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METHOD FOR ASSESSING THE QUALITY OF MASKING NOISE INTERFERENCES

Abstract. Currently, the number of various means of computer technology designed for processing, storing, and transmitting information is increasing. One of these threats is the presence of technical channels of information leakage arising from informative (dangerous) spurious electromagnetic radiation from technical means of its processing, storage and transmission. To protect information from leakage through the channels of spurious electromagnetic radiation and interference, systems of spatial electromagnetic noise are widely used.

However, the quality of the masking noise interference of these systems is not always assessed, both during their development, design, and production, and in confirming their compliance with information security requirements. As a rule, they are limited to checking the compliance of the operating frequency range, spectral density, type of radiated interference, etc. The noise quality entropy factor is used as a measure of the quality of the masking noise generated by the noise generator. A sufficient number of studies have been devoted to the creation of generators of spatial electromagnetic noise.

Thus, the study of the quality characteristics of generators of spatial electromagnetic noise is relevant. A technique for estimating the entropy noise quality factor using a spectrum analyzer and a digital storage oscilloscope is proposed. The procedure for calculating the entropy noise quality factor from the statistics of the instantaneous values of the noise signal amplitudes measured by a digital oscilloscope is given.

Key words: masking noise signal; noise generator; spectrum analyzer; entropy coefficient.

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ШУ КЕДЕЛДЕРІН БҮРКЕУДІҢ САПАСЫН БАҒАЛАУ ӘДІСТЕМЕСІ

Аннотация. Қазіргі уақытта ақпаратты өңдеуге, сақтауға және беруге арналған компьютерлік техниканың әртүрлі құралдарының саны артып келеді. Осы қауіптердің бірі оны өңдеудің, сақтаудың және берудің техникалық құралдарынан ақпараттық (қауіпті) жалған электромагниттік сәулеленуден туындайтын ақпараттың ағып кетуінің техникалық арналарының болуы болып табылады. Бұл ақпаратты жалған электромагниттік сәулелену және кедергі арналары арқылы ағып кетуден қорғау үшін кеңістіктік электромагниттік шу жүйелері (шу генераторлары) кеңінен қолданылады.

Алайда, бұл жүйелердің шу кедергілерін бүркемелеу сапасы оларды әзірлеу, жобалау және өндіру барысында да, олардың ақпараттық қауіпсіздік талаптарына, күнделікті жұмысына сәйкестігін растау кезінде де бағалана бермейді. Әдетте, олар жұмыс жиілігі диапазонының, спектрлік тығыздықтың, сәулелену кедергілерінің түрін, жұмыс режимдері мен шарттарын, сондай-ақ санитарлық нормаларды сақтау қажеттілігін және т.б. сәйкестігін тексерумен шектеледі. Шу сапасының энтропия коэффициенті шу генераторы тудыратын маска шуының сапасының өлшемі ретінде пайдаланылады. Кеңістіктік электромагниттік шудың генераторларын құруға зерттеулердің жеткілікті саны арналды. Бірақ казіргі уақытта шудың сапасын бағалау әдістері жоқ, олардың негізінде дайын техникалық шешімдер бар.

Осылайша, кеңістіктік электромагниттік шу генераторларының сапалық сипаттамаларын зерттеу өзекті болып табылады. Жұмыста спектр анализаторы мен сандық сақтау осциллографы арқылы шудың энтропиялық сапа факторын бағалау әдістемесі ұсынылған. Сандық осциллографпен өлшенетін шу сигналының амплитудаларының жылдам мәндерінің статистикасынан шу сапасының энтропиялық коэффициентін есептеу тәртібі келтірілген.

Түйін сөздер: бүркемелейтін шуыл сигналы; шуыл генераторы; спектр талдағышы; энтропия коэффициенті.

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МЕТОДИКА ОЦЕНКИ КАЧЕСТВА МАСКИРУЮЩИХ ШУМОВЫХ ПОМЕХ

Аннотация. В настоящее время увеличивается количество различных средств вычислительной техники, предназначенной для обработки, хранения и передачи информации.

Одной из таких угроз является наличие технических каналов утечки информации, возникающей вследствие информативных (опасных) побочных электромагнитных излучений технических средств ее обработки, хранения и передачи. Для защиты информации от утечек по каналам побочных электромагнитных излучений и наводок широко применяются системы пространственного электромагнитного зашумления. Однако не всегда осуществляется оценка качества маскирующих шумовых помех этих систем как в ходе их разработки, проектирования и производства, так и входе подтверждения их соответствия требованиям информационной безопасности. Как правило, ограничиваются проверкой соответствия диапазона рабочих частот, спектральной плотности, виду излучаемой помехи и др. В качестве показателя качества маскирующего шума, создаваемого генератором шума, используется энтропийный коэффициент качества шума.

Вопросам создания генераторов пространственного электромагнитного зашумления посвящено достаточное количество исследований. Но в настоящее время отсутствуют методы оценки качества шума, на основе которых имеются готовые технические решения. Таким образом, исследование характеристик качества генераторов пространственного электромагнитного зашумления является актуальным. В работе предложена методика оценки энтропийного коэффициента качества шума с использованием анализатора спектра и цифрового запоминающего осциллографа. Приведен порядок расчета энтропийный коэффициент качества шума по статистике мгновенных значений амплитуд шумового сигнала, измеренных цифровым осциллографом.

Ключевые слова: маскирующий шумовой сигнал; генератор шума; анализатор спектра; энтропийный коэффициент.

Introduction. Currently, electronics are used in almost all spheres of human life, ranging from simple means of communication to ensuring the security of the state as a whole. However, the use of electronic devices and computer technology carries a large number of information security threats. The basis for solving this problem is the protection of information in the field of optics, electronics, radio engineering, acoustics and other sciences.

The main and at the same time one of the most dangerous technical channels of information leakage at informatization objects is the channel of side electromagnetic emissions (SEME). Such an information leakage channel is called electromagnetic (Khorev A.A. 2012:20, Vasiliev I.V. et.al, 2010:6, A.P. Zaitsev et al., 2017:442, Buzov G.A. 2017:586, ST RK GOST R 51275-2006, ST RK 1700-2007). Protection of electronic means of information processing and transmission (EM) from leakage through SERP channels is achieved by using passive and active protection methods. 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 (Zaitsev et al. 2017:442, ND TZI 3.3-001-07, ST RK 1698-2007).

The use of passive methods of protecting EM is the most preferable, since using them there are no problems associated with electromagnetic compatibility and the presence of unmasking signs of the operation of protective means. However, the use of passive methods for protecting EM 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, which lead to a decrease in the signal-to-noise ratio at the input of the receiving device of the reconnaissance means and, consequently, to a decrease in the controlled zone for the EM (Khorev A.A. 2012:20).

Currently, there are energy and non-energy methods of active protection. The non-energy (statistical) method of active masking consists in the emission of a special masking signal (interference) with a spectrum similar to the spectrum of informative SEME EM. The spectral density of masking interference should be higher than the spectral density of SEME, and its level should not exceed the levels of SEME (Zaitsev et al., 2017:442, ST RK 1698-2007). The difficulty in implementing a non-energy protection method lies in the need to use pulses of random amplitude, similar in shape and time-correlated radiation with informative SEME pulses. In this case, it is required to accurately determine all informative SEME for each EM sample and create an individual for this sample (or identical EM) masking noise simulator. As a rule, simulators or jammers are used to protect personal computers.

The essence of the energy method lies in the formation and emission into the surrounding space in the immediate vicinity of the operating EM of a masking broadband noise signal ("white noise") in the entire frequency range of informative SEME with a spectral level exceeding the levels of these SEME. Electromagnetic noise (electromagnetic interference, radio noise, radio interference, active masking interference) is understood as a time-varying electromagnetic phenomenon that does not contain information and can be superimposed on or combined with a useful signal. In the context of this work, they are intended to degrade or distort the normal operation of enemy electronic equipment. Active masking interference creates a background at the input of the enemy receiver, which makes it difficult to detect informative SEME, their recognition and determination of parameters (ISO/IEC 19762-4-2011 2012:27, GOST R 55055-2012 2014:11). Therefore the use of generators of spatial electromagnetic noise (NG) should prevent or lead to the impossibility of intercepting informative SEME for their subsequent analysis and restoration of the original information or a significant complication of this process.

In the present work, the solution of the following problems is provided:

- determination of the main characteristics of the NG;
- conducting a review of existing methods for assessing the quality of masking noise interference and identifying their disadvantages;
- development of its own method for assessing the quality of masking noise interference;
- description of methods for measuring masking noise interference;
- determination of the quality of masking noise interference of some NG;
- search for the correlation of noise signals and the use of statistical methods (tests) for randomness as alternative methods for estimating the quality of masking noise interference.

Research Material and methods. Currently, there is a large number of NG with different technical characteristics and types of execution on the market (Zaitsev et al. 2017:442, Buzov G.A. 2017:586). Noise generators are available as a separate device or as a PCI board for a personal computer. NGs usually consist of a wideband signal generator and one or more antennas.

One of the most important requirements for the NG is the broadbandness of the noise signal spectrum and high uniformity of the noise power spectral density. For this reason, three schemes for generating a broadband noise signal are mainly used in noise generators (Khorev A.A. 2012:20):

1) classical method of forming direct noise interference. In this case, it is possible to use several noise sources operating in different frequency ranges. Noise resistors, diodes, transistors, zener diodes and other elements that form noise close in its characteristics to "white noise" can be used as primary sources of noise in such NGs.;

2) the use of a digital noise generator, the "digital" noise of which is a temporary random process, close in its properties to the process of physical noise and called the "pseudo-random process". Such generators form chaotic (pseudo-random) sequences of binary symbols and convert them into sequences of rectangular pulses of pseudo-random duration with pseudo-random intervals between them. Noise sources in such NGs can be microstrip elements, various integrated circuits, digital signal processors, programmable logic integrated circuits, and other elements (Zhanabayev Z.Zh. et al., 2010-7, Kogai G.D. et al., 2014-3, Gubanov D. et al., 1999:5, Dmitriev A.S. et al., 2009:16);

3) the use of a stochastic or chaotic method for generating a noise signal (Zhanabayev Z.Zh. et al., 2010-7, Ekhande1 R. et al., 2014:4). The signal from the harmonic signal generator is fed to a power amplifier operating in a nonlinear

mode and loaded onto a non-autonomous nonlinear dynamic system in the form of a parallel nonlinear oscillatory circuit, in which the amplified signal is converted into noise stochastic interference.

However, noisy informative SEME can be filtered, and in case of poor quality masking, the enemy can gain access to the protected information (Gavrilov, I.V. et al., 2015:11).

In NG, to generate a broadband noise signal, there can be used a scheme for dividing the entire frequency range into subbands using a frequency multiplier (Khorev A.A. 2012:20). In such cases, the generated noise in different subbands will be correlated, i.e. have the same parameters except for the frequency.

This will make it possible to subtract noise in different ranges, in which informative SERP have a large amplitude (power) and further restore the protected information. It should be noted that the presence of additional factors in the form of the repetition of an informative signal, the level of its amplitude (power), etc. is also important (Batyrgaliyev A.B. 2019:3).

In addition, in the absence of complete randomness of the generated noise, there are used statistical methods of analysis, through which it is possible to identify the patterns of noise formation, including their periodicity. In this regard, an important problem arises related to assessing the quality of the noise signal generated by the NG.

In order to determine the estimated characteristics of the masking noise, information (non-energy or statistical) and energy methods are used. Information methods consider the statistical parameters of noise signals in the time domain and allow to directly determine the numerical noise quality factor. Based on the calculation of the mathematical expectation, dispersion and entropy of the instantaneous values of time readings and their envelope, the degree of approximation to some reference distributions is calculated. They are aimed at finding the degree of uncertainty of the instantaneous values of noise signals, expressed, for example, in terms of the entropy quality factor of the masking noise. When using this method of active masking, the NG emits a special masking signal (interference) with a spectrum similar to that of informative SERP. In this case, the spectral density of masking interference should be higher than the spectral density of SERP, and its level should not exceed the levels of SEME.

The energy method for information protection uses the postulate about the need to exceed the energy of noise over SEME in the entire frequency range. Therefore, in order to check the noise quality, integral indicators are used that take into account the excess of the noise level over the level of the informative signal (ST RK 1698-2007 Protection of information, Gavrilov, I.V. et al., 2015:11).

Result and discussion. One of the effective ways to protect computer equipment (CE) from information leakage through the channel of side electromagnetic emissions (SEME) is spatial electromagnetic noise (Khorev A.A. 2012:20).

For clarity, the application of the method for assessing the quality of the masking noises of the NG on Fig. 1 shows the histograms of the noise signal amplitudes distribution. For the upper histogram, the entropy quality factor is 0.9, and for the lower one it is 0.7. The x-axis corresponds to the number of intervals, and the y-axis corresponds to the number of sample elements in the interval. The low entropy quality factor of the masking noise interference of the NG will not be able to ensure the security of the protected information.

A low entropy quality factor can, for example, be observed when the quality of the noise source is insufficient (noise diode, transistor, resistor, etc.) or in other cases. Such cases include the ability to control the level of the output signal of the NG, as well as the power supply of the NG with some boundary levels. For example, some manufacturers allow NG power supply within 220 V ± 10% at a power supply frequency of 50 Hz. This means that the power supply of the GS is possible within the range of 187-253 V. In some NGs, when they were powered at the boundary values, a significant deterioration in the entropy quality factor was observed. This circumstance directly increases the threat of leakage of information protected by the NG.

Entropy noise quality factor is used as an indicator of the quality of the masking noise $К_{ш}$ created by the NG, which characterizes the approximation of the noise power distribution law to the ideal "white" noise with a normal power distribution law.

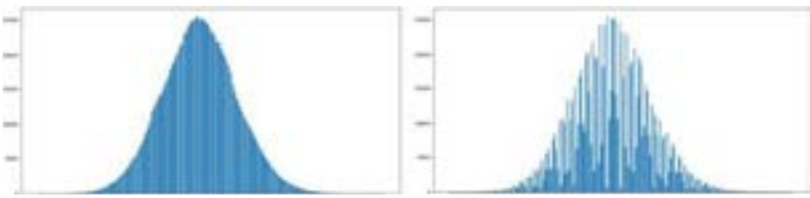

Figure 1. Histograms of noise signal amplitudes distribution: a) − $К_{ш}$ = 0,9; b) − $К_{ш}$ = 0,7

A technique for estimating ENQF using a spectrum analyzer and a digital storage oscilloscope is proposed.

The measuring installation for measuring and calculating the ENQF is shown in Figure 2.

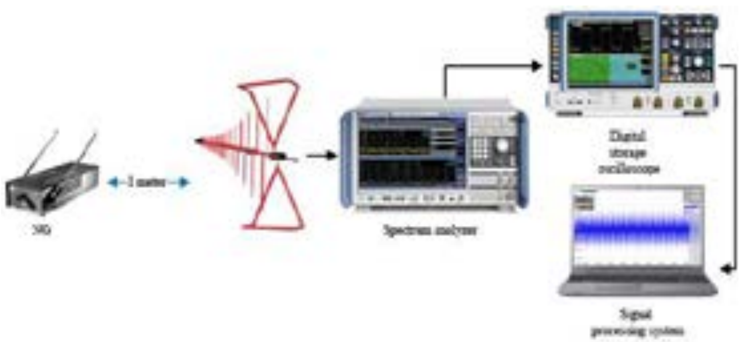

Figure 2. Measuring installation for measuring and calculating the ENQF

The measuring antenna is installed at a distance of 1 m from the noise generator antenna and connected to the antenna input of the spectrum analyzer. The maximum bandwidth (ΔF) of the spectrum analyzer is set. From the output of the intermediate frequency of the spectrum analyzer, the signal is fed to the input of a digital storage oscilloscope. The instantaneous values of the amplitude of the noise signal from the oscilloscope are transferred to the PC for processing.

The essence of the proposed methodology for assessing ENQF is following:

1) By analyzing the spectrum of the noise signal generated by the NG, the frequency intervals of the spectrum are selected, in which the greatest unevenness of the frequency response of the noise is observed. If the noise generator uses several channels for generating noise interference, then at least one such interval must be selected in each of them.

2) The spectrum analyzer is tuned sequentially to the center frequency of each of the frequency intervals. The electromagnetic noise signals received by the spectrum analyzer are converted into electrical signals and transmitted via an intermediate frequency to an oscilloscope that acts as an analog-to-digital converter.

3) Instantaneous values of the amplitude of the noise signal in *.csv format from the oscilloscope are sent to the signal processing system (personal computer with the calculation program) for further processing and calculation of the ENQF.

Below is the procedure for calculating the ENQF according to the statistics of the instantaneous values of the amplitudes of the noise signal generated by the NG:

1. The statistics of instantaneous values of noise signal amplitudes (n) with a volume of at least 106 elements is collected.

2. According to collected statistics X = {x1, x2, … xn} a statistical series $\{x_{(1)} \leq x_{(2)} \leq \cdots \leq x_{(k)} \leq \cdots \leq x_{(n)}\}$ is being constructed and calculated: average value ($\overline{X}$), dispersion (σ^2) and standard deviation (σ) according to the formulas:

$$\overline{X} = \frac{1}{n}\sum_{i=1}^{n} x_i. \qquad (1)$$

$$\sigma^2 = \frac{1}{n-1}\sum_{i=1}^{n}(x_i - \overline{X})^2. \qquad (2)$$

$$\sigma = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(x_i - \overline{X})^2}. \qquad (3)$$

3. The values of the statistical series x(k) are grouped by selected non-overlapping intervals (x(j-1); xj), j =1, 2, …, m, where m is the number of obtained intervals, and xj are the upper boundaries of the intervals. When choosing the interval width, it is recommended to use the rule:

$$\Delta \leq \frac{(x_{(n)} - x_{(1)})}{2^r}, \qquad (4)$$

where Δ – maximum spacing width;

x(1) и x(n) –minimum and maximum elements of the statistical series, respectively;

r – bit depth of the used analog-to-digital converter of the measuring instrument.

The interval width Δ_j is equal to:

$$\Delta_j = x_j - x_j - 1, \quad (5)$$

where j =1, 2, …, m.

It is recommended that all intervals be chosen equal in width.

4. After choosing the intervals Δ_j for the sample X={x1, x2,…, x_n}, the number n_j^* of the sample values $x_{(i)}$ that fall into the corresponding intervals is calculated. Based on the obtained values of n_j^*, the corresponding relative frequencies p_j^* and relative densities of sample values in each interval σ_j^* are calculated:

$$p_j^* = \frac{n_j^*}{n}. \quad (6)$$

$$\sigma_j^* = \frac{p_j^*}{h_j}. \quad (7)$$

The sum of the relative frequencies (p_j^*) must be equal to one, i.e:

$$\sum_{j=1}^{m} p_j^* = 1. \quad (8)$$

5. For cases when in any of the intervals n_j^* turns out to be equal to 0, you should combine this interval with the interval (j-1) or (j+1), recalculating the relative frequencies and relative densities in the newly formed intervals, or change Δ so, so that with a new partition, each of the intervals includes at least one sample value (x_j).

6. Based on the obtained data, Table 1 is compiled, which indicates the number of the interval (digit) j, the boundaries of the discharge x_{j-1} − xj, the number of discharge n_j^*, the relative frequencies p_j^* and the relative densities σ_j^* of sample values.

Based on this table, a histogram of the distribution of instantaneous voltage values of the noise signal is constructed.

7. For each digit of the histogram, the entropy (H_j) is calculated according to the formula:

$$H_j = p_j^* \cdot \ln \sigma_j^* \quad (9)$$

Table 1 - Initial data for calculating ENQF

The number of the interval (discharge) j	1	2	…	m
Discharge [x_{j-1};x_j] boundaries	[x_0;x_1]	[x_1;x_2]	…	[x_{m-1};x_m]
Value n_j^*	n_1^*	n_2^*	…	n_m^*
Relative frequencies p_j^*	p_1^*	p_2^*	…	p_m^*
Relative densities σ_j^*	σ_1^*	σ_2^*	…	σ_m^*

The number of the interval (discharge) j	1	2	…	m
Entropy of the discharge H_j	H_1	H_2	…	H_m
Entropy of the noise signal H				

8. Next, the entropy of the noise signal (H) is calculated by the formula (10), the entropy power of the noise signal ($P_э$) by the formula (11) and the entropy quality factor of the instantaneous values of masking noise voltages (K) by the formula (12):

$$H = -\sum_{j=1}^{m} H_j. \qquad (10)$$

$$P_э = \frac{e^{2H}}{2\pi e}. \qquad (11)$$

$$K_ш = \frac{P_э}{\sigma^2}. \quad (12)$$

The calculated value of $K_{шп}$ is compared with the normalized value of Кшп set for the given type of noise generator.

The proposed method has been tested in measuring the ENQF of noise generators installed at informatization facilities.

The tests were carried out using a laboratory complex consisting of an AI-5.0 active measuring antenna, an R&S FSW8 digital spectrum analyzer, an R&S RTO 1022 digital storage oscilloscope, and a laptop-based signal processing complex.

As an example, Figures 3 and 4 show the masking noise spectra generated by the noise generators LNG- 503, Gnome-3, Salyut 2000 B and Sonata-R2, and Table 1 shows the measured values of the entropy noise quality factor of these generators obtained during the research.

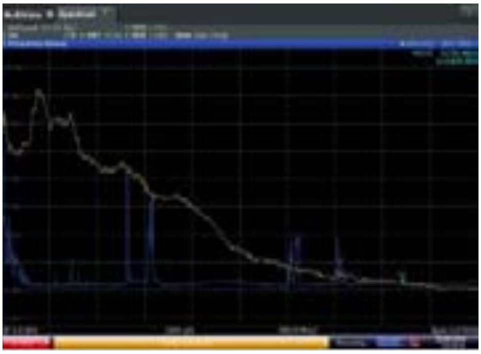

Figure 3.1

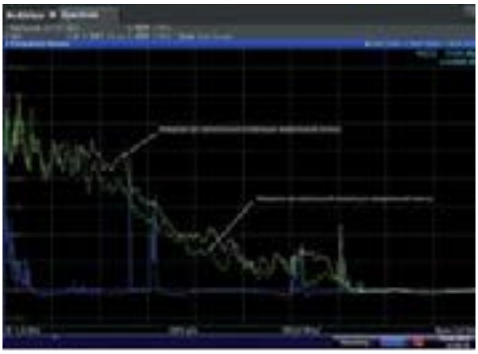

Figure 3.2

Figure 3. Spectra of masking noises generated by noise generators "LNG-503" (3.1) and "Gnom-3" (3.2)

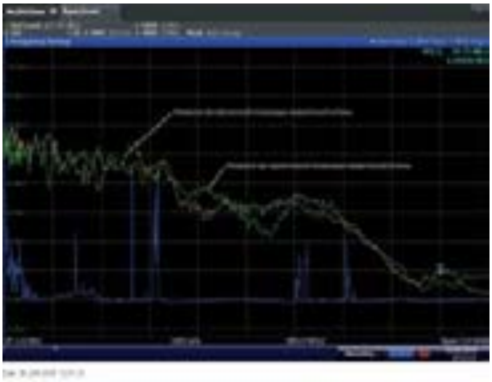

Figure 4.1

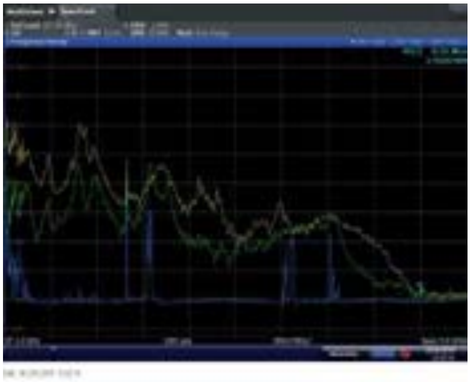

Figure 4.2

Figure 4. Spectra of masking noises generated by noise generators "Salyut 2000 B" (4.1) and "Sonata-R2" (4.2)

As can be seen from Table 2, the measured values of the entropy noise quality factors generated by noise generators basically correspond to their passport values.

Table 2 - Measured values entropy noise quality factor of noise generators

Noise generator type	Spectrum analyzer tuning frequency, MHz	Spectrum analyzer bandwidth, MHz	Radiation power	Measured value ENQF
"LNG-503"	500	80	Maximum	0,90
"Gnome-3M"	500	80	Maximum	0,97
"Salyut-2000B"	500	80	Maximum	0,96
"Sonata – R2"	500	80	Maximum	0,88
			Maximum	0,98

Thus, the proposed technique makes it possible to measure the entropy noise quality factors generated by noise generators of spatial electromagnetic noise systems without galvanic connection of measuring instruments to generators and provides sufficient measurement accuracy.

Carrying out manual calculations using the proposed alternative method for estimating the quality of masking noise interference is a very laborious and lengthy process. This is due to the need to process a large number of values (at least 1 million elements).

In this regard, there has been developed a software to implement the automatic calculation of measurement results. The program consists of several functions and the calculation itself.

Figure 5 shows an example of the calculation program result.

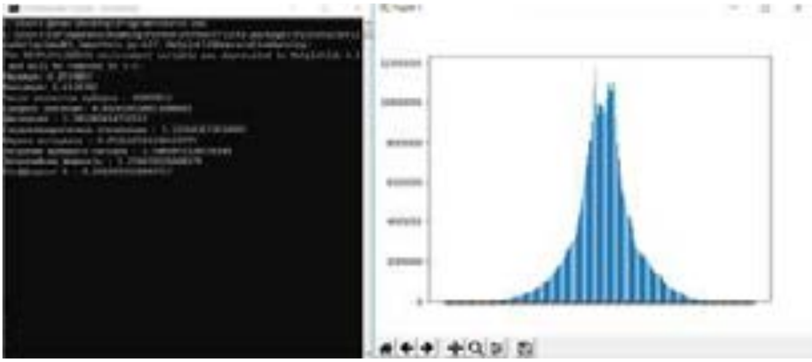

Figure 5. An example of the calculation program result

Conclusions. Spectrum analyzers (or other measuring receivers), digital storage oscilloscopes, or mixed signal oscilloscopes are considered appropriate to make the necessary measurements.

In this case, you should pay attention to the parameters of the selected measuring instruments: operating frequency range and bandwidth.

If you select an oscilloscope with the required bandwidth of 2-3 GHz (operating frequency range of the NG), then for measurements on the air this will be a practically impossible task. This is because even the best performing premium spectrum analyzers have less bandwidth. For example, the Keysight UXA (N9040B) spectrum analyzers have a maximum bandwidth of 1 GHz (real-time 510 MHz) and the R&S®FSW - 800 MHz (expandable to 5 GHz with an RTO2064 oscilloscope) [19, 20]. However, the cost of such devices is very high.

In this regard, to carry out measurements on the air using a spectrum analyzer, the operating frequency range of the NG will need to be divided into equal subbands that fit into the bandwidth of the spectrum analyzer.

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REFERENCES:

Batyrgaliyev A.B. Approaches to noise quality estimation of spatial electromagnetic noise generators // Contemporary technologies in science and education - STNO-2019 [text]: collection of works of the II international scientific and technical forum: in 10 volumes, Volume 5/ edited by O.V. Mylovzorova. - Ryazan: Ryazan State Radio Technical University, 2019; Ryazan – pp. 86: ill. - pp. 17-19.

Buzov G.A. Protecting restricted access information from leakage through technical channels. - M .: Hotline - Telecom, 2017. – pp. 586, ill.

Dmitriev A.S., Efremova E.V., Nikyshov A.Yu., Panas A.I. Chaos generators: from vacuum devices to nanocircuits // Radioelectronics, nanosystems, information technologies. - 2009. Vol. 1. - No. 1-2. - pp. 6-22.

Ekhande1 R., Deshmukh S, “Chaotic Signal for Signal Masking in Digital Communications”, IOSR Journal of Engineering Vol. 04, Issue 02 (February, 2014), V5, pp 29-33.

Gavrilov, I.V. Methods of estimating the quality of masking noise // Proceedings of the St. Petersburg Institute of Informatics and Automation of the Russian Academy of Sciences. - 2015. Issue 6 (43). - pp.179-190.

GOST R 55055-2012 Industrial radio interference. Terms and definitions. - M.: Standartinform, 2014. – pp.11.

Gubanov D., Dmitriev A., Panas A., Starkov S., Steshenko V. Chaos generators in integral execution // Chipnews. News about microcircuits. - 1999. - No. 8. - pp. 9-14.

ISO/IEC 19762-4-2011 Information technologies. Technologies of automatic identification and data collection (AIDC). Harmonized dictionary Part 4. General terms in the field of radio communication. - M.: Standartinform, 2012. – pp. 27.

Khorev A.A. Ways to protect informatization objects from information leakage through technical channels: spatial electromagnetic noise// Special Technique. - M.: 2012. - No. 6 - pp. 37-57.

Kogai G.D., Ten T.L. Methods and models of chaotic processes in communication systems // Modern science-intensive technologies. - 2014. - No. 10. - pp. 61-64.

N9040B UXA signal analyzer [Electronic resource]. – https://www.keysight.com/ru/pdx-x202152-pn-N9040B/uxa-signal-analyzer-multi-touch-3-hz-to-50-ghz?pm=spc&nid=-32508.1150334&cc=RU&lc=rus.

ND TZI 3.3-001-07 Protection of information at the objects of information activity. Creation of a complex of technical protection of information. Procedure for development and implementation of information protection measures.

R&S®FSW spectrum and signal analyzer [Electronic resource]. – *https://www.rohde-schwarz.com/ru/product/fsw-productstartpage_63493-11793.html*.

ST RK GOST R 51275-2006 Information security. Informatization object. Factors affecting information. General provisions.

ST RK 1700-2007 Technical protection of information in office premises. General technical requirements.

ST RK 1698-2007 Information security. Protection of information from technical intelligence and from its leakage through technical channels at the facility of computer facilities. Protection methods.

ST RK 1698-2007 Protection of information. Protection of information from technical intelligence and its leakage through technical channels at the facility of computing equipment. Protection methods.

Technical means and methods of information protection. Textbook for universities / A.P. Zaitsev, A.A. Shelupanov, R.V. Meshcheryakov. Ed. by A.P. Zaitsev and A.A. Shelupanov. - 7th ed., Rev. - M.: Hotline - Telecom, 2017. – pp. 442: ill

Vasiliev I.V., Kozin, I.D., Fedulina, I.N. Data protection. Tutorial. - Almaty: AUPET, 2010. – pp. 76.

Zhanabayev Z.Zh., Almasbekov N.E., Imanbayeva A.K., Manapbayeva A.B., Akhtanov S.N. Information protection by dynamic chaos with phase control. // Materials of the 7th international scientific conference. "Chaos and structure in nonlinear systems", June 15-17, 2010. Karaganda. - pp. 13-20.

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