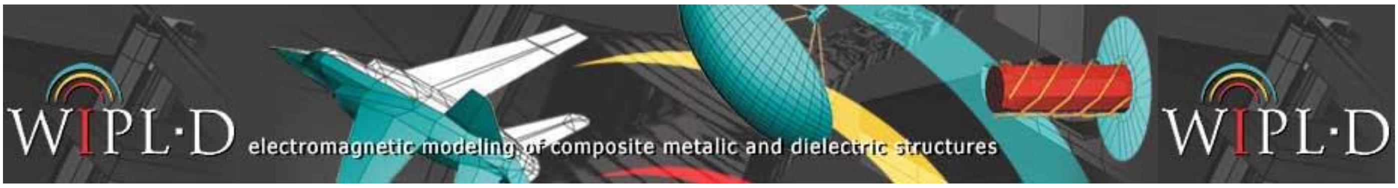

Hyperboloid Lens Antenna Illuminated by Cylindrical Waveguide

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

Hyperboloid lens used in this example is convex-plane type. That means that one side of lens is hyperboloid, while another side (toward radiation direction) is a plate. Hyperboloid lenses are used in radar systems and communication multibeam systems.

Waveguide used in this project is specially designed to suppress back radiation. That was done by adding a choke to horn aperture edge. Length of choke is equal to quarter of free-space wavelength.

This kind of waveguide is used in satellite systems, radar applications… It is usually used as feeder.

Theoretical Preferences

Rotationally symmetric lens structure focuses emitted signal. Analysis of given lens problem is based on optics theory. One should realize that whole optics theory is done for infinity high frequency. That means that variation occurs in calculations using finite, microwave frequencies.

We will focus on hyperboloid lenses.

Main characteristics of hyperboloid lenses are:

- They are electrically large,
- Dielectric influences on signal transition.

One antenna model consisted of hyperboloid lens and cylindrical waveguide is designed and analyzed using WIPL-D 3D EM solver. Full model is shown on Fig. 1.

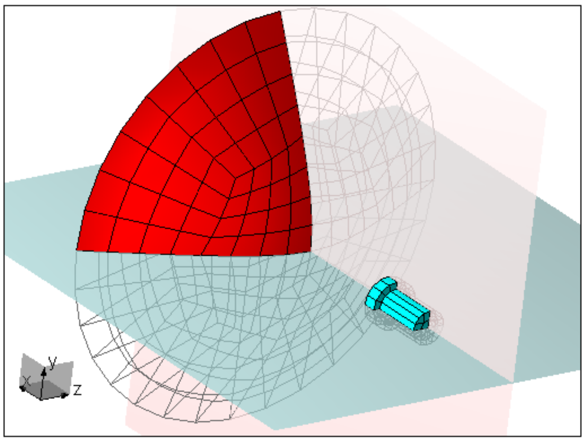

Figure 1. Hyperboloid lens and waveguide in WIPL-D

Quarter model, where dielectric layer can be clearly seen, is shown on Fig. 2, while model of waveguide is shown on Fig. 3.

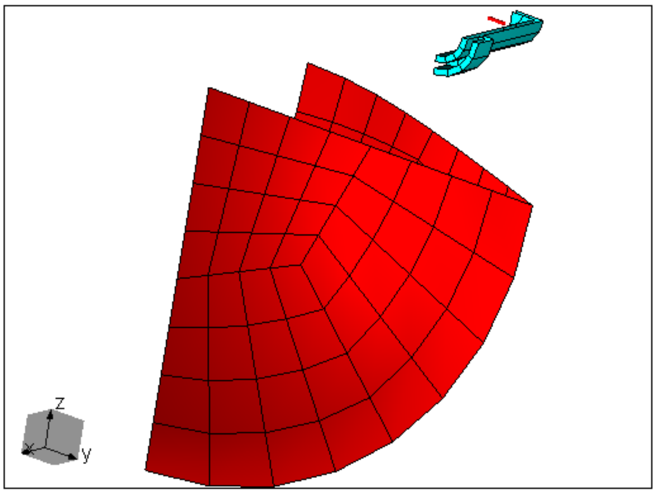

Figure 2a. Quarter model of hyperbolic lens and cylindrical waveguide

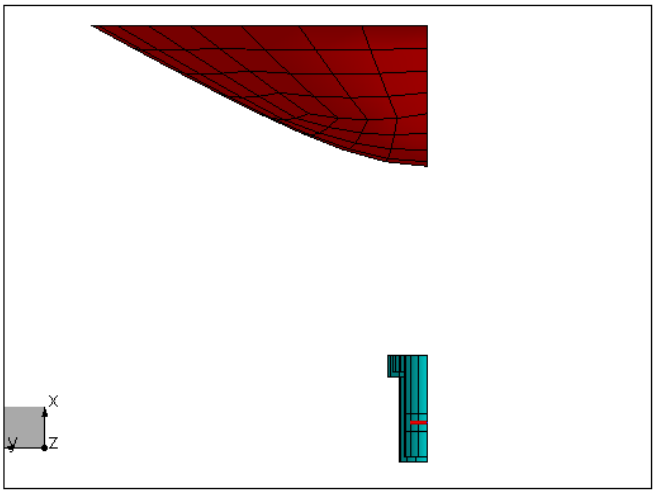

Figure 2b. Quarter model of hyperbolic lens and cylindrical waveguide – z projection

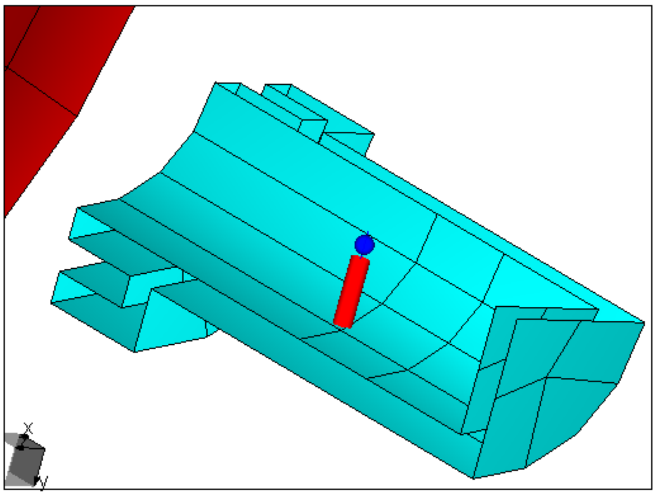

Figure 3. Cylindrical waveguide

Special shape of given antenna enables good focusing characteristics.

Our aim is to inspect simulation time, radiation pattern and near field.

WIPL-D Calculation

Computer used for these calculations is Intel® Core(TM) i7 CPU 950@3.07 GHz, 8 GB RAM.

Operating frequency is 25.5 GHz (K band – NATO band classification).

Antenna shown on Fig. 1, can be modeled in several ways because of diminishing simulation time and number of unknowns. One can use WIPL-D feature (Anti-) Symmetry, as in this problem and model only quarter of structure (Fig. 2).

Radiation pattern in 3D and in phi cut are given on Figs 4-5, respectively. Distribution of near field is shown on Fig. 6 All figures are presented for total electric field.

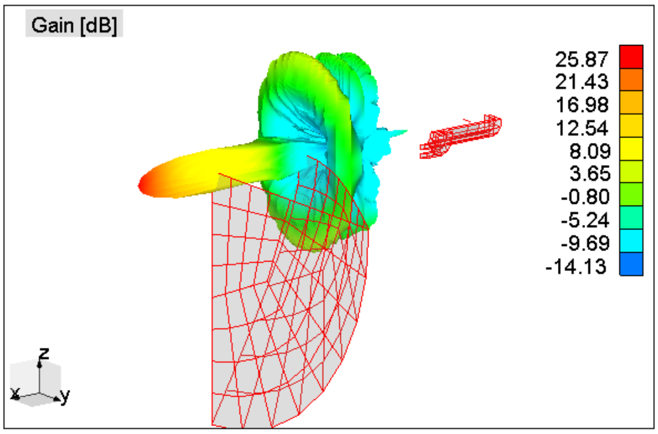

Figure 4. Radiation pattern in 3D

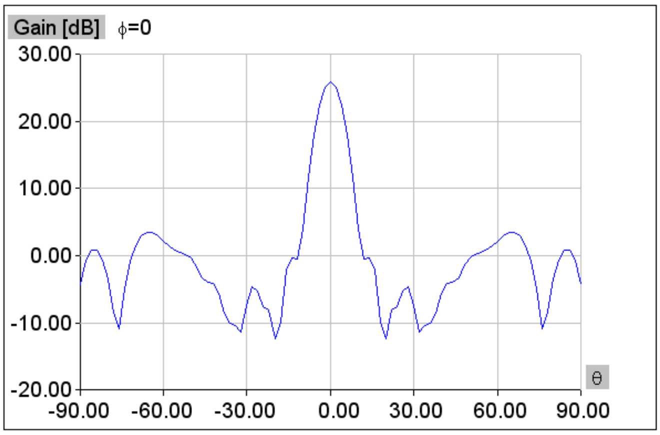

Figure 5. Radiation pattern in phi cut

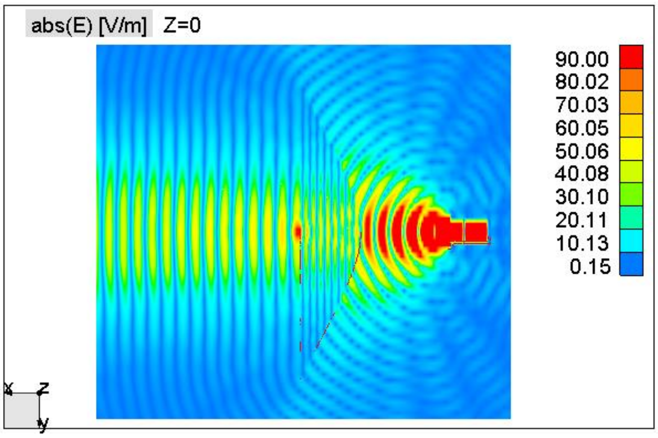

Figure 6. Near field

Number of unknowns and simulation time are given in Tab. 1. They are measured for calculation of radiation pattern and near field.

Table 1. Analysis characteristics

Number of unknowns	Time [sec]
3170	5.5

Conclusion

Advantages of given antenna are that it has good directivity and that it's made of only one dielectric layer. Dielectric used here is necessary because dielectric structure focuses EM rays. In real life dielectric also inserts losses.

In near field simulations, it is clearly seen how lens focuses signal.

This kind of antenna is sort of antenna usually analyzed using geometrical optics methods. However, WIPL-D successfully analyses that antenna using MoM.

Simulation times are relatively small.

Results given by WIPL-D and presented here coincide with theoretically assumptions.