Microcontrollers and System-on-Chip
Course Syllabus

This course contributes to the requirements for the Degree of MSc in Computer Science

Title of the Academic Program	Master's Degree Programs in English "Digital intelligent control systems"
Type of the course	core /mandatory
Course period	2 semesters First semester: from October, the 1st to February, the 1st (18 weeks) Second semester: from February, the 1st to June, the 1st (18 weeks)
Study credits	9 ECTS credits
Duration	324 hours
Language of instruction	English
Academic requirements	– BSc degree in Computer Science or equivalent (transcript of records), – good command of English (certificate or other official document) **Prerequisites:** – **base knowledge of** digital electronics, programming skills.

Course Description

«Microcontrollers and Systems-on-chip» is a core course.

The course will advance student skills in designing embedded digital systems based on Microcontrollers and System-on-Chip (SoC). Modern SoC are applied in a wide range of areas of industry. SoC is a programmable, flexible, widely used platform in a very large field of applications, much more extensive than standard microprocessors (MPU). Using SoC for designing electronics hardware has proved to be a good approach to balance and reduce the time required for implementation.

Applying SoC requires skills in special design techniques and professional CAD. This course familiarizes students with SoC architecture features and shapes a complete set of skills in SoC-based design.

Students will learn the C# and Microchip AVR® Assembler language and master the SoC design process using the Atmel Studio Software.

The course will use Atmel STK-500 evaluation boards (with sensors and expressions) and measurement equipment, such as Digital oscilloscopes, multimetrs etc.

Special Features of the Course

The course provides an opportunity for students to work personally using electronic and test equipment. The student will be able to go all the way from the emergence of an idea to project implementation using Arduino hardware or its analogs.

The aim of the course is to provide students with knowledge and skills of developing, testing and debugging embedded programmable system based on modern SoC by computer aided design tools and measurement equipment.

Course Objectives

- to familiarize students with principles functioning and architectures modern Microcontrollers and SoC;
- to acquaint students with the internal and external interfaces of SoC - based devices;
- to teach students to use computer aided tools and techniques for designing SoC-based applications.

Learning Outcomes of the Course

By the end of the course, students will know:

- structural features and applications of the most common Microcontroller families;
- general knowledge about internal and external interfaces of SoC;
- general ways of connecting SoC external systems;
- basics of low-level programming for AVR® devices;
- general principles and approaches to debugging and verification of SoC-based systems.

By the end of the course, students will be able to:

- choose the most appropriate class of SoC to solve a problem;
- develop interface circuit for external devices and implement SoC-based systems on AVR® - Microcontrollers and C# - programming language for Microchip AVR®;
- perform modeling, optimizing and debugging for a SoC-based projects.

By the end of the course, students will possess:

- the necessary skills to design SoC-based embedded devices and systems using computer aided tools and techniques.

Course (module) Structure

Learning Activities	Hours
Lectures	36
Practice sessions / Seminars,	36
Self-study Assignments	216
Final Exam (including preparation)	36
Total study hours	**324**

Detailed Schedule

Week	Lectures	Seminars/ Assignments	Hours Lec/Lab/HA
Semester 1			
1-2	Introduction: Basic information on microprocessor (MPU) and microprocessor`s system. Simple microprocessor system design. Introduction to assembler language.	CAD tools for SoC-based system design: Atmel Studio7 – Review. Introduction to AVR – Assembler.	4/4/16
3-4	Microcontrollers and SoC – technical review. 8st-bits RISC microcontroller Microchip AVR® – programming and functional model.	Memory and data application design.	4/4/16
5-18	Peripheral of SoC. IO-Ports, embedded controllers, EEPROM, timers. PWM – mode. Analog-to-Digital converter (ADC).	SoC – low – level application design. Peripheral drivers design by AVR – assembler.	10/10/36
Semester 2			
1-2	Electronic design for SoC – applications. Examples of schematic for final project.	SoC – high – level application design. Using SoC in conjunction with sensors, LCD and power resistance.	4/4/8
4-6	Remote control for external devices. Serial Interfaces I2C, SPI and UART. Networks of SoC – applications.	Using SoC in conjunction with external systems by serial interfaces. TCP/IP – connection.	8/6/24
7-16	SoC-based project design optimization: frequency, power consumption, etc. Improving reliability.	Individual project.	4/6/104
17-18	Conclusion. Microcontrollers and SoC for military applications.		2/2/8
	36	**36**	36/36/216
36	**Final Exam**		**36**

Course Instructor(s) and Tutor(s), Contact information

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Additional information is available at:
https://structure.sfu-kras.ru/node/2153

Assessment

Assessment strategy	Points, max	Evaluation criteria
Tests	10	Test questions for lectures in the e-course
Lab works	40	Lab report
Individual Project	40	Electrical schematics, code, report on the project, presenting the project
Final exam	10	2 questions and a practical task that require preparatory reading and knowledge of the concepts explained

Grading policy for final assessment is:

- A (excellent work) 91–100 points
- B (above average) 81–90 points
- C (average) 71–80 points
- D (below average) 50–70 points
- F (failed) < 50 points

Attendance Policy

Students are expected to attend classes regularly. In case of missing an in-lab activity a student should perform additional work submitted to the instructor within a week after a class was missed.

Every topic involves an assignment. A written report on the assignment should be submitted within two weeks from the moment students received a list of problems. The final mark will rely on the same grading policy as for the final exam.

Web page of the course

Course materials and required reading materials are available on the webpage of the Microcontrollers and System-on-Chip, SibFU E-learning portal, www.e.sfu-kras.ru . You must be logged in to access this course: https://e.sfu-kras.ru/course/view.php?id=13693

Core reading

1. Sarmad Naimi, Sepehr Naimi, Muhammad Ali Mazidi. The Avr Microcontroller and Embedded Systems Using Assembly and C: Using Arduino Uno and Atmel Studio. MicroDigitalEd, 2017. p.632. ISBN 0997925965, 9780997925968.

2. Steven F. Barrett, Daniel J. Pack. Microchip AVR® Microcontroller Primer: Programming and Interfacing, Third Edition. Synthesis Lectures on Digital Circuits and Systems. Morgan & Claypool Publishers, 2019. p.373. ISBN 1681736233, 9781681736235.

3. Getting Started with Atmel Studio 7. User Guide DS-50002712A. © 2018 Microchip Technology Inc. Access for free: https://ww1.microchip.com/downloads/en/DeviceDoc/Getting-Started-with-Atmel-Studio7.pdf

Facilities, Equipment and Software

Software:

Atmel Studio 7, Free, no license required;

Proteus Virtual System Modelling (VSM);
Microsoft Office®.

Laboratory equipment:
Atmel STK 500, STK501, STK600 Evaluation board;
Arduino Uno Evaluation board;
Sensors, actuators and connectors – bag.

Control, testing and measuring equipment:
Digital oscilloscopes PV6501, GW Instek GDS-8205, Tektronix TPS 2024;
Multimetr ABM-4307;
Signal generator GW Instek SFG-2010.