A Modified-Binomial Linear Array with Reduced Grating Lobes and One-Wavelength Element Spacing

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Phased array antennas are widely used in a variety of applications, such as satellite communications and radar, because of their high gain, high tracing accuracy, swift switching capability, and most importantly unique electronic beam scanning characteristic. However, scanning phased array antennas with element spacing greater than half a wavelength usually generate grating lobes in the visible region, which worsen for wide scan angles. Some previously reported techniques for grating lobe suppression in phased array antennas include non-uniform element separation, array element shaping, and different optimization methods. Unlike conventional single-mode antennas, multimode antenna elements exhibit unique characteristics in terms of radiation profile, which can be used in phased arrays to reduce grating lobes. For example, the odd-mode excitation in a horn antenna with large aperture sizes (R. J. Mailloux, and G. R. Forbes, IEEE Trans. Antennas Propag., 21, 5, 597-602, 1973) was adopted to reduce grating lobes and the number of elements in a phased array antenna. In the aforementioned techniques, either the element separation was half a wavelength with a limited scan coverage or the achieved grating lobe reduction was in the order of 14 dB only.

In this paper, a novel method is proposed to reduce grating lobes of a linear phased array antenna, consisting of dual-mode microstrip patch elements, with one-wavelength element spacing for scanned beams up to ±40°. The dual-mode circular microstrip patch antenna operates at the fundamental TM_{11} mode with a broadside radiation pattern and the higher order TM_{21} mode with a conical radiation pattern. A seven-element linear phased array, whose array elements are excited by a modified binomial expansion and distributed along the *x*-axis as shown in Fig. 1, is investigated. By simultaneously exciting these two modes with a proper mode content factor, a self-scanning and adaptive nulling radiation profile can be realized, which can effectively be utilized to nullify the unwanted grating lobes. It will be shown that, for the scan angles up to ±30°, the simultaneous excitation of the modes with a modified binomial amplitude distribution can reduce the grating lobes to well below -26 dB, and for the scan angle of ±40°, the grating lobes as low as -22.5 dB are achieved. Such reduced grating lobes in a scanning phased array antenna with one-wavelength element spacing is significant. The array performances in terms of grating lobes are compared for both standard binomial and the proposed modified excitation coefficients. The corresponding case studies of different scan angles will be presented and discussed in the conference.

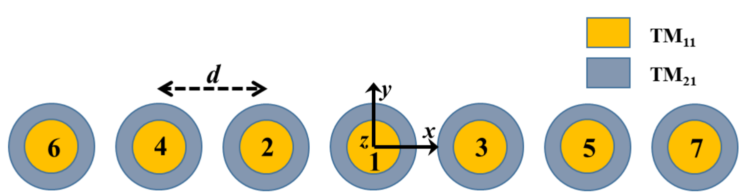

Fig. 1. Geometry of the seven-element linear phased array with a modified binomial amplitude distribution, consisting of dual-mode circular patch antennas with element spacing of $d = \lambda$.