Analysis of Magnetically-coupled Human Body Communications

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Abstract

Human body communications (HBC) uses the human body as a transmission medium to connect sensors and actuators in, on or in close proximity to the human body. The HBC approach offers tremendous potential for the design and implementation of emerging personalized healthcare systems, as well as security, and multimedia communications applications [1]. Currently two HBC mechanisms have been extensively explored and are included in HBC standardization initiatives: galvanic and capacitive coupled HBC which rely upon quasi-static electric field mechanisms to enable information transmission using low-power, low-frequency voltages and currents in the human body [2]. However the performance of galvanic and capacitive coupled HBC systems depends upon the surrounding environment. The quasi-static electric field mechanisms, can arbitrarily change the transfer function of the communications channel in many scenarios such as when in close proximity to metallic objects [3].

Magnetically-coupled HBC (MHBC) was proposed in response to challenges of this changing transfer function when using the galvanic and capacitive HBC mechanisms [3, 4]. In MHBC the communication quality is less affected by the proximity to the surrounding environment, particularly at low frequencies, and when the environment does not contain materials with high magnetic permeability. The performance of the magnetic coupling mechanism relies upon effective coupling, in which the human body acts as one part of the magnetic loop. Therefore effective system analysis and design would rely heavily upon the investigation and characterization of transmission parameters for scenarios which leverage MHBC. However there is still much work to be done to characterize the influence of magnetic coupling parameters including electrode configurations, human tissues and the surrounding environment.

In this work, MHBC is explored using 3D finite element analysis through COMSOL, the AC/DC module in particular. Through the investigation of a communication scenario using the human arm, a framework is presented for assessing the performance for MHBC using simulations. COMSOL analysis allowed for investigation of various transmission parameters including frequency, electrode separation, and electrode design. Furthermore, COMSOL simulation results demonstrate the MHBC technique and highlight the importance of finite element analysis as a powerful tool for investigating the performance of MHBC systems. This paper provides valuable insights into the emerging design space and research opportunities for this developing HBC technique as well as the importance of finite element analysis tools such as COMSOL for

system analysis and development.

Reference

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Figures used in the abstract

Figure 1

Figure 2

Figure 3

Figure 4