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High Order Impedance Boundary Condition for 3D Integral Equations

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Impedance Boundary Conditions (IBC) are widely used in computational electromagnetics to model thin coatings on perfectly conducting (PEC) objects. The IBC is used to reduce drastically the number of unknowns of the integral equations models and to obtain a better conditioned linear system that can be more efficiently iteratively solved.

Integral equations models can be built that mix homogeneous regions, whose material characteristics are defined by their electrical permittivities and magnetic permeabilities, PEC regions and IBC. These models are very efficient for the modeling of complex structures.

Usually, the impedance of a coating is assumed to be the same for all incidence angles and polarizations (standard IBC). This assumption is valid for coatings with high refractive index or significant losses. For coatings with smaller refractive index or lower losses, the accuracy of the IBC can be greatly improved by approximating it as a partial derivative equation ([1] D.J. Hoppe, Y. Rahmat-Samii, Impedance Boundary Conditions in Electromagnetics, Taylor and Francis, 1995). The second order IBC can be written as:

$E_t + b_1 \nabla_\Gamma div E_t - b_2 rot_\Gamma rot_\Gamma E_t = a_0 J + a_1 \nabla_\Gamma div J - a_2 rot_\Gamma rot_\Gamma J$
E_t and J are respectively the tangent electric field and the electric current.
Integral equations formulations for structures with homogeneous regions, PEC regions and SIBC can be generalized to take into account second order IBC.
In [1], the second order IBC is discretized with spline basis functions for 2D and body of revolution problems. Here, the second order IBC is applied to 3D problems. The currents J and $M = Exn$ are discretized with the lower order HDiv functions that can be used to model objects both smooth or with sharp edges.

A first set of validations will be presented that show the increased accuracy of high order IBC over standard IBC while the computational effort for solving the overall integral equations model remains similar.

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