Low-Power Long-Term Implantable Wireless Telemetry for Monitoring of Physiological Signals

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Abstract

In this study, we present a long term Implantable Medical Device (IMD) for continuous monitoring of physiological signals such as electrolytes, proteins, glucose, and temperature. The device consists of a small size dual band implantable antenna operating in Medical Implant Communications Service (MICS) (402 MHz – 405 MHz) and Industrial, Scientific, and Medical (ISM) (2.4 GHz – 2.48 GHz) bands with an interface circuit containing a transceiver, a microcontroller, and matching network components. In order to evaluate the transmission capability of the fabricated device, in vitro measurements are conducted using a tissue mimicking material and compared with *in vivo* measurements carried out in live porcine subjects. In vivo studies were performed over the course of two weeks to verify the proper functioning of the device. Results regarding the distance of the communication link between the device and base station and return loss of the implanted antenna are presented and discussed in detail.

1. Introduction

IN recent years, we have witnessed an exponential growth in research focused on developing electronic systems for medical applications. One of the emerging electrical engineering applications in medicine is wireless monitoring of physiological parameters (glucose, blood pressure, temperature, cardiac activity, oxygenation, etc.) over a distance via radio frequency (RF) technology [1]-[5]. Continuous health monitoring is vital to diagnose and treat patients without physical contact and rigorous schedules. An implantable monitoring system consists of a biosensor and interface circuit integrated with an antenna. The interface circuit processes data read by the biosensor and transmits pertinent results through the antenna to either an external wearable device or a nearby personal computer. The main challenges regarding the design of an implantable medical device include low-power requirements, miniaturization, biocompatibility with the tissue, life time of the implant, and good radiation performance. The components of the interface circuit (transceiver, microprocessor, power supply, operational amplifiers, etc.) should be selected to minimize the power consumption and maximize the integrity of the data. Since the implant needs to be small, designing miniaturized antennas is vital in order to reduce the overall size of the implant. High losses in biological tissues also add significant complexity to the problem of designing a very small size antenna with a high radiation efficiency. Moreover, encasing the implant with a biocompatible material is necessary to prevent the implant from harming the surrounding tissue and to reducing the effects of the capsular contracture. Capsular contracture is the capsule-shaped scar tissue that forms as an immune response around foreign materials such as implants. Sensor packaging should also be biocompatible otherwise it may cause degradation, calibration loss, or failure in sensor performance.

978-1-4244-6051-9/11/$26.00 ©2011 IEEE

In this study, our objective is to develop an implantable medical device which integrates a dual band implantable antenna with a low power interface circuit and evaluate the capability of wireless data link between the device and external environment through *in vitro* and *in vivo* studies. To do so, we first present the design of the implantable antenna and the interface circuit. The implantable antenna is then tested using a biological phantom mimicking human skin tissue and *in vitro* experiments are conducted in free space. *In vivo* measurements are carried out using porcine subjects at the MSU's College of Veterinary Medicine facilities to ensure successful data transmission and to investigate the possible reactions of the live tissue to the implant (see Fig.1.).

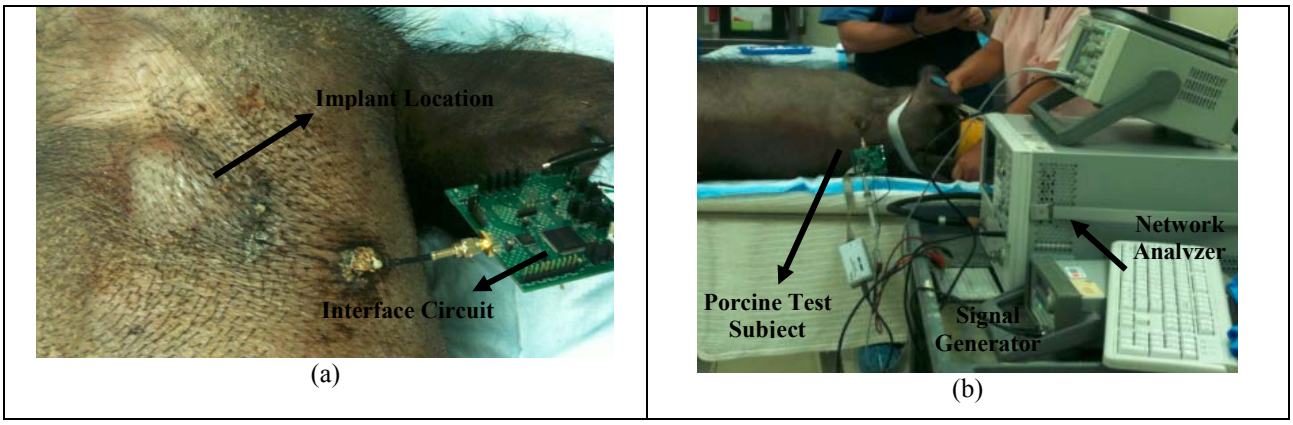

Fig. 1. A) The implant location and b) measurement setup for in vivo studies.

2. References

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