APPROVED
at a meeting of the Academic Council of NJSC «KazNU named after al-Farabi»
Protocol № 11 from 23. 05. 2025 y.

The program of the entrance exam for applicants to the PhD for the group of educational programs D096 – «Communications and Communication Technologies»

I. General provisions

1. The program was drawn up in accordance with the Order of the Minister of Education and Science of the Republic of Kazakhstan dated October 31, 2018 No. 600 «On Approval of the Model Rules for Admission to Education in Educational Organizations Implementing Educational Programs of Higher and Postgraduate Education» (hereinafter referred to as the Model Rules).

2. The entrance exam for doctoral studies consists of writing an essay, an exam in the profile of a group of educational programs and an interview.

Блок	Баллы
1. Interview	30
2. Essay	20
3. Exam according to the profile of the group of the educational program	50
Total admission score	100/75

3.The duration of the entrance exam is 3 hours 10 minutes, during which the applicant writes an essay and answers the electronic examination ticket. The interview is conducted at the university premises before the entrance exam.

II. Procedure for the entrance examination

1. Applicants for doctoral studies in the group of educational programs D096 – **«**Communications and Communication Technologies**»** write a problematic / thematic essay. The volume of the essay is at least 250words.

The purpose of the essay is to determine the level of analytical and creative abilities, expressed in the ability to build one’s own argumentation based on theoretical knowledge, social and personal experience.

Types of essays:

- motivational essay revealing the motivation for research activities;
- scientific-analytical essay justifying the relevance and methodology of the planned research;
- problem/thematic essay reflecting various aspects of scientific knowledge in the subject area.

2. The electronic examination card consists of 3 questions

Topics for exam preparation according to the profile of the group of the educational program:

1. **Integrated circuits and MOS transistors**: Transient processes and certain secondary effects in MOS transistors. Programmable read-only memory (PROM). Digital devices based on multiplexers. System-on-Chip (SoC) architectures.
2. **Programming languages for FPGAs**: Verilog, HDL, VHDL.
3. **Design of digital devices**: Design of memory and matrix devices. Parallel and parallel-pipelined computing methods. FPGA-, microcontroller-, and microprocessor-based systems.
4. **Modern approaches to telecommunication system design**: Analysis of contemporary approaches to digital signal routing. Bandwidth requirements for various types of services.
5. **Structural analysis and synthesis of communication networks**: Communication network as a complex system. System-level approach to network analysis and synthesis. Channel allocation in networks. Methods for network structure optimization. Optimization of evolving topologies. Forecasting of core network parameters. Statistical modeling of communication networks.
6. **Digital signal processing**: Pulse code modulation (PCM). Adaptive delta modulation (ADM). Adaptive differential PCM (ADPCM). Noise immunity against quantization noise for linear and nonlinear coding. Sampling noise.
7. **Principles of optical multiservice transport networks**: TCP/IP, ATM, and other technologies. Timing synchronization and distribution in transport networks. Principles of transport network management and protection.
8. **Features of fiber-optic transmission systems (FOTS)**: Wavelength-division multiplexing (WDM) techniques in fiber-optic communication lines. Characteristics of active and passive FOTS/FOL components. Dispersion properties of multimode optical fibers.
9. **Classification of optical waveguides**: Step-index and graded-index waveguides. Material and waveguide dispersion.
10. **Modern single-mode fiber usage**: Prospects for single-mode lines. Application areas of multimode fibers. Nonlinear effects in optical waveguides.
11. **Architecture of modern wireless technologies**: Simplex and duplex wireless communication. Optical and radio-frequency wireless systems. Operating principles and features of Bluetooth, RFID, ZigBee, NFC, LoWPAN, Wi-Fi, LoRa, WiMAX. Data transmission in GSM, CDMA, TDMA. Internet of Things (IoT) technologies.
12. **Broadband signals in communication systems**: Digital communication system models with broadband signals. Spread-spectrum techniques and processing gain. Frequency-hopping spread spectrum (FHSS). Correlation

properties of broadband signals using pseudo-random sequences and orthogonal codes. Synchronization in broadband digital communication systems.

13. **Satellite communication and broadcasting systems**: Radio wave propagation characteristics in satellite telecommunications. Main frequency bands used in satellite communications. Multiple-access methods in satellite systems.
14. **Antenna characteristics**: Near- and far-field zones, radiation patterns, directivity, polarization parameters, antenna classification. Antenna arrays and MIMO antennas, their advantages in directivity.
15. **Semiconductor conductivity**: Classification of solids by their electron energy spectrum; calculation of charge carrier concentration; intrinsic semiconductor conductivity; doping with donor and acceptor impurities; conductivity of doped crystals.
16. **Non-equilibrium processes in semiconductors**: Electron-hole recombination; recombination mechanisms; diffusion and drift currents; behavior of non-equilibrium carrier momentum.
17. **P–N junction in semiconductors**: Potential barrier; charge transport across the junction; current-voltage characteristics of the p–n junction; generation–recombination currents; junction capacitance and diffusion capacitance; transient responses; breakdown phenomena in p–n junctions.
18. **Nanoelectronics**: Applications of quantum-confined structures (QCS). Advantages of QCS-based devices over classical semiconductor devices. Quantum size effects. Electronic structure and optical properties. Correlation of size and functionality. Advanced electronic devices based on nanostructures.

III List of references

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