EMBEDDED SYSTEMS

Faculty of Computer Science				
Study programme:	**Computer Science**		Degree level:	**Engineer's degree full-time programme**
Specialization	**---**		Diploma path:	**2026/2027W - 2026/2027S**
Module name:	**Embedded Systems** (Systemy wbudowane)			
Module type:	**obligatory**	**Semester: 2**	ECTS:**5**	Module ID:**FCS-00072**
No. of hrs in semester:	Lecture (L) - **30** Classes(C) - **0** Specialization workshop (SW) - **30** Project (P) - **0** Laboratory classes (LC) - **0** Seminar (S) - **0**			
Prerequisites	Computer Organization and Architecture (FCS-00011), Modular Digital Systems (FCS-00107), Synthesis of Digital Systems (FCS-00106),			

Aims and objectives:	Familiarizing students with the methodology of designing embedded systems, embedded systems base technology and tools for the design of embedded systems. Learning how to use hardware description languages for the design of embedded systems. Learning the basics of embedded systems design using appropriate technological base. Learning methods for the use of external devices (keypad, LED and LCD displays, sensors). Implementation and testing of simple embedded systems.		
Forms of teching activities::	lecture, specialization workshop,	Assessment:	Evaluation must be relevant to the intended learning outcomes: Lectures - written exam; specialization wokshops - evaluation of reports, answers on questions concerning designed projects
Module content:	Lectures: Lecture: 1. Basic concepts related to control and embedded systems. CPLD and FPGA programmable devices as the basis for embedded systems. 2. Hardware description languages: Verilog, Part 1. 3. Hardware description languages: Verilog, Part 2. 4. Selected aspects of designing basic functional blocks of embedded systems and control systems based on FPGA circuits. 5. Designing combinational circuits (multiplexers, decoders, etc.) in FPGA. 6. Design of regular sequential circuits (registers, counters) in FPGAs. 7. Design of timing circuits in FPGAs. 8. Design of arithmetic circuits in FPGAs. 9. Design of finite-state machines in FPGAs. 10. Designing memory in FPGAs 11. Designing processors in FPGAs 12. Designing algorithmic automata in FPGAs 13. Designing DSP circuits in FPGAs 14. Microcontrollers and their features, architecture. Handling of I/O ports, LED and LCD displays, timing circuits, and switches. 15. Real-time operating systems and methodology for designing reliable embedded systems. Specialized wokshops: 1. Introduction to the Quartus Prime system. 2. Designing combinational circuits using hardware description language: multiplexers and decoders, Part 1. 3. Designing combinational circuits using hardware description language: multiplexers and decoders, Part 2. 4. Working with displays and BCD code. 5. Using latches, flip-flops, and registers in FPGAs. 6. Designing counters in FPGAs. 7. Designing timing circuits in FPGAs. 8. Designing arithmetic blocks in FPGAs. 9. Designing finite-state machines in FPGAs. 10. Designing memory in FPGAs. 11. Designing a simple processor in FPGAs. 12. Designing an advanced processor in FPGAs. 13. Designing algorithmic automata in FPGAs. 14. Designing digital filters in FPGAs. 15. Report defense and final assessment.		
Teaching methods:	simulation, laboratory exercises, programming, lecture problem, informative lecture,		

Learning outcomes

Symbol	Specify min. 4, max. 8 learning outcomes in the following order: knowledge – skills – competence. Each learning outcome must be verifiable	Reference to the programme learning outcomes of education
LO1	knows the construction and operation of embedded systems and their individual components	INF1_W03
LO2	knows the techniques of creating embedded systems on various platforms, in particular, using programmable logic devices and microcontrollers	INF1_W09
LO3	knows, in advanced level, selected hardware description languages	INF1_W04
LO4	can design functional blocks of embedded systems that meet specific requirements by selecting appropriate architectures, platforms and algorithms	INF1_U04
LO5	can implement various blocks of embedded systems based on FPGAs, selecting appropriate technologies and tools	INF1_U05
LO6	can test the embedded system in terms of functionality and performance, under specific conditions, using simulations and implementations on evaluation boards	INF1_U06
No. of learning outcome	Methods of assessing the learning outcome	

		Type of teaching activities (if more than one) during which the outcome is assessed
LO1	exam	L
LO2	exam	L
LO3	exam	L
LO4	Reports, observation of student's work	Sw
LO5	Report, realisation of project task, observation of student's work	Sw
LO6	Report, discussion on project and report, observation of student's work	Sw

Student's workload (in hours)	**1** - Attendance at lectures	None	30
	2 - Attendance at specialization workshops	None	30
	3 - Preparation for specialization workshops	None	15
	4 - Preparation of reports and realization of homeworks	None	50
		TOTAL:	**125**
Quantitative indicators	Student's workload - activities that require direct teacher participation: (1)+(2)	60	**ECTS** 2.4
	Student's workload connected with practical classes (2)+(3)+(4)	95	3.8

Basic references:	1. Taraate, Vaibbhav. Digital Logic Design Using Verilog. 2nd Ed. 2022 ed. Singapore: Springer Singapore. Web. 2. Chonnad, Shivakumar S, and Needamangalam B Balachander. Verilog. New York, NY: Springer New York, 2004. Web. 3. Jack Ganssle: Embedded hardware: Elsevier, 2008. 4. Tammy Noregaard: Embeded Systems Architecture, Elsevier, 2005. 5. Steve Kilts: Advanced FPGA design : architecture, implementation, and optimization. Hoboken : John Wiley a. Sons, 2007 336 p.
Further reading	1. Deschamps, Jean-Pierre, Enrique Cantó, and Gustavo D Sutter. Guide to FPGA Implementation of Arithmetic Functions. 1. Aufl. ed. Vol. 95. Dordrecht: Springer Netherlands, 2012. Lecture Notes in Electrical Engineering. Web. 2. Uwe Meyer-Baese: Digital signal processing with field programmable gate arrays. Berlin; Heidelberg: Springer, 2007. 774 p. 3. Patrick Lysaght: New algorithms, architectures and applications for reconfigurable computing. Dordrecht : Springer, 2005. 313 p. 4. Ashenden, Peter J. Digital Design (Verilog) : An Embedded Systems Approach Using Verilog. Amsterdam: Morgan Kaufmann, 2007. Web. 5. Frank Vahid, Tony Givargis: Embedded system design: a unified hardware/software introduction. New York : Wiley J., 2002.

Unit:	Department of Digital Media and Computer Graphics	Lecturer/ instructor	dr inż. Adam Klimowicz
Date of issuing the programme:	27th March 2026	Author of the programme:	dr inż. Adam Klimowicz

L - lecture, C - classes, LC - laboratory classes, P-project, SW - specialization workshop, S - seminar