Design and Optimization of Resonant Coils for Wireless Power Transmission System With Ferrite Core

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Background

The wireless power transfer (WPT) which can realize power transmission without wires, has attracted much attention in recent years. This technology is promising in the applications of mobile devices charging and biomedical implant powering with the advantages of contactless and flexible. In the WPT system, the transmitting and receiving coils (TX-coil and RX-coil) are the core components for the power transmission. It affects the system efficiency and the transmission power directly.

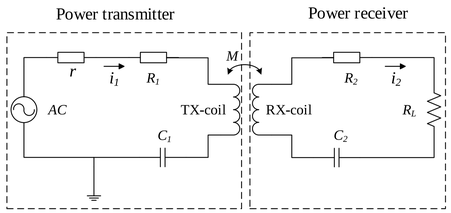
In this paper, a comprehensive analysis of the TX-coil and RX-coil is conducted based on the circuit and electromagnetic simulation. The effects of the structural parameters and the ferrite core of the coils on the power transfer performance are studied. Finally, aiming at the improvement of the transmission power and efficiency, an optimal design of the coils with ferrite core is carried out according to the characteristics of the WPT system.

Conclusion

- Printed circuit board(PCB) and ferrite core are employed for the optimization of the resonant coils in the WPT system.
- The output power and transfer efficiency are both improved in the WPT system with the optimal coils, especially when the transmission distance is far.
- In contrast to the WPT system without the ferrite core, he improvement in transfer efficiency of the optimal WPT system is 38% when the distance between the coils is 45mm.
- Around the RX-coil, the ferrite cores can reduce the magnetic flux density obviously. Therefore, the electromagnetic interference(EMI) to other circuits can be reduced.
- Compared to the system without the ferrite core, the maximum eddy density of the optimization in the square steel plate which is placed at a distance of 10 mm from the RX-coil is reduced by 57%.

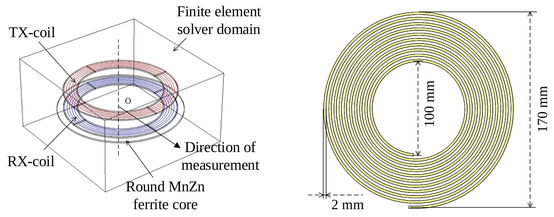
Simulations

The WPT system schematic



Magnetic resonance coupling is used to transmit power in the WPT system. Power is transmitted through the electromagnetic field produced by the resonant coils (TX-coil and RX-coil).

Schematic of system and the coil

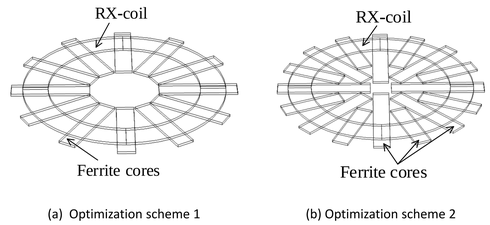


The simulation of the WPT system is carried out with COMSOL Multiphysics. And the system operating frequency is 1MHz.

PCB is employed to design the resonant coils of the WPT system to achieve the goal of the smaller size, lighter weight and better integration.

Experiments

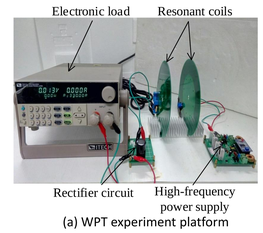
Ferrite core optimization schemes



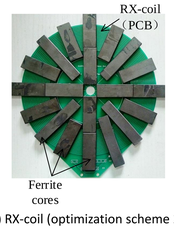
(a) Optimization scheme 1 (b) Optimization scheme 2

All of the magnetic stripes are made of MnZn ferrite and radially distributed in both of the two optimization schemes. And they are only used in the RX-coil side.

Experimental circuit



(a) WPT experiment platform

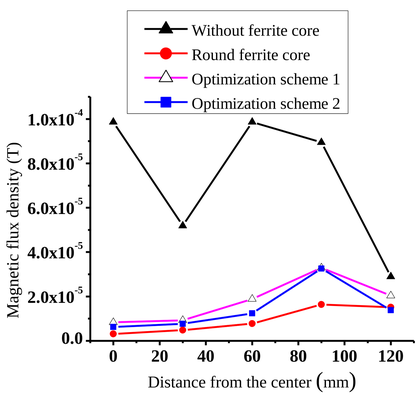


(b) RX-coil (optimization scheme 2)

The WPT system which includes high-frequency power supply, resonant coils, rectifier circuit and electronic load (IT8512).

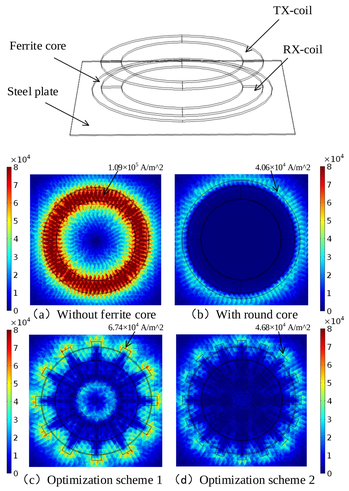
Results

Effects on magnetic flux density



Around the RX-coil, the ferrite cores reduce the magnetic flux density greatly. It means that the ferrite cores can reduce EMI to other circuits.

Eddy current density of steel plate



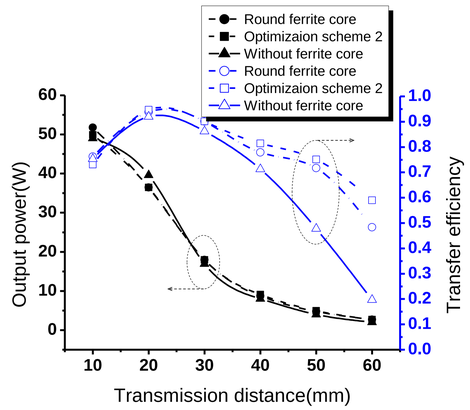
A square steel plate, whose thickness is 1 mm, is placed at a distance of 10 mm from the RX-coil.

Eddy current density is greatly reduced with the employment of the ferrite core.

The maximum eddy current density of optimization scheme 2 is 4.68×104 A/m^2, which is reduced by 57% compared to that without the ferrite core.

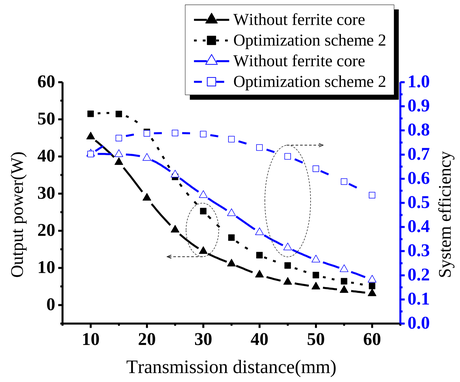
The optimization scheme 2 has the similar performance to the scheme with a round ferrite core.

Simulation results



The system with ferrite cores has better performance, especially when the transmission distance is far away.

Experimental results



Both of the output power and transfer efficiency are improved when the ferrite core is used. And the maximum improvement in transfer efficiency is 38% at the distance of 45mm.

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