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# Weird & Wireless: How can wireless power transmission work?

*Welcome again to the wonderful but sometimes weird world of wireless comms, written by Joel Young, CTO of Digi International.*

In the last post I teased you by first stating that the traditional transverse electromagnetic wave method, i.e. how the sun works, doesn't scale very well for more moderate systems on the earth and second, telling you that Nikola Tesla had figured out a better way.

Unfortunately I didn't give you any details. However, before we get into too many details, we need to understand a few things about waves and the need to guide them.

For without the ability to carefully control and direct a wave, they tend to spread out in all directions. And of course, when the spread out, not only does the energy density decrease, but they also have a nasty habit of running into things which both scatter and absorb them.

Hence we have a problem - we want to send power wirelessly so we don't need to worry about plugs and cables, but this means that we need to have the energy be distributed over a wide area because we don't know exactly where we need the power.

The act of spreading typical transverse waves everywhere means that it is really hard to capture much of it unless we have a sun-sized source. It seems we have a paradox.

They key to this puzzle is to think about the problem differently - something very difficult for most of the engineers in Tesla's time and difficult for many even today. To understand the notion of wireless power, we first must return to the world of wire-line power in Tesla's time. Tesla pushed AC and Edison pushed DC.

Most of us know that DC doesn't work over long distance because of Ohm's Law. Wires, even big transmission lines have a natural resistance. Hence, all DC transmissions are subject to Ohm's law - meaning that the longer the line, the higher the resistance and the larger the voltage drop. A lot of power gets wasted in the transmission process.

In contrast, sending an AC signal down a line means that the potential is constantly changing - the electrons "slosh" back and forth, sending a wave down the line and the resistance in the line is bounded by the "sloshing." The laws of Physics and Ohm's law still apply, but the effects are mitigated. Now for the sake of discussion, I want you to think about the wire for AC as a sort of guide or tunnel for the 50/60 Hz wave.

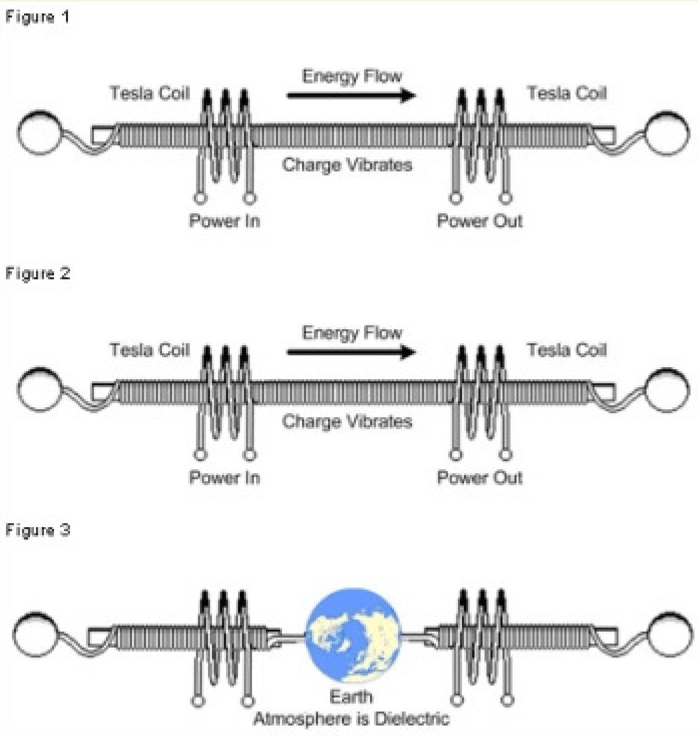
In electromagnetics, we have something called near field and far field effects. Far field effects are concerned with the sending and receiving of traditional, transverse waves like we have previously discussed. Near field deals with the interaction of circuits and elements that are very close together.

A transformer is a near field type of device where two coils are coupled electromagnetically. With a transformer, electric energy is transferred from one coil of wire to the other by means of induction. This happens because a changing current induces a changing magnetic field and a changing magnetic field induces a current.

For this to work efficiently, the coils of wire that have the currents must be very close together. You may have seen some battery chargers that don't appear to have any terminals for connection - like an electric toothbrush. These use induction for charging. So what if we could extend these near field effects over a distance?

To understand how we might transmit wireless power, we begin with Figure 1 (see below). This illustrates the concept of a single wire transmission system by coupling two Tesla coils together. Power goes into the coil on the left and is inductively transferred to the big coil, creating a high frequency AC power.

The same power then is transferred back to the coil on the other end to a load. In the wire, the electrons slosh around, back and forth such that the electric field difference is from wire to wire while the energy flows through magnetic field outside the coil. The sloshing electrons look like a compression wave down the coil.




Next in Figure 2, we split the large coil in the middle and insert a coaxial cable. The compression wave of sloshing electrons moves down the cable and the magnetic field is guided along the cable's dielectric so that it doesn't spread out over free space and lose density.

Finally in Figure 3 we replace the coaxial cable by the Earth and let the atmosphere act as the dielectric.

One hundred years ago, Tesla proved this system works by sending power wirelessly over 25 miles and lighting hundreds of lamps. Wireless power works and the laws of physics have not been violated.

Unfortunately, if you can just plug into the ground, there is no place to put the electric meter.

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