

## Compact Multi-band Antenna for Wireless Applications

The aim of this application note is to demonstrate the possibilities of WIPL-D Pro 3D EM Solver regarding simulation of complex printed antennas in a wide-band. Also, the aim is to illustrate the simplicity of creating models of this type of antennas in the WIPL-D Pro CAD. The software takes into account the influence of a finite-size ground plane backing the antenna. The antenna is simulated in the frequency range between 0.5 and 3 GHz and is modeled as being printed on a dielectric substrate with  $Er = 4.4$  and 1.6 mm thickness.

### Antenna Model

The antenna is fully modeled using **WIPL-D Pro CAD**, a powerful package for easy general 3D EM modeling and quadrilateral meshing. To obtain satisfactory results for printed structures techniques like edging and total imaging have to be applied. Total imaging, otherwise a lengthy process, is done in seconds by WIPL-D Pro CAD.

The model (Fig. 1) is made according to specifications from the Microwave Journal published in May 2008 [1]. Final dimensions are used, listed in Table 1 in [1] and repeated here for clarity in Tab.1. The complete process of fully-parametric model creation and transfer to WIPL-D Pro lasts a bit more than one hour.

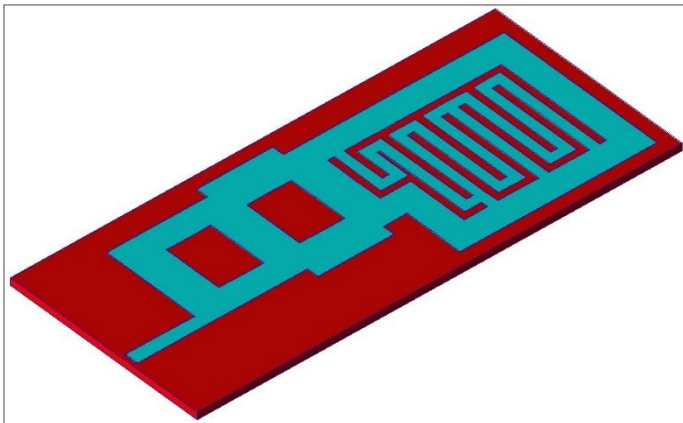


Figure 1. Antenna with finite ground plane

Table 1. Antenna dimensions in mm, according to [1]

Parameter	Value [mm]	Parameter	Value [mm]
xf	0	Wf	3
W1	6	W2	13.5
W3	2.75	W4	13.5
L1	8	L2	10
L3	17	L4	5.5
M	2.3	S	1.5

Final WIPL-D model is obtained after performing mesh from WIPL-D Pro CAD. The mesh process is fully automated.

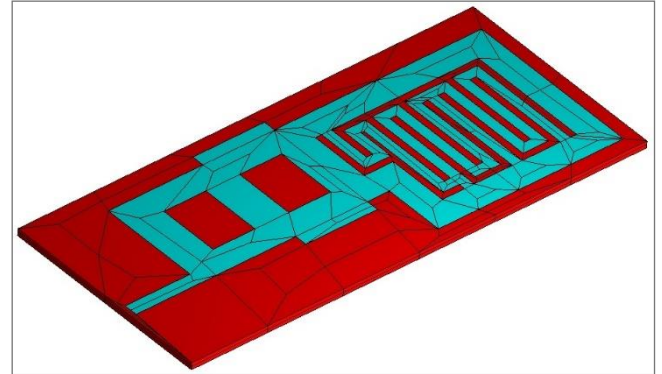


Figure 2. WIPL-D Pro model

### Simulation of Antenna

The created antenna model was simulated using WIPL-D Pro. The S11 parameter is plotted in the frequency range from 0.5 to 3 GHz (Fig. 3). The observed resonances were identified with simulation and measurements [1] as in Tab. 2. Corresponding radiation patterns were obtained for the operating frequencies of  $f=0.9$  GHz (Figs. 4 and 5),  $f=1.9$  GHz (Figs. 6 and 7), and  $f=2.4$  GHz (Figs. 8 and 9).

Table 2. Simulated and measured [1] resonances

Simulated resonance [GHz]	Measured resonance [GHz]
0.89	0.89
1.09	1.09
1.32	1.32
1.38	1.38
1.66	1.66
1.80	1.8
1.93	1.91
2.15	2.15
2.40	2.4
2.63	2.61

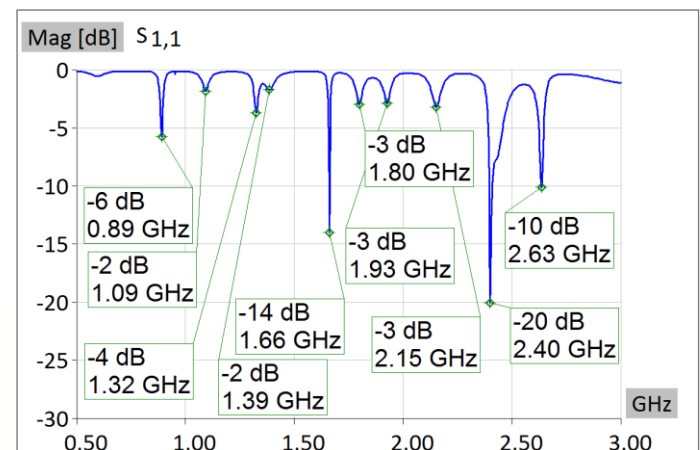


Figure 3. S11 parameter (0.5-3 GHz)

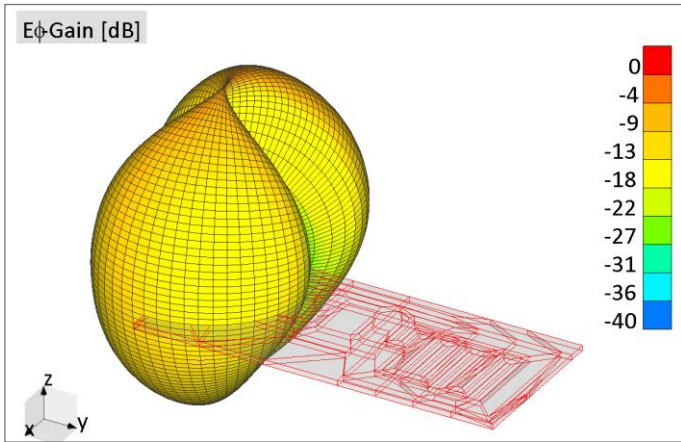


Figure 4.  $E\phi$  – 3D diagram at 0.9 GHz

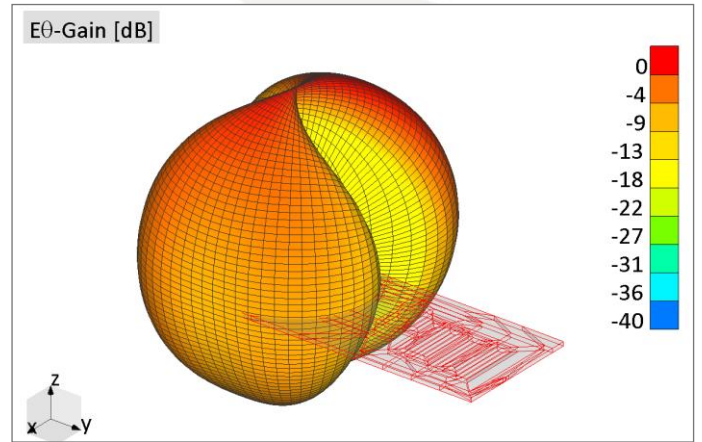


Figure 7.  $E\theta$  – 3D diagram at 1.9 GHz

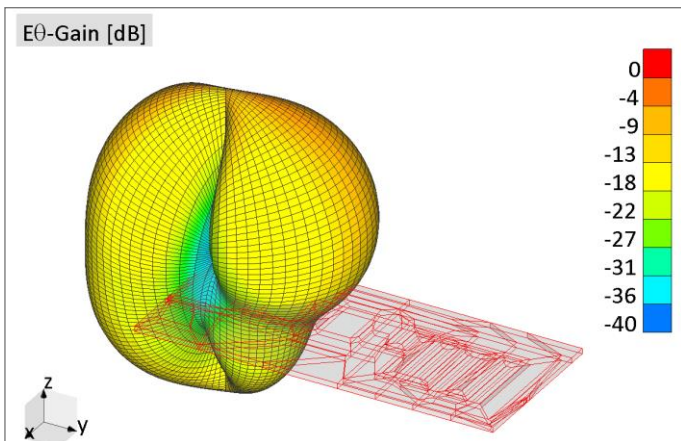


Figure 5.  $E\theta$  – 3D diagram at 0.9 GHz

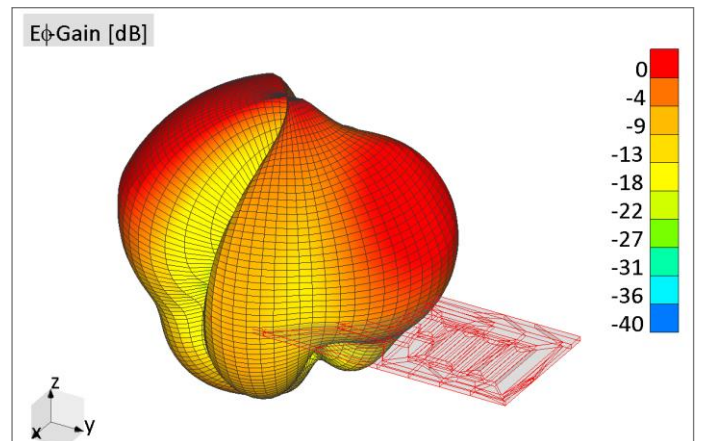


Figure 8.  $E\phi$  – 3D diagram at 2.4 GHz

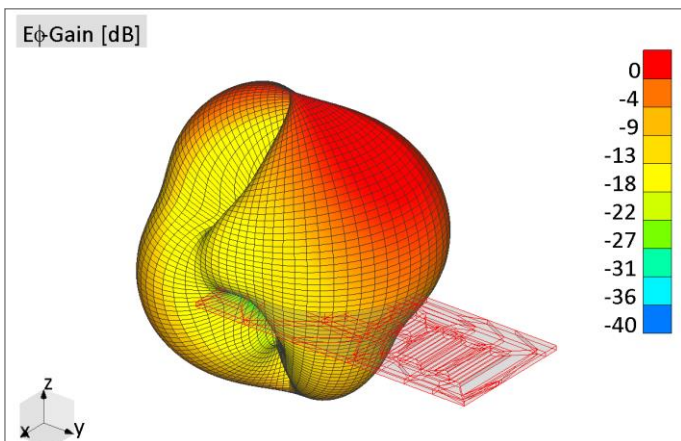


Figure 6.  $E\phi$  – 3D diagram at 1.9 GHz

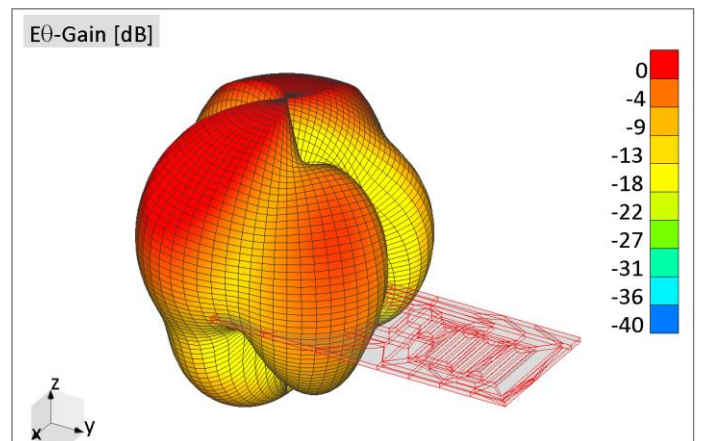


Figure 9.  $E\theta$  – 3D diagram at 2.4 GHz

The simulation at a single frequency lasts 8 seconds on Intel® Core(TM) i7-7700k CPU @3.60 GHz, a standard desktop PC. Due to wide band and numerous resonances, the simulation was run at 65 frequency points (owing to built-in interpolation mechanism), requiring only 3,418 unknowns.

[1] A. A. Eldek, "Analysis and Design of a Compact Multi-band Antenna for Wireless Communications Applications", Microwave Journal, vol. 51, no. 5, pp. 218-230, May 2008.