

MINISTRY OF SCIENCE AND HIGHER EDUCATION
RUSSIAN FEDERATION
Federal State Autonomous
educational institution of higher education
NORTH CAUCASIAN FEDERAL UNIVERSITY

I APPROVE

Dean of the Faculty of Mathematics
and Computer Science named after
Professor N. I. Chervyakov, Candidate of
Physical and Mathematical Sciences,
Associate Professor
Grobova T.A.

WORKING PROGRAM OF THE DISCIPLINE

Design of Electronic Devices / Проектирование электронных устройств

Field of study 02.04.01 Mathematics and Computer Science

Focus (profile) Training Program for Electronic Information

Full-time education

Start year of studies : 2026

Implemented in the 3rd semester

DEVELOPED BY:

Associate Professor of the
Department of Computational
Mathematics and Cybernetics
Gladkov Andrey Vladimirovich

Stavropol, 2026

1. The purpose and objectives of mastering the discipline

The main goal of mastering the discipline " Design of Electronic Devices / Проектирование электронных устройств " is for each student to acquire a set of professional and general cultural competencies in the field of hardware development of modern high-performance computing systems.

The main objectives of studying the discipline are:

1. Review of basic microelectronic circuits.
the Xilinx ISE 14.7 computer design environment .
3. Learning the basics of the VHDL high-speed circuit design language.
4. VHDL implementation of ordinary (binary) and modular arithmetic circuits.
5. VHDL implementation of high-performance digital signal processing circuits.
6. Optimization and synthesis of high-speed circuits.

2. The place of the discipline in the structure of the educational program

The course "Design of Electronic Devices / Проектирование электронных устройств" is part of the elective part of the elective courses B1.B.08.01 of the Master's program

3. A list of planned learning outcomes for the discipline, correlated with the planned learning outcomes for the educational program

Code, formulation of competence	Code, indicator formulation	Planned learning outcomes for the discipline, characterizing the stages of formation of competencies, indicators
PC-4. Capable of conducting patent research, determining forms and methods of legal protection and defense of rights to the results of intellectual activity, and managing rights to them to solve problems in the field of development of science, engineering and technology	ID-1 _{PC-4} Makes rational choices regarding methods of protecting intellectual property rights; ID-2 _{PC-4} Conducts patent research in the field of computing and communication systems.	Able to make rational choices regarding methods of protecting intellectual property rights. Conducts patent research in the field of computing and communication systems.
PC-5. Able to present and adapt mathematical knowledge, programming methods and information technology in various ways, taking into account the level of the audience	ID-1 _{PC-5} Assesses the level of preparation of listeners during their public speeches ID-2 _{PC-5} Adapts the presentation of mathematical knowledge and programming methods to the level of the students	Able to apply machine learning tools, models, and methods to solve professional problems

4. Volume of the academic discipline (module) and forms of control *

Amount of classes: total: 3 credits , 108 academic hours .	OFO, in academic hours
Contact work:	
Lectures/including practical training	0
Laboratory work /including practical training	0
Practical classes /including practical training	32

Independent work	40
Forms of control	
3rd semester exam	36
Credit	-
Credit with grade	-
Coursework	No

* The course (module) involves the use of e-learning and distance learning technologies

5. The content of the discipline, structured by topics (sections) indicating the number of academic hours and types of classes allocated to them

No.	Section (topic) of the discipline and brief content	Developed competencies, indicators	full-time education				Forms of ongoing monitoring of academic performance
			Contact work of students with a teacher/of which in the form of practical training, hours			Independent work, hours	
			Lectures	Practical classes	Laboratory work		
1.	Classification of modern electronic circuits	ID-1 _{PC-4} ID-2 _{PC-4} ID-1 _{PC-5} ID-2 _{PC-5}				47.0	Interview
2.	Xilinx ISE 14.7 Ultra-Large-Scale Integrated Circuits (VLSI) Development Environment	ID-1 _{PC-4} ID-2 _{PC-4} ID-1 _{PC-5} ID-2 _{PC-5}				47.0	Interview
3.	Basics of the VHDL hardware design language	ID-1 _{PC-4} ID-2 _{PC-4} ID-1 _{PC-5} ID-2 _{PC-5}					

4.	VHDL implementation of binary arithmetic circuits	ID-1 PC-4 ID-2 PC-4 ID-1 PC-5 ID-2 PC-5					
5.	VHDL implementation of modular arithmetic circuits	ID-1 PC-4 ID-2 PC-4 ID-1 PC-5 ID-2 PC-5					
6.	VHDL implementation of digital signal processing circuits	ID-1 PC-4 ID-2 PC-4 ID-1 PC-5 ID-2 PC-5					
7.	Energy optimization and high-speed circuit synthesis	ID-1 PC-4 ID-2 PC-4 ID-1 PC-5 ID-2 PC-5					
	TOTAL for 3rd semester			32.0	-	90.0	

No .	Section (topic) of the discipline	Implemented competencies	Contact work of students with a teacher, hours				Independent work, hours
			Lectures	Practical classes	Laboratory work	Group consultations	
5th semester							
1	Classification of modern electronic circuits	PC-7	3				40.5
2	Xilinx ISE 14.7 Ultra-Large-Scale Integrated Circuits (VLSI) Development Environment	PC-7	3		12		
3	Basics of the VHDL hardware design language	PC-7	7.5		15		
	Total for 5 semester		13.5		27		40.5
6th semester							
4	VHDL implementation of binary arithmetic circuits	PC-7	9		9		15
5	VHDL implementation of modular arithmetic circuits	PC-7	9		9		15
6	VHDL implementation of digital signal processing circuits	PC-7	3		3		15
7	Energy optimization and high-speed circuit synthesis	PC-7	3		3		15
	Total for 6th semester		24		24		60
	Total		37.5		51		100.5

7.2 Title and content of lectures

Topic No.	Name of the discipline topics, their brief content	Volume of hours	Interactive format of the event
5th semester			
1	Classification of modern electronic circuits. Overview of basic microelectronic circuits (not, buffer, and, or, exclusive or, and-not, or-not, multiplexers, demultiplexers, encoders, decoders, counters, flip-flops, registers). Synthesis of universal combinational circuits. Synchronous and asynchronous circuits. Mealy and Moore finite state machines.	3	Lecture-visualization

2	Xilinx ISE 14.7 , an integrated development environment for very large-scale integrated circuits (Create a new project, open an existing project, schematic editor, VHDL editor, circuit synthesis, error analysis, report viewing and analysis, circuit power consumption, circuit simulation, implementation, firmware)	3	Lecture-visualization
3	Fundamentals of the VHDL hardware design language (specifics of the hardware description language, project structure, data types, basic language constructs, libraries of modules and subroutines)	7.5	Lecture-visualization
Total for 5 semester		13.5	
6th semester			
4	VHDL implementation of binary arithmetic circuits (half adder, adder, addition, subtraction, comparator, multiplication, division, real arithmetic)	9	Lecture-visualization
5	VHDL implementation of modular arithmetic circuits (RNC theory, addition, subtraction, multiplication, comparison, division, RNC-PSS translation)	9	Lecture-visualization
6	VHDL implementation of digital signal processing circuits (one-dimensional and two-dimensional filters, discrete Fourier transform)	3	Lecture-visualization
7	Energy optimization and high-speed circuit synthesis	3	Lecture-visualization
Total for 6th semester		24	
Total		37.5	

7.3 Name of laboratory work

Topic No.	Name of the discipline topics, their brief content	Volume of hours	Interactive format of the event
5th semester			
Topic 1. Xilinx ISE 14.7 Integrated Development Environment for Very Large-Scale Integrated Circuits			
1	Xilinx ISE 14.7 Ultra-Large-Scale Integrated Circuits (VLSI) Development Environment	12	Project implementation
Topic 2. Fundamentals of the VHDL hardware design language			
2	Basics of the VHDL hardware design language	15	Project implementation
Total for 5th semester		27	
6th semester			
Topic 3. VHDL implementation of binary arithmetic circuits			
3	VHDL implementation of binary arithmetic circuits	9	Project implementation
Topic 4. VHDL implementation of modular arithmetic circuits			
4	VHDL implementation of modular arithmetic circuits	9	Project implementation
Topic 5. VHDL implementation of digital signal processing circuits			
5	VHDL implementation of digital signal	6	Project

	processing circuits		implementation
Total for 6th semester		24	
	Total	51	

7.4 Name of practical classes

This type of work is not provided for in the curriculum

7.5 Technological map of independent work of the student

Codes of implemented competencies	Type of student activity	The final product of independent work	Assessment tools and technologies	Volume of hours, including		
				SRS	Contact work with the teacher	Total
5th, 6th semester						
PC-7	Classification of modern electronic circuits	A handwritten report on the material studied	Written report	9	No	9
PC-7	Xilinx ISE 14.7 Ultra-Large-Scale Integrated Circuits (VLSI) Development Environment	A handwritten report on the material studied	Written report	9	No	9
PC-7	Basics of the VHDL hardware design language	A handwritten report on the material studied	Written report	9	No	9
PC-7	VHDL implementation of binary arithmetic circuits	A handwritten report on the material studied	Written report	12	No	12
PC-7	VHDL implementation of modular arithmetic circuits	A handwritten report on the material studied	Written report	12	No	12
PC-7	VHDL implementation of digital signal processing circuits	A handwritten report on the material studied	Written report	6	No	6
PC-7	Energy optimization and high-speed circuit	A handwritten report on the material studied	Written report	6	No	6

	synthesis				
Total for 5.6 semesters				100.5	100.5
Total				100.5	100.5

8. Fund of assessment tools for conducting interim assessment of students in the discipline

8.1 List of competencies with an indication of the stages of their development in the process of mastering the educational program of higher education . Passport of the assessment tools fund

Code of the assessed competence	Stage of competence formation (Topic number)	Assessment tools and technologies	Type of control (current/interim)	Type of control (current/intermediate)	Name of the assessment tool
PC-7	1.2	Lecture-visualization, Project implementation, Written report	current	current	Lab Work #1
PC-7	3.4	Lecture-visualization, Project implementation, Written report	current	current	Lab Work #2
PC-7	5	Lecture-visualization, Project implementation, Written report	current	current	Lab Work #3
PC-7	6.7	Lecture-visualization, Project implementation, Written report	current	current	Lab Work #4

8.2 Description of indicators and criteria for assessing competencies at various stages of their development, description of assessment scales

Levels of competence development (for each competency)	Indicators	Descriptors			
		2 points	3 points	4 points	5 points
Base	Know: .	the student does not demonstrate knowledge of ways to acquire new professional knowledge	the student has basic knowledge of methods for developing computer models and acquiring new	the student has a confident command of lecture material on methods of acquiring knowledge	

		about mathematical models and methods of synthesizing very large-scale integrated circuits	professional knowledge of mathematical models and methods for synthesizing very large-scale integrated circuits	and developing mathematical models and methods for synthesizing very large-scale integrated circuits	
	Be able to:	Cannot use acquired technologies to gain knowledge, is not able to create Design of electronic devices	can use mastered technologies to gain knowledge, is able to develop a simple mathematical model, synthesize a simple integrated circuit	can use mastered technologies to gain knowledge, is capable of developing simple mathematical models, but has difficulty developing very large-scale integrated circuits	
	Own:	is incapable of developing computer models and does not demonstrate skills in independently acquiring knowledge	able to independently acquire knowledge with additional assistance, but has difficulty putting it into practice	is capable of independently acquiring knowledge and has the skills to implement mathematical models and methods for synthesizing very large-scale integrated circuits	
Increased	Know				the student demonstrates a comprehensive knowledge of methods for acquiring professional knowledge and developing mathematical models and methods for synthesizing very large-scale integrated circuits
	Be able				can use any technology

	to				to gain knowledge, is capable of developing any type of mathematical models and methods for synthesizing very large-scale integrated circuits
	To own				able to independently acquire knowledge, easily implement any circuit design, able to independently create mathematical models, synthesize very large-scale integrated circuits

Description of the rating scale

For the course "Electronic Device Design," student knowledge is assessed using a rating system in accordance with the "Regulations on the Organization of the Educational Process Based on the Rating System for Assessing Student Knowledge at the Federal State Autonomous Educational Institution of Higher Professional Education "North Caucasus Federal University," approved by Rector's Order No. 955-o dated July 23, 2013. In the 5th semester, two assessment points are assessed during weeks 5 and 8 of the semester. In the 6th semester, three assessment points are assessed during weeks 3, 5, and 8 of the semester.

Ongoing student assessment is conducted by instructors conducting laboratory classes in the discipline in the following ways: by evaluating a written report on the lab work. The lab defense consists of presenting the results of an individual assignment and answering the instructor's questions. The student receives the maximum number of points if the report meets the established requirements and fully explains the essence of the work. Reasons for lowering the grade include:

- lack of confidence in the technology of completing the task;
- incomplete understanding of the theoretical basis of the research being conducted;
- lack of practical skills in working with the relevant software.

An *“excellent” grade* is awarded if a student:

- knows the terminology;
- applies theory to solve problems competently and accurately;
- highlights all the properties and rules for representing mathematical objects.

a *grade of “good”* if the student:

- understands the features and substantive meaning of the proposed tasks.
- makes significant mistakes when using scientific terminology, properties and rules.

A *“satisfactory” grade* is given if the student is able to solve only half of the given problem.

A grade of “unsatisfactory” is given if a student:

- does not understand the rules and methods of mathematics,
- does not know the terminology;
- unable to apply definitions and formulas to demonstrate examples.

Interim assessment

The midterm assessment in the form of **an exam** involves a mandatory examination procedure and is assessed with 40 points out of 100. The minimum number of points required for admission to the exam is 33 points. A student's positive response to the exam is assessed with rating points ranging from **20** to **40** (**20** $\square$ S_{copy} $\square$ **40**), a score of **less than 20** points is considered unsatisfactory.

The scale of compliance of the exam rating score with the 5-point system

Rating score for the discipline	Rating on a 5-point scale
35 – 40	Great
28 – 34	Fine
20 – 27	Satisfactorily

The final grade for a course studied in one semester is determined by the sum of the points earned for work during the semester and the points received upon passing the exam:

Rating score conversion scale for a discipline

in the assessment on a 5-point scale

Rating score for the discipline	Rating on a 5-point scale
88 – 100	Great
72 – 87	Fine
53 – 71	Satisfactorily
< 53	Unsatisfactory

8.3 Standard test assignments or other materials necessary for assessing knowledge, skills, abilities and (or) work experience characterizing the stages of competence development

Questions (task, assignment) to test the level of learning

Know

Classification of modern electronic circuits

Overview of Basic Microelectronics Circuits

Gates "not", "buffer", "and", "or", "exclusive or", "and-not", "or-not"

Multiplexers

Demultiplexers

Encryptors

Decoders

Triggers

Registers

. Counters

. Synthesis of universal combinational circuits based on multiplexers

. Synthesis of universal combinational circuits based on encoders and decoders

. Synchronous and asynchronous circuits.

. Mealy finite state machine

. Moore's finite state machine

. Xilinx ISE 14.7 Ultra-Large-Scale Integrated Circuits (VLSI) Development Environment

. Circuit simulation

. Implementation of the scheme

- . Flashing the circuit into FPGA
- . Specifics of the hardware description language
- . VHDL Project Structure
- . VHDL data types
- . Sequential and parallel processes in VHDL
- . Implementation of branching constructs in VHDL
- . Implementation of cyclic constructs in VHDL
- . Parameterized modules in VHDL
- . Signal attributes in VHDL
- . Modular design in VHDL
- . Addition and subtraction of binary numbers
- . Multiplication of binary numbers
- . Division of binary numbers
- . Comparison of binary numbers
- . Coding negative numbers in the binary number system
- . Representation of rational numbers in the binary number system
- . Modular arithmetic
- . Digital filters
- . Direct discrete Fourier transform
- . Inverse discrete Fourier transform
- . Optimizing the power consumption of the circuit
- . High-speed circuit synthesis

Be able
to

1. Using a computer with installed software, implement a circuit for a binary adder of arbitrary bit depth.
2. Using a computer with installed software, implement a binary subtractor circuit of arbitrary bit depth.
3. Using a computer with installed software, implement a circuit for a binary multiplier of arbitrary bit depth.
4. Using a computer with installed software, implement a binary divider circuit with a remainder of arbitrary bit depth.
5. Using a computer with installed software, implement a circuit of a binary comparator of arbitrary bit capacity.
6. Using a computer with installed software, implement the adder circuit for pre-set bases.
- a subtractor ROC circuit for pre-set bases.
- multiplier circuit for pre-set bases.
9. Using a computer with installed software, implement a comparator SOC circuit for pre-set bases.
10. Using a computer with installed software, implement a division scheme for numbers in the RNS for a predetermined set of bases
11. Using a computer with installed software, implement a SOC-PSS translation scheme based on the Chinese remainder theorem.
12. Using a computer with installed software, implement a scheme for transferring the SOC-PSS based on the OPSS.
13. Using a computer with installed software, implement the PSS-SOK translation scheme for a predetermined set of bases.
14. Using a computer with installed software, implement a filtering circuit for a one-dimensional signal
15. Using a computer with installed software, implement a filtering scheme for a two-dimensional image

16. Using a computer with installed software, implement a direct Fourier transform circuit
17. Using a computer with installed software, implement the inverse Fourier transform circuit
18. Using a computer with installed software, implement the Mealy finite state machine circuit.
19. Using a computer with installed software, implement the Moore finite state machine circuit.
20. Using a computer with installed software, implement a scheme for generating pseudo-random binary numbers of arbitrary bit depth.

To own

1. Methods of creation and synthesis of very large-scale integrated circuits

8.4 Methodological materials defining the procedures for assessing knowledge, skills, abilities and (or) work experience characterizing the stages of competence development

examination procedure is carried out in accordance with the Regulation on the current monitoring of academic performance and midterm assessment of students in higher education programs at SKFU.

The examination ticket includes 2 theoretical questions and a problem.

40 minutes are allocated for preparation according to the ticket

When preparing for an answer, the student is given the right to use reference tables, a calculator, and a personal computer with the discipline-specific software installed on it.

Current assessment of students is carried out by teachers, leading laboratory work on the subject

When checking a practical assignment, the correctness of the answer, the consistency and rationality of the execution, and the accuracy of the calculations are assessed.

A student receives the maximum number of points if the report formatting meets the established requirements and the report fully explains the essence of the work. Reasons for a lower grade include:

- minor violations of the rules for report preparation;
- students have difficulties answering some test questions;

The report may be sent back for revision in the following cases:

- absence of any report elements.
- absolute non-compliance with design requirements.

The criteria for assessing the results of independent work are given in the Assessment Tools Fund for the discipline.

9. Methodological guidelines for students on mastering the discipline

At the first stage, you need to familiarize yourself with the course syllabus, which covers the content of practical classes, topics, and types of independent work. Specific reporting forms are provided for each type of independent work.

To successfully master the discipline, it is necessary complete the following types of independent work using the recommended sources of information

o. p / p	Types of independent work	Recommended sources of information (Source number)			
		Main	Additional	Methodological	Internet resources
1	Xilinx ISE 14.7 Ultra-Large-Scale Integrated Circuits Development Environment (VLSI)	1,2,3,4	1,2,3,4,5	1.2	1.2
2	VHDL implementation of	1,2,3,4	1,2,3,4,5	1.2	1.2

	binary arithmetic circuits				
3	VHDL implementation of modular arithmetic circuits	1,2,3,4	1,2,3,4,5	1.2	1.2
	VHDL implementation of digital signal processing circuits	1,2,3,4	1,2,3,4,5	1.2	1.2

10. Educational, methodological and informational support of the discipline

10.1. List of basic and additional literature required for mastering the discipline

10.1.1. List of main literature:

1. GOST R 50754-95. VHDL Digital Systems Hardware Description Language. Language Description. Moscow: Gosstandart of Russia, 1995.
2. Bibilo P.N. Fundamentals of the VHDL language. 3rd ed., suppl. - M.: LKI Publishing House, 2014.
3. Harris D.M. , Harris S.L. Electronic Design and Computer Architecture. - M.: Morgan Kaufman , 2013.
4. B. Parhami , Computer Arithmetic: Algorithms and Hardware Designs, 2nd edition, Oxford University Press, New York, 2010.

10.1.2. List of additional literature:

1. Akushsky I.Ya., Yuditsky D.I. Machine arithmetic in residual classes. – M.: Soviet Radio, 1968.
2. Modular parallel computing structures of neuroprocessor systems / N. I. Chervyakov, P. A. Sakhnyuk , A. V. Shaposhnikov, S. A. Ryadnov ; Ed. N. I. Chervyakov . - M.: FIZMATLIT, 2003.
3. Xilinx FPGAs in the WebPACK environment ISE / comp. G.V. Malinin, S.V. Abramov, A.V. Serebryannikov. Cheboksary: Chuvash Publishing House. University, 2013.
4. Tanenbaum E. Computer Architecture. 5th ed. - St. Petersburg : Piter, 2007.
5. Amos Omondi , Benjamin Premkumar . Residue Number System. Theory and implementation. - London: Imperial Colledge Press, 2007.

10.2. List of educational and methodological support for independent work of students in the discipline

1. Bibilo P.N. Fundamentals of the VHDL language. 3rd ed., suppl. - M.: LKI Publishing House, 2014.
2. Harris D.M. , Harris S.L. Electronic Design and Computer Architecture. - M.: Morgan Kaufman , 2013.

10.3. List of resources of the information and telecommunications network "Internet" necessary for mastering the discipline

1. Electronic library "Wikipedia" [electronic resource] / <http://www.wikipedia.org>
2. Official website of Xilinx [electronic resource] / <http://www.xilinx.com>

11. List of information technologies used in the implementation of the educational process in the discipline, including a list of software and information reference systems

Information technology: IT analysis and software development, IT electronic office.

Information reference systems:

1. Electronic library "Wikipedia" [electronic resource] / <http://www.wikipedia.org>
2. Official website of Xilinx [electronic resource] / <http://www.xilinx.com>

List of software and information reference systems

1. Xilinx ISE Webpack, an integrated design environment for very large-scale integrated circuits (VLSIs). edition 14.7
2. Text editor for report design (Libre Office 4.x , 5.x or OpenOffice)
3. Operating system: Windows (version not less than XP, excluding 8.0, 8.1, 10), Linux (Mint 17.x)

12. Description of the material and technical base necessary for the implementation of the educational process in the discipline

A lecture hall with a white screen projection system connected to a computer and configured to play PDF presentation files . For practical classes, a computer lab (laboratory, classroom) with a number of functioning computers with sufficient performance for the course, corresponding to the number of students in the group, plus a teacher workstation, is required. All computers in the classroom (laboratory, classroom) must have the software recommended by the course program installed and configured, and internet access (with a speed sufficient for comfortable work) is required to access online resources for the course.