COURSE DESCRIPTION CARD - SYLLABUS

Course name
Digital signal processing

Course

Field of study
Mechatronics
Area of study (specialization)
Design and Control of Mechatronic Devices
Level of study
Second-cycle studies
Form of study
full-time

Year/Semester
2/3
Profile of study
general academic
Course offered in
Polish
Requirements
elective

Number of hours

Lecture
15
Laboratory classes
15
Other (e.g. online)
Tutorials
Projects/seminars

Number of credit points

2

Lecturers

Responsible for the course/lecturer:
dr hab. inż. Roman Barczewski
e-mail: roman.barczewski@put.poznan.pl
tel.61.6652684
Faculty of Mechanical Engineering
ul. Piotrowo 3, 60-965 Poznań

Responsible for the course/lecturer:

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. Moodle and others).

Course objective

Students receive theoretical knowledge and practical skills involving digital signal processing (including signals used in the monitoring and control of mechatronic devices). Introduction to "VI techniques" - creation of the virtual measurement and analysing systems. Inspiriting students to innovative solutions in the fields of digital signal processing (signal parametrization, signal analysis 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 as well as frequency-time 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 analysing device (virtual instrument) with a user interface including a control and visualization panel. Student knows how to create an application that performs digital processing of the indicated 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 mechatronics and the importance of these solutions in the development of technology. Student 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 correct operating of the application.
The final task: creating a virtual measuring system (proposed or based on your own idea) - optionally.

Lecture

Written or on-line tests (via eKursy platform): 10-20 issues covering the entire lecture material and issues indicated for own studies (self-studying).
Grading scale both laboratory and lecture (final test): below 60% unsatisfactory; 60-67% satisfactory, 68-74% satisfactory plus; 75-83% good; 84- 92% good plus; 93 -100% very good.

Programme content

Lectures:
Pre-processing and conditioning of an analogue signals. Fundamentals of the analogue to digital conversion and rules of signal acquisitions. Hardware: ADC and DAC converters, signal processors, serial and parallel interfaces (types, parameters, configuration). Digital signal processing of time series in the time, frequency and amplitude domains. Methods of time-frequency analysis. Data visualisation, data format conversion, data archiving. Software: the signal acquisition, real-time analysis and control - structure of programming tools, modules description.

Laboratory classes:

The exercises in the computer laboratory exemplify the content of the lectures. Tasks carried out by students are related to the improvement of skills included in the course-related learning outcomes. These tasks also include: individual programming and creating fragments of a digital signal processing system using the graphical programming environment ("G" language). The final result is the creation of an application - a virtual measurement and analysis system (real-time system) including the user interface (GUI).
Laboratory exercise topics:
LDS 91. Data Acquisition System Laboratory - environment, system navigation and configuration, principles of creating RTA structures, description of module libraries, driver installation, selection of analog-to-digital conversion parameters (sampling and quantization), the phenomenon of aliasing, signal visualization.
LDS 92. Signal generator: basic signals generation, signal synthesis, amplitude and frequency modulation, DAC conversion, signal parameters control, GUI panel creation.
LDS 93. Sound pressure level monitoring system. Determination of analog-to-digital conversion parameters for signal processing in the acoustic band, removal of the constant component of the signal, signal scaling, calibration of system with the use of a reference source, amplification, determination of the effective value of the signal, selection of the time constant, values averaging options, linear-log transformation, results visualization, use of global variables in the process of signals processing and control of the system, signaling and visualization of exceeded alarm levels.
LDS 94. Octave Analyzer - application of digital band filtering to analysis with constant relative bandwidth. Configuration of a bank of digital filters, synthesis of the octave spectrum. Controlling the system with sound.
LDS 95. Vibration supervision system. Signal preprocessing (amplification, anti-aliasing filtration), digital parameterization of signals: determination of: peak value, effective value, AVG, shape factor, impulse factor, crest factor, kurtosis; digital integration and differentiation of the signal, writing and reading signals to a file (different data formats). Visualization of fast and slowly changing time courses,

visualization and reporting of exceeded alarm and limit values.
LDS 96. Investigation of the influence of the time window on errors in the estimation of the components of the amplitude spectrum obtained by DFT / FFT. Selection of the type and parameters of time windows, determining the underestimation of the values of the components of the amplitude spectrum. Determination of the effective window duration, the influence of the type of time window on the selectivity of the amplitude spectrum.
LDS 97. Signal analysis system in the time domain, amplitude and frequency. Creating a digital signal analysis system and performing analyzes for representative signals, including: amplitude spectrum (instantaneous and averaged), phase spectrum, power density spectrum, probability density function, cumulative distribution function, autocorrelation function and cepstral analysis.
LDS 99 Final project (optional): Rotary machine monitoring and supervision system. The project includes the development of digital signal processing, control and GUI (*Graphical User Interface)*. Sets of vibration acceleration signals recorded from real rotating machinery are available.

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 eKursy 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. Qian S., Chen D., Joint Time-Frequency analysis, methods and applications, Prentice Hall PTR Asimon &Schuster Company, 1996.
2. DASYLab - Data Acquisition System Laboratory - User Guide, DASYTEC USA 1996.
3. Supplementary materials available on the eKursy e-learning platform.

Breakdown of average student's workload

	Hours	ECTS
Total workload	50	2,0
Classes requiring direct contact with the teacher	30	1,0
Student's own work (literature studies, self-education based on e-learning resources, preparation for laboratory classes, individual programming, reports, preparation for exam) [1]	20	1,0

[1] delete or add other activities as appropriate