Medical devices: Where wireless charging has real impact

Bill Schwebel - April 19, 2015

Wireless charging of personal devices such as smartphones, laptops, and tablets is a hot topic. Several standards are competing to make it possible to just place the device on a table's surface or charging pad, and sit back while energy is transferred without the need to connect to a discrete, physical cable. While this might seem a nice but not critical feature at home or office where you have your usual charger and connector already set up, it is a different story in a public place where you need the appropriate charger connector (USB, iPhone, and others), and the cord/connector are subject to extensive use, abuse, and even vandalism. Anytime you can seal the interface between unit A and unit B, that's good in terms of public access, reliability, and options for mischief.

Wireless charging still faces some challenges, but there has been lots of progress in standardization (admittedly with several competing standards), availability of needed ICs and other components, defining physical form factors, and other aspects. It's hard to say if it will catch on and have long-term success, as there are associated costs with respect to components, size, and charging time. If it doesn't work out, the traditional technique of connecting a charger via a cable assembly is still a viable and well-established fall-back alternative.

But there are situations where practical wireless charging would bring real benefits: implanted medical devices. In many cases, the battery's size is a limiting factor in use, since it needs to power the device for several years. In some cases, such as brain stimulators, the battery is actually sited in the patient's chest, with wires running between the two locations—obviously, not a desirable situation, but there is no choice.

Why not use wireless charging for medical implants? It has been done, but with mixed results. There are several obstacles: the distance of between one and as much as five cm, the body tissue and fluids between source and receiver, the small size of the implant (as little as a few millimeters), and movement of the receiver target, to cite a few. The obvious approach using inductive transfer only works adequately when the source and receiver are close and properly oriented, and the receiver coil is relatively large; it is already in use for some types of cochlear implants where these conditions can be met. However, it's not viable for pacemakers and other deeper implanted devices.
Yet there is innovation and progress, as shown by an article in *Physics Today*, "Wireless power for tiny medical implants." This informative and very readable article discussed work done at Stanford University using directed GHz energy to address the issue. The article included explanation of the core problems, the RF modeling they used, and the result achieved thus far.

These results were impressive. The Stanford group reports that "in experiments on a pig cadaver, 0.04% of the source power was transferred to a 2-mm receiver 5 cm beneath the surface" using 1.6 GHz radiation. Yes, you read that right: just 0.04% – which would be totally unacceptable for charging a consumer device such as a smartphone. But the report notes that even such a low efficiency is sufficient for many implanted devices (a state-of-the-art cardiac pacemaker uses under 10 uW, far, orders of magnitude less than a consumer product.

Assessing the effectiveness is not trivial. I often wonder "how did they measure that?" since acquiring meaningful, trustworthy data in leading-edge research is often as big a challenge as the experimental set-up itself, and it is not necessarily just an issue of needing advanced, expensive test instrumentation. In this situation, the researchers noted that the obvious approach of simply attaching leads to the receiver would affect the system's inductance and associated EM fields.

Instead, they devised a simple and clever instrumentation approach of using the receiver to power a small circuit within the implant which, in turn, flashed a tiny LED at a rate proportional to the received power. An optical fiber then conveyed the LED output to an external photodetector and circuit which sensed and counted the flash rate (once again, the RF-free nature of optical fibers opens up new approaches to many problems)...very nicely done, indeed.

What's your view on the desirability or viability of wireless charging for consumer products? Would you ever think that transfer efficiency of less than one-tenth of one percent would be sufficient and welcome in a unique application? What power-transfer efficiency would you accept in your application?

Not just a simple air or vacuum path: this model of the layered tissue structure between the skin surface and a 2-mm micro implant located 5 cm deep inside the human chest wall shows some of the challenges in wireless charging of in-body devices (from *Physics Today*, American Institute of Physics).

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