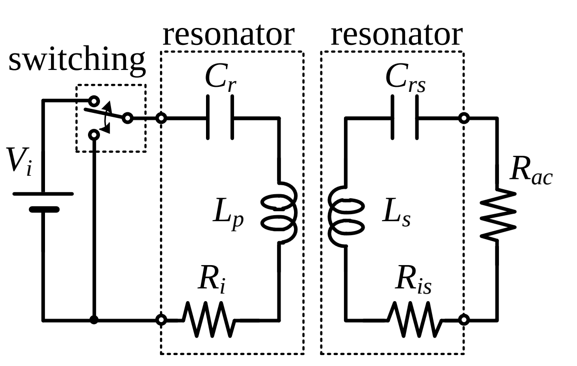
ELECTRIC POWER THROUGH THE AIR

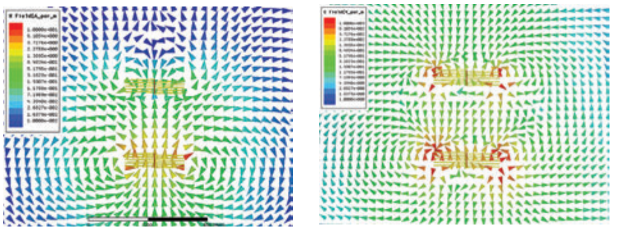
Murata Manufacturing developed a more-efficient method for wireless power transfer using simulation.

By Tatsuya Hosotani, Visiting Professor, Doshisha University, and Associate Chief Researcher, Murata Manufacturing Co., Ltd., Nagaokakyo, Japan

The dramatic increase in the number of devices in today's intelligent networks and the influence of the Internet of Things raise the question of how all of the devices will be powered. In many applications, the number and disperse locations of these devices rule out wiring all of them to a power supply. Using batteries for each device may create difficult maintenance challenges while also raising environmental issues regarding battery disposal. The ideal solution involves a wireless transfer system to power to these devices, but existing systems are not always up to this challenge. Murata Manufacturing used ANSYS simulation to test a wireless power transfer method called a direct-current-resonance power transfer system so that it can be commercialized.



▲ Direct-current-resonance power transfer circuit



Magnetic field vector

Electric field vector

▲ Magnetic and electric field vectors generated by transmitter coil

WIRELESS POWER TRANSFER ALTERNATIVES

The best known wireless power transfer method in current use is the Qi standard, which relies upon electromagnetic induction between planar coils. A base station connected to a power source incorporates a transmitting coil that generates an oscillating magnetic field. The magnetic field induces an alternating current in a receiving coil by Faraday's law of induction. However, because electromagnetic induction requires that the transmitting and receiving coils must be very close to each other, this approach does not provide a practical solution to the device proliferation problem. In the case of the Qi standard, the charger is normally physically connected to the device it is charging.

Another option, radio-frequency wireless power transfer, operates at much longer distances than electromagnetic induction but is not very efficient. One reason for the lack of efficiency is the many energy conversion steps that are required in these devices: from alternating current line power to insulated direct current power; to an intermediate radio-frequency power to operate the power amplifier; and then to radio-frequency power to drive the transmitting coil. Next, the radio frequency power is transferred over the air to the receiving device; this power is finally converted to direct current to operate the device on the receiving end. Each of these energy conversions consumes substantial amounts of power, resulting in very low efficiency for the overall system. The result is that radio-frequency power transfer systems generally are large and expensive, and consume relatively large amounts of power.

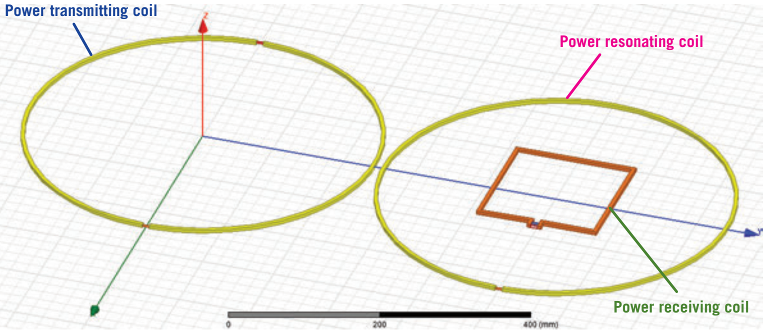
NEW DIRECT-CURRENT-RESONANCE METHOD

Murata Manufacturing creates innovative products and solutions to benefit society and the electronics industry. The company has developed and is in the process of commercializing a new technique for wireless power transfer called a direct-current-

Simulation saves months of testing time and tens of thousands of dollars in resources for each design project.

resonance power transfer system. This method involves rapidly switching direct current on and off to drive a transmitting coil that resides on a circuit turned to the frequency at which the current is switched. The transmitting coil produces a resonance field that efficiently transmits direct current through a receiving coil to a circuit tuned to the same frequency.

This method is very efficient because the transmitting coil operates on direct current, the form used by nearly all electronic devices, so no additional energy conversion step is required. And, because direct current is generated on the receiving circuit, no energy conversion step is required. The transfer system distance provided by the direct-current-resonance method is much higher than electromagnetic inductance, and it can be further extended through the use of unpowered resonator coils that relay power to distant receivers. The direct-current-resonance method can use a single power transmitter to drive multiple power receivers as well as resonator coils. The result is an excellent mix of distance and efficiency. This combination makes the direct power resonance method a good fit for powering a wide range of devices that cannot be wired together and for which batteries do not provide a good solution because the device is difficult to reach. Some examples include monitors, radio-controlled equipment, computers and electronics, lighting, and robots.



▲ ANSYS HFSS model with one transmitter, one receiver, one resonator

WIRELESS POWER TRANSFER
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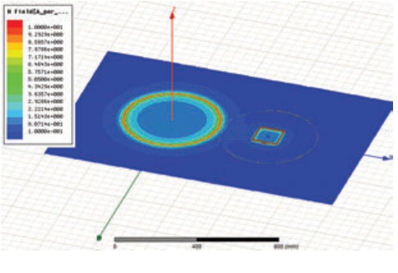
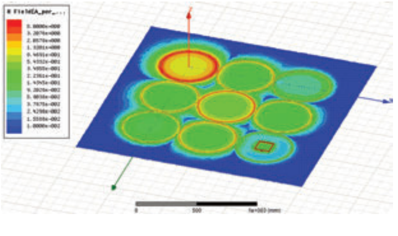


▲ Magnetic field analysis of model with one transmitter, one receiver, one resonator



▲ Magnetic field analysis of model with one transmitter, one receiver, eight resonators

COMMERCIALIZATION CHALLENGE

In developing its direct-current-resonance power transfer method, Murata faces the challenge of optimizing the power efficiency, size, cost and other features of its devices to produce a competitive commercial product. Optimizing the design of any wireless product requires evaluating many different design iterations. The number of iterations that need to be considered is larger than normal with direct-current power transfer systems because the concept is new, so there is very little experience to draw upon.

It would be very expensive and time-consuming to build and test a prototype for each of these iterations. The build-and-test method would progress relatively slowly toward an optimized design because the amount of diagnostic information it produces is limited. For example, while the amount of power transmitted to the receiving coil is easy to measure, it is usually possible to measure electric and magnetic field parameters only in a few locations.

SIMULATION SPEEDS DESIGN OPTIMIZATION

Murata electronic engineers address these design challenges by using ANSYS HFSS to simulate a wide range of design alternatives that take into account the actual geometry and location of the power transmitter, receiver and resonator coils, as well as the effects of other components in the area. Engineers can generate a variety of concept designs to achieve the required levels of power transfer to the target device while addressing other objectives such as minimizing device weight, size and cost.

The simulation sequence normally begins with modeling the transmitting coil alone as a subsystem and viewing the resulting electromagnetic field. Next, a single receiving coil is added to the simulation to evaluate power transfer performance. Most real-world applications involve many receiving coils and resonator coils, so these elements are incrementally added to the simulation. Finally, other electronic and structural components are added to evaluate their impact on power transfer performance. Simulation lets engineers explore the power transfer device's sensitivity to parameters such as coil topology, coil diameter, number of windings, resonant frequency, number of receiving coils, number of resonator coils, etc. Engineers can easily modify these and many other design parameters to understand their impact on power transfer performance.

The growing proliferation of connected devices makes it essential to improve on today's wireless power transfer technology. Simulation makes it possible to consider the impact of various design alternatives and deployment strategies in the early stages of the design process. Simulation saves months of testing time and tens of thousands of dollars in resources for each design project by enabling engineers to refine options through virtual prototypes rather than physical prototypes. Murata will continue its research and development with the goal of contributing to the development of wireless power transfer system science and technology.