Fast Solution of Large Composite Metallic and Dielectric Body of Revolution (BOR) Radiators

Jie Chen [1], Wendell A. Brokaw [1,2], and Thomas X. Wu [1]

[1] School of Electrical Engineering and Computer Science, University of Central Florida, Orlando, FL 32816
[2] Harris Corporation, Melbourne, FL 32902

A full wave analysis method to determine the scattering parameters and the radiation field intensities of arbitrary Body of Revolution (BOR) radiators consisting of both metallic and dielectric materials is explored. Structures that exhibit rotational symmetry about the longitudinal, or directional, axis are defined as bodies of revolution (BOR). The complexity of the domain of structures that can be treated with a general solver will be significantly reduced through the use of BOR symmetry of the structure. The method for solution of the structure will include a comprehensive treatment of Boundary Value Problems (BVP's) through modal analysis, aperture treatments, and a hybrid application of the method of moments and iterative solution methods.

Solutions for BOR structures with composite metallic and dielectric bodies can be divided into two regions of analytical concern, the inner guided wave region, and the outer radiating region. Excitations are normally fed from inside a guided metallic structure or at the end of the body. Dielectric materials could be present inside the guided structure. Modal analysis is used to determine the scattering matrix of the inner guided wave region. The modal analysis consists of subdividing the inner region into a number of finite step discontinuities, and then the method of mode matching is implemented to numerically solve the BVP's at each step discontinuity for a finite number of modal field distributions. A magnetic current is imposed to equate the excitation fields at the aperture. The guided metallic structure with aperture is considered as a metallic body with zero fields inside it. Only electrical current is induced at the surface of metallic bodies, but both electrical and magnetic current are induced at the surface of dielectric structures. Currents with the same quantity and opposite direction are present inside dielectric bodies, which maintain field continuation across the surface of dielectric bodies. A combined algorithm utilizing the method of moments (MoM) and the conjugate gradient (CG) method is applied to iteratively solve integral equations that are defined to treat the surfaces of the BOR structure using electromagnetic boundary conditions. Asymptotic evaluation technique is also applied to replace numerical integrals, which greatly accelerates the population of matrices. An admittance matrix will be numerically calculated. The admittance matrix will then apply to the inner guided wave region's scattering matrix to determine the reflection and transmission coefficients at the input of the BOR radiator.