WIRELESS POWER

CONSORTIUM

Dreaming of power through the air

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Every generation of engineers dreams about delivering power through the air. Tesla famously demonstrated it in 1891, using magnetic induction. Since then, many more people have attempted it and here are videos as evidence:

- In 1975, NASA demonstrated long distance transport with magnetic induction at microwave frequencies.
- In 2009, WiTricity demonstrated powering a television with magnetic induction.
- In 2011, uBeam demonstrated power transfer with ultrasound.
- In 2013, Ossia demonstrated delivery of 1 Watt over a couple of meters using an array of Wi-Fi transmitters
- In 2015, Energous demonstrated powering an iPhone at 5 meters using magnetic induction at microwave frequencies.
- In July 2016, Yank Technologies published a video about their 'Motherbox' wireless charging concept and in September 2016 te first demo video. In March 2017 they raised money on Indigogo.
- In spring 2016, PowerSphyr was founded. In January 2017 they announced plans to offer its first wireless power solution to the market in the third quarter 2017 and chipsets early 2018.
- In September 2017, Pi announced that they are the "first company to deliver a truly wireless charger for consumers. Its secret power? Our proprietary platform: the world's first magnetic field-shaping algorithm." "Pi comes in the form of a cone-shaped base station"
- In January 2021, Reasonance demonstrated yet another wirelessly powered TV

So far, none of these demos or concepts has led to a commercial product. What is it that makes it so hard to go from 'proof of concept' to a market-ready product?

The videos above demonstrate desirable benefits such as:

a) Transfer distance (= how far can I move the receiver away from the transmitter?)
b) Power level (=charging speed)
c) Spatial freedom (= how accurate do I need to position the receiver?)

These benefits are the **functional** requirements of wireless power transmission.

Interestingly, it's the **non-functional** requirements that represent the biggest design hurdles to clear in getting to market-ready products. Examples of nonfunctional requirements -- things that consumers rightfully take for granted -- include safety, radio-frequency interference (RFI), power-transfer efficiency and cost. These essential elements are ignored in the aforementioned demos or are addressed as challenge to be dealt with later during product development. Unfortunately, these non-functional requirements are the difficult and real problems that are harder to overcome than functional requirements. These non-functional design challenges are why this dream has continued to elude reality dating back to Tesla's original experiments more than 100 years ago.

Let's look at a few non-functional requirements of uncoupled wireless charging one by one:

Safety
Are you aware of the safety limits for human exposure to radio-frequency electromagnetic fields? Government regulations set limits on power levels that humans may be exposed to. The regulations are usually based on ICNIRP tables of selective absorption rates. These regulations limit the maximum output power and, indirectly, limit the achievable transmission distance.

RFI
Electromagnetic fields generated by one product can interfere with other products. You don't want a wireless charger in the room to interfere with a person's pacemakers in the room. That's an obvious risk, but it's also relatively easy to deal with because pacemakers are well-protected against interference. Less obvious and more difficult to deal with is RFI with NFC receivers, Wi-Fi reception, mobile phone base stations and car electronics. The choice of operating frequency used for power transfer can help: choosing a higher frequency (such as 6.78MHz or 5 GHz) makes the problem harder.

Efficiency
Not all consumers are worried about the efficiency of wireless power, but governments and NGO's are. Launching energy-wasting products can damage corporate brands. And energy-conscious regulators like the California Energy Commission may step in to limit the sale of a questionable product.
In the earlier YouTube videos the topic of efficiency were addressed. The NASA video claimed 82% efficiency. However, the 82% refers to the RF to DC conversion inside the receiver array. It doesn't take into account the losses during transmission, and it doesn't take into account the losses in the transmitter.

Misleading claims are common, and the presenters of this NASA video were sensitive about efficiency's significant challenges. The NASA video takes some liberties, but at least they explained how they measured the 82%. The actual numbers are 500 kW transmitted and 34 kW received. That is 7% efficient -- and it doesn't take losses inside the transmitter into account. It's understandable why the NASA prefers to use the number 82.

A product that charges mobile devices at a mere 7% efficiency is not viable by today's standards. Responsible suppliers should think twice about using this type of technology in their products, and regulators wouldn't look favorably at these inefficient products.

Cost

Next, cost is clearly an important factor for mass market consumer products. A wireless charging feature that costs $10 in additional components, manufacturing cost and license fees will result in very few phones actually incorporate this feature. A $999 wireless charger is a tough sell, especially if there are few receivers to charge. Products have to meet consumer-determined price points to achieve mass market adoption.

Critical Questions that must be posed about "Power through the Air"

When you get an offer to consider these far-field or "Power through the Air" technologies as a product developer or as an investor, there are several key questions that deserve substantiated answers, some include:

- Can you see the technical analysis of the RF exposure levels (ICNIRP guidelines) caused by the product for the proposed approach? If not, why?
- Will they let you measure their demo system for RFI and RF Exposure in an independent lab? What about efficiency, will they let you measure this independently?
- What are the safety, RFI and efficiency requirements of your own company?
- Can the technology you are considering meet your safety, RFI and efficiency requirements as well as the functional requirements? How does it do this?
- How are they measuring efficiency? Are they measuring it across a load range and range of X/Y/Z positions or just in one "sweet spot"? Do they know the absolute worst and best case efficiency a user will experience? If not, why not?
- Have you seen technical details and rigor showing this is possible (or just marketing hype, 'slideware' and cool demos?)
- What's the price point that you need to achieve? Can you get a quote for components or products with pricing, volume, and delivery dates? Do they have a detailed roadmap for cost reduction?

Outlets such as Seeking Alpha, IEEE-Spectrum, and Techcrunch offer skeptical analysis and seek answers to the same questions above based on claims by some of these fledgling start-ups, and namely are digging deeper about the non-functional requirements: safety and efficiency.

This interview with Paul Reynolds on the state of long-distance wireless charging gives a recent (March 2019) update on "power through the air".

Long distance power through the air is available in real products today – but only at ultra-low power levels

These unproven far-field attempts to charge mobile phones continue to garner a lot of attention by the press. However, industrial applications aren't being acknowledged although they appear to be more realistic. Take the company Powercast, for example, which uses a 3 Watt transmitter to deliver microwatts through the air. The RF exposure level and frequency range is the same as a Wi-Fi base station. That looks viable. You will also notice the lack of outrageous efficiency claims. Efficiency is not an issue when you transmit only 3 Watt and deliver in microwatts. Another example, by IMEC provides power to sensors in an industrial application (farming in glass house), also at microwatt level.

Achieving mass market adoption with safe, efficient and cost-efficient wireless power technology

Power through the Air is possible today for industrial ultra-low power applications. Mobile device charging through the air will remain impossible for the foreseeable future - the non-functional requirements make it impossible.

Besides far-field approaches, loosely coupled 6.78MHz wireless power approaches remain in the demo phase with repeated, unfulfilled, promises* to achieve commercial, general availability. Mass-market introduction of loosely coupled 6.78MHz products continued to be delayed and pushed out. The reasons for these repeated delays have never been publicly disclosed, but one good guess is because of issues with the non-functional requirements.

Qi represents the only wireless power technology that truly has moved from demo to mass market deployment in consumer commercially sold chargers. Today, between 50 and 100 million Qi chargers have been sold, with more than 150 million smartphones have a Qi receiver inside. The prime reasons for this is because Qi is proven to be safe, efficient, does not interfere with sensitive car electronics, and can be implemented at the right (low) price point.

* Articles from PocketLint and CNBC

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About the Wireless Power Consortium

The Wireless Power Consortium leads the world in ensuring consumers, retailers, and manufacturers that they can rely on universal, interoperable standards and certifications for wireless power. Through rigorous testing and certifications, the global body is dedicated to ensuring safe, efficient, and interoperable wireless charging and wireless power. The WPC's nearly 400 member organizations established and support the current Qi standard and are developing standards for innovative new wireless power applications, including the Ki Cordless Kitchen.

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