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The Indirect method of obtaining Estimates of the Parameters of Radio Signals of covert means of obtaining Information

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ABSTRACT

The article considers the method of indirect determination of the parameters of the signals of the means of covert receipt of information. Attention is paid to random signals. Because their presence gives the chance to record the fact of the existence of a signal of means of secret reception of the information. Random signals of different power are considered by the statistical method.

Modern statistical theory of radio signal detection considers the measuring device as a filter that extracts useful information (information about the parameters we need) from the whole mixture of signal and interference. An accurate mathematical description of radio signals is usually impossible. Therefore, an indirect method of estimating radio signals is proposed in order to detect the signals of the means of secretly obtaining information.

The method of comparing the signals obtained during radio monitoring is based on the fact that the output signal at any point, including estimates of maximum likelihood, can be approximated in a polynomial with a finite number of members. This allows you to update the input signal, based on the measurement of the corresponding values of the parameters of the output signal and their derivatives, which is within the evaluation range.

Key words: signals, parameters, information, the indirect method, illegal obtaining.

1. INTRODUCTION

In the face of competition in the international market, the scale of industrial intelligence is growing sharply. The achievements of scientific and technological progress are increasingly used. Industrial intelligence is becoming a more flexible and sophisticated means of obtaining information. Transnational corporations are most active in industrial intelligence. Like big business, industrial intelligence knows no boundaries. There are even secret exchanges that sell stolen trade secrets. For example, in the United States there is a legal "Society of experts in obtaining information about competitors", which has 1,500 permanent members. This "Society..." specializes in obtaining hard-to-reach information that characterizes the production capabilities of firms, lifestyle and personal preferences of their management. Both legal and illegal methods and tools are used to obtain this kind of information. Technical illegal means of extracting information include covert means of obtaining information. The development of technology has led not only to positive but also to negative consequences. The covertly means of obtaining information have significantly expanded their range, methods and means of camouflage. This forces us to look for fundamentally new ways to solve the problem of finding and blocking the covertly means of obtaining information and to use the statistical properties of different characteristics of the signals of the covertly means of obtaining information and interference.

Therefore, the detection and blocking of signals of modern technical covertly means of obtaining information, by calculating the statistical properties of various characteristics of the signals of covertly means of obtaining information and interference, is a very important task today.

1.1 Literature analysis and problem statement

In [1] the methods of determining the characteristics of signals are considered: carrier frequency, rate of change and types of modulation. These tasks are solved in order to determine the parameters of the signals that will be able to identify the radio transmitting means. The problem is solved in order to establish the signal, but the problem of identification of all detected signals (signals that can`t be renewed) in this work is not considered.

In [2] the issue of normalizing signal converters is considered. The solution of the following tasks is considered: realization of schemes and methods of measurement of primary signals with primary processing of measurement results; perform galvanic isolation of signals; unify signals in the system. This simplifies the construction of multi-channel systems of the second level. But the question of estimating the parameters of radio signals by comparing radio signals and signals of normalizing converters is not considered.

In [3], an approach to the automated determination of the frequency and error of clock synchronization of radio signals from quadrature amplitude modulation is proposed. The approach is based on determining the minimum correlation function of radio signals. But the full range of parameters of radio signals is not considered.

In [4] algorithms for determining the radio parameters of signals are considered, but the main disadvantage is that the presence of preliminary information is required. Methods are considered that allow to obtain information about radio signals under conditions when only the sampling frequency of the signal is known. A mathematical model of the phase-manipulated signal is described and a method for determining the signal parameters under a priori uncertainty is proposed. But the process of signal detection in the absence of data on sampling in the work is not considered.

In [5] the problem of estimation of the basic parameters of harmonic signals is solved. An algorithm for determining the phase shift of such signals by the probabilistic-statistical method is proposed. Mathematical modeling of the algorithm is carried out in order to study the errors and evaluate the possibility of practical implementation of the algorithm for processing radio signals during stochastic sampling. The issue of estimating the parameters of radio signals by comparing radio signals and signals of normalizing converters is not considered in this article.

In [6] the methods of determining the following characteristics are considered:

carrier frequency, manipulation speed and type of modulation for phase-locked signals. There are a number of algorithms for determining the radio parameters of signals, but the main disadvantage of some of them is the need for certain information. The most interesting are the methods that allow to obtain information about the signal in conditions where only the sampling frequency is known, as well as methods that allow you to accurately determine the type of modulation. The paper considers a narrow range of radio signals. General method Detection of signal parameters is not considered.

The article[7] discusses the need to create a single portrait of a radio source and identification methods. Radio monitoring tools are used to detect, identify and locate sources of radio waves in the coverage area. The classification issues of the main parameters of the sources of radio emission are considered, the classification of the types of modulation and the main parameters of its types are given. The signal structure can be determined by autocorrelation and correlation methods. To detect a source of radio emission, two generalized algorithms are given: recognition of the type of source of radio emission from unknown parameters and an algorithm for identifying a source of radiation from given parameters. A simulation result of a radio emission source recognition algorithm with given parameters is presented; a linear frequency-modulated signature was used as a given signal. However, other types of radio signals are not considered in this article.

In [8], based on research conducted in MATLAB, an optimization model was developed to measure power in circuits. The proposed algorithms can be used to develop the characteristics of various information signals, including signals from the covert means of obtaining information.

From the analysis of the modern literature it is possible to draw a conclusion that questions of detection of signals which have the features in the course of detection of covert means of obtaining information, are practically not considered. Therefore, to date, it is advisable to investigate the detection of signals of covert means of obtaining information, especially indirect methods.

1.2 Aim of the article

The purpose of the article is to consider the radio signals of the means of covert obtaining of information as random signals of different power using the statistical method and the proposed method of indirect determination of the parameters of radio signals.

Conduct computer simulations in the MATLAB environment according to the proposed and existing methods in order to evaluate the effectiveness of the proposed method.

2. THE MAIN SECTION

The technique of signal detection and evaluation of their parameters has achieved significant success. But further improvement of most devices by improving design and technological solutions has its limitations. These limitations are determined by physical processes, fluctuations and disturbances of natural and artificial origin [9]. This forces us to look for new ways to detect signals from covert means of obtaining information.

Particular attention should be paid to random interference signals [10]. Because, their presence does not make it possible to record the fact of the presence of a signal of covert means of obtaining information. Therefore, we will consider the interference as random signals of different power. In this regard, we will use the statistical method.

Modern statistical theory of radio signal detection considers the measuring device as a filter that extracts useful information (information about the parameters we need) from the whole mixture of signal and interference [11].

By interference we mean the sides perturbation that act in the path of the signal from its source to the receiver and prevent the correct detection of the signal.

An accurate mathematical description of the interference is usually impossible. Informative parameters of interference are determined by their analysis. Sources of interference can be internal and external [12].

Implementation of optimal receiving devices with continuous change of the reference signal parameter, except for estimates of the position of the signal in time and its derivatives, is almost impossible. Therefore, an indirect method of estimating radio signals is proposed in order to detect the signals of the means of secretly obtaining information.

To do this, it is proposed to use multi-channel receivers, which immediately perform the function of signal selection.Selection of signals which differ from others is carried out. Otherwise, it is possible to say that the signal of inconsistency is determined. To explain, we introduce the concept of "fixed signal". That is, the mismatch signal is the difference between a valid radio signal and a "fixed signal".

The method of comparing the signals obtained during radio monitoring is based on the fact that the output signal at any point *L*, including the estimation of the maximum likelihood, can be approximated in a polynomial with a finite number of terms [13]. This allows you to update the input signal as a function of the parameter *L* based on the measurement of the corresponding values of the parameters of the output signal and their derivatives atsome point L_f , which is within the evaluation range.

Consider the output signal $V(L)=S(L)+N(L)$, the optimal receiver if it receives a known signal.

We approximate the signal $V(L)$, in the vicinity of point $L_v=L$, in the Taylor series, and we introduce the assumption that for sufficiently large signal-to-noise ratios, we take only the first two nonzero terms of this approximation:

$$V(L)\approx V(L_v)+\left[\frac{d^2V(L)}{dL^2}\right]_{L_v}\frac{(L-L_v)^2}{2}. \qquad (1)$$

The first and second derivatives of this signal at point $L=L_f$, which is near point L_v will, respectively, have the form:

$$\left[\frac{d\,V(L)}{dL}\right]_{L_f}\approx(L_f-L_v)\left[\frac{d^2V(L)}{dL^2}\right]_{L_v}, \qquad (2)$$

$$\left[\frac{d^2V(L)}{dL^2}\right]_{L_f}\approx\left[\frac{d^2V(L)}{dL^2}\right]_{L_v}. \qquad (3)$$

Converting expressions (2) and (3) with respect to the mismatch signal we obtain the expression:

$$\Delta=L_f-L_v=\left[\frac{d\,V(L)/dL}{d^2V/dL^2}\right]_{L_f}. \qquad (4)$$

Expression (4) allows to analyze the expression for the mismatch signal if the first and second derivatives of the output signal are known for some fixed value of the signal parameter L_f , which is in the vicinity of the estimate L_v , where there is an approximation of the form (1). Then the assessment of maximum likelihood is determined by measuring the first and second derivatives of the output signal of the optimal receiver at point $L_f=L_v$, :

$$\begin{cases}\left[\dfrac{d\,V(L)}{dL}\right]_{L_v}=\int\limits_0^T x(t)\dfrac{\partial\vartheta(t,L_f)}{\partial L}dt,\\ \left[\dfrac{d^2V(L)}{dL^2}\right]_{L_v}=\int\limits_0^T x(t)\dfrac{\partial^2\vartheta(t,L_f)}{\partial L^2}dt.\end{cases} \qquad (5)$$

The block diagram of the process of determining the mismatch signal is described by expression (5), and will look like (Figure.1):

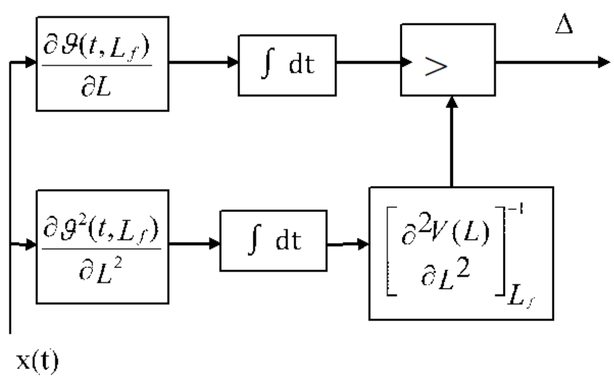

Figure 1: Block diagram of the receiving and computing devices

This block diagram consists of two channels: the first - forms a non-matching signal; the second is a variable gain, which depends on the noise intensity and the useful signal.

Our task is to show that the characteristics of the parameter *L* obtained using the indirect measurement method coincide with the characteristics of the evaluation of the maximum output signal of the optimal receiver[15].

For calculation of characteristics will make the assumption that the evaluation, in the first approximation, it is possible to neglect the second derivative in the denominator of the noise function in comparison with a second derivative signal of the function at the point $L_f=L_v$, which is true for a sufficiently large ratio of signal/noise. Then the expression (4) would be:

$$\Delta\approx L_f-L_v=\left[\frac{d\,V(L)/dL}{d^2S/dL^2}\right]_{L_f}. \qquad (5)$$

Calculate the average value of the mismatch signal, taking into account the assumption that $V(L)=S(L)$, with a sufficiently large signal-to-noise ratio, may be limited to the approximation of $S(L)$ in the vicinity of point $L_f = L_0$ in the form of a quadratic parabola:

$$S(L)=S(L_0)+\left[\frac{d^2S(L)}{dL^2}\right]_{L_0}\frac{(L_f-L_0)^2}{2}. \quad (6)$$

Performing the transformation of the expression taking into account the derivatives we obtain:

$$\left[\frac{d\ V(L)}{dL}\right]_{L_v}=\frac{d^2S(L)}{dL^2}(L_v-L_0),$$

$$\left[\frac{d^2V(L)}{dL^2}\right]_{L_v}=\frac{d^2S(L_0)}{dL^2} \quad (7)$$

The average value of the mismatch signal determined from expression (5) has the form:

$$\Delta \approx L_f-L_v \approx L_f-L_0=\Delta_{mid} \quad (8)$$

and coincides with the deviation of the essential value of the estimated parameter L_0 from the fixed value of the parameter L_f , so the estimation of the parameter for this method is fixed.

The variance of the parameter estimate will be determined by the expression:

$$D=\sigma^2=\left(\Delta-\Delta_{medium}\right)^2=$$

$$=\left[\frac{d^2\big/dL_1dL_2\left(V(L_1)-V(L_2)\right)}{\left(\frac{d^2S(L)}{dL^2}\right)^2}\right]_{L_f}-(L_f-L_0)^2. \quad (9)$$

Given that $V(L_1)V(L_2)=S(L_1)S(L_2)-S(L_1-L_2)$ and the expression (6), have the expression:

$$D(L)=\sigma^2(L)=-1/\left[\frac{d^2S(L)}{dL^2}\right]_{L_0} \quad (10)$$

This formula coincides with the formula for variance estimation of non-energy parameter with respect to the first approximation in the estimation on the basis of optimal signal as a function of a measurement parameter with the rating for this parameter to the maximum of this signal [14]. That is the first approximation for the variance of non-energy parameter is inversely proportional to the curvature of the signal functions.

Expression (5) for the mismatch signal can be simplified by moving from the derivatives to the final increases of the function at the point:

$$\left[\frac{d\ S(L)}{dL}\right]_{L_f}\approx\left[S(L_f+\frac{\Delta}{2})-S(L_f-\frac{\Delta}{2})\right]\times\Delta^{-1}. \quad (11)$$

$$\left[\frac{d^2S(L)}{dL^2}\right]_{L_f}\approx\left[S(L_f+\Delta)+S(L_f-\Delta)\right]\times\Delta^{-2}-2S(L_f)\times\Delta^{-2}. \quad (12)$$

Characteristics of estimation of the parameter obtained taking into account approximations for small values. For those values for which the representation in the form of a quadratic polynomial is true, coincide with the characteristics of the optimal estimate.

The characteristic of the parameter estimate, which we received, given the assumption that the signal $V(L)$ can be approximated in a quadratic polynomial coincide with the characteristics of the optimal estimates. But if the deviation of estimates from the signal sample is large and it is not possible to represent $V(L)$, $S(L)$, as a quadratic polynomial, then the average value of the output signal from the expression (5) will be some nonlinear function *F* of the value of $\Delta,\left[F(\Delta)\right]$.

Consider this dependence when it can be represented as a series (considering the fact that the function is even with respect to point $L=L_0$:

$$S(L)=\sum_{n=0}^{\infty}\left[\frac{d^{2n}S(L_0)}{dL^{2n}}\right]\frac{(L-L_0)^{2n}}{(2n)!} \quad (13)$$

Based on expression (11), the first and second derivatives will look like:

$$\left[\frac{dS(L)}{dL}\right]_{L_f}=\sum_{n=1}^{\infty}\left[\frac{d^{2n}S(L_0)}{dL^{2n}}\right]\frac{(L-L_0)^{2n-1}}{(2n-1)!},$$

$$\left[\frac{dS(L)}{dL}\right]_{L_f}=\sum_{n=1}^{\infty}\left[\frac{d^{2n}S(L_0)}{dL^{2n}}\right]\frac{(L-L_0)^{2n-2}}{(2n-2)!}. \quad (14)$$

We use expressions (14) to calculate the average value of the output signal and get:

$$F(\Delta)=\frac{\sum_{n=1}^{\infty}\left[\frac{d^{2n}S(L_0)}{dL^{2n}}\right]\frac{(L-L_0)^{2n-1}}{(2n-1)!}}{\sum_{n=1}^{\infty}\left[\frac{d^{2n}S(L_0)}{dL^{2n}}\right]\frac{(L-L_0)^{2n-2}}{(2n-2)!}}. \quad (15)$$

We will simulate the process of determining the average estimate of signal parameters for different numbers of approximation components. This graph is shown in Figure 2.

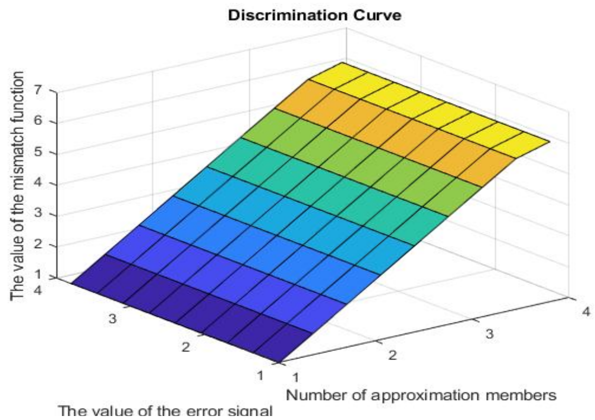

Figure 2: Graph of simulation results of the average parameter estimation error the output signal from the fixed signal proposed by the method.

As you can see from Figure 2 for small values of error, the discrimination curve is practically linear. Therefore, the value of estimating the parameters of radio signals is very easy to determine and analyze. But at large values of error, the dependence of the estimate becomes nonlinear and obtain the parameters of the signals to analyze their origin, becomes a very difficult task.

For certainty in the obtained results, we use the expression for the implementation of receiving devices [10]. This expression looks like:

$$\varphi(\Delta)=\frac{V(L_f+\frac{\delta}{2})-V(L_f-\frac{\delta}{2})}{V(L_f+\frac{\delta}{2})+V(L_f-\frac{\delta}{2})}, \quad (16)$$

where: δ is the average value of the estimation error.

To calculate the average value of the signal parameters, we take into account the assumptions:

- signal function significantly exceeds the noise function;

- $\Delta << L_f$, the error is much less than the signal.

$$\varphi(\Delta)=\delta\frac{\Delta_{mid}}{k^2+\Delta_{mid}^2}, \quad (17)$$

where: $k^2=\frac{2S(L_0)}{d^2S(L_0)/dL_0}$ is the coefficient of proportionality, which does not depend on the amplitude of the input signal.

We perform simulations to determine the error in determining the parameters of the signal by expression (15). The simulation results are shown in Figure. 3:

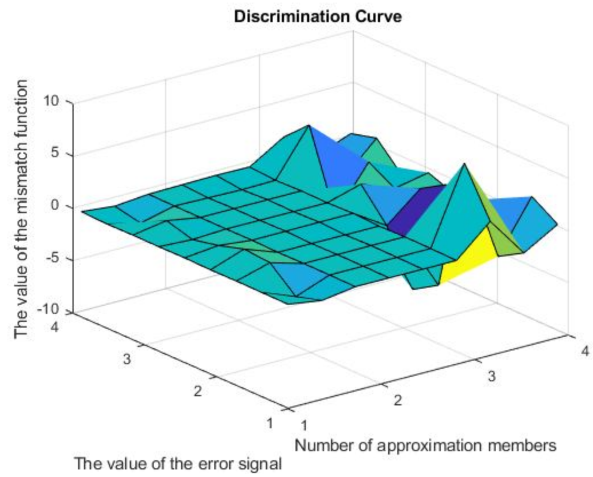

Figure 3: Graph of the average error evaluation of the output signal from the fixed value signal to the host device, according to the existing method.

As you can see from the graph of Figure 3, in the range of small values, the dependence of the average estimate of the output signal of the meter practically repeats the signal, and then the dependence becomes directly proportional. That is, the results of another approach to determining the average value of the error of the true value from the fixed obtained almost the same result. This indicates the correctness of the approach to the determined parameters of the signals by the indirect method. The peculiarity of the proposed technique is that it can be used to determine the parameters of radio signals with a random initial phase and amplitude.

The proposed technique very clearly solves the problem of determining the parameters of the signals of the covert means of obtaining information at small values of deviations from the fixed signal. But there are a lot of pulsed radio signals. Pulsed radio signals can significantly exceed the average fixed signal. The deviation will be large. Therefore, the proposed method of indirect measurements will give significant errors. Based on this, the direction of further research is to create a method or technique for determining the parameters of radio signals when compared not with a fixed signal, but with a variable signal.

3. CONCLUSIONS

For the elevation information used covert means of obtaining information. Covert means of obtaining information has significantly extended the nomenclature, methods and means of disguise. This makes the search for fundamentally new ways of solving the problem of finding and blocking the work of these tools.

The radio signals of the covert means of obtaining information as random signals of different power and using the statistical method were considered.

To estimate the parameter of radio signals, an indirect method of comparing the signals obtained during radio monitoring with a fixed signal, which can be approximated in a polynomial with a finite number of members, is proposed. This allowed to update the input signal as a function of the signal parameter based on the measurement of the corresponding values of the output signal parameters and their derivatives at some point that is within the evaluation range.

The effectiveness of the proposed approach was evaluated using computer simulations in the MATLAB environment according to the proposed and existing methods.

The obtained graphs showed convergence of the results by the proposed and the existing technique. The results showed a linear dependence at small values of the inconsistencies signals from the fixed signal. It proved the possibility of qualitative assessment of radio signal parameters at small signals of the inconsistencies from the fixed signal. The obtained results give the possibility to determine the radio covert means of obtaining information, which have slight variations in power, amplitude and other parameters from the parameters of a fixed signal.

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