How Can Bi-Omega Particles Enhance the Self-Filtering Capabilities of a Horn Antenna?

Self-Filtering Horn Antenna

In this example, we introduce a self-filtering horn antenna designed for satellite communications. The antenna features a WR-62 (15.8 x 7.9) radiator and achieves self-filtering capabilities through strategically placed bi-omega particles within the waveguide. These particles enable the antenna to operate within an extremely narrow bandwidth centered around 12.6 GHz, maintaining radiation performance similar to a WR-62 radiator. Subsequent figures illustrate the antenna's structure and the slab used in this design.

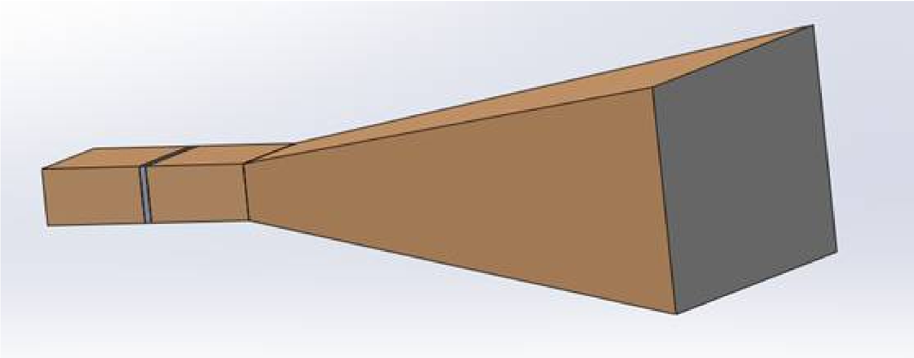


***Figure 1** - the structure's 3D view in SolidWorks*

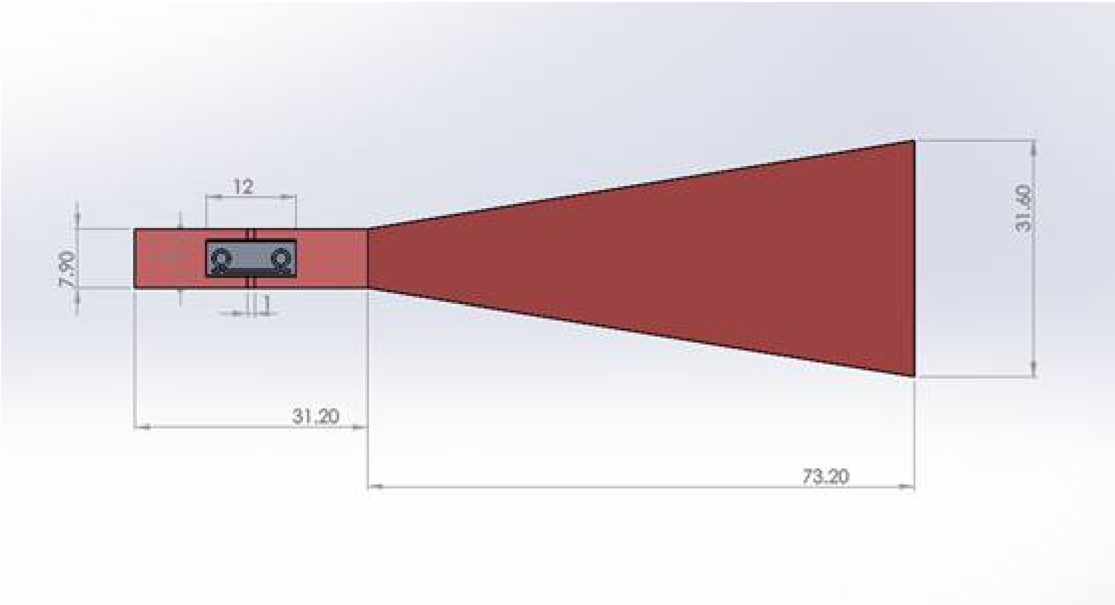


__Figure 2__ - the structure's dimensions

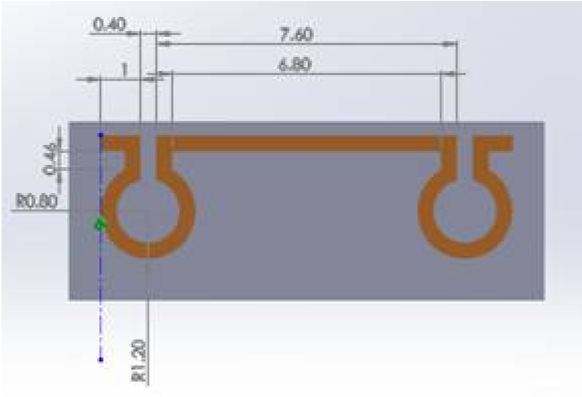


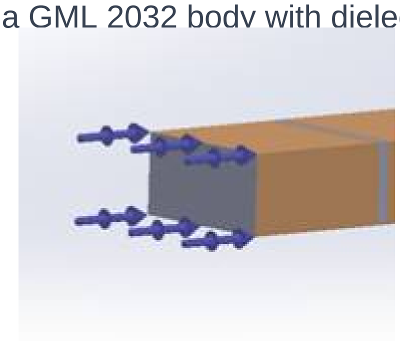
__Figure 3__ - The bi-omega particles' structure

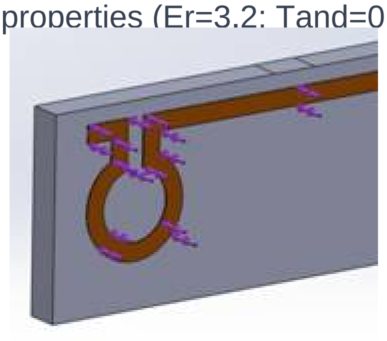
Simulation

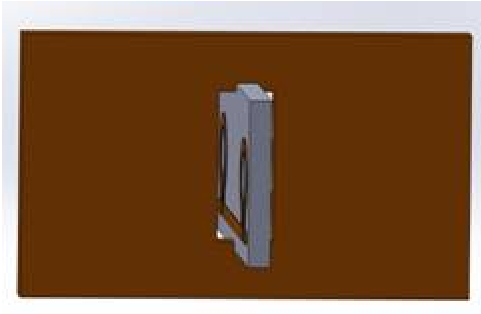
Initially, we can simulate the antenna's behavior without particles. Utilizing SolidWorks' multi-configuration feature, we create various configurations, such as one with the slab and another without it. Subsequently, we set up separate HFWorks studies for each configuration and initiate the simulations.
Regarding the bi-omega particles, they function as a filter. Therefore, we can simplify the simulation by placing them in the WR-62 waveguide to observe their impact while disregarding the antenna's flaring. This approach reduces simulation time and memory demands

Loads/ Restraints

The antenna consists of 1 mm thick Perfect Electric Conductor (PEC) metal. The port is positioned on the lateral small face of the horn antenna. The omega particles are represented as PEC material printed on a GML 2032 body with dielectric properties (Er=3.2; Tand=0.0029).







The antenna's port *The conductor on the slab* *The slab through the screen's slit*

Mesh

To ensure accurate meshing, it's essential to maintain mesh element sizes below one-tenth of the free space wavelength. For the slab's conductor, which has a thin thickness of 35 microns and curved shapes, a finer mesh is necessary to capture details effectively.

Results

The return loss of the antenna exhibits a sharp curve centered around 12.6 GHz. To approximate the S11 plot efficiently, a fast sweep simulation is conducted. The following figures illustrate the simulated S11 using HFWorks' discrete sweep frequency plan:

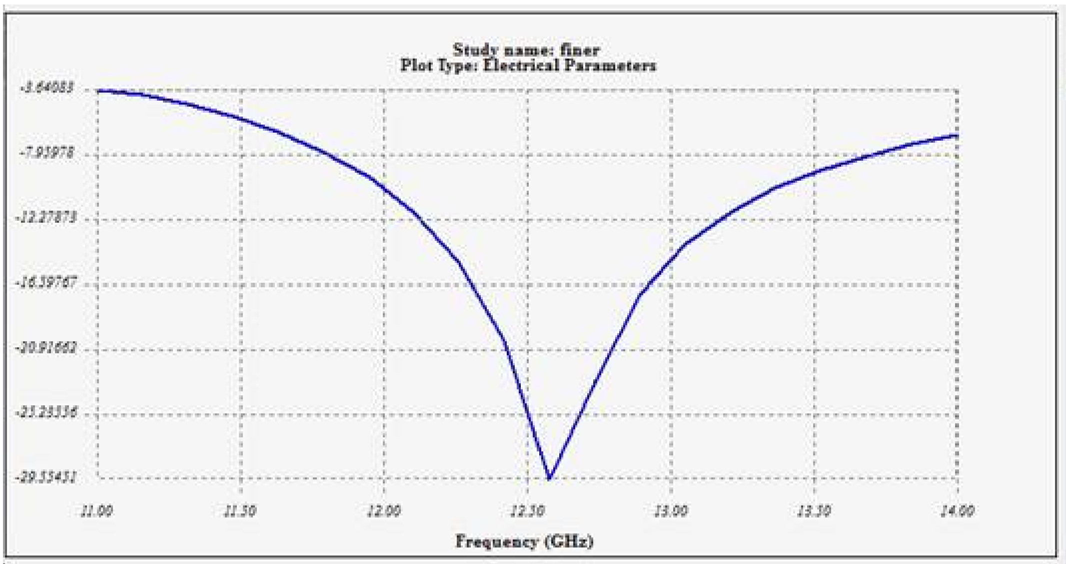
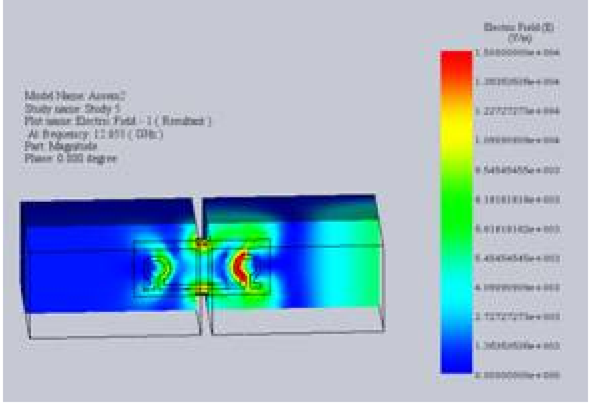


Figure 4 *- Simulated return loss (HFWorks)*

HFWorks offers the section clipping feature, allowing us to visualize the electric field distribution within specific inner areas at the desired frequency. Additionally, it enables viewing the electric field on isolated parts or bodies for detailed analysis.



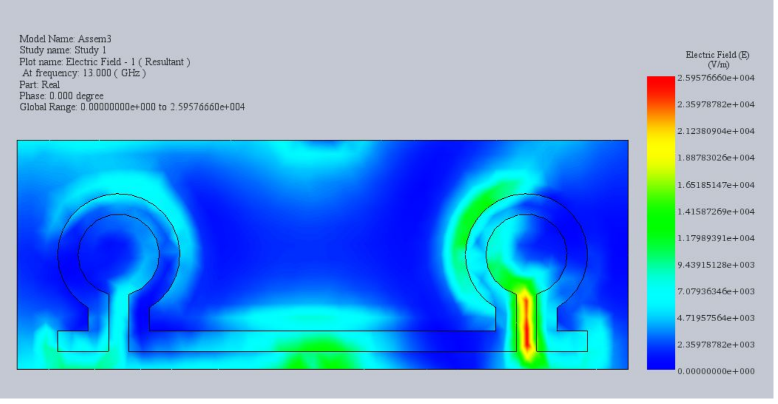


Figure 5 - *Electric field inner distribution*

The results have been consolidated into a single plot for easy comparison between HFWorks' simulations and measurements. This plot prominently showcases the filtering function of the bi-omega particles.

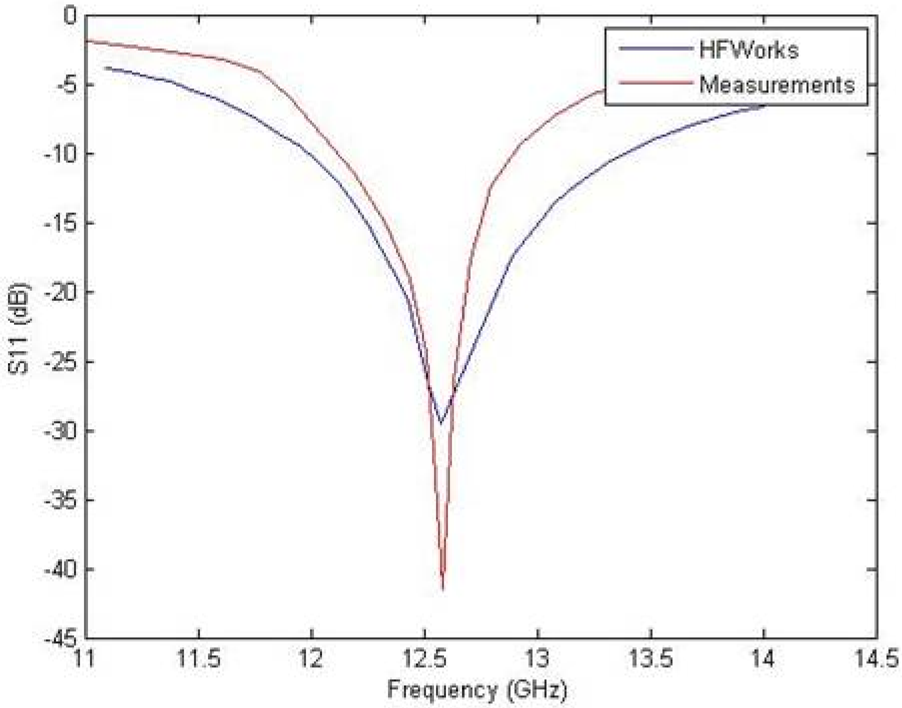


Figure 6 *- Simulated and Measured return loss*

The simulated results, as evident, align closely with the measured data [1]. It's worth mentioning that we employed the Scattering Parameters solver to calculate the return loss. Additionally, the Antenna solver can be utilized to generate radiation patterns and compute various antenna parameters such as gain and axial ratio, if desired.

Conclusion

This application note details the design and simulation of a self-filtering horn antenna, tailored for satellite communications. Featuring a WR-62 radiator and enhanced with bi-omega particles, the antenna stands out for its narrow bandwidth centered around 12.6 GHz, mimicking the radiation performance of a conventional WR-62 radiator while incorporating self-filtering capabilities. The simulation process, facilitated by SolidWorks and HFWorks, evaluates the antenna's performance in configurations with and without the bi-omega particles, focusing on the impact these particles have on the antenna's return loss characteristics.
The simulation approach, including the strategic placement of the bi-omega particles within the waveguide, significantly contributes to the antenna's self-filtering functionality, effectively narrowing its operational bandwidth. The return loss simulations demonstrate a sharp resonance precisely at 12.6 GHz, corroborating the antenna's design objectives. The close alignment of simulated results with measured data underscores the effectiveness of the chosen simulation methodology in accurately predicting the antenna's performance.

References

[1] Self-Filtering Low-Noise Horn Antenna for Satellite Applications Filiberto Bilotti, Senior Member, IEEE, Luca Di Palma, Davide Ramaccia, and Alessandro Toscano, Senior Member, IEEE