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Wireless-Power Devices: Solutions Beyond Cell Phones

Electronic Design
Jerry Twomey
Thu, 2015-03-19 16:01
Efficiency, regulatory compliance, and standardization have arrived.

We have become numb to the ball and chain of power cords on electronic devices. Power cords are a constant annoyance—anyone who visits the college coffee shop has seen the spaghetti of students, power cords, and laptops trying to plug in and charge up. If not the inconvenience of the power cord, then there are batteries that fail somewhere inside... right? Unfortunately, battery problems are seen as inevitable due to their rather colorful history of leakage, explosions, and catching on fire over the years. The aggravation of power cords and problematic battery systems become the weakest links in many electronic devices.

Experienced designers of power and battery systems know that high reliability requires certain important things. First, battery systems need to be designed with ample power margin, and most consumer products don't do that. Second, charging methods must be strictly controlled with current, voltage, and temperature monitors, which older systems did not incorporate, leading to some spectacular fires and failures. Finally, periodic maintenance of batteries has to be part of the equation. If those limitations are respected, battery systems become very reliable.

Is there a better way, or is getting rid of power cords and batteries wishful thinking? A great deal of research is going into building better batteries, supercapacitors, and other energy-storage methods, and the foreseeable future has energy storage as part of any device that does not stay plugged in. The power cord is a different story, though. There are ways to get rid of them, though, using wireless-power devices now in the early stages of adoption.

Wireless power is nothing new. Back in 1897, Nikola Tesla was working on wireless power. His forward thinking was successful in many areas of modern power transmission, although providing wireless power to the entire world fell short (see the Tesla Memorial Society of New York's "Nikola Tesla's Idea of Wireless Transmission of Electrical Energy is a solution for World Energy Crisis"**)**. Back then, less was understood on circuits, systems, and antenna devices needed to make these devices both practical and efficient.

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reless power now coming into use are variations on electromagnetic coupling, also known as inductive pling. The method uses electric current to create an electromagnetic field, radiate and receive the electromagnetic field, and convert it back to usable power at the receiver. Many variations exist: near and distant coupling, frequencies used for ac coupling, use of resonance techniques, types of radiators and receivers, and various circuits at the receiver and transmitter.

Recently, several groups have demonstrated wireless power over distance, which sounds exciting until you know the details. Invariably, you run into the basics of physics, limitation of safety, and efficiency questions.

Transferring wireless electromagnetic energy over distance is inherently inefficient, due to the non-directional nature of the transmission radiators and the need to contain, or lose, the energy radiated. Similar to a microwave oven, unless you build a Faraday cage around the environment, most of that energy will be lost. If you use a directional radiator, mobility and freedom from the power cord becomes hampered by limited location placement, which can be more awkward.

In addition to inefficiency, significant power transmission will violate most of the guidelines for safety restrictions associated with electromagnetic fields. Anyone doing distance transmission of wireless power needs to be asked several questions: What is your power-transfer efficiency? At what distance? Will you be compliant with UL 2738, FCC Part 47 Subpart 15 B, IEEE C95.1, and ICNIRP regulations and guidelines? Don't let those questions go unanswered.

Without high efficiency and a path to compliance, wireless power over distance will remain a curiosity, not a commercial product.

What about the distance charging that Tesla wanted? Unfortunately, physics tends to get in the way. The efficiency drops off with distance, and many are ignoring the economics of low efficiency and regulatory requirements of electromagnetic fields. Most of the ideas proposed for high-power distance transmission violate ICNIRP and IEEE-ICES guidelines for electromagnetic safety and human exposure.

As for widespread use, the local coffee shop has free Wi-Fi for customers. Will they pay a utility bill that includes burning a thousand watts of power to provide a free wireless-power connection for customers? Probably not, but close-proximity charging of small electronics is much more energy efficient, and many plans are in the works to deploy it widely.

Unless people want to ignore safety regulations and are willing to bear the expense of high energy use due to inefficient transmission, then distance charging is not practical with existing technology. Close-proximity wireless charging solves that problem, performing with respectable efficiency that generally exceeds 80%.

In fact, close-proximity wireless power already sees some usage. Among older products, one of the most visible is the slow trickle charging of the electric toothbrush. However, with proper electromagnetic design, high-power transfer is now readily done. Wireless power systems are already transferring kilowatts of power, where the limitation of charging rate is the capability of the batteries.

Standard Fare

Presently, wireless charging is emerging in many different cell phones. Not learning from the lessons of history (namely, countless incompatible format and standards wars), two groups are currently waging a format war over their wireless-power standards used in small handheld electronics: the Alliance for Wireless Power (Rezence systems) and the Wireless Power Consortium (Xi systems). They are struggling to determine who will dominate this market.

Widespread deployment is delayed due to doubts about adopting a possibly obsolete standard. One will prevail ome point, and many component OEMs participate in both standards, with a ready to ship perspective for h. Both of these are low power (5 W), similar to the charging capabilities of a USB connector. However, with millions of cell phones, tablets, and other handhelds, the market remains huge.

At the other end of the power spectrum is the ability to charge an electric vehicle (EV) without a power cord. In this case, you need system power in the 1- to 5-kW region. Plugless Power has done exactly that with its 3.3-kW system—you simply drive the car over the power source that's floor-mounted in your garage.

Considering they ask for 7-kW input power, we can deduce a power efficiency of 45% or better, with 4 inches between source and receiver. Efficiency can be improved, and wasting energy will not be popular with environmentally aware customers. Expect a more efficient variant of this to become standard rather quickly on EVs, due to ease of use. Who wants to wrestle with a dirty power cord twice a day?

WiPow Solutions Strike a Cord

So, where else does it make sense to cut the cord? There's already heavy interest and initial offerings coming from two of the biggest markets—small handhelds (5 W) and EVs (1 to 5 kW). A smaller market exists for other mobile and portable devices. Exploring this area, the WiPow Group has developed the needed technology and is now working with OEMs to provide wireless-power solutions in the 50- to 300-W range, which covers a multitude of devices (full disclosure: the author is CTO of the WiPow Group).

In this space, getting rid of the power cord adds convenience and safety in many areas. The WiPow Group is targeting OEMs grappling with the high-visibility burden of the power cord, which could benefit immediately from the improved convenience and safety of no cord. Such applications include medical instruments, computers on wheels, personal mobility scooters/wheelchairs, and mobile robotics. However, certain important criteria must be met to be a successful addition to a product.

Efficiency of power transfer needs to be as high as possible. Testing of WiPow devices shows that the power-transfer efficiency, as expected, depends on distance. However, close-proximity charging with enough separation for wheeled devices can be done at 80% to 97% power-transfer efficiency.

Reliability is enhanced, since there are no mechanical contacts to break, corrode, or in need of critical alignment in a docking station. The WiPow Power Pad is designed to function at full charging rate, even when the device is 10 cm off center.

Sophisticated docking and alignment stations in robots can be eliminated with WiPow technology. Keep it simple, make it reliable.

Safety of these devices requires regulatory compliance and design architecture. On that front, WiPow technology meets the most stringent safety requirements, particularly for medical devices (IEC 60601-1) *(see "Know Your Regulations Before You Design Medical Electronics")*.

Techniques for electromagnetic-field containment (ICNIRP and IEEE-ICES electromagnetic-compliant), suitable techniques to be able to pass UL, and FCC 15 B emissions were also part of WiPow design criteria. Not wanting to get into a standards war, the WiPow group is asking for interested industry OEMs to join the coalition and help drive a common standard.

Considering the IP issues have been well researched and filed on, high-efficiency wireless power will ultimately go through the WiPow Group. Consequently, a coalition for a desired common standard is the most efficient way to achieve widespread utilization. Also, as I explained at a conference on disabilities: "The ultimate bad press will be getting into a standards competition with electric wheelchair users caught in the middle."

er seeing the problems with power cords in a hospital setting, and talking with healthcare professionals ut the associated safety and contamination problems, the need became well defined. Finding a better way resulted in the development of WiPow technology. Effective Electrons started R&D in this area, and then founded the WiPow Group to fulfill the goals.

Because there's no standardization on device batteries, putting WiPow technology into an OEM product requires some customization. Variations of battery chemistry, charging profiles, etc., become a variation on a theme exercise. Standardization on the power-source side looks promising, though. Depending on the needs and capabilities of the OEM, the WiPow Group can handle end-to-end product development, manufacturing, and regulatory compliance, or simply provide the intellectual property and reference designs for the wireless-power system of your product.

A flexible approach is available to help OEMs get a WiPow-enabled product to the production stage. It's time to cut the cord.

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