

80509 DIGITAL LINEAR FILTERING I

by Tapio Saramäki

The PURPOSE of this course is to make the reader familiar with the the following:

- 1) The basics and needs for linear digital filtering, illustrated by means of examples.**
- 2) FIR (finite impulse response) and IIR (infinite impulse response) filters.**
- 3) How to study the filter performance with the aid of the transfer function: stability, frequency response.**
- 4) Filter design process: Traditional design techniques.**
- 5) Requirements for the amplitude, phase, phase delay and group delay responses.**
- 6) Filter implementation: Traditional filter structures.**
- 7) Finite wordlength effects: (a) Filter scaling; (b) Output noise due to the multiplication roundoff errors, (c) (c) Effects of coefficient quantization to filter responses; (d) Various kinds of oscillations.**

More efficient implementation forms and design techniques are given in the courses "Digital Linear Filtering II", "Multirate Signal Processing", and "System Level DSP Algorithms"; welcome to these courses!!

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This course consists of the following five parts:

Part I: What are linear digital filters and how to analyse their performance?:

- 1) Structures for implementing digital filters.**
- 2) Finite-impulse response (FIR) and infinite-impulse IIR filters.**
- 3) Studying the filter performance with the aid of the transfer function: Stability and frequency response.**
- 4) Filter design process.**
- 5) Requirements for the amplitude, phase, phase delay, and group delay responses.**
- 6) Various approximation criteria meeting the given criteria including time-domain constraints, illustrated by some classical digital filters**

Part II: Introductory filtering examples

- 1) The needs for filtering.**
- 2) The difference between IIR and linear-phase FIR filters.**
- 3) The roles of poles and zeros in contributing to various filter response: amplitude, phase, phase delay, group delay, and impulse responses.**
- 4) Characteristics of all-pass transfer functions.**

Part III: Design of FIR filters

- 1) Four types of linear-phase FIR filters.**

- 2) How to express their frequency responses in simple forms; their impulse, phase and group delay responses; their implementation exploiting the coefficient symmetry; their use in filtering applications.
- 3) Various design techniques: Main emphasis in this course is on designing linear-phase filters using windowing and the Remez algorithm. The remaining techniques as well as some additional synthesis schemes are considered in the in the course entitled "Digital Linear Filtering II" .

Part IV: Design of IIR filters

- 1) Synthesis of IIR filters by transforming an analog filter to its digital equivalent using the bilinear transformation.
- 2) Basic types of classical analog and digital filters.
- 3) Synthesis of highpass, bandpass, and bandstop digital filters based on transforming a lowpass digital filter into the desired one using a proper transformation.

Part V: Finite word length effects in digital filters

- 1) Output noise due to the multiplication roundoff errors.
- 2) Filter scaling using various scaling norms.
- 3) Coefficient quantization errors.
- 4) Various kinds of oscillations.

Feedback:

All comments on the material are welcome; please send to saram@vip.fi; typos; negative and positive feedback. The ultimate dream of the lecturer is to write an easy-to-read international textbook on the material of the above-mentioned four courses.