

Electromagnetic Sub-MHz Modeling of Multilayer Human Limb for the
Galvanic Coupling type Intra-Body Communication

by

Pun Sio Hang

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Faculty of Science and Technology
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Abstract

The research and development in the field of Body Area Networks (BAN) have recently drawn increasing attention in both academic and industrial arenas. The driving force originates from the benefit of being able to share information between devices and sensors adhered to the human body. However, due to the high requirements of BAN in terms of weight, size, energy efficiency, and electromagnetic interference, the conventional wireless technologies are not optimal for the implementation of BAN. Recently, the emergence of the Intra-Body Communication (IBC), which employs the human body as a communication channel, could be an innovative networking method for the realization of BAN.

In order to conduct a systematic analysis to manifest the underlying principle of IBC, a prospective based on the electromagnetic theory and the volume conductor theory was introduced to the analysis of the IBC. In this approach, the human body was represented by means of the dielectric properties; and, the IBC problem was viewed as a combination of the electrical stimulation system and the biopotential recording system. By the simplification of the human limb with concentric tissue layer cylinder and quasi-static approximation, a multilayer analytical model of the Galvanic Coupling type IBC was obtained.

To validate the accuracy of the developed model of the IBC, both *in vitro* and *in vivo* experiments were conducted. From the *in vitro* experiments, comparisons between measurements and calculations showed that the model agreed with the IBC signal distribution inside phantoms (maximum error less than 10%). Additionally, the model also showed its prediction capability of IBC signal distribution

within the human limb in the *in vivo* experiments.

Through the theoretical and experimental investigation of the Galvanic Coupling type IBC, the formulations of the IBC signal distribution on the human limb have been obtained. The formulations not only show the feasibility of IBC, but also indicate that the Galvanic Coupling type IBC is able to provide connectivity with the implanted devices. Additionally, the analysis also shows that signal of the Galvanic Coupling type IBC is confined within the human body whenever the carrier frequency is less than 1MHz.



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