POZNAN UNIVERSITY OF TECHNOLOGY

EUROPEAN CREDIT TRANSFER AND ACCUMULATION SYSTEM (ECTS)

COURSE DESCRIPTION CARD - SYLLABUS

Course name
Digital instrumentation for control and measurement [S1TK1E>CAKP]

Course

Field of study
Quantum technologies

Year/Semester
3/5

Area of study (specialization)
–

Profile of study
general academic

Level of study
first-cycle

Course offered in
English

Form of study
full-time

Requirements
compulsory

Number of hours

Lecture
30

Laboratory classes
15

Other
0

Tutorials
0

Projects/seminars
0

Number of credit points

3,00

Coordinators

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Lecturers

Prerequisites

Analysis of mathematical analysis and linear algebra. Coding and implementation of algorithms. Fundamentals of research methodology. Knowledge and skills in analog devices for quantum engineering.

Course objective

The course aims to provide advanced knowledge and practical skills in the design of control and measurement equipment. Students will learn to use LabVIEW software and integrate it with external components. They will learn to design their own user interface, analyze and process analog signals, and integrate the environment with a control and measurement system.

Course-related learning outcomes

Knowledge:
(W1) Possesses advanced knowledge enabling the design and construction of classical layer modules for quantum devices using the LabVIEW environment. (K_W02)
(W2) Is proficient in using programming tools and available libraries in the process of designing and implementing control and measurement equipment responsible for control and data acquisition. (K_W14)

(W3) Is able to use acquired knowledge of LabVIEW to control quantum systems, data acquisition, and signal conditioning. (K_W15)

Skills:
(U1) Can use LabVIEW and Python with appropriate libraries to conduct classical and quantum numerical simulations. (K_U09)
(U2) Can design and implement a complete control and measurement system integrated with a quantum module, selecting appropriate design methods in electronics and computer science. (K_U10)
(U3) Using LabVIEW and available laboratory equipment, can configure and build selected measurement systems based on quantum sensors using advanced electronic, optical, or photonic devices, as well as plan and perform advanced physical measurements, including those related to experimental material characterization. (K_U16)

Social competences:
(KS1) Is ready to use interdisciplinary technical resources and documentation, including open-source solutions, to solve complex practical problems at the intersection of materials science, digital electronics, analog electronics, and programming. (K_K02)
(KS2) Is ready to act responsibly and ethically, ensuring the highest reliability of quantum module measurements and the transparency of their results. (K_K03)

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

The subject-specific learning outcomes in terms of knowledge will be assessed in the form of a written assessment at the end of the semester. The subject-specific learning outcomes in terms of skills and social competencies will be assessed on an ongoing basis during progress assessments of laboratory tasks.

Programme content

Lectures:
1. Analog and digital signals.
2. Fourier transformation and series.
3. Filtering finite and infinite impulse response signals.
4. Digital data processing and compression.

Lab labs:
1. Designing control and measurement systems using LabVIEW.
2. Integrating LabVIEW with external components (Arduino, Raspberry Pi).
3. Building a dedicated laboratory station using available control and measurement devices.

Course topics

Lectures:
1. Signals and Systems. Basic concepts of signals and control systems.
2. Sampling and Quantization. Concepts of resolution and sampling rate, including the Nyquist frequency.
3. DSP Software. Overview of selected software (LabVIEW, octave) for signal processing capabilities.
4. Continuous Fourier Transform. Theoretical Introduction and Applications.
5. Continuous Fourier Series. Theoretical Introduction and Applications.
6. Discrete Fourier Transform. Theoretical Introduction and Applications.
7. Discrete Fourier Series. Theoretical Introduction and Applications.
8. Finite Impulse Response Filters. Filter Characteristics and Design.
9. Infinite Impulse Response Filters. Filter Characteristics and Design.
10. Digital Signal Processors. Hardware Implementations of Signal Processing.
11. Data Compression. Lossy and lossless compression. Compressing images and audio.
12. Complex numbers. Signal analysis using complex numbers.
13. Laplace transform. Applications in signal processing and control.
14. Z transform. Applications in signal processing and control.
15. Design and application of control and measurement equipment. Review of application examples in quantum physics.

Labs:
1. Introduction to LabVIEW. Creating a user interface with charts, graphics, and buttons.
2. Signal processing in LabVIEW. Using programming structures, data types, and signal analysis and processing algorithms.
3. Debugging and troubleshooting applications.
4. Logging data to a file.
5. LabVIEW LINX and Arduino - a control and data acquisition system. 6. LabVIEW LINX and Raspberry PI - control and data acquisition system.
7. Integrating LabVIEW with laboratory equipment. Designing a laboratory setup using a power supply, oscilloscope, and generators controlled using LabVIEW.

Teaching methods

Lecture: multimedia presentation, aids in the form of scientific articles and external audiovisual materials.
Laboratory exercises: problem-solving, practical exercises, data analysis, simulation, discussion, teamwork, case studies, multimedia presentation.

Bibliography

Basic:
1. Julio César Rodríguez-Quiñonez, Oscar Real-Moreno(2022), Graphical Programming Using LabVIEW. Fundamentals and advanced techniques, Institution of Engineering and Technology
2. Cotfas P., LabVIEW Virtual Instrumentation in Education and Industry, IntechOpen, 2024
3. Andrzej Handkiewicz, Grzegorz Krzywoszyja, Wojciech Zajac, Mariusz Naumowicz, Filter Design Based on Multi-port and Multi-dimensional gC Circuits, Circuits, Systems, and Signal Processing, vol. 44(7), 2025
4. Ansari I., Signal Processing with Python. A Practical Approach, Iop Publishing Ltd, 2024

Additional:
A. Andrzej Handkiewicz, Marek Kropidłowski, Szymon Szczsny, Mariusz Naumowicz, ADC based on a fully differential current mode integrator, Analog Integrated Circuits and Signal Processing, 2019/4/25
B. Paweł Śniatała, Mariusz Naumowicz, Joao L.A. de Melo, Nuno Paulino, João Goes, A hybrid current-mode passive second-order continuous-time ΣΔ modulator, 2014 Proceedings of the 21st International Conference Mixed Design of Integrated Circuits and Systems (MIXDES)

Breakdown of average student's workload

	Hours	ECTS
Total workload	75	3,00
Classes requiring direct contact with the teacher	45	2,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	30	1,00