POZNAN UNIVERSITY OF TECHNOLOGY

EUROPEAN CREDIT TRANSFER AND ACCUMULATION SYSTEM (ECTS)

COURSE DESCRIPTION CARD - SYLLABUS

Course name
Digital Signal Processing [S1IBio1>CPS]

Course

Field of study
Biomedical Engineering

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
0

Tutorials
0

Projects/seminars
0

Number of credit points

2,00

Coordinators

dr hab. inż. Roman Barczewski prof. PP
roman.barczewski@put.poznan.pl

Lecturers

Prerequisites

Fundamentals of programming and measurements of physical quantities. Ability for self-learning and knowledge acquiring, basing on library (including e-resources) and Internet resources (e.g. eKursy and others).

Course objective

Students receive theoretical knowledge and practical skills involving digital signal processing (including biomedical signals). Introduction to “VI techniques” - creation of the virtual measurement and analyzing systems. Inspiriting students to innovative solutions in the fields of digital signal processing (signal prametrization, signal anaysis and data visualisation).

Course-related learning outcomes

Knowledge:
Student after completing the course has knowledge about digital signal processing: signal preconditioning, rules of digital to analogue and digital to analogue conversion, parameters of ADC conversion depending on types and features of signals, proper selection of signal acquisition devices. Student has knowledge about measures and characteristics of signals in the amplitude, time and

frequency domain; knows methods, procedures and algorithms to determine them. Student has the knowledge necessary to create the structures of signal processing systems (including parameterization, analysis and visualization of signals and results).

Skills:
Student after completing the course knows how to configure the basic digital signal processing system including such elements as: acquisition, scaling, amplification, signal synthesis, filtration, decimation, triggering, determination of signal measures, averaging, visualization and data archiving. Student knows how to configure the structure of digital signal processing, which performs basic signal analysis in the time, amplitude and frequency domain. Student knows how to choose the type and parameters of time windows for various types of signal analysis and signal processing techniques. Student knows how to create a virtual measuring and analyzing device (virtual instrument) with a user interface including a control and visualization panel. Student knoes how to create an application that performs digital processing of the indicated biomedical signal.

Social competences:
Student after completing the course is well aware of the necessity for continuous self-learning . Student is aware of the role of engineering activities in creating new innovative solutions in the field of biomedical engineering and the importance of these solutions in medical diagnostics and medical therapy. He knows how to think and act creatively and proactively.

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Laboratory classes:
Assessment - on the basis of the current progress of the tasks (programming).
Knowledge of theoretical issues necessary to develop the application.
Completeness and proper functioning of an application.
The final task: creating a virtual measuring system (proposed or based on your own idea) - optionally.
Lecture
Written or on-line tests (via MOODLE platform): 10-20 issues covering the entire lecture material and issues indicated for own studies (self-studying).
Grading scale both laboratory and lecture (exam): below 60% unsatisfactory; 60-67% satisfactory, 68-74% satisfactory plus; 75-83% good; 84- 92% good plus; 93 -100% very good.

Programme content

Lecture:
Pre-processing and conditioning of analog signals and their analog-to-digital and digital-to-analog conversion (theoretical foundations and hardware solutions). Digital processing of time series: signal parameterization, analyses in the domains of: time, amplitude and frequency, time-frequency analysis methods. Data visualization, data format conversion, data archiving. Software: signal acquisition system, real-time analysis (RTA) and control; structure of programming tools and characteristics of modules.

Laboratories:
Computer lab exercises are an example of the lecture content. The tasks performed by students are aimed at improving the skills included in the subject learning outcomes. These tasks also include: individual programming and creating fragments of the digital signal processing system using the graphical programming environment ("G" language). The final effect is the creation of an application - a virtual measurement and analysis system (real-time system) and a user interface (GUI).

Course topics

Lecture:
Signal classification. Theoretical foundations of signal acquisition: preconditioning and analog-to-digital conversion. Sampling, quantization, coding. Aliasing phenomenon and methods of preventing it. Hardware: ADC and DAC converters, signal processors, serial and parallel ports (types, parameters, selection and configuration). Digital signal filtration. Ideal and real filter (passband, transition band, stopband, filter order). Filters: Butterworth, Chebyshev, Bessel - amplitude-frequency characteristics, phase-frequency characteristics, properties and applications. Filters: lowpass, highpass, bandpass, bandstop, comb filter -

transmittances, applications. Basic signal parameterization: peak value, peak-to-peak value, effective value, average value, constant component, crest factors, shape factor, impulse factor, kurtosis, Rice frequency.
Spectral analysis with constant relative bandwidth - theoretical foundations, purpose of application. Octave and third octave analysis: implementation method, visualization, interpretation of results, application areas.
Spectral analysis with constant bandwidth analysis. Fourier series, Fourier transform (FT). Discrete Fourier transform (DFT), fast Fourier transform (FFT). Complex spectrum, amplitude spectrum, phase spectrum, power spectral density. Instantaneous spectrum, average spectrum, spectrum of the synchronously averaged signal (TSA) - differences, features, applications. Picket fence effect, spectral leakage, frequency resolution.
Signal windowing - purpose and principles. Basic types of time windows: rectangular, Hanning, Hamming, flat-top, Kaiser-Bessel, Bartlett, Gauss. Time window parameters: effective duration, shape factor.
Influence of time windows on the shape of the amplitude spectrum. Signal analysis in the amplitude domain: probability density function, distribution function. Signal processing and analysis in the time domain: synchronous averaging, autocorrelation, cross-correlation. Advanced signal processing techniques: cepstral analysis, short-time Fourier transform (STFT), Wigner-Villa distribution (WVD), wavelet transform (WT) Data visualization, data format conversion, archiving. Software: acquisition, real-time analysis (RTA) and control system; structure of programming tools and characteristics of program modules.

Laboratories:
Generation of signals with amplitude and frequency modulation
Parameterization of mechanical vibrations. Sound pressure level meter.
Octave analyzer.
Influence of time windows on errors in estimating amplitudes in the spectrum. Analyses of test signals in the domains: time, amplitude and frequency.
Influence of the type of digital filters and their parameters on the form of the transfer function - amplitude-frequency and phase-frequency characteristics (optional exercise)
Presentation of individually developed programs or applications.

Teaching methods

Lecture - multimedia presentations. The content of the lectures is made available in electronic form before the start of classes, which allows comfortable and active participation in the lectures.
The laboratories take place in the Digital Signal Processing lab equipped with workstations and RTA (Real Time Analysis) programming environment. Optionally, remote work is possible.
The subject is comprehensively supported on the Moodle e-learning platform. There are available resources such as: lecture materials, multimedia, source materials (selected publications, technical notes), instructions for laboratory exercises, report templates, sample reports. It is also possible to perform exercises remotely based on tutorials and individual data sets.

Bibliography

Basic:
1. Zieliński T. Cyfrowe przetwarzanie sygnałów. Od teorii do zastosowań, WKŁ, Warszawa 2005
2. Marven C., Ewers G., A simple approach to digital signal processing, Wiley 1996.
3. Braun S., Discover signal processing, Wiley 2008.

Additional:
1. Moczko J Kramer L, Cyfrowe metody przetwarzania sygnałów biomedycznych, Wydawnictwo Naukowe UAM, Poznań 2001.
2. Qian S., Chen D., Joint Time-Frequency analysis, methods and applications, Prentice Hall PTR Asimon &Schuster Company, 1996.
3. DASYLab - Data Acquisition System Laboratory - User Guide, DASYTEC USA 1996.
4. Supplementary materials available on the MOODLE e-learning platform.

Breakdown of average student's workload

	Hours	ECTS
Total workload	50	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)	20	1,00