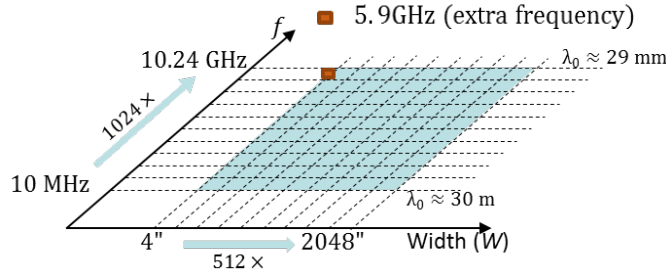


Description of Scattering Object

A perfect electrically conducting (PEC) plate of size $W \times 7W/4 \times 31$ mil.

Length Scale and Frequency Range



The problems of interest cover a range of 512x in physical length scale and 1024x in frequency; the ranges are logarithmically sampled to yield 120 scattering problems. Because the plates are PEC, there are only 20 + 1 unique scattering problems in Problem Set IIB. In these problems, the plate sizes are in the range $0.0034 \leq W/\lambda_0 \leq 1776$, where λ_0 is the free-space wavelength.

Interesting Features

1. The set includes 1 extra frequency for 1 size because of a publicly available measurement result [1].
2. The thin side wall presents meshing and accurate integration challenges.

Quantities of Interest

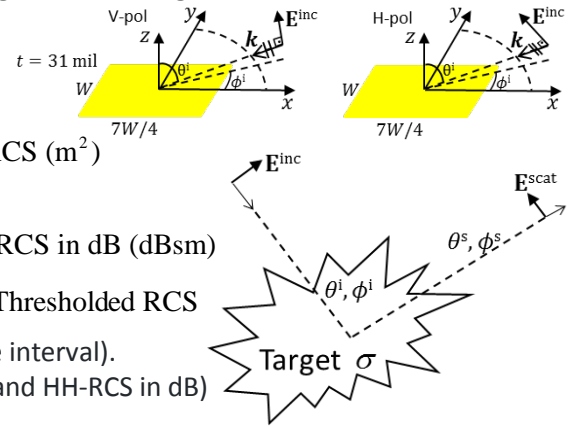
Radar cross section (RCS) definition

$$\sigma_{vu}(\theta^s, \phi^s, \theta^i, \phi^i) = \lim_{R \rightarrow \infty} 4\pi R^2 \frac{|\hat{v}(\theta^s, \phi^s) \cdot \mathbf{E}^{\text{scat}}(\theta^s, \phi^s)|^2}{|\hat{u}(\theta^i, \phi^i) \cdot \mathbf{E}^{\text{inc}}(\theta^i, \phi^i)|^2} : \text{RCS (m}^2\text{)}$$

$$\sigma_{vu,\text{dB}}(\theta^s, \phi^s, \theta^i, \phi^i) = 10 \log_{10} \sigma_{vu} : \text{RCS in dB (dBsm)}$$

$$\sigma_{vu,\text{dB}}^{\text{TH}}(\theta^s, \phi^s, \theta^i, \phi^i) = \max(\sigma_{vu,\text{dB}}, TH_{vu,\text{dB}}) - TH_{vu,\text{dB}} : \text{Thresholded RCS}$$

1. Set $\theta^i = 80^\circ$. Vary $0^\circ \leq \phi^i \leq 90^\circ$ (every 0.5° in the interval).
2. Compute back-scattered $\sigma_{\theta\theta,\text{dB}}$ and $\sigma_{\phi\phi,\text{dB}}$ (the VV- and HH-RCS in dB) at $N_\phi = 181$ directions.



Performance Measures

Error Measure: Simulation errors shall be quantified using

$$\text{avg. err}_{uu,\text{dB}}^{\text{TH}} = \frac{1}{2\pi} \int_0^{2\pi} |\sigma_{uu,\text{dB}}^{\text{TH}}(\phi^s) - \sigma_{uu,\text{dB}}^{\text{ref},\text{TH}}(\phi^s)| d\phi^s \approx \frac{1}{N_\phi} \sum_{n=1}^{N_\phi} |\sigma_{uu,\text{dB}}^{\text{TH}}(\phi^s) - \sigma_{uu,\text{dB}}^{\text{ref},\text{TH}}(\phi^s)| \text{ (dB) for } u \in \{\theta, \phi\}$$

where

$$TH_{uu,\text{dB}} = \max_{\phi^s} \sigma_{uu,\text{dB}}^{\text{ref}} - 80 \text{ (dB)}$$

This error measure discounts errors in RCS values below TH .

Cost Measure: Simulation costs shall be quantified using observed wall-clock time and peak memory/core

$$t_{\text{main}}^{\text{wall}} \text{ (s)}$$

$$mem_{\text{main}}^{\text{maxcore}} \text{ (bytes)}$$

as well as the “serialized” CPU time and total memory requirement

$$t_{\text{main}}^{\text{total}} = N_{\text{proc}} \times t_{\text{main}}^{\text{wall}} \text{ (s)}$$

$$mem_{\text{main}}^{\text{max}} = N_{\text{proc}} \times mem_{\text{main}}^{\text{maxcore}} \text{ (bytes)}$$

Here, N_{proc} denotes the number of processes used in a parallel simulation. It is expected that results will be reported for at least 2 runs: “Efficient” (small N_{proc}) and “Fast” (large N_{proc}).

Study 1: Error vs. Cost Sweep

Fix frequency and fix plate dimensions. Simulate many error levels (proxy: mesh densities) for 4 cases:

Case 1: $f=10$ MHz, $W=4$ in Case 2: $f=5.9$ GHz, $W=4$ in (Measurement Frequency)

Case 3: $f=10$ MHz, $W=128$ in Case 4: $f=320$ MHz, $W=128$ in

It's recommended to simulate as many error levels (mesh densities) as possible. 3-5 error levels is typical. A typical error-vs.-cost study will consist of $4 \times 3 \times 5 = 12 \times 20$ simulations.

Study 2: Frequency Sweep

Fix plate dimensions and error level (proxy: mesh density). Simulate many frequencies for 4 cases:

Case 1: $W=4$ in, error level 1 (coarsest mesh) Case 2: $W=128$ in, error level 1 (coarsest mesh)

Case 3: $W=4$ in, error level 2 (finer mesh) Case 4: $W=128$ in, error level 2 (finer mesh)

Frequencies shall be chosen as $f \in \{10, 20, 40, \dots, 5120, 10240\}$ MHz. It's recommended to simulate as many frequencies as possible. A full frequency-sweep study will consist of $4 \times 11 = 44$ simulations.

Study 3: Size Sweep

Fix frequency and error level (proxy: mesh density). Simulate many sizes for 4 cases:

Case 1: $f=10$ MHz, error level 1 (coarsest mesh) Case 2: $f=320$ MHz, error level 1 (coarsest mesh)

Case 3: $f=10$ MHz, error level 2 (finer mesh) Case 4: $f=320$ MHz, error level 2 (finer mesh)

Diameters shall be chosen as $D \in \{4, 8, 16, \dots, 1012, 2048\}$ in. It's recommended to simulate as many sizes as possible. A full size-sweep study will consist of $4 \times 9 = 36$ simulations.

Reference Quantities of Interest

The following RCS data are made available in the benchmark to enable participants to calibrate their simulators:

4 RCS results corresponding to the cases in study 1 found by using ARCHIE-AIM code, a frequency-domain FFT-accelerated integral-equation solver developed at UT Austin [2]-[4].

References

- [1] A. C. Woo, H. T. G. Wang, M. J. Schuh, and M. L. Sanders, "EM programmer's notebook-benchmark plate radar targets for the validation of computational electromagnetics programs," in *IEEE Ant. Propag. Mag.*, vol. 34, no. 6, pp. 52-56, Dec 1992.
- [2] M. F. Wu, G. Kaur, and A. E. Yilmaz, "A multiple-grid adaptive integral method for multi-region problems," *IEEE Trans. Antennas Propag.*, vol. 58, no. 5, pp. 1601-1613, May 2010.
- [3] F. Wei and A. E. Yilmaz, "A more scalable and efficient parallelization of the adaptive integral method part I: algorithm," *IEEE Trans. Antennas Propag.*, vol. 62, no. 2, pp. 714-726, Feb. 2014.
- [4] J. W. Massey, V. Subramanian, C. Liu, and A. E. Yilmaz, "Analyzing UHF band antennas near humans with a fast integral-equation method," in *Proc. EUCAP*, Apr. 2016.