High-Order Integral Equations for Fast Parallel RCS Benchmarking of PEC Targets

Omid Babazadeh(1), Jin Hu(2), Emrah Sever(3), Ian Jeffrey(1), Constantine Sideris(2), and Vladimir Okhmatovski(1)

(1) University of Manitoba, Winnipeg, MB, Canada, www.umanitoba.ca

(2) University of Southern California, Los Angeles, CA, 90089, USA, www.usc.edu

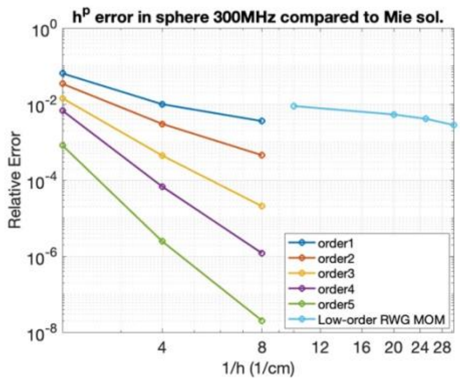
(3) Aselsan, Ankara, Turkey, www.aselsan.com.tr

This work presents a fast, accurate, and robust method for benchmarking the Radar Cross Section (RCS) of electrically large Perfect Electric Conductor (PEC) targets. To accurately capture complex scattering phenomena, we employ either a High-Order Locally Corrected Nyström (LCN) method or a Chebyshev-Based Integral Equation (CBIE) formulation for the Integral Equations. Each approach is designed to deliver high fidelity in modeling the electromagnetic behavior of large-scale PEC structures.

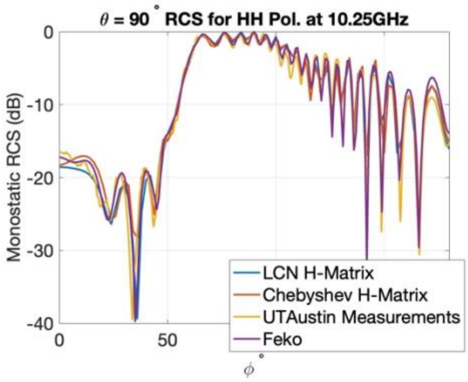
To further enhance computational efficiency, our method leverages an $\mathscr{H}$-matrix framework combined with distributed parallelism, significantly reducing both computation time and memory requirements. Extensive numerical experiments on various PEC models demonstrate the methods' O(h^p) convergence, confirming its high-order accuracy and robustness. Scalability tests are done and shows that the parallel implementation effectively handles increased problem sizes, making the approach suitable for practical, real-world applications.

The proposed solver serves as a versatile benchmark tool for RCS analysis, with significant implications for design optimization. For example, Fig. 1(a) illustrates the O(h^p) convergence behavior for a 1 m radius sphere at 300 MHz, clearly achieving higher accuracy compared to low-order methods and the Mie solution. Additionally, Fig. 1(b) presents an RCS comparison for the NASA Almond under HH polarized incident fields at 10.25 GHz, benchmarked against Austin results.

Detailed discussions on the numerical implementation, convergence properties, and performance improvements will be presented, underscoring the potential of this method in addressing complex electromagnetic scattering challenges.



(a) h^p convergence behavior of the method



(b) L = 25.23744 cm PEC NASA Almond at f = 10.25 GHz incidence: HH polarization

Figure 1. Convergence in high-order fast integral equations

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