COURSE DESCRIPTION CARD - SYLLABUS

Course name
Synchronization and control systems [S1MiKC1>SSiS]

Course

Field of study
Microelectronics and digital communications

Year/Semester
3/6

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
24

Laboratory classes
30

Other
0

Tutorials
0

Projects/seminars
0

Number of credit points

3,00

Coordinators

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Lecturers

Prerequisites

A student joining the course should have basic knowledge of signal and system theory. Knowledge of the basics of signal processing, including filtering and frequency analysis, and the ability to interpret the characteristics of dynamic systems are required. Basic programming skills that enable the implementation of control algorithms and signal analysis are also recommended.

Course objective

The course aims to familiarize students with the principles of operation of synchronization systems in the context of time and frequency control systems. Students will learn about implementing phase- locked loops (PLL) in analog and digital terms and their use as PID controllers. The course develops the ability to design and analyze synchronization systems and respond to disturbances and failures. Additionally, students will acquire competencies in the independent acquisition of information on the latest solutions in the field of ICT system synchronization.

Course-related learning outcomes

Knowledge:
The student has knowledge of signal theory and methods of analysis of nonlinear systems, which allows him to understand the operation of phase-locked loops (PLL) and their digital and analog implementations. (K1_W02)
The student acquires the ability to use modern measuring equipment to assess the synchronization quality and study the parameters of phase control systems in practical applications. (K1_W11)
The student has knowledge of software engineering methods, which allows him to implement control algorithms in selected programming environments. (K1_W05)

Skills:
The student is able to apply mathematical tools, including mathematical analysis and probability theory, to solve problems related to the design and analysis of synchronization systems, such as phase-locked loops. (K1_U03)
The student is able to measure signal and device parameters in synchronization systems, including testing and analyzing the quality of synchronization in digital and analog systems. (K1_U10)
The student is able to analyze design requirements and specify synchronization systems, select appropriate components, and implement projects in the field of time and frequency control. (K1_U05)

Social competences:
The student is aware of the impact of synchronization quality on the functioning of modern teleinformatic networks and also notices how these systems shape the information society and affect the effectiveness of global communication. (K1_K05)
The student is ready to play a responsible role as an engineer in the field of ICT, observing professional ethics and ensuring the high quality and reliability of the designed synchronization and control systems. (K1_K07)

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Lecture:
The verification of learning outcomes is conducted through a multiple-choice test. The assessment topics, on which the questions are based, will be made available to students via the university's online learning platform. To obtain a grade of 3.0, it is necessary to earn more than half of the possible points, while the remaining grades are awarded according to the standard grading thresholds, increasing by 10% intervals.
Laboratory:
The learning outcomes are assessed through:
1. Continuous assessment - each verification of knowledge through oral answers to questions asked during laboratory exercises - weight in the final grade: 20%.
2. Reports on the exercises performed, including an analysis of the results' correctness and identification of potential problems - weight in the final grade: 30%.
3. The grade obtained from the test summarizing the exercises, checking both theoretical knowledge and practical skills - weight in the final grade: 50%.
4. Additional points for activity during laboratory classes, e.g., for initiative in solving problems related to the laboratory exercises performed.
To obtain a grade of 3.0, it is necessary to earn more than half of the possible points, while the remaining grades are awarded according to the standard grading thresholds, increasing by 10% intervals.

Programme content

The lecture and laboratory program provides comprehensive knowledge and skills in telecommunications systems' phase-locked loops, synchronization circuit design, and synchronization quality analysis. The laboratories provide practical experience in implementing and measuring synchronization signals and using PID control techniques.

Course topics

Lecture Topics:
1. Introduction to Synchronization and Control Systems (1 hr.)

Introduction to synchronization and control in telecommunications systems, discussion of basic concepts, and the importance of synchronization in the context of various ICT systems.
2. Analog and Digital Clock and Carrier Reproduction (2 hrs.)
Analysis of analog and digital technologies for reproducing clock and carrier signals. Understanding the mechanisms of signal generation and synchronization in telecommunications devices.
3. Phase-locked loop for Continuous and Discrete Signals (3 hrs.)
A detailed discussion of the theory and implementation of phase-locked loops (PLL) in analog and digital systems. Presentation of basic types of loops and applications in signal synchronization.
4. Phase-locked loop as a PID Controller in Synchronization (2 hrs.)
A review of using a phase-locked loop as a PID controller for signal synchronization. Discussion of methods for implementing such systems in communication and telecommunications systems.
5. Synchronization in digital systems - design of synchronizing circuits (3 hrs.)
Analysis of methods for designing synchronizing circuits in digital systems. Discussion of the importance of synchronization in digital systems and design of circuits using FPGA and microprocessors.
6. Assessment of synchronization quality in telecommunications systems (3 hrs.)
Examination of synchronization quality parameters in telecommunications systems, such as time error, jitter, and wander, and discussion of methods for assessing the quality of synchronization in telecommunications devices.
7. Summary (1 hr.)
Summary of lectures, questions and answers, assessment of the knowledge acquired by students.
Laboratory topics:
Lab. 1: Implementation and measurement of a phase-locked loop (5 hrs.)
In this project, students will familiarize themselves with the structure and operation of a phase-locked loop. They will implement a PLL loop in a software version using a real oscillator, measure the quality of synchronization, analyze and compare the results.
Lab. 2: Design of a digital synchronization circuit (15 hrs.)
Students will create a circuit in a digital system using FPGA. The project will include the implementation of a fully digital phase-locked loop in a frequency synthesis circuit and the evaluation of the frequency signal quality.
Lab. 3: Implementation of a PID controller in a phase-locked loop (10 hrs.)
The aim of the project is to design and implement a phase-locked loop as a PID controller in a miniature atomic standard control system. Students will work on optimizing signal synchronization using PID control techniques.

Teaching methods

Lectures:
1. Multimedia presentation: the lecturer presents the material using slides, supplemented with photos, videos, and other visual elements, real devices/measurements of synchronization systems.
2. Interactive lecture: the lecturer engages students in discussion, asks questions, and encourages them to share their thoughts, supporting a better understanding of the material and developing critical thinking skills.
3. Case study: the lecturer discusses a specific example, analyzes the problem, and proposes solutions. This allows for the application of theoretical knowledge in practice.
Laboratory:
1. Simulations: Students work with computer programs that imitate real situations.
2. Practical exercises: Students perform tasks under the lecturer's supervision, learning how to apply their knowledge in practice.
3. Group work: Students cooperate to solve problems, share knowledge, and develop communication and teamwork skills.

Bibliography

Basic:
[1] J. D. Powell, A. F. Emami-Naeini, C. M. Ivler, "Feedback Control of Dynamic Systems", 9th ed., Pearson, 2025.
[2] R. E. Best, "Phase-Locked Loops: Design, Simulation, and Applications," 6th ed., New York, McGraw-Hill, 2007.
[3] J. G. Proakis and D. G. Manolakis, "Digital Signal Processing: Principles, Algorithms, and Applications," 4th ed., New Delhi, Pearson Education, 2007.

Additional:
[4] K. Ogata, "Modern Control Engineering," Upper Saddle River, Prentice Hall, 2010.

Breakdown of average student's workload

	Hours	ECTS
Total workload	84	3,00
Classes requiring direct contact with the teacher	54	2,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	30	1,00