Separation of Electric and Magnetic Surface Currents in Equivalent EM Problems

Ravi C. Bollimuntha*[1], Mohammed F. Hadi[1,2,3], Melinda J. Piket-May[1], and Atef Z. Elsherbeni[3]

[1] Electrical, Computer and Energy Engineering Department, University of Colorado at Boulder
[2] Electrical Engineering Department, Kuwait University
[3] Electrical Engineering and Computer Science Department, Colorado School of Mines

The surface equivalence principle shows that the problem of solving for electric and magnetic fields (E and H) due to current sources (J and/or M) can be replaced by an equivalent problem. The equivalent surface currents (J_s and M_s) on a single closed surface enclosing the volume containing the sources in the original problem, produce the same fields E and H as the original problem outside the volume and zero fields inside the volume.

We have studied whether the equivalence principle can be modified in such a manner that surface electric and magnetic currents (J_s and M_s) on two separate surfaces can produce the same fields (E and H) beyond the outermost surface.

Implementation of surface equivalence principle using FDTD inherently uses two separate surfaces for J_s and M_s, since the planes containing the tangential E and H components (used to calculate J_s and M_s) in a uniform Yee grid are offset by half a spatial step. During this presentation, we will show a detailed analysis of errors due to the separation of equivalent electric and magnetic surface currents.

In addition, we will explore the possibility of separating J_s and M_s surfaces analytically for the cases of plane, cylindrical and spherical waves. For example, we will show that it is possible to separate the equivalent current surfaces which are normal to incident plane waves, i.e. equivalent J_s and M_s from two different surfaces separated by an arbitrary distance can produce the same fields beyond the outermost surface. We will also show that the equivalence principle still holds for cylindrical waves when the separation is an integer multiple of half wavelengths of the time-harmonic source.