Analysis of Slotted Sectoral Waveguide Array Antennas with Multilayer Radomes and Nonzero Metal Thickness

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Slotted waveguide array antennas offer low cross-polarization and high power handling capacity, and they are low-profile which enables them to be used in conformal and structurally-integrated antenna solutions. Hence, they are excellent candidates for phased array antennas in radar applications, especially in air platforms. Aerodynamics and radar cross section (RCS) for an air platform are critical design considerations for air platforms; therefore, conformal and structurally-integrated solutions with integrated multilayer (sandwich) radomes are desired. Although the accurate and efficient design and analysis of low-profile conformal slotted waveguide arrays is of great interest, available solution methods in the literature usually suffer in terms of efficiency and memory requirements. Among the available solution methods, one of the widely used solvers are integral equation (IE) based ones that utilize the method of moments (MoM). However, IE solvers suffer from long matrix fill times, especially when cylindrically stratified media are considered.

In the previous works of the authors, a slotted sectoral waveguide antenna, covered by multiple dielectric layers was successfully analyzed with a hybrid MoM/Green's function technique in the space domain (M. Kalfa and Vakur B. Ertürk, 2014 USNC-URSI, 2014). In this study, the nonzero thickness of the metal on which the slots are cut is also taken into consideration. With the ability to model the nonzero metal thickness, more accurate simulations can be performed which can model the actual antenna to be produced, without crude assumptions about the geometry. In the developed analysis method, only the fundamental mode (TE_{11}) is assumed to be excited inside the waveguide(s). The longitudinal slots are on the broadside wall of the waveguide and are very short in the transverse direction, so that longitudinal electric fields can be neglected. Invoking the equivalence theorem, and using fictitious magnetic current sources on both ends of the waveguide slots, while covering the slots' two apertures with perfect electric conductors (PEC) the solution domain of the problem is divided into three regions: sectoral waveguide(s), sectoral cavities, and the multilayer cylindrically stratified medium, which are coupled to each other through equivalent magnetic currents. Then the equivalent magnetic sources are expanded by piecewise sinusoid (PWS) basis functions, and the continuity of the tangential magnetic fields across the slots is used to construct the magnetic field integral equation (MFIE). The integral equations are then converted into matrix form using Galerkin's procedure. To compute the elements of the mutual admittance matrix, three Green's function representations for the three solution regions are required. For the waveguide interior and the exterior stratified region, the dyadic Green's function components that were previously developed by the authors are used. For the sectoral cavities, Green's function components are rigorously derived. Finally, the equivalent magnetic currents are computed using iterative matrix inversion techniques.

Numerical results in the form of equivalent magnetic currents, S-parameters, far-field patterns, and realized gain for various antenna designs will be presented, and compared to the results obtained from the commercially available full-wave electromagnetic solvers.