Influence of Shroud, Absorber and Radome to Splash-plate Reflector

Introduction

The scope of this application note is to present the procedure for design and modeling the splash plate reflector antenna. Other WIPL-D guides have detailed procedure for this type of antennas. Here, the work is focused to realistic reflector antenna parts impacting the performances.

Splash plate reflector antenna typically consists of cylindrical waveguide feeder and splash plate subreflector (antenna feeder), and main parabolic reflector.

Splash-plate Feeder

The cross section of antenna feeder (based on circular waveguide technology) is shown in Fig. 1.

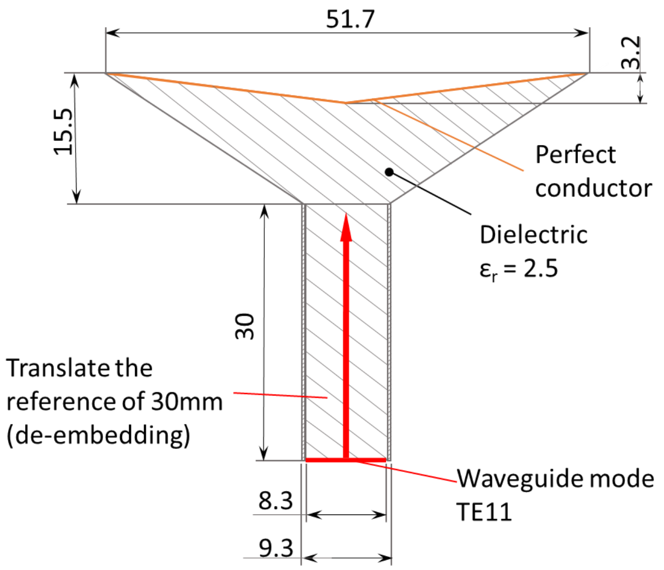

Fig. 1. Cross section of antenna feeder

The cross section of the parabolic reflector and placement of antenna feeder is given in Fig. 2.

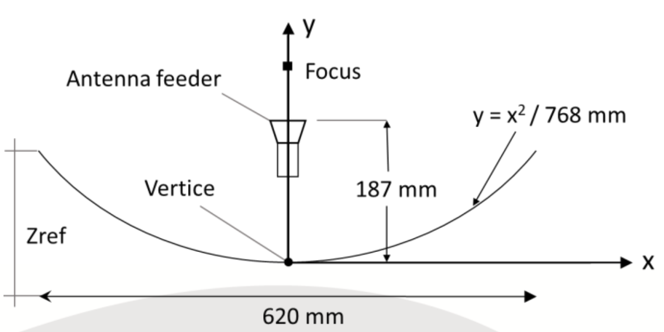

Fig. 2. Cross section of antenna

Splash-plate Reflector

The parabola is completely determined with the following parameters:

Fref – focal distance of the parabola,

Rref – half radius of the parabola,

Zref – the height of the parabola edge.

Zref is related to other parameters as:

$$Zref = \frac{Rref^2}{4Fref}$$

The splash plate subreflector and parabolic reflector are built using *Rflct*, *BoR* and *Circle* objects in WIPL-D. An example of usage of WIPL-D objects used to define the antenna is presented in Fig. 3.

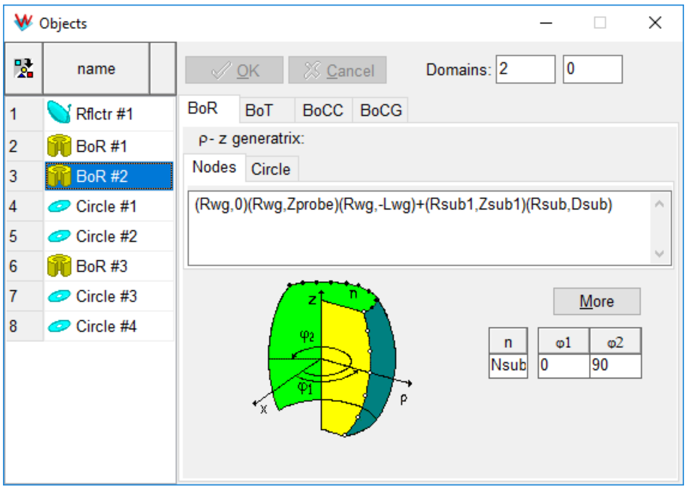

Fig. 3. WIPL-D *Objects* window

One quarter of the modeled structure is illustrated in Fig. 4.

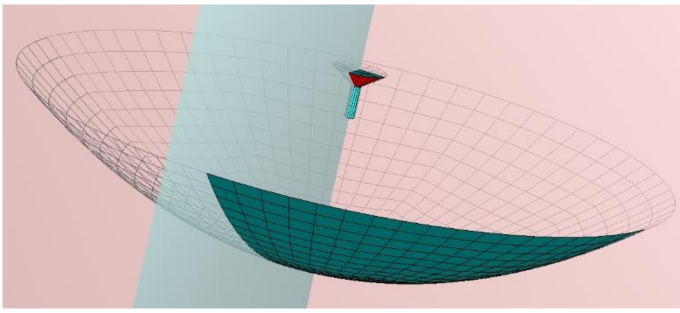

Fig. 4. Model of the splash plate reflector with cylindrical waveguide feeder in WIPL-D

Antenna feeder should be located approximately in the reflector focus, in order to obtain the best possible radiation pattern.

WIPL-D Simulation

The structure is fully parameterized and all further modifications and optimization are easy to perform thanks to WIPL-D symbolic mechanism. The full model (where usage of symmetries is ignored) is shown in Fig. 5.

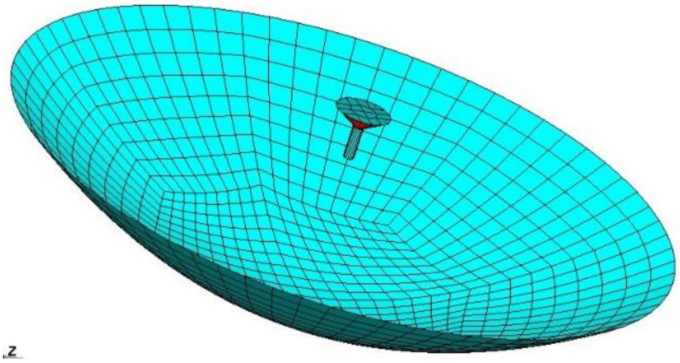

Figure 5. Antenna, full model

The antenna is simulated at 16 GHz and with 18 segments per quarter of reflector circumference in order to secure that metallic patches are about 1 lambda by 1 lambda (to ensure maximum accuracy). For the antenna only, the chosen accuracy is *Enhanced 1* for *Integral accuracy* which provides more than stable results. For the additional parts, the *Integral accuracy* is set to *Enhanced 2*. All other simulation parameters are left at default values.

WIPL-D simulated radiation pattern of the basic antenna is presented in Fig. 6, in two principal cuts.

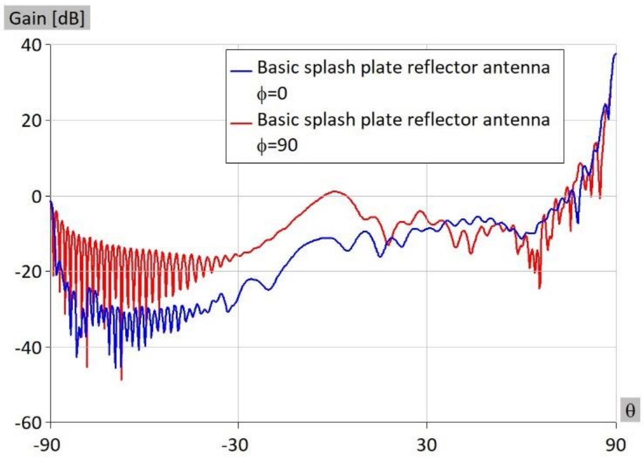

Figure 6. Radiation pattern (Splash plate antenna only, Cartesian coordinate phi cuts for two principle planes)

In addition, different objects can be mounted to antenna to improve performance and shape of the radiation pattern. In this case, the related structures are radome, absorber and shroud.

The first, antenna radiation pattern is shaped using metallic shroud (which is 300 mm high). The shroud is modeled using WIPL-D *Plates* and *Manipulations* and it is shown in Fig. 7. *Integral accuracy* is increased to *Enhanced 2* which is more than enough to provide stable and accurate result. Radiation pattern is shown in Fig. 11. In order to check the influence of absorbing materials to radiation pattern, the dielectric absorber with Er = 1 -j1 is added to the antenna. The absorber thickness is 10 mm and the inner side of the shroud is coated with the absorber. The structure is presented in Fig. 8 and radiation pattern is shown in Fig. 12.

A flat radome (without absorber) is also added to the antenna (Fig. 9). The radome has Er=2.56 and thickness is chosen as 5.859 mm (2.93 mm) which is equal to lambda/2 and lambda/4, respectively. That way, minimum and maximum reflection from the radome is set. The influence of radome to radiation pattern is presented in Fig. 13 (Fig. 13a and Fig. 13b). The result shows that effect of radome is significantly smaller than the influence of absorber.

Finally, the antenna is modeled with radome, shroud and absorber (Fig. 10 and Fig. 14). The results and number of unknowns is summarized in Tab. 1.

Hardware used is a regular desktop quad core PC equipped with Nvidia GPU card with CUDA enabled capabilities. Adding even a single GPU card to standard desktop PCs transforms the configurations into WIPL-D platforms able to simulate extremely large models in minutes owing to use of WIPL-D GPU Solver.

The hardware configuration is: Intel i7 7700 CPU (3.6 GHz), 64 GB RAM, Nvidia GeForce GTX 1080 GPU card

Table 1 Summarized results.

Model	Number of unknowns	Gain [dB]	Front to back	Simulation time [sec]
Antenna	4,103	37.65	39.06	7
With shroud	9,269	37.84	50.11	20
With shroud and absorber	25,613	37.12	60.84	104
With shroud and radome	28,061	37.94	52.65	145
With shroud, radome and absorber	45,269	37.13	59.25	302

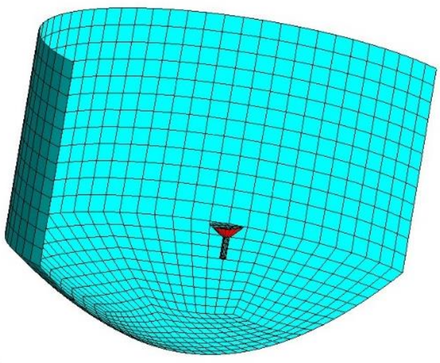

Figure 7. Model of antenna with shroud

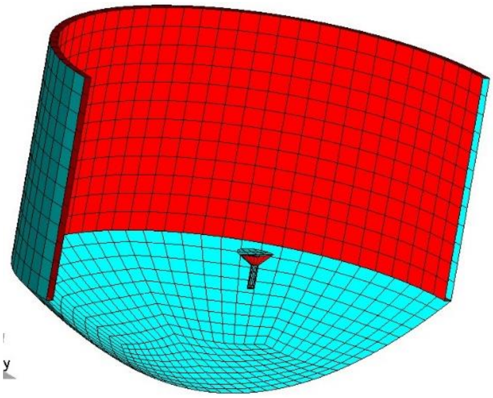

Figure 8. Antenna with shroud and absorber

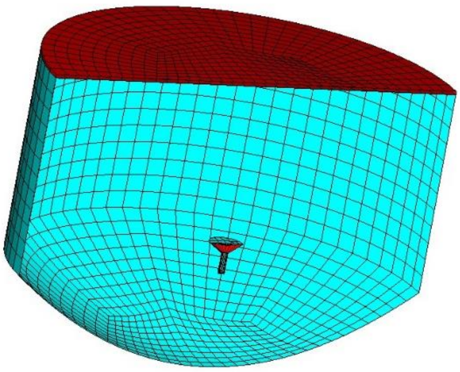

Figure 9. Antenna model with shroud and radome

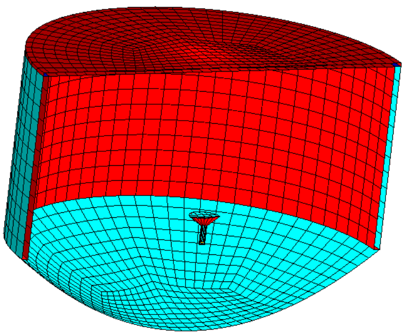

Figure 10. Antenna model with shroud, radome and absorber

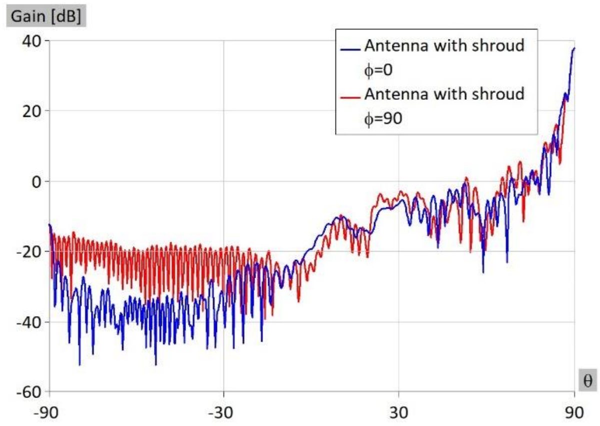

Figure 11. Radiation pattern (antenna with shroud)

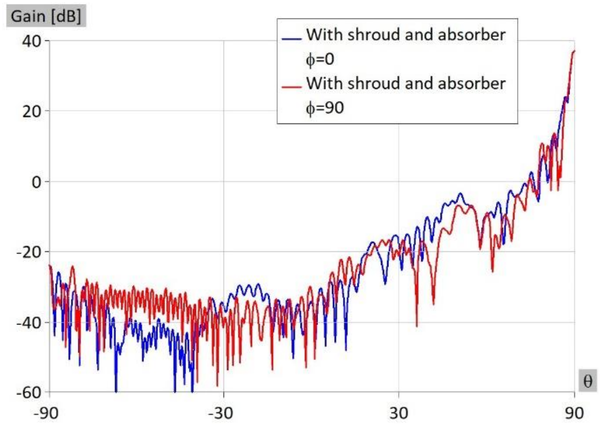

Figure 12. Radiation pattern (with shroud and absorber)

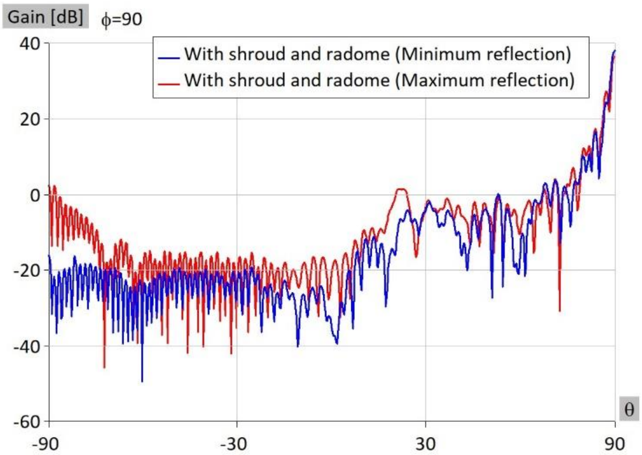

Figure 13a. Radiation pattern (with shroud and radome)

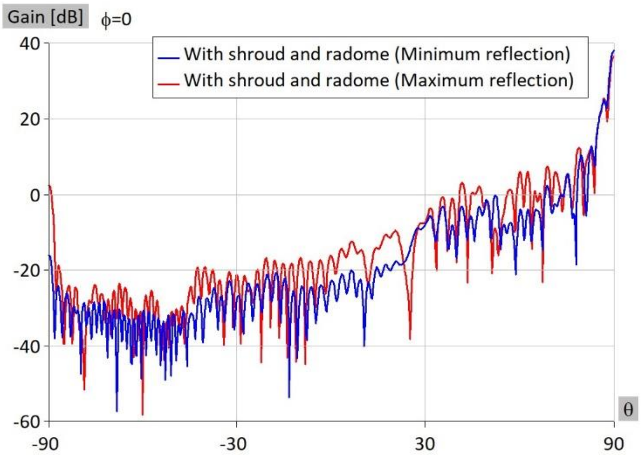

Figure 13b. Radiation pattern (with shroud and radome)

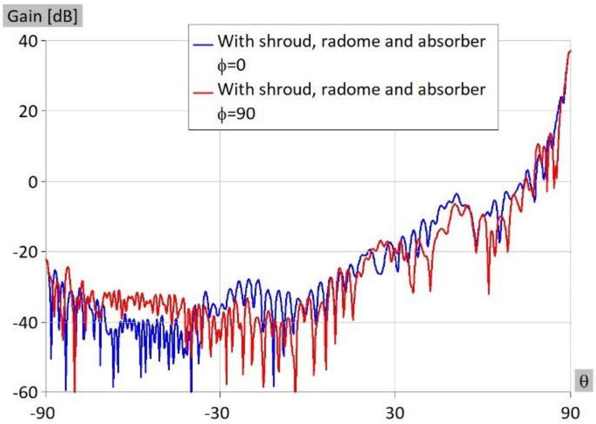

Figure 14. Radiation pattern (with shroud, radome and absorber)

Conclusion

Owing to the efficient implementation of Method-of-Moments (higher order basis functions, quadrilateral mesh, specialized reflector object), WIPL-D Pro is able to solve electrically large reflector antennas in dramatically small computational time at regular desktops or laptops. This is efficiently shown in numerous application notes and reflector antenna guides available at the WIPL-D web site.

In this application note, this is briefly described by showing a basic splash plate reflector antenna. The antenna itself has feeder illuminating 35-lambda reflector (620 mm diameter at 16 GHz). The simulation of the feeder is advanced considering the shape of the splash plate and the dielectric support included. However, such simulation requires only several thousand unknowns and can be run in seconds at any modern laptop or desktop. Such simulation is referred as the basic antenna.

As an advanced level of simulation, the basic antenna is modified by adding metallic shroud, which is then covered with the dielectric absorber. In the final step, a simple flat radome is added to cover the aperture. Lambda/2 and lambda/4 thick radome is simulated to demonstrate theoretically minimum and maximum reflection.

The results indicate the dramatic effect of the shroud to front to back ratio. Adding absorber further improves front to back for another 10 dB, but such lossy material reduces the gain for 0.8 dB. Theoretically maximum transparent radome does not compromise the gain and front to back ratio.

All models are simulated at the regular desktop PC equipped with single inexpensive GPU card. This transforms the regular desktop into powerful WIPL-D workstation. The simulation times are rather low. Less complex models are simulation in seconds while the most complicated ones are carried out in minutes at most.