ANALYSIS OF FINITE ARRAYS WITH ELEMENTS OF COMPLEX SHAPE

Hans Steyskal * (1), Sergey Makarov (2)
(1) ARCON Corp., Waltham, MA 02451, USA
(2) WPI, Worcester, MA 01609, USA

The description of the current on a phased array element of complex shape typically requires on the order of 100 subdomain basis functions and thus the analysis of a finite array of (say) 100 elements leads to the order of 10,000 unknowns. This may cause inconveniently long computer times, particularly for use in an iterative design loop, and makes a reduction of the number of unknowns desirable.

Most phased array elements are small in terms of wavelength and often behave like a resonator. On physical grounds, therefore, it may be expected that the scan-dependent element currents can be closely approximated by only a few modes. This observation motivated our search for `custom modes' for arbitrarily shaped array elements, and lead to a computational technique based on the Karhunen-Loeve expansion. We showed these modes to efficiently approximate several given, exact current distributions on elements at various locations in a finite array and at various scan angles [H. Steyskal, J. Herd, PIERS, 1998]. However, our ultimate intent was to employ these modes for the analysis of the currents on an entire finite array, where they would potentially reduce the number of unknowns by one or two orders of magnitude. This is demonstrated in the present paper.

The custom modes are obtained from the current distribution on an element in an infinite array. We presently consider planar patch elements. Using a method of moments analysis we determine the surface current **j**(x,y,u,v) as a function of the spatial variables x,y and the scan variables u,v. Applying the Karhunen-Loeve expansion to **j** we obtain the desired set of modes { $\mathbf{f}_n$ }, which are functions of x,y only. Finally, in the finite array analysis, each element current is approximated by a set of M_c such modes with unknown amplitudes, rather than by a set of M subdomain currents with unknown amplitudes. Since $M_c \ll M$ this leads to a much smaller system of equations and to considerable computational savings.

We apply the modal expansion to the currents on several finite arrays, and show that it converges well also for elements on the array periphery, even though the modes are derived from the infinite array element.