electromagnetic modeling of composite metallic and dielectric structures

Spiral Antennas

In this application note, we analyze two spiral antennas. The first one is with the air substrate. This means that spiral metallic arms will be located above reflector and air will fill space between arms and the reflector. The other antenna will include substrate consisting of the dielectric with relative dielectric permittivity of $\varepsilon_r = 2 + j \cdot 0$ (further appointed as antenna with dielectric substrate). This means that the dielectric will be located between metallic arms and the reflector.

Our aim will be inspection and comparison of S-parameters and gain of the antennas. Simulation times, number of unknowns and required memory will be presented in all the mentioned cases.

WIPL-D Pro, as full wave 3D EM method of moments (MoM) based solver with higher order basis functions is the tool that will be used both for modelling and simulation of the antennas.

Models of Spiral Antennas

The first spiral antenna (with air substrate) is shown in Figure 1.

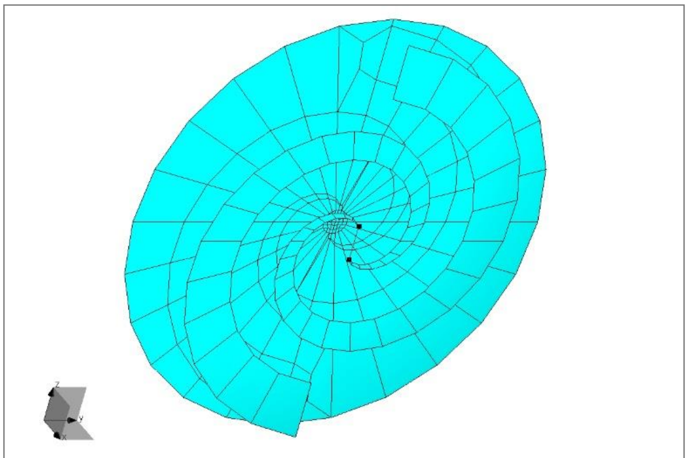

Figure 1. Spiral antenna with air substrate.

The second spiral antenna is shown in Figure 2.

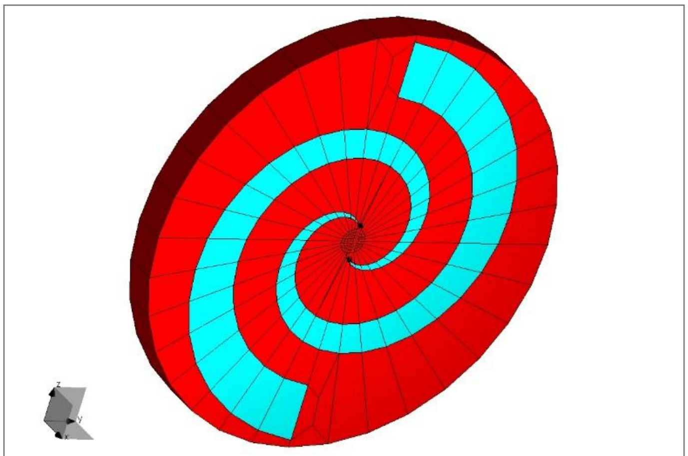

Figure 2. Spiral antenna with dielectric substrate.

In WIPL-D Pro, a spiral can be easily created and modified using built in *Helix* object. Especially if the same mesh over the close surfaces is required (here, antenna reflector and surface where spiral arms are located), built in manipulation named *Copy\Layer* can be very useful.

Both antennas are fed using small feeding wires connected with the metallic arms. Feeding zone of the spiral antenna with dielectric substrate is shown in Figure 3. Feeding zone of the spiral antenna with air substrate is created in the same way.

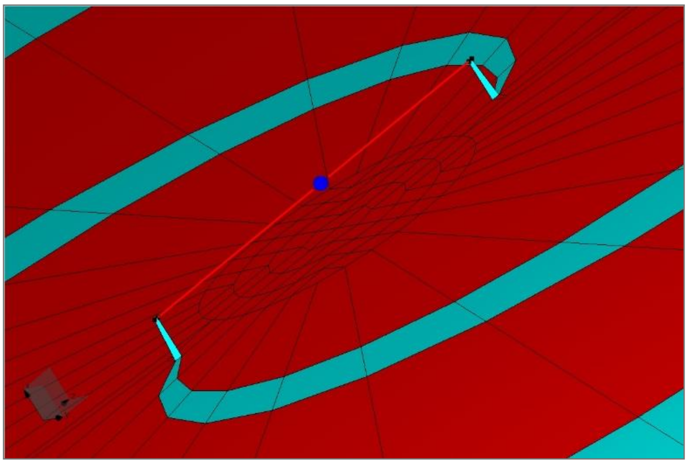

Figure 3. Feeding zone - spiral antenna with dielectric substrate.

WIPL-D Simulations

The antennas will be simulated from 0.3 GHz to 6 GHz in 50 frequency points. The low number of frequency points in such a wide band is possible due to usage of logarithmic scale and built-in interpolation.

We show the radiation pattern and near field at 3 GHz. Separately, we will show right-handed circular polarization (further, RHCP) and left-handed circular polarization (further, LHCP) also at 3GHz. Radiation patterns will be calculated in 37 directions over theta angle and 73 directions over phi angle. Near field will be calculated in 20,000 points distributed in 2D space.

In order to achieve stable output results, convergence of S-parameters was tested. This means that the opposite requirements has to be satisfied: the acceptable results should be achieved with as less as possible unknowns and with simulation time which is as shorter as possible. After the appropriate models were selected, output results are calculated.

Computer used for these simulations is regular desktop PC Intel® Core® i7-7700 CPU @ 3.60 GHz. The number of unknowns and the simulation time are low, and there is no need for any sort of expensive hardware. Simulation times per analyzed frequency, number of unknowns and occupied memory for both models where S-parameters and gain in one direction were calculated, are presented in Table 1.

Table 1.Number of unknowns, occupied memory and simulation time per frequency for both antennas.

Antenna model	Number of unknowns	Memory [MB]	Simulation time per frequency [sec]
Air substrate	1785	24.31	0.4
Dielectric substrate	7153	390.36	6

Results

The comparison of S-parameters of the antenna with air substrate and the antenna with dielectric substrate is shown in Figure 4. Similar, the comparison of gain results is shown in Figure 5.

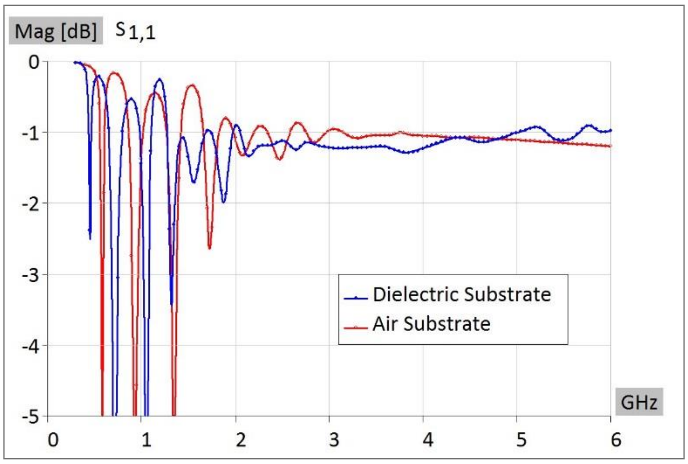

Figure 4. Comparison of S-parameters – antenna with air substrate and antenna with dielectric substrate

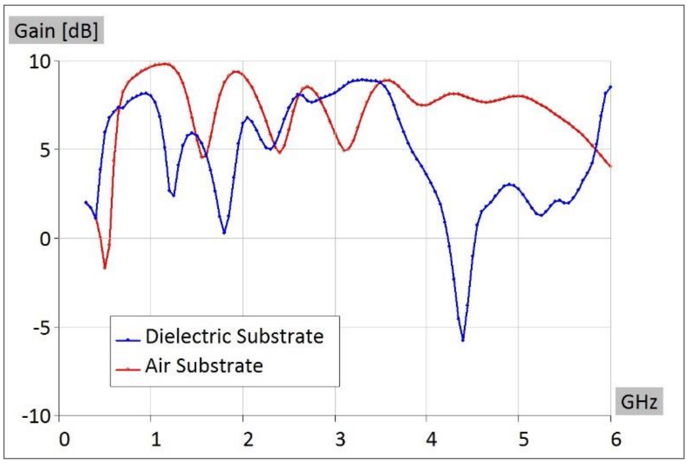

Figure 5. Comparison of gain results– antenna with air substrate and antenna with dielectric substrate

3D radiation pattern of antenna with air substrate, calculated at 3 GHz, is shown in Figure 6, while appropriate RHCP and LHCP are shown in Figure 7 and Figure 8, respectively. Near field result of the antenna with air substrate is shown below, in Figure 9.

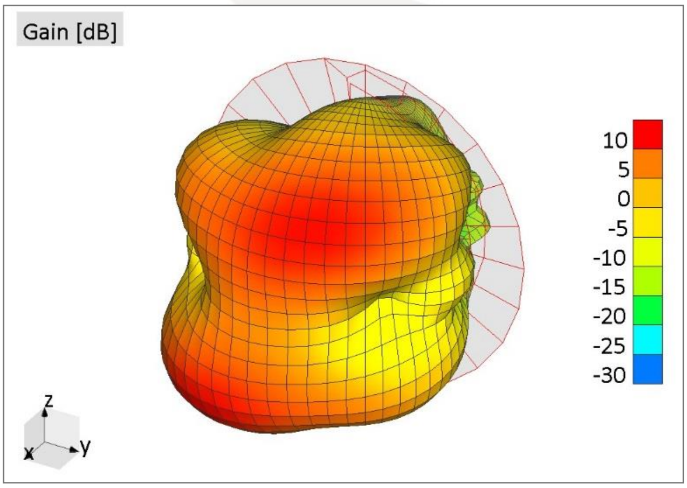

Figure 6. 3D radiation pattern calculated at 3 GHz - antenna with air substrate

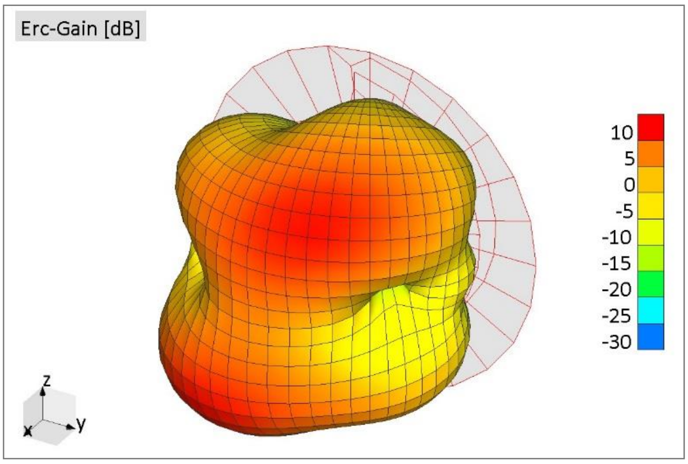

Figure 7. RHCP at 3 GHz - antenna with air substrate

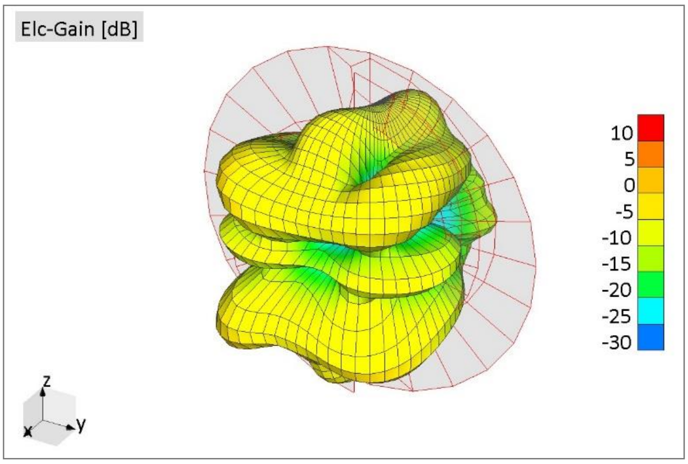

Figure 8. LHCP at 3 GHz - antenna with air substrate

3D radiation pattern of antenna with dielectric substrate, calculated at 3 GHz, is shown in Figure 10, while appropriate RHCP and LHCP are shown in Figure 11 and Figure 12, respectively.

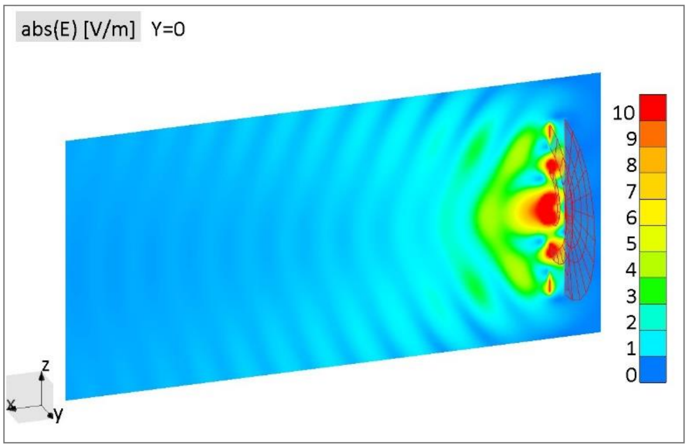

Figure 9. Near field calculated at 3 GHz - antenna with air substrate

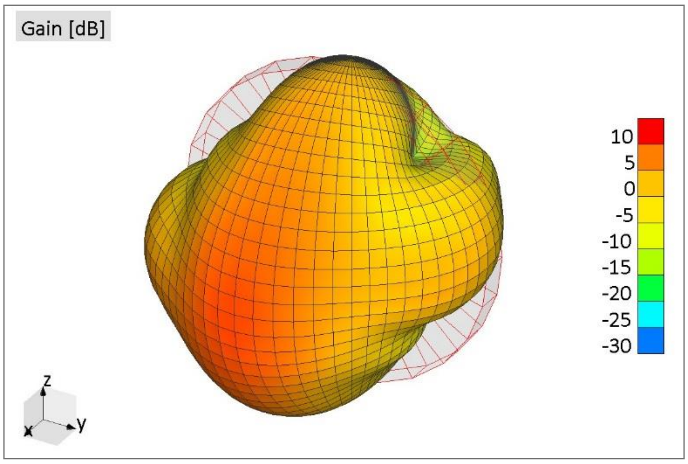

Figure 10. 3D radiation pattern calculated at 3 GHz - antenna with dielectric substrate

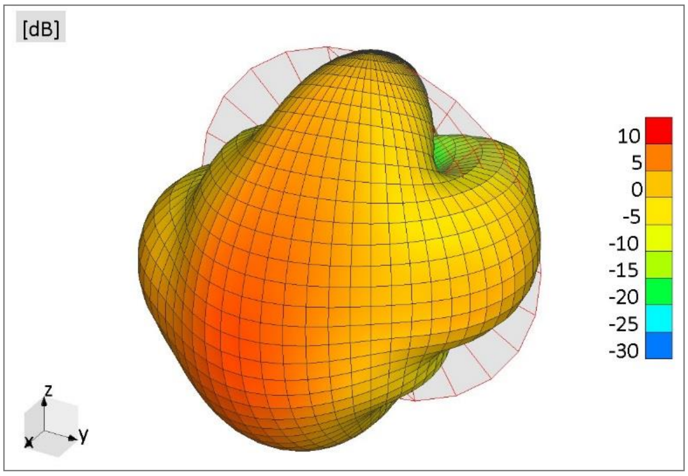

Figure 11. RHCP at 3 GHz - antenna with dielectric substrate

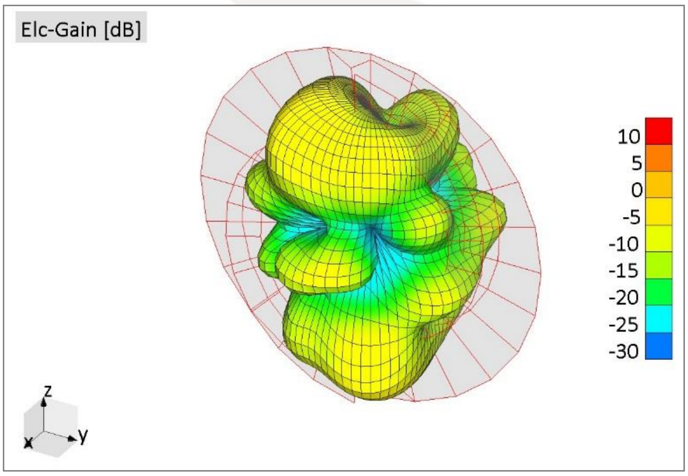

Figure 12. LHCP at 3 GHz - antenna with dielectric substrate

Near field result of the antenna with dielectric substrate is shown in Figure 13.

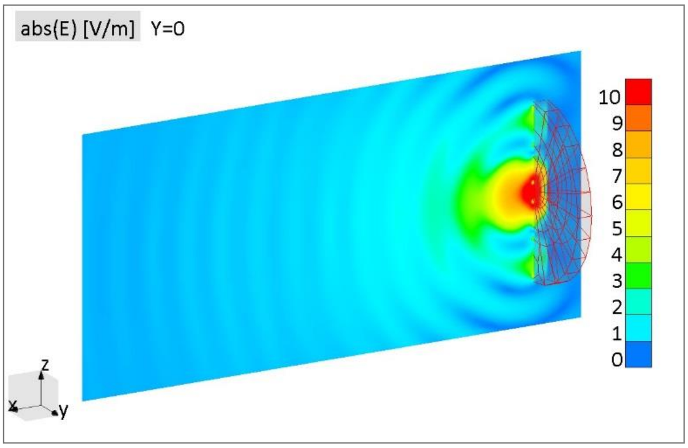

Figure 13. Near field calculated at 3 GHz - antenna with dielectric substrate