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MINISTRY OF SCIENCE AND HIGHER EDUCATION OF THE RUSSIAN
FEDERATION

Federal State Autonomous Educational Institution
Higher Education
"NORTH CAUCASUS FEDERAL UNIVERSITY"

APPROVED BY

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

DISCIPLINE ASSESSMENT TOOLS FUND
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

Introduction

1. Purpose

The fund of assessment tools for the discipline "Digital Signal Processing Technology and Its Application" is designed for an objective assessment of the level of competence formation.

2. FAT is an appendix to the program of the discipline "Digital Signal Processing Technology and Its Application" / DSP Technology and Application.

3. Developer G.I. Linets, Associate Professor of the Department of Digital, Robotic Systems and Electronics of the Institute of Advanced Engineering.

4. An examination of the FOC was carried out.

Members of the expert group:

Chairman: V.P. Mochalov, Professor of the Department of Digital, Robotic Systems and Electronics of the Institute of Advanced Engineering.

Members of the Commission:

S.V. Yakovlev, Associate Professor of the Department of Digital, Robotic Systems and Electronics of the Institute of Advanced Engineering.

S.V. Melnikov, Senior Researcher of the Interdisciplinary Training and Research Center for Agricultural Technologies, Associate Professor of the Department of Digital, Robotic Systems and Electronics of the Institute of Advanced Engineering.

Representative of the employer's organization:

Mironov V.A., General Director of Orintex LLC.

Expert opinion: The FAT for the discipline allows you to assess the level of competence formation. Start approbation.

5. The validity period of the FAT is determined by the period of implementation of the educational program.

1. 1. Description of indicators and assessment criteria at various stages of their formation, description of assessment scales

Levels of competence and indicators	Levels of competence formation(s),			
	The minimum level has not been reached (Unsatisfactory) 2 points	Minimum level (satisfactory) 3 points	Intermediate level (good) 4 points	High level (excellent) 5 points
Competency: PC-3				
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.	Unable to complete tasks related to this competency achievement indicator	Performs tasks at the reproductive level related to this indicator of competence achievement	Performs tasks related to this indicator of competence achievement in standard situations, making minor mistakes	Fully performs tasks related to this indicator of competence achievement, including in non-standard situations
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.	Unable to complete tasks related to this competency achievement indicator	Performs tasks at the reproductive level related to this indicator of competence achievement	Performs tasks related to this indicator of competence achievement in standard situations, making minor mistakes	Fully performs tasks related to this indicator of competence achievement, including in non-standard situations
ID-3PK-3 calculates the parameters and	Unable to complete tasks	Performs tasks at the	Performs tasks related	Fully performs

characteristics of the network and infocommunication facilities, analyzes their qualitative indicators based on statistics and radio measurements, and uses specialized design software. .	related to this competency achievement indicator	reproductive level related to this indicator of competence achievement	to this indicator of competence achievement in standard situations, making minor mistakes	tasks related to this indicator of competence achievement, including in non-standard situations
ID-4PK-3 identifies and analyzes the advantages and disadvantages of design solutions, assesses the risks associated with the implementation of the project.	Unable to complete tasks related to this competency achievement indicator	Performs tasks at the reproductive level related to this indicator of competence achievement	Performs tasks related to this indicator of competence achievement in standard situations, making minor mistakes	Fully performs tasks related to this indicator of competence achievement, including in non-standard situations
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	Unable to complete tasks related to this competency achievement indicator	Performs tasks at the reproductive level related to this indicator of competence achievement	Performs tasks related to this indicator of competence achievement in standard situations, making minor mistakes	Fully performs tasks related to this indicator of competence achievement, including in non-standard situations
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	Unable to complete tasks related to this competency achievement indicator	Performs tasks at the reproductive level related to this indicator of competence achievement	Performs tasks related to this indicator of competence achievement in standard situations,	Fully performs tasks related to this indicator of competence achievement, including in

solutions, conducts automated modeling and experimental work to check the technical characteristics of the modernized radio-electronic facilities			making minor mistakes	non-standard situations
Competency: PC-5				
ID-1PK-5 understands the current industry standards that determine the requirements for the parameters of the operation of equipment, channels and paths; methods for checking the technical condition of equipment, paths and transmission channels.	Unable to complete tasks related to this competency achievement indicator	Performs tasks at the reproductive level related to this indicator of competence achievement	Performs tasks related to this indicator of competence achievement in standard situations, making minor mistakes	Fully performs tasks related to this indicator of competence achievement, including in non-standard situations
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	Unable to complete tasks related to this competency achievement indicator	Performs tasks at the reproductive level related to this indicator of competence achievement	Performs tasks related to this indicator of competence achievement in standard situations, making minor mistakes	Fully performs tasks related to this indicator of competence achievement, including in non-standard situations
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	Unable to complete tasks related to this competency achievement indicator	Performs tasks at the reproductive level related to this indicator of competence achievement	Performs tasks related to this indicator of competence achievement in standard situations, making minor mistakes	Fully performs tasks related to this indicator of competence achievement, including in non-standard situations

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.	Unable to complete tasks related to this competency achievement indicator	Performs tasks at the reproductive level related to this indicator of competence achievement	Performs tasks related to this indicator of competence achievement in standard situations, making minor mistakes	Fully performs tasks related to this indicator of competence achievement, including in non-standard situations
ID-5PC-5 selects and uses the appropriate test and measuring equipment, uses the equipment software when setting it up	Unable to complete tasks related to this competency achievement indicator	Performs tasks at the reproductive level related to this indicator of competence achievement	Performs tasks related to this indicator of competence achievement in standard situations, making minor mistakes	Fully performs tasks related to this indicator of competence achievement, including in non-standard situations

ASSESSMENT TOOLS TO CHECK THE LEVEL OF FORMATION OF COMPETENCIES

Job Number	Correct answer	Content of the question	Competence
<u>Semester 6</u>			
1.	1	How is a deterministic signal determined? 1. The value of this signal at any given time is determined accurately. 2. At any given time, this signal is a random variable that takes a specific value with some probability. 3. At any given time, this signal is not a random variable that takes a specific value with some probability. 4. The value of this signal cannot be determined accurately at any given time.	PP-5 PC-3
2.		What is the main idea of spectral analysis of periodic signals?	PC-3
3.	1	The system of orthogonal functions is called complete: 1. If no new function can be added to it that would be orthogonal to all other functions of this system. 2. If new variables cannot be added to one of the functions 3. If it is impossible to add new functions and new variables to it 4. If you can't add new features to it	PP-5 PC-3
4.		What does the Fourier series record look like for periodic signals $s(t)$ on the time interval $-\infty \leq t \leq \infty$	PP-5 PC-3
5.		Give the notation of the Fourier series in a complex form	PC-3
6.		How is Parseval's equality formulated?	PP-5
7.		What is the reason for the Gibbs effect in the spectral synthesis of periodic signals? How does this effect manifest itself?	PC-3

8.	4	When the operators of ideal frequency filters are truncated on jumps in the transfer functions of the operators, the Gibbs phenomenon occurs. How can the Gibbs phenomenon be neutralized? 1. Increasing the operator's window. 2. Reducing the operator's window. 3. By multiplying the operator by the weight function. 4. Smoothing the operator with a weight function.	PC-3
9.	1	When the operators of ideal frequency bandpass filters are truncated on the jumps of the transfer functions of the operators, the Gibbs phenomenon occurs. Can the value of the amplitude of the Gibbs phenomenon exceed 10% of the value of the jump of the transfer function? 1. Yes 2. Yes	PC-3
10.	3	What parameters determine a harmonic signal? 1. Amplitude A and frequency ω. 2. Amplitude A and the initial phase of φ. 3. Amplitude A, frequency ω and initial phase φ. 4. Frequency ω and initial phase φ.	PP-5
11.	2	What conditions must the Dirichlet series satisfy for the Fourier series to exist? 1. There should be no breaks of the second kind and the number of extremes should be finite. 2. There should be no breaks of the second kind, the number of breaks of the first kind should be finite and the number of extremes should be finite. 3. There should be no breaks of the second kind and the number of breaks of the first kind should be finite. 4. The number of discontinuities of the first and second types must be finite.	PP-5
12.	3	The representation of an arbitrary signal as a set of a constant component and a sum of harmonic oscillations with multiple frequencies is called _____ this signal in the basis of harmonic functions	PC-3

		1. Frequency separation 2. Phase decomposition 3. Spectral decomposition 4. Normal decomposition	
13.	1	How the amplitude and phase spectrum of the signal changes when the reference point is shifted: 1. The amplitude spectrum of the signal does not change, the phase spectrum changes. 2. The amplitude and phase spectra of the signal change 3. The amplitude spectrum of the signal changes, the phase spectrum of the signal does not change 4. No changes	PC-3
14.	3	What interval is used in the case of using Laguerre functions in signal decomposition: 1. Interval $(-\infty, \infty)$ 2. Interval $(-a, a)$ 3. Interval $(0, \infty)$ 4. Interval $(-\infty, 0)$	PP-5
15.	1	What happens to the signal spectrum on the frequency axis when the signal on the time axis is compressed by k times: 1. Its spectrum expands k times on the frequency axis. 2. Its spectrum on the frequency axis narrows by a factor of k . 3. Spectrum does not change 4. The spectrum changes to infinity	PC-3
16.		Give the formula for the direct Fourier transform	PC-3
17.		Give the formula for the inverse Fourier transform	PC-3
18.		Explain the main differences between the frequency response of Butterworth and Chebyshev filters of the first kind	PP-5 PC-3
19.		Explain the differences in the location of the poles of the Butterworth and Chebyshev filters of the first kind	PC-3

20.		What is meant by filter denormalization? When and how is this operation used?	PC-3
21.		How is LPF transformed into other types of filters?	PP-5
22.		Explain the main differences between the frequency response of Butterworth and Chebyshev filters of the first kind	PC-3
23.		Differential Equation of a Linear Stationary System	PP-5
24.		Transmission function of a linear stationary system.	PC-3
25.		Frequency transfer function and frequency characteristics of a linear stationary system.	PP-5
26.	2	The Laguerre function $li(t)$ is the same in shape: 1. With the impulse response of a system consisting of oscillating electric circuits connected in series. 2. With the impulse response of a system consisting of simple electrical circuits connected in series. 3. With the impulse response of a system consisting of simple electrical circuits connected in parallel. 4. With the impulse response of a system consisting of simple electrical circuits covered by negative feedback.	PC-3
27.	3	What is the power spectral density of white noise? 1. $W(\omega) = 0$ 2. $W(\omega) = 1$ 3. $W(\omega) = \text{const}$ 4. $W(\omega) = \text{Infinity}$	PC-3
28.	4	What is the division of a range of values of a quantity into a finite number of intervals called? 1. Interpolation 2. Extrapolation 3. Linearization 4. Quantization	PC-3
29.	3	What is equal to Average Periodic Waveform: 1. Equal to the sum of the average powers allocated by the individual harmonics	PP-5

		2. Equal to the sum of the powers released by the fundamental harmonic and its constant component 3. Equal to the sum of the average powers allocated by the individual harmonics and its constant component 4. Equal to the sum of the average powers released by the first of the three harmonics	
30.	1	If, in an analog system, an arbitrary delay in the input signal leads to only the same delay in the output signal, without changing its shape, the system is called: 1. Stationary 2. Non-stationary 3. Parametric 4. Variable Parameter System	PC-3
31.	2	The impulse response is: 1. Response to influence in the form of a harmonic function 2. Response to the impact in the form of a Heaviside function 3. Response to impact in the form of a square pulse 4. Response to Impact as an Exponential Function	PC-3
32.	3	The process of converting an analog signal into a sequence of values is called: 1. Quantization of the signal by level 2. Receiving a digital signal 3. Signal sampling 4. Signal modulation	PP-5 PC-3
33.	3	The Z-transform has the following properties: 1. Nonlinearity and cyclicity 2. Cyclicity and linearity 3. Linearities, delays, convolutions 4. Stationarity, delay and cyclicity	PP-5 PC-3
34.	2	Which property is not related to the discrete Fourier transform? 1. Linearity 2. Circular convolution	PC-3 PP-5

		3. Delay 4. Symmetry	
35.	1	A normalized filter means a filter with a bandwidth cutoff frequency: 1. $\omega_c=1$ 2. $\omega_c=10$ 3. $\omega_c=100$ 4. $\omega_c=1000$	PP-5 PC-3
36.		Describe and transform discrete sequences. .	PP-5
37.		Properties of the direct z-transform.	PP-5
38.		Discrete Laplace transform. Z - transformation	PC-3
39.		Inverse Z Transform	PP-5
40.		Representation of a discrete sequence as a discrete function of time.	PP-5 PC-3
41.		Explain the characteristics of window functions	PC-3
42.		Explain the Reason for the Frequency Response Periodicity of a Digital Filter	PC-3
43.		Butterworth filters.	PC-3
44.		Chebyshev filters of the first kind.	PP-5
45.		What methods are used to convert the transfer function of an analog prototype filter to the transfer function of a digital filter?	PC-3 PP-5 PC-3
46.		Explain the essence and benefits of cascading implementation of recursive digital filters	PC-3
47.		How is the correlation function of a periodic signal calculated?	PP-5
48.		How to determine the mutual correlation function of two signals?	K-5
49.		Under what conditions can the mutual correlation function of two periodic signals be determined?	PP-5
50.		Explain why it is impossible to restore the original signal using the correlation function?	PC-3
51.	3	What interference dispersion gain should a smoothing filter have?	PC-3

		1. Can be arbitrary 2. Less than 1 3. Equal to one 4. Greater than 1	
52.	1	Can data be integrated with non-recursive digital filters? 1. Yes 2. Yes	PC-3
53.	2	How does the integration of a signal change its spectrum in the low frequency (LF) and high frequency (HF) range? 1. The frequency ratio does not change 2. HF increases 3. RF amplitudes increase and LP decreases 4. Lows increase 5. LF amplitudes increase, HF decreases	PC-3
54.	4	How does signal differentiation change its spectrum in the low frequency (LF) and high frequency (HF) range? 1. The frequency ratio does not change 2. HF increases 3. RF amplitudes increase and LP decreases 4. Lows increase 5. LF amplitudes increase, HF decreases	PC-3
55.	1	What type of filters are delta operators? 1. Symmetrical 2. Asymmetrical 3. Causal	PC-3
56.	2	Deregulation consists of: 1. In the transition from true parameters to normalized ones 2. In the transition from normalized parameters to true	PC-3

		3. In the transition from the parameters specified by the design condition to the standardized ones 4. In the transition from ideal filter parameters to true ones	
57.	4	The frequency scaling procedure involves the transformation of: 1. Conversion of LPF – PF 2. Conversion of LPF – HPF 3. Conversion of HPF – LPF 4. Conversion of LPF – LPF	PC-3
58.	1	A system is called dynamic if: 1. The current value of the output signal depends not only on the current, but also on earlier values of external influences (input signals) 2. The current value of the output signal does not depend not only on the current, but also on earlier values of external influences (input signals) 3. The current value of the output signal depends on the current values of external influences (input signals) 4. The current value of the output signal is independent of the values of external influences (input signals)	PC-3
59.	2	A continuous system is called linear if, and only if: 1. Its operators have the properties of additivity, homogeneity, and emergence 2. Its operators have additivity and homogeneity properties 3. Its operators have additivity and emergence properties 4. Its operators have the properties of emergence and homogeneity	PP-5 PP-5
60.	3	Linear operators are: 1. Constant-number multiplication, summation, integration, and logarithm operators 2. Operators of multiplication by a constant number, exponentiation, integration and differentiation 3. Operators of multiplication by a constant number, summation, integration and differentiation 4. Logarithm, exponentiation, summation, integration, and differentiation operators	PP-5

61.	4	A system is called stationary (invariant in time) if its parameters: 1. Change in time according to the exponential law 2. Change in time according to a normal law 3. Change over time 4. Do not change over time	PP-5
62.	2	The function $W(\omega)$, $\omega \in [0, \infty)$, is called the amplitude-frequency response of the system and is: 1. The amplitude of the steady-state output harmonic signal at the input signal frequency equal to ω. 2. The ratio of the steady-state output harmonic signal amplitude to the input harmonic signal amplitude at the input signal frequency ω. 3. The amplitude of the steady-state harmonic input signal at the input signal frequency equal to ω. 4. The ratio of the steady-state harmonic signal amplitude to the output harmonic signal amplitude at the input signal frequency equal to infinity.	PP-5
63.	1	The phase-frequency response of the system shows: 1. How much output signal $y(t)$ at a given frequency ω is shifted in phase relative to the input signal $x(t)$ 2. What is the margin of stability of the system at the frequency ω. 3. How much is the input signal $x(t)$ at a given frequency ω ahead of the output signal $y(t)$ in phase 4. Characterizes the dynamic properties of the system when using the $x(t)$ <i>input signal</i> at the frequency ω	PP-5 PC-3
64.	2	The pulse transient function $w(t)$ is: 1. The response of a system with zero initial conditions to the input action in the form of a single step action $1(t)$. 2. The reaction of a system with zero initial conditions to the input action in the form of a delta function $\delta(t)$.	PC-3

		3. The reaction of a system with zero initial conditions to the input action in the form of $\sin(t)$. 4. The response of a system with zero initial conditions to the input action in the form of $e^{-a \cdot t}$.	
65.	3	The pulse transient function and the transfer function of the system are interconnected: 1. Formulas for spectral decomposition of signals by Laguerre functions 2. Formulas of forward and inverse Fourier transforms 3. Laplace's formulas for direct and inverse Laplace transformations 4. Formulas for spectral decomposition of signals by Walsh functions	PP-5 PC-3
66.		Pulse transient function of a linear stationary system.	PP-5 PC-3
67.		Stability of linear stationary systems.	PC-1 PC-3
68.	4	In order for a linear system to be stable, it is necessary and sufficient that: 1. All real poles were positive, and all complex poles had negative material parts 2. All real poles were negative, and all complex poles had positive real parts 3. All real poles were positive, and all complex poles also had positive real parts 4. All real poles were negative, and all complex poles had negative material parts	PC-3
69.		Explain how the transfer function of a linear stationary system is determined by its differential equation	PP-5
70.		Differential equations of systems of the first and second order are given: $\text{a) } a \frac{y(t)}{dt} + y(t) = b \frac{x(t)}{dt}; \quad \text{б) } \frac{d^2 y(t)}{dt^2} + 2 \frac{dy(t)}{dt} + 25 y(t) = x(t).$ Write down the transfer functions of the systems.	PP-5
71.		The systems described by transfer functions are given:	PP-5

		$\text{a) } W(s) = \frac{Y(s)}{X(s)} = \frac{0,5s}{0,01s+1}; \text{ б) } W(s) = \frac{Y(s)}{X(s)} = \frac{0,05s+1}{0,02s^2+0,1s+1}.$ Write down the differential equations of the systems.	
72.		Formulate V.A. Kotelnikov's theorem	PP-5
73.		What is the purpose of sampling analog signals?	PC-1 PC-2 PC-3
74.		What signal is called discrete?	PP-5
75.		How to restore the original analog signal from a set of its discrete samples?	PC-3
76.		How to determine the upper limit frequency of the signal spectrum?	PC-3
77.		How is the Kotelnikov series written if the function with a limited spectrum $x(t)$ to be sampled is given on a finite time interval t ?	PC-3
78.		What is called a signal base?	PC-3
79.		What is the reason for the error of signal recovery based on the set of its discrete samples?	PP-5
80.		How to reduce the error of signal recovery from a set of its discrete samples?	PP-5
81.		How to determine the relative root mean square error of the recovery of the original continuous signal $X(t)$ from a set of its discrete samples?	PP-5
82.	1	Explain why non-recursive digital filters are always stable: 1. Due to the lack of feedback 2. Due to the presence of positive feedback 3. Due to the presence of negative feedback 4. Due to the presence of cross-links of filter elements	PC-3
83.	4	What kind of impulse response do non-recursive filters have: 1. Harmonic, unquenchable for an infinite period of time	PC-3

		2. Unquenchable in a finite period of time 3. Fading over an infinite period of time 4. Attenuating in a finite period of time	
84.		Typical discrete sequences.	PC-3
85.	2	In which cases <i>the signals $s_1(t)$ and $s_2(t)$</i> will be uncorrelated: 1. Signals with overlapping spectra are uncorrelated 2. Signals with non-overlapping spectra are uncorrelated 3. Signals with partially overlapping spectra are uncorrelated signals with non-overlapping spectra are uncorrelated 4. Signals with the same amplitude spectra and different phase spectra	PC-3

2. Description of the rating scale

Students' progress in each discipline is assessed during current control and intermediate certification.

3. Criteria for assessing competencies

The grade "excellent" is given to the student if the theoretical content of the topic is mastered completely, without gaps; exhaustively, consistently, clearly and logically harmoniously presents the material; freely copes with tasks, questions and other types of application of knowledge; uses additional material in the answer all the tasks provided for by the program are completed, the quality of their performance is evaluated by the number of points close to the maximum; analyzes the results obtained; shows independence in the performance of tasks.

A grade of "good" is given to a student if the theoretical content of the topic is fully mastered, the necessary practical competencies are basically formed, all the educational tasks provided for by the training program are completed, the quality of their performance is quite high. The student knows the material firmly, presents it competently and to the point, without making significant inaccuracies in answering the question.

The grade "satisfactory" is given to a student if the theoretical content of the topic is partially mastered, but the gaps are not significant, most of the tasks provided for by the program are completed, but there are errors in them, when answering the question, the student makes inaccuracies, insufficiently correct wording, there are violations of the logical sequence in the presentation of the program material.

An "unsatisfactory" grade is given to a student if he does not know a significant part of the program material, makes significant mistakes, performs practical work unconfidently, with great difficulty, the necessary practical competencies are not formed, most of the educational tasks are not completed, the quality of their performance is evaluated by the number of points close to the minimum.