Chapter 85
Wireless Implant Communications Using the Human Body

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ABSTRACT

This chapter first examines a new analytical electromagnetic model that uses galvanically coupled intra-body communication (IBC). Frequencies ranging from hundreds of kHz up to a few MHz are considered under quasi-static assumptions. The model is unified in the sense that it can be applied to any part of the body (i.e., head, torso, limbs, etc.). It also describes influences of tissue property and geometry of the body part. The security and low power consumption of IBC are also apparent in this model. The path loss characterization of IBC implants shows lower values compared to their MICS counterparts. In addition, the chapter also elaborates on the use of human body as antenna. A scenario where an RF current is fed by a tiny toriodal inductor clamped around tissues in the ankle is studied. The frequency range of 1-70 MHz is considered. Theoretical results show that the system has a maximum gain of - 25 dB between 20 to 40 MHz, assuming an isotropic radiation from human body. For improved performance, mitigation techniques for losses are also discussed.

INTRODUCTION

Advancements in medical diagnostics and bio-sensing technology opened up a great venue for research in electronic medical implant. To improve accuracy and timeliness of diagnosis, electronic devices could be implanted inside human body to provide various real-time diagnostics information. However, effec-

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tive technique for implant communication is still an open problem. Early efforts based on radio wave propagation are standardised as the Medical Implant Communication Services (MICS) for 402– 405 MHz frequency range which was later adopted as Medical Devices Radio Communications Services (MedRadio) for 401–406 MHz frequency range (Hanna, 2009).

Currently, the radio-frequency (RF) implant wireless communication is enabled by utilizing small antennas that radiate radio waves inside the human body. As a bid to find alternative wireless implant communication mechanisms within the Wireless Body Area Network (WBAN), in this work, the authors explored two complementary techniques. The first uses galvanically coupled Intra-body communication (IBC) for implant-to-surface communication. IBC is a relatively new technique that uses the human body as a channel with communication frequencies not exceeding several MHz. The second technique uses the human body itself as an antenna by feeding an RF current into the tissues.

This chapter first examines a new analytical electromagnetic model that uses galvanically coupled IBC where the implant transmitter differentially injects current into the tissue via its anode and cathode electrodes. A wearable receiver on the surface of the skin samples the resulting potential difference using its two electrodes. Frequencies ranging from hundreds of kHz up to a few MHz are considered under quasi-static assumptions. The model is unified in the sense that it is based on multilayered ellipsoidal geometry that can be applied to any part of the body (i.e., head, torso, limbs etc.). It also effectively describes influences of tissue properties and geometry of the body part. The security and low power consumption of IBC are also apparent in this model. The path loss characterisation of IBC implants shows lower values compared to their MICS counterparts.

In addition, the chapter also elaborates on the scenario when the RF current is fed by a tiny toriodal inductor that is implanted and clamped around the tissues in the ankle. The frequency range of 1-70 MHz is considered, which includes the resonance frequency of the human body. Theoretical results show that the system exhibit broadband characteristics with a maximum gain of - 25 dB between 20 to 40 MHz, assuming an isotropic radiation from human body. However, for the case of the small toroidal inductors considered, the radiation resistance of the system is very small, which increases the power consumption.

BACKGROUND: IMPLANT COMMUNICATION IN THE WBAN ARCHITECTURE

To improve accuracy and timeliness of diagnosis, and hence improve quality of life, sophisticated actuators and biosensors are emerging for various diagnostic applications; for example, glucose sensors for continuous diabetes monitoring (Heo et al., 2013). In broad terms, implant communication technique explored in literature use radio wave propagation, magnetic induction and volume conduction(Poon, 2010), (Bjorninen et al., 2012), (Yang, 2006).

For implant communication it is important that the transmitter consumes small power to conserve battery life. The implant should also be miniaturized for a minimal invasive embedding. Besides, due to sensitive nature of medical data, security is a paramount requirement of implant communication. To achieve security either the signal needs to be encrypted at the transmitter or be confined to within the body detectable by as far as an on-body receiver. In the case of MedRadio based implant, the signal is radiated outside the human body; hence, requires all security features be implemented right at the transmitter which increases the transmitter complexity. Hence, the transmitter consumes large power and is difficult to miniaturise.

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