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The Estimation of Noise Signals Characteristics of Wind Power Units

The paper presents the problems of estimating the characteristics of noise signals of wind power units. The received characteristics are expedient to use in the further for technical diagnostics of wind power units.

Introduction. To increase the reliability of technical systems and energy objects, an important role is played by functional diagnostic systems. The source of information in such systems are noise signals - vibrations, acoustic noises, etc. Adequate mathematical models of noise signals are necessary for the development of diagnostic systems. Such models should not only reflect the physics of signal origin, but also provide the ability to search for new diagnostic parameters that are based on different probabilistic characteristics of noise signals. However, to date, the issue of determining mathematical models of signals suitable for solving problems of modeling diagnostic noise signals has not yet been fully developed.

In recent decades Ukraine, like the rest of the world, has paid considerable attention to non-traditional and renewable sources of electricity, in particular, wind power. The wide introduction of wind power units requires the simultaneous creation of specialized diagnostic systems for them. The development of such systems requires, first of all, detailed study of the technical object itself, including studies using mathematical models of a number of physical processes that accompany the operation of wind power units.

In connection with this, the report presents the problem of estimating the characteristics of the noise signals of wind power units.

Formulation of the problem. To present a constructive model of a noise signal for mathematical and computer modeling. Develop an algorithm and software for estimating the characteristics of noise signals of wind power units on the basis of the presented model.

The main results. A constructive method for creating models of noise signals based on the use of a random process such as white noise is known in various applied problems of signal analysis as a method:

- a linear forming filter;
- generating process;
- stochastic integrated images.

Analyzing the use of these methods in creating models of noise signals, we can conclude that the method of stochastic integral images essentially summarized the results of these other methods and justified the class of linear random processes.

Usually, when modeling linear random sequences as noise signals, attention is paid only to the stationary case. At the same time, in practice, almost all real noise signals are non-stationary, so the use of such sequences as a model is inappropriate. In order to describe all possible variants of the formation of noise signals, a constructive model of the noise signal was developed. This model can be used for mathematical and computer modeling as a three-component vector random process of the form:

$$\Xi_3(\omega,t) = \left({}_1\xi(\omega_1,t),\ {}_2\xi(\omega_2,t),\ A(t)\right),\omega = (\omega_0,\ \omega_1,\ \omega_2),\ t\in T. \quad (1)$$

As components of a random process of the form (1), the following use:

1. component ${}_1\xi(\omega_1,t) = \sum_{i=1}^{n} {}_1\xi_i(\omega_1,t)\, I(t,\Delta T_i)$ where ${}_1\xi_i(\omega_1,t), i=\overline{1,n}$ - sequence of stationary linear random processes;

2. component ${}_2\xi(\omega_2,t) = \sum_{j=1}^{m} {}_2\xi_j(\omega_2,t)\, I(t,\Delta T_j)$ where ${}_2\xi_j(\omega_2,t), j=\overline{1,m}$ - sequence of harmonized processes;

3. component $A(t) = \sum_{l=1}^{k} A_l(t) I(t,\Delta T)$ where $A_l(t),\ l=\overline{1,k}$ - approximating functions for the realization of a random variable $\xi(\omega_0,t_0)$

4. the indicator function is given by expression:

$$I(t,\Delta T_j) = \begin{cases} 1, & t\in \Delta T_j \\ 0, & t\notin \Delta T_j. \end{cases}$$

and in practice it is formed by instant time moments of the disorder of the homogeneity (stationarity) of the components. In other words – homogeneity intervals $[0,\Delta T_1) \cup [\Delta T_1,\Delta T_2) \cup \ldots \cup [\Delta T_{n-1},\Delta T_n] = [0,T]$ of components.

Evaluation of the characteristics of noise signals of wind power units occurs for their further diagnosis. As diagnostic features are used the attenuation coefficients, the character of the probability distribution function curve, the magnitude of the first and central moments of the noise signals. In addition, attention is paid to spectral-correlation and histogram analysis of noise signals for the diagnosis of wind power units.

In all listed diagnostic features, there is one drawback: they do not take into account non-stationarity and the law of distribution of noise signals of wind power units, therefore, the authors proposed to supplement the database of diagnostic features in that each feature is located for each homogeneity interval separately. In addition, it is possible to separate the location of diagnostic features depending on the distribution law of the noise signal of wind power units (table 1).

Table 1.

Base noise signal characteristics

Gaussian Distribution	Non-Gaussian Distributions
The vector of statistical estimates of the first four moments of the signal $A = (a_1, a_2, a_3, a_4)$	
	The vector of statistical estimates of the first ten cumulants $\kappa = (\kappa_1, \ldots, \kappa_{10})$

The vector of statistical estimates - numerical sequences: - autocorrelation function; - power spectral density; - empirical distribution density; - impulse response function; - sequences of autoregressive coefficients

According to table 1, we can give the following algorithm for performing a procedure for estimating the characteristics of noise signals, presented in fig. 1.

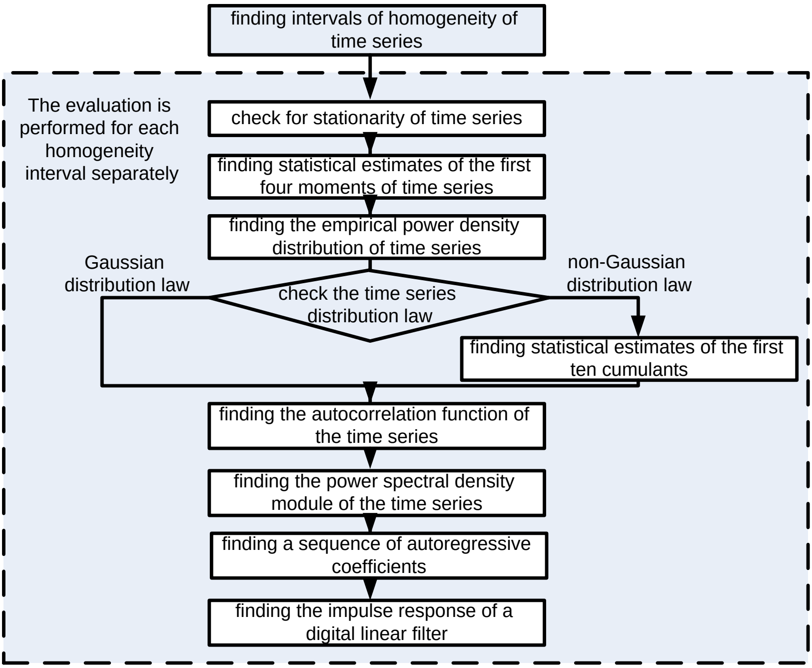

Fig. 1. A software algorithm for estimating the characteristics of noise signals

As can be seen from Fig. 1, before proceeding to an evaluation of the characteristics of noise signals represented in the form of time series, it is first necessary to divide the given time series into stationary intervals. The method for finding the intervals of stationarity is presented in [].

All other operations related to the evaluation of the characteristics of noise signals will be realized directly for each stationarity interval separately.

By finding the impulse response of the digital linear filter, we mean the finding of a set of values of the digital filter core [].

The output data of the program are output in a text file and on the monitor screen. The initial information consists of the values of variables, messages, tables and graphs.

Conclusion. The work is devoted to the estimation of characteristics of noise signals of wind power units. A constructive model of a noise signal for mathematical and computer modeling is presented. The basis of the characteristics of noise signals, which can be used to diagnose wind power units, is given. A software algorithm is developed to evaluate the characteristics of noise signals.

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