COURSE DESCRIPTION CARD - SYLLABUS

Course name
Microprocessor systems [S1AiR2P>SM]

Course

Field of study
Automatic Control and Robotics

Year/Semester
3/5

Area of study (specialization)
–

Profile of study
practical

Level of study
first-cycle

Course offered in
Polish

Form of study
full-time

Requirements
compulsory

Number of hours

Lecture
30

Laboratory classes
30

Other
0

Tutorials
0

Projects/seminars
0

Number of credit points

4,00

Coordinators

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Lecturers

Prerequisites

Knowledge: A student starting this subject should have basic knowledge of electronics and basic programming. Skills: The student should have the ability to solve basic problems in the field of digital signal processing and the ability to obtain information from specified sources. He should also understand the need to expand his competences and be ready to cooperate in a team. Social competences: In addition, in the area of social competences, the student must exhibit such qualities as honesty, responsibility, perseverance, cognitive curiosity, creativity, personal culture, respect for other people.

Course objective

1. To provide students with basic knowledge about the architecture and programming of microcontrollers. 2. Developing students' skills to solve problems related to data processing and communication using interfaces in microprocessor electronic systems. 3. Developing the importance of knowledge of standards and recommendations related to the construction and programming of microprocessor electronic devices in students.

Course-related learning outcomes

Knowledge:
1. Student has ordered knowledge of computer architectures, computer systems and networks as well as operating systems including real-time operating systems - [K1_W9]
2. knows and understands at an advanced level the theory and methods in the field of architecture and programming of microprocessor systems, knows and understands selected languages of high and low level programming of microprocessors; knows and understands the principle of operation of basic peripheral modules and communication interfaces used in microprocessor systems - [K1_W13]
3. knows and understands typical engineering technologies, principles and techniques for constructing simple automation and robotics systems; knows and understands the principles of selection of executive systems, computational units as well as measuring and control elements and devices - [K1_W20]

Skills:
1. The student is able to read the design technical documentation and simple technological diagrams of automation and robotics systems - [K1_U2]
2. is able to use selected tools for rapid prototyping of automation and robotics systems - [K1_U13]
3. is able to choose the type and parameters of the measuring system, control unit and peripheral and communication modules for the selected application and integrate them in the form of the resulting measurement and control system - [K1_U22]
4. is able to construct an algorithm for solving a simple measurement and control task as well as implement, test and run it in a selected programming environment on a microprocessor platform - [K1_U27]

Social competences:
1. The student is ready to critically assess his knowledge, understands the need and knows the possibilities of continuous training - raising professional, personal and social competences, is able to inspire and organize the learning process of other people - [K1_K1]
2. is aware of the need for a professional approach to technical issues, meticulous familiarization with the documentation and environmental conditions in which the devices and their components can function; is ready to comply with the principles of professional ethics and to require this from others, respecting the diversity of views and cultures; - [K1_K5]

Methods for verifying learning outcomes and assessment criteria

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 the laboratory:
based on assessment of knowledge and understanding of current issues presented in the course of the subject.
c) In both forms of classes, it is possible to use Problem-Based Learning (PBL) tasks that support the current research and technical needs of the course coordinator and are supervised by the instructor, taking into account the iterative and cyclical nature of task implementation, provided that they are consistent with the course content.

Summative rating:
a) in the scope of lectures, verification of assumed learning outcomes is carried out by:
i. assessment of knowledge and skills demonstrated during the exam in the form of a test
ii. discussion of exam results.
b) in the scope of laboratory, verification of assumed learning outcomes is carried out by:
i. assessment of student's preparation for individual classes,
ii. continuous assessment, during each class (oral answers) - rewarding the increase in the ability to use known principles and methods,
iii. assessment of reports prepared partly during classes and also after their completion.
c) The summative assessment may include the results of Problem-Based Learning (PBL) assignments developed for the research and technical needs of the course coordinator and supervised by the instructor, provided they are consistent with the course curriculum.
d) Obtaining additional points for activity during classes, in particular for:

i. independent construction of an electronic module with a microprocessor and preparation of documentation
ii. effectiveness of applying the acquired knowledge while solving a given problem
iii. comments related to the improvement of teaching materials.

Programme content

This subject covers a wide range of issues related to microprocessor systems, emphasizing their construction, programming and application. Students learn both the theoretical foundations and practical skills necessary to work with microprocessor systems in various fields.
The program covers the following topics: construction and programming of microcontrollers, digital inputs/outputs, A/D and D/A converters, serial communication, counter systems, memories in microprocessor systems, low-power modes, network communication, implementation of regulators, digital signal processing algorithms, real-time operation systems.

Course topics

The lecture program includes the following topics:
1. Elements and tasks of the microprocessor system, microcontroller construction, market, manufacturers and families of microcontrollers, development modules with a microcontroller, programming environments. Motivation to learn.
2. Digital inputs / outputs (GPIO) - internal structure, electronic interface (button, keyboard, LCD, LED, 7 segment display, optoisolation, relays, transistors), software support (polling, NVIC). Switch bouncing problem.
3. Serial communication (UART) internal structure, electronic interface (RS232, RS485), software support (polling, NVIC, DMA).
4. Counter systems (TIM) - internal structure, electronic interface, software operation, use as PWM, one pusle, quadrature meter, triac control, H bridge, transistor, LED.
5. Communication: SPI, I2C, CAN, 1-Wire, USB, Ethernet.
6. ADC and DAC converters - internal structure, electronic interface, PWM with analog filter as an analog output, signal generation, calibration problem.
7. Implementation of discrete regulators and transmittances. Discretization of dynamic objects. Introduction to CMSIS-DSP.
8. Implementation of digital signal processing algorithms using CMSIS: digital filtration (FIR, IIR, LMS), calculation of discrete Fourier transform with the use of FFT algorithms. Matrix operations.
9. Introduction to FreeRTOS real-time operating system.
10. Network communication; LwIP library; TCP, UDP protocols.
11. WWW interface (HTTP server) on the microprocessor system (FreeRTOS + LwIP).
12. Memories used in microprocessor systems. Data Integrity Verification (CRC).
13. Reduced power consumption modes. Protection of microprocessor systems against program malfunction (watchdog).
14. Real time in microprocessor systems (RTC and NTP protocol).
15. Summary.
The program of laboratory classes includes the following issues:
1. Organizational classes - familiarization with OHS apparatus and footnotes, introduction to the design environment
2. Digital inputs / outputs, interrupt support; LED, monostable buttons, rotary encoder
3. Serial port; uC communication with PC
4. Programmable counters; bulb phase control system
5. PWM control; RGB LED
6. I2C; digital light sensor
7. SPI; digital temperature / pressure sensor, manufacturer's library
8. ADC ; support for analog sensors (photoresistor, thermistor)
9. DAC ; generation of analog signals with given parameters using interrupts and DMA
10. CMSIS library - matrix operations, FIR / IIR digital filters
11. CMSIS library - PID controller
12. FreeRTOS real time system
13. SD card support; FatFS file system;
14. Network communication; LwIP library; TCP, UDP, HTTP (web server) protocols
15. Presentation of the final task: a microprocessor-based measurement and control system

Teaching methods

1. Lecture: multimedia presentation illustrated with computer simulations
2. Laboratory classes: the use of STM microprocessor development modules, IDE programming environments
3. Both forms of instruction offer the opportunity to incorporate elements of Problem-Based Learning (PBL), in which students work on problems and projects defined for the research and technical needs of the course coordinator and supervised by the instructor. This approach places particular emphasis on the iterative nature of work, encompassing problem analysis, solution design, practical verification, and systematic refinement.

Bibliography

Basic:
1. M. Szumski, Mikrokontrolery STM32 w systemach sterowania i regulacji, BTC, 2018.
2. A. Kurczyk, Mikrokontrolery STM32 dla początkujących, BTC, 2019.
3. K. Paprocki, Mikrokontrolery STM32 w praktyce, BTC, 2009.
4. P. Hadam, Projektowanie systemów mikroprocesorowych, BTC, 2004.

Additional:
1. W. Gay, Beginning STM32 Developing with FreeRTOS, libopencm3 and GCC, APRESS, 2018.
2. T.Marciniak, A. Dąbrowski, R.Puchalski, D. Dratwiak, W. Marciniak, Zastosowanie mikrokontrolera STM32F410 do prezentacji zagadnień cyfrowego przetwarzania sygnałów, Przegląd Elektrotechniczny R. 95, s. 118-120, 2019.
3. D. Łuczak, A. Wójcik, DSP implementation of state observers for electrical drive with elastic coupling , Przegląd Elektrotechniczny R.92 nr 5, s. 100-105, 2016.
4. Mikrokontroleray i IoT zapewniają elektronice szybki rozwój - raport, Elektronik nr 8, s. 28-47, 2019.
5. Łuczak, D. Machine Fault Diagnosis through Vibration Analysis: Continuous Wavelet Transform with Complex Morlet Wavelet and Time–Frequency RGB Image Recognition via Convolutional Neural Network. Electronics 2024, 13, 452, doi:10.3390/electronics13020452.

Breakdown of average student's workload

	Hours	ECTS
Total workload	120	4,00
Classes requiring direct contact with the teacher	60	2,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	60	2,00