electromagnetic modeling of composite metallic and dielectric structures

Illuminating Reflectors by Analytical Feed via Field Generators

Introduction

This application note presents how to **efficiently apply analytical feed in the WIPL-D software** suite as an excitation of the EM problem. The feature used is Field Generators.

This is demonstrated on a **reflector antenna example** with radius and focal distance set to 10 wavelengths. Reflector should be illuminated with a radiation pattern specified to have -12 dB radiation bandwidth at 106 degrees.

Problem Statement

The basic idea is to illuminate reflector antenna with a radiation pattern specified analytically. There are **two solutions**:

- to model a real antenna with radiation characteristic similar to the requested pattern, or
- to define analytical feed by using formulas in the WIPL-D Field Generator feature.

The first approach can be done by using a rectangular horn antenna depicted in Fig. 1 with tunable length and aperture size.

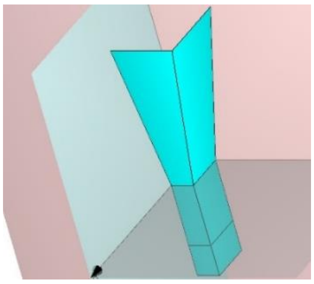

Figure 1. Horn used to illuminate reflector antenna

At the operating frequency of 25.5 GHz, horn length is 15 mm, aperture cross section is 15x12 mm, while feeding waveguide cross section is 8.636x4.318 mm. As presented in Fig. 2, the specified horn yields radiation pattern similar to the required analytical field.

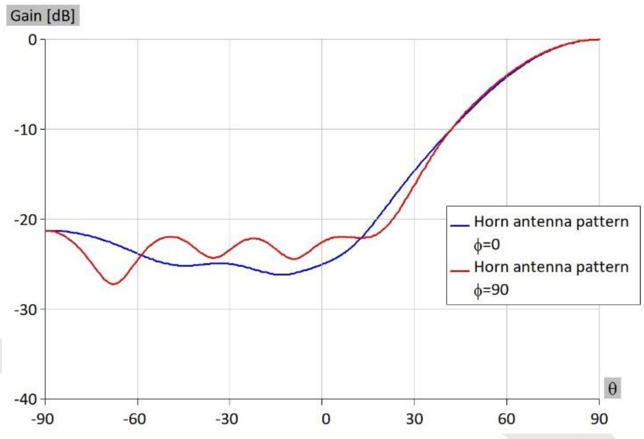

Figure 2. Horn pattern similar to the required feed

Such a feeding antenna is now imported as feeder into the reflector project, as shown in Fig. 3.

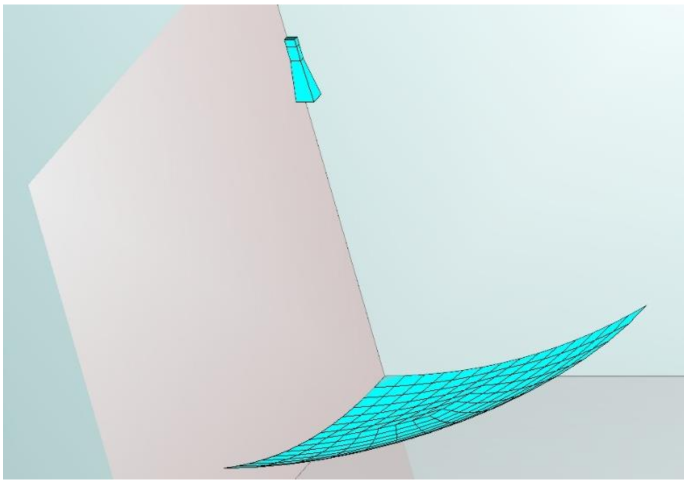

Figure 3. Horn antenna illuminating reflector antenna

As an alternative to horn antenna, analytical feed can be generated by using next two sets of formulas:

Real part of Ephi set to **zero**

Imaginary part of Ephi set to **zero**

Real part of Etheta set to:

(abs(cos(Theta))^2.75)*(abs(cos(Phi))^2.75)

Imaginary part of Etheta set to **zero**,

$$Re\{E_\varphi\} = 0 \quad Im\{E_\varphi\} = 0$$

$$Re\{E_\theta\} = |\cos^{2.75}(\theta)| \cdot |\cos^{2.75}(\varphi)| \quad Im\{E_\theta\} = 0$$

or

Real part of Ephi set to:

-(abs(sin(Theta))^2.75)*cos(Phi)

Imaginary part of Ephi set to **zero**

Real part of Etheta set to:

(abs(sin(Theta))^2.75)*sin(Phi)

Real part of E theta set to **zero**.

$$Re\{E_\varphi\} = -|\sin^{2.75}(\theta)| \cdot \cos(\varphi) \quad Im\{E_\varphi\} = 0$$

$$Re\{E_\theta\} = |\sin^{2.75}(\theta)| \cdot \sin(\varphi) \quad Im\{E_\theta\} = 0$$

The first set of formulas yields a slightly asymmetrical feed, while the second set yields perfectly symmetrical feeder pattern presented in Fig. 4. The equations are presented in two forms, the first corresponding to the syntax related to the specifics of the Field Generators feature, and the second corresponding to the traditional mathematical form.

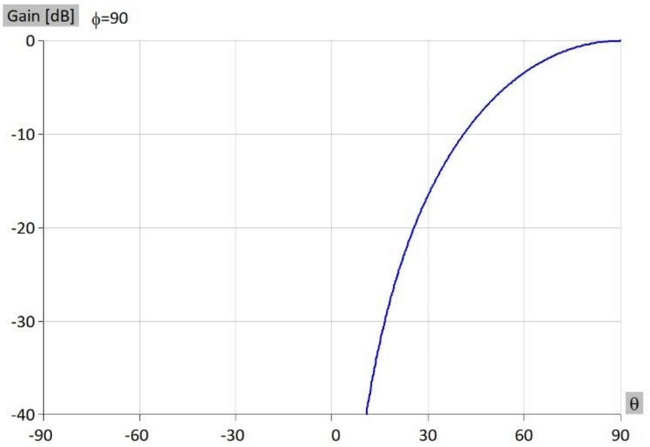

Figure 4. Radiation pattern of two analytical feeds (axis symmetrical)

Results

Simulation itself is very simple. For accurate results (main lobe and the side lobes), WIPL-D Pro requires **only 2,700 unknowns** and simulation time is **typically several seconds**. The result of interest is radiation pattern in 3 principle azimuth cuts as presented in Fig. 5.

Conclusion

This application note presents the procedure for **efficient definition of analytical feed in the WIPL-D** software suite. The defined feed further serves as an excitation of the EM problem. The feature used is Field Generators.

The procedure is described on a **reflector antenna** example with radius and focal distance set to 10 wavelengths. For the efficient WIPL-D implementation of higher order basis functions and method of moments (MoM), such an example can be considered as electrically small. The simulation is practically instantaneous on **any common laptop or desktop PC**. In the particular design a requirement was to illuminate the reflector with a feed specified with radiation pattern having -12 dB radiation bandwidth exactly 106 degrees.

There are two solutions for such a problem. One involves tuning a rectangular horn antenna, while the other is a simple definition of the analytical feed via the Field Generators feature. The app note shows exact equations which generate the analytical pattern according to predefined specifications. The reflector is simulated as illuminated with the traditional horn and two analytical feeds. **The results indicate that the Field Generators can be used successfully to replace the actual illuminator**. This is particularly important when the horn geometry is not known, or only the measured pattern is available. WIPL-D Field Generators allow the field to be generated either as **radiation pattern file** (in the WIPL-D format) or as **analytical set of equations** defining the field. In more complex scenarios, a pattern can be subsequently shifted or tilted, multiplied to form an array etc.

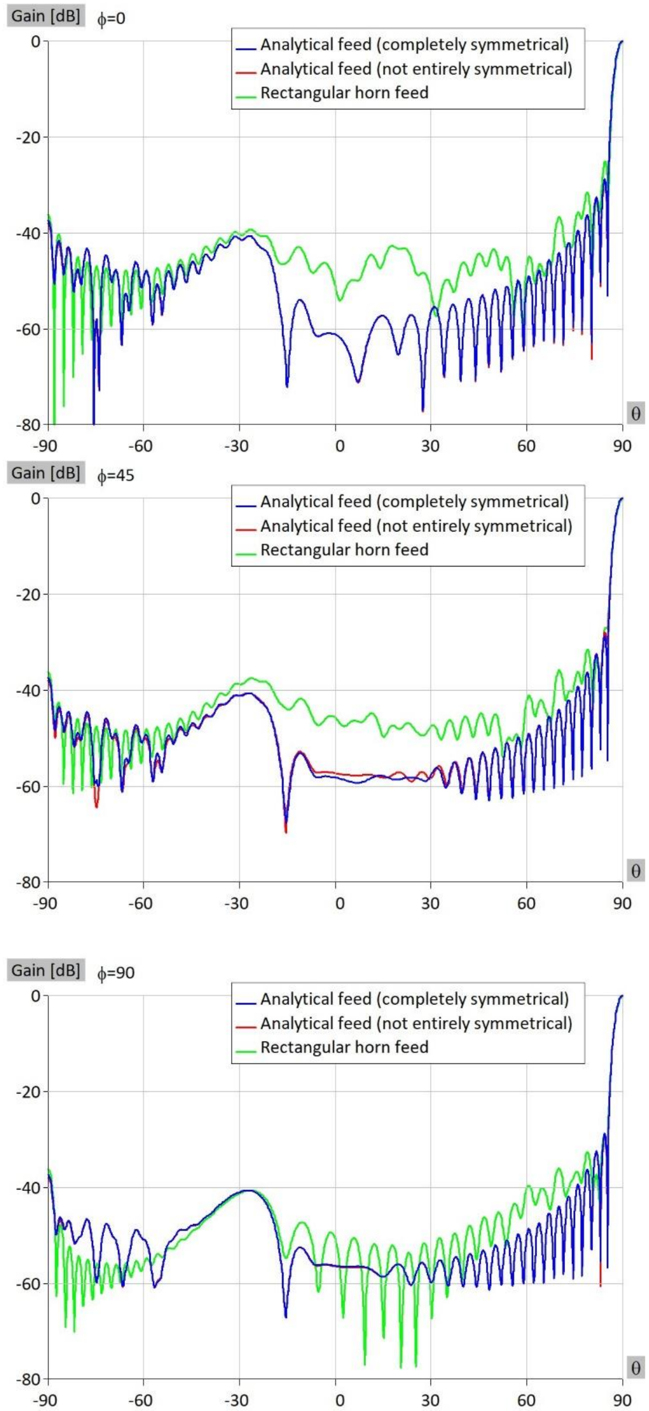

Figure 5. Comparison of radiation pattern obtained with three different feeders