Various Lens Types

WIPL-D Pro is a frequency-domain **full 3D EM Method-of-Moments** (further, MoM) **based solver**. It enables **very fast and accurate** EM simulations of various 3D structures. Owing to application of sophisticated techniques (for example, application of higher order basis functions-**HOBF**s on bilinear surfaces and truncated cones), usage of WIPL-D enables even large structures to be simulated on standard desktop workstations.

Three designs of lens antennas with different lens types will be presented in this document. The motivation for presenting the scenarios with lens antennas will be showing some **real-life antenna models** which can be **simulated in a couple of seconds** on **regular desktop or laptop** workstations with **minimal WIPL-D software requirements.** Since the antennas with lenses, represent the antennas which can be used in, for example, some real-life radar applications, they become suitable to be exploited as models used for this demonstration of software capabilities. In addition, our aim will be to show and compare various 3D radiation patterns.

WIPL-D Models and Results

As stated above, three scenarios (designs) of lens antennas will be simulated. The excitation horn which will be used in all three cases is with the same dimensions. Also, it is always positioned in the lens feed point. All models are efficiently simulated by applying the feature *Symmetry*. All lens models assume dielectric material with Er=4. The operating frequency is 25.5 GHz for each of three scenarios.

The first scenario (Fig. 1) assumes that the first illuminated surface of the lens (closer to the horn antenna) is hyperbolic while the second is flat (farther from the horn antenna). Lens diameter is 120 mm. The total length of the antenna (horn and lens) is 78 mm. Equations explaining lens geometry in the 1st scenario are in the Fig. 2. Gain in two phi cuts is shown in Fig. 3.

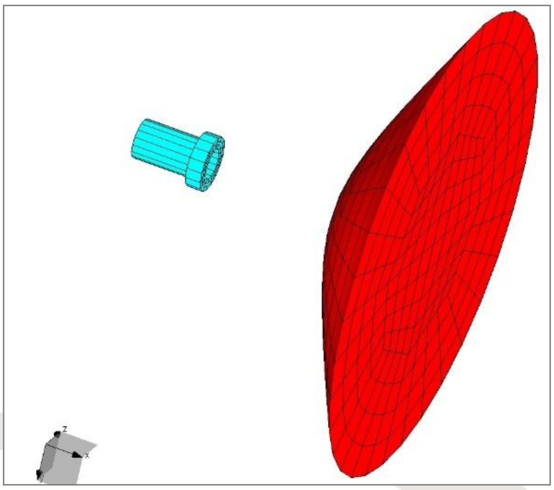


Figure 1. Horn and hyperboloid lens – the first scenario

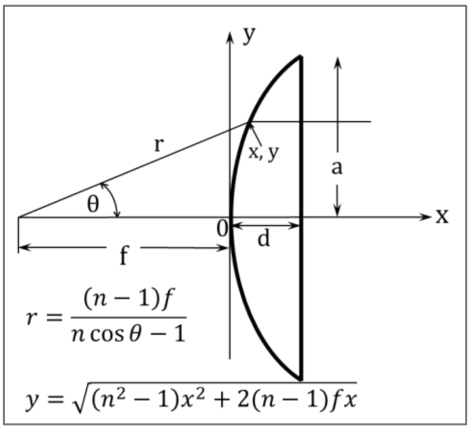


Figure 2. Hyperboloid lens equations – the first scenario

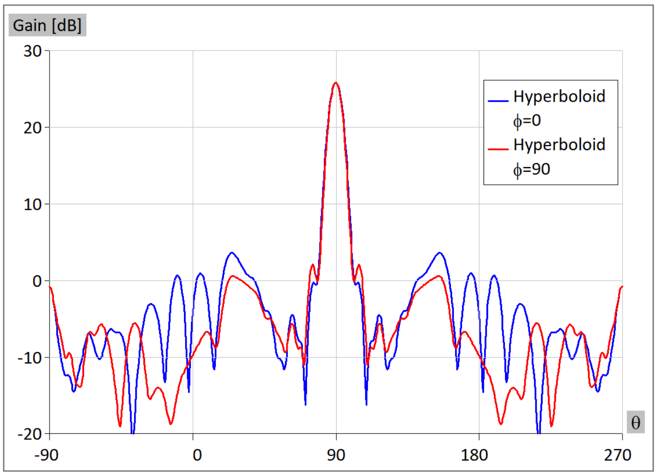


Figure 3. Radiation patterns – the first scenario

The 2nd scenario (Fig. 4) is similar to the first, but the first illuminated lens surface (closer to the horn antenna) is flat while the second (farther from the horn antenna) is convex. Thus, this lens is referred as plane-convex. Lens diameter is 121 mm and antenna total length (horn and lens) is 104 mm.

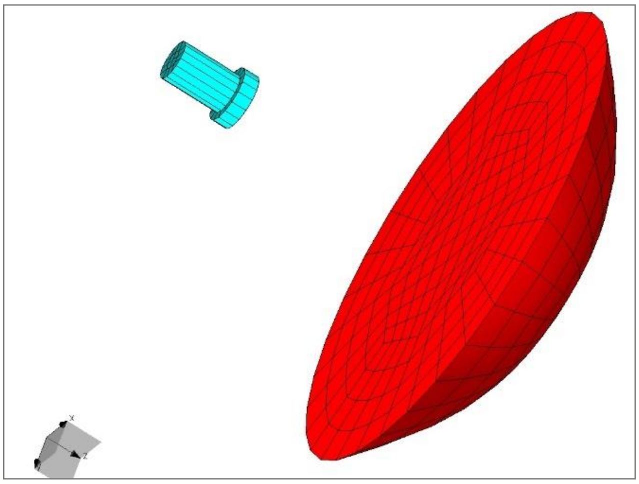
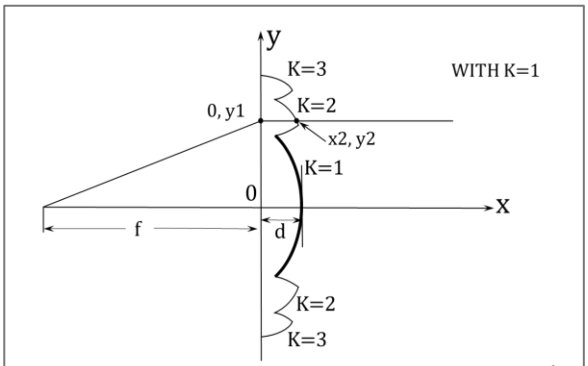


Figure 4. Horn and plane-convex lens – the second scenario

Equations explaining lens geometry in the second scenario are given in the Fig. 5. Gain in two phi cuts is shown in Fig. 6.



$$x_2 = \left\{ \frac{(K-1)\lambda + (n-1)d + f - \sqrt{f^2 + y_1^2}}{n - \left(1 - \frac{y_1^2}{n^2(f^2+y_1^2)}\right)^{1/2}} \right\} \cdot \left[1 - \frac{y_1^2}{n^2(f^2+y_1^2)}\right]^{1/2}$$

$$y_2 = y1\left[1 + \frac{x_2}{[n^2(f^2+{y_1}^2) - {y_1}^2]^{1/2}}\right], \qquad K = 1, 2, 3, 4 \ldots$$

Figure 5. Plane-convex lens equations – the second scenario

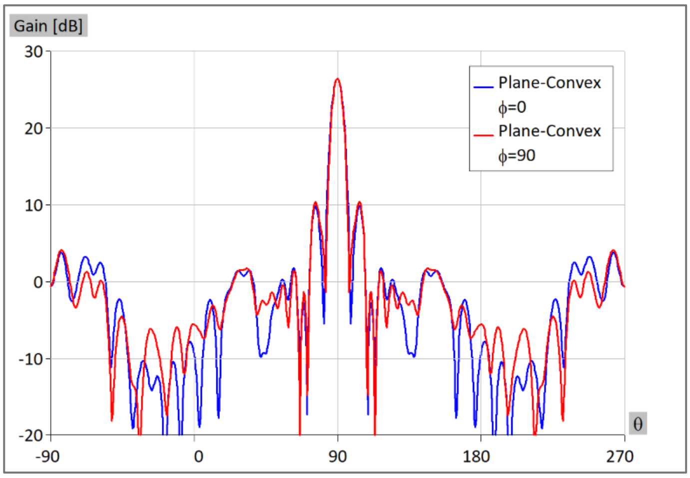


Figure 6. Radiation patterns – the second scenario

The third scenario is shown in Fig. 7. It includes two curved surfaces where the first lens surface (closer to the horn antenna) is concave spherical surface, while the second surface (farther from the horn antenna) is convex. Thus, this scenario is referred as concave-convex. Lens radius is 60 mm. The total length is 79 mm. Equations explaining lens geometry in the third scenario are given in the Fig. 8. Gain in two phi cuts is shown in Fig. 9.

Conclusion

All calculations are extremely efficient due to usage of Method of Moments (MoM) with unique higher order basis functions. Thus, the mesh elements can be 2 wavelengths large and all of the three simulated scenarios require about 3,200 unknowns. In addition, WIPL-D built-in reflector object is customized to yield minimum simulation requirements for large apertures. The accuracy is controlled simply by adjusting number of segments. Simulations are prompt and results are tested for perfect convergence in only a few quick runs.

Reflector objects allows the user to define specific shape of surface and the contour of rim via user defined reflector files. All the details are explained in manual with demo examples.

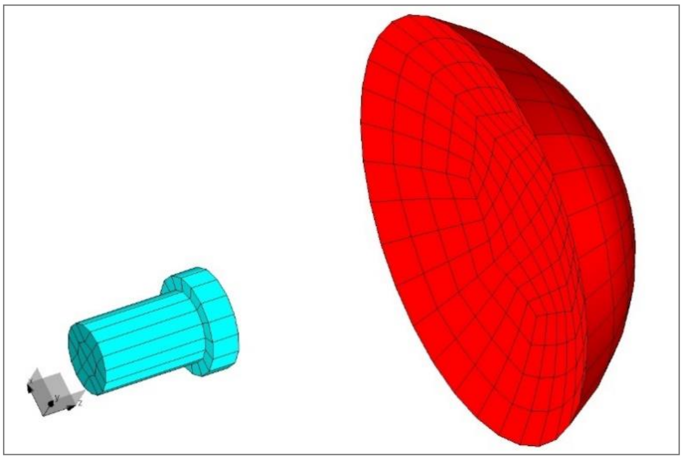
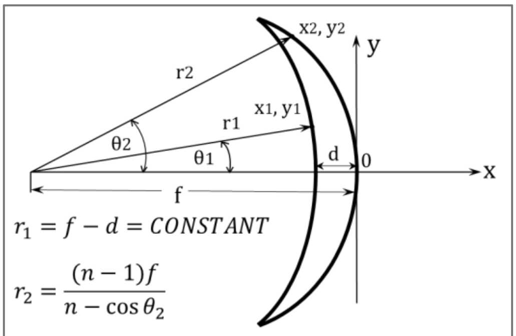


Figure 7. Horn and concave-convex lens – third scenario



$$r_1 = f - d = CONSTANT$$

$$r_2 = \frac{(n-1)f}{n - \cos\theta_2}$$

$$y_1 = \sqrt{(f-d)^2 - (x_1+f)^2}$$

$$y_2 = \left\{-2\left(\frac{n-1}{n}\right) f x_2 - \left(\frac{n^2-1}{n^2}\right){x_2}^2\right\}^{1/2}$$

Figure 8. Concave-convex lens equations – third scenario

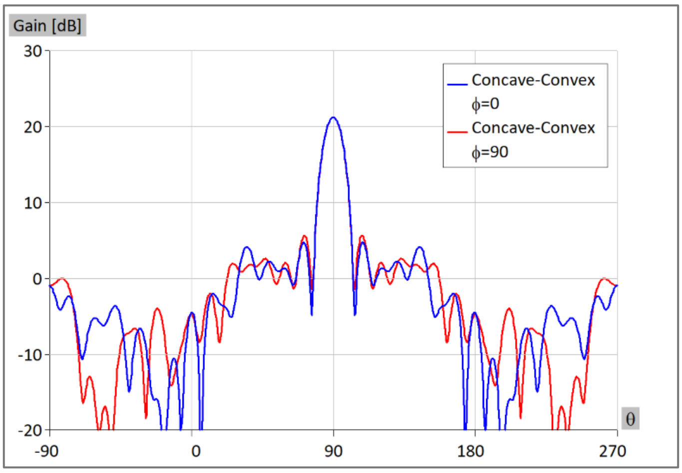


Figure 9. Radiation patterns – the third scenario

References

1. J. Volakis, 2007, "Antenna Engineering Handbook", 4th edition, McGraw Hill.