Self-Resonant Coils for Wireless Power Transfer

PCB Coil-based WPT System for up to 11kW

Graduate Candidate

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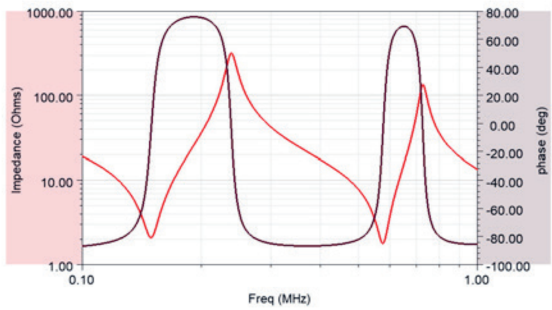
Introduction: The growing focus on sustainability is driving technological advancements for electric vehicles and equipment largely dependent on battery power. Small devices such as smartphones and watches already frequently use wireless power transfer (WPT) to charge their batteries. However, for high-power applications, including charging of electric vehicles, it is still an emerging technology. It offers a few key advantages over wired connections, notably the ability to transfer power without degradation due to contact wear or obstruction by mud and dirt.

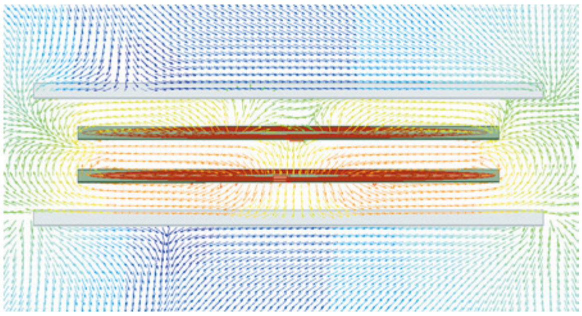
Approach: This project explores the possibilities of self-resonant coils for high-power WPT. They promise cost savings compared to traditional wound coils used in combination with expensive high-performance ceramic capacitors. Several publications and patents covering such approaches are available in literature. However, most of them operate in the MHz frequency range.
The existing BRUSA ICS (Inductive Charging System) complies with SAE J2954 and, therefore, operates in the 79 to 90 kHz frequency range. To reuse this existing inverter technology, the operating frequency of the self-resonant coil must be lowered considerably. Various coil designs are investigated using analytical methods where applicable, and FEM simulations in ANSYS HFSS as well as Maxwell 2D/3D. The most promising approach is then further developed into a prototype which uses aluminum sheets for magnetic shielding instead of ferrites, thereby offering additional cost savings.

Conclusion: The investigations revealed that achieving a self-resonant coil design for an operating frequency below a few hundred kHz is challenging. Some of the investigated approaches may work well in the MHz range, but reducing the operating frequency leads to a significant increase in dielectric loss. The realized prototype was tested, demonstrating good agreement with simulation results and affirming that such designs can indeed be utilized for high-power WPT applications.

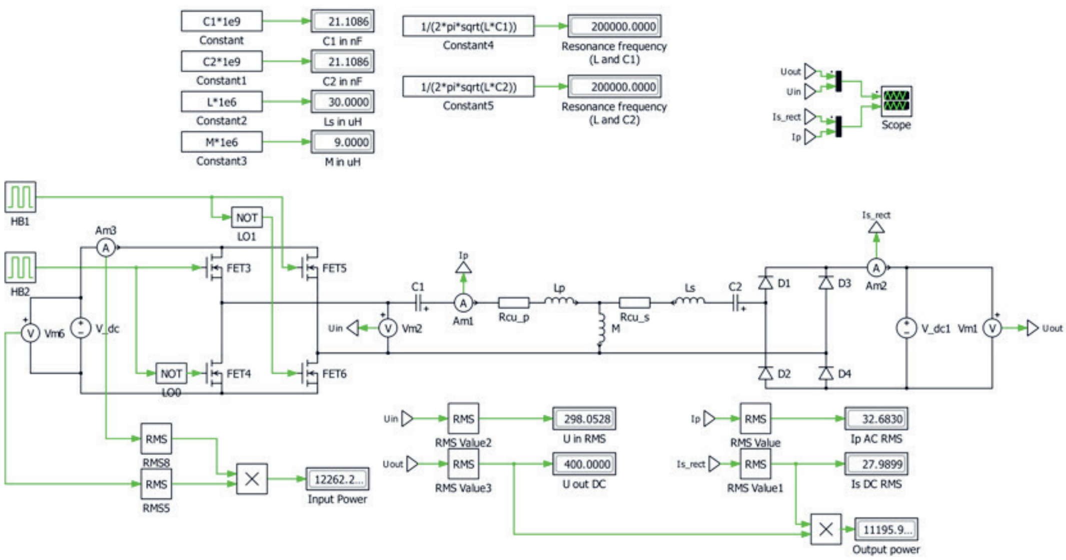
Impedance plot illustrating the rather complex behavior of a certain self-resonant coil.
Own presentment



Magnetic field plot of the self-resonant coil with aluminum sheets for magnetic shielding.
Own presentment



PLECS simulation of the WPT system, including rectifier and FBI (Full Bridge Inverter).
Own presentment



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Subject Area
Electromagnetic Fields and Waves

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