An Overview of Intra-Body Communication Transceivers for Biomedical Applications

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INTRODUCTION

Currently, the primary focus of technological development is on various healthcare measurement instruments and monitoring devices which seek to improve the quality of healthcare monitoring. Biomedical sensors are miniature and lightweight devices that are used to monitor human vital signs e.g. heart rate, body motion, blood pulse pressure, blood glucose levels (Patel, Park, Bonato, Chan, & Rodgers, 2012), process physiological data, and transmit the information to monitors. Wireless Sensor Networks (WSNs) technology in healthcare is a recent paradigm which incorporates wireless data communication and miniaturized sensors that measure these quantities, allowing portable health monitoring (Lai, Begg, & Palaniswami, 2011). Generally, wireless radio propagation is used to transmit data among the multiple sensors to a decision marker (hub node) or hub node to an actuator which is attached to the human body. The critical issue with radio frequency (RF) propagation is that it consumes battery life quickly and decreases the usefulness of portable monitoring devices (Seyedi, Kibret, Lai, Faulkner, 2013). For example, the IEEE 802.15.4 Zigbee wireless standard has a number of profiles that provide a wireless solution targeted at monitoring and control applications such as Zigbee Health Care and Smart Energy (IEEE 2011; Wikipedia 2013a and b). It indicates a transmission power output of 1.0 mW and bit rate of 250 kbps. However, its power consumption at this rate limits a normal lithium ion battery to a matter of hours.

The main objective of this article is to present a review on a new wireless communication technique that, recently, has gained attention for its reliability and energy efficiency. Intra-Body Communication (IBC) or Body Channel Communication (BCC) is a novel non-RF wireless data communication technique using the human body itself as the communication channel or transmission medium with transmission power below 1 mW and data rates of more than 100 kbps (Wegmueller, Oberle, Felber, Kuster, & Fichtner, 2010). In this communication method human body acts as conductor to transmit all or a major portion of information data between sensors attached on or implanted in the body and hub node (Figure 1).

BACKGROUND

IBC can be classified into two basic procedures based on how data is transmitted through the body: (a) the capacitive coupling (electric field) method and (b) the galvanic coupling (waveguide) method. In the capacitive coupling method, the induced electrical signal is capacitively coupled through the air or the ground. This method is also known as the near field

effect. The galvanic coupling method achieves signal transfer by injecting alternating current into

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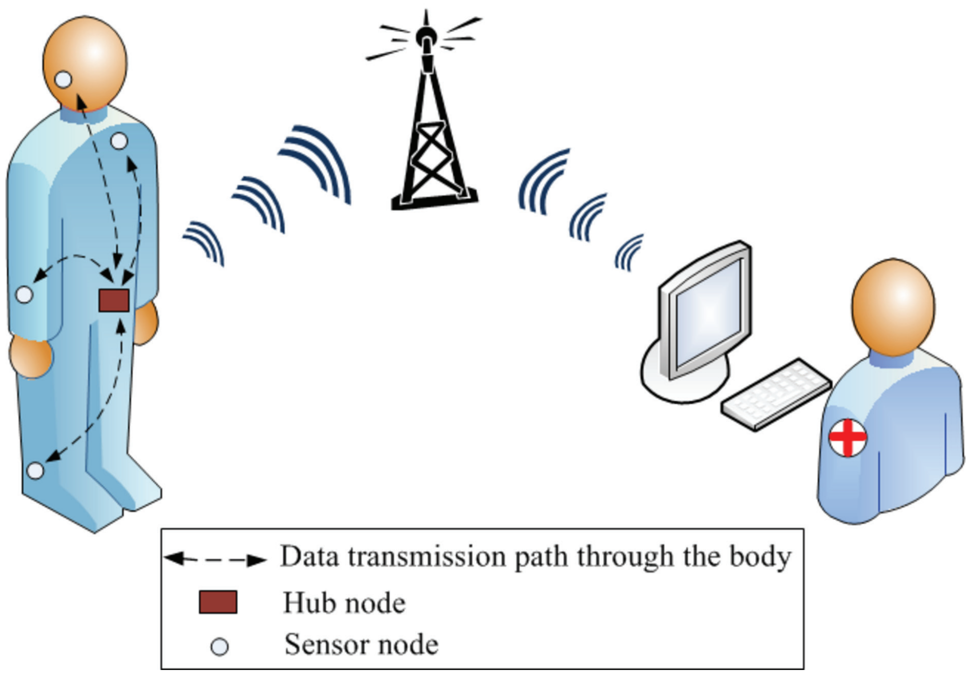
Figure 1. A healthcare monitoring system applying wireless communication techniques



the human body. In this method, the human body becomes a transmission line or waveguide. Figure 2 illustrates schematically the concept of the two IBC methods. In the capacitive coupling method, only one of the electrodes (signal electrode) of the transmitter and the receiver is attached to the body while the other electrode (ground electrode) is floating and creates a signal return path through air. In contrast, in galvanic coupling IBC, both transmitter and receiver electrodes are attached to the body; and an electrical signal is applied differentially between the two electrodes of the transmitter. Governed by the conductive properties of human body tissues, major portion of the electric current in this method flows between the two transmitter electrodes while a small portion flows toward the two receiver electrodes. This small current results in a potential difference that is detected differentially by the receiver electrodes.

In the both coupling methods, the induced AC current to the human body must be below 1 mA. Therefore, the induced current is 20 times below the maximum allowed contact current based on the exposure guidelines of the international commission on non-ionizing radiation protection (ICNIRP, 1998).

The capacitive and galvanic coupling methods have been employed in several IBC attempts. The human body channel modelling based upon dielectric properties of biological tissues have to be noted to examine transmission characteristics of the human body, which is significantly important in IBC transceiver design (Bae, Song, Lee, Cho, & Yoo, 2012).

IBC Channel Modeling

The dielectric properties of biological tissues and cell suspensions determine the response of the human body to applied electrical stimulus through the body. For this reason, they are very important in the analysis of IBC. The design of IBC system includes developing accurate mathematical model of the electrical nature of human body in the context of its application as electrical signal communication channel. The electrical nature of tissue is determined based on its specific conductivity and relative permittivity. Because there is a variety of cell types and cell distributions inside a tissue, the microscopic description of the response is highly complicated. Accordingly, a macroscopic approach

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