Hyperboloid Lens Illuminated by Choke Horn Antenna

Lens antennas can be used to prevent spreading of EM wave energy to undesired directions (focusing the beam). They can be used in various application. For example, hyperboloid lenses are used in radar systems.

In this application note, a rotationally symmetric lens structure which focuses emitted signal is simulated and investigated. Simulations of similar models with lenses are usually based on optics theory. However, WIPL-D Pro, a full-wave 3D EM solver sucesfully handles hyperboloid lens illuminated by choke horn antenna applying full wave Method-of-Moments (MoM).

Hyperboloid lens investigated here is convex-plane type. This means that one side of the lens is convex (hyperboloid), while another side of the lens (the side which is away from the horn) is flat (Fig. 1). Horn antenna used in this project is specially designed to suppress back radiation. This was done by adding a choke to the aperture rim of the horn.

Our aim is to inspect simulation time, 3D radiation pattern and near field distribution. 3D radiation pattern will be compared with 3D radiation pattern obtained after simulation of free space choke horn antenna. It will be shown that the results coincide with theoretically assumptions. Furthermore, it will be shown that all simulations were performed relatively fast.

WIPL-D Models

WIPL-D model of hyperboloidal lens illuminated by choke horn consists of hyperboloid lens made of dielectric material and a horn antenna. The whole antenna (the lens and the horn) was created after applying two symmetry planes. The entire antenna is shown in the Fig. 1. Applying two symmetry planes (and obtaining *quarter* model) enables decreasing number of unknowns, which yields decreasing simulation time (while preserving accuracy of the results).

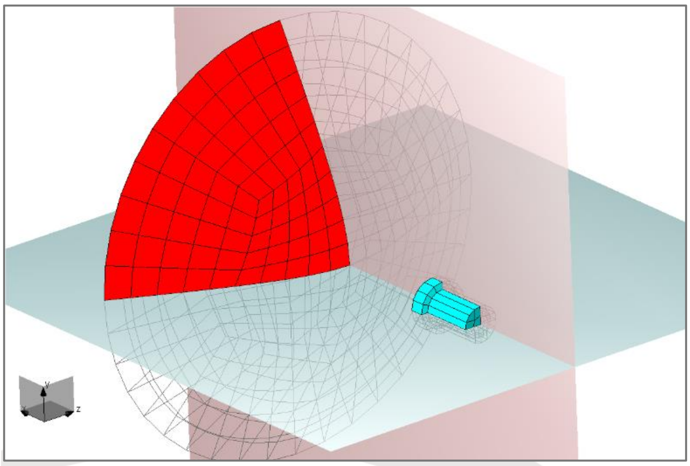

Figure 1. Hyperboloid lens with choke horn antenna

In order to enable better preview of the antenna, the *quarter* model was rotated which enabled a better insight to the entire structure (Fig. 2, Fig. 3). Also, free space choke horn antenna is shown (Fig. 4).

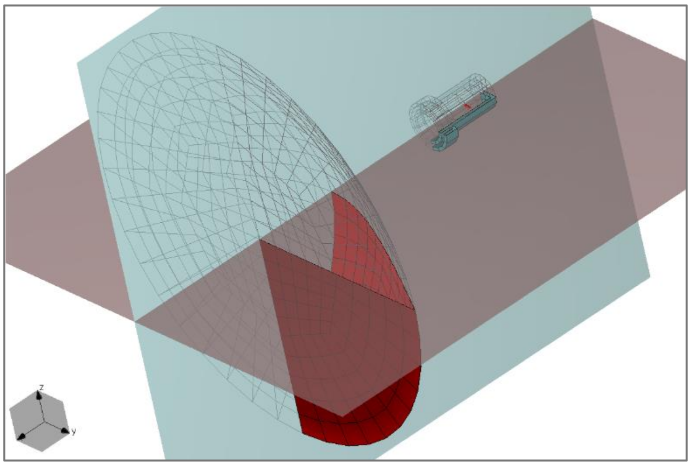

Figure 2. Hyperboloidal lens with horn – rotated preview

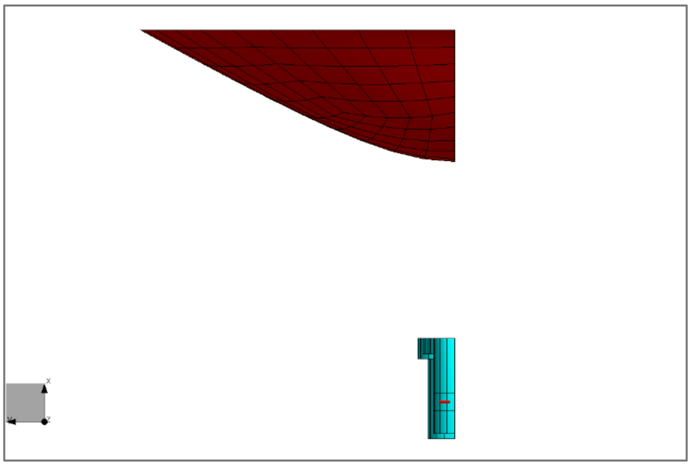

Figure 3. Hyperboloidal lens with choke horn antenna – z projection

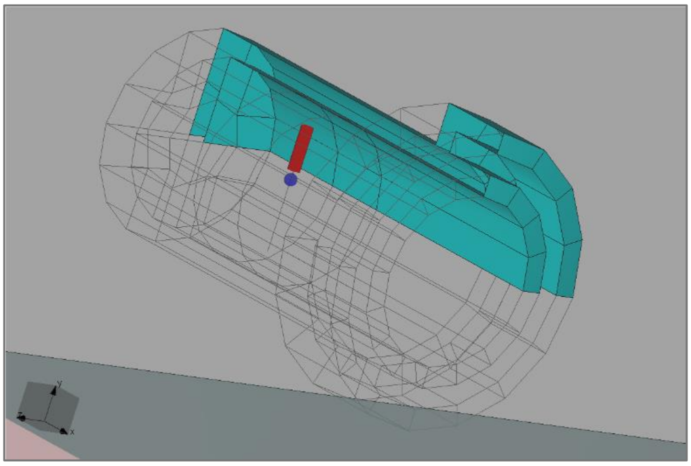

Figure 4. Choke horn antenna

Results and Simulations

Hyperboloidal lens illuminated by choke horn antenna and free space choke horn antenna were simulated at 25.5 GHz. Radiation patterns in 3D for free space choke horn and the lens antenna are presented in Fig. 5 and Fig. 6. Radiation patterns are calculated in $361 \cdot 91 = 32{,}851$ directions, in both cases. The same range (-20 dB, 25 dB) was applied to both radiation pattern diagrams.

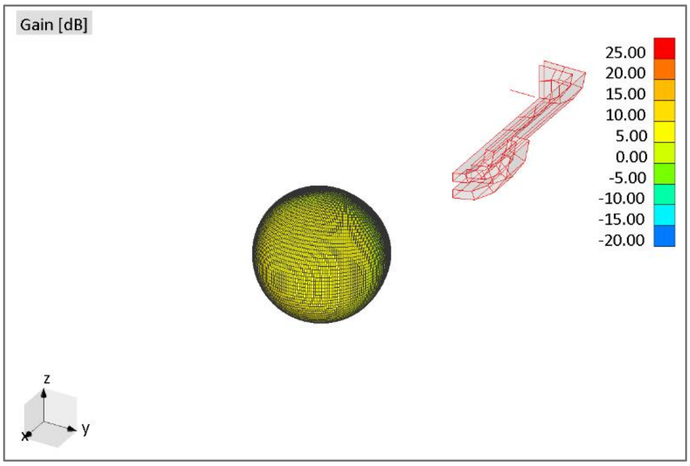

Figure 5. Radiation pattern in 3D – free space choke horn antenna

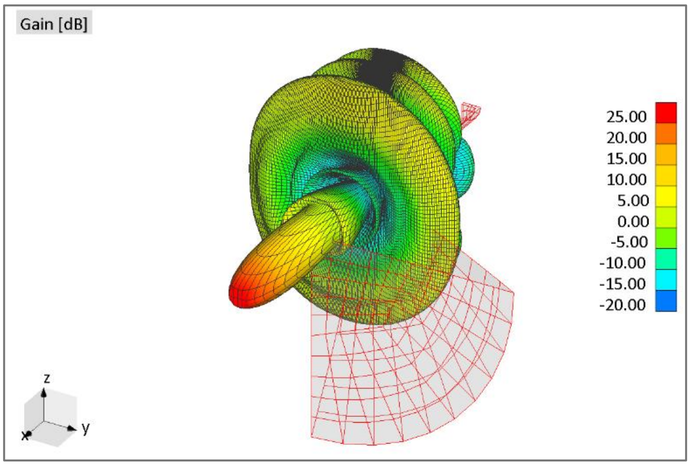

Figure 6. Radiation pattern in 3D – hyperboloidal lens illuminated by choke horn antenna

Near field distribution for hyperboloidal lens with the choke horn is presented in Fig. 7.

Computer used in presented simulations is Intel® Core™ i7-7700 CPU@3.60 GHz. Number of unknowns, computer memory requirement and simulation time are presented in Table 1. Total simulation time mainly consists of matrix fill-in, matrix solution and radiation pattern calculation (in this case, near field calculation was not considered as a part of total simulation time).

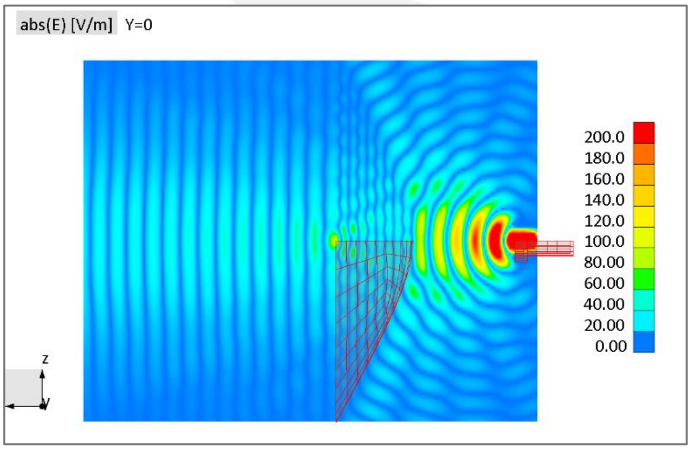

Figure 7. Near field distribution

Table 1. Number of unknowns, computer memory requirement and total simulation time

Model	Number of unknowns	Memory [MB]	Total simulation time[sec]
Choke Horn Antenna	298	0.68	2.59
Hyperboloidal Lens Illuminated by Choke Horn Antenna	4478	152.99	14.67

Conclusion

The model of hyperboloidal lens illuminated by choke horn antenna was successfully created and simulated using WIPL-D Pro. Process of modelling includes usage of WIPL-D Pro built in objects. This approach speeds up and makes easier the process of modelling. The simulations comprised two scenarios. In the first scenario, free space choke horn antenna was simulated. In the second scenario, hyperboloidal lens illuminated by choke horn antenna was simulated.

All simulations were performed relatively fast. Results presented in Figs 5-7 indicate that the output results were calculated accurately. Also, output results coincide with the theory assumptions. The focusing effect of hyperboloidal lens is clearly seen in Figs 5-7.