Subject (course) name: **Digital Signal Processing**		
Field of study: **Electronics and Communications** Specialization: **DSP**		Subject code: **2S**
		Title graduate: **Engineer**
Type of course: **obligatory**	Course level: **First-cycle studies**	Year: **III** Semester: **VI** Semester: **summer**
Form of classes: **Lectures, Classes, Labs, Seminar, Project**	Number of hours per week: **2L^{E}, 0C, 2Lab, 0S, 0P**	Credit points: **4 ECTS**

GUIDE TO SUBJECT

SUBJECT OBJECTIVES

C1. Understand fundamentals of discrete-time signals and systems.

C2. Perform spectral analysis of sampled signals using the discrete Fourier transform.

C3. Process signals using digital filters, design and implement digital filters.

C4. Acquire knowledge on selected applications of digital signal processing.

C5. Use computer-aid tools for analysis and design of digital signal processing systems.

SUBJECT REQUIREMENTS

1. Basic knowledge of complex analysis, linear algebra.

2. Knowledge on continuous-time signals and systems.

3. Basic knowledge in numerical methods and basic programming skills.

LEARNING OUTCOMES

EK1 - Student understands fundamentals of discrete-time signals and systems (sampling, quantization, Z-transform, convolution).

EK2 - Student is able to perform spectral analysis of sampled signals using the discrete Fourier transform.

EK3 - Student is able to design and implement digital filters (according to specifications in the frequency domain).

EK4 - Student knows selected applications of digital signal processing.

SUBJECT CONTENT

Form of classes - Lectures

Topic	Hours
L1 – Motivation for digital signal processing. Overview of DSP applications	**2**
L2 – Signal sampling and quantization	**2**
L3,4 – Discrete Fourier transform and signal spectrum	**4**
L4 – Difference equations and impulse responses. Convolution. The Z-transform	**2**
L5 – Digital filters: transfer functions, frequency responses	**2**
L6 – Design of FIR filters	**2**
L7 – Design of IIR filters	**2**
L8 – Fundamental of digital image processing	**2**
L9 – Random signal processing – correlation analysis. Detection of signal in noise (matched filtering)	**2**
L10 – Estimation of power spectrum	**2**
L11 – Multirate signal processing. Interpolation and decimation. Subband coding	**2**

L12 – Linear prediction and optimum filtering. Adaptive filtering	**2**
L13 – Selected DSP algorithms for audio processing and coding	**2**
L14,15 – Implementation of DSP on C6713 DSK board. Hardware and software	**4**
Total	**30**

Form of classes – laboratory

Topic	Hours
Lab1 – Matlab Signal Processing Toolbox. Sampling and quantization of continuous-time signals	**2**
Lab2 – Spectral analysis of deterministic sampled signals using the DFT transform	**2**
Lab3,4 – Design of digital filters (linear time-invariant IIR and FIR filters)	**4**
Lab5,6 – Correlation and spectral analysis of random signals	**4**
Lab7,8 – Fundamentals of digital image processing	**4**
Lab9,10 – Interpolation and decimation. Subband decomposition	**4**
Lab11 – Optimal and adaptive filtering	**2**
Lab12,13 – Real-time implementation of DSP algorithms on C6713 DSK board	**4**
Lab14,15 – Matlab/Simulink project	**4**
Total	**30**

STUDY METHODS

1. Lectures using multimedia presentation, accompanied by discussion.
2. Laboratory experiments – work in groups on computers with dedicated software

EDUCATIONAL TOOLS

1. Audiovisual equipment, blackboard, lecture slides in PDF version
2. Computers with Matlab/Simulink software including Signal Processing and DSP System Toolboxes.
3. C6713 DSK boards with DSP processors and Code Composer Studio software.

METHODS OF GRADING (F – Forming, P – Summary)

F1. Laboratory – preparation to lab experiments – individual oral answer (50% of the laboratory grade)
F2. Laboratory - group reports on paper with results of lab experiments (50% of the laboratory grade)
P1. Lectures – written final exam

STUDENT WORKLOAD

Form of activity		Averaged workload (hours)		
		[h]	∑ [h]	ECTS
Participation in class activities	lectures	30	60	2.5
	laboratory	30		
Studying literature		10	40	1.5
Preparation to laboratory and preparation of lab reports		15		
Preparation to the exam		15		
Total			**100**	**4**

A. BASIC READING

1. Tan L., Jiang J.: *Digital Signal Processing. Fundamentals and Applications,* 2nd ed. Academic Press, 2013.
2. Manolakis D., Ingle V.: *Applied Digital Signal Processing. Theory and Practice*. Cambridge, 2011.
3. Proakis J., Manolakis D.: *Digital Signal Processing. Principles, Algorithms and Applications,* 4th ed. Prentice Hall, 2006.
4. Smith S.W.: *Digital Signal Processing. A Practical Guide for Engineers and Scientists*. Newnes, 2003.
5. Ingle V., Proakis J.: *Essentials of Digital Signal Processing Using Matlab*, 3rd ed, Cengage, 2012.

B. FURTHER READING

1. Lyons R.: *Understanding Digital Signal Processing,* 3rd ed. Prentice Hall, 2010.
2. Mitra S.: *Digital Signal processing. A Computer-Based Approach*, 4th ed, McGraw-Hill, 2011.

3. Dutoit T., Marques F.: *Applied Signal Processing. A Matlab-Based Proof of Concept*. Springer, 2009.
4. Chassaing R., Reay D.: *Digital Signal processing and Applications with the TMS320C6713 and TMS320C6416 DSK,* 2nd ed. John Wiley & Sons, 2008.
5. The Mathworks Inc.: *Signal Processing Toolbox. User's Guide, DSP System Toolbox. User's Guide.*

Learning outcomes	In relation to the learning outcomes specified for the field of study	Subject objectives	Study methods	Methods of assessment
EK1	K_W14 K_U08	C1	lectures, laboratory	**F1, F2,** **P1**
EK2	K_W10 K_W17 K_U08 K_K02	C2, C5	lectures, laboratory	**F1, F2,** **P1**
EK3	K_W09 K_U16 K_U22	C3, C5	lectures, laboratory	**F1, F2,** **P1**
EK4	K_W08 K_U10	C4	lectures	**P1**

II. EVALUATION

Grade	Outcome
EK1	**Student understands fundamentals of discrete-time signals and systems (sampling, quantization, Z-transform, convolution)**
2 (F)	Student does not know basics of discrete-time signals and systems
3 (E)	Student has partial formal knowledge of discrete-time signals and systems basics
4 (C)	Student has knowledge of discrete-time signals and systems basics but without full understanding
5 (A)	Student knows and fully understands basics of discrete-time signals and systems
EK2	**Student is able to perform spectral analysis of sampled signals using the discrete Fourier transform (DFT)**
2 (F)	Student does not know the DFT transform
3 (E)	Student knows the DFT Fourier transform but is not able to apply it to spectral analysis
4 (C)	Student is able to perform spectral analysis but does not understand details
5 (A)	Student performs spectral analysis of sampled signals using the DFT
EK3	**Student is able to design and implement digital filters (according to specifications in the frequency domain)**
2 (F)	Student is not able to design and implement even a simple digital filter
3 (E)	Student is able to design only simple digital filters
4 (C)	Student is able to design digital filters but do not know all presented design methods
5 (A)	Student designs and implements digital filters using suitable software tools if needed
EK4	**Student knows selected applications of digital signal processing (DSP)**
2 (F)	Student does not know (with some details) any application of DSP
3 (E)	Student is able to enumerate presented applications and describe at least one of them
4 (C)	Student knows applications of digital signal processing and his/her knowledge is mostly correct
5 (A)	Student knows all presented applications of digital signal processing and can describe them in details

III. OTHER USEFUL INFORMATION

1. All information for students on the schedule are available on the notice board and on the website: www.el.pcz.pl
2. Information on the consultation shall be provided to students during the first lecture and will be placed on the website www.el.pcz.pl
3. Terms and conditions of credit courses will be provided to students during the first lecture