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ESTIMATION OF INFLUENCE OF ADDITIVE DISTURBANCE ON INPUT OF A RECEIVER OF SIGNALS WITH THE IDENTIFICATION OF DISTRIBUTION LAWS

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Abstract

In the article a method of estimation of influence of additive disturbance with various laws of distribution on an input of the receiver of telecommunication system according to combined parameter of identification for signals with modulation by the minimal frequency shift is considered.

Keywords: information, law of distribution, identification, disturbance, quality of communication, immunity, signal.

Introduction

The communication system should be designed so that so she can best withstand the effects of interference. To do this, it is necessary to know the characteristics of this interference and analyze their effect on information signal. As the main parameters that characterize the quality of communication is used the signal / noise ratio variations and so on.

In modern communication systems, signals are used that provide high noise immunity, to which, in particular, include signals with minimum frequency shift keying (FSK). With a modulation index of 0.5, FSK signals have a greater concentration of energy in the central region of the spectrum, which provides a high immunity to non-concentrated interference.

In the case of lumped noise immunity turns out to be directly proportional to modulation index.

Typically, threshold devices based on various decision-making methods that use different criteria; for example, the Neumann – Pearson criterion, estimate the effect of interference.

Literature review

A number of publications on the subject have been analyzed and studied. First, the Feer K. "Wireless digital communication" and the Algorithmic methods of increasing the accuracy of analog blocks of measuring systems were studied,

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which analyzed the important aspects of communication systems. In addition, Krotova E. I. Identification of the type of distributions experimental research results was studied and high attention was paid to its scientific aspects. [1-7].

Research Methodology

In order to obtain analytical expressions for the optimal processing algorithm (rule) mixtures when making decisions (hypotheses) about the action signal or its absence, it is necessary to probabilistically describe the mixture at the input of the system in the presence of a signal and interference in it or the action of only one interference. Deciding on the presence of a signal is accompanied by minimum average risk:

$$l(x) = \frac{p(x_1\, x_2 \ldots x_{kn}/sn)}{p(x_1\, x_2 \ldots x_{kn}/n)} > \Pi, \qquad (1)$$

where P=r_pP(s)/r_{po}P(0) is the threshold; l(x) is the likelihood ratio; $p(x_1\, x_2 \ldots x_{kn}/sn)$, $p(x_1\, x_2 \ldots x_{kn}/n)$- probability densities probabilities of a mixture of signal and disturbance and one disturbance respectively [1].

Analyzing disinformation action random interference with different laws of probability distribution, K. Shannon concluded that disruptive misinformation is not defined only by the power of this interference, ie, its root-mean-square deviation (RMSD) σ, but also by the form of the interference distribution law [2]. Analyzing mathematical operations provided by expression (1) can be synthesize an optimal detector circuit discrete radio signal [3]. This article presents a method that allows evaluating and controlling the signal and interference at the input of the receiving device of the communication system of FSK signals in real time according to the combined parameter of identification of the probability density of their sample values. Frequency Shift Keying -it is Binary Frequency Shift Keying. Such the signal can be represented as [4]:

$$y(t) = \cos\left(\omega_0 t + \frac{C_k \pi}{2T} t + \varphi_0\right) \qquad (2)$$

where φ (t) is the phase change:

$$\varphi(t) = \frac{C_k \pi[t-(k-1)T]}{2T} + \sum_{j=1}^{k-1} \frac{C_j \pi}{2} \varphi_0; \qquad (3)$$

kT≤t≤(k+1)T, k=1,2,3,…; $\omega_0 = 2\pi f_0$ −average signal frequency; T-is the duration of a single character; $\varphi_0 -$ initial phase.

In order to use this or that method reception, it is necessary to know the type of interference affecting the signal, that is, the law of its distribution. During the observation, the distribution laws are analyzed original signal and mixture.

There are several methods for identifying distribution laws, however, only those of interest are of interest that provide unambiguous identification.
Analysis of the disinformation actions of random interference with different laws of probability distribution leads to the conclusion that the misinformation introduced by the interference depends not only on the power of this interference, ie, its RMS, but also on the form of the distribution law of this interference [4].
The possibility of identifying the shape of the distribution of experimental data was limited before only by the smallness of the sample size. With a large sample size, for example, several thousand observations, the construction of a histogram allows you to obtain a smooth curve that reflects all the characteristic features of the observed law, but will require a significant processing time. The unambiguity of identification at small sample sizes can be ensured if the coefficient Z is used as an identification parameter, obtained by summing the ratio of the entropy coefficient k to the counter excess χ with the asymmetry coefficient A, which is multiplied by the scaling factor 4 [5]:

$$Z = \frac{k}{\chi} + 4A \qquad (4)$$

When this parameter is introduced, the identification accuracy increases sharply due to the identification at different sample sizes.
Analysis and results
Algorithm for identifying the type of distribution a random process with respect to the parameter Z can be implemented using sample values of the observed process. This algorithm consists of five steps.
Step 1. Determine the value of the counter-excess χ and asymmetry A:
- the mathematical expectation is found:

$$m_1^* = \frac{1}{n}\sum_{i=1}^{n} x_i \qquad (5)$$

where n is the number of measurements; x_i- value of a random variable;
- the estimate of the third order moment is determined:

$$\mu_3^* = \frac{1}{n}\sum_{i=1}^{n}(x_i - m_1^*)^3 \qquad (6)$$

the estimate of the moment of the fourth order is found:

$$\mu_4^* = \frac{1}{n}\sum_{i=1}^{n}(x_i - m_1^*)^4 \qquad (7)$$

the variance estimate is calculated:

$$\sigma^{2*} = \frac{1}{n}\sum_{i=1}^{n}(x_i - m_1^*)^2 \quad (8)$$

- kurtosis are found:

$$\varepsilon = \frac{\mu_4^*}{\sigma^{*4}}, \quad (9)$$

and counterexcess:

$$\chi = \frac{1}{\sqrt{\varepsilon}}; \quad (10)$$

the asymmetry is determined:

$$A = \frac{\mu_3^*}{\sigma^{*3}}, \quad (11)$$

Step 2. Determine the entropy coefficient k_e - numerical characteristic of the distribution form for the same sample as the array is considered for the investigated process and the histogram and is used RMS estimate:

$$k_e = \frac{dn}{2\sigma^*} 10^{-\frac{1}{n}\sum_{j=1}^{m} n_j lg n_j} \quad (12)$$

Where d is the width of the histogram column; n is the sample size; σ - standard deviation; m -the number of histogram columns m= n4ln (n); n_j- number observations in the column.

Step 3. The parameter Z is determined by the formula (4).

Step 4. The magnitude of the absolute value of the deviation of the ratios | d_i (Z) | is calculated, which characterizes the difference between the studied distribution and the theoretical one for a given distribution law and a given sample size:

$$| Z_{et}-Z | = d_i (Z) \quad (13)$$

where Z_{et} is the ratio parameter for the theoretical distribution law; Z is the parameter of the studied distribution.

Step 5. The value d_i (Z) is compared with the admissible deviation value d_{ei} (Z) , the result of the comparison S_i is the defining parameter characterizing the type of distribution.

Experimental curves obtained in the study of the dependence of the proposed parameter identification of the form of the distribution law Z, determined by formula (4), from the sample size (Fig. 1), for sample sizes n> 20, they do not intersect and do not lie close to each other, which makes it possible to unambiguously identify the type of distribution with volumes sample n> 20. In this case, the relative error determination of the parameter Z depending on the volume the sample does not exceed 8% (Fig. 2).

The considered method was applied to study the effect of additive noise with different distribution laws: normal, Laplace and arcsine - to the FMn signal.

Experiment parameters: carrier frequency of FM signal fн = 10 MHz; sample size of experimental data n = 1,000; frequency band 100 KHz; index modulation d = 0.5; the signal distribution in the absence of interference is identified as arcsine. The additive mixture of signal and interference was investigated.

As a result of the experiments, it was found that the noise immunity of the FSK signal at additive effect of the Laplace noise at signal-to-noise ratio (SNR) more than 1 in power is worse than when exposed to normal interference (fig. 3). When SNR <1, the noise immunity of the FM signal under the influence of the Laplace and normal interference is about the same. Arcsine noise at in all ratios "signal / noise" has a minimal effect on the type of distribution of the FM signal (the minimum of the parameter Z on the graphs corresponds to the closeness of the distribution of the signal and noise mixture to the arcsine distribution of the FM signal).

The results obtained also indicate a decrease in the coefficient of variation γ with a GSS <0.5, which corresponds to a decrease in the magnitude of the spread signal mix data and interference from mean value (fig. 4). When the OSD is> 0.5, the coefficient of variation does not change. Thus, OSP = 0.5 is the threshold for the FSK signal when exposed to an additive interference.

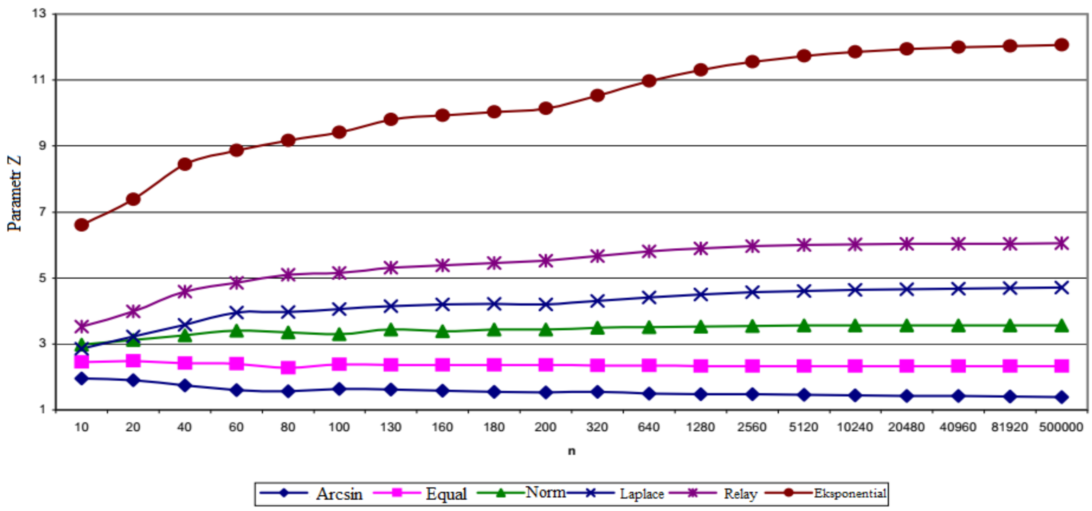

Fig. 1. Dependence of the parameter Z on the sample size for different distribution laws

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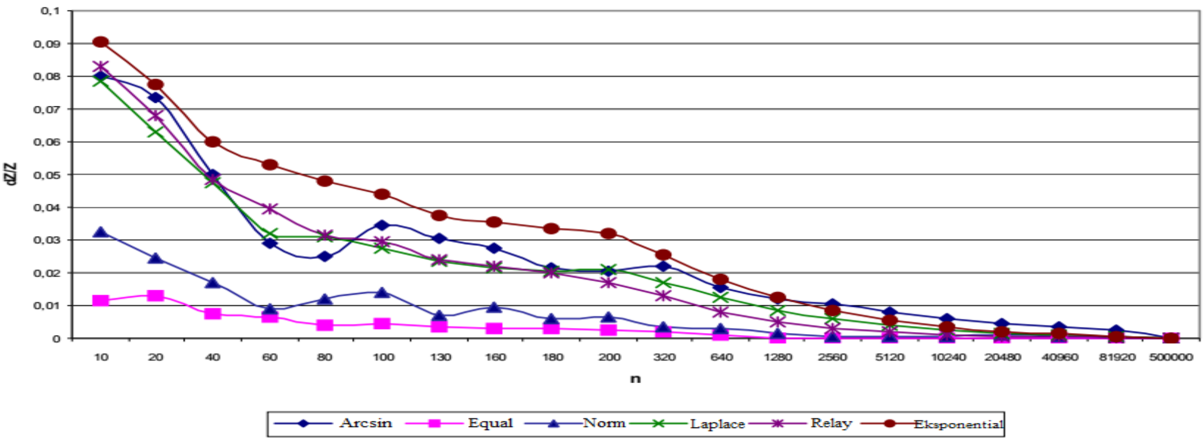

Fig. 2. Dependence of the relative error in determining the parameter Z on the sample size

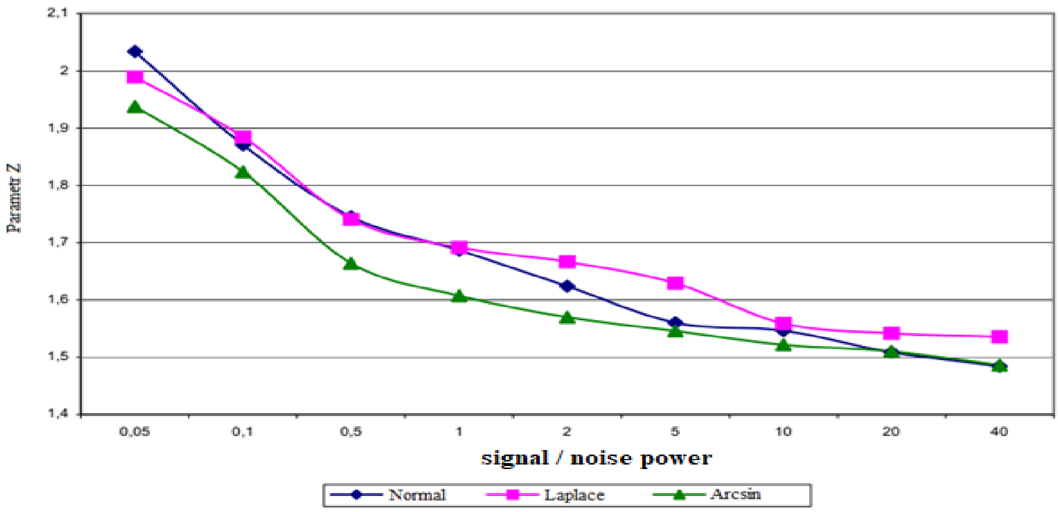

Fig. 3. Dependence of the Z parameter on the signal-to-noise ratio in power when exposed to for FSK interference signal with different distribution laws for a frequency band of 100 kHz

If we consider the dependence of the relative errors in determining the parameter Z from the signal-to-noise ratio in terms of power for frequency bands of 100 KHz and noise with normal, Laplace and arc sinusoidal distributions (Fig. 5), then we can note an increase in the relative error in determining parameter Z with a decrease in the GSS to a value of 0.1 and further decreasing the error after reaching this value, which is explained by the change in the form of the distribution law of the additive mixture of signal and noise for the given values of the signal / noise ratio: the distribution changes from arcsine to uniform.

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This value suppresses the FSK signal by interference. The relative error in determining the parameter Z in all
cases does not exceed the value dZ / Z = 0.22. Analysis of the proposed impact assessment method interference to the FSK signal using the identification parameter of the form of the distribution law Z showed that
this parameter can be used to qualitatively and quantitatively assess the presence of interference in an additive mixture of the FSK signal and interference with different distribution laws. In contrast to the coefficient of variation γ, the parameter Z changes the numerical value not only for GSP <1, but also for GSP>1. The Z parameter is also more sensitive to the presence of interference in comparison with the coefficient variations of γ.

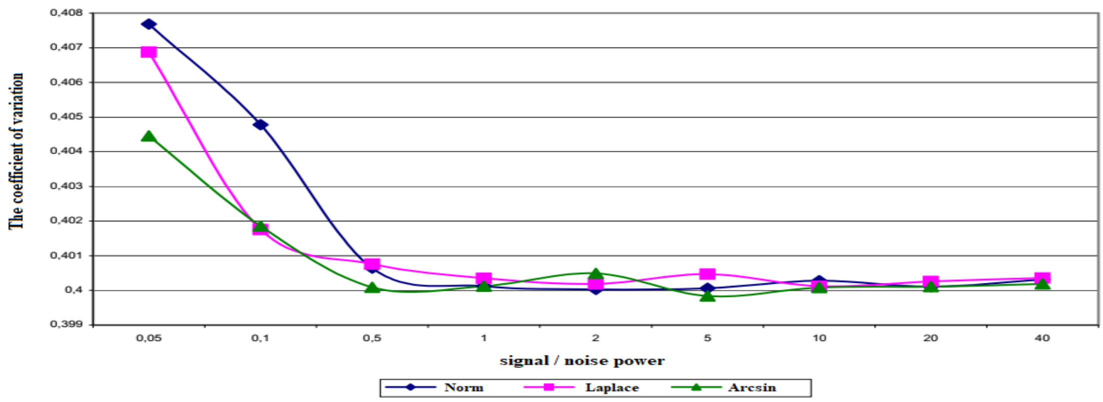

Fig. 4. Dependence of the coefficient of variation ☐ on the GSS in terms of power when the FMn signal is affected by interference with different distribution laws for a frequency band of 100 kHz

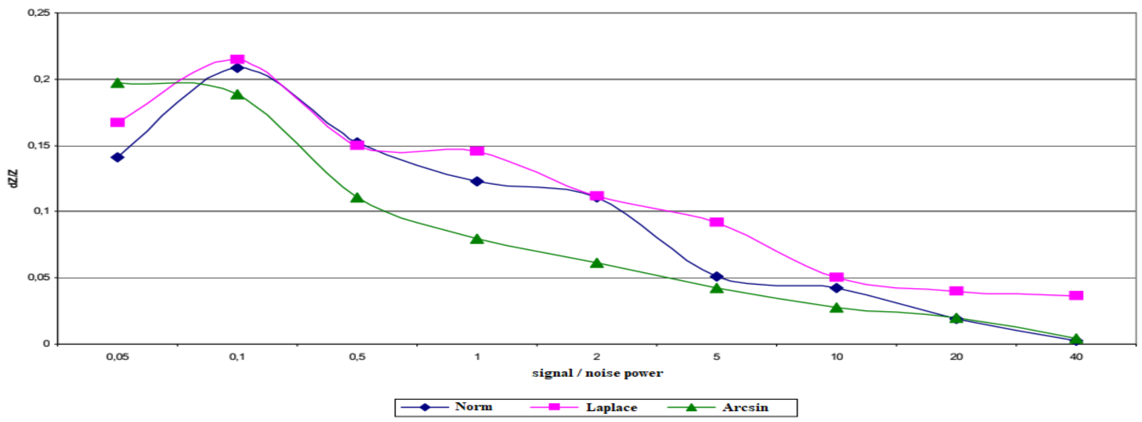

Fig. 5. Dependence of the relative error in the determination of the parameter Z on the SIR by power for the band frequencies of 100 KHz when the FMn signal is affected by interference with different distribution laws.

Conclusion

Modeling was carried out with an error identification of the type of distribution by parameter Z less than 8% for sample sizes n> 100 for all considered distributions. According to the degree of reduction of the negative impact on the FMn signal, the investigated interference was arranged in the following order: Laplace, normal and arcsine.

Thus, using this method provides the following advantages:

- Unambiguous identification with small sample sizes;
- Easy implementation using a computer, while analog processing methods are excluded, which leads to a reduction in the cost of the system (for complex systems);
- Universality of the algorithm (for new conditions just modify the program).

In addition, information about the type of distribution the interference that is present in the communication channel and the identification parameter Z can be used to improve the efficiency of automatic systems.

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