Wire Thickness Effect in Wound Coils

Introduction

This paper will present influence of thickness of wires on simulation of wound coils. Two pair of examples will be shown. The examples are direct comparison of identical WIPL-D Projects created by using wires or plates. Wire models are very easy to build and simulate, but wire models apply thin wire approximation. This assumes that current distribution does not change on the circumference of the wire but only along its axis. The aim is to investigate how well this model applies to simulation of coils. For this application, the field is mainly located inside of the coil itself. The first pair of examples will regard to straight wound coils. The other pair will regard to toroid wound coils.

Straight Wound Coils

The model of coil was created using WIPL-D *Wire* entity. It represents solitary coil in free space (Fig. 1). The second model of the coil was created using WIPL-D *Plate* entity (Fig. 2). It also represents a solitary coil in free space.

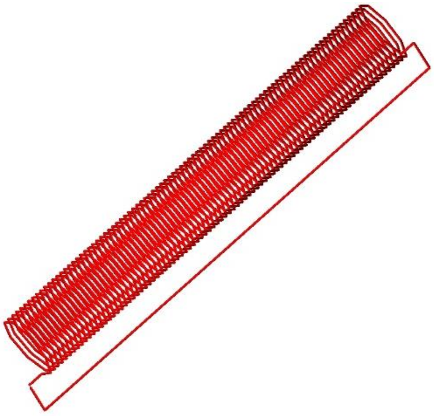

Fig. 1. Coil - wire model.

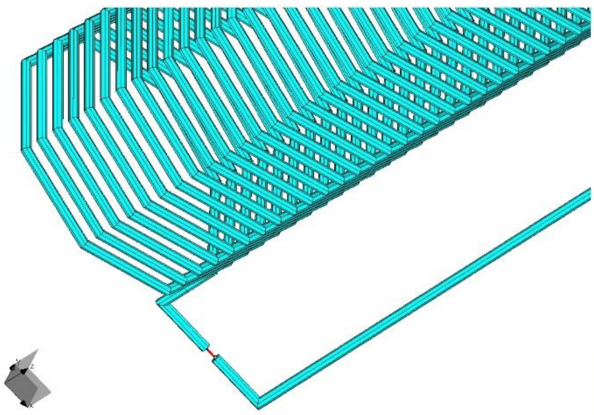

Fig. 2. Coil – detail of the plate model.

The examples are generic, and wire model is very easy to build by using WIPL-D Pro *Helix* built in object. Building the plate model is more demanding and the process includes creating nodes of plates manually exactly on the surface of the wire coil. After that, one segment of the helix is grouped and copied required number of times to achieve the helix object.

In order to compare results obtained using these models, imaginary part of z parameter is shown in Fig. 3.

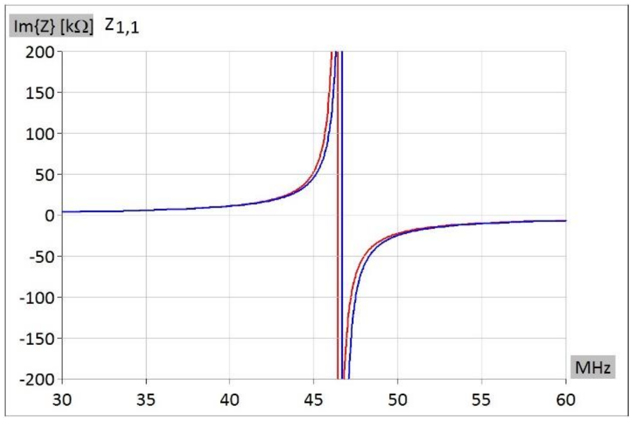

Fig. 3. Comparison between wire and plate straight wound coil.

The two models yield almost identical results although they are simulated in a completely different manner. This proves that thin wire approximation applied to wire objects does not compromise the accuracy, but it significantly reduces simulation time and requirements, and allows simpler projects building.

Coupling between Toroid Coils

Two models of pair of toroid coils in free space were created. The first pair was created using WIPL-D *Wire* entity (Fig. 4). The second pair was created using WIPL-D *Plate* entity. The model is more complex than the previous one and the simulation is more challenging.

Fig. 4. Toroid coil – wire model.

The models were compared using s21 parameter. Comparison is shown in Fig. 5. We can again inspect that wire model gives very good accuracy.

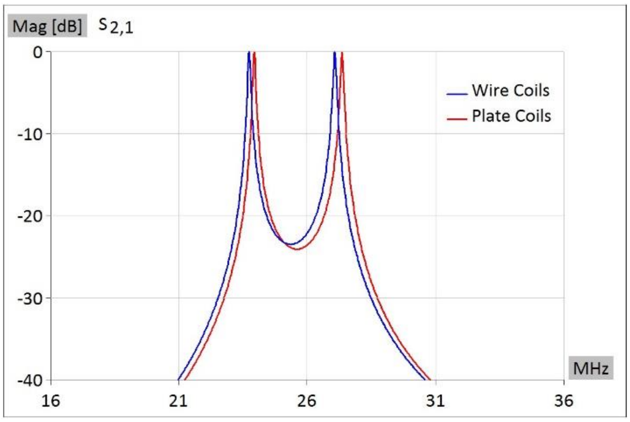

Fig. 5. Comparison between wire and plate pairs of toroid coils – s21 parameter.

Dense Straight Wound Coils

The model of coil was created using WIPL-D *Wire* entity. The question arises how well this model works if increase the density of winding, as in the following figure.

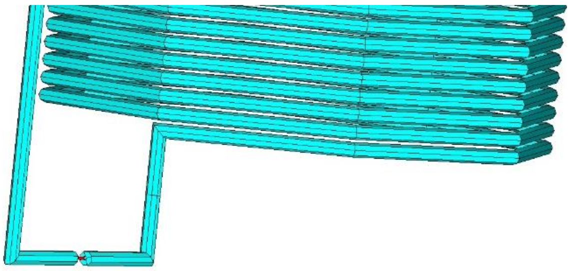

Fig. 6. Dense straight coil.

The model is same as straight segment toroid but the winding dense is increased more than 2 times, almost to the physical limit.

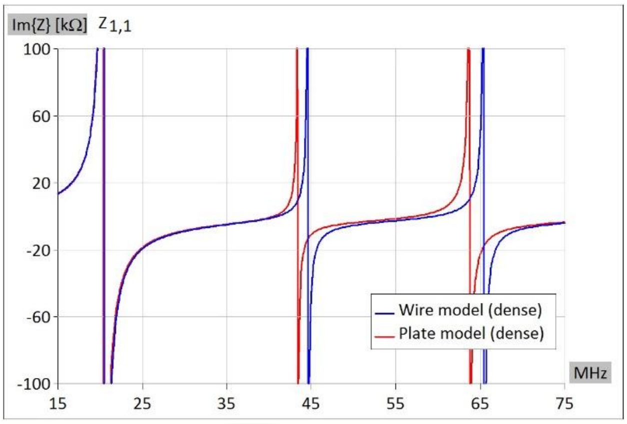

Fig. 7. Comparison between wire and plate pairs of dense toroid coils.

The result indicates excellent agreement between wire and plate model. The quality of plate becomes important at very high frequencies.

Simulation Time

Computer used in this application is regular desktop PC: Intel® Core ™ i7 CPU 7700 @ 3.60 GHz.

Simulation time and number of unknowns for straight wound toroids are presented in Table 1. All the models are simulated with the default projects settings, except the *Double* precision is used to account low frequency simulations.

Table 1. Simulation time per frequency and number of unknowns.

Model	Number of unknowns	Simulation time per frequency point [sec]
Wire	725	0.3
Plate	11,816	130

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