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Enhancing the Efficiency of Coherent Processing of Chaotic Signals During the Transmission of Binary Messages Using Surrogate Signals

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Abstract—A method has been proposed for reducing the influence of noise in observations of chaotic carrier during the binary message transmission using the technology of surrogate data generated with due regard for maintaining the signal attractor in phase space. The impact of the correlation of observation noise and its difference from the Gaussian noise on the probability of correct separation of one message bit is analyzed.

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INTRODUCTION

It is noteworthy that the last two decades a new sphere of knowledge combined by concept "deterministic or dynamic chaos" and its application in information technologies have undergone intensive development. The interest to this topic is primarily determined by the properties of chaotic oscillations featuring a set of specific properties that are attractive from the viewpoint of data processing and transmission with a specific degree of signal security and confidentiality of message transmission.

Chaotic oscillations can be compared to noise-like signals that are widely applied in modern telecommunications [1, 2]. The use of chaotic oscillations as an information carrier makes it possible to solve the problems of constructing new nonconventional communications systems. One of the peculiar properties of chaotic oscillations is related to the phenomenon of chaotic synchronization making it possible to obtain copies of the transmitter-generated chaotic signal [1] at the output of nonlinear filter.

At the same time attempts to implement the communication systems employing chaotic carriers exposed a series of problems. Due to the complexity of the structure of chaotic signals, their exceptional sensitivity to the initial conditions leading to exponential spreading of initially close trajectories (images of signals) in the limited area of the phase space, it is necessary to impose high demands on the "precision" of implementing separate elements of chaotic schemes and ensure the sample-to-sample reproducibility of their characteristics for ensuring the synchronous response in the receiving section of system. In addition, linear and nonlinear distortions in real physical communication channels, external noises, and other factors significantly impair the quality of transmission and frequently make it practically impossible.

One of the potential solutions of the problem dealing with destruction of synchronous response is related to the reduced duration of fragments of chaotic signals (reduced amount of sampling). As is known, however, in the presence of noise the reduced duration of signal observation leads to the degradation of signal detection characteristics and estimation of signal parameters. The methods of randomized data processing are often employed for solving the problem of maintaining the efficiency of signal processing under conditions of small-size samplings [3–7].

The purpose of this study is to demonstrate the efficiency of applying one of the methods of randomized data processing [6, 7] using the technology of surrogate data for estimating the binary message element in terms of the chaotic signal observation against the background of both the white and colored noise with normal distribution and the noise with uniform distribution.