Master Thesis Proposal
Modeling Contactless Energy Transfer using Integro-Differential Equations with Application to a System of Spiral Antennas

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1 Problem Description

The introduction of electronic equipment on parts that are difficult to reach or that are moving, may cause a problem of powering. Either a wire or a battery is used to provide the necessary energy. A battery may reduce the life-time of the device or may be impossible because of its size. A wire connection may be impossible or may suffer from of mechanical wear when applied between moving parts. For all these reasons, there is a search for *wireless powering* systems, i.e., systems where electrical power is brought to the consumer without wires or batteries [5, 4]. Typically, an inductive, capacitive or resonant antenna system is used for this purpose.

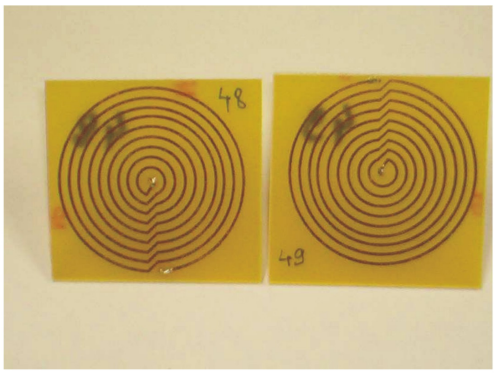
A possible antenna system consists of two spiral antennas (Fig. 1) brought into resonance by a capacitor at both sides and used at a frequency of 27 MHz. The wave length is about $\lambda = 10$ m whereas the antennas have a cross-section of a few centimeter and are at a distance of typically a few centimeter. A possible further design consists of a multi-layer antenna structure organised as a self-resonant system and therefore discarding the additional capacitors.

2 Solution Technique

The current induced in wires antennas as described above can be modeled by integro-differential equations (see e.g. [1, 3]). In [2] we developed an hp-adaptive solution technique for solving this type of equations accurately and efficiently. As preliminary studies have shown the finite element technique to be prohibitively expensive, we aim in this thesis at exploiting this expertise and model the contactless energy transfer system under system. Doing so will require extending the simulation code previously developed for single wire antennas to configurations consisting of different wires.

3 Context of the Research

As this research in placed in the context of a Flemish-Dutch collaboration, we foresee the possibility that master students from TU Delft will travel to KU Leuven, campus Kortrijk, and vice-versa.



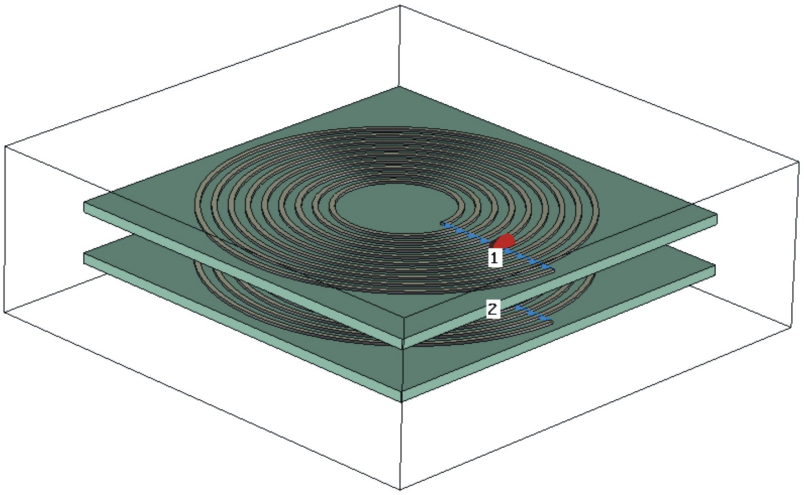


Figure 1: FE model of a pair of spiral antennas.

References

[1] P. J. Davies, D. B. Duncan, and S. A. Funken. Accurate and Efficient Algorithms for Frequency Domain Scattering from a Thin Wire. *J. Computational Physics*, 168:155–183, 2001.

[2] P. W. Hemker and D. J.P. Lahaye. An hp-Adaptive Strategy for the Solution of the Exact Kernel Curved Wire Pocklington Equation. *Computational Methods in Applied Mathematics*, 8(1):39–59, 2008.

[3] D. S. Jones. *The Theory of Electromagnetism*. International Series of Monographs on Pure and Applied Mathematics. Pergamon Press, 1964.

[4] A. Karalis, J.D. Joannopoulos, and M. Soljacic. Efficient wireless non-radiative mid-range energy transfer. unknown.

[5] A. Kurs, A. Karalis, R. Moffatt, J.D. Joannopoulos, P. Fisher, and M. Soljacic. Wireless power transfer via strongly coupled magnetic resonances. *Science*, 317:83–86, July 2007.