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Enhancing Accuracy Determination of Sources of Radio Emission Coordinates by Linear Antenna Arrays

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Abstract—Two methods have been proposed for enhancing the accuracy in determining the coordinates of radio emission sources by using phase systems based on reducing the dynamic and random errors in terms of the curvature of electromagnetic wave phase front during processing the signals at inputs of linear antenna array. The reduction of dynamic errors stipulated by the limited number of terms of the Maclaurin expansion of the distance-to-source function is achieved by estimating each value of distance and bearing without use of iterative methods. The reduction of random errors occurring during the source motion is performed at the expense of preliminary estimation of values of phase difference of received signals in the process of bearing estimation and values of the difference of phase differences in determining the distance by using the least squares method in the sliding window.

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1. INTRODUCTION

The solving of problems of monitoring of sources of radio emission (SRE) implies the use of a series of techniques and systems, including the phase ones. While SRE is in the far-field zone, the SRE direction (bearing) is mostly determined by using the phase systems (PS). However, in the case of several SRE simultaneously present within one bearing, the problem of their selection cannot be solved by ordinary techniques, except the technique making it possible to determine the SRE distance on the basis of the curvature of phase front of electromagnetic wave (EMW) at the receiving end. Therefore, the possibility of estimating the motion variables of mobile SRE with high accuracy by using the spherical front of electromagnetic wave is a vital task.

The PS proposed in [1] determines the distance using the curvature of EMW front neglecting the measurement errors that complicates the practical implementation of these systems. The questions of distance estimation in PS for stationary SRE in the presence of only random errors of measurements are considered in [2, 3].

At the same time, there is a series of errors related to the processing of measurement results by approximate mathematical methods stipulated, for example, by the expansion of a function into the Taylor series with reduced number of its terms. We shall call such error dynamic and shall estimate it in determining the distance from the stationary to mobile SRE with subsequent allowance for random errors of measurements.

2. PROBLEM STATEMENT

The determination of SRE distance in PS under consideration is performed by using signals received by the linear antenna array (AA) based on measuring the difference of phase shifts ($\Delta\varphi$) between its elements (Fig. 1). Parameter $\alpha = 1/d$ is used as a basis. Its value characterizes the degree of curvature of EMW front, where d is the distance to SRE with respect to the AA central element.

AA consists of $M + 1$ receiving elements ($M = 2, 4, 6, \ldots$). The distance $D(L, \beta, d)$ from an arbitrary AA element to SRE in the first quarter of coordinate system (Fig. 1) is determined on the basis of the cosine theorem:

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

ADDITIONAL INFORMATION

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