Efficient Asymptotic Closed Form Evaluation of the MoM Impedance Matrix for Antennas and Large Antenna Arrays in a Grounded Multilayered Medium

C. W. Chuang, P. H. Pathak and P. Janpugdee*

ElectroScience Lab, The Ohio State University
1320 Kinnear Road, Columbus, OH 43212, USA
E-mail: pathak.2@osu.edu

The conventional procedure for the evaluation of MoM impedance matrix arising in the integral equation solutions for antennas in grounded multilayered medium generally involves a numerical treatment of the Sommerfeld-type integral representation for the field. The latter integral exhibits pole and branch cut singularities in the integrand; also, the integrand oscillates very rapidly with increasing separation between the source and field points, thus making the computation of the off-diagonal impedance matrix elements very time consuming or even intractable. To overcome the problems in computing the Sommerfeld-type integral, an asymptotic closed form solution was obtained for the integral pertaining to a single layered structure (M. Marin, S. Barkeshli and P. H. Pathak, IEEE Trans. MTT, 4, 669-679, 1989; S. Barkeshli, P. H. Pathak and M. Marin, IEEE Trans. AP, 9, 1374-1383, 1990; G. A. Somers and P. H. Pathak, Radio Sci., 29, 465-481, 1994; P. R. Haddad and D. M. Pozar, IEEE Trans. AP, 11, 1545-1549, 1994). These asymptotic closed form solutions are seen to be accurate not only for lateral separations of the source and field points which are large, but also for separations which are as small as half a free space wavelength. This technique was also extended to a double-layer medium (M. A. Marin and P. H. Pathak, IEEE Trans. AP, 11, 1357-1366, 1992). Unfortunately, at that stage, the extension to multilayered structures appeared formidable due to its mathematical complexity. In particular, the leading term in the asymptotic expansion vanishes in all of these cases so the evaluation of the second term becomes necessary. The second term in the asymptotic expansion is generally far more cumbersome to evaluate than the first term, and this is even more so for the multilayered case. However, recently it was discovered that despite the formidable expression in the integrand for the multilayered case, a simplification does occur toward the end of the development leading to a relatively simple scheme to obtain the second order term. The latter development of the asymptotic solution for the multilayered case is reported in this paper. Numerical results for the multilayered case show that the asymptotic closed form solution obtained also remains accurate for source and field point separations as small as half the free space wave length. In addition, the results also compare very well to those presented in the above references for the special cases of single and double layers. The present asymptotic solution is applicable and useful to the analysis of large finite arrays in multilayered structures, where it will significantly reduce the computational time by one or more orders of magnitude depending on the size of the array. In addition, numerical results for printed crossed dipole arrays in a grounded multilayered medium will be shown to demonstrate the efficiency of the present asymptotic solution.