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MEASUREMENT OF PARTIAL DIRECTIVITY CHARACTERISTICS OF RECEPTION CHANNELS IN DIGITAL ANTENNA ARRAYS

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A new technique is suggested for measurement of directivity characteristics of reception channels in a digital antenna array when the channels are not identical.

Accurate measurement of echo signal parameters in digital antenna arrays (DAA) presumes the knowledge of partial directivity characteristics (DC) of reception channels. In order to estimate the DC as applied to phased antenna arrays (PAA), a rich variety of methods have been suggested. However, application of the same methods to DAA is hardly possible because of different circuit solutions in the above classes of antenna systems. This can be explained first of all by a peculiar analytical description of the responses of PAA reception channels. According to [1], such a response, being related to the time instant s, represents the total voltage

$$y_s = \sum_{n=0}^{N-1} C_n a_n + \varepsilon_s$$

where C_n are some known coefficients; a_n is the amplitude of excitation of the nth channel; and ε_s is the measurement error.

Summation of the channel voltages in PAA with shaping only several beams makes impossible the measurement of directivity characteristics of the whole totality of N channels with the aid of a single time sampling. In DAA the response of every primary channel exists autonomously and can be expressed independent of other channel's voltages. Because of this, the technique used in [2] for estimating DC through solution of a system of equations set up by the voltages of the reception channels, can be applied in the case of DAA only after a radical adaptation.

As a rule, the known techniques of DC estimation are oriented to a "well stabilized" source of the test signal [2, 3], otherwise they are not optimal for DAA and may give considerable errors. So, of interest is development of procedures for measurement of directivity characteristics of the primary channels of the receiving DAA, which, despite poor stability of the test signal, could guarantee an estimation accuracy close to that potentially attainable.

Note that the algorithms suggested in this paper can be employed not only in methods dealing with an immobile antenna, but also with its rotation [2]. In our calculations this fact will not considered in detail. As for the digital antenna array configuration, we assume that it represents a string of equidistantly arranged elements.

In real-valued description of directivity characteristics in such an antenna, the test signal voltage at the output of the kth reception channel at the sth time instant can be written in the form

$$\dot{U}_{k_s} = U^c_{k_s} + \mathrm{j}U^s_{k_s} = \dot{a}_s F_k(x)\exp(\mathrm{j}x_k) + \dot{n}_{k_s}, \tag{1}$$

where $\dot{a}_s = a^c_s + \mathrm{j}a^s_s$ is the complex amplitude of the test signal at the sth time instant ($a^c_s = a \cdot \cos\varphi$ and $a^s_s = a \cdot \sin\varphi$ are the quadrature components, while φ is the signal's initial phase); $F_k(x)$ is the value of the directivity characteristic of the kth primary channel in the direction x; $x_k = x(k-1)$, $x = (2\pi/\lambda)d\sin\theta$ is the generalized angular coordinate of the test source with

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