Wireless Powering of Ultra-low-power Sensors

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This study evaluates the remote powering of ultra-low-power sensors with wireless power transfer technology. Magnetic resonance wireless powering was assessed with respect to longitudinal and lateral positions of sensors. The developed solution operates in the ISM band (13.56 MHz). The study showed that wireless powering of ultra-low power sensors at relatively long distances is a realistic approach leading to practical use cases.

Radiofrequency wireless power transfer (WPT) has been well known since the 19th century when N. Tesla first studied magnetic resonant coupling (WPT-MRC) to illuminate a tower. This is, however, not a simple topic and Tesla failed in his development. One of the main limitations of WPT-MRC is that the energy transfer efficiency drops as the distance between the source and the sensor increases. The inverse-cube law states that to achieve the same power level at twice the distance one needs to feed eight times as much energy. The other challenge concerns Electromagnetic Safety—exposure shall be limited according to standards and guidelines. WPT could be applied in our daily life in many mobility and household appliances, e.g., for the recharge of mobile phones and headsets.

At CSEM, the feasibility of wirelessly powering ultra-low-power sensors was carried out as a technology study focused on vital signs monitoring in hospitals. A typical setting consists of several sensors placed on a patient admitted in an intensive care unit. Monitoring and recording shall continue when the patient is moved to another service. The current solutions need cumbersome wiring attached from the monitor to the patient. Wireless powering may greatly simplify the whole setup and facilitate the patient mobility between services, as well as the access of the caregivers to the patients. The absence of cables also suppresses the risk of tearing the device away.

A possible use case for ECG monitoring is presented in Figure 1 where CSEM's patented cooperative sensors – attached to a patient by means of a simple uninsulated conductive tape – are wirelessly powered.

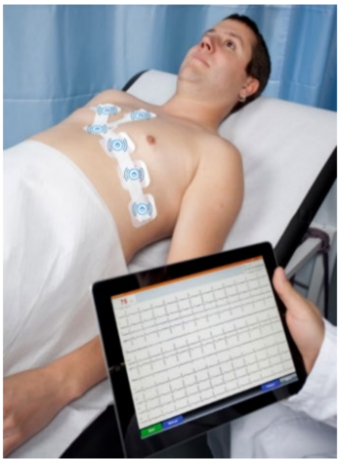

Figure 1: ECG monitoring using CSEM's patented cooperative sensors simply connected with conductive tape (no wire).

WPT-MRC has the potential to power up sensors placed on the body, or even implants, but shall fulfill many constraints to reach an acceptable transfer efficiency at a given position of the wireless sensor. The study considered continuous WPT both directly to the sensors and to a battery.

Figure 2 shows a test setup that was used to verify the accuracy of finites elements simulations which were performed.

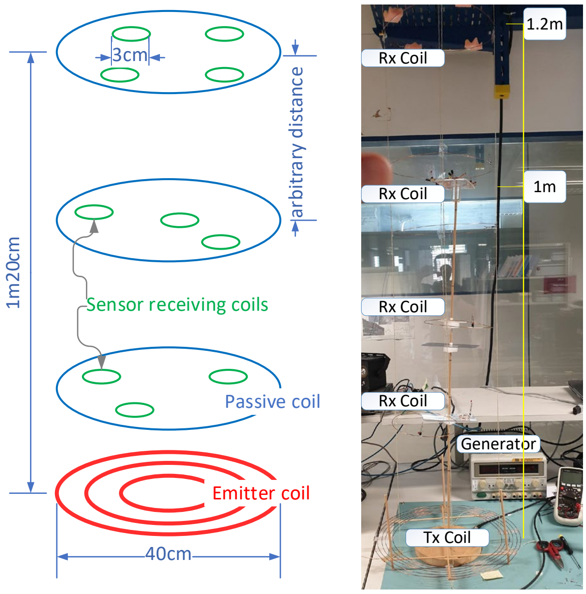

Figure 2: Experimental test setup correlated with simulation.

Several types of WPT solutions have been designed, prototyped, optimized, and tested. Tests and simulations were in good agreement, and simulations (Figure 3) were used to extend the geometry and to evaluate the limits to power directly arbitrarily distributed sensors (coil diameter: 3 cm) with nearly 500 µW or a battery (coil diameter: 20 cm) with 10 mW in a volume of roughly 2x2x2 m³ by using at the source only a few watts (typically 2 to 10 W). The free orientation of the sensors has been assessed and, with some other aspects, such as frequency tuning of the coils and limitations of the electromagnetic field strength close to the generator, will require further design steps.

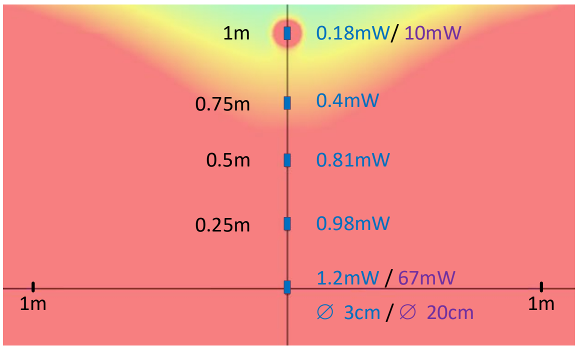

Figure 3: Simulation output example (field intensity (background color) and power versus horizontal and vertical position from a 2 W generator).

The power available in the volume depicted by Figure 3 (cylindrical around the horizontal axis) demonstrates that wireless powering is adapted to such a use case where the needed power is low and the sensor(s) stand(s) in a limited but wide area.

Wirelessly powered cooperative sensors can offer a unique implementation solution for the monitoring of bio-signals by removing the cumbersome arrangement of cabling associated with the usual setup.