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Wireless power in flux

Wireless power has been around for a very long time – ever since Tesla began demonstrating impressive displays of remote power delivery in the 1800's.

Recently, wireless power has come back into the limelight with a great deal of media and advertising hype surrounding it – this article aims to remove some of the confusing fog about this technology kicked up in this flurry of activity. There are essentially two mainstream 'standards' to wireless power and two different consortia of companies supporting each. The two major players in this market – the consortia – specify wireless charging standard specifications. There is inevitably competition between consortia as each tries to gain a foothold in markets, to 'push' its technology into prevalence. Similar past examples of this situation, such as Betamax vs VHS vs Laserdisc, show that it takes time before one standard gains the upper hand, or technologies merge. Even then, if one standard does gain the upper hand, technology from another may still be implemented in future advances (Laserdisc technology forming the basis for CD and DVD is a useful parallel). So it is worth understanding the benefits and drawbacks of each supported platform, whether it becomes successful in the short term or not.

¬ Wireless Power Consortium (WPC)

The standard for this consortium is known as 'Qi'. This consortium in the past had based its technology on purely inductive power transfer, but has now moved to incorporate resonant systems. It has begun to get a solid foothold in the market with many devices using this standard becoming available. The member companies (of which there are 215 at the time of writing) include giants such as Hitachi, Toyota, Panasonic, Samsung, IKEA and Microsoft. Systems based on this standard are being incorporated into IKEA furniture, mobile phones and cars. Public places are also being equipped with charging stations, such as cafés, trains and airports. With several hundred products on the market, this technology is making headway and forcing conformity of new devices because of it.

Qi is based on an inductive non-resonant transfer process that operates at relatively low frequencies (in the order of 10-200 KHz) for close, strongly coupled coils. For weakly coupled coils (e.g. further separated), the newer versions of the system can be operated at resonance (i.e. transmission frequency is in resonance with the receiver). The power transfer capacity for these systems is currently set to a maximum of around 5W (soon to be 15W), but mid power systems (up to 120W) are being developed. High power (2.4 kW) systems have been demonstrated for powering home appliances, but not released.

The communication link between the receiver and transmit is carried out in the same frequency band as the power transfer, to ensure correct power is being delivered at the right frequency.

¬ AirFuel Alliance: the mergers of Power Matters Alliance (PMA) and Alliance for Wireless Power (A4WP)

A4WP is focused on a 'magnetic resonant' power transfer system (under a standard called 'Rezence'), which is basically a pair of resonant circuits that auto tunes resonance via a Bluetooth communication channel to ensure efficient coupling. The load impedance on the receiver coil also affects overall efficiency, so this may also be altered to improve efficiency. The power transfer operates at the 6.78 MHz ISM band, with communications at the 2.45 GHz Bluetooth band.

PMA supports an inductive power transfer system, operating at higher frequencies than WPC at around 450 kHz – this places limits on its usage in Europe from an emissions standpoint.

The 'magnetic resonance' system has enhanced coupling factors between the coils compared with inductive charging, but requires a separate communication network to maintain the optimum regime. Whilst there are no products currently using the Rezence standard, there is a standard fully in place with the support of CSR (Cambridge Silicon Radio).

Although AirFuel Alliance has 195 member companies, some of these, like Qualcomm, Broadcomm and Samsung, are supporting both Qi and PMA.

In the merging of these two consortia, they match WPC in terms of being able to offer non-resonant and resonant power transfer systems.

¬ Transfer limits

Given the various approaches described above, what are the limits of power for these systems? There are basically two major factors at play here – emissions regulation and safety. Since this technology is relatively new, the do's and don'ts may be prone to change, although regulatory bodies have a reputation of moving at a glacial pace.

The emissions regulatory system plays a particularly important role when considering devices on various continents – only certain frequency bands are acceptable for significant powers, and communication protocols add further complexity to this. Going into full detail would fill up many pages, but suffice to say that given an operating frequency, power/communication protocol, power level and country of use, EMC/emission testing regulations must be heeded carefully.

Safety can be split into two parts – human safety and device safety.

The human safety aspect is covered by the IEEE and ICNIRP guidelines that set field limits as a function of frequency. The dangers posed by a high frequency magnetic field can be broken up into two frequency bands. Up to about 100 kHz, currents induced in the body can cause twitching and spasms over certain field levels. Beyond this frequency, body tissue heating becomes the issue – which has a SAR (specific absorption rate) associated with it. Because neither of these can be simply converted into magnetic field strength, the guidelines generate estimates of fields at which these may be a problem, and sets them as public and occupational limits. Given that these are only guidelines and not regulations, they can be disputed, but are useful as a ballpark figure. Custom FEM modelling of the field interactions with the human body are carried out where a potential risk may present itself.

The last part of the danger is device safety. This is basically the inductive heating of metallic objects due to induced currents by the magnetic fields. This obviously causes problems for many consumer devices due to casings, connections and housings being generally made out of metal. Coupled with this, the batteries which are being charged are damaged by high temperatures – therefore some consortia have limits of power transfer. Foreign object detection is also built into products where stray fields may cause dangerous heating of nearby objects. Higher frequencies (over 1 MHz) tend to not heat metallic objects as effectively as lower frequencies due to the skin depth only penetrating tens to hundreds of microns. For comparison, induction hobs work at tens of kilohertz, and cause heating in ferrous metal pans due to the skin depth being optimal to cause heating (although the skin depth for copper and aluminium is too large in this case, and heating is ineffective for the opposite reason as with high frequencies).

However, designers needn't be limited to the consortia approaches: custom solutions can be easily developed provided they comply with safety and EMC. Several other wireless power technologies are presently being developed and advertised, such as electric field wireless power transfer and 'directed' RF charging stations. These have seen less commercial activity than the magnetic field based charging systems and have their own unique challenges.

Despite all these potential risks, wireless power certainly seems to be gaining traction in several markets. Some major potential users have yet to 'choose sides' in the standards contest currently playing out, which makes the future hard to predict. New standards might crop up and new wireless power technologies may appear or merge, but regardless of the outcome, this is an exciting and rapidly evolving technology space.