On the Method of Grating Lobe Reduction of Scanning Phased Array Antennas

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Over-moded antenna elements have been used in phased array antennas to accomplish certain goals. For example, an odd mode scanning technique (R. J. Mailloux, and G. R. Forbes, IEEE Trans. Antennas Propag., 21, 5, 597-602, 1973) was introduced to reduce the number of elements to realize thinned arrays with low grating lobes, where a horn antenna was used as an array element. Another method (L. Shafai, and H. A. Ragheb, Canadian Jour. Elec. Comp. Engr., 17, 3, 98-106, 1992) was reported to reduce the number of elements as well as grating lobes in phased array antennas comprising of dual-mode open-ended waveguides. In the aforementioned works, the overall structures of the phased array antennas were bulky due to the three-dimensional profile of the constituting waveguide/horn elements. Moreover, uniform amplitude excitation was mainly reported for these phased array antennas.

Herein, a novel approach is presented to reduce grating lobes in a planar scanning phased array antenna with reasonably large element spacing in the order of one wavelength. The array is comprised of one central element surrounded by six evenly distributed elements forming a circle of one wavelength (λ) radius, as shown in Fig. 1. The array element is a dual-mode circular microstrip patch antenna, capable of generating axial and conical radiation patterns by exciting the TM_{11} and TM_{21} modes, respectively. It will be shown that in order to reduce the grating lobes for broadside radiation patterns, only the TM_{11} mode needs to be excited. By controlling the amplitude distribution of the peripheral elements, grating lobe level is decreased to well below -30 dB for broadside radiation patterns. However, as the main beam is scanned off the boresight direction of $\theta=0^o$, the grating lobe level starts to rise, and the excitation of a single TM_{11} mode is no longer sufficient to reduce the grating lobe to an acceptable limit. Thus, to effectively reduce grating lobes, the higher order TM_{21} mode is excited along with the fundamental TM_{11} mode in the circular microstrip patch phased array. By controlling the mode content factors of the dual-mode patch element, as well as amplitude distribution of the peripheral elements, reduction of grating lobe level, down to -30 dB, is achieved for scanning angles up to $\pm 50^o$, which is promising for such scanning phased array antennas. It should also be noted that this is realized for large element spacing in the order of one wavelength. The corresponding results for several case studies in terms of different scan angles and element spacing will be presented and discussed in the conference.

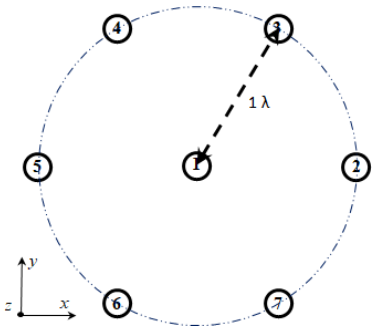

Fig. 1. A 7-element antenna array of a triangular lattice with six elements on the periphery and one element in the center.