Surface Integral Equations for Mixed Impedance Boundary Conditions

Pasi Ylä-Oijala*, Sami P. Kiminki, Henrik Wallén, and Ari Sihvola
Aalto University, Department of Radio Science and Engineering, Finland

Surface integral equations can be used to find time harmonic electromagnetic fields scattered by arbitrarily shaped homogeneous and piecewise homogeneous objects. In some special cases, the fields inside the scatterer can be modeled with mathematical boundary conditions. With these conditions the solution procedure can be restricted to the boundary surface of the scatterer only and the fields inside the body need not to be modeled. The most well-known electromagnetic boundary conditions are the PEC (perfect electric conductor) condition, and its dual, PMC (perfect magnetic conductor) condition. These conditions state that the tangential component of the electric or magnetic field vanishes on the surface of the scatterer. Impedance boundary condition (IBC) is a generalization of the PEC condition and defines a relation between the tangential electric field and the rotated tangential magnetic field.

Recently, the classical IBC has been generalized by writing the boudnary condition for the TE and TM components of the fields (H. Wallén, I.V. Lindell and A. Sihvola, IEEE Trans. Antennas Propag., 59, 1580-1586, 2011). This gives arise to two scalar impedance boundary conditions, called as "mixed impedance boundary conditions". The usual PEC and PMC, as well as the more recently introduced DB and D'B' (I.V. Lindell and A. Sihvola, IEEE Trans. Antennas Propag., 58, 1128-1135, 2010) boundary conditions, are all special cases of the mixed IBC.

The purpose of this work is to introduce a surface integral equation method that can be used to numerically model time-harmonic scattering by arbitrarily shaped objects equipped with mixed IBC conditions. Using (incomplete) surface Helmholtz decomposition, the mixed IBC is written as an axially anisotropic IBC for the solenoidal and non-solenoidal components of the surface current densities. The adopted surface integral equation formulation is based on the self-dual formulation of Yan and Jin (S. Yan and J.-M. Jin, IEEE Trans. Antennas Propag., 61, 5533-5546, 2013) and the discretization process utilizes Galerkin method and Rao-Wilton-Glisson loop and star functions. As a result we obtain a single method that can be used to model different types of boundary conditions, such as the above-mentioned PEC, PMC, DB and D'B' conditions, by altering the values of the scalar surface impedances.