Modeling Wires in Planar Spiral Coils

WIPL-D Suite

WIPL-D Pro CAD is extremely powerful state-of-the-art 3D EM solver. It is based on unique implementation of Method of Moments, since it applies quadrilateral meshing and higher order basis functions (they allow usage of both large and small mesh elements, up to 2 wavelengths large). The method itself requires only to mesh surface of the model (no boundary box). For the application in question (planar spiral coils), the modeling can be performed either via wires or quadrilateral plates. The kernel uses thin wire approximation (no change of circular component of current distribution but only the current distribution along wire axis). We will demonstrate how efficient are simulation is at low frequencies (frequency range 5-10 MHz).

Modeling

The focus of this application note is modeling of planar spiral coils. The modeling process is very simple and it is based on using of built-in spiral/helix objects. The basic idea is to make a simple wire spiral coil, the copy it and examine coupling and return loss. The model is shown in Figure 1.

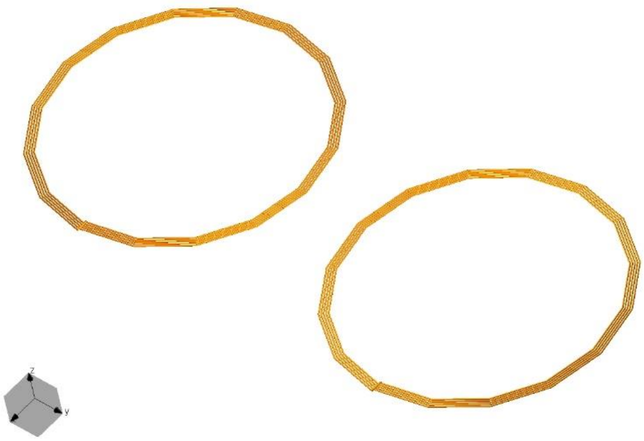

Figure 1. Two coupled planar spiral coils

Each coil consists of 5 turns of wire. Inner coil radius is 190 mm. Wire radius is 1 mm and spacing between adjacent wire loops is 2 mm. The model can be made of wires, solid tubes and hollow tubes. Figs 2-4 illustrate the feeding of the model in the 3 aforementioned cases. At the location of the generator, concentrated loading in form of 7pF capacitor is added to enable good return loss. Wall thickness was set to 0.2 mm (inner radius of the tube is 0.8 mm).

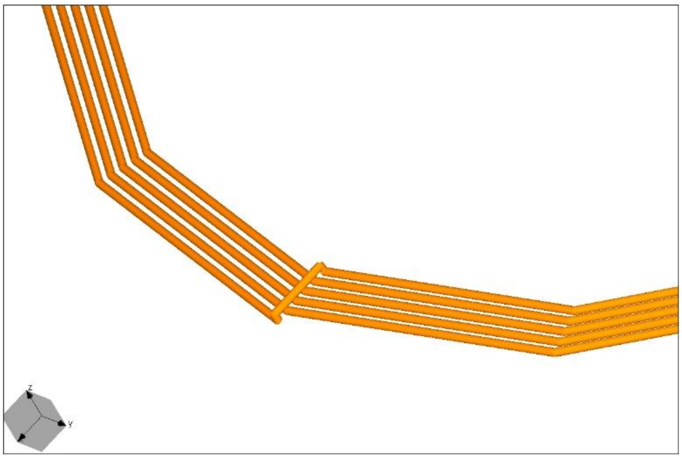

Figure 2. Coils made of wire

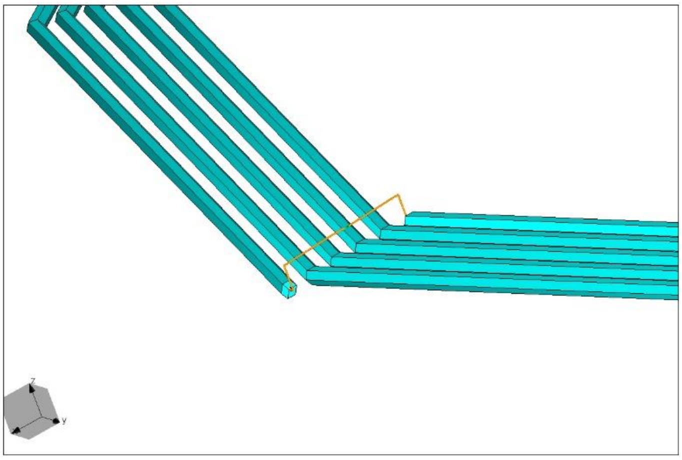

Figure 3. Coils made of solid plates

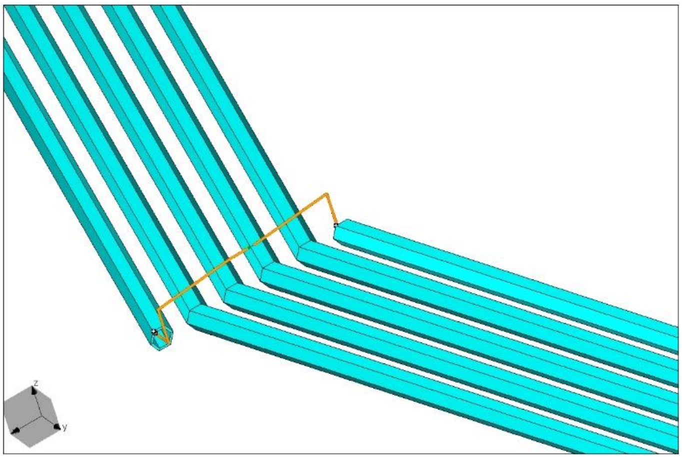

Figure 4. Coils made of hollow tubes

Simulation and Results

The results for return loss and coupling for the 3 models are shown in the following figures.

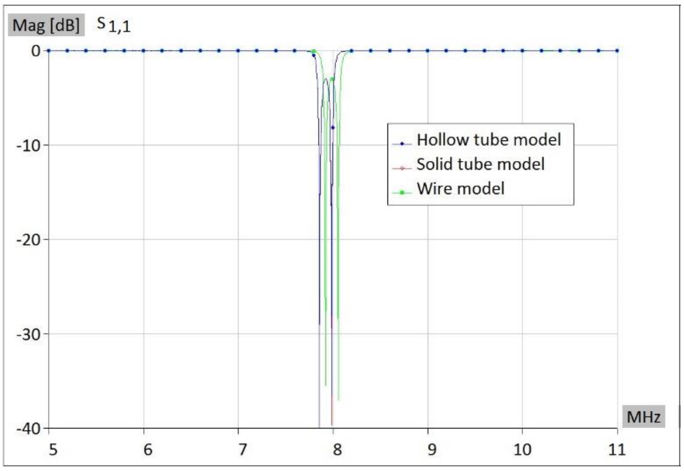

Figure 5. Return loss for the three models

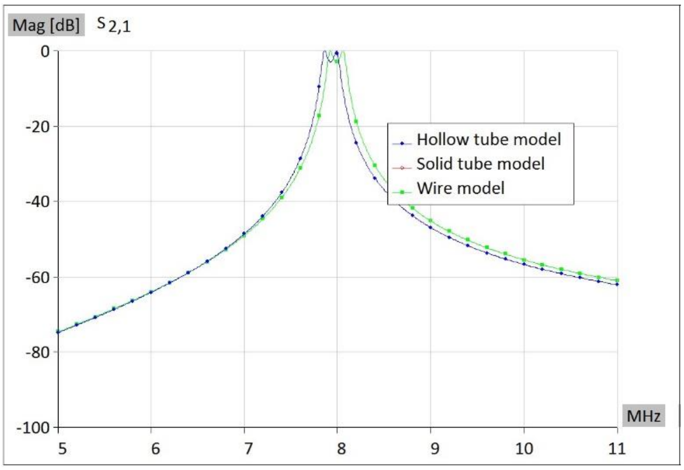

Figure 6. Coupling for the three models

It can be observed that the hollow and solid model yield almost the same results. There is a small difference between the wire model and solid model. The solid model was simulated with 6 segments per wire circumference, but larger or smaller number can be used based on required accuracy. Equivalent radius allows accurate simulation with lower number of segments.

Wire model yields very good accuracy for this application, despite the proximity of metallic conductors. The advantages are huge. It requires only 150 unknowns and simulations last only part of the second. Solid plate model requires 1,500 unknowns and the simulation lasts under one minute per frequency. The hollow tube model has two currents sheets and requires twice the number of unknowns (3,000). Simulation time is couple of minutes per frequency points. All simulations can be done on regular desktop or laptop PCs. Simulations are faster on multi-core CPUs (all the times are given for quad core CPU). The simulation is automatically adjusted according to low frequency, elongated metallic plates and the fact that the walls of the tube are rather thin. This makes simulation time mush longer than for the typical problem of such size.

One of the important aspects of EM simulation is to investigate the effects of ohmic losses. The skin depth is in the order of 1 mm at 10 MHz frequencies so this might be important for certain geometries. Presence of losses does not harden simulation.

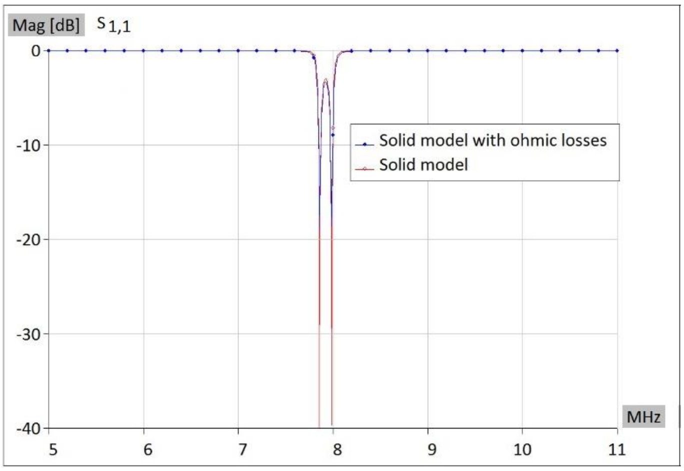

Figure 7. Return loss for the three models

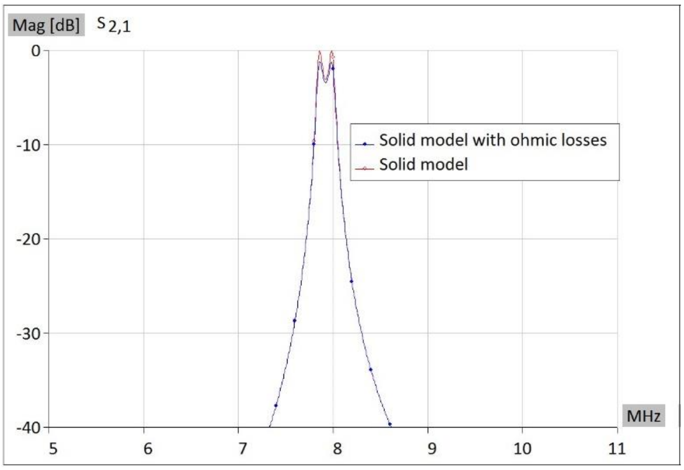

Figure 8. Coupling for the three models

Conclusion

WIPL-D Software is very suitable for simulation of planar spiral loops. Analysis time is very small. Models can be simulated as made of wires for extremely fast simulations (with excellent accuracy) or as plate models for the best accuracy. All simulations can be performed on inexpensive (everyday) hardware. Even the effects of metallic tube thickness can be investigated easily.