary renewal theorem.
6. Renewal equation and its solution and applications.
7. Key renewal theorem and its applications.
8. Extensions: delayed renewal processes and application to Markov chains.
9. Alternate renewal processes, renewal reward processes.
10. Semi-Markov processes and example of application to protocol analysis.

References:

[1] Taylor & Karlin, An introduction to stochastic modeling, 3rd ed., Academic Press, 1998 - ch. V & VII.

[2] Karlin & Taylor, A first course in stochastic processes, 2nd ed., Academic Press, 1975 - ch. 5.

[3] Ross, Stochastic processes, 2nd ed., Wiley, 1996.

[4] Research papers.

Time table: 20 hours. Lectures (2 hours) on Monday and Friday, 10:30–12:30 A.M. First lecture on Monday, May 15, 2006 (there will be no class on May 2). Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Course requirements: Standard probability theory background and some general knowledge of networking and protocols.

Examination and grading: Homework and (possibly) final exam.

14 Selected Topics in Analog Integrated Circuit Design

Instructor: Prof. Andrea Neviani, Dept. Ingegneria dell'Informazione (DEI), University of Padova, e-mail: `neviani@dei.unipd.it`

Aim: Despite the pervasivity of digital signal processing, the most critical parts of an integrated system, in terms of power, speed, design effort, are analog front-ends and output stages, where low-noise, low-distortion amplification, conditioning and conversion of the signal takes place. This course is focused on the theory and design of switched-capacitor circuits, that represent the main technique used today to implement analog, sampled-data filters.

Topics: Introduction to switched-capacitor (SC) circuits. Design of analog filter prototypes and s-to-z transformation methods. Filter implementation based on cascaded biquad cells. Design of low-Q, high-Q and Flescher-Laker biquad cells. Filter implementation based on the ladder approach. Approximate design of SC ladder filters. Exact design of SC ladder filters using the bilinear transformation. Non-ideal effects in SC circuits. Practical activity in CAD laboratory.

References:

[1] Paul R. Gray, et al "Analysis and Design of Analog Integrated Circuits" 4th Edition, 2001.

[2] Douglas R.Holberg, Phillip E. Allen "CMOS Analog Circuit Design" 2nd edition, 2002.

[3] Roubik Gregorian, Gabor C. Temes "Analog MOS Integrated Circuits for Signal Processing", 1987.

[4] David Johns, Ken Martin, "Analog Integrated Circuit Design", 1996.

Time table: Course of 18 hours (one two-hours lecture per week, for 9 weeks): Classes on Monday 10:00–12:00 A.M. First lecture on Monday, October 2, 2006. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Course requirements: Introductory course on CMOS analog integrated circuit design.

Examination and grading: Final circuit-design assignment.

15 Selected Topics in Optimization

Instructor: Michele Pavon, e-mail: `pavon@math.unipd.it`

Aim: Basic results in Convex Optimization and in the Calculus of Variations with applications to Control Engineering.

Topics:

- Elements of Convex Optimization.
- Elements of Calculus of Variations.
- Optimal control problems.
- Maximum entropy problems. Applications to Control and Spectral Estimation.

References:

[1] W. Fleming and R. Rishel, *Deterministic and Stochastic Optimal Control*, Springer-Verlag, 1975.

[2] G. Leitman, *The Calculus of Variations and Optimal Control*, Plenum Press, 1981.

[3] P. Kosmol, *Optimierung und Approximation*, De Gruyter Lehrbuch, 1991.

[4] C. I. Byrnes, S. Gusev, and A. Lindquist, A convex optimization approach to the rational covariance extension problem, *SIAM J. Control and Opimization*, vol. 37, pp. 211-229, 1999.

Time table: 20 hours. Lectures (2 hours) on Tuesday and Friday, 10:30–12:30 A.M. First lecture on Friday, January 13, 2006. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Course requirements: Basic knowledge in control and optimization.

Examination and grading: 4 HW assignments.

16 Statistical Methods

Instructor: Lorenzo Finesso, Istituto di Ingegneria Biomedica, ISIB-CNR, Padova
e-mail: `lorenzo.finesso@isib.cnr.it`

Aim: The course will present a survey of statistical techniques which are important in applications. The unifying power of the information theoretic point of view will be stressed.

Topics:

Background material. The noiseless source coding theorem will be quickly reviewed in order to introduce the basic notions of entropy and informational divergence (Kullback-Leibler distance) of probability measures. The analytical and geometrical properties of the divergence will be presented.

Divergence minimization problems. Three basic minimization problems will be posed and, on simple examples, it will be shown that they produce the main methods of statistical inference: hypothesis testing, maximum likelihood, maximum entropy.

Multivariate analysis methods. Study of the probabilistic and statistical aspects of the three main methods: Principal Component Analysis (PCA), Canonical Correlations (CC) and Factor Analysis (FA). In the spirit of the course these methods will be derived also via divergence minimization. Time permitting there will be a short introduction to the Nonnegative Matrix Factorization method as an alternative to PCA to deal with problems with positivity constraints.

EM methods. The Expectation-Maximization method was introduced as an algorithm for the computation of Maximum Likelihood (ML) estimator with partial observations (incomplete data). We will present the EM method as an alternating divergence minimization algorithm (à la Csiszár Tusnády) and show its application to the ML estimation of Hidden Markov Models.

The MDL method. The Minimum Description Length method of Rissanen will be presented as a general tool for model complexity estimation.

Monte Carlo methods. The basic ideas of the Monte Carlo methods, including Markov Chain Monte Carlo, will be presented in the context of deterministic and stochastic problems.

References: A set of lecture notes and a list of references will be handed out on first day of classes.

Time table: 20 hours. Lectures (2 hours) on Wednesday, 10:30–12:30 A.M.. First lecture on Wednesday, October 4, 2006. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Course requirements: Basics of Probability Theory and Linear Algebra.

Examination and grading: homework assignments and take-home exam.

17 Techniques for the Effective Transmission of Multimedia Signals

Instructor: Gian Antonio Mian, Università di Padova, e-mail: `mian@dei.unipd.it`, and Roberto Rinaldo, Università di Udine, e-mail: `rinaldo@uniud.it`

Aim: The aim of the course is to provide a comprehensive overview of recent techniques for image and video coding and for robust transmission of multimedia signals over error prone networks.

Topics:

Lossless coding: entropy; uniquely decodable codes; I Shannon theorem; the typical set; Huffman, arithmetic and Ziv-Lempel coding (2 lessons).

Lossy coding: distortion measure; differential entropy; the typical set for continuous random variables; the rate-distortion and distortion-rate functions; the gaussian case and the Shannon lower bound (2 lessons).

The image coding JPEG and JPEG2000 standards (2 lessons).

The video coding H.264/AVC standard (1 lesson).

Robust Transmission of image and video sequences. (1 lesson).

Multiple description coding: generalities and the frame based approach (1 lesson).

Distributed video coding (1 lesson).

References:

The main references are listed below. Additional material will be distributed during class.

[1] T. M. Cover and J. A. Thomas. Elements of Information Theory. Wiley Interscience, 1990.

[2] Taubman, David S. and Michael W. Marcellin. 2002. JPEG2000: Image Compression Fundamentals, Standards, and Practice. Kluwer International Series in Engineering and Computer Science. Boston: Kluwer Academic Publishers.

[3] G. K. Wallace, "The JPEG still picture compression standard", IEEE Trans. Consumer Electronics, Vol. 38, No. 1, 1992, pp. xviii-xxxiv.

[4] Vivek K Goyal, "Multiple Description Coding: Compression Meets the Network", IEEE Signal Processing Magazine, vol. 18, no. 5, pp. 74-93, Sept. 2001.

[5] Z. Xiong, A. Liveris, and S. Cheng, "Distributed source coding for sensor networks," IEEE Signal Processing Magazine, vol. 21, pp. 80-94, September 2004.

[6] Ostermann, J. Bormans, J. List, P. Marpe, D. Narroschke, M. Pereira, F. Stockhammer, T. Wedi, T. "Video coding with H.264/AVC: tools, performance, and complexity," IEEE Circuits and Systems Magazine, 2004, Volume: 4, Issue: 1 pp. 7- 28.

Time table: 20 hours (10 lectures of 2:00 h. each). Lectures on Tuesday and Thursday, 10:30–12:30 A.M. First lecture on Tuesday, April 4, 2006 (there will be no classes in April 18 and April 25). Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Course requirements: Any elementary course in Probability and Statistics and Signal Processing. It is desirable to have basic notions of Coding and Information Theory.

Examination and grading: 5 homeworks.

January 2006

December 2005

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January 2006

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February 2006

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Ph.D. courses: Room DEI/G

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February 2006

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February 2006

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March 2006

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Ph.D. courses: Room DEI/G

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
30	31 10:30 Pavon	1	2	3 10:30 Pavon	4	5
6	7 10:30 Pavon	8	9	10 10:30 Pavon	11	12
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20	21 10:30 Damm	22 10:30 Paccagnella	23 10:30 Damm	24 10:30 Paccagnella	25	26
27	28 10:30 Damm	1 10:30 Paccagnella	2 10:30 Damm	3 10:30 Paccagnella	4	5

March 2006

February 2006

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March 2006

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April 2006

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Ph.D. courses: Room DEI/G

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27	28 10:30 Damm	1 10:30 Paccagnella	2 10:30 Damm	3 10:30 Paccagnella	4	5
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April 2006

March 2006

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April 2006

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May 2006

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Ph.D. courses: Room DEI/G

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
27	28	29	30	31	1	2
3 10:30 Dughiero	4 10:30 Mian–Rinaldo	5 10:30 Toffolo	6 10:30 Mian–Rinaldo	7 10:30 Dughiero	8	9
10 10:30 Dughiero	11 10:30 Mian–Rinaldo	12 10:30 Toffolo	13 10:30 Mian–Rinaldo	14 10:30 Dughiero	15	16
17 10:30 Dughiero	18	19	20 10:30 Mian–Rinaldo	21 10:30 Dughiero	22	23
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May 2006

April 2006

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May 2006

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June 2006

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Ph.D. courses: Room DEI/G

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
1	2 10:30 Mian–Rinaldo 14:30 Narduzzi	3 10:30 Toffolo 14:30 Cester	4 10:30 Mian–Rinaldo 14:30 Narduzzi	5 10:30 Dughiero 14:30 Cester	6	7
8 10:30 Dughiero	9 10:30 Mian–Rinaldo 14:30 Narduzzi	10 10:30 Toffolo 14:30 Cester	11 10:30 Mian–Rinaldo 14:30 Narduzzi	12 10:30 Dughiero 14:30 Cester	13	14
15 10:30 Zorzi 14:30 Trevisan	16 14:30 Narduzzi	17 10:30 Toffolo 14:30 Cester	18 14:30 Narduzzi	19 10:30 Zorzi 14:30 Cester	20	21
22 10:30 Zorzi 14:30 Trevisan	23 14:30 Narduzzi	24 14:30 Cester	25 14:30 Narduzzi	26 10:30 Zorzi 14:30 Cester	27	28
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June 2006

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June 2006

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Ph.D. courses: Room DEI/G

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July 2006

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Ph.D. courses: Room DEI/G

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August 2006

July 2006

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Ph.D. courses: Room DEI/G

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September 2006

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Ph.D. courses: Room DEI/G

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October 2006

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November 2006

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Ph.D. courses: Room DEI/G

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
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2 10:00 Neviani	3 14:30 Giancarlo	4 10:30 Finesso	5 10:30 Giancarlo	6	7	8
9 10:00 Neviani	10 14:30 Giancarlo	11 10:30 Finesso	12 10:30 Giancarlo	13	14	15
16 10:00 Neviani	17 14:30 Giancarlo	18 10:30 Finesso	19 10:30 Giancarlo	20	21	22
23 10:00 Neviani	24 10:30 Ciatti 14:30 Giancarlo	25 10:30 Finesso	26 10:30 Giancarlo 14:30 Ciatti	27	28	29
30 10:00 Neviani	31 10:30 Ciatti	1	2 14:30 Ciatti	3	4	5

November 2006

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November 2006

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December 2006

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Ph.D. courses: Room DEI/G

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13 10:00 Neviani 14:30 Meneghesso	14 10:30 Ciatti	15 10:30 Finesso	16 14:30 Ciatti	17 10:30 Meneghesso	18	19
20 10:00 Neviani 14:30 Meneghesso	21 10:30 Ciatti	22 10:30 Finesso	23 14:30 Ciatti	24 10:30 Meneghesso	25	26
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December 2006

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December 2006

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January 2007

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Ph.D. courses: Room DEI/G

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
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4	5 10:30 Ciatti	6 10:30 Finesso	7 14:30 Ciatti	8	9	10
11 14:30 Meneghesso	12	13 10:30 Finesso	14	15 10:30 Meneghesso	16	17
18 14:30 Meneghesso	19	20	21	22 10:30 Meneghesso	23	24
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