Shielding Material for Reducing Electromagnetic Interference (EMI)

Problem

Electromagnetic interference (EMI) occurs all around us, particularly with electronics used for personal and DoW purposes. Signal interruption, damaged components, and misinformation are all results of EMI. These disruptions pose a threat to sensitive information and electronic system reliability, making shielding an important factor in cybersecurity and DoW missions. To combat this, electronics are being surrounded by shields made from materials such as metals and plastics; however, it is not clear on which of these materials are most efficient at shielding.

Key Ideas

- Determine most effective shielding materials
- Evaluation of how apertures on structures effect shielding
- Look at structures effected by EMI and are commonly used in DoW and warfare applications
- Develop more realistic sources of energy for EM simulations

Technical Approach/Methodology

Electromagnetic Simulation Models

- Computer case models using perfect electric conductor (PEC), lossy acrylic of different thicknesses, and tempered glass
- Modified dipole antenna to produce EMI similar to real-life situations

Computational Methods

- Evaluating the average shielding effectiveness of each case material
- Developing an empirical formula for shielding effectiveness using a 3rd degree polynomial

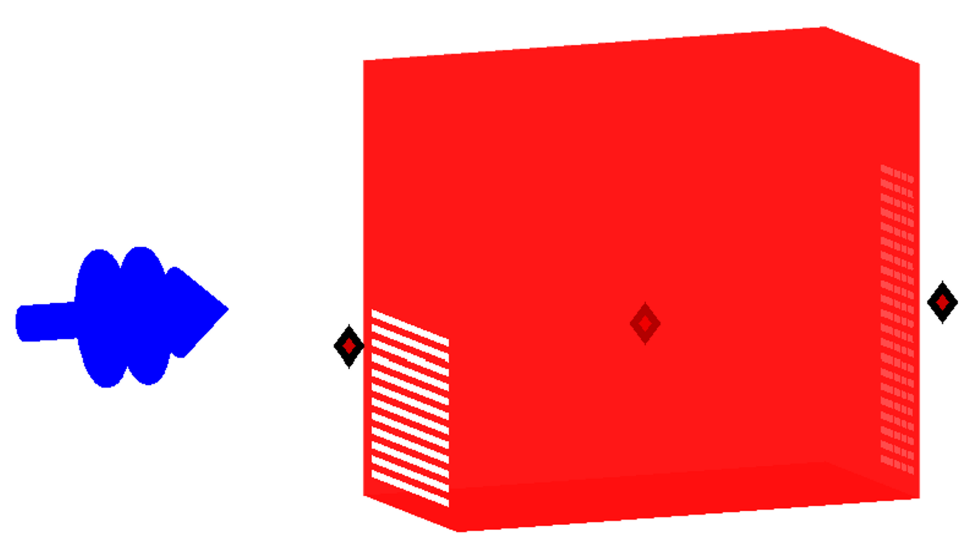

Figure 1: PEC computer case simulation set-up with incident wave direction. Diamonds represent sampling field positions.

Modified Dipole Antenna

- The current simulation uses a plane wave to impose an electric field on the case in Figure 1, and to measure the shielding effectiveness at three probing points
- A modified dipole antenna is used to simulate a more practical excitation situation
- The modified dipole design introduces four shunt elements, shown in Figure 2, to optimize bandwidth while maintaining omnidirectional radiation
- A classic dipole antenna has a bandwidth of around 11%, whereas the improved dipole reaches 44.5%, representing a 30% increase
- This provides a viable alternative to the unrealistic incident wave typically used in EMI shielding simulations

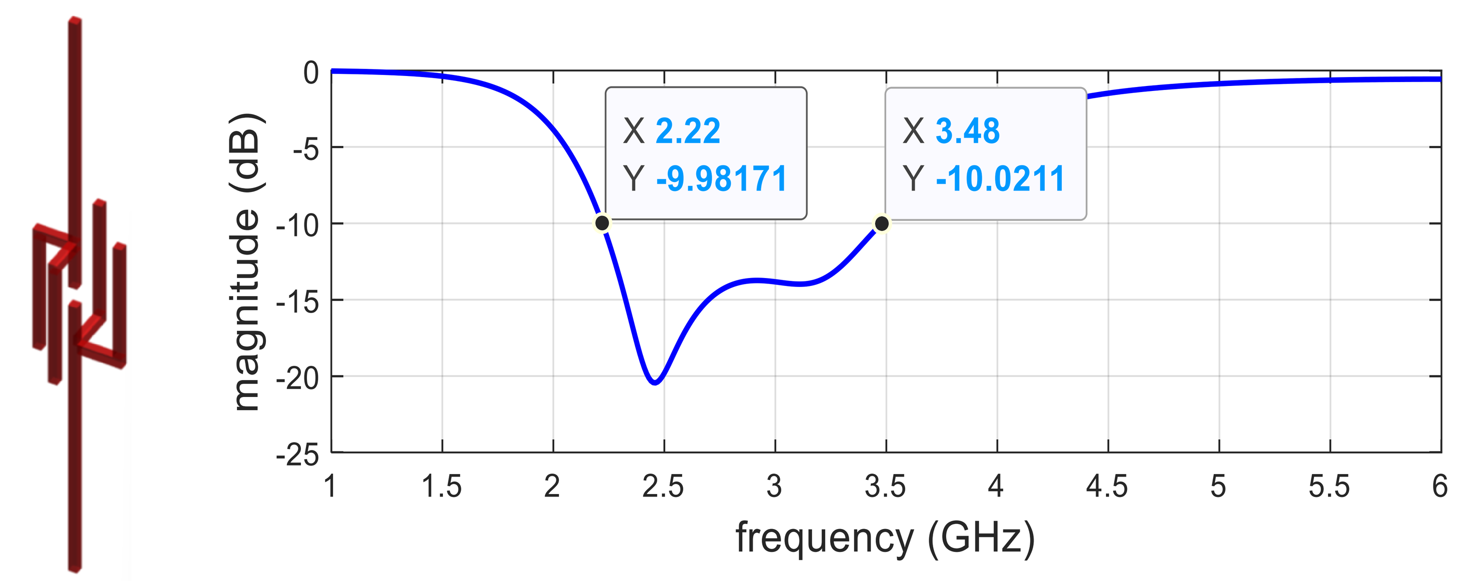

Figure 2: Modified dipole antenna and its S11 showing a wider operating bandwidth from 2.22GHz to 3.48GHz.

Results

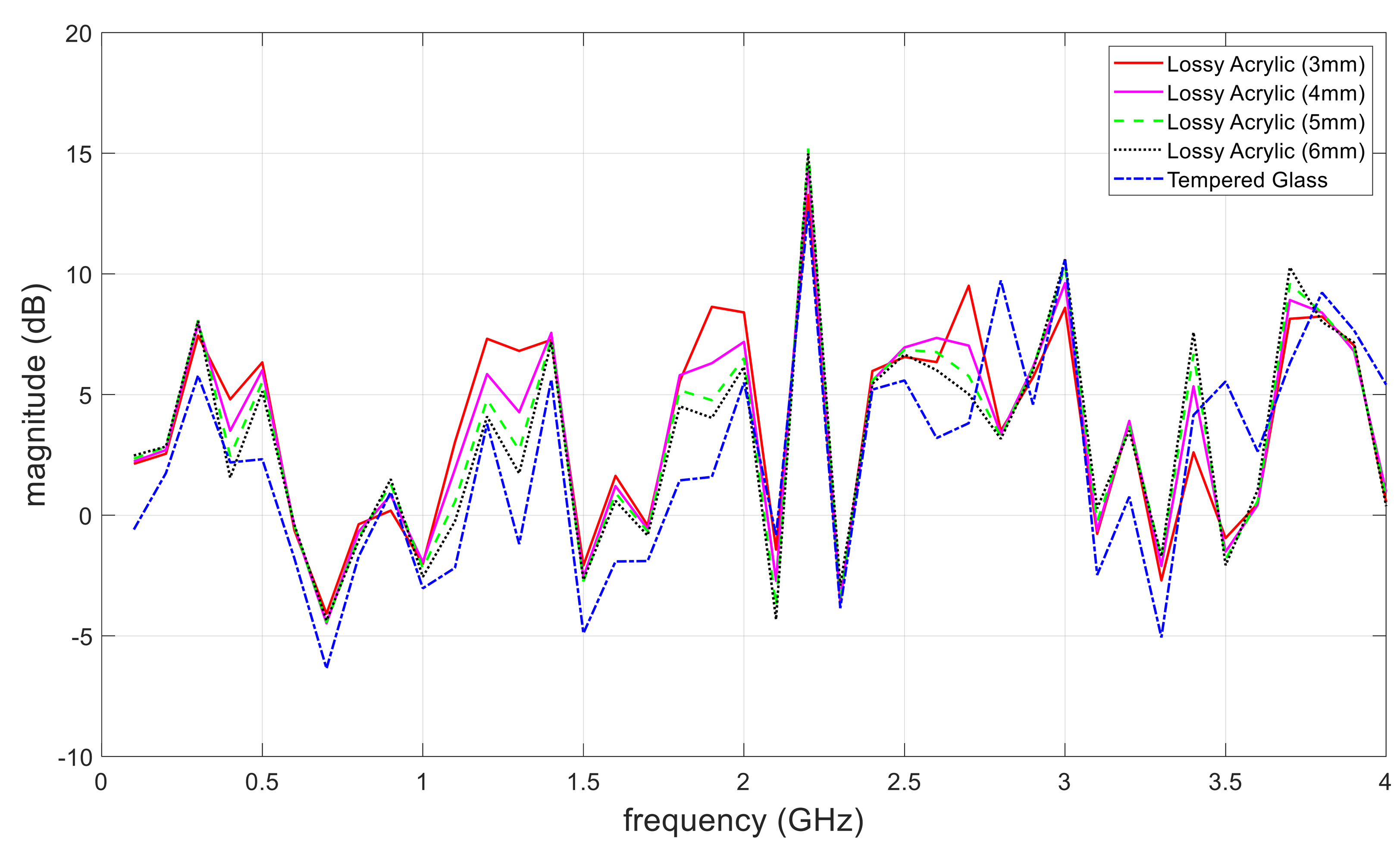

Figure 3: Magnitude of the electric field inside the case with acrylic and tempered glass with respect to the PEC case using incident plane wave.

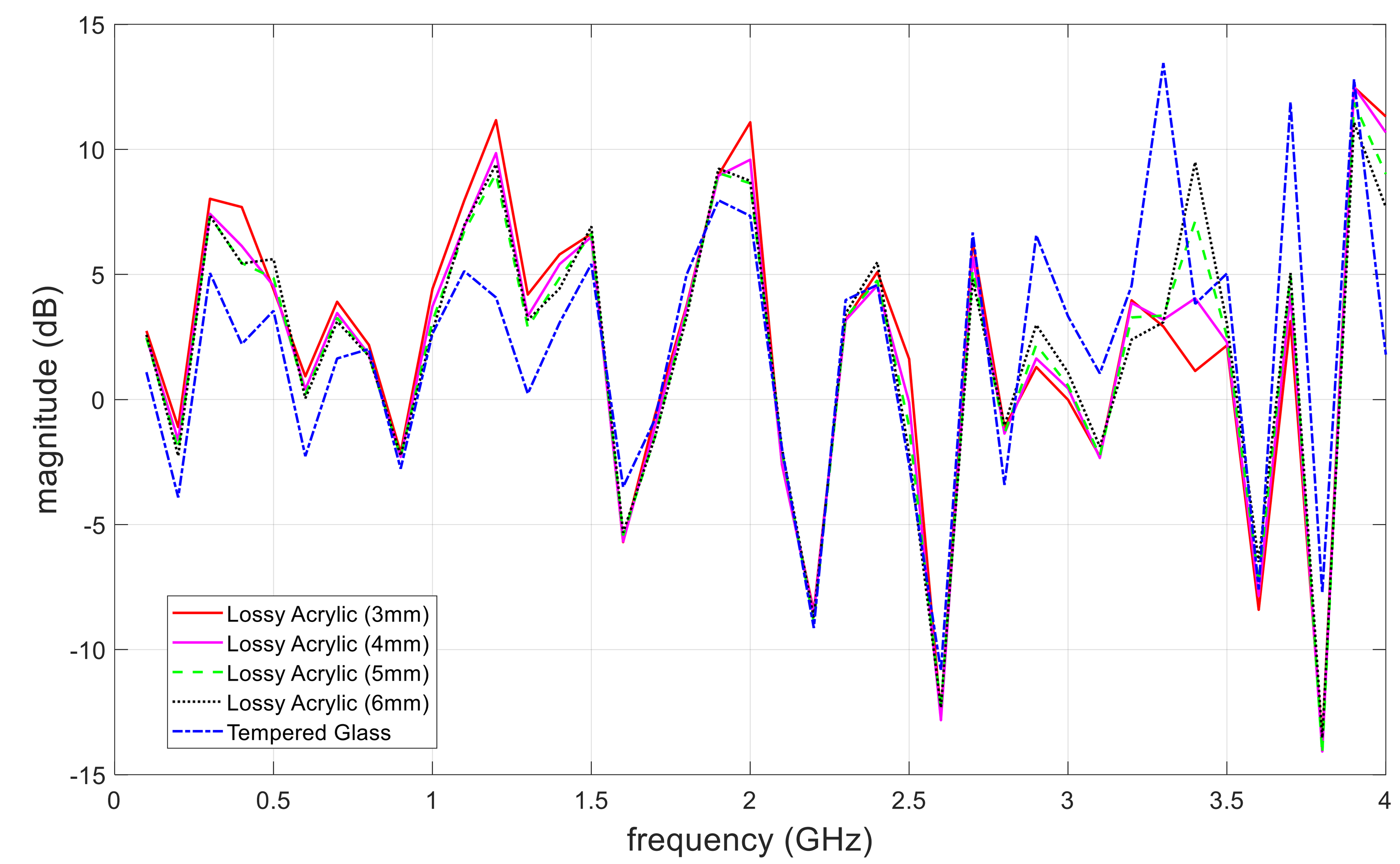

Figure 4: Magnitude of the electric field inside the case with acrylic and tempered glass with respect to the PEC case using modified dipole antenna.

- All examined materials, on average, shielded better than PEC material as seen in Figures 3 and 4. The 3mm lossy acrylic had the best performance out of the tested materials for both the plane wave and the dipole antenna.
- Plane wave excitation provides 3.5903 dB improvement over PEC case with the following Shielding Effectiveness Polynomial Approximation:

$$y = -0.3578x^3 + 1.8478x^2 - 1.7553x + 2.9755$$

- Dipole excitation provides 2.2388 dB improvement over PEC case with the following Shielding Effectiveness Polynomial Approximation:

$$y = 1.2817x^3 + 1.8478x^2 - 1.7553x + 2.9755$$

Next Steps

- Look at the effectiveness of other materials and material thicknesses
- Explore how stacking materials can improve or degrade shielding efficiency
- Further characterize and mathematically explain the material properties and shielding effectiveness
- Develop simulations to model electronic devices similar to those used in defense applications

Team

Colorado School of Mines

Students: Elizabeth Petersen, Natalie Smith, Silje Ostrem

Advisor: Dr. Atef Elsherbeni

Funding for VICEROY is provided by The Office of the Under Secretary of War for Research and Engineering in collaboration with the Air Force Research Laboratory and is facilitated through the Griffiss Institute.
VICEROY is authorized under the National Defense Authorization Act for Fiscal Year 2019 Section 1640, "Program To Establish Cyber Institutes at Institutions Of Higher Learning."