Digital signal processing - course description

General information

Course name	Digital signal processing
Course ID	06.0-WE-AutP-DigSigProc-Er
Faculty	Faculty of Computer Science, Electrical Engineering and Automatics
Field of study	Automatic Control and Robotics
Education profile	academic
Level of studies	First-cycle Erasmus programme
Beginning semester	winter term 2019/2020

Course information

Semester	4
ECTS credits to win	5
Course type	obligatory
Teaching language	english
Author of syllabus	• dr inż. Mirosław Kozioł • dr hab. inż. Radosław Kłosiński, prof. UZ

Classes forms

The class form	Hours per semester (full-time)	Hours per week (full-time)	Hours per semester (part-time)	Hours per week (part-time)	Form of assignment
Lecture	30	2	-	-	Exam
Laboratory	30	2	-	-	Credit with grade

Aim of the course

- To familiarize students with basic notions of the digital signal processing.
- To provide basic knowledge about fundamentals of a spectral analysis and digital filtration of discrete signals.
- To give skills in practical implementation of a spectral analysis and filtration of discrete signals.
- To provide knowledge about design of digital filters.

Prerequisites

- Programming

Scope

Fundamentals of signal theory. Notion of signal. Classifications of signals. Mathematical models of selected signals. Fourier series and Fourier transform for continuous time signals. Fourier series and Fourier transform properties. An influence of a signal observation in finite time interval on its spectrum.

Analog-to-digital and digital-to-analog conversion. Chain of signal processing during analog-to-digital and digital-to-analog conversion. Sampling, quantization and coding. Quantization error. Spectrum of a sampled signal. Aliasing. Sampling theorem. Anti-aliasing filter. Recovery of an analog signal from samples.

Discrete Fourier transform (DFT). Derivation of amplitude and phase spectrum. Leakage. Parametric and non-parametric spectral windows. Spectrum resolution improvement by zero padding. Examples of spectral analysis of discrete-time signals and their interpretation.

Fast Fourier transform (FFT). Butterfly computation schema in radix-2 FFT algorithm. Computational profit.

Linear and causal time-invariant (LTI) systems. Definitions of a discrete, linear and time-invariant system. Definition of causal system. Convolution. Stability of LTI systems in BIBO sense. Difference equation.

Z-transform. The Z-transform definition. Z-transform properties. The transfer function. Poles and zeros of the transfer function. Pole locus and stability of a system.

Digital filters. Finite and infinite impulse response filters. Processing discrete-time signals by digital filters. Basic structures of digital filters. Determination and interpretation of the frequency response of digital filters. Significance of linear phase response in the processing of signal. Group delay.

IIR digital filter design by bilinear transformation method. FIR digital filter design by the method based on the windowed impulse response.

Introduction to discrete simulation of analog circuits

Teaching methods

- Lecture: conventional/traditional lecture with elements of discussion.
- Laboratory: laboratory exercises, work in groups with elements of discussion.

Learning outcomes and methods of theirs verification

Outcome description	Outcome symbols	Methods of verification	The class form

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Student can use digital signal processing to analyze discrete signals, perform its spectral analysis, and interpret the obtained graphs of spectra.		• an ongoing monitoring during classes • carrying out laboratory reports	• Laboratory
Student can describe a discrete system using differential equations and transmittance.		• an evaluation test	• Lecture
Student can write programs in C language, which make spectral analysis of signals and their filtering with the application of digital filters with finite and infinite impulse response.		• an ongoing monitoring during classes	• Laboratory
Student can design the infinite and finite impulse response digital filter.		• an ongoing monitoring during classes	• Laboratory

Assignment conditions

- Lecture: to receive a final passing grade student has to receive positive grade from written tests conducted at least once a semester.
- Laboratory: to receive a final passing grade student has to receive positive grades in all laboratory exercises provided for in the laboratory syllabus.

Calculation of the final grade = lecture 50% + laboratory 50%

Recommended reading

1. Lyons R.G.: Understanding Digital Signal Processing, Prentice Hall, 2004
2. Mitra S.: Digital Signal Processing: A Computer-Based Approach, McGraw-Hill, 2005
3. Orfanidis S.J.: Introduction *to Signal Processing*, Prentice Hall, 1999
4. Oppenheim A.V., Schafer R.W., Buck J.R.: *Discrete-Time Signal Processing*, Prentice Hall, 1999

Further reading

1. Oppenheim A.V., Willsky A.S., Nawab H.: *Signals & Systems*, Prentice Hall, 1997
2. Owen M.: *Practical signal processing*, Cambridge University Press, 2007
3. Smith S.W.: Digital Signal Processing: A Practical Guide for Engineers and Scientists, Newnes, 2002

Notes

Modified by dr hab. inż. Wojciech Paszke, prof. UZ (last modification: 29-04-2020 08:22)