| Subject (course) name: **Signal Processing** | | |
|---|---|---|
| Programme: **Electronics and Telecommunication**<br>Specialty: | | Subject code: **9K** |
| | | Title graduate: **Engineer** |
| Type of course: **obligatory** | Course level:<br>**First-cycle studies** | Year: **II** Semester: **IV**<br>Semester: **summer** |
| Form of classes:<br>**Lectures, Classes, Labs, Seminar, Project** | Number of hours per week:<br>**2L, 0C, 2Lab, 0, 0** | Credit points: **4 ECTS** |

## GUIDE TO SUBJECT

### SUBJECT OBJECTIVES

C1. Provide students with knowledge covering elements of signal theory and signal processing in the analogue circuits and discrete-time systems.

C2. Acquisition by the students ability to use acquired knowledge during lectures for solving signal processing.

C3. The acquisition of skills by the students description and analysis of signals and their processing.

C4. Acquisition by students practical skills of computer use environment Matlab / Simulink to analyse the signals and their processing.

### SUBJECT REQUIREMENTS

1. Knowledge and skills in mathematics, in the field of linear ordinary differential equations and operators of the methods of solving them.
2. Knowledge and skills in the subject "Circuits and Signals."
3. Ability to use a computer environment Matlab / Simulink.
4. The ability to use literature and online resources.

### LERNING OUTCOMES

EK 1 – The student has knowledge covering elements of signal theory and signal processing in the analogue circuits and discrete-time systems.

EK 2 – Student is able to solve tasks of signal processing.

EK 3 – Student is able to describe and analyse the signals and processes of their processing.

EK 4 – The student can take advantage of the computing environment Matlab to analyse the signals and their processing.

### SUBJECT CONTENT

**Form of classes - lectures**

| Topic | Hours |
|---|---|
| **W 1 –** Introduction. Classification and mathematical models of signals. | **2** |

| | |
|---|---|
| **W 2 –** Dirac delta and sampling signals. Analogue-to-digital and digital-to-analogue. | **2** |
| **W 3 –** The periodic signals. Fourier series. Properties of Fourier series. The spectrum of the signal. | **2** |
| **W 4 –** Fourier transform. Properties of Fourier transforms. Spectral density of the signal. | **2** |
| **W 5 –** Sampling theorem. | **2** |
| **W 6 –** Mathematical models of systems. | **2** |
| **W 7 –** Linear stationary systems. Laplace Transform. | **2** |
| **W 8 –** The transmittance of the system. poles and zeroes transmittance.. | **2** |
| **W 9 –** Stability of the SLS. The criteria for stability. | **2** |
| **W 10 –** Examples of selected SLS systems. analogue filters. | **2** |
| **W 11 –** Diagrams and equations systems with discrete time. Transformation of Z. The basic properties of the transformation of Z. | **2** |
| **W 12 –** Applying the Restatement Z to solving differential equations. | **2** |
| **W 13 –** The stability of systems with discrete time. The criteria for stability. | **2** |
| **W 14 –** The transmittance. Finite systems and infinite impulse response. Frequency characteristics. Basics of digital filtering. | **2** |
| **W 15 –** Simulation of analogue circuits. The simulator characteristics of impulse. The simulator frequency response. Differentiation simulators. | **2** |
| **Total** | **30** |

**Form of classes – laboratory**

| Topic | Hours |
|---|---|
| **L 1 –** Introduction to the Matlab. | **2** |
| **L 2 –** Determination of parameters and waveforms of signals. | **2** |
| **L 3** – The survey spectra of analog signals. | **2** |
| **L 4** – The survey spectra of discrete-time signals. | **2** |
| **L 5** – Study the consequences of the theorem of sampling signals. | **2** |
| **L 6** – Introduction to Simulink. | **2** |
| **L 7** – Determination of the response set. | **2** |
| **L 8** – Determination of system response in transient state. | **2** |
| **L 9 –** Examination of the stability of the system with feedback. | **2** |
| **L 10** – Examination Butterworth and Chebyshev filters | **2** |
| **L 11** – Solving differential equations. | **2** |
| **L 12** – Examination of the stability of the discrete time systems | **2** |
| **L 13** – examination of frequency characteristics. | **2** |
| **L 14** – RL circuit simulation. | **2** |
| **L 15** – Final test. | **2** |
| **Suma** | **30** |

## STUDY METHODS

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|---|
| **1.** Lectures with use of multimedia presentations. |
| **2.** Lab – experiments in sections (two or three students). Computer analysis. |
| **3.** Discussion during the course and individual consultations. |

## EDUCATIONAL TOOLS

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|---|
| **1.** Audiovisual equipment |
| **2.** Lab instructions |
| **3.** Computer lab |
| **4.** Matlab software |

## METHODS OF ASSESMENT (F – Forming, P – Summary)

| |
|---|
| **F1.** Validation of the results of computer analyses in the laboratory and timely preparation of reports on the subsequent laboratory. |
| |
| **P1**. Lecture - written exam. |
| **P2.** Laboratory classes - the average of the ratings for laboratory exercises 50% and 50% of the final test. |

## STUDENT WORKLOAD

| Form of activity | Averaged workload (hours) |
|---|---|

| | | [h] | ∑ [h] | ECTS |
|---|---|---|---|---|
| Participation in class activities | lectures<br>labs | 30<br>30 | 60 | 2 |
| Preparation for tutorials (reading literature) | | 10 | 60 | 2 |
| Preparation for labs | | 10 | | |
| Preparation of lab reports | | 15 | | |
| Preparation for tests | | 5 | | |
| Preparation for exam | | 20 | | |
| **Total** | | | **120** | **4** |

### A. BASIC READING

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|---|
| 1. Paolo Prandoni and Martin Vetterli: Signal Processing for Communications. http://www.sp4comm.org/docs/sp4comm_corrected.pdf |
| 2. Boashash, Boualem, ed. Time frequency signal analysis and processing a comprehensive reference (1 ed.). Amsterdam: Elsevier., 2003. |
| 3. Richard G. Lyons: Understanding Digital Signal Processing (3rd Edition). Prentice Hall. 2010. |

### B. FURTHER READING

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|---|
| 1. Smith S.W.: The Scientist and Engineer's Guide to Digital Signal Processing. http://www.dspguide.com/pdfbook.htm. |
| 2. Owen M.: Practical Signal Processing. Cambridge University Press. 2012. |

| Learning objectives | In relation to the learning outcomes specified for the field of study | Subject objectives | Study methods | Methods of assessment |
|---|---|---|---|---|
| EK1 | K_W14 | C1 | lecture | P1 |
| EK2 | K_U08<br>K_W14 | C2 | lecture<br>laboratory | P1<br>P2 |
| EK3 | K_U07<br>K_W14 | C3 | lecture<br>laboratory | P1<br>P2 |
| EK4 | K_U07<br>K_U08<br>K_U02<br>K_K04 | C2,C3,C4 | laboratory | F1<br>P2 |
| EK5 | K_W09<br>K_W14<br>K_U07 | C1 | lecture | P1 |

## II. EVALUATION

EK 1 – The student has knowledge covering elements of signal theory and signal processing in the analogue circuits and discrete-time systems.

EK 2 – Student is able to solve tasks of signal processing.

EK 3 – Student is able to describe and analyse the signals and processes of their processing.

EK 4 – The student can take advantage of the computing environment Matlab to analyse the signals and their processing.

| Grade | Outcome |
|---|---|
| **EK1** | The student has knowledge covering elements of signal theory and signal processing in the analogue circuits and discrete-time systems**.** |
| 2 (F) | The student does not have an elementary knowledge covering elements of signal theory and signal |

| | |
|---|---|
| | processing in the analogue circuits and discrete-time systems. |
| 3 (E) | The student has an elementary knowledge covering elements of signal theory and signal processing in the analogue circuits and discrete-time systems. |
| 4 (C) | The student has sufficient knowledge covering elements of signal theory and signal processing in the analogue circuits and discrete-time systems and enables him to describe and analyse the signals and processes of their processing. |
| 5 (A) | The student has a thorough knowledge covering elements of signal theory and signal processing in the analogue circuits and discrete-time systems and enable it in different ways to describe and analyse the signals and processes of their processing. |
| **EK2** | Student is able to solve tasks of signal processing**.** |
| 2 (F) | The student is not able to solve simple tasks of signal processing. |
| 3 (E) | The student is able to formulate equations for solving the problem of signal processing, but it can not solve them. |
| 4 (C) | Student is able to solve tasks of signal processing, but it can not properly interpret the results. |
| 5 (A) | The student is able to solve various tasks of signal processing methods and correctly interpret the results. |
| **EK3** | Student is able to describe and analyse the signals and processes of their processing**.** |
| 2 (F) | The student is not able to describe and analyse simple signals and their processing. |
| 3 (E) | Student is able to describe and analyse some simple signals and processes of their processing. |
| 4 (C) | Student correctly describes and analyses the signals and processes of their processing. |
| 5 (A) | Student, in various methods, correctly describes and analyses and processes the signals of the processing by referring to the description of various embodiments and various methods of analysis. |
| **EK4** | The student can take advantage of the computing environment Matlab to analyse the signals and their processing**.** |
| 2 (F) | The student is unable to properly use a computer environment Matlab / Simulink to analyse the signals and their processing. |
| 3 (E) | The student only to a limited extent able to use the computing environment Matlab / Simulink to analyse only simple signals and their processing. |
| 4 (C) | Student is able to properly utilize the computing environment Matlab / Simulink for analysis in the laboratory exercises selected signals and their processing. |
| 5 (A) | Student is able to take full advantage of the possibilities of computer environment Matlab / Simulink for signal analysis and treatment processes, using different software variants of the task. |

## 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