ISSN 0735-2727, Radioelectronics and Communications Systems, 2013, Vol. 56, No. 3, pp. 107–113. © Allerton Press, Inc., 2013.
Original Russian Text © A.E. Kalashnikov, A.M. Bobreshov, 2013, published in Izv. Vyssh. Uchebn. Zaved., Radioelektron., 2013, Vol. 56, No. 3, pp. 3–10.

Forming of Energy Radiation Patterns of Ultra-Wideband Antenna Arrays with a Low Side-Lobe Level[1]

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Received in final form March 27, 2012

Abstract—Analytical expressions have been obtained for calculating an optimal waveform of the pulse exciting elements of an ultra-wideband antenna array. The criterion of optimality is the minimum of integral side-lobe level. The proposed approach enables us to take into account the signal duration and spectrum limitations and also the impulse response of antenna elements.

DOI: 10.3103/S0735272713030011

STATEMENT OF PROBLEM

The use of ultrashort pulses in radiolocation and telecommunications is a new and promising trend [1]. Such pulses allow us to retrieve much more information about the target than traditional narrow-band signals and provide an opportunity for both enhancing the accuracy of radars and performing more exact target identification.

The ever increasing attention in the scientific periodical publications has been recently paid to the radiation of ultrashort pulses by antenna arrays. By analogy with the conventional ones these arrays make it possible to enhance the directional properties of antenna system, improve the energy characteristics of radar and increase its spatial resolution.

The vast majority of papers dealing with this topic imply that such arrays are built by using the principle of coherent combining of signals in space [2–7]. In this case, the signals fed to all array elements have the same waveform and magnitude. The delays of signals are selected in such way that ensures their coherent combining in the desired direction of the far-field region. Only some papers [2–4, 8–11] involved attempts to estimate the impact of the waveform of drive (excitation) pulses on the array characteristics. However, the specified papers either consider the radiation patterns for a specific set of preselected input signals [2–4, 8, 10] or make only general conclusions regarding the impact of pulse parameters on the array characteristics [9, 11].

Paper [12] deserves particular attention. This paper presents an approach for possible calculation of the required waveform of input signal using the predetermined angle-and-time field relationship in the far-field region with due regard for the impulse response of radiating elements.

In practice, however, the proper angle-and-time field relationship in the far-field region $f(t,\varphi)$ is not important. Under the circumstances it is of interest only antenna system characteristics such as directive gain, side-lobe radiation level, etc. In this case, there are often only general limitations for signal parameters, such as the maximum duration of input pulse and the minimum and maximum frequencies of its spectrum. Such problems arise, for example, in the field of ultra-wideband radiolocation and radioelectronic countermeasures.

The present paper proposes mathematical tools making it possible to calculate the required waveform of input signal of linear equidistant ultra-wideband antenna array using the criterion of minimum of the average side-lobe level. It involves the account of limitations on the input pulse duration and its frequency spectrum boundaries. It is assumed that antenna elements are excited independently and in the general case the

[1] This study was carried out within the framework of Federal Target Program "Research and Academic-Teaching Staff of the Innovation Russia" for the period of 2009–2013.