TDK
COMPONENTS
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Wireless power transmission coils December 2012

Smart charging on the go

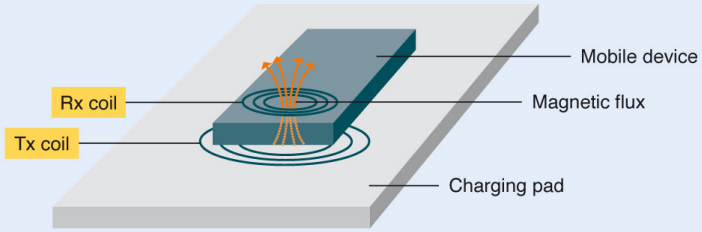
Wireless charging now promises to finally free mobile devices completely from their last cord – something that is sure to please smartphone users. TDK has developed ultra-flat power transmission coils that meet the most demanding Qi specifications of the Wireless Power Consortium (WPC).

The transmission of electric power without wires or connectors is already widely used in many products such as toothbrushes, LED candles, remote controls, medical equipment or induction cooktops, where it has proven to be reliable and convenient. Up until now, however, wireless charging systems were designed for a particular product or application and could not work universally for a wide range of devices with different sizes and shapes. Users now demand that charging stations will work universally with products from any manufacturer, and will work with next-generation models as well.

In the future, users of mobile equipment will be able to use their devices without being concerned about battery consumption because universal wireless charging will be available in multiple locations nearly everywhere they go. Currently, more than 120 companies worldwide are participating in the WPC to create and promote the standardization of wireless power transmission. Based on WPC's Qi specification, TDK has developed new ultra low-profile wireless power transmission coils, which enable standardized wireless charging of mobile devices. TDK's vision is that of a completely flat surface that can charge any device that complies with WPC specifications, providing an easy-to-use charging platform accessible just about anywhere.

Basic principles of wireless power transmission
Electromagnetic induction is the most widespread method of wireless power transmission and is based on the principle of transmitting and converting the magnetic flux (Figure 1). Here, the magnetic energy is transmitted from a primary coil (Tx coil) to a secondary coil (Rx) by the electromagnetic induction between them.

Figure 1: Basic principle of wireless charging for mobile devices



Energy is transmitted from the Tx coil to the Rx coil by the electromagnetic induction between them.

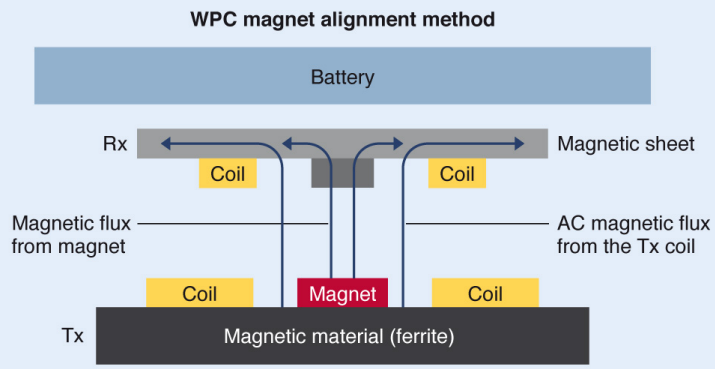
Wireless power transmission using electromagnetic induction will enable the wireless charging of a wide range of devices with different sizes and shapes. A universal system will require compatible Tx and Rx coils with regard to the number of windings and their overall geometry.

One technical challenge encountered in wireless charging is aligning the Tx and Rx coils for the most efficient transmission of power. Mechanical positioning aids such as a device holder or similar construction had to be avoided in order to enable the design of universal charging pads for devices with different sizes and shapes.

The WPC has proposed and specified three positioning methods for achieving optimal charging coil alignment:

- Guided positioning with a magnet at the center of the Tx coil and a magnetic material at the center of the Rx coil (Figure 2)
- Free positioning with a moving Tx coil able to detect the position of the Rx coil
- Free positioning with selective activation of one of multiple Tx coils in a coil array that is closest to the Rx coil

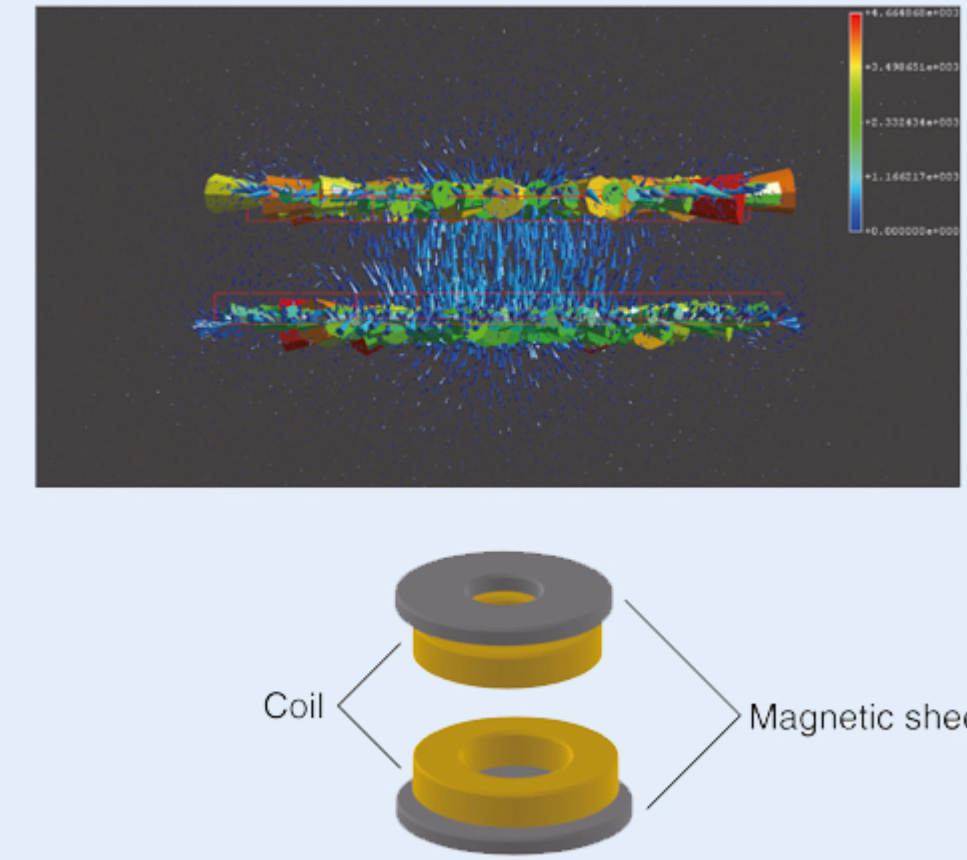
Figure 2: Guided positioning with a magnet



The proper alignment of the Tx and Rx coil is essential to achieve the most efficient transfer of magnetic energy. The guided positioning method uses a magnet in the Tx coil to attract the Rx coil to the right position.

The WPC has adopted a certification system that verifies mutual operation of the Rx and Tx sides for the above alignment methods. As the Rx coil certification cannot be acquired unless the coil operates properly for all Tx types, TDK has designed an actual Rx coil unit which gives the user the most flexible and easy-to-use solution. This is achieved by placing a magnet at the center of the Tx coil and a magnetic material at the center of the Rx coil.

Figure 3: Magnetic flux between the Tx and Rx coils



Magnetic shielding is needed for the Rx coil in guided positioning to prevent high-frequency magnetic flux. The material and thickness of the magnetic sheet on the Rx side must be designed so that it does not reach the magnetization saturation point.

The magnetic sheet challenge
Each method has its advantages and disadvantages. For example, although the guided positioning method has a simpler design on the Tx side, it requires considerations for magnetic shielding.

When designing an Rx coil for the guided positioning method as described above, a magnetic shield is essentially required in order to prevent high-frequency magnetic flux (exceeding 100 kHz) generated by the Tx coil from reaching the aluminum battery case and producing unwanted eddy currents that are converted into excess heat.

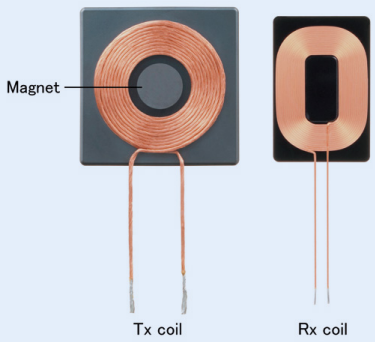
The material and thickness of an Rx-side magnetic sheet, therefore, must be designed so that it does not reach the magnetization saturation point. In this case, magnetic flux from the magnet will pass through the Rx-side magnetic sheet (Figure 3). This will become the magnetic bias component and will be magnetized to saturation if the magnetic sheet is too thin, causing the inductance of the coil to decrease significantly. In this state, normal wireless power supply operations are not possible – a very complex design issue that TDK has resolved based on its extensive experience in this field. This includes magnetic materials technology and process technology, winding pattern technology expertise gained through the manufacture of a wide range of coils, as well as magnetic circuit design technology.

TDK coil design
The ultra low-profile wireless charging coils developed by TDK meet the most demanding specifications set by the

WPC, taking into account the evaluations or designs described above (Figure 4). TDK's smartphone receiving coil unit, which is installed in the smartphone to receive the magnetic flux for charging, employs a proprietary flexible thin magnetic sheet, achieving an industry-leading thickness of only 0.57 mm. Development of a 0.50 mm type has also started to enable even slimmer charging designs for smartphones. At this point, output current is on the order of 0.5 A to 0.6 A, but an even thinner 0.50 mm type with equal or better output current is already in development, with a view towards starting mass production in 2013.

The development reflects TDK's extensive expertise in fields such as magnetic materials technology and process technology, and involved the creation of a unique, extremely thin and flexible metal magnetic sheet. As a result, the coil unit is not only ultra thin and lightweight, but also highly resistant to shock, therefore providing excellent reliability. TDK will continue to offer low-cost, high-performance, high-reliability products and comprehensive solutions that achieve all of these requirements, so as to contribute to the development and universal use of wireless charging power transmission.

Figure 4: Ultra low-profile TDK charging coils



The ultra low-profile wireless charging coils developed by TDK meet the most demanding specifications set by the WPC. TDK's smartphone receiving coil unit (right), which is installed in the smartphone to receive the magnetic flux for charging, employs a proprietary flexible thin magnetic sheet, achieving an industry-leading overall thickness of only 0.57 mm.

Future benefits for designers

Wireless power isn't just about freedom from power cords and convenience; it also changes the way manufacturers can design devices. Eliminating the power socket is a major step toward a sealed and even thinner smartphone that's waterproof and dustproof. Such a device would at the same time be more reliable and rugged, and it would not need a flat edge to mount the power socket on.

The availability of wireless charging everywhere would further allow designers to consider smaller batteries because users would be able to simply top up their battery charge as needed.