Method of Detecting Radio Signals using Means of Covert by Obtaining Information on the basis of Random Signals Model

Oleksandr Laptiev[1], Vitalii Savchenko[1], Andrii Pravdyvyi[1], Ivan Ablazov[2], Rostyslav Lisnevsky[3], Oleksandr Koloss[4], Viktor Hudyma[5]

[1] Cybersecurity Institute, State University of Telecommunications, Kyiv, Ukraine.
[2] Military Diplomatic Academy Named after Yevheniy Bereznyak, Kyiv, Ukraine.
[3] Taras Shevchenko National University of Kyiv, Kyiv, Ukraine
[4] The Hetman Petro Sahaidachnyi National Army Academy, Lviv, Ukraine.
[5] National Defence University of Ukraine named after Ivan Cherniakhovskyi, Kyiv, Ukraine.

Abstract: The article presents a developed method for determining random radio signals. Random signals can be signals from hidden means of obtaining information.

The signal is considered as a random process. The description of such signals is based on probability theory and the theory of random functions. In the practice of analysis of random radio signals, static methods based on the theory of stationary random functions have become widespread. The existing models of a stationary random process are not adequate for a large number of random processes, especially for processes that are dynamic in nature and are observed during a finite time interval.

The developed method allows to detect signals from hidden means of obtaining information with greater efficiency. The novelty of the method is to determine the deviation of the main parameters of the signals from the function of the sample. The method is based on determining the function of a sample of signals of a given radio range. The function of the sample is obtained as the implementation of the smoothing function of a random process, by the method of least squares using the principle of sliding smoothing.

It is proposed to determine the signals of the means of covert receipt of information by the instantaneous deviation of the parameters of random signals. To determine the signals of the means of covert obtaining information, it is proposed to determine the deviation of the amplitude of the random signals from the amplitude of the signals of the sample function, then, if necessary, to determine the deviation of the signal phases. So, the effectiveness of the method is achieved by determining two parameters of the deviation of the amplitude and phase. This makes it possible to detect random signals with a higher probability.

Determining the function of the sample of the required radio band significantly increases the probability of determining random signals, by reducing the scanning time of a given radio band, by excluding known signals from the additional software analysis of a given radio band.

Keywords: sample function, smoothing polynomial, random signal, scanning, radio range, means of secretly obtaining information, hidden means of obtaining information..

1. Introduction

The value of information in the life of any civilized society is constantly growing. Information technologies are constantly improving in the direction of their automation and ways to protect information. The development of new information technologies is accompanied by such negative phenomena as industrial intelligence, computer crimes and unauthorized access to classified, official and confidential information. Therefore, information security is the most important state task in any country.

One method of obtaining unauthorized access to information is technical intelligence. It is estimated that the share of technical intelligence accounts for more than 50% of all extracted information. Therefore, the problem of protection against technical intelligence becomes especially relevant.

Protection against technical means of information protection is an integral part of scientific and production activities of enterprises, institutions and organizations of all forms of ownership. The development of technical intelligence is associated with increasing its technical capabilities, which provide:

- reducing the risk of physical detention of the agent by the relevant authorities, because remote contact is used, the agent with the technical means of obtaining information;
- obtaining information by removing it from media that do not affect the human senses;

To obtain information people use the means of covert receipt of information. The range of such devices today is extremely large. The rapid development of means of communication and technology has led only to positive and negative results. Modern means of covert information, have good quality camouflage and special specifications. The means of covertly obtaining information are constantly being improved, based on which the issues of identifying such means are very difficult and need constant improvement. For this purpose, it is necessary to constantly improve the software and mathematical apparatus for describing and modeling random radio signals, which may be signals of covert means of obtaining information.

A mathematical model of random signals is a description of a signal in the formal language of mathematics, that is, using formulas, inequalities, or logical relations. Different mathematical models can be used to describe the same signals. The choice of model is determined by the adequacy of the model to the real signal, the simplicity of the mathematical description, the purpose of the model, etc.

A feature of the models of measuring information signals is always the a priori uncertainty of the values of informative parameters, due in the general case to the unknown dimensions of the measured values.

There are different approaches to building mathematical models of signals.

1. The signal is received quasi-deterministic. In this case, various deterministic time functions are used to mathematically describe the signal. Models of such signals are called quasi-deterministic (or deterministic), thus emphasizing that the type of function that describes the signal is known, and unknown (informative) are its parameters.
2. The signal is considered as a random process. The description of such signals is based on probability theory and the theory of random functions. In this case, the change in the signal in time and space is characterized by the law of distribution, mathematical expectation, variance and correlation function. Models of such signals are called random.
3. The signals are represented as a combination of random and deterministic components, in particular in the form of the sum of the signal of the measuring information (quasi-deterministic component) and interference (random component).

In the practice of analysis of random radio signals, static methods based on the theory of stationary random functions have become widespread.

For the analysis of radio signals, especially random radio signals, which may be signals of covert means of obtaining information, the second option is most often used.

However, the available models of the stationary random process are not adequate for a large number of random processes, especially for processes that are dynamic in nature and are observed during a finite time interval. There is a gap between the existing methodological apparatus for the analysis of random radio signals and the need to develop a new mathematical apparatus, which will eliminate the existing shortcomings.

In this regard, there is a need to develop a new scientific and methodological apparatus for detection and analysis of random radio signals. That is, the development of scientific and methodological apparatus for detection and analysis of random radio signals is an relevant scientific task.

2. Literature Analysis And Problem Statement

A significant number of publications are devoted to the development of scientific and methodological apparatus for detection and analysis of random radio signals, so in [1] the analysis of radio monitoring systems with different technical parameters, which combines one thing - their software or hardware can only show and at best save panoramas signal spectra. They do not solve the problem of software signal analysis at all.

[2,3,21] considers the hardware and software complex of radio monitoring "Delta", which continues the line of the most advanced and technological solutions in the field of radio monitoring. The complex provides ample opportunities for detection and identification of signal sources, based on the hardware-software method. Its disadvantage may be the use of the Fourier transform method for signal detection, which cannot perform the conversion of digital signals in full.

In [4,12,17] the substantiation of the mathematical model of the additive mix of useful and interfering signals for the analog wire signaling channel of the security system of military facilities is presented. The useful signal is given as a deterministic function with an unknown information parameter. The interference signal is represented as the current implementation of a random process, given at a limited interval of observation in the form of a finite Fourier series. The information parameter of the useful signal, which determines the state of the security system, is found as a solution of a system of linear algebraic equations. But the mathematical model of a random signal for detection and analysis is not considered.

The work [5,13,15] is devoted to the development of mathematical modeling of cyclic signals with double stochasticity, namely, the construction of their mathematical model in the form of a conditional cyclic random process of a discrete argument. This model makes it possible to consistently take into account the stochasticity of cyclic signals both in their morphological statistical analysis and in the statistical analysis of their rhythm. Simulations of random signals to obtain signal characteristics are not considered.

In [6,14,18] the problem of detection and distinction of random signals of short-range radio detection devices used in security systems is considered. The main essential parameters of short-range radio detection devices are determined. It is shown that the signal receiver of the detection device is optimal when exposed to a random signal. Practically significant formulas for determining the probabilities of correct and erroneous detection for random signals reflected from the detected object are given. However, the option to increase the reliability of the detection of radio signals is not considered.

In [7,19,20] the probabilistic characteristics of coherent detection of reflected signals with completely known parameters when using stochastic probing radio signals are determined. An analytical relation is obtained for the probability density of the decisive statistics in the presence of only the reflected signal at the input of the detector, only interference and in the presence of both signal and interference. The dependences of the probability of false alarm on the threshold ratio and the probability of correct detection of the signal-to-noise ratio at different values of the stochastic signal base are calculated, the family of detection characteristics for a fixed base and different values of false alarm probability are calculated. However, detection based on direct parameters of radio signals is not considered.

In [8,16,23] a comparative analysis of parametric models of periodically nonstationary random processes is performed. Expressions for the components of the correlation functions of the periodically autoregressive model of the moving average and the parametric model based on the harmonic representation are derived. It is proved that the periodic autoregressive model of the moving average is a subclass of the vector autoregressive model built on the basis of coherent representation. Mathematical models of random signals for the purpose of detection and analysis of signals of means of covert receipt of information have not become complete.

The work [9,24] is aimed at establishing the limits of application of signal description models in optoelectronic systems in efficiency calculations. The description of process of formation of signals taking into account corpuscular and wave properties at registration of signals in a wide range of intensities is offered. The description of statistical features of output signals depending on energy properties of signal and noise components is offered. Questions of mathematical modeling of random radio signals for the purpose of features of their modeling are not considered.

In [10,22] the problem of substantiation of methods of modeling of various processes, in particular white noise is considered. The simplest models of noise with discrete time are described, and also features and properties of such models. The results of white noise modeling with discrete time are presented. In-depth analysis of random signals and methods of their modeling are not considered.

In [11,20,25] the problem of substantiation of methods of modeling of various processes, in particular the band process is considered. Simple models of noise with discrete time, features and properties of such models are described and graphs of estimation of correlation function and spectral power density of band process are constructed. The process of detecting random signals using the developed models is not paid attention.

From the analysis of modern literature it is possible to draw a conclusion, hardware and software complexes or software complexes using for methods of detection and analysis of random signals scientific methods based on models of random signals. In which the description of random signals is based on the theory of probabilities and the theory of random functions, in relation to the tasks of search radio control is now virtually non-existent. Based on this, the task of developing a new scientific and methodological apparatus for detecting and analyzing radio signals of means of covert information based on a model of random signals is relevant.

Develop a method for detecting signals of means of covert retrieval of information, using the definition of the deviation of the main parameters of the signals from the function of the sample. The function of the sample, defined as the implementation of the smoothing function of a random process, by the method of least squares using the principle of sliding smoothing.

3. Proposed Mechanisms

The model of a random radio signal will be developed on the basis of one-dimensional random functions $X(t)$. Note that any random variable X is a function of a random event P, is an event whose result is unknown in advance and which may or may not happen. Therefore, the random variable X may denote as $X(P)$, and the random process as $X(P,t)$.

Fixed the value of a non-random parameter $t = t_i$, we obtain a random variable $X(P,t_i)$. But in the process of radio monitoring, search for random radio signals, the parameter t changes, so we get a set of random variables. Therefore, a random function can be represented as a set of random variables.

Random processes are entirely determined by probabilistic characteristics:

- the probability of occurrence of this event P for random events;
- random distribution functions;
- distribution function for random functions.

Correlation functions, both autocorrelation and intercorrelation. Structural functions proposed by Kolmogorov A.M.

Spectral characteristics:

- spectral power density;
- spectral function;
- the spectrum width of the random process;
- position and values of maxima of power spectral density;
- cut-off frequencies, etc.

A random radio signal of a digital means of secretly receiving information operating in pulse mode is an additive non-stationary random signal, which can be represented as:

$$X(t) = Y(t) + \varphi(t), \quad (1)$$

where $\varphi(t)$ - is a deterministic function that satisfies the requirements $\varphi(t) \neq const, \quad t \in T$.

The first moment for this process will look like:

$$MX(t) = MY(t) + \varphi(t). \quad (2)$$

If $MY(t) = 0$ we get a random process, nonstationary with respect to mathematical expectation. In our case, the presence of a residue is very important for this process. The balance is characterized by the function of the balance. The expression for the remainder function looks like this:

$$Y(t) = X_0(t) = X(t) - MX(t) = X(t) - \varphi(t). \quad (3)$$

Note that the functions are polynomial in nature, it is possible to write the expression:

$$\varphi(t) = \sum_{i=1}^{n} a_i t^i. \quad (4)$$

Characteristically, for the additive nonstationary process to which we attribute random radio signals, the correlation function depends only on the shift (on τ), and does not depend on the current time t:

$$R_x(t_1, t_2) = M[X_0(t_1)X_0(t_2)] = M[Y_0(t_1)Y_0(t_2)] = R_y(\tau), \quad (5)$$

where $\tau = t_2 - t_1$.

In general, the additive model characterizes nonstationary processes by mathematical expectation, which can be converted to stationary when centered. This will greatly simplify the calculations, which will reduce the analysis time and significantly increase the probability of detecting a random pulse radio signal.

The choice of method is performed from the possible methods of solving the smoothing problem, that is from the following methods:

- method of testing statistical hypotheses;
- maximum plausible method;
- least squares method;
- method of optimal filtration;
- dynamic programming method;
- method of stochastic approximation, etc.

For our case, we will choose the method that is better in the implementation of the appropriate signal processing algorithm and the adequacy of the selected hypothesis regarding the a priori characteristics of a random radio signal. Therefore, we choose the method of smoothing operators which are based on the method of least squares.

We use the method of least squares. Let's build smoothing operators. The peculiarity of such operators is:

- use of the principle of sliding smoothing;
- selection of the start and direction of reference for the smoothing function;
- taking into account the end effects.

The choice of sliding smoothing is used because it allows you to use a low degree of polynomial, by choosing a sufficiently small smoothing interval. This is an algorithmic method based on the idea of averaging the observed adjacent values of a series.

The choice of start and direction of reference for a polynomial provides simplification of operators.

To explain the proposed method, assume that in the time interval $\left[t-T,t\right]$ we have:

- implementation of x(t) smoothing random process X(t), where X(t) is a function of the process of radio monitoring of a given frequency radio band;
- static polynomial of the species: $\sum_{j=0}^{m} a_j \varphi_j(x)$,

where is the basis function $\varphi_j(x)=\tau^j$, which is a static function

τ - time parameter, some changes on the segment $\left[-\frac{T}{2}-b, \frac{T}{2}+b\right]$, where b- the beginning of the axis τ which is calculated from the middle of the segment $\left[t-T,t\right]$.

The instantaneous error will be determined by the expression:

$$\varepsilon(t)=x(t\pm\tau-\frac{T}{2}-b)-\sum_{j=0}^{m} a_j\varphi_j(x) \qquad (6)$$

The integral root mean square error will be determined by the expression:

$$\varepsilon^2(t)=\frac{1}{T}\int_{-\frac{T}{2}-b}^{\frac{T}{2}+b}[x(t\pm\tau-\frac{T}{2}-b)-\sum_{j=0}^{m} a_j\varphi_j(x)]^2\,d\tau\,. \qquad (7)$$

or

$$\varepsilon^2(t)=\int_{-\frac{T}{2}-b}^{\frac{T}{2}+b}[x(t\pm\tau-\frac{T}{2}-b)-\sum_{j=0}^{m} a_j\tau^j)]^2\,d\tau\,. \qquad (8)$$

In expressions (7) and (8) the sign ± determines the direction of the axis τ

In expression (8) $A_n=\sum_{j=0}^{m} a_j\tau^j$ - the operator of polymial smoothing.

a_j - is determined from the conditions of the minimum standard error, so:

$$\varepsilon^2(t)=\int_{-\frac{T}{2}-b}^{\frac{T}{2}+b}[x(t\pm\tau-\frac{T}{2}-b)-\sum_{j=0}^{m} a_j\tau^j)]^2\,d\tau\rightarrow\min \qquad (9)$$

Taking into account that the coefficients are not subject to any restrictions, we apply the requirements of the unconditional extremum:

$$\frac{\partial\varepsilon^2(t)}{\partial a_j}=0, \quad j=0,1,2...m. \qquad (10)$$

From expression (10) we obtain a system of linear equations:

$$\sum_{j=0}^{m}\alpha_{j+n}a_j=\beta_n, \quad n=1,2,...m, \qquad (11)$$

In expression (11) we introduced the following notation:

$$\alpha_{j+n}=\sum_{i=1}^{m}(t_i-t_0)^{j+n} \quad ,n=1,2,...m \qquad (12)$$

$$\beta_n=\sum_{i=1}^{m}(t_i-t_0)^n x_i, \quad n=1,2,...m \qquad (13)$$

From the system of linear equations (11) we determine the smoothing operators a_j.

Thus, we obtained the implementation of the smoothing function of a random process. The least squares method using the principle of sliding smoothing.

The smoothing function is required for use as a reference function.

The reference function will be used in the hardware and software package as a function of the sample. Detects an instant error, we will obtain the deviation of the random signal from the function of the sample. The greater the instantaneous error, the more likely it is that the detected random signal will be a signal of a means of obtaining secret information.

It should be noted that the smoothing function in the process of finding means of covert information should be determined earlier at the time of the threat of information leakage, or get the implementation of the radio monitoring process at a time when the likelihood of clueless operation is very small. For example, at night.

The presence of a mathematically approximated file of the required radio range, and this is determined by the proposed method of the smoothing function - allows you to very quickly detect new random signals. The speed is explained by the fact that the scanning of the radio range is not on the general range, but only on the detection of deviations from the function of the sample.

Among the important tasks of research of smoothing operators for the development of the method should be: definition of their own functions, detection of smoothing errors and optimization of smoothing parameters (quantization step, interval, etc.).

When using the principle of sliding smoothing should take into account the fact that the greatest accuracy of smoothing is achieved in the middle of the smoothing interval (in our case it is $t=t_0$).

However, at the end of the implementation, the smoothing accuracy decreases. Therefore, we propose to choose the smoothing algorithm as follows:

The time interval $0\leq t\leq T_0$ must be divided into three intervals:

1. $0\leq t\leq t_0$;
2. $t_0\leq t\leq T_{0-}t_0$;
3. $T_0-t_0\leq t\leq T_0$.

To smooth the implementation $x(t)$ on the first interval, we use the value of this implementation from the segment $0\leq t_i\leq T$ where the T-smoothing interval, *i = 1,2,... n.*

In the second interval, smoothing is performed as follows. Set t_1 - any time from the second time interval. By the value of the implementation of segments $t_i-\frac{T}{2}\leq t\leq t_i+\frac{T}{2}$, calculate $\overset{0}{a}_{ni}$. I use assumptions $t_0=t_i$, we receive

$A_n x(t) = a^0_{ni} x(t)$, where a^0_{ni} - values on a segment $t_i - \frac{T}{2} \le t \le t_i + \frac{T}{2}$.

The third interval is similar to the first, but the difference is that the implementation $x(t)$ is taken from a period of time $T_0 - t_0 \le t \le T_0$.

For the purpose of practical verification of the obtained results, we calculate the coefficients of the polynomial smoothing a_j for $1 \le m \le 5$, and $x(t) = \sum_{j=0}^{m} a_j (t - t_0)^j$.

The polynomial smoothing coefficients a_j in General will look like:

$$m{=}1, \quad a_0 = \frac{\beta_0}{n}, \; a_1 = \frac{\beta_1}{\alpha_2}.$$

$$m{=}2, \quad a_0 = \frac{\alpha_4\beta_0 - \alpha_2\beta_2}{n\alpha_4 - \alpha_2^2}, \; a_1 = \frac{\beta_1}{\alpha_2}, \quad a_2 = \frac{n\beta_2 - \alpha_2\beta_0}{n\alpha_4 - \alpha_2^2}.$$

$$m{=}3, \quad a_0 = \frac{\alpha_2\beta_0 - \alpha_2\beta_2}{n\alpha_4 - \alpha_2^2}, \; a_1 = \frac{\alpha_6\beta_1 - \alpha_4\beta_3}{\alpha_2\alpha_6 - \alpha_4^2},$$

$$a_2 = \frac{n\beta_2 - \alpha_2\beta_0}{n\alpha_4 - \alpha_2^2}, \; a_3 = \frac{\alpha_2\beta_3 - \alpha_4\beta_1}{\alpha_2\alpha_6 - \alpha_4^2}.$$

m=4,

$$a_0 = \frac{(\alpha_4\alpha_8 - \alpha_6^2)\beta_0 + (\alpha_4\alpha_6 - \alpha_2\alpha_8)\beta_2 + (\alpha_2\alpha_6 - \alpha_4^2)\beta_4}{n\alpha_4\alpha_8 + 2\alpha_2\alpha_4\alpha_6 - \alpha_4^3 - n\alpha_6^2 - \alpha_2^2\alpha_8},$$

$$a_1 = \frac{\alpha_6\beta_1 - \alpha_4\beta_3}{\alpha_2\alpha_6 - \alpha_4^2},$$

$$a_2 = \frac{(\alpha_4\alpha_6 - \alpha_2\alpha_8)\beta_0 + (n\alpha_8 - \alpha_4^2)\beta_2 + (\alpha_2\alpha_4 - n\alpha_6)\beta_4}{n\alpha_4\alpha_8 + 2\alpha_2\alpha_4\alpha_6 - \alpha_4^3 - n\alpha_6^2 - \alpha_2^2\alpha_8},$$

$$a_3 = \frac{\alpha_2\beta_3 - \alpha_4\beta_1}{\alpha_2\alpha_6 - \alpha_4^2},$$

$$a_4 = \frac{(\alpha_2\alpha_6 - \alpha_4^2)\beta_0 + (\alpha_4\alpha_2 - n\alpha_6)\beta_2 + (n\alpha_4 - \alpha_2^2)\beta_4}{n\alpha_4\alpha_8 + 2\alpha_2\alpha_4\alpha_6 - \alpha_4^3 - n\alpha_6^2 - \alpha_2^2\alpha_8}.$$

m=5,

$$a_0 = \frac{(\alpha_4\alpha_8 - \alpha_6^2)\beta_0 + (\alpha_4\alpha_6 - \alpha_2\alpha_8)\beta_2 + (\alpha_2\alpha_6 - \alpha_4^2)\beta_4}{n\alpha_4\alpha_8 + 2\alpha_2\alpha_4\alpha_6 - \alpha_4^3 - n\alpha_6^2 - \alpha_2^2\alpha_8},$$

$$a_1 = \frac{(\alpha_6\alpha_{10} - \alpha_8^2)\beta_1 + (\alpha_6\alpha_8 - \alpha_4\alpha_{10})\beta_3 + (\alpha_4\alpha_8 + \alpha_6^2)\beta_5}{\alpha_2\alpha_6\alpha_{10} + 2\alpha_4\alpha_6\alpha_8 - \alpha_6^3 - \alpha_2^2\alpha_8 - \alpha_4^2\alpha_{10}}$$

$$a_2 = \frac{(\alpha_4\alpha_6 - \alpha_2\alpha_8)\beta_0 + (n\alpha_8 - \alpha_4^2)\beta_2 + (\alpha_2\alpha_4 - n\alpha_6)\beta_4}{n\alpha_4\alpha_8 + 2\alpha_2\alpha_4\alpha_6 - \alpha_4^3 - n\alpha_6^2 - \alpha_2^2\alpha_8},$$

$$a_3 = \frac{(\alpha_6\alpha_8 - \alpha_4\alpha_{10})\beta_1 + (\alpha_2\alpha_{10} - \alpha_6^2)\beta_3 + (\alpha_4\alpha_6 - \alpha_2\alpha_8)\beta_5}{\alpha_2\alpha_6\alpha_{10} + 2\alpha_4\alpha_6\alpha_8 - \alpha_6^3 - \alpha_2^2\alpha_8 - \alpha_4^2\alpha_{10}},$$

$$a_4 = \frac{(\alpha_2\alpha_6 - \alpha_4^2)\beta_0 + (\alpha_4\alpha_2 - n\alpha_6)\beta_2 + (n\alpha_4 - \alpha_2^2)\beta_4}{n\alpha_4\alpha_8 + 2\alpha_2\alpha_4\alpha_6 - \alpha_4^3 - n\alpha_6^2 - \alpha_2^2\alpha_8},$$

$$a_5 = \frac{(\alpha_4\alpha_8 - \alpha_6^2)\beta_1 + (\alpha_4\alpha_6 - \alpha_2\alpha_8)\beta_3 + (\alpha_2\alpha_6 - \alpha_4^2)\beta_5}{\alpha_2\alpha_6\alpha_{10} + 2\alpha_4\alpha_6\alpha_8 - \alpha_6^3 - \alpha_2^2\alpha_8 - \alpha_4^2\alpha_{10}}.$$

The smoothing error of a given function at m = 5 no longer has a significant effect on random deviations from the obtained function, which allows you to determine random radio signals. It is impractical to calculate coefficients of a larger order. Further calculation of the smoothing coefficients leads to an increase in the calculation time, which is a more influential factor in the detection of random short-term signals than the smoothing error of a given function.

4. Discussion of experimental results

The developed method of determining random radio signals, signals that can be signals of means of covert receipt of information, allows to detect signals of these means with greater efficiency. The novelty of the method is to determine the deviation of the main parameters of the signals from the function of the sample. The method combines the method of determining the function of the sample of the required radio band. This is achieved by defining the function of the sample - the implementation of the polynomial smoothing function of a given radio range, by the method of least squares using the principle of sliding smoothing.

It is proposed to determine the signals of the means of covert receipt of information by the instantaneous deviation of the parameters of random signals.

Moreover, to determine the means of covertly obtaining information, it is proposed in the first stage to determine the deviation of the amplitude of random signals from the amplitude of the signals of the sample function, in the second stage, if necessary, to determine the phase deviation of the signals. Thus, the effectiveness of the method is achieved by the ability to determine the deviation of two parameters: amplitude and phase, in contrast to the classical methods of detecting means of covert information. This makes it possible to detect random signals with a high probability.

Another difference with the propane method is that the presence of a certain function of the sample of the required radio range significantly increases the probability of determining random signals. This is achieved by significantly reducing the scanning time by excluding known signals (signals of the sample function) from the additional software analysis of a given radio range. This is another difference of the proposed method.

Further ways to improve the method can be done by taking into account the noise of devices and interference from the signals of the search radio range.

5. Conclusions

The analysis of the existing methods of determination of random radio signals is carried out, the hardware and software complexes using scientific methods based on the model of random signals for detection and analysis of random signals are revealed. In which the description of random signals is based on the theory of probabilities and the theory of random functions, in relation to the tasks of search radio control is now virtually non-existent. Therefore, the problem of developing a new method for determining random radio signals was solved.

A method for determining random radio signals, signals that can be signals of covert means of obtaining information, which allows to detect signals of means of covert reception of information with greater efficiency. The novelty of the method is to determine the deviation of the main parameters of the signals from the function of the sample. The method combines the method of determining the function of the sample of the required radio band. This is achieved by determining the function of the sample, the implementation of the smoothing function of a random process, by the method of least squares using the principle of sliding smoothing.

The difference with the propane method is that determining the function of the sample of the required radio range significantly increases the probability of determining random signals. This is achieved by significantly reducing the scanning time by excluding known signals (signals of the sample function) from the additional software analysis of a given radio range.

To confirm the proposed developed method of detecting radio signals of covert information based on the model of random signals, the calculation of polynomial smoothing coefficients for the proposed function was performed.

The obtained results, which fully confirm the possibility of determining the signals of the means of covert receipt of information by the proposed method, prove the advantages of the developed method over the methods and techniques that currently exist.

References

[1] S. Khan, K. K.. Loo. Real time cross layer flood detection mechanism," Elsevier Journal of Network Security, Vol. 16, No. 5, pp. 2-12, 2009.

[2] Bieliaevi V.F., Chyhrin R.M., Myronovych V.M., Mathematical model of a random signal of an analog conducting signaling channel of security systems of military objects on the basis of a multidimensional system of algebraic linear equations. Collection of scientific works of Kharkiv University of the Air Force, 2009, issue 1 (19). P.95 – 99

[3] Yavorskiy I.M., Isaiev I.Y., Kravets I.B., Comparison of parametric models of periodically nonstationary random processes. Selection and processing of information: Collection of scientific works 2019. Issue 31 (107). pp.12-17. 2019

[4] Strilkova T.O., Lytiuha O.P., Kalmykov O.S., Khoroshun H.M., Riazantsev A.O., Riazantsev O.I. Influence of signal description model on calculations of efficiency indicators of optoelectronic systems. Eastern European Journal of Advanced Technologies. Vol. 4. N 5 (106). P.1-20. 2020.

[5] Marchenko N.B. Band process modeling. Electronics and control systems.2012.№3(33). P.97-101. 2012.

[6] Milov O., Yevseiev S. Milevskyi S. Ivanchenko Y., Nesterov O., Puchkov O., Yarovyi A., Salii A., Tiurin V., Timochko O., "Development the model of the antagonistic agent's behavior under a cyber-conflict" Eastern European Journal of Advanced Technologies. Kharkiv. 4/9 (100). Pp. 6–19. 2019

[7] Lubov Berkman, Oleg Barabash, Olga Tkachenko, Andri Musienko, Oleksandr Laptiev, Ivanna Salanda6 The Intelligent Control System for info communication networks. International Journal of Emerging Trends in Engineering Research (IJETER) Volume 8. No. 5, May 2020. Scopus Indexed - ISSN 2347 – 3983. P1920 – 1925. 2025.

[8] Olexandr Laptiev, German Shuklin, Spartak Hohonianc, Amina Zidan, Ivanna Salanda Dynamic model of Ceber Defence Diagnostics of information Systems with the Use of Fozzy Technologies IEEE ATIT 2019 Conference Proceedings Kyiv, Ukraine, December 18-20, P.116-120.Oleksandr Laptiev, Oleh Stefurak, Igor Polovinkin, Oleg Barabash, Savchenko Vitalii, Olena Zelikovska. The method of improving the signal detection quality by accounting for interference. 2020 IEEE 2nd International Conference on Advanced Trends in Information Theory (IEEE ATIT 2020) Conference Proceedings Kyiv, Ukraine, November 25-27, pp.172 –176. 2020.

[9] Oleksandr Laptiev, Savchenko Vitalii, Serhii Yevseiev, Halyna Haidur, Sergii Gakhov, Spartak Hohoniants. The new method for detecting signals of means of covert obtaining information. 2020 IEEE 2nd International Conference on Advanced Trends in Information Theory (IEEE ATIT 2020) Conference Proceedings Kyiv, Ukraine, November 25-27, pp.176 –181. 2020.

[10] Valentyn Sobchuk, Volodymyr Pichkur, Oleg Barabash, Oleksandr Laptiev, Kovalchuk Igor, Amina Zidan. Algorithm of control of functionally stable manufacturing processes of enterprises. 2020 IEEE 2nd International Conference on Advanced Trends in Information Theory (IEEE ATIT 2020) Conference Proceedings Kyiv, Ukraine, November 25-27, pp.206 –211. 2020.

[11] Vitalii Savchenko, Oleksandr Laptiev, Oleksandr Kolos, Rostyslav Lisnevskyi, Viktoriia Ivannikova, Ivan Ablazov. Hidden Transmitter Localization Accuracy Model Based on Multi-Position Range Measurement. 2020 IEEE 2nd International Conference on Advanced Trends in Information Theory (IEEE ATIT 2020) Conference Proceedings Kyiv, Ukraine, November 25-27, pp.246 – 251. 2020.

[12] Vitalii Savchenko, Oleh Ilin, Nikolay Hnidenko, Olga Tkachenko, Oleksander Laptiev, Svitlana Lehominova, Detection of Slow DDoS Attacks based on User's Behavior Forecasting. International Journal of Emerging Trends in Engineering Research (IJETER) Volume 8. No. 5, May 2020. Scopus Indexed - ISSN 2347 – 3983. pp.2019 – 2025. 2020.

[13] Laptiev O., ShuklinG., Savchenko V., Barabash O., MusienkoA., Haidur H. The Method of Hidden Transmitters Detection based on the Differential Transformation Model. International Journal of Advanced Trends in Computer Science and Engineering. 2019. Vol. 8, №6, November- December. pp. 538 – 542. 2019.

[14] Olexandr Laptiev, German Shuklin, Spartak Hohonianc, Amina Zidan, Ivanna Salanda Dynamic model of Cyber Defence Diagnostics of information Systems with the Use of Fozzy Technologies IEEE ATIT 2019 Conference Proceedings Kyiv, Ukraine, December 18-20, P.116-120.2019.

[15] Hryshchuk R., Korobiichuk, V. Horoshko V., Y. Khokhlacheva Y. Microprocessor Means for Technical Diagnostics of Complex Systems.Computer Modeling and Intelligent Systems – 2019. – Vol. 2353. p. 1020–1029. 2019.

[16] M. Z. Ahmad, D. Alsarayreh, A. Alsarayreh, I. Qaralleh Differential Transformation Method (DTM) for Solving SIS and SI Epidemic Models. Sains Malaysiana. 2017. Vol. 46(10). pp. 2007 – 2017. 2017.

[17] A. Musienko, O. Barabash, V. Sobchuk, N. LukovaChuiko. Application of Petri Networks for Support of Functional Stability of Information Systems. 2018 IEEE First International Conference on System Analysis & Intelligent Computing (SAIC). 08-12 October 2018. Igor Sikorsky Kyiv Polytechnic Institute, Kyiv, Ukraine. pp. 36–39. 2018.

[18] S. Korotin, Y. Kravchenko, O. Starkova, K. Herasymenko, R. Mykolaichuk, "Analytical determination of the parameters of the self-tuning circuit of the traffic control system on the limit of vibrational stability", International Scientific-Practical Conference Problems of Infocommunications Science and Technology, PIC S&T`2019 – Proceedings, pp. 471–476. 2019.

[19] Rakushev, M., Permiakov, O., Tarasenko, S., Kovbasiuk, S., Kravchenko, Y. and Lavrinchuk, O. Numerical Method of Integration on the Basis of Multidimensional Differential-Taylor Transformations. In Proceedings of the IEEE International Scientific-Practical Conference Problems of Infocommunications Science and Technology, PIC S&T`2019 – Proceedings, pp. 675 – 678. 2019.

[20] Y. Kravchenko, O. Leshchenko, N. Dakhno, O. Trush, O. Makhovych "Evaluating the effectiveness of cloud services", IEEE International Conference on Advanced Trends in Information Theory, ATIT`2019 – Proceedings, pp.120–124. 2019.

[21] Mashkov O.A., Sobchuk V.V., Barabash O.V., Dakhno N.B., Shevchenko H.V., Maisak T.V. Improvement of the variational-gradient method in dynamical systems of automated control for integrodifferential models. Mathematical Modeling and Computing.Vol. 6, No 2, pp. 344 – 357. 2019

[22] Musienko A.P., Serdyuk A.S. Lebesgue-type inequalities for the de la Valée-Poussin sums on sets of analytic functions. Ukrainian Mathematical Journal September 2013, Volume 65, Issue 4, pp. 575 – 592. 2013.

[23] Musienko A.P., Serdyuk A.S. Lebesgue-type inequalities for the de la Vallée poussin sums on sets of entire functions. Ukrainian Mathematical Journal October 2013, Volume 65, Issue 5, pp. 709 – 722., No.2, March-April 2020, pp.1113 - 1120.

[24] Maha Abdelhaq, Raed Alsaqour, Noura Albrahim, Manar Alshehri, Maram Alshehri1, Shehana Alserayee, Eatmad Almutairi, Farah Alnajjar.The Impact of Selfishness Attack on Mobile Ad Hoc Network. International Journal of Communication Networks and Information Security (IJCNIS).Vol. 12, No. 1, April 2020, pp.42 – 46, 2020.

[25] Abdullah Shakir, Raed Alsaqour, Maha Abdelhaq, Amal Alhussan, Mohd Othman, Ahmed Mahdi. Novel Method of Improving Quality of Service for Voice over Internet Protocol Traffic in Mobile Ad Hoc Networks. International Journal of Communication Networks and Information Security (IJCNIS). Vol. 11, No. 3, December 2019, pp.331–341, 2019.