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MINISTRY OF SCIENCE AND HIGHER EDUCATION OF THE RUSSIAN FEDERATION
Federal State Autonomous Educational Institution of Higher Education
"NORTH CAUCASUS FEDERAL UNIVERSITY"

APPROVED BY
Acting Director of the Institute
Advanced Engineering
Cand. Tech. Sci., Associate Professor
A.A. Porokhnya

WORK PROGRAM OF THE DISCIPLINE DSP Technology and Application

Field of study	11.03.02 Infocommunication Technologies and Communication Systems
Profile	Intelligent Data Processing in Infocommunication Systems and Networks
Year of start of training	2026
Form of study	Full-time
Implemented in a semester	6

Developed by
Professor at the School of Digital Sciences,
of Robotic Systems and Electronics of the
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Dr. Tech. Sci., Professor
Linets G.I.

1. Purpose and objectives of mastering the discipline (module)

The purpose of mastering the discipline "Digital Signal Processing Technology and Its Application" is to form a clear understanding of the fundamental provisions of the theory of digital signal processing and its application, to acquire knowledge, skills, and abilities on the basics of signal theory and mathematical methods that underlie modern algorithms for their processing. Particular attention is paid to the methods of spectral analysis and filtering methods, which occupy an important place in the professional training of specialists in the field of training 11.03.02 Infocommunication Technologies and Communication Systems.

The objectives of mastering the discipline are:

- Formation of clear ideas about the fundamental provisions of the theory of digital signal processing;
- training in the basics of analytical and numerical methods for calculating and analyzing digital signal converters;
- development of skills in designing digital converters, processing experimental results and their analysis.

2. Place of the discipline (module) in the structure of the educational program

The discipline Digital Signal Processing (B1.V.O4) refers to the part formed by the participants of educational relations.

3. List of planned learning outcomes in the discipline (module) correlated with the planned results of the development of the educational program

Code, formulation of competence	Indicator code, wording	Planned learning outcomes in the discipline (module), characterizing the stages of the formation of competencies, indicators
PC-3. Able to use the provisions, laws and methods of natural sciences and mathematics to solve problems of engineering activities	ID-1PK-3 understands regulatory, regulatory, technical, organizational and methodological documents that regulate the design preparation, implementation and operation of communication systems (telecommunication systems), the construction of facilities and communication lines.	implementation and operation of communication systems (telecommunication systems), construction of facilities and communication lines in accordance with regulatory, normative, technical, organizational and methodological documents governing project preparation
	ID-2PC-3 operates with technologies used in the transport network, modern requirements for performance, availability, security, scalability, integration of technologies, manageability of communication systems (telecommunications); principles of planning the capacity of radio access networks.	is proficient in the technologies used in the transport network, modern requirements for performance, availability, security, scalability, technology integration, manageability of communication systems (telecommunications); principles of planning the capacity of radio access networks.
	ID-3PK-3 calculates the parameters and characteristics of the network and	

Code, formulation of competence	Indicator code, wording	Planned learning outcomes in the discipline (module), characterizing the stages of the formation of competencies, indicators
	infocommunication facilities, analyzes their qualitative indicators based on statistics and radio measurements, and uses specialized design software. ID-4PK-3 identifies and analyzes the advantages and disadvantages of design solutions, assesses the risks associated with the implementation of the project. ID-5PK-3 collects initial data for the design of the network and infocommunication facilities, determination of the optimal configuration and topology of the transport network; develops technical solutions for the implementation of the communication system (telecommunication system) and its components. ID-6PK-3 carries out the development of circuit design solutions for the components of radio-electronic facilities, the selection of the element base for the development of circuit solutions, conducts automated modeling and experimental work to check the technical characteristics of the modernized radio-electronic facilities	Knows how to calculate the parameters and characteristics of the network and infocommunication tools, analyzes their qualitative indicators based on statistics and radio measurements, uses specialized design software. Knows the methods of identifying and analyzing the advantages and disadvantages of design solutions, assesses the risks associated with the implementation of the project. Knows the methods of collecting initial data for the design of the network and infocommunication tools, determining the optimal configuration and topology of the transport network; develops technical solutions for the implementation of the communication system (telecommunication system) and its components. It is able to carry out the development of circuit design solutions for the components of radio-electronic facilities, the selection of the element base for the development of circuit solutions, conducts automated modeling and experimental work to check the technical characteristics of the modernized radio-electronic facilities
PC-5. Ability to carry out installation, configuration, adjustment, testing of	ID-1PK-5 understands the current industry standards that determine the requirements for the parameters of the operation of equipment, channels and	understands the principles, basic algorithms and devices of digital signal processing; the principles of building telecommunication

Code, formulation of competence	Indicator code, wording	Planned learning outcomes in the discipline (module), characterizing the stages of the formation of competencies, indicators
equipment, development of operating modes, control of design parameters of operation and testing of communication equipment, ensuring compliance of technical parameters of information and communication systems and/or their components with established operational and technical standards	paths; methods for checking the technical condition of equipment, paths and transmission channels. ID-2PK-5 complies with the technologies for setting up, adjusting and testing communication (telecommunications) equipment, operating rules and methods of using measuring and testing equipment. ID-3PK-5 performs settings, adjustments and tests of communication equipment (telecommunications) using technical and technological documentation; maintains technical and technological documentation in accordance with the established forms; checks the quality of equipment and communication facilities. ID-4PK-5 carries out incoming inspection of equipment, preparation of testing equipment, measuring equipment, devices; testing of equipment and development of equipment operating modes. ID-5PC-5 selects and uses the appropriate test and measuring equipment, uses the equipment software when setting it up	systems of various types and methods of information distribution in communication networks. Is able to comply with the technologies for setting up, adjusting and testing communication equipment (telecommunications), operating rules and methods of using measuring and testing equipment. Is able to adjust, adjust and test communication equipment (telecommunications) using technical and technological documentation; maintains technical and technological documentation in accordance with the established forms; checks the quality of equipment and communication facilities. Able to carry out incoming inspection of equipment, preparation of test equipment, measuring equipment, devices; testing of equipment and development of equipment operating modes Able to select and use appropriate test and measurement equipment, uses the hardware software when setting it up

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

Class volume: total:5 ECT, <u>180</u> academic hours	OFO, in acad. hours
Contact work:	24.00
Lectures/from them practical training	

Practical training / of which practical training	24.00 /24.00
Independent work	156.00
Forms of control	
Exam	-
Credit	Yes
Credit with a grade	-
Course work	no

5. The content of the discipline (module), structured by topics (sections) with an indication of the number of hours and types of classes

5.1. Thematic plan of the discipline (module)

№	Section (topic) disciplines and short Table of Contents	Emerging competencies, indicators	Full-time				Current Forms control Academic Performance
			Contact work of students with the teacher / of them in the form of practical training, hours			Independent work, hours	
			Lectures	Practical exercises	Laboratory work		
Semester 5							
1	General characteristics of signals. Basic concepts: information, message, signal. Mathematical model of an analog signal. Classification of signals. Energy characteristics of signals. Representation of a deterministic signal using the simplest functions. Representation of a deterministic signal using orthogonal functions. Sampling of analog signals. Discrete and digital sequences. Signal processing. Practical LessonNo 1 Harmonic Analysis of Periodic Signals	PC-3 ID-1PK-3 ID-2PK-3 ID-3PK- ID-4PK-3 ID-5PK-3 ID-6PK-3 PP-5 ID-1PK-3 ID-2PK-3 ID-3PK- ID-4PK-3 ID-5PK-3		4.00/4.00		18.00	Interview
2	Harmonic analysis of periodic signals. Basic system of signals. Fourier trigonometric series. Complex (exponential) Fourier series. Spectra of the simplest periodic signals. Conditions for the convergence of the Fourier	PC-3 ID-1PK-3 ID-2PK-3 ID-3PK- ID-4PK-3 ID-5PK-3 ID-6PK-3 PP-5 ID-1PK-3		4.00/4.00		18.00	Interview

	series. Gibbs phenomenon. Power distribution in the periodic signal spectrum. Practical spectrum width. Practical LessonNo 2 Harmonic Analysis of Nonperiodic Signals	ID-2PK-3 ID-3PK- ID-4PK-3 ID-5PK-3					
3	Harmonic analysis of non-periodic signals. Fourier transform. Spectral characteristics of the simplest non-periodic signals. Basic properties of the Fourier transform. Energy distribution in the spectrum of a non-periodic signal. Practical width of the spectrum. Practical lessonNo 3 Signal decomposition According to the Laguerre function system	PC-3 ID-1PK-3 ID-2PK-3 ID-3PK- ID-4PK-3 ID-5PK-3 ID-6PK-3 PP-5 ID-1PK-3 ID-2PK-3 ID-3PK- ID-4PK-3 ID-5PK-3		4.00/4.00		18.00	Interview
4	Spectral decomposition of signals by Laguerre and Walsh functions. Polynomials and Laguerre functions. Decomposition of signals by Laguerre functions. Walsh functions and ways to order them. Decomposition of signals by Walsh functions. Practical lessonNo 4 Signal decomposition According to the Walsh function system	PC-3 ID-1PK-3 ID-2PK-3 ID-3PK- ID-4PK-3 ID-5PK-3 ID-6PK-3 PP-5 ID-1PK-3 ID-2PK-3 ID-3PK- ID-4PK-3 ID-5PK-3		4.00/4.00		18.00	Interview
5	Linear stationary systems. General concepts. Differential equation of a linear stationary system. Transfer function of a linear stationary system. Frequency transfer function and frequency characteristics of a linear stationary system. Pulse transient function of a linear stationary system. Stability of linear stationary systems. Practical lessonNo 5 Signal decomposition by Haar function system	PC-3 ID-1PK-3 ID-2PK-3 ID-3PK- ID-4PK-3 ID-5PK-3 ID-6PK-3 PP-5 ID-1PK-3 ID-2PK-3 ID-3PK- ID-4PK-3 ID-5PK-3		4.00/4.00		18.00	Interview
6	Analog filters. Filtering problem. Basic filters and their ideal frequency characteristics.	PC-3 ID-1PK-3 ID-2PK-3 ID-3PK-		4.00/4.00		18.00	Interview

	Approximation problem. Typical LPF. Butterworth filters. Chebyshev filters of the first type. Denormalization and transformation of filters. Examples of filter calculation. Practical lessonNo 6 Study of analog low-pass and high-pass filters	ID-4PK-3 ID-5PK-3 ID-6PK-3 PP-5 ID-1PK-3 ID-2PK-3 ID-3PK-3 ID-4PK-3 ID-5PK-3					
7	Discrete signal models. Typical discrete sequences. Description and transformation of discrete sequences. Representation of a discrete sequence as a discrete function of time. Discrete Laplace transform. Z - transformation. Properties of the direct Z-transform. Inverse Z-transform. Fourier transform of a discrete signal. Discrete Fourier transform (FFT). Properties of the discrete Fourier transform. Reconstruction of the signal from its samples. Practical lessonNo 7 Representation of signals using a boiler series	PC-3 ID-1PK-3 ID-2PK-3 ID-3PK-3 ID-4PK-3 ID-5PK-3 ID-6PK-3 PP-5 ID-1PK-3 ID-2PK-3 ID-3PK-3 ID-4PK-3 ID-5PK-3		2.00/2.00		16.00	Interview
8	Linear discrete systems. The concept of a discrete system. Transfer function of a discrete system. Impulse response of a discrete system. Convolution control. Frequency transfer function of a discrete system. Amplitude and phase frequency responses. Structural diagrams of a discrete system. Stability of discrete systems. Discrete integration. Discrete differentiation. Practical LessonNo 8 Discrete Integration and Differentiation	PC-3 ID-1PK-3 ID-2PK-3 ID-3PK-3 ID-4PK-3 ID-5PK-3 ID-6PK-3 PP-5 ID-1PK-3 ID-2PK-3 ID-3PK-3 ID-4PK-3 ID-5PK-3		2.00/2.00		16.00	Interview
9	Principles of construction and classification of digital filters. Functional diagram of a digital filter. Advantages and disadvantages of digital	PC-3 ID-1PK-3 ID-2PK-3 ID-3PK-3 ID-4PK-3 ID-5PK-3		2.00/2.00		16.00	Interview

	filters. Classification of digital filters. Implementation of digital filters. Practical lesson No 9 Anti-aliasing discrete sequences	ID-6PK-3 PP-5 ID-1PK-3 ID-2PK-3 ID-3PK- ID-4PK-3 ID-5PK-3					
	TOTAL for the semester			24.00		156.00	
	TOTAL			24.00		156.00	

6. Fund of assessment tools for current monitoring of progress and intermediate certification of students in the discipline (module)

The Assessment Tools Fund (ESF) for current monitoring of progress and intermediate certification of students in the discipline (module) "Digital Signal Processing Technology and Its Application" is based on a list of competencies to be mastered with an indication of the stages of their formation in the process of mastering the discipline (module). The CSF provides objective control over the achievement of planned learning outcomes. The CSF includes:

- description of indicators and criteria for assessing competencies at various stages of their formation, description of assessment scales;
- methodological materials that determine the procedures for assessing knowledge, skills, and (or) experience of activity, characterizing the stages of competence formation;
- standard control tasks and other materials necessary to assess knowledge, skills and the level of mastery of the formed competencies in the process of mastering the discipline (module).

The FAT is an appendix to this program of the discipline (module).

7. Methodical instructions for students on the development of the discipline

Starting work, each student should take into account the following provisions.

The discipline (module) is built on a thematic principle, each topic is a logically complete section.

The lecture material is devoted to the consideration of the key, basic provisions of the courses and the explanation of educational tasks submitted for independent work of students.

Practical work is carried out in order to consolidate the acquired information, to acquire the skills of its application in solving practical problems in the relevant subject area.

Independent work of students is aimed at independent study of additional material, preparation for laboratory work, as well as performing all types of independent work.

For the successful development of the discipline, it is necessary to perform all types of independent work, using the recommended sources of information.

8. Educational, methodological and information support of the discipline

8.1. List of basic and additional literature necessary for mastering the discipline (module)

8.1.1. List of basic literature:

1. Neches I. O. Digital processing of signals Elektronnyi resurs [Digital processing of signals Elektronnyi resurs]. - Rostov-on-Don: RGUPS, 2019. - 84 p. - ISBN 978-5-88814-893-8, unlimited copies.

2. Pasechnikov I.I. Digital processing of signals Elektronnyi resurs / Pasechnikov I.I.: textbook. - Tambov: TSU named after G.R. Derzhavin, 2019. - 156 p. - ISBN 978-5-00078-261-3, unlimited copies.

3. Novikov P.V. Digital Signal Processing Elektronnyi resurs: uchebno-metodicheskoe posobiye [Digital Signal Processing Elektronnyi resurs: uchebno-metodicheskoe posobie]. - Saratov:

Vuzovskoe obrazovanie, 2018. - 75 p. - The book is in the basic version of EBS IPRbooks. - ISBN 978-5-4487-0286-0, unlimited copies.

4. Vadutov O.S. Mathematical Foundations of Signal Processing. Practicum Elektronnyi resurs: Uchebnoe posobie [Elektronnyi resurs: Uchebnoe posobie]. - Tomsk: Tomsk Polytechnic University, 2014. - 102 p. - The book is in the premium version of EBS IPR BOOKS. - ISBN 2227-8397, unlimited copies.

8.1.2. List of additional literature:

1. Alan Oppenheim Digital Signal Processing [Elektronnyi resurs] / Oppenheim Alan, Schafer Ronald; transl. by S. A. Kuleshov, E. B. Makhyanova, N. F. Orlova. — Electron. textual data. — Moscow: Technosphere, 2012. — 1048 p. — 978-5-94836-329-5. — Mode of access: <http://www.iprbookshop.ru/26906.html>, copies are unlimited.

2. Solonina A.I. Digital Signal Processing. Modeling in Simulink: Textbook. Manual for Higher Educational Institutions / A. I. Solonina. - St. Petersburg: BHV-Petersburg, 2012. - 425 p.: ill.; 24. - (Textbook). - Vulture: Rek. UMO. - Refs.: p. 417-418. - Object. Reference: p. 421-425. - ISBN 978-5-9775-0686-1 – 15 copies.

3. Fedosov V. P., Nesterenko A.K. Digital Signal Processing in LabVIEW; ed. Fedosov V. P. - M.: DMK, 2007. - 472 p.: ill. - Appendix: p. 397-452. - References: p. 454-455. - ISBN 5-94074-342-0 - 7 copies.

4. Umnyashkin S.V. Osnovy teorii tsifrovogo obrabotki signalov: uchebnoe posobie [Fundamentals of the theory of digital signal processing: a textbook]. - 4th ed., correction. - Moscow: Technosphere, 2018. - 528 p.: ill. - ISBN 978-5-94836-508-4; [Electronic resource]. - URL: <http://biblioclub.ru/index.php?page=book&id=496608>, copies unlimited.

8.2. List of educational and methodological support for students' independent work in the discipline (module)

- 1 Laboratory Practicum on the discipline "Digital Signal Processing". Direction of training 11.03.02 Infocommunication Technologies and Communication Systems. Linets G.I.
- 2 Novikov, P.V. Digital Signal Processing Elektronnyi resurs : uchebno-metodicheskoe posobie [Digital Signal Processing] / P.V. Novikov. - Saratov : Vuzovskoe obrazovanie, 2018. - 75 p. - The book is in the basic version of the EBS IPRbooks. - ISBN 978-5-4487-0286-0

8.3. List of resources of the information and telecommunication network "Internet" necessary for mastering the discipline (module)

- 1 <http://padabum.com/>
- 2 <http://www.dsps.ru/>

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

When giving lectures, computer equipment is used to demonstrate presentation multimedia materials.

In the course of laboratory work, students perform research on analog and digital signal processing devices using computer simulation software and industrial laboratory installations.

Information reference systems:

Information and reference and information and legal systems used in the study of the discipline:

1.	http://padabum.com/
2.	http://www.dsps.ru/

Software:

1	Viola Workstation 10
2	Alt Workstation K
3	Viola "Server"

4	Office software package - P7-Office
5	Mathcad 15
6	Matlab 6.5

10. Description of the material and technical base necessary for the implementation of the educational process in the discipline (module)

The material and technical base provides all types of disciplinary and interdisciplinary training, laboratory, research work of students (portable laptop, portable projector, computers with the necessary software and Internet access).

Lectures	The classroom for lecture-type classes is equipped with specialized furniture and technical teaching aids that serve to present educational information to a large audience: a laptop, a projector. Educational and visual aids in the form of thematic presentations corresponding to the work programs of disciplines.
Practical exercises	Room 9-520, equipped with equipment and technical means of training for the presentation of educational information: - Interdisciplinary laboratory platform with NI ELVIS II + Circuit Design software kit – 10 pcs. (with the laboratory complex "Fundamentals of Radio Engineering and Telecommunications", the laboratory module "Fundamentals of Digital Engineering and FPGA Programming"); - 12 workstations included: Dell Intel Core i3-3240 3.4GHz/4096Mb/500Gb/ DWD-RW/ keyboard/mouse, DELL E2014H monitor. Connection to the Internet, access to the university's corporate network.
Independent work	The room for independent work of students is equipped with computer equipment with the ability to connect to the Internet and provide access to the electronic information and educational environment.
Practical Preparation	It is carried out in the structural divisions of the university and (or) in organizations that carry out activities in the profile of the relevant educational program, including its structural subdivision

11. Features of mastering the discipline (module) by persons with disabilities

Students with disabilities are provided with special textbooks, teaching aids and didactic materials, special technical teaching aids for collective and individual use, the services of an assistant (assistant) who provides students with the necessary technical assistance, as well as the services of sign language interpreters and typhlo-sign interpreters.

The development of a discipline (module) by students with disabilities can be organized together with other students, as well as in separate groups.

The development of a discipline (module) by students with disabilities is carried out taking into account the characteristics of psychophysical development, individual capabilities and health status.

In order to ensure the accessibility of higher education under the educational program by persons with disabilities when mastering the discipline (module), the following is ensured:

1) for visually impaired persons:

- the presence of an assistant who provides the student with the necessary technical assistance, taking into account individual characteristics (helps to take a workplace, move, read and complete the task, including by writing down by dictation),
- written tasks, as well as instructions on the procedure for their implementation, are drawn up in enlarged font,
- special textbooks, teaching aids and didactic materials (with large print or audio files),
- individual uniform lighting of at least 300 lux,
- if necessary, the student is provided with a magnifying device to complete the task;
- 2) for persons with hearing disabilities:
 - the presence of an assistant who provides the student with the necessary technical assistance, taking into account individual characteristics (helps to take a workplace, move, read and complete the task, including by writing down by dictation),
 - the availability of sound-amplifying equipment for collective use is ensured, if necessary, the student is provided with sound-amplifying equipment for individual use;
 - is provided with appropriate sound means of reproducing information;
- 3) for persons with disabilities with musculoskeletal disorders (including those with severe disorders of the motor functions of the upper extremities or the absence of upper limbs):
 - written tasks are performed on a computer with specialized software or dictated to an assistant;
 - At the request of the student, tasks can be performed orally.

12. Features of the implementation of the discipline using distance educational technologies and e-learning

According to Part 1 of Article 16 of the Federal Law of December 29, 2012 No 273-FZ "On Education in the Russian Federation" e-learning is understood as the organization of educational activities with the use of information contained in databases and used in the implementation of educational programs and information technologies, technical means, as well as information and telecommunication networks that ensure the transmission of this information through communication lines, the interaction of students and teachers.

Distance educational technologies are understood as educational technologies implemented mainly with the use of information and telecommunication networks with indirect (at a distance) interaction of students and teachers.

The discipline can be implemented using distance learning technologies and e-learning in whole or in part.

The components of the teaching materials of the discipline (the work program of the discipline, assessment and methodological materials, forms of certification), implemented with the use of distance educational technologies and e-learning, contain an indication of their use.

When organizing educational activities with the use of distance educational technologies and e-learning, asynchronous and synchronous ways of interacting with participants in educational relations through the information and telecommunication network "Internet" may be provided.

When using distance learning technologies and e-learning, the schedule for the discipline indicates: ways of interaction between participants in educational relations through the information and telecommunication network "Internet" (videoconferencing, ET - electronic testing); links to the electronic information and educational environment of NCFU, to educational platforms and resources of other organizations to which open access is provided through the information and telecommunication network "Internet"; for synchronous learning - the time of online classes and teachers; for asynchronous learning - the authors of online courses.

When organizing interim certification using distance learning technologies and e-learning, the Methodological Recommendations for the Use of Technical Means That Ensure the Objectivity of Results in the Conduct of Interim and State Final Certification in Educational Programs of Higher Education - Bachelor's Degree Programs, Specialist Programs and Master's Degree Programs with the Use of Distance Educational Technologies (Letter of the Ministry of Education and Education of

Russia dated 07.12.2020 No MN-19/1573-AN "On the Direction of Methodological Recommendations") are used.

The implementation of the discipline using e-learning and distance learning technologies is carried out using the electronic information and educational environment of NCFU, to which students have access through the information and telecommunication network "Internet", or using the resources of other organizations, including platforms that provide services for video conferences, online meetings and distance learning (MTS-Link), as well as using the capabilities of social networks for communication between students and teachers.

Educational and methodological support of the discipline implemented with the use of e-learning and distance educational technologies includes a work program, teaching aids or a course of lectures presented in electronic form, guidelines for the implementation of various types of educational activities of students provided for by the discipline, and other educational materials posted in the information and educational environment of NCFU.