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Detection Efficiency of Signal with Unknown Non-Power Parameter Using Algorithms Based on the Compressive Sensing Theory

D. Yu. Golovanov* and V. I. Parfenov**

Voronezh State University, Voronezh, Russia
**ORCID: 0000-0002-2070-9944, e-mail: golovanov@amm.vsu.ru*
***ORCID: 0000-0001-9815-5657, e-mail: vip@phys.vsu.ru*

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Abstract—The problem of detecting quasi-deterministic signals against the background of noise during the digital processing has been considered. In this case, at the specified detection efficiency, the minimum criterion of required arithmetic operations was used as a synthesis criterion for such algorithms. To this end, such algorithms were synthesized based on concepts of the compressive sensing theory. The computer simulation was used to check the efficiency of developed algorithms making it possible to determine the manner in which the total probability of detection errors depends on the signal-to-noise ratio and the compression ratio (ratio of the number of elements in the sufficient statistic vectors before and after "compression"). The detection efficiency losses of proposed algorithms were determined in comparison with the classical optimal algorithm in accordance with the maximum likelihood method at different values of signal-to-noise ratio and compression ratio. At the same time, the paper indicates the gain in the number of used arithmetic operations of proposed algorithms as compared to the classical one. The presented results allow us to make a sound choice of detection algorithm depending on the available hardware resources and admissible degradation of the detection efficiency.

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INTRODUCTION

The detection theory is a well-known and well-established issue of statistical radio engineering that has been repeatedly presented in monographs and study materials [1–4]. However, the investigations dealing with the detection theory continue that is indicated by regularly published journal papers devoted to this subject.

Generally, only special issues of this theory are considered. This paper is devoted to the development and investigation of new algorithms for the detection of digital signals with unknown parameters, the practical implementation of which requires a much smaller quantity of mathematical operations as compared with known algorithms.

A consistent trend toward building of different-purpose radio systems completely in digital domain has emerged in recent years [5]. In this case, the signal from the receiving antenna output is fed directly into an analog-to-digital converter and further processing is performed directly over the samples of input signal. The number of samples undergoing processing is determined by the maximum frequency in spectrum of this signal [4, 5]. An increase of this frequency representing a tendency of the modern development of radio electronics leads to the need of processing the increasing number of samples that in turn necessitates an essential rise of material expenses for implementation of employed algorithms. However, expensive processing devices (e.g., FPGA) in some cases cannot be used mostly due to their high cost.

As an example, we can mention the sensing networks applied for guarding extended facilities. In this case, the detection of perimeter breach of the facility involves the need of using a large number of sensors, the output signals of which can be expediently processed by using simpler and cheaper microprocessor units. It is obvious that the largest time-consuming operations at such processing will be related to multiplications and additions.

In view of the above, the main purpose of this paper is to develop new methods of signal detection against the background of interferences that require much smaller number of such arithmetic operations for their practical implementation.

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