Turning your living room into a wireless charging station

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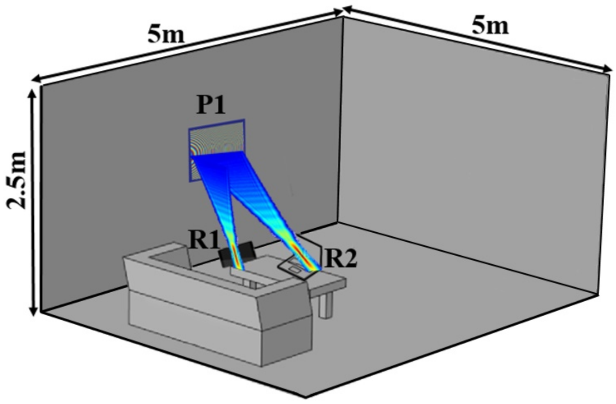

This graphic illustrates how a flat-screen Fresnel zone wireless power transfer system could charge smart devices in your living room. Credit: Duke University

A flat-screen panel that resembles a TV on your living room wall could one day remotely charge any device within its line of sight, according to new research.

In a paper published Oct. 23, 2016, on the *arXiv* pre-print repository, engineers at the University of Washington, Duke University and Intellectual Ventures' Invention Science Fund (ISF) show that the technology already exists to build such a system—it's only a matter of taking the time to design it.

"There is an enormous demand for alternatives to today's clunky charging pads and cumbersome cables, which restrict the mobility of a smart phone or a tablet. Our proposed approach takes advantage of widely used LCD technology to seamlessly deliver wireless power to all kinds of smart devices," said co-author Matt Reynolds, UW associate professor of electrical engineering and of computer science and engineering.

"The ability to safely direct focused beams of microwave energy to charge specific devices, while avoiding unwanted exposure to people, pets and other objects, is a game-changer for wireless power. And we're looking into alternatives to liquid crystals that could allow energy transfer at much higher power levels over greater distances," Reynolds said.

Some wireless charging systems already exist to help power speakers, cell phones and tablets. These technologies rely on platforms that require their own wires, however, and the devices must be placed in the immediate vicinity of the charging station.

This is because existing chargers use the resonant magnetic near-field to transmit energy. The magnetic field produced by current flowing in a coil of wire can be quite large close to the coil and can be used to induce a similar current in a neighboring coil. Magnetic fields also have the added bonus of being considered safe for human exposure, making them a convenient choice for wireless power transfer.

The magnetic near-field approach is not an option for power transfer over larger distances. This is because the coupling between source and receiver—and thus the power transfer efficiency—drops rapidly with distance. The wireless power transfer system proposed in the new paper operates at much higher microwave frequencies, where the power transfer distance can extend well beyond the confines of a room.

To maintain reasonable levels of power transfer efficiency, the key to the system is to operate in the Fresnel zone—a region of an electromagnetic field that can be focused, allowing power density to reach levels sufficient to charge many devices with high efficiency.

"As long as you're within a certain distance, you can build antennas that gather electromagnetic energy and focus it, much like a lens can focus a beam of light," said lead author David Smith, professor and chair of the Department of Electrical and Computer Engineering at Duke. "Our proposed system would be able to automatically and continuously charge any device anywhere within a room, making dead batteries a thing of the past."

The problem to date has been that the antennas in a wireless power transfer system would need to be able to focus on any device within a room. This could be done, for example, with a movable antenna dish, but that would take up too much space, and nobody wants a big, moving satellite dish on their mantel.

Another solution is a phased array—an antenna with a lot of tiny antennas grouped together, each of which can be independently adjusted and tuned. That technology also exists, but would cost too much and consume too much energy for household use.

The solution proposed in the new paper instead relies on metamaterials—a synthetic material composed of many individual, engineered cells that together produce properties not found in nature.

"Imagine you have an electromagnetic wave front moving through a flat surface made of thousands of tiny electrical cells," said Smith. "If you can tune each cell to manipulate the wave in a specific way, you can dictate exactly what the field looks like when it comes out on the other side."

Smith and his laboratory used this same principle to create the world's first cloaking device that bends electromagnetic waves around an object held within. Several years ago, Nathan Kundtz, a former graduate student and postdoc from Smith's group, led an ISF team that developed the metamaterials technology for satellite communications. The team founded Kymeta, which builds powerful, flat antennas that could soon replace the gigantic revolving satellite dishes often seen atop large boats. Three other companies, Evolv, Echodyne and Pivotal have also been founded using different versions of the metamaterials for imaging, radar and wireless communications, respectively.

In the paper, the research team works through calculations to illustrate what a metamaterials-based wireless power system would be capable of. According to the results, a flat metamaterial device no bigger than a typical flat-screen television could focus beams of microwave energy down to a spot about the size of a cell phone within a distance of up to ten meters. It should also be capable of powering more than one device at the same time.

There are, of course, challenges to engineering such a wireless power transfer system. A powerful, low-cost, and highly efficient electromagnetic energy source would need to be developed. The system would have to automatically shut off if a person or a pet were to walk into the focused electromagnetic beam. And the software and controls for the metamaterial lens would have to be optimized to focus powerful beams while suppressing any unwanted secondary "ghost" beams.

But the technology is there, the researchers say.

"All of these issues are possible to overcome—they aren't roadblocks," said Smith. "I think building a system like this, which could be embedded in the ceiling and wirelessly charge everything in a room, is a very feasible scheme."

More information: An Analysis of Beamed Wireless Power Transfer in the Fresnel Zone Using a Dynamic, Metasurface Aperture: arxiv.org/abs/1610.06799

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