POZNAN UNIVERSITY OF TECHNOLOGY

EUROPEAN CREDIT TRANSFER AND ACCUMULATION SYSTEM (ECTS)

COURSE DESCRIPTION CARD - SYLLABUS

Course name
Signal Theory [S1Elmob1>TS]

Course

Field of study
Electromobility

Year/Semester
3/5

Area of study (specialization)
–

Profile of study
general academic

Level of study
first-cycle

Course offered in
polish

Form of study
full-time

Requirements
compulsory

Number of hours

Lecture
15

Laboratory classes
15

Other (e.g. online)
0

Tutorials
0

Projects/seminars
0

Number of credit points

2,00

Coordinators

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Lecturers

Prerequisites

The student starting this course should have basic knowledge of mathematics, physics and the basics of electrical engineering, as well as the ability to work in a laboratory group.

Course objective

Expanding student's knowledge of general signal theory. Understanding the differences between analogue and digital signal processing. Understanding the limitations of digital signal processing resulting from, e.g.: aliasing, leakage of spectrum, problem of recreation of continuous signal from samples. Getting to know different signal analysis tools in the domain of time, frequency, time- frequency. Expanding knowledge in the field of filter design. Acquiring practical skills to use ready-made engineering tools in signal processing. Experimental verification by the student of the working and limitations of selected methods of signal processing.

Course-related learning outcomes

Knowledge:
1. Student has knowledge of the basics of signal theory.
2. Student has knowledge of the limitations of discrete signal processing.
3. Student has knowledge of frequency analysis of continuous and discrete signals.
4. Student has knowledge of the operation and design of analogue and digital filters.
5. Student has knowledge of AM / FM / PM modulation of signals and knows the analytical representation of the signal.
6. Student has knowledge of signal decomposition.

Skills:
1. Student is able to experimentally verify the limitations of discrete signal processing.
2. Student is able to use ready-made engineering tools to analyse and process analogue and continuous signals.
3. Student is able to design a filter with specific properties with the use of computer assistance.

Social competences:
1. Understands that knowledge of signal theory is necessary to properly process continuous and discrete signals.
2. Is aware that in engineering signal processing tasks, expert knowledge in the field of signal theory is necessary beyond the content taught in the Electromobility field of study.

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Lecture: evaluation of the knowledge and skills shown during a written test (a test sheet includes information necessary to solve computational tasks). Passing threshold of test equals 50%. The grade from laboratory as well as attendance and activities during the lectures are taken into account.
Laboratory: the skills acquired in the laboratory exercises are verified on the basis of reports prepared by students at home after the exercises. Exercises are held in a parallel variant. During the laboratory classes, verbal preparation of students for the exercise is verified. Passing the laboratory classes requires the completion of all exercises and individual implementation of the reports indicated by the teacher.

Programme content

Lecture:
W1: General elements of signal theory (signal concept, signal classification, signal-information relationship, signal representations, signal parameters, distribution signals).
W2: Sampling of continuous signals. Aliasing. Spectrum leakage. Reproducing a continuous signal from samples.
W3: Frequency analysis of analog signals (Fourier transform, signal spectrum). Discrete signals and analogies with analog signals. Analysis of discrete stationary signals - DFT and FFT algorithm. Analysis of discrete non-stationary signals - STFT analysis. Introduction to the wavelet theory - CWT and DWT.
W4: Correlation analysis of the signal (autocorrelation function, cross-correlation function, relationship of the autocorrelation function with the spectrum). The problem of determining the fundamental frequency of a signal.
W5: Selected issues of filtering discrete signals. Statistical filters. Filters with finite and infinite impulse response. The problem of signal decomposition and a conceptual presentation of new decomposition methods (EMD, VMD, EWT, HHT).
W6: AM / FM / PM modulation of signals and signal representation with an analytical signal.
W7: Supporting signal processing with the use of artificial intelligence methods.
Laboratory:
L1: BHP + introduction to programming language Python.
L2: Reproduction of a continuous signal from a series of samples, aliasing, spectrum leakage.
L3: Determination of selected signal parameters. Signal FFT analysis.
L3: Determination of the fundamental frequency of the signal (autocorrelation function, cepstrum, FFT, detection of zeros).
L4: Construction of statistical filters with a finite and infinite impulse response.
L5: Determination of the analytical form of the signal. Performing signal decomposition with the use of selected empirical distribution methods (EWT, VMD, EMD).

L6: Presentation of the Scikit-Learn package to support signal processing using artificial intelligence methods.
L7: Possibility of making up for classes or trying to solve selected problems with the use of tools presented during the course (in case when there is no need for rework).

Teaching methods

Lecture: multimedia presentations expanded by examples shown on a board. Theoretical questions are presented in the exact reference to the practice.
Laboratory: performing laboratory exercises independently or in small teams (preparation of the stand, construction of measurement systems, performance of experiments, implementation of signal processing methods in the environment of the selected engineering support program, use of ready-made tools for signal processing) with the help and supervision of the teacher.

Bibliography

Basic:
Szabatin J., Przetwarzanie sygnałów, https://doc.lagout.org/dsp/J.Szabatin-PrzetwarzanieSygnalow.pdf , 2003.
Zieliński T.P., Cyfrowe przetwarzanie sygnałów - od teorii do zastosowań, Wydawnictwo Komunikacji i Łączności Sp. z o.o., Warszawa 2014.
Marven C., Ewers G., A Simple Approach to Digital Signal Processing, John Wiley & Sons, 1996.
McKinney W., Python for data analysis, O'Reilly Media, 2013.

Additional:
Tretter S.A., Communication System Design Using DSP Algorithms, Springer, Boston 2008.
Madisetti V., The Digital Signal Processing Handbook, 2nd ed. Boca Raton, CRC Press, FL, USA 2009.
Downey A.B., Digital Signal Processing in Python, Green Tea Press, Needham, Massachusetts 2016.
Charbit M., Digital Signal Processing (DSP) with Python Programming, Wiley-ISTE, 2017.
Porr Bernd, Uniwersytet w Glasgow, Kurs projektowania filtrów z Pythonem: https://www.youtube.com/user/DSPcourse/playlists.
Kuwałek P., AM Modulation Signal Estimation Allowing Further Research on Sources of Voltage Fluctuations, IEEE Trans. on Industrial Electronics, vol. 67, no. 8, pp. 6937 6945, 2020.
Kuwałek P., Estimation of Parameters Associated with Individual Sources of Voltage Fluctuations, IEEE Trans. on Power Delivery, Early Access - DOI: 10.1109/TPWRD.2020.2976707, 2020.

Breakdown of average student's workload

	Hours	ECTS
Total workload	55	2,00
Classes requiring direct contact with the teacher	30	1,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	25	1,00