Residual Terms for the Wire Antenna Computation

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The wire antenna problem is a classic problem for numerical methods in electromagnetics. The common approach to the wire problem is to use the thin-wire approximation due to the extra complexity of integrating the exact kernel of the antenna problems. To integrate the kernel, it is common to separate the integral into singular and residual parts, the latter that may be integrated numerically. The singular part is basically logarithmic in nature. However, the computation of the residual part for the numerical integration requires repeated evaluation of logarithms, a computationally expensive process. The basic singular integral is a complete elliptic integral of the first kind, having a logarithmic singularity. By careful selection of the singular part, the residual part or the elliptic integral becomes almost constant. Thus one may possibly integrate the residual part analytically and much of the extra cost in using the exact kernel is lost, making the computation comparable to the thin-wire approximation while retaining the accuracy of the exact kernel.

This paper addresses the selection of the singular part, particularly some of the multiplier terms of the singular part, and the approximation of the residual left after removing the singular part. The approximation is of a rational polynomial form and eliminates the logarithmic computation. In addition, the terms may be integrated in closed for and the need for numerical integration can be eliminated. In either case, the advantage of the approximation is to reduce the computational complexity. The basic integration becomes one of integrating a typical singular part in closed form as well as integrating a simple residual approximation, either numerically or in closed form.

Indeed, for large radii wires, it may be better to use a surface formulation for the wire current and account for both components of currents on the surface (longitudinal and azimuthal). However, many problems are well suited to wire modeling and the ability to use the exact kernel with simpler computation is a major advantage to the solution of the problem.