Wireless power challenges and opportunities

Steve Taranovich - January 26, 2017

Wireless power transfer (WPT) technology is destined, in the very near future, to rock the electrics and electrical world we live in. Eric Giler, now president of WiTricity, an MIT spinoff, gave an excellent TED presentation in 2009 entitled, "A demo of wireless electricity." In this demonstration, Giler powered a small TV via wireless power transfer—that was 2009. We have come a long way since then; please read on for a technical glimpse into this amazing field (pun intended) of opportunity for designers.

I had a recent discussion with Dr. Michael de Rooij, VP of Engineering for Efficient Power Conversion (EPC), in which we discussed wireless power challenges and opportunities going forward in 2017. I chose Dr. de Rooij for this discussion because of the industry-leading development that EPC has done with the GaN power element (in this case EPC’s eGaN) and the breadth of design support in demo boards and reference designs as well as their educational support to designers, including Dr. deRooij’s Handbook for Wireless Power.

This year at the CES 2017 show, EPC demonstrated a 43” flat-screen HDTV being powered through a sheetrock wall via wireless power. In 2017, you will see the amazing advanced technology EPC has put together that eclipses the early demo shown by Giler.

WPT over longer distances

I asked Dr. de Rooij about the limitations and possibilities right now that need to be overcome in order to make wireless power charging effectively work over longer distances. How can we make it a reality for all consumers as far as acceptable efficiency in the power transfer? How is the GaN power element (eGaN in the case of EPC) going to help in this effort going forward?

Dr. de Rooij first mentioned the coil design as a limitation; a rule-of-thumb is that right now, beyond a 7” diameter, performance degrades. The rule for long range with efficiency is affected by the quality factor for each coil, Q and the coupling coefficient between the coils, k. The size and geometry of the transmit and receive coils greatly influence the Q and k independently (Reference 1). Figure 1 shows the basic wireless power transfer principle.
Dr. de Rooij mentioned that for the E-field method of wireless power transfer there are technological issues but power travels over longer distances (There may be some general concerns here related to ozone generation and interaction with other materials including biological). This method may be better for drone charging while hovering over a charge pad. The straightforward implementation of the electric field coupling technique is to use the parallel plate capacitance between the source and the load. The input impedance should be matched for efficient power transfer. So one plate would be at the bottom of the drone and another plate at the re-charging pad (Figure 2).
Figure 2 The structure for electric field coupling in a wireless power transfer (a) and the circuit model (b) are shown here (Image courtesy of Reference 2).

Drone charging while hovering with magnetic resonant coupling is also a good alternative (Figure 3).

Figure 3 Here is a drone re-charging its battery by hovering over a terrestrial pad station with a rectangular shaped coil design in which the receiving coil on the drone is adapted to the landing support so that the gap between transmit and receive coils is minimized to only a few millimeters thereby maximizing the coupling factor between the coils (Image courtesy of Reference 3).

Today’s technology and the future regarding WPT coils

Dr. de Rooij says that NuCurrent is developing some improved efficiency coils for WPT. NuCurrent claims that their existing ‘antennas’ will be more efficient than any alternative printed antenna/coil/resonator. The company says that their present designs commonly experience efficiency improvements of greater than 20% for Qi/PMA frequencies (~200KHz) and 60% for A4WP (6.78MHz) and NFC (13.56MHz) frequencies.

Embedding floor tiles with WPT coils can help distribute fields which may improve distance slightly, but more importantly it will dramatically improve the area available to collect power. This is a more efficient method than designing a single coil for the same area coverage.

Powering an HDTV wirelessly

EPC’s CES 2017 WPT demo of an HD flat panel TV is one of the most useful applications I have seen to date, aside from Starbucks putting WPT into their tables in some of their stores to charge your smart phone. In most cases, they also sell an adapter for your phone in case it does not yet have internal WPT capability (Figure 4).
Now let's look at how to power a TV in 2017. EPC chose a Vizio model D43-D1, a 43” HD flat panel TV. Specs are available [here](#). It draws 85 W max based on testing. Some other previous tests have used a lower power 20” TV.
Figure 5 The WPT design architecture shows the technology through a standard piece of sheetrock powering the Vizio HDTV. (Image courtesy of EPC)

The TV uses AC with unity power factor, so all the energy supplied by the source is consumed by the load. Since the TV electronics need DC power, all the existing AC rectifier, large electrolytic capacitors, and bridge diodes are not needed. When the TV is first powered on it draws less than 5W. The WPT transmitter can throttle back when the TV requires less power.

The schematic design of the demonstration that EPC provided at CES is shown in Figure 6. The designers used a differential zero Voltage switching (ZVS) Class D amplifier to drive the transmit coil. (Note: A differential architecture, especially above a 300 MHz frequency range, improves the effect of radiated EMI over a single-ended design. In a differential design, half of the magnitude of the voltage transition at the output of the amplifier with respect to ground for the same load power). But in this case they are only transmitting at the highly resonant 6.78 MHz ISM band and EPC demonstrates that an eGaN FET has significant advantages over a conventional MOSFET power element (Reference 4).
Surely consumers will want their TV to be completely wireless in the future so that they can easily mechanically mount them on walls or on/in an entertainment center. This will definitely extend beyond the flat screen TV to appliances and other electrically AC powered devices as well as those that, in reality and function, only need DC power.

**Opportunities to make life better with WPT**

WPT’s use with drones could be beneficial to companies like Amazon, UPS, and Federal Express that are considering using them to deliver packages.

In the medical field, implants that presently have cables through the skin could have far less risk of infection with WPT added to these designs. Nerve stimulation and heart-assist pumps are prime candidates, and pacemakers and spinal cord and nerve stimulators will be able to charge some day while a patient is sleeping four or five feet away. Coils that pick up signals from the patient can be increased in number for better magnetic resonance imaging (MRI) while reducing costs, eliminating cables, and lowering complexity by using WPT.

Bars, cafes, and airports can have WPT devices in the next phase of designs in furniture, desks, and tables, and less or even no power outlets will be necessary in the home with WPT repeaters in walls, furniture, and floors.

Cabling in automobiles are costly, unreliable, and add weight. WPT will enable lights, audio, phones, EV charging, power for RADAR and LIDAR, and more electronics without being tethered to copper cables within the vehicle. Wireless power may also be used in the seat, doors, and trunk areas. This simplifies car manufacturing by allowing a more modular approach rather than a custom design architecture.
WPT would prevent dangerous sparks causing explosions and fires at gas stations, underwater, Oxygen-rich space environments, seaside homes/facilities, or areas like grain silos with dust atmosphere.

One day, high voltage power lines will be eliminated via WPT and that may even provide a chance to bring Nikola Tesla's dream to life with ubiquitous high voltage WPT in the future.

Dr. de Rooij tells us to watch for more WPT innovations at APEC this year. The face of electronic and electrical systems will one day be forever changed as new developments emerge in this amazing technology.

References

4. Performance Comparison for A4WP Class-3 Wireless Power Compliance between eGaN FET and MOSFET in a ZVS Class D Amplifier, EPC

Also see:

- When will wireless charging be everywhere?
- Nikola Tesla and wireless power future
- Wireless power transfer from the antenna side of the design
- Intuitive innovation in wireless power transfer