Analysis and Design of Hard Surface Guided-wave Structures

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In the present paper, we study a rectangular waveguide with an ideal hard surface, which is modeled by alternating a longitudinal perfect electric conductor (PEC) and perfect magnetic conductor (PMC) strips with vanishing widths. We also design a realistic hard surface rectangular waveguide structure based on numerical simulations using the commercial software HFSS [Version 9.2.1, 2004 Ansoft Corporation]. Compared to PEC and PMC rectangular waveguides, which can support only TM and TE modes, the most important feature of this “ideal hard surface rectangular waveguide” is that it allows propagation of a TEM mode with a zero-cutoff frequency, which can provide new applications for this type of guided-wave structure.

The purpose of the this paper is to develop an electric dyadic Green’s function for the modal analysis of an ideal hard surface rectangular waveguide excited by an arbitrarily-oriented electric current source. A procedure of deriving the Green’s function in terms of solenoidal and irrotational parts is presented, wherein the solenoidal part of the Green’s function is obtained in the eigenmode expansion form as a superposition of three terms associated with TM, TE, and TEM modes of the ideal hard surface waveguide. A term corresponding to the TEM mode is obtained analytically as the solution of a vector Helmholtz’s equation in the zero-cutoff limit subject to the boundary conditions of electric field on the ideal hard surface. Numerical results for the field distribution are demonstrated for the TEM mode and a few representative TM and TE modes propagating in a rectangular waveguide with ideal hard surface boundary conditions due to an arbitrarily-oriented electric dipole source. To validate the proposed model, a realistic hard surface rectangular Waveguide is simulated using the commercial software HFSS. A square hard surface waveguide with narrow PEC strips placed on top of dielectric walls is modeled at 10 GHz. The following parameters are used in the design: waveguide dimension are 23.74 mm × 23.74 mm, relative dielectric constant is 2.5, slab thickness is 6.12 mm, strip width is 0.5 mm and gap width is 1.5 mm. The uniform magnitude and vector E-field distribution plots of the realistic structure will also be shown in the presentation.