A New Synthesis Technique for Near-Field Focusing Systems

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Pattern synthesis techniques have been widely used during the years to define and sculpt the radiation patterns of an antenna system in its far-field region. However, in several applications such as near-field probing and radiometry, medical imaging, etc. it is important to focus the energy in the Fresnel zone or even in the extreme near-field (reactive zone) of an electromagnetic device. In (J. W. Sherman, III, IRE Trans. Antennas Propagat., vol. AP-10, no. 4, pp. 399-408, July 1962), the properties of the electromagnetic fields in the far-field and Fresnel zone of a focusing radiating aperture are examined. The latter are the fields near the axis of a defined focal plane parallel to the aperture. It is shown that the fields in these two zones present the same properties as long as a quadratic phase taper of the tangential field distribution is adjusted on the focusing aperture. Therefore, the optimization/shaping of fields in the Fresnel zone can be achieved by using classical far-field techniques. However, this is not possible within the near-field or reactive zone of a radiating system.

In contrast to previous works derived from Sherman's conclusions, here we propose a new technique for shaping the near field of a focusing aperture based on an alternate projection method (O. M. Bucci, et al. Proc. IEEE, vol. 82, no. 3, pp. 358-371, Mar. 1994). The required near field is defined along a focusing plane in front of the aperture in terms of the desired axial pattern around the focal point and/or transverse plane patterns. The required field is described in terms of the focus depth, relative amplitude of forelobes and aftlobes. side lobe level, half power beamwidth, etc. Circular and linear polarized fields are considered. The possibility to control specific components of the field is also envisaged. Once the required near field pattern is defined, the aperture field distribution is found thanks to a combination of the alternate project method and a Fast Fourier Transform (FFT) algorithm. The FFT algorithm is used to evaluate the field at the focusing and aperture plane avoiding unnecessary approximations of previous works. Finally, a radial line slot array (RLSA) is used to synthetize the derived aperture field distribution in phase and amplitude. An in-house fast Method of Moments is employed during this step to control the aperture efficiency and distribution error.

Several examples will be proposed during the conference. In particular, the possibility to generate with an RLSA arbitrary propagating Bessel beams will be presented. The proposed technique paves the way to the synthesis of any desired field shape in the near-field zone of a radiating structure.