The Basic of High Efficiency Wireless Power for Medical Devices

In today's medical technology field, having a reliable and stable power source is a critical requirement for safe operation. Wireless power provides a unique advantage in that a device can now be completely sealed, thus allowing a device to be safe, robust and simpler to maintain. And with improvements in wireless power delivery, new developments allow up to 500 watts.

Most users today are familiar with wireless power transmission used in applications as your cordless toothbrush or induction stove tops. With stove tops, power is transmitted from the stove in the form of an alternating electromagnetic current to the bottom of a pot or pan, where it is then transformed into heat in the form of eddy currents. The stove top itself remains cool.

But what would happen if the power transmitted was not transformed into heat, but rather made available as electrical current with as little loss of energy as possible? At the core of RRC's wireless power transmission system is a sophisticated coil construction and activation technique that enables a highly efficient power transfer. In contrast to the traditional transformer, there is no closed core that magnetically couples the coils. In fact, the coils which the power is transmitted between, are actually structurally separate from one another. Special ferrite materials bundle the magnetic field so that the stray field is reduced and at the same time, efficiency is increased. This efficiency meets the requirements for the market and enables the development of medical applications and products.

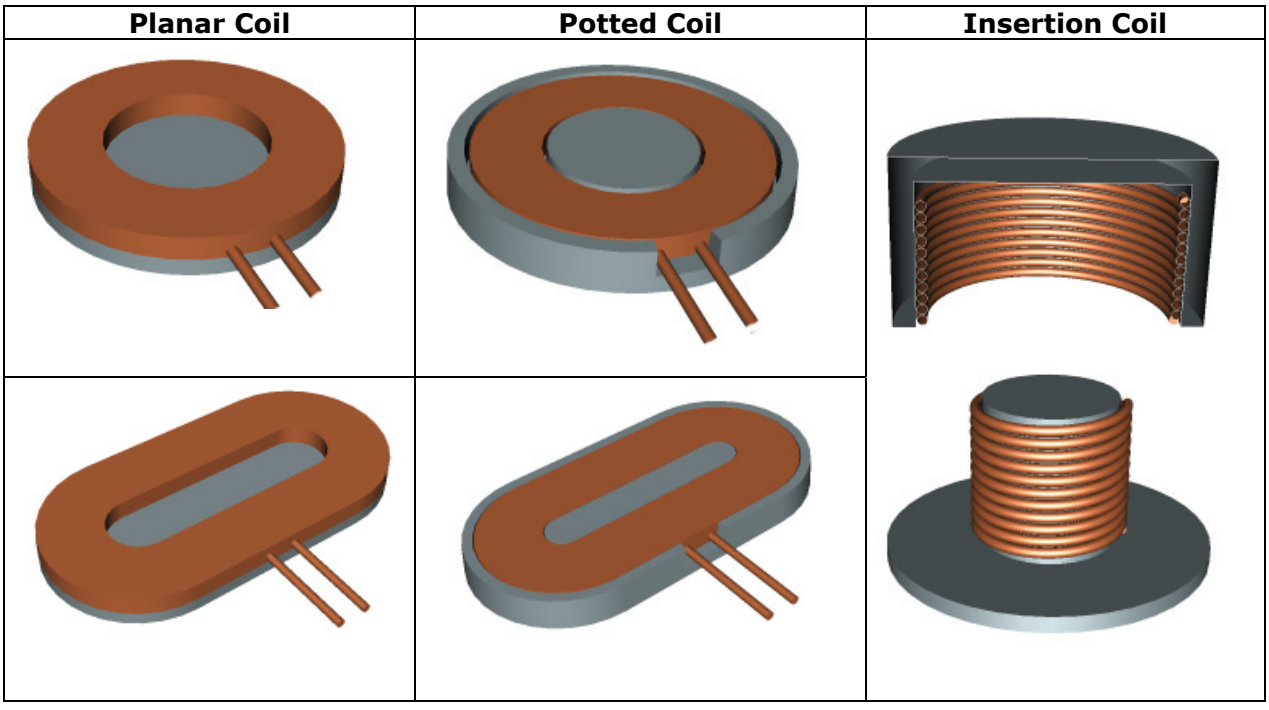

Image 1: Examples of coils used for inductive power transmission

RRC's technology makes it possible to substantially reduce the loss of power between the source (transmitter) and the load (receiver) and thus, noticeably optimize efficiency. We have been able to obtain over 90% efficiency, meaning 90% of the power that is sent by the transmitter coil reaches the receiver coil just as it would in a wired system. And this is possible even when the distance between the coils amounts to several millimeters (4-10 mm).

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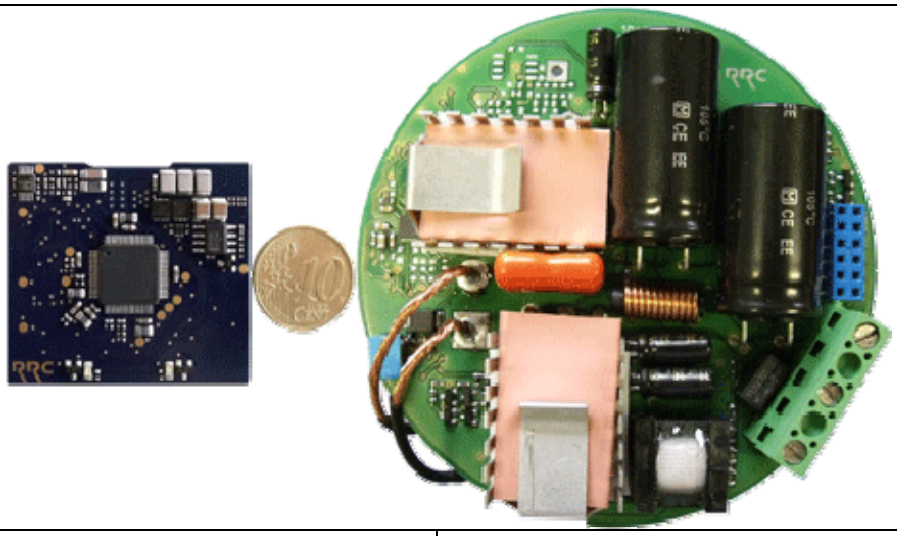
A wireless or inductive power system consists of a Transmitter (Tx) and Receiver (Rx) board & necessary supporting components. The transmitter for wireless power always contains the following components: a coil, compensation circuit, an inverter and a controller. We will refer to the functional block consisting of these electronic devices as the "IPT cell" (**I**nductive **P**ower **T**ransmission). The compensation circuit is used to improve efficiency and reduce the idle power consumption of the inductive transmission path. Today we have various IPT module designs with a power range from 5W up to 500W, which can be implemented by RRC. These modules not only differ in their power range, but also in their operating voltage range as well. All of the modules are powered by an intermediate DC circuit. The input voltage range of the low voltage cells (LV) is a nominal 19V while the high voltage version (HV) is powered by a 400V intermediate circuit.



5W LV-IPT primary side evaluation kit	500W HV-IPT primary side

Image 2: Examples of primary (transmitter) side electronics based on reference designs of low voltage and high voltage IPT modules

The systems receiver (Rx) consists of the following electronic components: coil, IPT controller, modulator and a compensation circuit. The power transmission starts only after the receiver side has been identified. Safety functions such as foreign object detection, overload detection and protection against overheating have been integrated into the system. The receiver's controller can be configured so that a battery connected to the output can be charged, which reduces the requirement of an additional charge controller in the application.

Low power loss and higher efficiency are prerequisite for the success of wireless power technology. Less energy loss means less unwanted heat, which in turn means less effort spent on heat management in the final application. Lower energy consumption through the use of efficient products is synonymous with sustained climate protection. The technology for wireless power transmission developed by RRC enables the fulfillment of the requirements for EnergyStar in the USA and the ECODESIGN directive from the European Commission.

In addition to the proprietary solutions described above, we offer two other platforms in our product portfolio. The first platform is a 5W Qi-compliant wireless power system solution according to the WPC (**W**ireless **P**ower **C**onsortium) standard. This 5W solution has been integrated into an evaluation kit in order to acquaint users with the technology for wireless power transmission. The evaluation kit is composed of a power transmitter with a transmitter coil, a universal power supply with 19VDC output voltage, a power receiver module with a receiver coil and various headers and receptacles (for use in a developmental environment). The receiver module provides a regulated output voltage of 5V at 1A and a maximum of 5W power output. The power transmitter has the safety functions described above, as well as functions for monitoring the input voltage and the

input current. The receiver also has integrated safety functions. Both the transmitter and the receiver are controlled with a microcontroller and they use proprietary firmware**.** This allows for the easy adaptation of specific requirements. The kit is demonstration ready, and can also be integrated in a developmental environment.

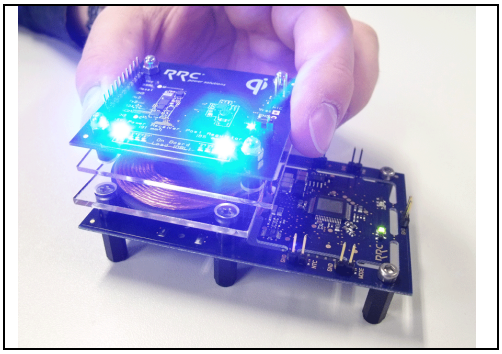


Image 3: Qi compatible evaluation kit in operation

The second platform solution has been designed for a 12W to 20W output, 12V to 20V range with a maximum current of 1 amp. The platform was designed according to the guidelines of the IEC 60601-1 and IEC 60601-1-2 so that it can be used in the medical market. It consists of a transmitter and a receiver with the corresponding pair of coils, each with a diameter of 4 cm. The coil shape may vary, see Image 1. The receiver unit can provide a device with power, as well as charge a battery. A range of operating information and safety functions are integrated into the design and are also transmitted wirelessly.

The proprietary and platform-specific system solutions described above allow the use of wireless power in a range of medical applications such as intensive care, home care or implants. For example:

- Hospital specific equipment, such as patient monitors, infusion pumps, pulse oximeters, etc., provide a significant advantage: Since they are closed systems (no contacts) that can be easily cleaned and sterilized.

- Another application is an AED (**A**utomated **E**xternal **D**efibrillator) which is supplied with wireless power via a wall mount. At the same time, data from the AED is transmitted wirelessly to the wall mount that in turn sends the data to a server center for the purpose of service monitoring.

- Devices implanted for myocardial support can be charged through the patient's skin which spares the patient extensive surgical procedures and eliminates the risk of infection. Data transmission makes it possible to carry out target queries for device information or carry out firmware updates.

In conclusion, the introduction of high efficiency wireless power solutions and the benefits that they provide, will continue to drive more and more medical devices to utilize this technology. The wireless power market is estimate to grow from $0.9 billion in 2011 to $23.7 billion in 2015!

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