Ph.D. School in Information Engineering
Department of Information Engineering
University of Padova

Catalogue of the courses

2005

Students of the Ph.D. school in Information Engineering have the following duties:

1. Take for credits courses for *at least* 120 hours in the first two years of the Ph.D. program. Hours of the courses outside the present catalogue will be weighted depending on the course (each hour of the courses in the "Laurea specialistica" program will be normally considered as 1/2 hour).
2. Take for credits the basic courses "Applied functional analysis" and "Applied linear algebra".

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

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 22 hours (2 two-hours lectures per week): Classes on Tuesday and Thursday, 16:30 to 18:30, first lecture on September 20, 2005. 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: Final written examination.

2 Applied Linear Algebra (co-sponsored by the Ph.D. school in Mathematics)

Instructor: Prof. Harald Wimmer, Universität Würzburg
e-mail: `wimmer@mathematik.uni-wuerzburg.de`

Aim: Concepts and techniques of linear algebra will be studied, which are important for applications. 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:

1. Singular values and unitary invariant norms: Polar form and the singular value decomposition, min-max characterization of singular values, interlacing inequalities, unitary invariant matrix norms, the Moore-Penrose generalized inverse, s-numbers and singular values in Hilbert space, analogies between singular values and invariant factors
2. Gap, angles between subspaces: Invariants of a pair of subspaces in $\mathbb{R}^n$, CS-decomposition, oblique projections, perturbation of direct complements, the gap between subspaces, isolated solutions of matrix equations, the gap in Banach spaces, the metric space of subspaces
3. Schur complements and matrix inequalities: Schur complements and oblique projections, norm minimization and matrix completions, applications of Schur complements to discrete-time Riccati operators and the continuous-time algebraic Riccati equations, Schur complements in C^*-algebras
4. Special classes of matrices: Stochastic matrices and convergence theorems, doubly stochastic matrices and Birkhoff's theorem, Frobenius-Koenig theorem of combinatorics , tridiagonal matrices.

References:

A. Ben-Israel and Th. N.E. Greville, Generalized Inverses, 2nd edition, Springer, 2003.

R. Bhatia, Matrix Analysis, Graduate Texts in Mathematics 169, Springer, 1997.

I. Gohberg, P.Lancaster and L. Rodman, Invariant Subspaces of Matrices, Wyley, 1986.

R.A. Horn and Ch.R. Johnson, Topics in Matrix Analysis, Cambridge University Press, 1994.

Time table: Course of 16 hours: Classes on Tuesday 16:30–18:30 room Ee (1-rd floor, Dept. of Information Engineering, via Gradenigo Building - classroom side) and Friday 9:00–11:00 room LuF1 (Math. Dept.), first lecture on February 22, 2005.

Course requirements: A good working knowledge of basic notions of linear algebra.

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

3 Data Compression: Order Zero Entropy Coding is Enough

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

Aim: This course will review some recent advances in Data Compression that are of considerable practical and theoretic interest. Yet, they are also very puzzling since the major claim is that permuting the input, partitioning it and then compressing each piece separately with an Order Zero Compressor, i.e., Huffman Codes, is an efficient and competitive way of compressing data. The course will focus both on foundational aspects as well as experimental ones, with a look at algorithm engineering when appropriate. Several notions related to Data Structures and Combinatorial Optimization will also be touched upon.

Topics:

1. BASICS: Empirical Entropies and Related Measures, Huffman Codes, Arithmetic Codes: How do you go from the idea to working C Code? Coding of the Integers and Combinatorial Lower Bounds on Compression.
2. OFF-LINE TEXTUAL COMPRESSION: The Burrows-Wheeler Transform (BWT), Experiments and Engineering of BWT Compression, Compression Boosting, Wavelet Trees.
3. TABLE COMPRESSION: Motivation: Data Werhousing, Partitioning Tables Optimally, Rearranging Tables via Traveling Salesman Techniques, Rearranging Tables via Column Dependency, Max-SNP Hardness Results.

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

1. J. Bentley, D. Sleator, R. Tarjan, and V. Wei. A locally adaptive data compression scheme. *Comm. of ACM*, 29:320–330, 1986.
2. A.L. Buchsbaum and G.L. Flowler and R. Giancarlo. Improving Table Compression with Combinatorial Optimization *J. of ACM* , 50:825-851, 2003.
3. M. Burrows and D. Wheeler. A block sorting lossless data compression algorithm. Technical Report 124, Digital Equipment Corporation, 1994.
4. T. M. Cover and J. A. Thomas. *Elements of Information Theory.* Wiley Interscience, 1990.
5. P. Elias. Universal codeword sets and representations of the integers. *IEEE Transactions on Information Theory*, 21(2):194–203, 1975.
6. P. Ferragina and R. Giancarlo and G. Manzini and M. Sciortino. Boosting Textual Data Compression in Optimal Linear Time. *J. of ACM, to appear*
7. P. Fenwick. The Burrows-Wheeler transform for block sorting text compression: principles and improvements. *The Computer Journal*, 39(9):731–740, 1996.
8. 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.

9. G. Manzini. An analysis of the Burrows-Wheeler transform. *Journal of the ACM*, 48(3):407–430, 2001.
10. E. M. McCreight. A space-economical suffix tree construction algorithm. *Journal of the ACM*, 23(2):262–272, 1976.
11. 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/`.
12. J. Seward. The BZIP2 home page, 1997. `http://sources.redhat.com/bzip2`.

Time table: Course of 10 hours: (4 lectures of 2:30 h. each): Wednesday September 7, 2005 from 15:00 to 17:30, Friday September 9, 2005 from 10:00 to 12:30, Monday September 12, 2005 from 15:00 to 17:30, Wednesday September 14, 2005 from 10:00 to 12:30. 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 Diffraction theory with applications to optics and information transmission

Instructor: Prof. Gianfranco Nalesso and Prof. Carlo Giacomo Someda, Dept. Ingegneria dell'Informazione (DEI), University of Padova, e-mail: `nalesso@dei.unipd.it`, `someda@dei.unipd.it`.

Aim: To strengthen the mathematical-physical background on a fundamental chapter of optics and electromagnetic propagation. At the same time, to cover significant samples of modern practical applications.

Topics:

1. Vector formulation of the diffraction problem
2. The scalar theory of diffraction
3. Fresnel and Fraunhofer diffraction regions
4. Example: rectangular aperture
5. Diffraction from a circular aperture: parabolic antenna
6. Diffraction gratings
7. Diffraction in free space: gaussian beams

References: C. G. Someda, "Electromagnetic Waves", Chapman & Hall, 1998, Chapter 13. Class notes.

Time table: Course of 18 hours (one two-hours lecture per week, for 9 weeks): Classes on Friday, 14:30 – 16:30, from Oct. 3 to Dec. 7. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Course requirements: Students are supposed to be familiar with the basics of electromagnetic fields and waves. Typically, they should have attended one class in Physics II (6-8 credits) and one or two classes in applied electromagnetics (min 8 credits).

Examination and grading: Written and possibly oral examination.

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 Monday and Wednesday, 10:00 to 12:00, first lecture on May 2nd. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Examination and grading: Final project assignment.

6 Distributed Systems

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

Aim: The course is intended for postgraduate students that want to address issues to be resolved in the design of distributed systems and that want to deepen their knowledge about abstract models, algorithms and applications of the most widely-used systems.

Topics:

1. Systems models and architectures.
2. Distributed objects and remote invocation.
3. Transaction and concurrency control: distributed transaction.
4. Data replication and distributed file systems.
5. Middleware support for distributed systems.
6. Web systems.
7. Models and tools for distributed applications design.
8. Grid computing.
9. The EU efforts in Distributed Systems

References: Selected reference material will be handed out during the course.

Time table: Course of 18 hours (2 two-hours lectures per week): Classes on Tuesday and Thursday, 10:00 to 12:00, first lecture on May 17. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building). On June 7th, lecture will be in room 301 in DEI/A Building.

Course requirements: Object Oriented Programming, Operating Systems, Computer Networks, Data Bases at the undergraduate level.

Examination and grading: Final project assignment.

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 (two two-hours lectures per week): Classes on Monday and Thursday, 10:00 to 12:00, first lecture on October 31. 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 Identification techniques

Instructor: Professor Giorgio Picci, Dept. Ingegneria dell'Informazione (DEI), University of Padova, e-mail: `picci@dei.unipd.it`

Aim: This course is intended to provide a deep comprehension of modern method for identifications of multivariable (MIMO) systems.

Topics:

1. BACKGROUND OF STATISTICS AND PARAMETER ESTIMATION

   Hypothesis testing (Statistical tests) and estimation. Parametric problems. Whiteness tests. Cumulated periodogram test. Parametric estimation theory. Cramèr Rao inequality. Examples of unbiased minimum variance estimators. Introduction to asymptotic theory. Consistency and asymptotic efficiency. Identifiability. Maximum likelyhood estimator and its asymptotic properties. Examples. Statistical Simulation. Monte-Carlo methods.

   Parametric Estimators for Linear-Gaussian models. Least squares estimators and multistages linear least squares for linear statistical models. SVD, oblique projections, collinearity, ill-conditioning. Variance Estimators. χ^2 distribution and model complexity tests.

2. PEM IDENTIFICATION FOR ARX AND ARMAX MODELS

   PEM (Prediction error methods) for multivariable ARX and ARAMAX models. Iterative Algorithms for the minimization of the mean quadratic error in general ARMAX models. Quasi-Newton method. Main complications: identifibility in multivariable models. Canonical forms, local minima, over-parameterization and ill-conditioning.

3. SUBSPACE IDENTIFICATION FOR MULTIVARIABLE STATE SPACE MODELS

   The "subspace" approach. State construction: stocastic realization. Role of the Singular Value decomposition. Main algorithms: CCA, N4SID and MOESP. Main numerical routines: SVD and QSVD. The positivity issue. Discussion of the routines available in the literature. Numerical comparison of different methods on simulated examples.

4. CLOSED-LOOP IDENTIFICATION

   Introduction to feedback. Stochastic Feedback and causality. Feedback Models. Invariance of the feedback model. Subspace Identification with feedback.

5. NON-LINEAR IDENTIFICATION AND NEURAL NETWORKS.

   Approximation of non linear functions. Origins of the "neural" structure. General approximation properties. Classes of approximating functions. Sigmods, radial basis function, wavelets. Bayesian estimation and neural networks. Solution of static problems. Decision problems. Numerical optimization algorithms for Neural Networks.

   Structure of certain non linear dynamical models. Identifiability. Recursive networks. Structure of NARX and NARMAX models. Non linear PEM algorithms. Model Validation and choice of complexity. Approximation using wavelts. Bayesian Interpretation. Case studies.

   Computer simulations and case studies.

References: For the first part of the course references are:
1. T. Söderström, P. Stoica, *System Identification*, Prentice Hall 1989.
2. L. Ljung *System Identification, Theory for the user* (2^a ed).
For the second part of the course the instructor will provide specific material (journal and conference papers, etc.).

Time table: Course of 20 hours (two two-hours lectures per week): Classes on Monday and Thursday from 16:30 to 18:30, first lecture on March 7, 2005. There will be no lectures on March 28 and 31, 2005. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Course requirements: Basic knowledge on discrete-time linear systems, Bayesian statistical estimation, modeling of systems and MATLAB/SIMULINK control toolbox.

Examination and grading: Homework assignments and final test on identification and validation of a model with data provided by instructor.

9 Introduction to coding theory

Instructor: Professor Fabio Fagnani, Dipartimento di Matematica, Politecnico di Torino, e-mail: `fabio.fagnani@polito.it`

Aim: This course is intended to provide an introduction to fundamental aspects of coding theory for channel transmission with emphasis on recent *turbo-codes* and *low density codes* that have almost reached the Shannon's fundamental limit.

Topics:

1. Introduction and motivations. Transmission over a noisy channel. Examples: BSC, BEC, binary AWGN. Coding schemes: encoder, decoder, code, rate of a coding scheme. Word and bit error probabilities. Maximum a posteriori (MAP) decoding on the word and on the bit, maximum likelihood (ML) decoding, analysis for specific channels.
2. Ensemble of codes. The error probability averaged over an ensemble. Shannon RCE ensemble and Shannon theorem. Error exponents.
3. Linear codes. Definition and examples. Generator matrices and syndromes. Fundamental properties of linear codes (congruence of Voronoi regions and the uniform error property). The union bound estimation. Averaged properties ofn the ensemble of linear codes.
4. The dynamical structure of codes. State and trellis representations for linear codes. Systems theoretic properties: reachability, observability, minimality. Convolutional codes as time invariant input/state/output systems. The Viterbi algorithm on trellises for ML decoding.
5. The belief propagation algorithm. Factor graphs associated to functions. The belief propagation algorithm to compute marginals of functions which have a tree-like factorization. The Tanner graph associated to a syndrome and the Wyberg-Tanner graph associated to a trellis. The belief propagation algorithm to compute the MAP decoding on bit for codes represented by tree-like graphs. The forward-backward algorithm. Iterative implementations of the belief propagation algorithm for graphs with cycles.
6. Ensemble of high performance codes. Turbo codes and low density parity check (LDPC) codes. Averaged performance results under the hypothesis of ML decoding. The iterative decoding algorithm for these codes. Some theoretical results on the iterative decoding of LDPC codes.

References: For some parts of the course the instructor will provide specific material. Other references are:

1. S. Benedetto, G. Montorsi, Unveiling turbo-codes: some results on parallel concatenated coding schemes, IEEE Trans. Inf. Theory, 42, pp.409-428, 1996.
2. C. Berrou, A. Glavieux, P. Thitimajshima, Near Shannon limit error-correcting coding and decoding, in Proc. Int. Communications Conf. (ICC93), Geneva, 1993, pp. 1064-1070.
3. R.G. Gallager, Low density parity check codes. Cambridge, MA, MIT press, 1963.

4. H. Jin, R.J. McEliece, Coding theorems for turbo code ensembles, IEEE Trans. Inf. Theory, 47, pp. 498-519, 2001.
5. F.K. Kschischang, B.J. Frey, H.-A. Loeliger, Factor graphs and the sum-product algorithm, IEEE Trans. Inf. Theory, 48, pp. 1451-1461, 2002.
6. G. Miller, D. Burshtein, Bounds on the maximum-likelihood decoding error probability of low-density parity-check codes, IEEE Trans. Inf. Theory, 47, pp. 2696-2710, 2001.
7. T.J. Richardson, R.L. Urbanke, The capacity of low-density parity-check codes under message-passing algorithms, IEEE Trans. Inf. Theory, 47, pp. 599-618, 2001.
8. A.J. Viterbi. J.K. Omura, Principles of digital communication and coding. McGraw-Hill, New York, 1979.

Time table: Course of 20 hours (8 lectures of 2:30 h. each): Monday from 15:00 to 17:30, and Thursday from 9:00 to 11:30, first lecture on January 17, 2005. There will be no lecture on January 24, 2005. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building). On Feb. 10-th lecture will be in room AULA MAGNA DEI.

Course requirements: Basics of mathematical analysis and probability theory.

Examination and grading: Weekly homeworks assignments.

10 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 Tuesday and Thursday, from 10:00 to 12:00, first lecture on April 26. Room 201 (2-nd floor, Dept. of Information Engineering, ex-Agraria Building).

Course requirements: Electrotechnics, Electromagnetism, Numerical Methods.

Examination and grading: Final project assignment.

11 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: Gain a deeper insight into advanced topics in analog integrated circuit design, with focus on building blocks for discrete-time analog signal processing.

Topics: Switched-capacitor (SC) circuits. Design of SC FIR and IIR filters. CMOS transconductance amplifiers (OTA) for SC applications. Second order effects in CMOS OTA's. Design of off-chip drivers. Band-gap references. 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 Wed. 10:30 – 12:30 from Oct. 5 to Nov. 30. 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.

12 Space-time coding and signal processing for wireless communications

Instructor: Professor Nevio Benvenuto, Dept. Ingegneria dell'Informazione (DEI), University of Padova, e-mail: `nb@dei.unipd.it`

Aim: This course is intended to provide an introductory coverage of the subject of space-time coding and signal processing. With the integration of Internet and multimedia applications in next generation wireless communications, the demand for wide-band data rate communication services is growing and this can be met only by designing more efficient signaling techniques. Space-time coding is based on introducing joint correlation in transmitted signals in both space and time domains. Through this approach, simultaneous diversity and coding gains can be obtained, as well as high efficiency.

Topics: We first give an overview of design principles and major space-time coding techniques starting from multiple-input multiple-output (MIMO) system information theory capacity bounds and channel models. Then some applications of space-time codes and their performance evaluation in wide-band wireless channels are given.

References: B. Vucetic, J. Yuan, "Space-Time Coding", Chichester: Wiley, 2003.

Time table: Course of 20 hours (two two-hours lecture per week): Classes on Monday and Thursday from 14:30 to 16:30, first lecture on April 18, 2005. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Course requirements: Background on digital communication (Proakis's book).

Examination and grading: Weekly homeworks assignments which may require the use of Matlab.