Towards a Miniature Long Term Continuous Glucose Monitoring Device: *In vitro* and *In vivo* Studies

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Abstract

As of 2005, according to Center for Disease Control and Prevention (CDC), estimated 20.8 million people (7% of the population) have diabetes in the United States alone. In 2002, 224,092 people died due to complications related to diabetes (*www.cdc.gov*). Though finding a cure for diabetes is the ultimate solution, there is an urgent need to research technologies to help patients better manage their diabetes in order to reduce or totally eliminate these diabetes related deaths. In this study, we introduce an alternative implantable long term continuous glucose monitoring technology. This alternative technology is based on integrating a dual band miniature implantable antenna operating at Medical Implant Communication Service (MICS: 402-405 MHz) and Industrial, Scientific, and Medical (ISM: 2.4-2.48 GHz) bands, and an implantable glucose monitoring sensor. The antenna is optimized for dual band operation by combining an in-house Finite Element-Boundary Integral electromagnetic simulation code and Particle Swarm Optimization (PSO) algorithm.

Introduction

A need has been presented for reliable continuous glucose monitoring technology to aid diabetics by improving their quality of life. Many advances in medical telemetry allow patients' physiological parameters to be monitored using radio-frequency communications between an implantable device containing a transmitter and a monitoring base station. The biosensors that are used to monitor glucose levels rely on the interstitial fluid within the dermis to measure the interstitial glucose levels. This data has to be processed and stored, so it can later be transmitted to the base station. The implanted biosensor needs an integrated antenna in order to send the received data to an external receiver [1].

The design of implantable antennas is challenging because of the size requirements, impedance matching, low-power requirements, and biocompatibility with the body's physiology [2]-[4]. Power conservation maximizes the implant life, so consideration of high losses due to the biological tissue adds to the complexity of designing this hybrid implantable system. The implantable antennas propose in this study operate in MICS and ISM bands. The MICS band is allocated for data transmission, and the ISM band, is used to wake up the implanted device [5]. A dual band antenna is designed using particle swarm optimization algorithm in combination with an in house finite element boundary integral (FE-BI) solver. Finally, *in vitro* measurements are performed using an E8362B PNA network analyzer and results are compared with the simulations.

For antenna-sensor integration we use Texas Instruments MSP430F1612 Mixed Signal Microcontroller and Zarlink's low power implantable transceiver. This processor has ultra low power consumption, embedded flash memory, and analog functionality. The biosensor has already been designed and implemented, so the circuitry to provide the signal to the microcontroller is needed for this implantable device. The final system is compact enough to be surgically implanted in the human abdomen.

References

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