Validation of an Arm-Swinging Human Phantom Model for the Study of Wireless Body Area Networks

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Wireless body area network (WBAN) technology has many valuable, real-world applications, such as in the field of remote, long-term health monitoring. Designing practical WBAN systems, with long battery life and consistent performance, requires an understanding of the electromagnetic (EM) wave propagation mechanisms on and around the human body during human motions, which allows for optimal on-body antenna design. Previous studies have used phantom models to study how the human body can affect antenna signal transmission (Yamamoto, *et al.*, *IEEE Trans. on Ant. and Prop.*, 61, 4315-4325, 2013). This study uses a modular arm-swinging phantom model to gain additional insight by performing more in-depth analysis on how human body parameters, such as arm speed, body size, and tissue properties, affect EM wave propagation, as well as using the phantom model as a platform to validate and improve computer models of on-body EM wave propagation.

For this experimental study, on-body antenna transmission data is collected for both the phantom model and human volunteers performing arm swinging motions. The upper-body human phantom model consists of the trunk and two arm segments. It is constructed of plexiglass and filled with liquid having similar dielectric properties as human muscle tissue. The phantom model arm's pivot at the shoulder in the sagittal plane under motorized computer control, producing consistent, repeatable arm-swinging motions. Motion capture techniques are used to measure the arm swing motions so that similar velocity profiles, periodicity, and amplitudes can be produced in the phantom model and for comparing the phantom model and human volunteers. Both the phantom model and human volunteers wear transmitting and receiving antennas placed at various points on each of the bodies. The EM transmission data is recorded using a vector network analyzer at 433MHz, 915MHz, and 2.45GHz.

The overall pattern of EM transmission data from the phantom model shows generally good agreement with that of the human volunteers. Variations of signal reception amplitude correspond similarly with position and motion of the arms. The phantom model, being simple, consistent, and highly controllable, will facilitate development and refinement of computer simulation techniques in CST Microwave Studio software in order to further increase understanding of on-body EM wave propagation for optimal antenna design in WBAN applications.