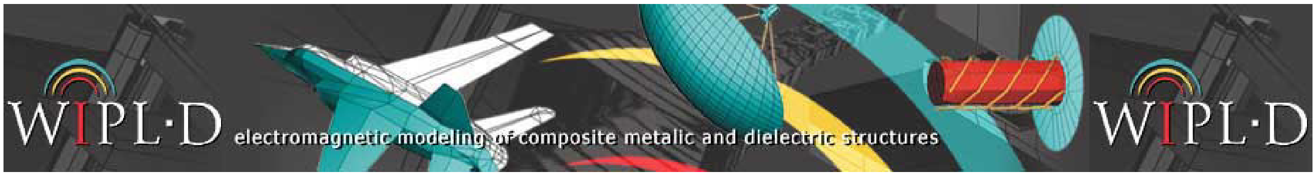

Luneberg Lens Antenna Illuminated by Corrugated Horn

Lenses are used to collimate incident energy to prevent it from spreading in undesired directions.

Luneberg lenses are broadband. These kinds of lenses are usually used in microwave frequencies. They are used in antenna constructions, radar calibrations, satellite systems and they are expected to be used in future in some of the internet communication systems.

Corrugated horn antennas are a type of horn antennas developed for achieving high efficiency. Horn antennas are used in satellite systems, radar applications, etc. and are the main type of feeders of reflector and lens antennas.

Theoretical Background

Luneberg lens is a spherically symmetric structure with variable refracting index, decreases radially out from the center. Luneberg lens creates two conjugate foci outside of the lens. Each point on the surface of an ideal Luneberg lens is the focal point for parallel radiation incident on the opposite side.

Placing grooves on the walls of a horn antenna is implemented so that the same boundary conditions to all polarizations are achieved and that the field distribution is tapered at the aperture in all the planes. Same boundary conditions eliminate the spurious diffractions at the edges of the aperture.

Main characteristics of Luneberg lenses are

- Broad band,
- Dielectric lens influences the signal transition.

WIPL-D Simulation

An antenna model which consists of a Luneberg lens and a corrugated horn, simulated using WIPL-D Pro 3D EM solver, is presented here. Full model is shown in Fig. 1. Quarter model, where dielectric layers can be clearly seen, is shown in Fig. 2. The variable refracting index is approximated by using five layers of dielectrics with different electrical properties. The corrugated horn model is shown in Fig. 3.

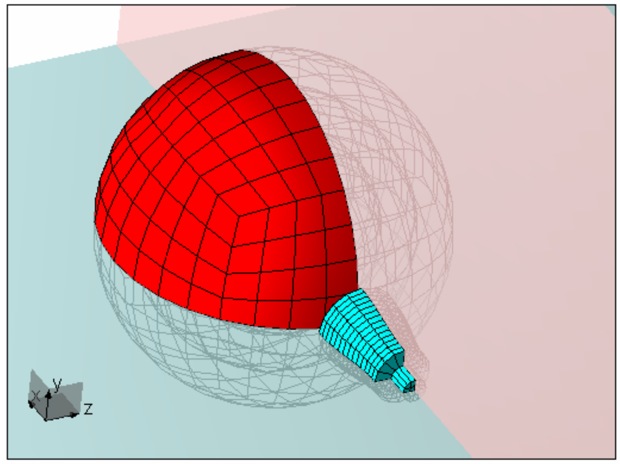

Figure 1. Luneberg lens and corrugated horn antenna

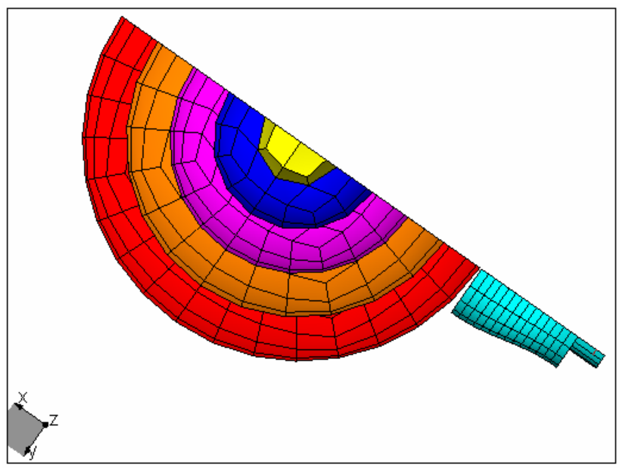

Figure 2. Quarter model of Luneberg lens and corrugated horn antenna

Our aim is to inspect simulation times and memory requirements, radiation pattern and near field at the operating frequency.

Operating frequency is 1414 MHz (D band – NATO band classification).

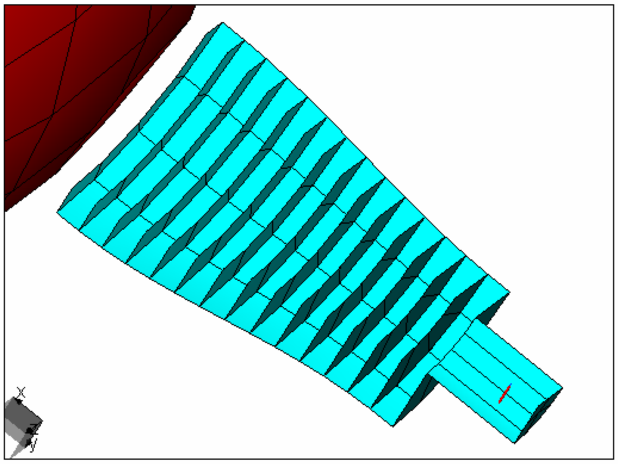

Figure 3. Corrugated horn antenna

Radiation pattern in 3D and a phi-cut are given in Figs 4-5, respectively. The diagram shows relatively high directivity and low side-lobes, as expected. Please note that the theta angle is measured with respect to the xOy plane.

Distribution of the near field is shown in Fig. 6. The focusing effect of the lens is clearly seen where a spherical EM wave comes into the lens originating from the horn while on the other side it is transformed into a plane wave.

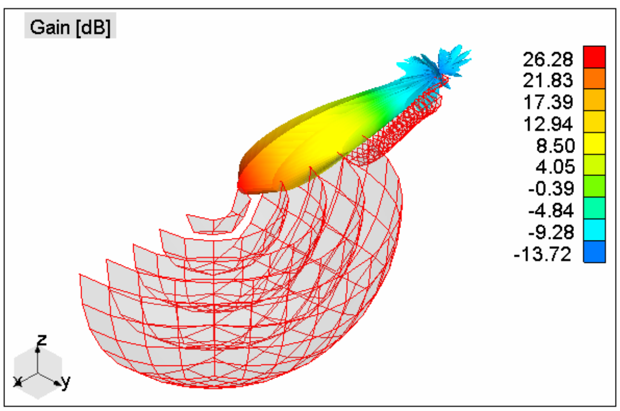

Figure 4. 3D radiation pattern

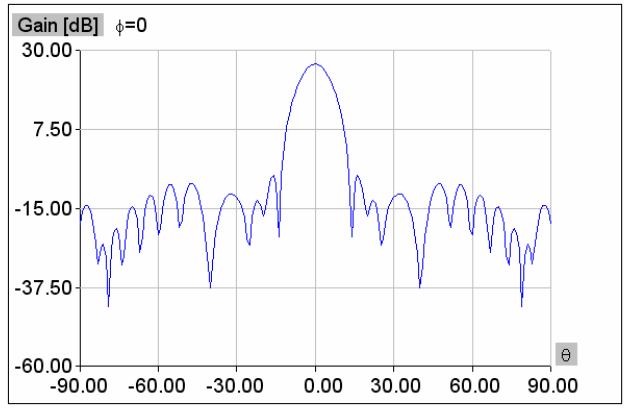

Figure 5. Radiation pattern in phi-cut

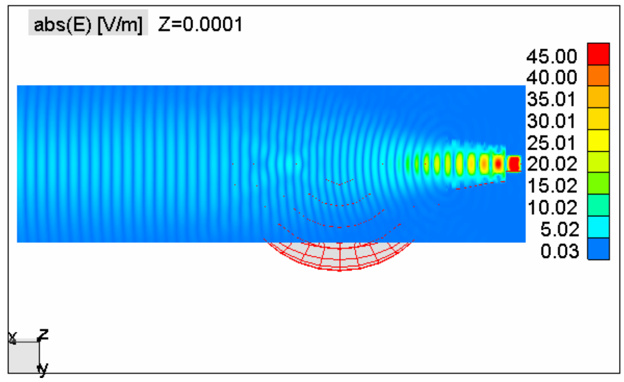

Figure 6. Near field

Number of unknowns and simulation time are given in Tab. 1. Computer used for these calculations is Intel® Core2 Quad CPU @ 2.83 GHz, 8 GB RAM.

Table 1. Analysis characteristics

Number of unknowns	Time [sec]
17174	256

Conclusion

This kind of antenna is usually very difficult for simulation using a rigorous computational electromagnetics code. However, WIPL-D Pro successfully analyses the antenna using MoM thanks to sophisticated techniques such as higher order basis functions. Simulation times are very short comparing to other computational methods of similar accuracy. This makes WIPL-D Pro an excellent tool for tackling very challenging lens antenna designs.

Results given here by WIPL-D Pro coincide with theoretical expectations.