Antennas and Wave Propagation in Body Area Networks

Jasmin Grosinger* and Arpad L. Scholtz
Vienna University of Technology
Institute of Communications and Radio-Frequency Engineering
Gusshausstrasse 25/389, 1040 Wien, Austria
E-mail: jasmin.grosinger@tuwien.ac.at

Abstract

Wireless body area networks (BANs) connect independent nodes for example sensors situated in clothes, on the body, or under the skin of a person through a wireless communication channel. They are offering many new promising applications in the field of remote health monitoring, home/health care, medicine, and sports. A medical application in home/health care is for example mobile cardiotocography. A device on the woman's abdomen monitors the fetal heart rate and uterine contractions during pregnancy and transmits the monitored sensor data via a low energy Bluetooth connection to a mobile phone. This acts as a gateway to a medical expert for interpretation of the sensor data and to a server for recording of the data.

The mobile nature of the human body requires that wireless BANs operate in a range of diverse environments. Additionally, the human body is an uninviting and often hostile environment for a wireless signal. Thus, antennas and wave propagation are key study areas in wireless BANs [1].

Antennas in wireless BAN are strongly influenced by the close proximity of the human body. This is due to the adverse electromagnetic properties of the human tissues which vary significantly with tissue type and frequency [2]. The induced proximity effects depend on the antenna placement on the body and change the antenna's parameters. These effects include a shift in resonance frequency and input impedance known as antenna detuning, a distortion of the radiation pattern, and a reduction of the radiation efficiency of the antenna [3]. Thus, the primary requirement for antennas in BANs is an insensitivity of the antennas to the proximity of the body, meaning a low mutual influence between the antennas and the human body.

Wave propagation in wireless BANs using microwave frequencies for communication strongly depends on the body movement, the surrounding environment, and the antenna. During normal activities – even when standing or sitting – the body is subject to movements which influences the radio link geometry and thus the path gain [4]. The influences during the playing of sports may be extreme. A multipath environment originating from multiple paths around the human body and scatterers in the closest environment eventually improve the on-body links for some antennas [5]. The position of the antennas determines the propagation mode. For example, for a waist-to-chest link, the propagation is predominantly due to a surface or creeping wave [6]. Similarly, a waist-to-wrist path will in some cases be a free-space path,

This work was performed as part of the project "MAS – Nanoelectronics for Mobile Ambient Assisted Living-Systems" which is funded by "ENIAC Joint Undertaking" and Austria's "Österreichische Forschungsförderungsgesellschaft" (FFG).

when the hand is in front of the body, and a shadowed free-space path with diffration around the body, when the arm is behind the body. In the case of a creeping wave around the surface, an antenna with a radiation pattern maximum along the body's surface and with vertical polarization is needed [7]. For a free-space link, an antenna with maximum radiation away from the body is needed. From this follows that the investigation of the propagation link is necessary for BANs to assist the antenna design and assure a reliable transmission.

References

[1] P. Hall, Y. Hao, and K. Ito, "Guest Editorial for the Special Issue on Antennas and Propagation on Body-Centric Wireless Communications," *IEEE Trans. Antennas Propag.*, vol. 57, no. 4, 2009.

[2] S. Gabriel, R. Lau, and C. Gabriel, "The Dielectric Properties of Biological Tissue: III. Parametric Models for the Dielectric Spectrum of Tissues," *Phys. Med. Biol.*, vol. 41, 1996.

[3] G. Conway and W. Scalon, "Antennas for Over-Body-Surface Communication at 2.45 GHz," *IEEE Trans. Antennas Propag.*, vol. 57, no. 4, 2009.

[4] P. Hall, Y. Hao, Y. Nechayev, A. Alomainy, C. Constantinou, C. Parini, M. Kamarudin, T. Salim, D. Hee, R. Dubrovka, A. Owadally, W. Song, A. Serra, P. Nepa, M. Gallo, and M. Bozzetti, "Antennas and Propagation for On-Body Communication Systems," *IEEE Antennas Propag. Mag.*, vol. 49, no. 3, 2007.

[5] G. Conway, W. Scalon, and S. Cotton, "The Performance of On-Body Wearable Antennas in a Reapeatable Multipath Environment," in *Proc. IEEE Antennas and Propagation Society International Symposium (AP-S)*, 2008.

[6] A. Lea, P. Hui, J. Ollikainen, and R. Vaughan, "Propagation Between On-Body Antennas," *IEEE Trans. Antennas Propag.*, vol. 57, no. 11, 2009.

[7] M. U. Rehman, Y. Gao, Z. Wang, J. Zhang, Y. Alfadhl, X. Chen, C. Parini, Z. Ying, and T. Bolin, "Investigation of On-Body Bluetooth Transmission," *IET Microw. Antennas Propag.*, vol. 4, no. 7, 2010.