Modeling, Simulation and Verification of Contactless Power Transfer Systems

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Introduction: This work presents the analysis of a wireless power transfer (WPT) system making use of FEM simulations to calculate the involved variables such as coupling, quality factor and winding resistance. The simulations were compared against experimental measurements on a prototype showing consistence.

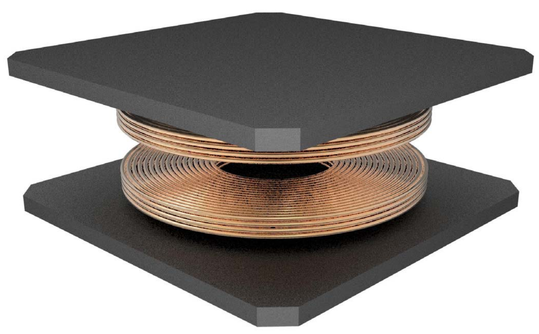

Figure 1. Wireless power transfer system.

Key performance indicators: The maximum efficiency of a WPT system is given by the product of the coupling factor, *k*, an the quality factor, *Q*. This product can be expressed as a function of the self inductance of each coil, L_1 and L_2, the mutual inductance M, and the resistance of each coil R_1 and R_2.

$$kQ = \frac{M}{\sqrt{L_1 L_2}} \sqrt{\frac{(\omega_0 L_1)(\omega_0 L_2)}{R_1 R_2}}$$

Model: The inductor is modeled as an external current density. The voltage in the coil is calculated by integration of the simulated electric field.

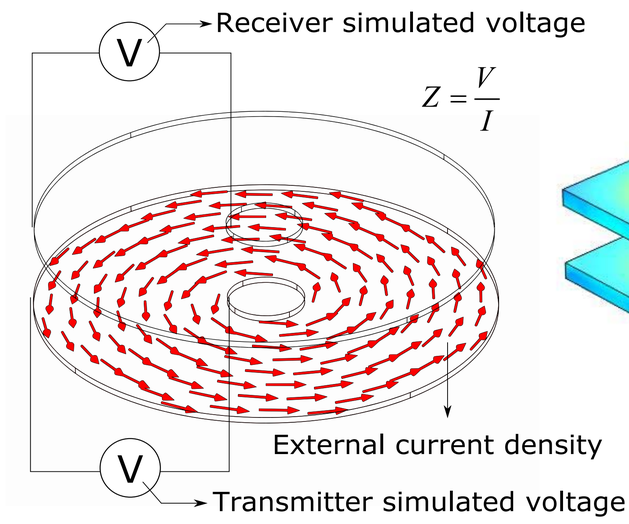

Figure 2. Impedance calculation method

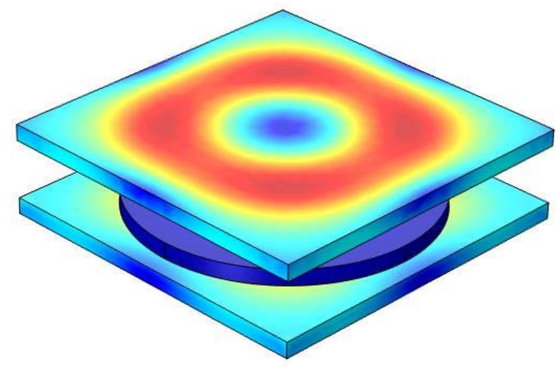

Figure 3. Simulated model. Magnetic field intensity.

- L_1, L_2 and M are obtained from the imaginary part of the impedance.
- R_1 and R_2 are obtained from the analytical expressions for litz wire.

Results: Simulated (lines) and measured (circles) results are compared.

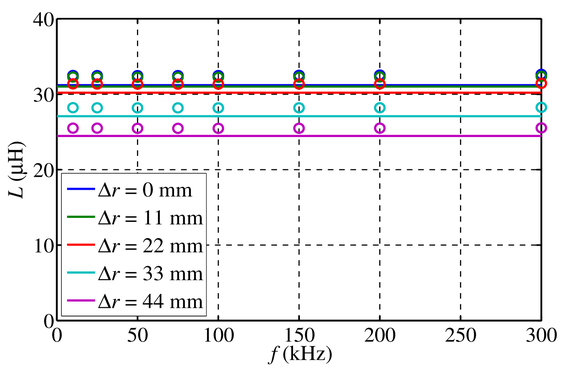

Figure 4. Inductance L_1=L_2=L for different misalignments.

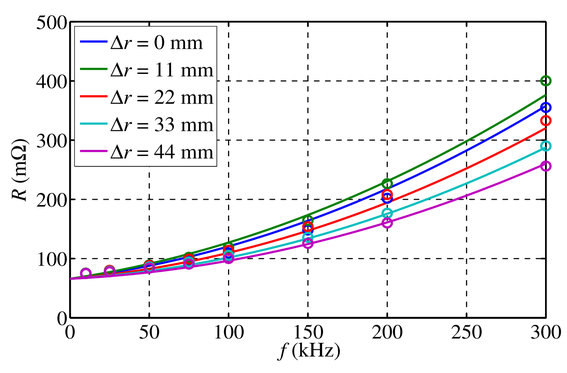

Figure 5. Resistance R_1=R_2=R for different misalignments.

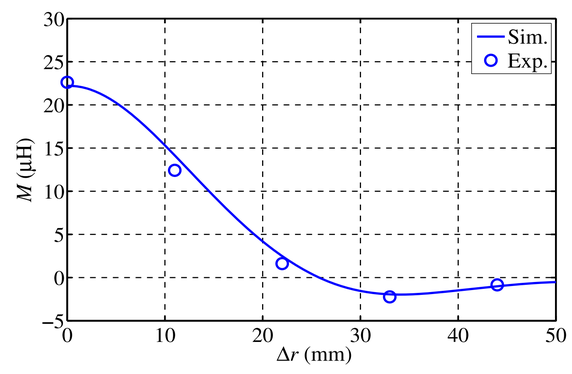

Figure 6. Mutual inductance M as a function of misalignment.

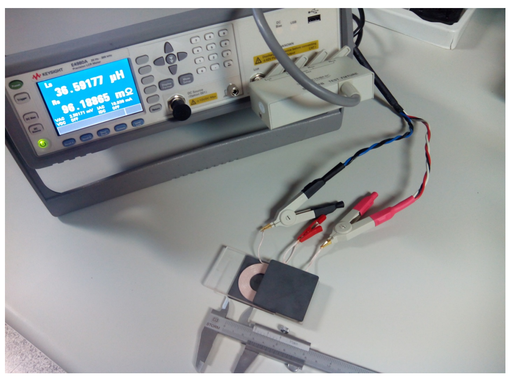

Figure 7. Measuring arrangement.

Conclusions: The simulation model is verified with experimental results. The method provides accurate predictions of the WPT key performance indicators.