

ABSTRACT

the topic dissertation work:

«**Investigation of the quality characteristics of generators of spatial electromagnetic noise**» submitted for the degree of Doctor of Philosophy (PhD) in the specialty «6D071900 - Radio engineering, electronics and telecommunications»

BATYRGALIYEV ASKHAT BOLATKANOVICH

Relevance of the topic. In the 21st century, in all areas of human life, widespread informatization and the introduction of digital technology achievements are of key importance. The transition to new technologies occurs within a matter of months and years, and not decades, as it used to be. Anticipating such a situation, the Cyber Security Concept "Cyber Shield of Kazakhstan", the State Program "Digital Kazakhstan", the Roadmap for the Development of the Electronic Industry and other regulatory legal acts aimed at accelerating the pace of economic development of the republic and improving the quality of life of the population through the use of digital technologies were adopted.

At the same time, even today, electronic systems are used in almost all possible aspects of human life, ranging from modern means of communication, online payment for utilities, to complex medical operations on the brain and interplanetary flights. At the same time, the use of electronic devices and computer technology carries a large number of various threats to information security.

One of these threats is the presence of technical channels for information leakage arising from informative (dangerous) spurious electromagnetic radiation from technical means of its processing, storage and transmission. The physics of this phenomenon lies in the fact that when an alternating electric current flows through the conductors, an electromagnetic field is emitted. This field carries the same information that is transmitted through circuits, interface conductors, data buses or circulates in nodes, blocks and components of electronic devices. Thus, all transmitted and processed data, to a greater or lesser extent, can be emitted into the radio. However, there are information, for example, about personal data or national security, which are classified as confidential or secret information, the free distribution of which can cause damage if it is not authorized to be distributed.

The protection of information of limited access from leakage through the channel of spurious electromagnetic radiation is solved by organizational or technical measures using passive or active means of protection. Passive protection methods include shielding, grounding, decoupling and filtering, and active methods include the use of systems of spatial electromagnetic noise and imitating (masking) interference.

The use of passive methods for protecting computer equipment is the most preferable, since when using them, there are no problems associated with electromagnetic compatibility and the presence of unmasking signs of the operation of protective equipment.

However, the use of passive methods for protecting computer equipment is not always possible due to the complexity of their implementation, high cost, the need for additional development work, etc.

In such cases, active protection methods are used that create an increased background of the electromagnetic field, thereby masking the informative signal.

A sufficient number of studies have been devoted to the creation of generators of spatial electromagnetic noise. However, the subject of assessing the quality of masking noise interference still needs to be worked out. Currently, there are no methods for assessing the quality of noise, on the basis of which there are ready-made technical solutions.

Thus, the study of the quality characteristics of spatial electromagnetic noise generators is an urgent task.

The purpose of the research is to study the quality characteristics of spatial electromagnetic noise generators, which can be used to evaluate the effectiveness of noise generators.

Research objectives. To achieve the goal of the work, the following tasks were set:

- to analyze the main characteristics of generators of spatial electromagnetic noise;
- to determine methods for measuring masking noise interference of generators of spatial electromagnetic noise;
- to design and manufacture a measuring installation;
- develop a method for assessing the quality of masking noise interference;
- to carry out mathematical and computer modeling;
- to carry out instrumental measurements of masking noise interference of generators of spatial electromagnetic noise;
- determine the possibility of using statistical randomness tests to evaluate the quality of masking noise interference;
- to design a small-sized automated complex based on the developed measurement and evaluation methods.

The object of research is the generators of spatial electromagnetic noise.

The subject of research is the quality of noise interference generators of spatial electromagnetic noise.

Research methods. To solve the tasks set, it is supposed to use analytical methods, instrumental studies, methods of mathematical and computer modeling.

Scientific novelty.

The proposed mathematical and computer models, the algorithm of the alternative method will improve the current regulatory documents regulating the protection of information through TEMPEST channels, as well as ensure the wide use of available tools for assessing the quality of masking noise interference of noise generators.

Defense provisions.

1. An alternative method for assessing the quality of masking noise interference based on the entropy quality factor has been developed.

2. An algorithm and a program for automating calculations using an alternative method for assessing the quality of masking noise interference have been developed.

3. The use of statistical methods (tests) for randomness to assess the quality of masking noise interference is proposed.

4. Techniques for measuring masking noise interference using spectrum analyzers and digital storage oscilloscopes have been developed.

5. It is proposed to use a small-sized automated complex based on available SDR receivers for calculating the entropy quality factor using the developed alternative method, searching for noise correlation in different frequency subbands, as well as using statistical and (or) graphical methods (tests) for randomness.

A review of active and passive methods and means of protecting information from leakage through TEMPEST channels is made. It is noted that the use of passive methods of protection is the most preferable, since when using them there are no problems associated with electromagnetic compatibility and the presence of unmasking signs of the operation of protective equipment.

However, their use is not always possible due to the complexity of implementation, high cost, the need to perform additional development work, etc. Therefore, active protection methods are used that lead to a decrease in the SNR at the input of the reconnaissance asset's receiving device.

Measuring instruments used in existing methods for assessing the quality of noise are considered, as well as arguments are given on the need to use other measuring equipment at the present time.

Two methods for measuring masking noise interference are proposed:

1) using digital storage oscilloscopes;

2) using spectrum analyzers and digital storage oscilloscopes.

Appropriate techniques for measuring masking noise interference have been developed, requirements for measuring installations and tools have been described.

Experimental noise measurements were carried out, the optimal parameters of measuring instruments were selected.

A new method for assessing the quality of masking noise interference based on the calculation of the entropy quality factor, as well as its mathematical model, has been developed.

Based on the mathematical model, an algorithm and a program for the automation of calculations were compiled.

The use of statistical methods (tests) for randomness to assess the quality of masking noise interference is proposed.

Techniques for measuring masking noise interference using spectrum analyzers and digital storage oscilloscopes have been developed.

It is proposed to use SDR receivers for measurements with further calculation of the entropy quality factor using the developed alternative method, search for noise correlation in different frequency subbands, as well as for the application of statistical and (or) graphical methods (tests) for randomness.

Created laboratory stands, including measuring instruments and measuring equipment.

In accordance with previously developed methods, measurements were made of the characteristics of the masking noise interference of the GS installed at the informatization objects: "LGSH-503", "Gnom-3", "Salyut 2000 B" and "Sonata-R2".

The proposed alternative method for calculating the entropy noise quality factor has been tested on the measurement results. In this case, the calculations were carried out using the developed automation program.

In the course of the work, it was found that the proposed method allows calculating the entropy quality factor of noise generated by the NG of systems of spatial electromagnetic noise, without galvanic connection of measuring instruments to generators and provides sufficient measurement accuracy.

The author's personal contribution consists in formulating and substantiating the topic of the dissertation research, setting tasks, conducting theoretical and experimental research, developing an alternative method for assessing the quality of masking noise interference based on the entropy quality factor and methods for measuring electromagnetic noise parameters, using statistical methods (tests) for randomness and inexpensive SDR receivers.

The relationship of the topic of dissertation research with research work. The results of the dissertation work were used in the research work on the topic "Assessing the quality of spatial electromagnetic noise in active information protection systems" within the framework of grant funding for 2020-2022 (IRN project AP08856630), the scientific supervisor of the project is Ph.D., Dean Faculty of Computer Technologies and Cybersecurity JSC "International University of Information Technologies" Seilova N.A.

Approbation of the research results.

The main provisions and results of the study were reported: at the II International Scientific and Technical Forum "Modern Technologies in Science and Education" (STNO-2019) (Ryazan, Russia, Ryazan State Radio Engineering University, February 27 - March 1, 2019), at the International scientific and practical conference under the motto "Great people of the Great Steppe - Satpaev K.I." on the topic "Innovative technologies - the key to successfully solving fundamental and applied problems in the ore and oil and gas sectors of the economy of the Republic of Kazakhstan" (Almaty, Kazakhstan, Satbayev University, April 11, 2019), at The 17th International Scientific Conference "Information Technologies and Management" (Riga, Latvia, ISMA, April 25-26, 2019), at the International Scientific and Practical Conference on the topic "International experience in countering the challenges, dangers and threats to the security of the state in modern conditions" (Almaty, Kazakhstan, Academy of the BS of the National Security Committee of the Republic of Kazakhstan, August 27, 2019), at the International Scientific and Practical Conference on the topic "Comprehensive modernization of the technical support of the Armed Forces, border and military formations of the Republic of Kazakhstan in the context of the Strategy Kazakhstan - 2050: problems and solutions" (Almaty, Kazakhstan, Academy of the BS NSC RK, August 28, 2019), at the IV International Scientific and Practical Conference "Computer Science and Applied Mathematics", dedicated to the 70th to the summer anniversary

of professors Biyarov T.N., Waldemar Vuytsik and the 60th anniversary of professor Amirgaliev E.N. (Almaty, Institute of Information and Computing Technologies of the Ministry of Education and Science of the Republic of Kazakhstan, September 25-29, 2019), in the III International Scientific and Technical Forum "Modern Technologies in Science and Education" (STNO-2020) (Ryazan, Russia, Ryazan State Radiotechnical University, March 11, 2020), at the 75th International Conference "Radioelectronic Devices and Systems for Infocommunication Technologies" (REDS-2020) (Moscow, Russia, November 2-6, 2020), at the International Scientific and Practical Conference " Satbayev Readings-2021" (Almaty, Kazakhstan, Satbayev University, April 12, 2021).

Also, the results of the dissertation research were implemented in the educational process of the federal state autonomous educational institution of higher education "National Research University" Moscow Institute of Electronic Technology "in the preparation of bachelors studying in the direction 10.03.01 "Information security" and masters studying in the direction 10.04.01 "Information Security". "Method of calculating the entropy quality factor of the noise of systems of active protection of SVT from information leakage through the channel of spurious electromagnetic radiation and interference" was used in the laboratory work "Research of the characteristics of spatial electromagnetic noise systems" in the courses "Protection of information from leakage through technical channels" (bachelor's program) and "Technologies for protecting information from leakage through technical channels" (Master's program), read by Professor Khorev A.A. (Appendix B).

Publications. On the topic of the dissertation, 16 papers were published, of which 3 were published in publications recommended by the Committee for Control in the Sphere of Education and Science of the Ministry of Education and Science of the Republic of Kazakhstan, 2 articles were published in publications included in the Scopus database, 9 reports were published in collections of international scientific and practical conferences, 2 articles published in peer-reviewed publications.

The structure and scope of the dissertation. The dissertation consists of an introduction, four sections, a conclusion, a list of references from 155 titles and 5 appendices.