Calculation of the Inner EFIE Integral over a Bilinear Quadrilateral to Machine Precision

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We present a new method for calculating the inner integral of the matrix element in the application of the method of moments to the Electric Field Integral Equation. The geometry panels are bilinear quadrilaterals (BQ) and the basis functions are polynomials. We show that the unstable part of this two-dimensional integral can be reduced analytically to a *one-dimensional* integral that can be stabilized to provide numerical results to double precision.

We split the integral in question into a numerically stable integral and one that has a singularity when the observation point (OP) is near or on the integration BQ. This last integral is a double integral that we evaluate analytically along one rectangular coordinate. The outcome, however, involves a logarithmic singularity and the remaining integral becomes unstable as the observation point approaches the integration BQ. We overcome this instability by rewriting the logarithmic argument. We demonstrate the robustness of the new expression by calculating the remaining integral using OPs both in the interior and on the boundary of the BQ. We use both the Gauss-Kronrod and double-exponential quadratures, two very dissimilar approaches to numerical integration, and find that they agree to at least 14 significant digits.