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Structural Identification of Pseudorandom Sequences Based on Using the Nonlinear Kalman Filter

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Abstract—This study has shown the relevancy of investigating new techniques for notation and processing of signals built on pseudorandom sequences (PRS) of the maximum period. For the first time an arbitrary PRS was represented in the form of a multidimensional nonlinear finite-difference structure. On the basis of the above representation it was proposed to use a nonlinear suboptimal discrete algorithm of Kalman filtration for the problem of structural identification of received PRS. A numerical example of filtration of the sequence generated in accordance with the specified recurrent rule was considered and its efficiency was also shown.

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INTRODUCTION

Nowadays the problem of creating effective systems of signal identification built on pseudorandom sequences of the maximum period becomes increasingly urgent, while its solution appears to be ever more relevant in different areas of practical activity, for example, in actively developed now telecommunications systems with code division of subscribers, in satellite radio navigational systems (SRNS), in information security systems (ISS), etc. [1–3].

The existing methods for identifying the structure of received PRS that are based on using their correlation properties possess sufficiently high performance indicators at low "signal-to-noise" ratios, however, for their efficient operation they require a large sample volume of the values of observed signals, i.e. they do not ensure the required promptness of analysis. In addition, their implementation involves substantial computational burden. Note also that in the case of determining the structure of received PRS under conditions of its time shift with respect to its copy generated in the receiver it is also necessary to calculate and analyze cross-correlation functions for all possible values of the time shift that also results in the need of essential rise of the volume of computations.

The recent advent of optimal identification methods based on representation of pseudorandom sequences by Markov chains with several equiprobable states and also the methods based on using a parametric model in the form of a quasirandom process [4, 5] result in a somewhat lower demands to the volume of hardware costs, however, the above methods do not ensure the sufficient promptness and accuracy of processing, since they do not take into account in full measure the existing intracombinational relationships of symbols of received pseudorandom sequences.

Thus, the problem of development and analysis of alternative methods of representation and processing of signals built on PRS appears to be fairly urgent, since such techniques allow us to take into account more fully the specific features of structures used in code sequences, and also to ensure a more reliable reception and enhance the promptness of identification.

In order to solve the specified problem, next we shall consider pseudorandom sequences from the viewpoint of their notation (for implementing the possibility of subsequent estimation) in the form of time multidimensional nonlinear finite-difference structures.

SYNTHESIS OF A MULTIDIMENSIONAL PRS STRUCTURE

A pseudorandom sequence formed in accordance with the specified recurrent rule (in technical implementation—by using a shifting register with the feedback specifying the rule of sequence formation) can be presented (while using the "rising" difference circuit) in the form of a modular difference equation having the following form: