3D Electromagnetic Simulation for Wideband Wireless Power Transfer via Resonance Inductive Coupling

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Introduction

Wireless Power transfer (WPT) can be classified into capacitive power transfer (CPT), inductive power transfer (IPT) and far-field radiative power transfer.

IPT working at resonance is called resonant inductive coupling, which is suitable for mid-range WPT (e.g., indoor electronics charging and WPT for biomedical implants).

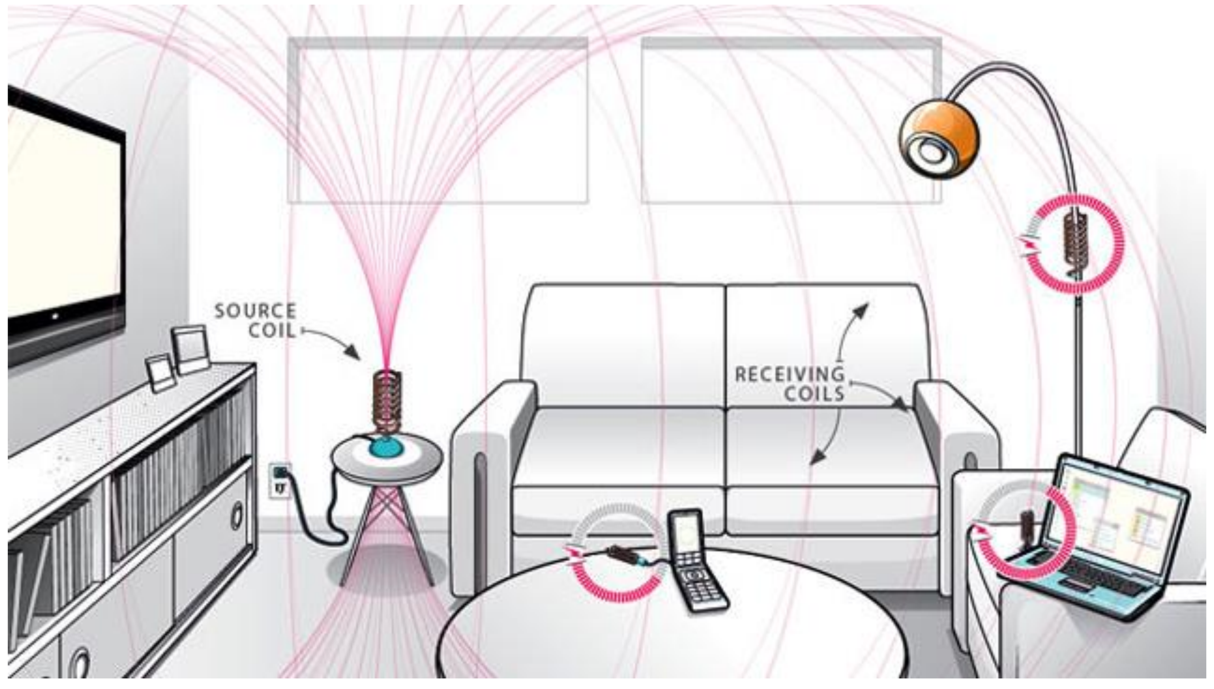

Figure 1. The resonant inductive wireless power systems demonstrated by WiTricity a company by MIT Team [1]

Computational Methods

First, the Eigenfrequency simulation was used to compute the fundamental resonant frequency of the WPT model.

Secondly, a Frequency Domain simulation was used to compute the response of the model subjected to a time-harmonic excitation driving-port at the frequency obtained from the first step.

Transmit/Receive coil

Transmit and receive coils are placed close (< 3 cm) to the corresponding resonators to enhance the mutual inductance.

Impedance matching is done at both transmit and receive coils.

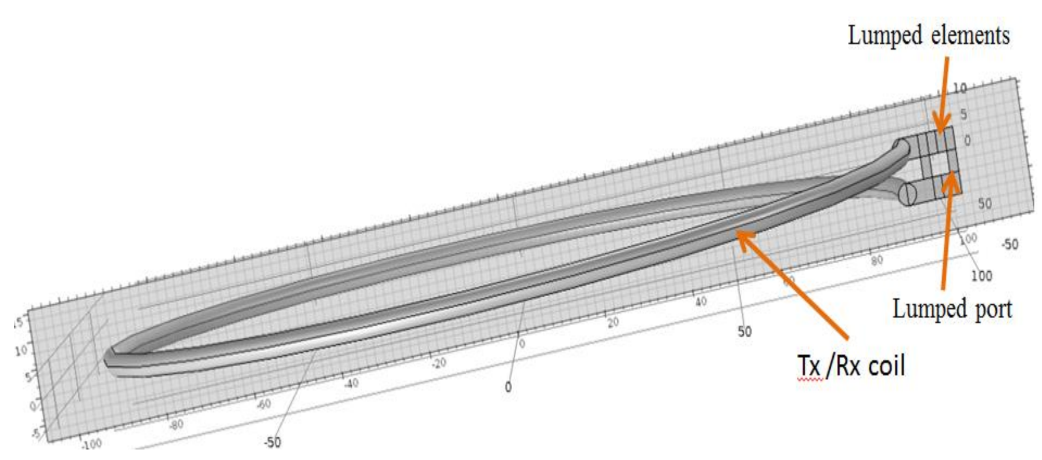

Figure 2. Snapshot showing a Tx/Rx coil connected to impedance matching board using COMSOL Multiphysics®.

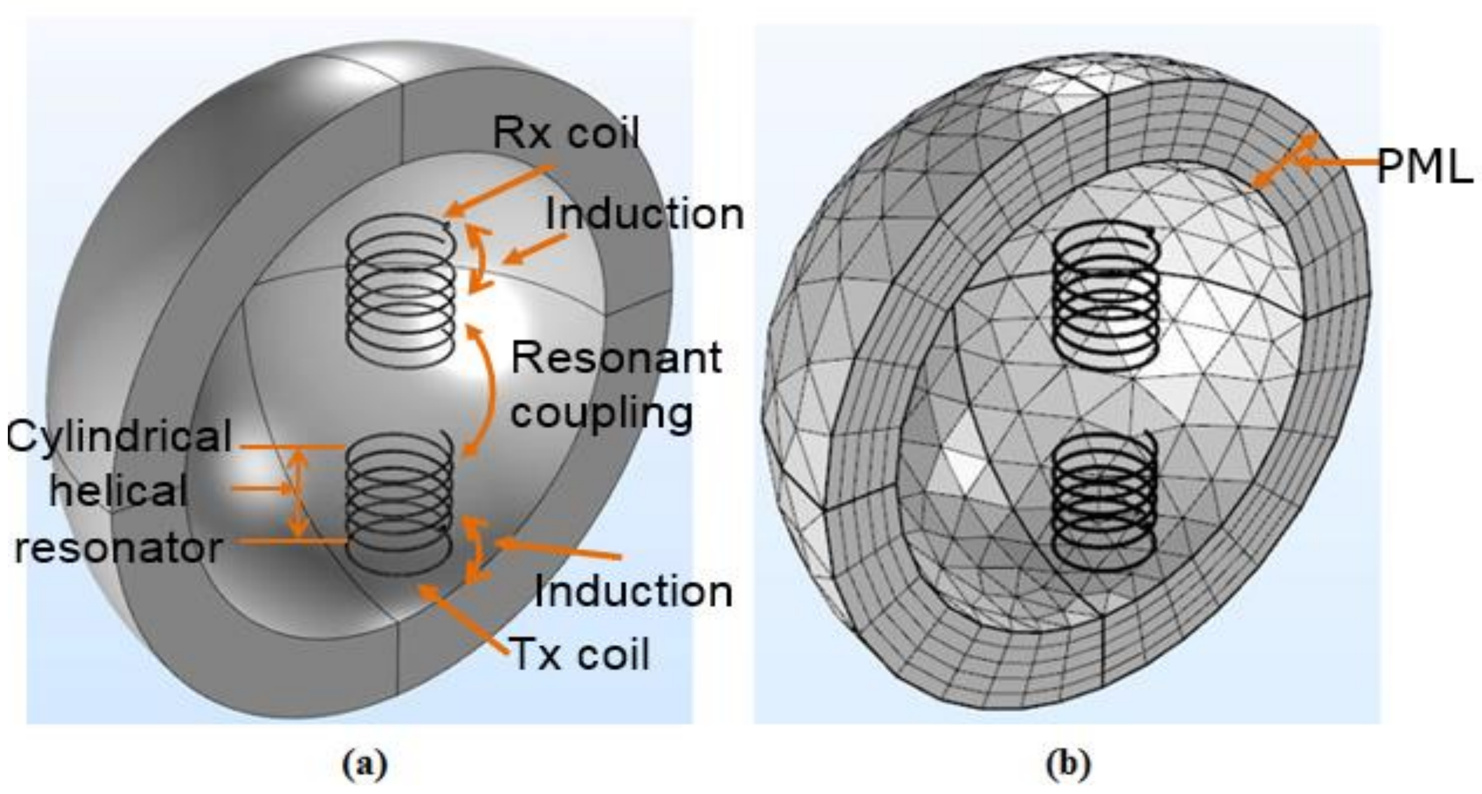

Figure 3. Radiofrequency and Eigen-frequency simulation setup of WPT (a) a conventional 4 coil WPT system (b) a mesh having tetrahedral elements for inner domain, 4 coils, lumped elements and ports and having swept mesh for Perfect Matched Layer (PML).

Results of the Proposed Ellipsoidal Helix WPT

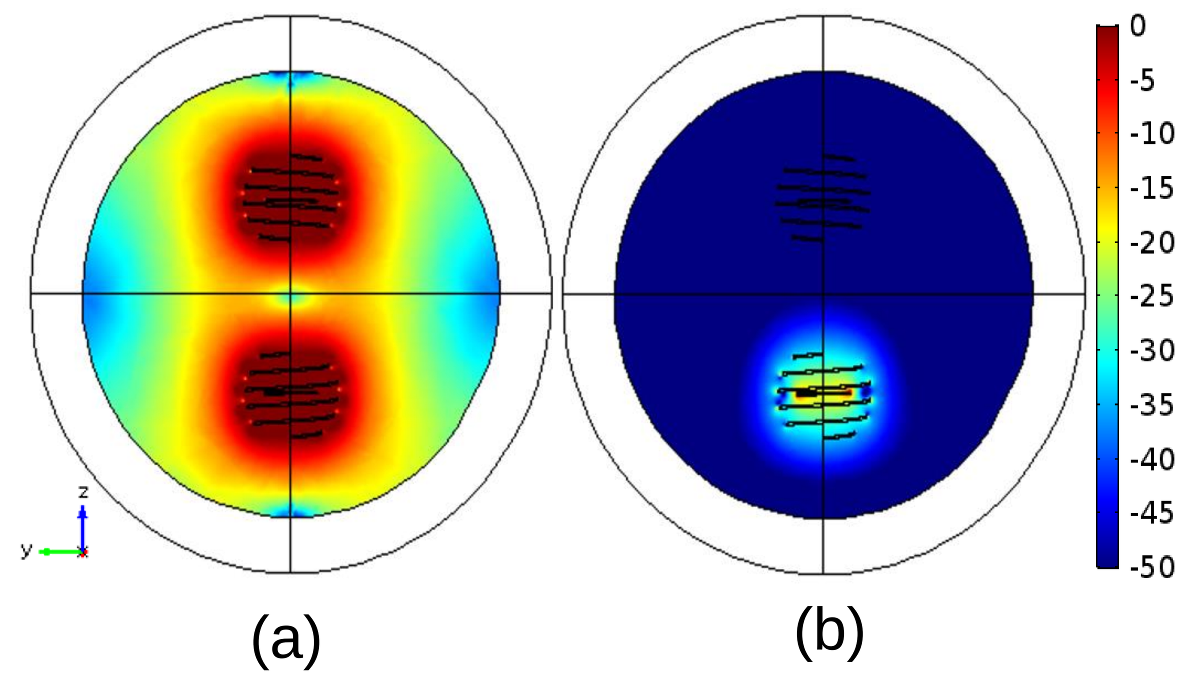

Figure 3. Magnetic field distribution (20*log(|H|)) of the ellipsoidal helix WPT at (a) 53.45 MHz (at resonance) and (b) 40.95 MHz (off resonance)

Power Transfer Efficiency [2]

$$\eta = \frac{|S_{21}|^2}{1 - |S_{11}|^2}$$

where S_{21} and S_{11} are the transmission and reflection coefficients respectively.

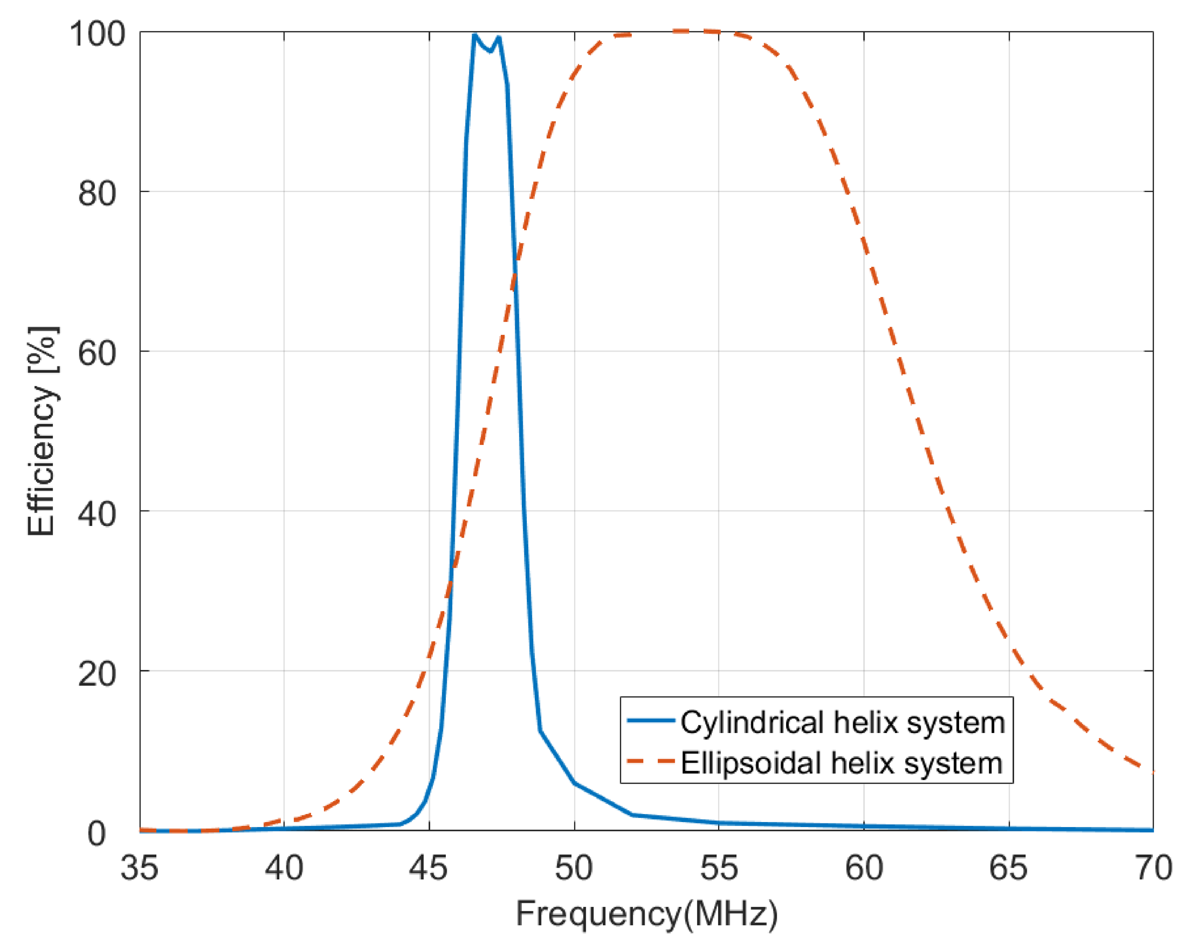

Figure 5. Simulated efficiency of the proposed ellipsoidal helix system and the cylindrical helix system

Table 1. Resonant frequency and bandwidth of two systems

	Ellipsoidal helix	Cylindrical helix
Resonant frequency (MHz)	53.45	47.10
90 %-efficiency-bandwidth	15.0 %	2.3 %

Conclusions

An ellipsoidal helix coil is proposed as the resonator for a resonant inductive coupling WPT system.

The bandwidth of the system is increased while a high transfer efficiency is maintained, which is verified by COMSOL Multiphysics® simulation.

References

1. Kurs A, et al, Science, 317(5834):83-86, 2007
2. O. Jonah et al, IEEE-Trans.-Antennas-Propag., vol-61, no-3, pp.1378–1384, 2013