Sinuous Antenna

WIPL-D Pro is highly efficient EM solver, based on Method of Moments (MoM). One of the most important advantages of WIPL-D kernel is the fact it uses **quadrilateral mesh**, unlike majority of other EM solvers which use triangular mesh. Usage of all-quad mesh instead of a triangular one brings the benefits of halving the number of unknowns for the particular EM model. This means that the **memory requirements are decreased** up to 4 times. In case of a direct, LU-decomposition type of linear system solver, **matrix solution** is provided up to 8 times **faster**.

In addition to all-quad mesh, WIPL-D uses **higher order basis functions (HOBFs)** up to the 8th order. This combination of MoM and HOBFs enables usage of relatively large mesh elements of size up to 2 wavelengths-by-2 wavelengths. This results in additional **decreasing number of unknowns**.

In order to show WIPL-D capabilities, two sinuous antennas will be simulated. It is assumed that input signal should be converted from unbalanced to balanced. Thus, a balun and a taper are included into antenna models. One model contains a sinuous antenna with a Klopfenstein taper. The second model contains a sinuous antenna with an exponential balun. The aim will be to show and compare S-parameters and radiation patterns.

WIPL-D Models

WIPL-D Pro model of the sinuous antenna with printed balun is shown in Figure 1. The geometry of the antenna is generated according to the equation:

$$\varphi(r) = (-1)^p \cdot \alpha_p \cdot \sin\left[\frac{\pi \cdot \ln\left(\frac{r}{R_p}\right)}{\ln(\tau_p)}\right]$$

The balun is located just below the sinuous antenna (Figure 1). It is implemented as a printed microstrip device. The Klopfenstein taper and exponential balun are shown in Figure 2.

Simulations and Results

The simulations of the sinuous antenna were carried out on a desktop workstation Intel® Core™ i7-7700 CPU@3.60 GHz. Number of unknowns and simulation times per frequency are shown in Table 1. The simulation time mainly consists of simulation time required for matrix fill in and matrix inversion. All simulations were performed at 31 frequency points.

S_{11}-parameters are presented and compared for both of sinuous antenna models (Figure 3). Radiation patterns at 5 GHz, 10 GHz, 15 GHz, and 20 GHz are calculated for the sinuous antenna with the exponential taper. These are presented in Figure 4.

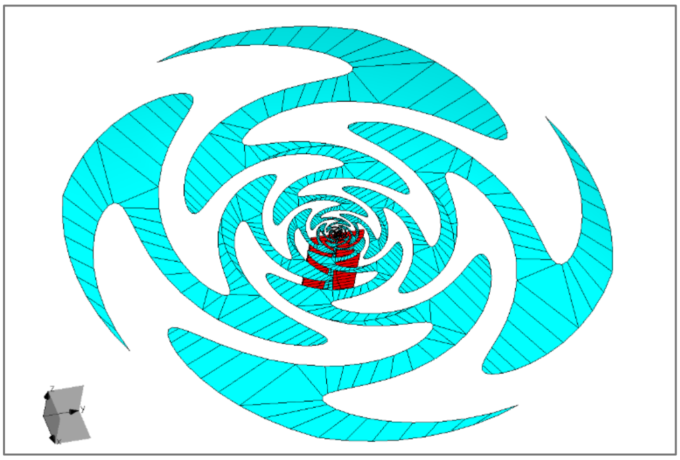

Figure 1. WIPL-D Pro model of the sinuous antenna with printed balun.

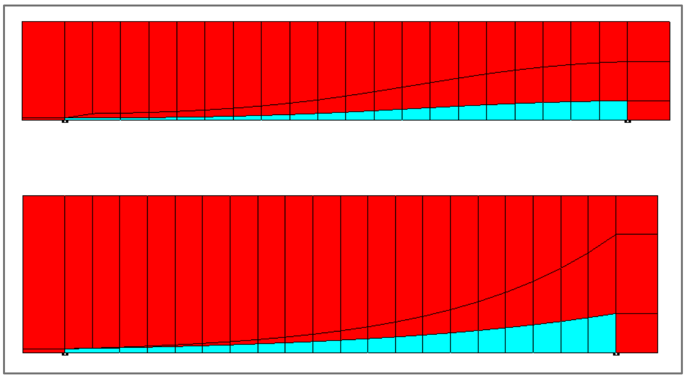

Figure 2. Klopfenstein taper (TOP) and exponential balun (BOTTOM).

Table 1. Number of unknowns and simulation time per frequency.

Model	Number of unknowns	Simulation time per frequency [sec]
With exponential balun	9,884	24
With Klopfenstein taper	9,678	21

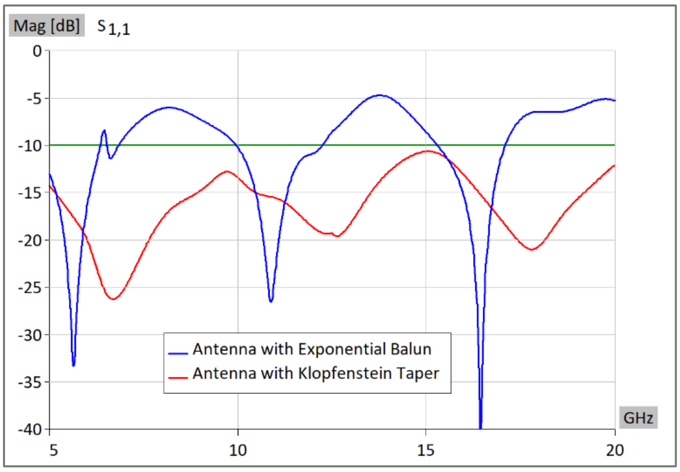

Figure 3. Compared S_{11}-parameters.

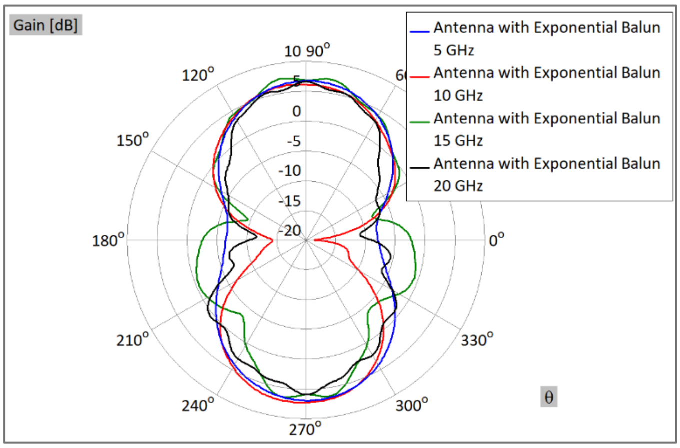

Figure 4. Radiation patterns at 5 GHz, 10 GHz, 15 GHz, and 20 GHz for the sinuous antenna with the exponential taper.

Conclusion

Two models of sinuous antennas – a model with Klopfenstein taper and a model with exponential balun were simulated. S_{11}-parameters were presented and compared in Figure 3. In addition, radiation patterns at 5 GHz, 10 GHz, 15 GHz, and 20 GHz are calculated for the sinuous antenna with the exponential taper. The radiation patterns are shown in Figure 4.

It is adopted that convention boundary for good matching is -10 dB. Thus, we see that usage of Klopfenstein taper gives S_{11} lower than -10 dB in the whole range and lower than sinuous antenna with exponential balun (Figure 3). Radiation patterns calculated at four frequencies shown in Figure 4 are similar in terms of shape and the gain level. This is in accordance with claim that the antenna can operate in wide frequency band. Thus, the antenna is suitable for airborne and communication applications [1].

WIPL-D Pro software yielded the solutions very fast. According to data shown in Table 1, we see that the code was executed quickly on a standard CPU platform.

References

[1] S. Palreddy, A. I. Zaghloul, R. Cheung, “An Optimized Lossy Back Cavity Loaded Four Arm Sinuous Antenna”.