Wireless Power Transfer

Wireless power transfer is the transmission of electrical energy from a power source to an electrical load without interconnecting conductors. It was first studied by the Serbian-American physicist Nikola Tesla in late 1800s. The method uses two coils physically separated, and when one of the coils is excited with a time-varying current, the resulting magnetic field couples to the second coil and transfers power. The main issue with this method is that at operating frequencies amenable to the transfer of large amounts of power, energy cannot transferred through radiation; rather, it is stored in the near magnetic fields, making energy transfer difficult over relatively large distances.

Products Used
ANSYS® Maxwell® 15.0, ANSYS HFSS™ 14.0, ANSYS Simplorer® 10.0

Keywords
Wireless power transmission

A diverse variety of applications can benefit from wireless power transfer:
- Sensor networks
- Implanted medical devices
- Electric vehicle charging

The concept of available ambient power for electronic devices is a great enabler of increasingly portable designs, especially since they eliminate the tether required for charging.

The most common form of wireless power transmission uses direct induction; resonant magnetic induction applications are second. Both are related to electromagnetic fields and can be modeled with ANSYS Maxwell or ANSYS HFSS. In solving for electric and magnetic fields, you must drive the coils with appropriate circuitry. ANSYS solutions offer this flexibility through coupling between full-field solvers, such as Maxwell and HFSS, and circuit design tools such as ANSYS Simplorer and ANSYS Designer™.

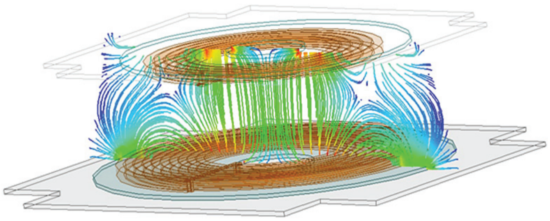

Figure 1. Flux lines calculated with ANSYS Maxwell

Inductive Type Coupling

Magnetic induction has been extensively used for wireless power transfer, but its performance is directly linked with the mutual inductance between transmitter and receiver coils, which decays as the inverse cube of separation distance. These types of designs rely on large numbers of coil turns or bulky magnetic core materials to obtain higher coupling coefficients and, therefore, higher efficiency. Using Maxwell, it is possible to automatically

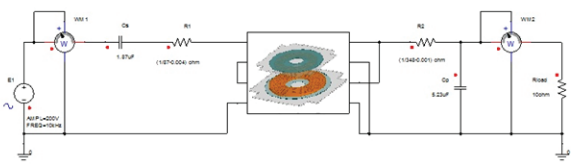

Figure 2. ANSYS Simplorer schematic of a simple power transfer system, cosimulating with transmitter and receiver coils from ANSYS Maxwell

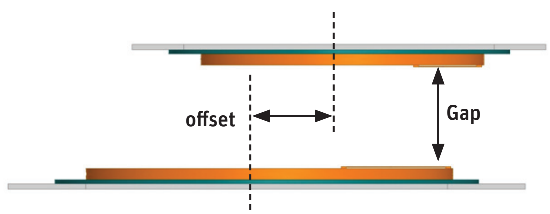

Figure 3. Variables considered to create efficiency map

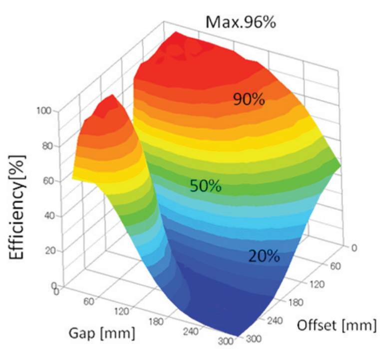

Figure 4. Efficiency map for power transmission system considering axial offset and gap

calculate mutual and self inductances with the field solution, enabling a variety of analyses, such as:

- Coupling efficiency
- Different coil topologies and separation distances
- Material properties and possible core saturation

Resonance Type Coupling

This type of power transfer depends on the electrical characteristics of the source and the load — that is, both coils must be tuned to resonate at the same frequency. This can be achieved through a combination of discrete elements added to the excitation circuit and coil geometry. The ability to solve for electric and magnetic fields at the same time allows the full-wave field solver, HFSS, to directly account for capacitance in the coil geometry; alternatively, with the possibility of adding discrete capacitors into the coupled external circuits, Maxwell is suitable for this type of resonant wireless coupling.

Figure 1 shows the flux lines in a pair of inductively coupled coils simulated using Maxwell. With a complete set of available quasi-static solvers, you can extract the electrical parameters needed to characterize the coupling and create optimized circuitry for the load and source components. Taking advantage of the coupling with Simplorer, the coils modeled in Maxwell are connected to a system (Figure 2) in which the power generated on the left side of the circuit is transmitted to the load in the right part of the circuit. This power transfer system can use variables for any of the electrical or geometric design parameters. Using several such variables, as shown in Figure 3, you can create the efficiency map of the electric power transmission system when the axial offset and gap between the coils is changed, as shown in Figure 4.

Summary

The full solution of the wireless power transfer problem requires a systems-level approach with dynamically linked parameters between the circuit and 3-D FEA model. With a complete set of coupled tools, ANSYS enables an efficient workflow design for Simulation-Driven Product Development™.

ANSYS, Inc.
Southpointe
275 Technology Drive
Canonsburg, PA 15317
U.S.A.
724.746.3304
ansysinfo@ansys.com

Toll Free U.S.A./Canada:
1.866.267.9724
Toll Free Mexico:
001.866.267.9724
Europe:
44.870.010.4456
eu.sales@ansys.com