THEORETICAL FOUNDATIONS OF INTERFERENCE ANALYSIS OF NOISY SIGNALS AND POWER OBJECTS

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ABSTRACT

It is known that some interference components of signals of power objects which are formed under the influence of various factors indirectly reflect certain processes occurring on the investigated, monitored and controlled object. It is also shown that these interference components are carriers of valuable information. The theoretical bases of analysis of interference, determination of its characteristics are suggested. It is also suggested that these characteristics should be used both for increasing the reliability of the results of the signal analysis and for solving other important problems for which the application of traditional technologies is not possible.

Keywords: signal, interference, noisy signal, interference analysis, object, power objects, filtration, information technology

I. INTRODUCTION

Interference $\varepsilon(t)$ of signals of power objects is created under the influence of different factors $\varepsilon_1(t)$, $\varepsilon_2(t)$, ... $\varepsilon_j(t)$, ... $\varepsilon_m(t)$. Some of these factors $\varepsilon_j(t)$, $\varepsilon_k(t)$, ... $\varepsilon_m(t)$ indirectly reflect particular processes that occur at investigated, monitored, or controlled objects and are the carriers of valuable information. Therefore, elimination of the influence of interference should reduce to the analysis of the information contained in interference, the determination of the characteristics of interference, and the use of interference both for correcting errors in the results of analysis employing classical algorithms and for the solution of other critical problems for which traditional methods cannot be applied.

Today it is difficult to find a field where the different information technologies involved in signal analysis have not been employed. As a rule, physical signals are accompanied by interference. This makes it difficult, and sometimes impossible, to solve many extremely important problems [1].

Methods of filtration of the interference spectrum from the total signal are used in well-known information technologies and systems for these purposes. Methods for the suppression of the influence of interference through mutual compensation of its positive and negative errors have also found extensive application. To achieve greater efficiency, these methods are often used in conjunction, making it possible to combine their advantages [1–4].

II. BODY OF THE TEXT

If the filtration method is employed, there is distortion in the useful signal on the one hand, and irreversible loss of information which, in many cases, is carried by interference, on the other hand, simply because of the difficulty of selecting the range of the interference spectrum. For this reason, when different methods of filtration are employed the desired results may be obtained only if the range of the interference spectrum is correctly selected and does not intersect the spectrum of the useful signal. In the general case, however, when it is a matter of solving every imaginable problem through signal processing, more or less acceptable results may be obtained through use of well-known information technologies only if the classical conditions are satisfied, i.e., the signals that are being analyzed are stationary, obey the normal distribution law, the correlation between the interference and the useful signal is equal to zero, and the interference constitutes "white noise" [1, 5]. Even in this case the results that are obtained do not possess the property of robustness, since the interference of physical signals differs from "white noise" and the variance and spectral composition of interference vary over time [5].

At the same time under ordinary conditions these types of conditions are not, in general, satisfied, and in many cases reliable results cannot be obtained nor is it possible to construct solutions in the corresponding information systems that conform sufficiently to the situations that do arise. For this reason the number of accidents at different crude oil and natural gas production and petrochemical sites, power plants, aviation centers, and other facilities with catastrophic, human, material, and ecological consequences has not decreased, despite the fact that in recent years the reliability of microcircuitry and the hardware of information systems has increased many times over [5].

Such a situation derives from the fact that traditional methods and algorithms do not take sufficient account of the specific nature of the influence which interference in

physical signals exerts on a desired result, since there is no possibility of extracting and analyzing the information contained in the interference in the analyzed signals. Therefore, the need to create a methodology for the analysis of interference and use of such a methodology both to increase the degree of reliability of the solutions of problems derived from the results of signal processing and as carriers of useful information is of great importance at the contemporary stage of development of information technologies [1–5].

The proposed algorithms and information technologies create great opportunities for the construction of information systems that guarantee the reliability of the solution of a host of extremely important problems, including problems in mathematical simulation, identification, recognition, monitoring, diagnostics, prediction, control, etc. in different areas of life. Many traditional technologies follow from the proposed technologies as special cases. Below we present some of the technologies [1, 5–9] that have been created on the basis of the methods and algorithms proposed in the present article.

1. An information technology for correlation and spectral analysis of interference [5, 8, 9].

2. Through a combination of methods and algorithms for interference analysis and the methodology of statistical processing, a robust technology of correlation and spectral analysis of noisy signals that guarantees the reliability of results when the classical conditions are satisfied as well as when these conditions are not satisfied [5, 8, 9].

3. Methods, algorithms, and technologies for improving the conditionality of correlation matrices through weighting of the errors of the matrix elements by means of estimators of the interference in analyzed signals have been created.

4. Methods, algorithms, and technologies of identification have been created based on adequacy support by correction of the coefficients of mathematical models employing results from interference analysis of the input and output signals of investigated facilities [5–7].

III. CONCLUSIONS

Basically, through use of the proposed theory it is also possible to employ interference as a carrier of useful information, since in most cases there exists an interrelation between interference in measurement information and latent micro-variations that precede the onset of accident stages in actual facilities. For this reason there occur variations in the estimators of the variance of 10. interference, in its correlation and spectral characteristics, and in the cross-correlation function and correlation coefficient between the signal and interference long before there is any change in the characteristics of the signal from the facility that might reflect the onset of micro-variations in the state of the facility. Calculation of these estimators in the course of operation opens the way towards the creation of information technologies for the prediction of accidents in underwater stationary sea platforms and pipelines, at compressor plants, and at electric power stations, the prediction of accidents in the course of drilling of oil wells, increased reliability in the diagnostics of the technical state of controlled plants, etc. [5, 9].

Use of these algorithms will also make it possible to significantly increase the quantity of information extracted from dynamograms, seismic signals, electrocardiograms, etc., which will in turn greatly increase the degree of reliability of the results of the problems that we wish to solve.

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