Chapter 6
On-body UWB Communications for Health Monitoring

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ABSTRACT

Body area communication technique is an essential technical support for medical and healthcare services. This chapter presents on-body communication aspects using ultra-wide band (UWB) technique for neonates and infants monitoring service. With numerical analysis tool, the transmission characteristic around the infant body is first investigated in terms of on-body UWB path loss model, in which shadow fading around the body is modeled. Then the communication performance for impulse radio (IR) scheme system is evaluated based on the derived infant on-body UWB path loss model. The methodology for evaluating the average bit error rate (BER) in a shadow fading channel is proposed. The communication link budget for infants is thus presented based on the average bit error rate conclusions in infant on-body UWB fading channel.

INTRODUCTION

The information and communication techniques have played more and more important roles in supporting medical and healthcare services. The ever-advancing miniaturization of electronic devices, combined with recent developments in wearable computer technology, is leading to the creation of a wide range of personal information and communication appliances which can be attached to the bodies or clothes of users. This may provide new possibility of high-quality service in hospital by linking various biotal sensors to establish a body area network (BAN) of personal health information. In general manner, a BAN device is a BAN transceiver paring with a life sign sensor or a set of life sign sensors. These sensors can collect various vital and healthcare

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data for medical or healthcare purposes. Examples of collectable sensor data include blood pressure, electroencephalogram (EEG), electrocardiogram (ECG), carotid pulse, glucose rate, body temperature, etc. A typical application scenario of using these sensor data is real time monitoring of the health status of neonates or ill infants in a hospital. By attaching BAN devices to neonates or infants, vital or healthcare data can be automatically collected, which is then forwarded to a nurse centre for health state monitoring. The benefit of this scenario is that it can result in increased survival rate of neonates as well as increased efficiency on neonates or infants management.

Body area communication is of high importance for health monitoring applications. On-body communications differentiate from the traditional radio channel communications due to the body proximity effects. The wave propagation characteristics in human body area are very complicated. There are scattering and absorption phenomena in the human body due to frequency-dependent dielectric properties of body tissues, as well as diffractions and creeping waves along the body surface. Moreover, since the human body might take various postures, or one or more body parts might move during the communication period, this results in a complicated multi-path signal transmission. The ultra wideband (UWB) transmission is a promising candidate for use in such situations due to its efficiency with respect to multi-path fading, low power consumption, high transmission speed, and simple structure (Schmidt et al., 2002; Gyselinckx et al., 2005).

The main objective of this chapter is to present on-body UWB communication aspects for neonates and infants monitoring service. Two major aspects are addressed: (1) channel modeling, (2) communication performance. The first main issue of this chapter is to derive an infant on-body UWB path loss model based on frequency-dependent finite difference time domain (FDTD) numerical approach with a six-month old infant model. It introduces the methodologies used for static channel investigations based on simulation setup. The derived path loss model is a log-normal distance model which accounts for the shadow fading due to UWB radio diffraction propagation around the body. The second main issue is to evaluate the communication performance for impulse radio UWB (IR-UWB) communications in the on-body channel based on the derived path loss model. In order to derive communication probability of error, a method for evaluating the average bit error rate (BER) in a shadow fading channel will be given in detail. It will be shown that the fading around the infant body is the dominant reason for communication performance degradation. In the end, the on-boy communication link budget in the fading channel will be discussed and addressed.

BACKGROUND

As an emerging technology, BAN has caught significant attention in recent years (Astrin et al., 2009; Kohno, et al., 2008). A working group for medical body area network IEEE 802.15.6 was established under IEEE 802.15 in November 2007 and the standardization is now under the way (Li, 2009). The objective of 15.6 is to define new physical and media access control layers for wireless BAN (WBAN). Main focus of IEEE802.15.6 is laid on medical healthcare applications. (Kohno et al., 2008) introduces a progress of research and development of BAN standardization in IEEE 802.15.6 in a field of medical information communication technology. The progress of the IEEE 802.15.6 standardization covers a number of issues like frequency regulations, human safety, specific absorption rate (SAR), low power radio requirement, high quality of service and low latency as well as PHY layer discussion for wearable BAN and implant BAN. Moreover, a simple prototype of wearable BAN has been given to address the issues of modulation scheme and possible data rate.

The successful realization of a wireless BAN requires new wireless interface solution to meet

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