Measurement and Simulation of the Human Body Channel Electromagnetic Coupling Characteristics

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The human body communication (HBC), which utilizes the human body itself as a medium for signal transmission, is one of the wireless body area network (WBAN) communication technologies specified in IEEE 802.15.6 standard. Compared to the commonly used WiFi or Bluetooth protocols, the HBC can provide excellent energy efficiency and privacy as power is not radiated away from the body. These desirable attributes enable HBC as an excellent candidate for reliable and robust telehealth systems that require the use of low energy continuous monitoring technology and protection of patient privacy.

In order to fully realize the potential of the HBC technology, the electromagnetic (EM) signal coupling characteristic on the human body due to transmitting and receiving electrodes must be accurately modeled and understood. Previous papers have investigated two coupling schemes for HBC signal coupling: galvanic, which injects current into the body tissue, and capacitive, which couples signal to the surface of the body (Callejon *et. al., IEEE Transactions and Measurement, Vol. 62, No. 9,* 2015). Most works have empirically measured signal transmission of the HBC on various parts of the upper body (Lucev *et al., IEEE Transactions and Measurement, Vol. 61, No. 12,* 2012). However, few papers have attempted to take measurements on the lower body. Furthermore, most of the measurements remain to be verified by full-wave simulations using realistic human phantom model.

This study investigates the HBC signal transmission characteristics on both upper and lower parts of the human body using in-situ measurements and full-wave simulations. For measurements, the transmitting and receiving pairs of electrodes are placed on various parts of the body (e.g. head, arm, and leg) in two different coupling configurations. A vector network analyzer connected to the electrode pairs through decoupling baluns is used to measure the transmission data from 1 to 100 MHz for three test subjects. For simulations, the measurement setups are generated using CST Microwave Studio with a realistic, full body voxel model. The results of the study show simulations agree well with the measurements for both coupling schemes. The study also finds that for all body regions, the capacitively coupled signal transmission has the highest gain at all frequencies, while the galvanic coupling shows different gain between the head and limb regions.