Digital Signal Processing

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http://sp.utcluj.ro/Teaching_IIIEA.html

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http://etti.utcluj.ro

Faculty of Electronics, Telecommunications and Information Technology

Signal Processing Group

Course contents

Ch. I **Discrete-time signals and systems**

- Signals and systems: Concept of frequency in continuous-time and discrete-time signals; Discrete angular frequency; Alias effect
- Discrete-time signals: Some elementary discrete-time signals; Classification of discrete-time signals; Simple manipulations of discrete-time signals
- Discrete-time systems: Block diagram representation of discrete-time systems; Classification of discrete-time systems; Interconnection of discrete-time systems

Course contents (cont.)

Ch. II **Analysis of discrete-time linear time-invariant systems (LTIS)**

- Convolution sum and impulse response sequence
- Causal LTIS
- Stability of LTIS
- Finite impulse response (FIR) and infinite impulse response (IIR) systems: Recursive and nonrecursive discrete-time systems; Forced and free response; LTIS characterized by constant-coefficient difference equations; IIR systems – solution of linear constant-coefficient difference equations; Impulse response of an LTI recursive system
- Correlation of discrete-time signals: Crosscorrelation sequence; Autocorrelation sequence; Properties of the autocorrelation and crosscorrelation sequences; Correlation of periodic sequences
- Implementation of discrete-time systems – direct-forms: IIR systems; FIR systems

Course contents (cont.)

Ch. III **Frequency analysis of discrete-time signals and systems**

- Fourier series – discrete-time periodic signals
- Fourier transform – discrete-time aperiodic signals: Definition; Properties
- Frequency-domain characteristics of LTIS

Ch. IV **Discrete Fourier transform**

- Sampling in time and frequency-domain
- Discrete Fourier transform (DFT): Definition; Properties; DFT as a linear transformation; Relationship of DFT to other transforms
- Applications of DFT: Linear filtering methods based on DFT; Frequency analysis of signal using DFT

Ch. V **Fast Fourier transform**

- Discrete Fourier transform – remarks
- Fast Fourier transform (FFT) – radix algorithms: Radix-2 FFT algorithms: decimation-in-time; Radix-2 FFT algorithms: decimation-in-frequency; Spit-radix FFT algorithms

Course contents (cont.)

Ch. VI *z*-Transform and its applications to the analysis of LTIS

- *z*-Transform: definition, convergence
- Inversion of *z*-transform
- Properties of *z*-transform
- Rational *z*-transform: Poles and zeros; System/transfer function of an LTIS
- One-sided *z*-transform
- Analysis of LTIS in *z*-domain: Response of systems with rational system functions; Causality and stability; Schür-Cohn stability test

Ch. VII Implementation of discrete-time systems

- Introduction
- Structures for FIR systems: Direct-form structure; Cascade-form structure; Frequency-sampling structure; Lattice structure
- Structures for IIR systems: Direct-form structures; Cascade-form structure; Parallel-form structure; Lattice and lattice-ladder structures

Course contents (cont.)

Ch. VIII **Design of digital filters**

- Design of filters in frequency-domain: General considerations; Characteristics of practical frequency-selective filters; Relationships between system function and frequency response function; LTIS as frequency-selective filters
- Design of FIR filters: Linear-phase FIR filters; Design of linear-phase FIR filters using windows; Design of linear-phase FIR filters by frequency sampling method; Design of optimum equiripple linear-phase FIR filters
- Design of IIR filters: Design of IIR filters from analog filters; Frequency transformations; Design of digital IIR filters in discrete-domain

Laboratory contents

1. Introduction to MATLAB
2. Discrete-time signals
3. Sampling of analog signals
4. Discrete-time LTIS
5. Discrete Fourier transform
6. Linear and circular convolution
7. *Practical exam 1*
8. FIR filters. Design methods
9. Discrete-time LTIS as frequency selective filters
10. IIR filters. Indirect design methods
11. IIR filters. Direct design methods
12. Structures for the realization of FIR systems
13. Structures for the realization of IIR systems
14. *Practical exam 2*. Questions

References


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Prelucrarea numerică a semnalelor. Ed. "Gh. Asachi" Iași, 1995.

Teaching WEB page

- http://sp.utcluj.ro/Teaching_IIIEA.html
  - Course contents
    - Slides
  - Laboratory contents
    - Examples (implemented in MATLAB)
    - Exercises (must be implemented in MATLAB – practical exams)
  - References
  - Solved problems
  - Proposed problems
  - Miscellanea

Grading

1. Written exam (WE): $1 \div 10$ points – 2 hours
   - 3 problems
2. 2 practical exams
   - Practical exam 1 (PE1): $1 \div 10$ points – 30 minutes
     - 7^{th} week of the semester – April 10-15, 2017 (at the laboratory class)
     - 2 exercises (must be implemented in MATLAB) – from laboratory exercises
   - Practical exam 2 (PE2): $1 \div 10$ points – 30 minutes
     - 14^{th} week of the semester – May 29-31, June 1-2, 2017 (at the laboratory class)
     - 2 exercises (must be implemented in MATLAB) – from laboratory exercises

$$\textbf{Final mark} = 0,6 \cdot \text{WE} + 0,2 \cdot \text{PE1} + 0,2 \cdot \text{PE2}$$

if $\text{WE} \geq 4$ and $0,6 \cdot \text{WE} + 0,2 \cdot \text{PE1} + 0,2 \cdot \text{PE2} \geq 4,5$

Where can we meet?

1. **Course**: Room P01 (G. Barițiu street)
2. **Laboratory**: Room 367 (G. Barițiu street)
3. **Contact**: Lacrimioara.Grama@bel.utcluj.ro