A Simple Wireless Power Transfer Scheme for Implanted Devices

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Efforts to transfer power wirelessly began in earnest with the commissioning of Nikola Tesla's Wardenclyffe tower in 1901 which used the disturbed charge of ground and air method for wireless power transfer at large distances. Modern day efforts, however, have largely been concentrated on using resonant magnetic induction coupling for powering consumer electronics and other portable devices. Of particular interest to us in this paper is using wireless power transfer for powering biomedical implanted devices for biosensing, drug delivery or therapeutic applications. Two parameters that are used to characterize any wireless power transfer scheme are its Power Delivered to the Load (PDL) and Power Transfer Efficiency (PTE). Designs have been proposed that maximize PDL and/or PTE for various applications, usually resulting in a tradeoff between the two. Here, we will analyze our design based on both criteria and compare our model against pre-existing schemes as a means of comparison.

Most implanted devices rely on inductive loops or electrical antennas such as a patch, dipole or the Planar Inverted F-Antenna (PIFA) for coupling power to implanted devices. Electrical antennas suffer from having large electric field near the antenna which leads to high Specific Absorption Rate (SAR) values and consequent power limitations for use inside the human body. Multi-coil approaches that improve the frequency bandwidth for biotelemetry applications as well as improve the PTE have been suggested to improve the inductive link between transmitter and receiver. In this paper, we discuss a new approach to coupling power to implanted devices using only two loop antennas. We use a system with two Electrically Coupled Loop Antennas (ECLAs) - a transmitter which is placed outside the human body and a miniaturized receiver placed inside an insulating material under the skin. The ECLA is unique in the fact that it requires no matching circuitry and thus a co-axial cable can be used to couple the transmitter circuitry directly to the antenna. This system is designed for an operational frequency of 403 MHz and the desired frequency and matching are obtained by controlling the dimensions of various elements of the ECLA. One of the drawbacks of using multi-turn inductive loops is the large inductance posed at the feed point. The ECLA is capacitively fed and hence is devoid of such a defect.

Simulations are performed in a full-wave simulator and circuit models are also presented. The setup is analyzed from a coupled filter theory perspective. Measurement results are used to validate our simulation results and for comparison with other techniques. Results for various distances and composition of the biomaterial are also included to study their effect on the power coupled.