

Efficient Simulation of Electromagnetic Scattering From Bodies of Revolution Using High-Order Pulse Green's Functions

Abdullah Noor* and Su Yan

Department of Electrical Engineering and Computer Science, Howard University, Washington, DC 20059-1015, USA (abdullah.noor@bison.howard.edu; su.yan@howard.edu)

Bodies of revolution (BoRs) are rotationally symmetric structures created by revolving a generating curve (referred to as the generatrix in its discretized form) about an axis of symmetry. The surface currents on a BoR can be represented using a finite Fourier series in the azimuthal direction and linear piecewise basis functions along the longitudinal direction. Two types of Green's functions, namely modal Green's functions (MGFs) and pulse Green's functions (PGFs), are commonly utilized in the electromagnetic scattering and radiation analyses of BoRs. While MGFs (M. Andreasen, *IEEE Trans. Antennas Propag.*, 13(2), 303–310, 1965), as 1-D integrations regarding the azimuth angle, have been widely studied, their application requires a complex combination of 2-D integrations along the generatrix and the azimuthal direction after the MGFs are generated. These integrations often necessitates computationally intensive techniques, such as forward and backward recurrences, which significantly increase the computational burden, particularly for large-scale problems.

In contrast, PGFs (J. R. Mautz and R. F. Harrington, *Appl. Sci. Res.*, 20(1), 405–435, 1969) are computed as 2-D integrals over the azimuthal angle ϕ and the plane curve t . A key advantage of PGFs is that the integral along the generatrix can be analytically evaluated in closed form using a Taylor series expansion. However, historically, the PGF approach has been limited by the 1st-order Taylor series expansion, which constrained the spacing between adjacent discretized points on the generatrix to $\lambda/10$, making the method less attractive for broader applications. This limitation contributed to the relative scarcity of literature on PGFs compared to MGFs.

Recent advancements have addressed this limitation through the development of a 4th-order approximation for PGFs of the first kind, $G^{(1)}$, and applied to the electric field integral equation (EFIE) for perfectly electrically conducting (PEC) objects (C. Zhu, *et al.*, *IEEE Trans. Antennas Propag.*, 71(11), 8799–8805, 2023). Subsequently, this formulation has been extended to PGFs of the second kind $G^{(2)}$, facilitating broader applications such as the magnetic field integral equation (MFIE) for PEC, the EFIE for dielectric objects, and the combined field integral equation (CFIE) (C. Zhu, *et al.*, *IEEE Trans. Antennas Propag.*, 72(6), 5171–5178, 2024). These higher-order approximations allow for more flexible discretization while maintaining computational accuracy.

In our forthcoming presentation, we will present a generalized formulation for the N th-order approximation of PGFs $G^{(i)}$, encompassing both $G^{(1)}$ and $G^{(2)}$. Closed-form analytical expressions will be derived to replace the numerical integrations required along the generatrix, substantially reducing computational overhead. The proposed generalized approach is not limited to a specific order N , allowing for adjustable trade-offs between computational accuracy and efficiency. We will demonstrate the performance of this formulation by applying it to the method of moments (MoM) analysis of BoR problems. The flexibility of the proposed approach enables improved performance in both accuracy and efficiency compared to existing PGF implementations, making it a practical tool for the efficient analysis of complex BoR structures. The results highlight the potential of higher-order PGFs in computational electromagnetics, particularly in scenarios where MGFs are computationally prohibitive.