LC-tank Inspired Miniature Antenna for Implantable Biomedical Backscattering Sensing Application

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Abstract

We introduce an LC tank based miniature implantable UHF RFID tag antenna with a footprint of only 5 mm × 5 mm × 1 mm. The method of using a resonant LC tank to minimize the antenna footprint is analyzed with the antenna equivalent circuit and the electromagnetic simulation. The performance of the proposed antenna is evaluated by electromagnetic simulations with a maximum read range of 0.7 m with a 15 mm implant depth in tissue environment.

1 Introduction

Radio frequency identification (RFID) is a contactless automatic identification technology, which has already been widely implemented in item tracking and identifying. In recently years, due to its favorable attributes such as the low power consumption and simple RF front-end structure, RFID has attracted much attention in building the wireless data link for wearable and implantable sensors for biomedical applications [1] [2]. As one of the essential parts, the RFID tag antenna not only influences the overall RF link performance but to some extend determines the size of the sensor. Various techniques have been proposed to miniaturize the tag antenna [3-5]. In this paper, a novel LC tank inspired technique is introduced to downsize the antenna total volume to only 19.6 mm^3. To our knowledge, this is the smallest implantable UHF RFID tag antenna in the literature.

2 Antenna Development and Simulation Results

The antenna is composed of two concentric copper rings with a diameter of 5 mm and a trace width of 1 mm. The two rings are placed on the upper and lower sides of a 0.25 mm thick polyethylene (ε_r=2.25, tanδ=0.001 at 915 MHz), respectively. The NXP UCODE G2iL series RFID IC with the impedance of 23-j224 Ω at 915 MHz and the wake-up power of 15.8 µW is attached to the upper ring split. To build the LC tank that is resonating around 866 MHz, a 5.6 pF capacitor is connected to the split gap in the lower ring. We use 1 mm silicone coating (ε_r=2.2, tanδ=0.007 at 915 MHz) to protect the whole antenna from contacting the tissue environment.

We built the electromagnetic model for the proposed antenna in the ANSYS High Frequency Structure Simulator (HFSS). With the help of the optimization tools from the HFSS, the optimized antenna achieves a maximum power transfer efficiency of 78 %. The estimated maximum read range of the antenna in a 7-layer tissue environment reaches 0.75 m at 866 MHz. The corresponding simulated radiation efficiency is 5.3 % and the antenna radiation pattern has a doughnut-shaped with a maximum directivity of 1.85 dBi in the antenna plane.

3 Conclusion

We introduced an LC tank inspired miniature implantable RFID tag antenna. The mechanism of the proposed antenna is analyzed with an equivalent circuit. The antenna performance is verified by the electromagnetic simulator and a maximum read range of 0.75 m is achieved with an implant depth of 15 mm in the layered tissue model. In the future work, we will fabricate the prototype and conduct the wireless measurement.

References

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