Національний технічний університет України
«КИЇВСЬКИЙ ПОЛІТЕХНІЧНИЙ ІНСТИТУТ
імені ІГОРЯ СІКОРСЬКОГО»

Department of Applied Radio Electronics

[RE-339] PROGRAMMABLE TOOLS IN INTELLIGENT RADIO ELECTRONICS

Curriculum of the academic discipline (Syllabus)

Course details

Level of higher education	First (bachelor's)
Field of knowledge	17 - Electronics, Automation, and Electronic Communications
Specialization	172 - Electronic Communications and Radio Engineering
Educational program	172B ITRET+ - Intelligent Technologies of Radio Electronics
Discipline status	Regulatory
Form of higher education	Full-time
Year of training, semester	2nd year, spring semester
Scope of the discipline	5 credits (Lectures 18 hours, Practical work 72 hours, Laboratory work 0 hours, Independent work 60 hours)
Semester control/control measures	Exam
Class schedule	https://rozklad.kpi.ua
Language of instruction	Ukrainian
Information about the course director/teachers	Lecturer: Nikitchuk A. V., Practical training: Nikitchuk A. V.,

Course placement https://do.ipo.kpi.ua/course/view.php?id=8115

Curriculum

1. *Description of the course, its purpose, subject matter, and learning outcomes*

Modern radio electronics actively uses programmable tools to create intelligent systems capable of autonomous analysis and real-time decision-making. The implementation of algorithms in embedded devices opens up opportunities for the development of unmanned vehicles, adaptive sensor networks, intelligent control systems

etc.

The aim of the course is to develop practical skills in programming systems at various levels, including the use of operating systems, machine learning, and popular data exchange technologies.

General competencies

- GC 01 Ability to think abstractly, analyze, and synthesize
- GC 02 Ability to apply knowledge in practical situations.
- GC 07 Ability to learn and acquire modern knowledge.
- GC 08 Ability to identify, pose, and solve problems.

Professional competencies

- PC 01 Ability to understand the essence and significance of information in the development of a modern information society.
- PC 03 Ability to use basic methods, means, and tools for obtaining, transmitting, processing, and storing information.
- PC 04 Ability to perform computer modeling of devices, systems, and processes using universal application software packages.
- PC 09 Ability to accept and master new equipment in accordance with current standards.
- PC 18 Ability to assess the place and advantages of introducing elements of intelligent technologies and intelligent radio electronics into various fields of human activity.
- PC 19 Ability to apply object-oriented programming technology and basic design patterns when creating software with appropriate functionality for radio-technical information systems and to implement programs in various programming environments.
- PC 20 Ability to select methods and means of information processing using intelligent technologies.
- PC 24 Ability to develop algorithms and implement them in software-configurable radio-electronic systems.

Program learning outcomes

- PLO 01 Analyze and make informed decisions when solving specialized tasks and practical problems in telecommunications and radio engineering, which are characterized by complexity and incomplete certainty of conditions.
- PLO 06 Adapt to changes in information and communication network technologies, telecommunications and radio engineering systems.
- PLO 09 Analyze and evaluate the effectiveness of methods for designing information and telecommunications networks, telecommunications and radio engineering systems.
- PLO 13 Apply fundamental and applied sciences to analyze and develop processes occurring in telecommunications and radio engineering systems.
- PLO 18 Find, evaluate, and use information from various sources necessary for solving professional tasks, including reproducing information through electronic search.
- PLO 26 Design and implement elements of intelligent technologies using software-configurable hardware.

2. *Prerequisites and post-requisites of the discipline (place in the structural-logical scheme of training under the relevant educational program)*

Prerequisite disciplines:

- Higher mathematics.
- Computer science.

Derived disciplines:

- Communication methods in intelligent radio-electronic systems.

Related elective disciplines:

- Programming of embedded systems of the Internet of Things.
- Embedded systems: ARM architecture microcontrollers.
- Design of digital devices on FPGA.
- .NET technologies for software development.
- Software quality control.
- Computer networks and security using CISCO technologies.

3. *Course content*

TOPIC 1. Fundamentals of programmable devices in radio electronics

Introduction. Classification of programmable devices in radio electronics. General structure and key characteristics. Architecture of the computing system and command system. Types of documentation. Toolchain. Development environment.

TOPIC 2. Features of program creation and assembly

Key stages and aspects of software development. Types of embedded system programming. Operating systems and overhead costs. Programming languages. Program compilation process. Preprocessing. Compilation. Assembly. Linking. Loading into a microcontroller. C/C++ operators. Program flow control. Functions.

TOPIC 3. Intra-system and inter-system communication

Parallel and serial communication. Synchronous serial communication. Asynchronous serial communication. Interfaces and working with peripherals. Communication topologies. Communication protocols. UART. SPI. I2C. Internet connection.

TOPIC 4. Programming with operating systems

Operating systems. Super Loop architecture. Multitasking. RTOS architecture. Scheduler. The need for soft and hard real-time systems. Installing and using FreeRTOS. Memory allocation. Synchronization. Queues. Semaphores. Timers.

TOPIC 5. Optimizing program code and using microcontroller resources

Techniques for optimizing C/C++ code. Direct access to registers. Assembly inserts (Inline Assembly). Energy-saving modes.

TOPIC 6. Integration of artificial intelligence into radio-electronic devices

Artificial intelligence and machine learning (ML). Cloud AI and Edge AI (model execution directly on the device). Libraries for ML. Data sources for model training. Basics of classification of dynamic processes in embedded systems.

4. *Training materials and resources*

Recommended basic literature

1. Nikitchuk, A. V. (2024). Programming embedded systems of the Internet of Things: lecture notes

lectures.
2. Nikitchuk, A. V. (2024). Programming Embedded Internet of Things Systems: Laboratory Practicum.

Supplementary literature

1. Espressif Systems (2023). ESP32-C3 Wireless Adventure: A Comprehensive Guide to IoT.
2. Barrett, S. F. (2022). Arduino II: Systems. Switzerland: Springer International Publishing.

Information resources

1. Arduino Documentation. URL: https://docs.arduino.cc/
2. FreeRTOS task states and state transitions described. FreeRTOS. URL: https://www.freertos.org/RTOS-task-states.html

Educational content

5. *Methodology for mastering the academic discipline (educational component)*

Лекції	Практичні роботи
ТЕМА 1. Основи програмованих засобів у радіоелектроніці 1. Introduction. Classification of programmable devices in radio electronics. General structure and key characteristics. Architecture of the computing system and command system. Types of documentation. Toolchain. Development environment.	1. Introduction to the development environment and simulation microcontrollers
TOPIC 2. Features of program creation and compilation	
2. Key stages and aspects of software development. Types of embedded system programming. Operating systems and overhead costs. Programming languages. 3. Program assembly process. Preprocessing. Compilation. Assembly. Linking. Loading into a microcontroller. C/C++ operators. Program flow control. Functions.	2. Operators and subroutines 3. Program flow control 4. Loops, time delays, and timers
TOPIC 3. Intra-system and inter-system communication	
4. Parallel and serial communication. Synchronous serial communication. Asynchronous serial communication. Interfaces and working with peripherals. Communication topologies. Communication protocols. UART. SPI. I2C.	5. Communication with peripheral devices using UART, SPI, and I2C protocols 6. Connecting to a wireless network and determining the exact network time 7. Client-server communication using the HTTP protocol
TOPIC 4. Programming using operating systems	
5. Operating systems. Super Loop architecture. Multitasking. RTOS architecture. Scheduler. The need for soft and hard real-time systems. Installing and using FreeRTOS. 6. Memory allocation. Synchronization. Queues. Semaphores. Timers. 7. Techniques for optimizing C/C++ code. Direct access to registers. Inline	8. Use of a real-time operating system (RTOS) 9. Synchronization of access to shared resources in RTOS 10. Program optimization using direct access to microcontroller
TOPIC 5. Software code optimization and microcontroller resource utilization	
assembly. Energy-saving modes.	registers 11. Improving computational efficiency and reducing execution time 12. Ensuring energy efficiency and using low-power modes
TOPIC 6. Integration of artificial intelligence into radio-electronic devices	
(model execution directly on the device). Libraries for ML. Data sources for model training. Basics of classification of dynamic processes in embedded systems.	processes 14. Deploying an artificial intelligence model on a microcontroller

6. *Independent student work*

1. Throughout the semester:

- *Study of materials assigned for independent study at the end of each lecture.*
- *Working through literary sources.*
- *Answering questions for self-assessment and taking tests.*

2. During the week before the planned activity:

- *Prepare for practical work.*
- *Preparation for writing a test.*
- *Preparation and completion of homework assignments.*

- *Preparation for the exam.*

Policy and control

7. *Academic discipline policy (educational component)*

Rules for attending classes:

- *for lectures and practical classes - attendance at classes (Zoom video conferences) according to the schedule;*
- *independent study of the material using lecture recordings and other materials posted in the relevant distance learning course is permitted;*
- *asynchronous completion of practical assignments is permitted.*

Rules of conduct in class:

- *during classes, you must use the Internet to: complete assignments in the distance learning course; familiarize yourself with the links provided; access modern, organized sources of information;*
- *The use of mobile phones, laptops, and other devices is permitted.*

Rules for performing practical work:

- *if the teacher has questions about the results obtained, it is necessary to undergo an oral defense procedure (answer questions);*
- *The defense procedure is considered timely if it is completed during the class dedicated to the work or the next class according to the schedule.*

Rules for awarding bonus points:

- *Bonus points are awarded for completing additional tasks specified in the assignments.*

Rules for awarding penalty points:

- *Penalty points may be awarded for late submission/defense of practical work.*

Deadline and retake policy:

- *Tests, exams, and practical assignments must be completed by the last class of the semester.*

8. *Types of control and rating system for assessing learning outcomes*

- *Ongoing assessment: quizzes (tests) on lecture topics (4 points), practical work (35 points), Module control work (5 points), Home control work (6 points).*
- *Calendar assessment: conducted twice per semester as monitoring of the current status of syllabus requirements fulfillment.*
- *Conditions for admission to semester exams: semester rating above 30 points.*

Table of correspondence between rating points and grades on the university scale

Number of points	*Grade*
10	Excellent
94	Very good
84	Good
74-65	Satisfactory
64-60	Sufficient
Less than 60	Unsatisfactory

Admission requirements not met	Not admitted

9. *Additional information on the discipline (educational component)*

Description of material, technical, and informational support for the discipline

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Working program of the academic discipline (syllabus):
Compiled by Nikitchuk A. V.;
Approved by the PRE Department (Minutes No. 06/2025 dated 06/25/2025)
Approved by the methodological commission of the faculty/research institute (protocol No. 06/2025 dated 26.06.2025)