COURSE DESCRIPTION CARD - SYLLABUS

Course name
Programmable digital circuits and signal processors [N2AiR1-SW>PUCiPS]

Course

Field of study
Automatic Control and Robotics

Year/Semester
1/1

Area of study (specialization)
Vision Systems

Profile of study
general academic

Level of study
second-cycle

Course offered in
polish

Form of study
part-time

Requirements
compulsory

Number of hours

Lecture
20

Laboratory classes
10

Other (e.g. online)
0

Tutorials
0

Projects/seminars
20

Number of credit points

4,00

Coordinators

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Lecturers

Prerequisites

Knowledge: A student starting this subject should have basic knowledge of logic, digital circuits, microprocessor systems, the basics of signal theory. Skills: Should have the ability to solve basic problems in the design of digital circuits, microprocessor programming and programming in C language as well as the ability to obtain information from specified sources. She or he should also understand the need to expand her/his competences and be ready to cooperate in a team. Social competences: In addition, she or he should exhibit qualities such as honesty, responsibility, perseverance, cognitive curiosity, creativity, personal culture and respect for other people.

Course objective

1. To provide students with basic knowledge of programmable digital circuits and signal processors in the scope of design and use of hardware description languages, as well as in programming of signal processors in the typical applications associated with the signal processing. 2. Developing students ability to solve problems in the implementation of projects with the programmable digital circuits and signal processors. 3. Developing students' teamwork skills in implementing projects of the electronic circuits.

Course-related learning outcomes

Knowledge
A student:
1. has specialized knowledge of remote and distributed systems, real-time systems and network techniques - [K2_W3]
2. understands the design methodology for specialized analog and digital electronic systems, - [K2_W4]
3. has knowledge of adaptive systems - [K2_W9]
4. has an structured and in-depth knowledge of specialized microprocessor systems for control and measurement systems - [K2_W18]
5. has knowledge of the design of programmable digital circuits and hardware description languages necessary for the implementation of projects - [-]
Skills
A student:
1. is able to analyze and interpret the project technical documentation and to use scientific literature related to a given problem - [K2_U2]
2. is able to select and integrate elements of a specialized measuring and control system including: control unit, executive system, measuring system as well as peripheral and communication modules - [K2_U13]
3. is able to build an algorithm for solving a complex and unusual measurement and computing-control task and to implement, test and run it in a selected programming environment on a microprocessor platform - [K2_U26]
4. is able to design and program a system for signal processing (including a real time system), using programmable digital circuits or signal processors - [-]
Social competences
1. A student is aware of the responsibility for own work and has willingness to comply with the principles of teamwork and taking responsibility for jointly implemented tasks. She or he can lead a team, set goals and define priorities leading to the task - [K2_K3]

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Learning outcomes presented above are verified as follows:
Formative assessment:
a) in the scope of lectures:
based on answers to questions about the material discussed in previous lectures
b) in the scope of project classes:
based on an assessment of the current progress of tasks implementation.

Summative assessment:
a) in the scope of lectures: the verification of the assumed learning outcomes is carried out by:
i. assessment of knowledge and skills demonstrated on the multiple-choice written test (15-20 test questions), 2-3 open questions and a problem task; on the test the student can get 23 points, for a positive grade she or he must get at least 12 points,

i. assessment of knowledge and skills demonstrated on the multiple-choice written test (15-20 test questions) and 2-3 open questions in the part on programmable digital circuits and 15 open questions in the part on signal processors. For a positive grade, the student must get at least 50% of the points available,

ii. discussion about results of the test and open questions ,
b) in the scope of project classes: verification of assumed learning outcomes is carried out by:
i. assessment of student's preparation for individual sessions of project classes
ii. assessment of knowledge and skills related to the implementation of project tasks,
iii. assessment of the technical documentation of the project; this assessment also includes teamwork skills.

Obtaining additional points for activity during classes, in particular for:
i. discuss of additional aspects of the issue,
ii. effectiveness of applying the acquired knowledge while solving a given problem,
iii. ability to work as part of a team that practically performs a specific task in the laboratory,
iv. comments related to the improvement of teaching materials,

v. indicating students' perceptive difficulties enabling ongoing improvement of the didactic process.

Programme content

The lecture program includes the following topics:
1. Introduction, synthesis of digital circuits - description of technologies for manufacturing of digital programmable circuits (CMOS), alternative technologies, minimum feature size, preparation of integrated circuit design for production, MPW (multi project wafer), definition of hardware / software co-design; historical changes in the approach to designing of digital circuits, intellectual property (IP); designing of systems with limited power consumption, design for manufacturability, design complexity and distribution of engineering costs; perspectives for microelectronics in Europe.
2. Synthesis of digital circuits - terminology associated with programmable circuits, the process of designing digital circuits, logic and combinational circuits, minimization of logic functions, two-level and multi-level synthesis, decomposition of Boolean expressions, functional decomposition, sequential systems and their synthesis, digital programmable systems.
3. Digital systems technologies, PAL, PLA, PLD, CPLD systems, FPGA systems, microcell structure, use of memory as a programmable system, review of Xilinx, Altera, Lattice hardware solutions, systems supporting digital signal processing, implementation of digital filters in programmable systems .
4. Harware description languages - VHDL, AHDL, basics of AHDL syntax, part 1.
5. Harware description languages - basics of AHDL, part 2.
6. Computer aided design, example of Altium Designer, high-level design with Open Bus language.
7. GPGPU - general purpose processing on GPUs. GPU architectures.
8. Testing of digital circuits. JTAG (Joint Test Action Group) interface.
9. Features and benefits of signal processors, requirements related to real-time processing, fixed and floating point processors, the use of superscalar architecture execution units, elements of the digital signal processing algorithms.
10. Structure of the signal processor, processing units, communication interfaces, examples of development modules.
11. IDE design environments for DSPs, project structure, basic configuration of the signal processor, definition of memory areas, configuration of the compilation process and debugging process using development platforms, CMSIS DSP library.
12. Implementation of finite impulse response (FIR) filters and adaptive filters.
13. Implementation of infinite impulse response (IIR) filters, generation and detection of tone signals, application of the Goertzel algorithm.
14. Implication of Fast Fourier Transform (FFT) algorithms.
15. Processing of video sequences and images using signal processors.

Project classes are conducted in the form of fifteen 2-hour meetings held in the laboratory. The purpose of the first five classes is to familiarize students with the electronic modules of Xilinx, Altera, Lattice, Texas Instruments, Analog Devices, Microchip and STMicroelectronics as well as IDE design environments. Further classes are of a project nature. The subject of the project concerns the implementation of multimedia signal processing operations using the embedded system. Projects are implemented by 1 or 2-person teams.

Laboratory classes are conducted in the form of seven 2-hour exercises and one 1-hour summary meeting. Exercises are carried out by 2-person teams with the use of modules with signal microcontrollers. The program of laboratory classes covers the following topics:
1. Introduction to the integrated development environment (IDE)
2. GPIO and serial interfaces
3. A / C and C / A converters
4. Design and implementation of FIR digital filters
5. Design and implementation of IIR filters, analysis of tone signaling
6. Implementation of Fast Fourier Transform (FFT) algorithms
7. Realization and use of adaptive filters
8. Summary

Teaching methods

1. Lecture: multimedia presentation, solving of tasks, simulations in the programming development
2. Project classes: the use of FPGA electronic modules and modules with signal processors, teamwork

Bibliography

Basic
1. Podstawy projektowania układów cyfrowych, Zieliński C., Wydawnictwo Naukowe PWN, 2012.
2. Komputerowe projektowanie układów cyfrowych, Łuba T., Zbierzchowski B., WKŁ, Warszawa, 2000.
3. Przetwarzanie sygnałów przy użyciu procesorów sygnałowych, Dąbrowski A. (red.), WPP, Poznań, 1997.
4. Materiały edukacyjne University Program dotyczące procesorów sygnałowych firm: ARM i Texas Instruments, 2016.
5. Mikrokontrolery STM32 w systemach sterowania i regulacji, M. Szumski, BTC, 2018.
Additional
1. Język VHDL w praktyce, Kalisz J. (red.), WKŁ, Warszawa, 2002.
2. Rapid prototyping of digital systems, 2nd edition - a tutorial approach, Hamblen J., Furman M., Kluwer Academic Publishers, 2002.
3. Digital signal processing using the ARM® CORTEX®-M4, Reay D. S., John Wiley & Sons, Inc., 2016.
4. Real-time digital signal processing from MATLAB to C with the TMS320C6x DSPs, 3e, Wright C.H.G., Morrow M.G., CRC Press, 2017.
5. Digital signal processing and applications with the OMAP - L138 eXperimenter, Reay D., Wiley, 2012.

Breakdown of average student's workload

	Hours	ECTS
Total workload	100	4,00
Classes requiring direct contact with the teacher	50	2,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	50	2,00