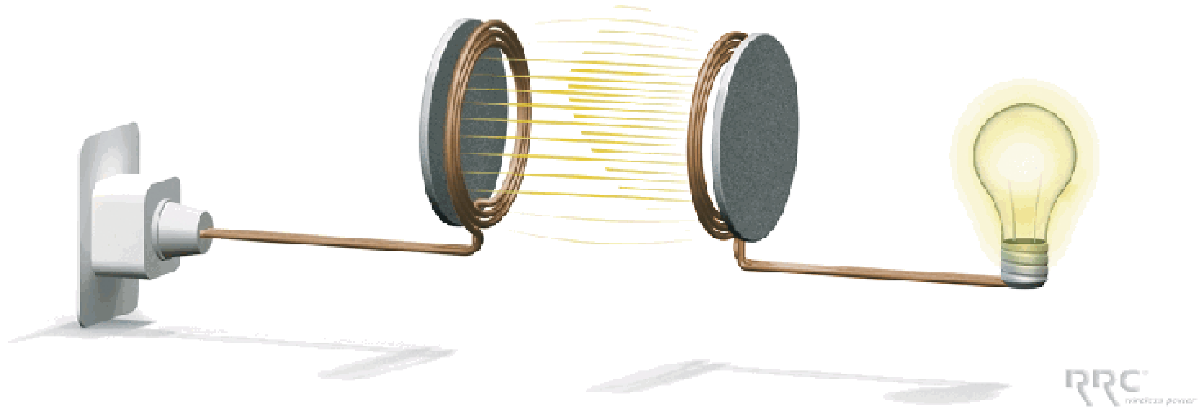
Wireless power transmission has many advantages, especially in the field of medical technology. But where is the difference between industry compatible standards and proprietary solutions?

Wireless Power Medical Innovations

The desire to use wireless energy transmission for the supply of power to electronic devices goes back to the 19th century thanks to visionaries such as Nicola Tesla. Despite the foundations laid in those days (Image 1), this topic has gained in scientific importance within the past few years, which is documented by the recent marked rise in scientific publications and patent applications.

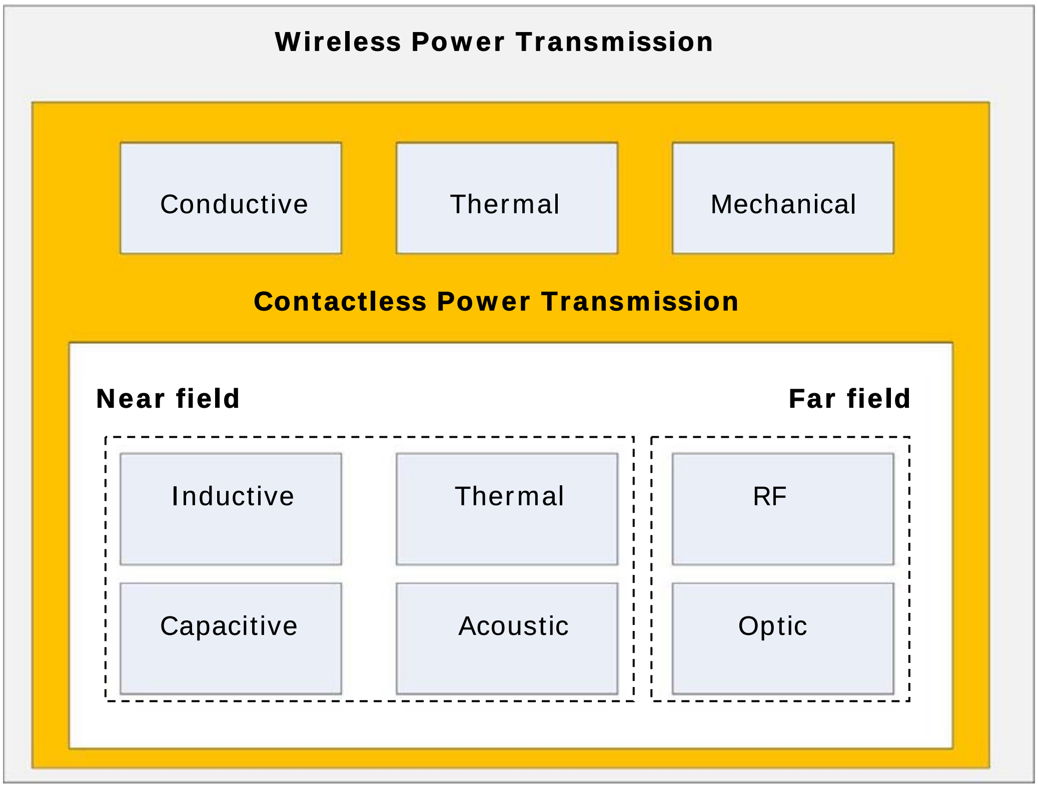


"Image 1"

Wireless energy transmission provides a range of advantages with regard to implants, and also for other medical devices that must be disinfected regularly. One of these advantages is for example, low construction costs.

The reasons for this are, on the one hand, the trend towards increased mobility and the resulting growing demand for mobile devices and on the other, technical advancements. While today almost every power supply unit and charger is equipped with a microcontroller, in the past this was not possible due to component costs. Today, efficient power transmission systems that require a minimum on space are a reality.

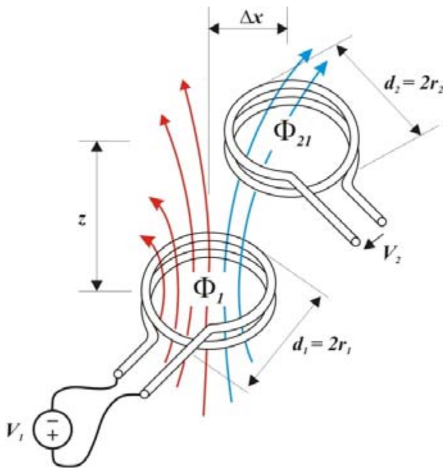
Wirelessly transmitted power ranges from a few microwatts, such as that produced in energy harvesting, to several kilowatts. The energy transmission usually occurs inductively, capacitively or radiatively (Image 2). In the following, this article concentrates on inductive transmission systems with transmission rates up to 100 W.



"Image 2: Different types of wireless power transmission"

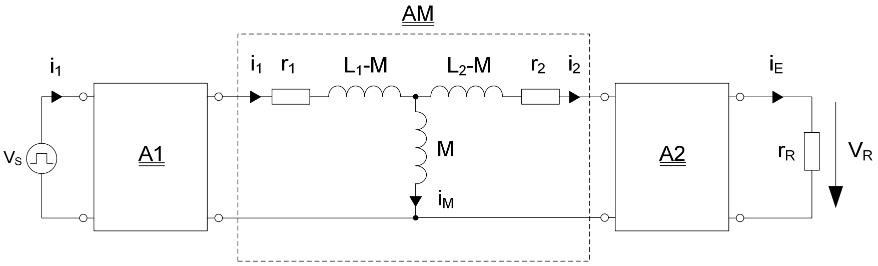
In inductive power transmission, power is transmitted via a loosely coupled pair of coils. The common magnetic flow Φ_{21} that flows through both coils depends on the coupling of the coils (Image 3). A measure for the coupling of both coils is the coupling factor k defined by the self-inductances of the transmitting (L_T) and the receiving coils (L_g), as well as the mutual inductance (M) as follows:

$$k = M \times \sqrt{L_T \times L_R}$$



"Image 3: Inductive power transmission with a loosely coupled pair of coils [2]"

The coupled pair of coils can be represented for example, by the equivalent circuit diagram framed by the dotted line in Image 4. In this case, r_T and r_R describe the winding loss of the transmitting and receiving coils. Depending on the self-inductances, the coupling between the transmitter and receiver and the load resistance, the compensation networks A_T and A_R are dimensioned so that energy is transmitted as efficiently as possible and the power to be transmitted can be easily adjusted. The efficiency depends on the coupling factor, as well as on the quality of the resonance circuit.



"Image 4: Equivalent circuit diagram of an inductive transmission system"

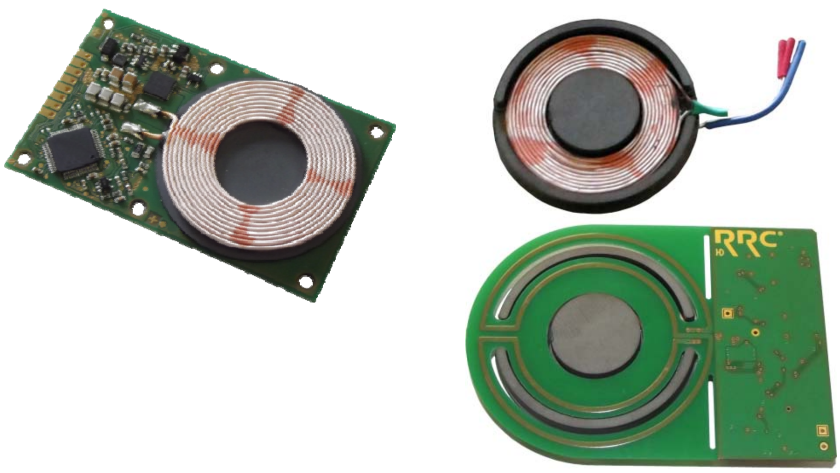
When developing a wireless power transmission system, factors such as the maximum amount of power to be transmitted, the desired positioning tolerance between the receiver and transmitter with regard to the maximum vertical and lateral offset and the usually very limited installation space have a decisive influence on the selection of the topology and the technical implementation. Due to the multitude of different implementation possibilities, general interoperability between the power transmitters and the receivers is principally not given, even when both are developed to transmit the same power. However, in order to establish cross-manufacturer interoperability, three industrial consortia were formed in the past few years, who compete with one another for preeminence in the field of wireless power transmission and who have, in part, set different priorities with regard to positioning tolerance and the optimum transmission efficiency.

More than 170 companies now belong to the Wireless Power Consortium (WPC). In 2010 the WPC published the first specification for wireless power transmission [1]. The transmitter and receiver defined in it transmit up to 5 W across distances of a few millimeters and are recognizable by the Qi logo. In addition, in the new Volume II Medium Power specification, systems are defined that allow a power transmission of up to 15 W. Today, the first Qi-compliant duplicate parts can be found chiefly in smart phones. Due to the increase in the installation of charging stations in automobiles, the WPC hopes that their specification will establish itself and become part of a standard.

The Power Matters Alliance (PMA), founded last year at the initiative of Procter & Gamble and Powermat Technologies, pursues similar aims. In the Power 2.0 specification, PMA defines interfaces for power transmission and transceiver communication. In order to provide device manufacturers with the greatest possible design freedom, considering the circuit, only the transmitter-side resonant circuits were specified.

The third group of industrial consortia for wireless power technologies is the Alliance for Wireless Power (A4WP). Initiated by the companies Samsung and Qualcomm, A4WP now has over 60 members. The consortium pursues the aim of transmitting power over large distances whereby the positioning tolerance compared to systems with tight coupling, at the same time, is increased. The consumer market is the primary addressee, i.e. the wireless charging of products such as headsets, smartphones and laptops. By focusing on loosely coupled systems and the transmission of power across distances of several centimeters, the technology could be interesting for the field of medical technology, for example for the power supply to implants.

Interoperability often does not play a role or is deliberately avoided. In this case, proprietary solutions, such as the 20 watt module from RRC power solutions can provide benefits. For example, in Qi systems the power and the data is transmitted via a single pair of coils, while in the proprietary solutions data transmission is decoupled from the power transmission by an additional pair of auxiliary coils in the solution shown on the right in Image 5 [2].



"Image 5: Comparison of a Qi-compliant 5 W module (left) with a proprietary 20 W module that has an additional auxiliary pair of coils for quicker, bi-directional data transmission"

By integrating the auxiliary coils into the circuit board no additional component costs arise, while the size of the coils for the power transmission remains the same. In addition, the pot-core form of the ferrite reduces the stray field. In combination with a new modulation process the system transmits data bi-directionally with a much higher bandwidth, in comparison to the Qi specification. Because the data transmission in wireless power transmission systems is also used as a feedback path for controlling the power to be transmitted, the dynamics of the power regulation increase with the higher data rate. Thus, the system controls dynamic load changes much faster. In addition, application-specific data can also be transmitted via the bi-directional interface within a limited range, in order to for example, install firmware updates, read out system parameters or transmit other data.

Wireless power transmission has many advantages when used in the field of medical technology in contrast to the conventional, wire-based supply of power. Applications can be found in the provision of power for devices without electroconductive contacts on the outside. Devices with hermetically sealed casings can be constructed much more robustly against mechanical stress and are much easier to clean. Equipment and devices regularly come into contact with aggressive cleaning agents and disinfectants, especially in the field of medicine. The reliability of these devices can be increased by eliminating external plug connectors and contacts. Because medical devices usually depreciate over a longer period of time due to their high acquisition costs, the elimination of wear parts such as plug connectors has a positive effect on the operating costs. This makes devices with this sort of technology much less susceptible to defects and less likely to require repairs throughout their lifecycle. At the same time, water and dustproof products that can be used in harsh environmental conditions can be manufactured. The attainment of a comparably high protection class with conventional contacts requires, in many cases, a significantly higher amount of engineering that is reflected in higher production costs.

Implants can also be supplied with power via wireless power transmission. As a rule, this is much more comfortable for patients than wired provisioning. For example, infections can occur at the emersion point of wires on the body, for example with artificial hearts. For battery-powered implants with rechargeable batteries that can be charged via wireless power transmission, the complex and risky operative battery change becomes superfluous [3]. Wireless power transmission provides medical technology with new perspectives in product development. If manufacturer-independent interoperability is not required, proprietary solutions allow a larger scope of functions in contrast to a specified interface. This means that not only innovative devices can be realized, but implants can also be supplied with power or charged wirelessly, which makes things much easier for medical personnel, as well as for patients.

Literature

[1] "System Description Wireless Power Transfer Volume I: Low Power Part 1: Interface Definition." p. 80, 2011.

[2] D. Huwig, "Inductively Coupled Power Trander - Kontaktloser Leistungstransfer und synchrone Informationsübertragung zwischen Systemen schwacher induktiver Kopplung," Hochschule für Technik und Wirtschaft des Saarlandes, 2007.

[3] A. K. Ramrakhyani, S. Member, and S. Mirabbasi, "Design and Optimization of Resonance-Based Efficient Wireless Power Delivery Systems for Biomedical Implants," IEEE Transactions on Biomedical Circuits and Systems, vol. 5, no. 1, pp. 48–63, 2011.