Helix Antennas

Discovered by scientist Krauss in 1946, helix antenna is used in space applications, radar systems... Usually, it is manufactured as a wire, coiled around dielectric cylinder. Helix antenna is very demanding structure for synthesis. It produces circular polarization of emitted EM wave. Also, its operating modes depend on used frequency.

The motivation for writing this application note encompasses comparing simulation times, number of unknowns and radiation patterns for three simulated helix antennas. 3D radiation pattern and 2D near field distribution will be presented, also. The software tool used for obtaining these results is WIPL-D Pro. It is full 3D EM, Method-of-Moments based solver.

WIPL-D Models

Simulated models of helix antennas are shown in Figs. 1-3. All simulated helix antennas consist of radiating elements and a reflector. In addition, one model of the antenna contains dielectric. In WIPL-D software, various helix antennas can be successfully designed using powerful built-in object named *Helix*. Combining object *Helix* with WIPL-D symbolic mechanism, a user can exploit very efficient modelling of helicoidal structures. This way of modelling enables fast and easy changing of structure dimensions, number of turns, number of segments…

Helix antenna with radiating elements modeled using WIPL-D *Wire* entities is shown in Fig. 1 (further, wire helix). WIPL-D *Wire* entity is very suitable for approximation of real-life wires. It is considered that only axial component of current exists in WIPL-D *Wire* entity. Helix antenna with radiating elements modeled using infinitesimally thin plates is shown in Fig. 2 (further, plate helix). Finally, helix antenna with radiating elements modeled using infinitesimally thin plates mounted on the dielectric supporting cylinder is shown in Fig. 3 (further, plate helix with dielectric). The used dielectric is with the following parameters: $\varepsilon_r = 2 + j \cdot 0$ and $\mu_r = 1 + j \cdot 0$.

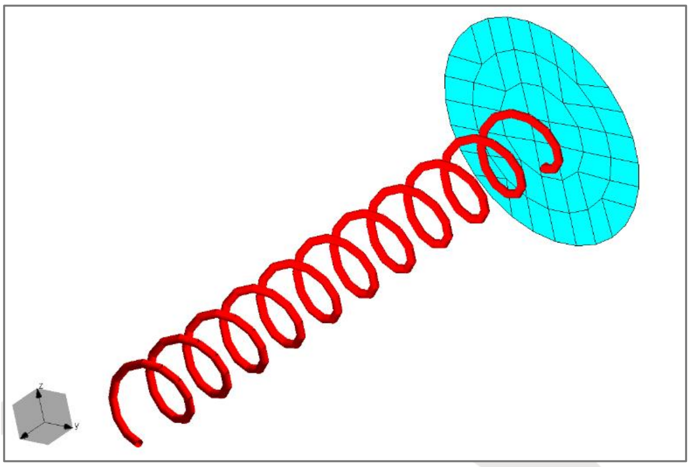

Figure 1. Wire helix

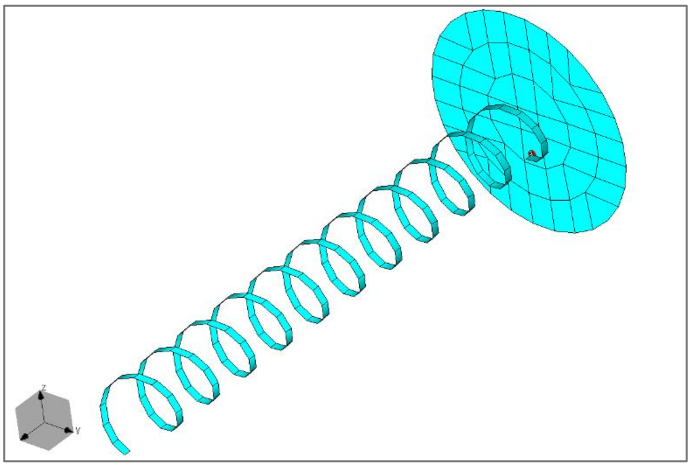

Figure 2. Plate helix

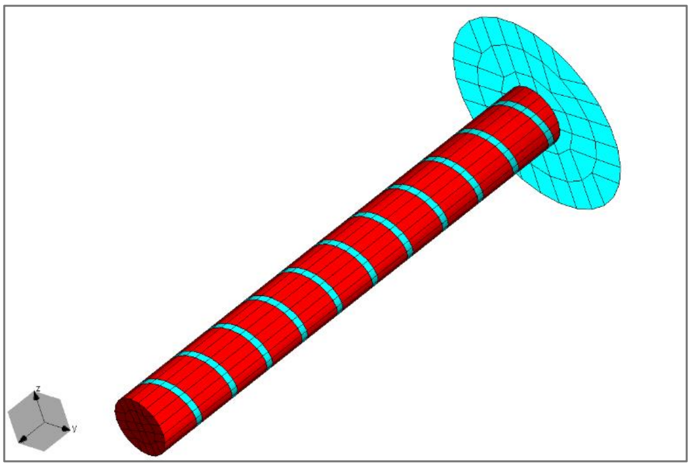

Figure 3. Plate helix with dielectric support

The three antennas are with the same dimensions of the reflector and radiating elements. Still, some approximations are adopted. For instance, it is considered that feeding zones do not influence the results (all of three antennas are with different feeding zones). Also, width of infinitesimally thin plates from plate helix is equal to dimeter of wires used in modelling radiating elements in wire helix.

Results and Simulations

All models were simulated at 9 GHz. The results of interest are radiation patterns in theta cut. In addition, for wire model, 3D radiation pattern and 2D near field distribution is calculated.

Radiation pattern of wire helix in 3D is shown in Fig. 4. It is calculated in 91x91=8,281 points. Radiation patterns in main beam direction for three models of helix antenna (wire helix, plate helix and wire helix with dielectric support) are shown in Fig. 5. These radiation patterns are calculated in 721x1=721 points. Finally, 2D distribution of near field for wire helix is presented in Fig. 6. The 2D near field distribution is calculated in 251x201x1=50,451 points.

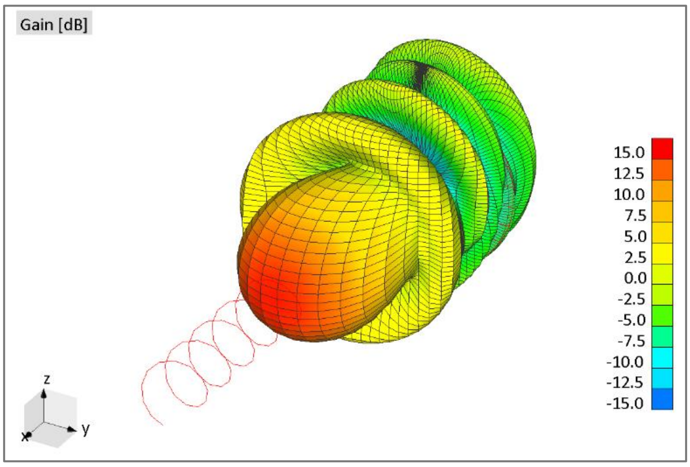

Figure 4. 3D Radiation pattern-wire helix antenna

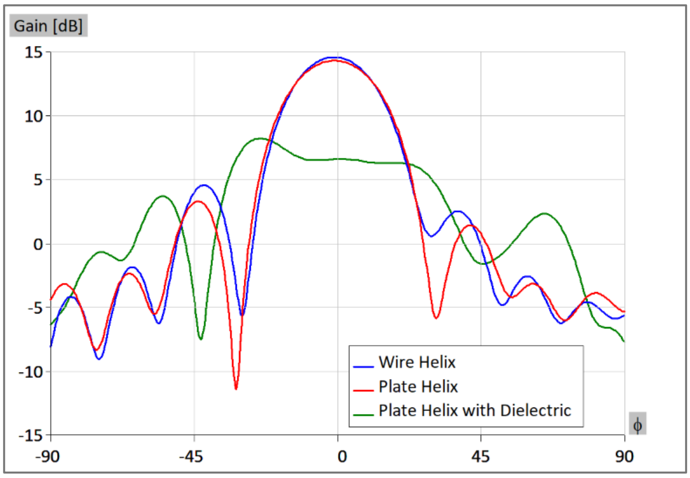

Figure 5. Radiation patterns-wire helix, plate helix and plate helix with dielectric support

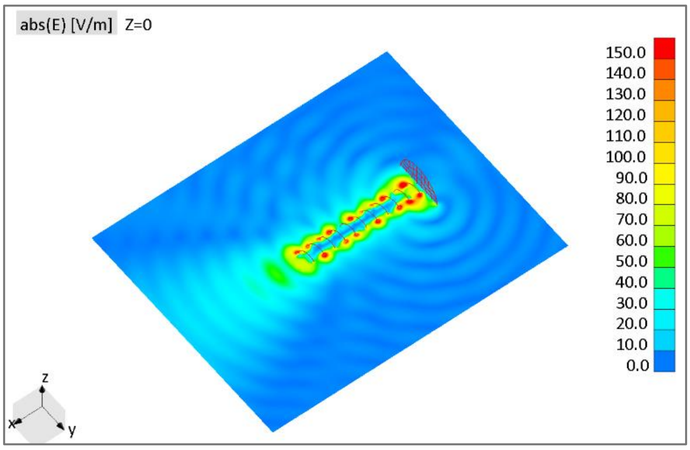

Figure 6. Near field distribution-wire helix antenna

Computer used for these simulations is Intel® Core™ i7-7700 CPU @ 3.60 GHz. Number of unknowns, computer memory required and simulation times are given in Table 1. Simulation time mainly consists of computer time necessary for matrix filli-in, computer time necessary for matrix solution and computer time spent in calculating output results.

Table 1. Number of unknowns, computer memory requirement and total simulation times

Model	Number of unknowns	Memory [MB]	Total simulation time[sec]
Wire helix	357	0.97	0.27
Plate helix	620	2.93	0.34
Plate helix with dielectric	3,097	73.18	2.50
Wire helix (3D radiation pattern)	357	0.97	0.58
Wire helix (2D near field)	357	0.97	2.47

Conclusion

Simulation results published in presented application note lead us to several conclusions.

The first–all simulation times are relatively small. Furthermore, computer memory requirements are minimal since the problem is electrically small. This means that such a small simulation time allows design process to be accomplished through optimization or sweep of design variables, via appropriate modules which are part of WIPL-D software suite.

The second-similar results between plate helix and wire helix are achieved. This means that, in this case, the plates are properly approximated using WIPL-D *Wire* entities. Beside achieving good agreement between the results, number of unknowns and simulation time are reduced if the model with wires is used. This simply approximation can lead us to solution of very complex problems. In the other words, if simulated model is complex, we can dramatically reduce simulation time and memory requirements by applying proper approximation.

Finally, the third-influence of dielectric is clearly seen. Model of the helix antenna with dielectric supporting cylinder, which is often used in real-life because of antenna solidity, has significantly different radiation pattern (comparing to the other two models). It is expected, since the presence of the dielectric influences antenna characteristics. The proposed overcoming of this situation can be in considering presence of the dielectric in design process.