Application of High-order Singular Hierarchical Divergence-Conforming Bases Functions for Quadrilateral Elements to Solve the Flat Plate Problem

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For problems with smooth surfaces or other regular features, high order hierarchical bases successfully improve accuracy and efficiency. However, for geometries with edges or corners where unbounded fields or other singular types of behavior occur, high degree polynomial expansion functions often do not improve the solution accuracy. Instead, to improve the accuracy of these problems special *additive* bases that incorporate the singular field behavior were developed in the past by the authors of this paper together with other co-authors. As the order of expansion is increased, these additive bases retain the entire original polynomial set and augment it with additional singular basis functions that define the so-called *Meixner* subset. Additive bases are more flexible than other type of bases (e.g., those employing substitutive basis functions) and can model appropriate field behavior even if the expected singularity is not excited by the source, or if the cells are electrically large. A drawback to the additive approach is that the resulting system of equations is often poorly conditioned, due to the lack of linear independence between the regular and Meixner subspaces except in the immediate vicinity of the singularity.

High-order hierarchical vector basis functions of the type considered in this work are presented and discussed in detail in a recent book **[(1)** R.D. Graglia, A.F. Peterson, *Higher-order Techniques in Computational Electromagnetics* (Mario Boella Series on Electromagnetism in Information and Communication), Schitech 2015], while a comprehensive review of the special basis functions proposed throughout the literature for vertex, edge, and corner singularities has been recently published **[(2)** A.F. Peterson, R.D. Graglia, "Basis functions for vertex, edge and corner singularities: a review," DOI 10.1109/JMMCT.2017.2650962, IEEE Journal on Multiscale and Multiphysics Computational Techniques].

The high-order singular divergence-conforming bases functions for quadrilateral elements are hence available for Method of Moments (MoM) applications, although results obtained by their use are not yet well known. This presentation will assess their efficiency on a test case problem: a rectangular plate illuminated by a plane wave. Several issues to be addressed include: (1) the transformations required to deal with the singularity of the Green function and the singularity of the basis functions when evaluating the MoM self-term integrations; (2) a method for constructing the singular basis functions on-the-fly so to be able to include several singularity coefficients; (3) the impact on the system matrix condition number occurring when using several singularity coefficients, and (4) the relative quality of the results obtained.