Numerical Estimation of Indoor Propagation Characteristics Considering Human-Body Blockage for a Beam-type Wireless Power Transfer

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Abstract

This study focuses on the effects of human body shadowing/blockage on beam-type wireless power transfer systems (beam-type WPT) propagation characteristics in an indoor environment. Since literature concerning the evaluation of shadowing/blockage due to the human body for beam-type WPT was limited, we modeled a typical indoor propagation environment including some humans and evaluate propagation characteristics using a large scale 3-dimensional numerical analysis based on the FDTD method. We calculate electromagnetic field distributions inside an office environment created by a 915 MHz beamtype WPT transmitter and obtain propagation characteristics considering human body blockage. Some numerical humans that can be applied posture change are used in the simulations. Based on our numerical simulations and statistical analyses, we discuss the effect of human body blockage on the receivable area for a beamtype WPT terminal. We intend to conduct estimations that consider a different indoor scenario, more humans, and new RF-WPT transmitters, including multiple antennas.

1 Introduction

Wireless Power Transfer (WPT) that performs charging and power supply using wireless technology will be used in various fields. Recently, the development of the beamtype WPT system that enables more long-distance power transmission is performed. The beam-type WPT is used as a short-range wireless sensor, more long-distance remote electric power transmission, or disaster countermeasure transmission. For example, the Broadband Wireless Forum (BWF) prepared domestic institutionalization of beam-type for practical use around 2020. Even internationally, aggressive efforts toward commercialization were implemented. The International Telecommunication Union's Wireless Communications Department (ITU-R) issued the report of ITU-R SM.2392.

This study evaluates the effects of human body blockage on beam-type WPT propagation characteristics in an indoor environment.

The characteristic evaluation method considering the human body becomes important in the indoor environment since radio wave absorption and blockage by the human body cannot be ignored. Moreover, in an indoor environment, reflected waves from surrounding fixtures and walls generate, so the propagation characteristics become complex multiple reflection environments. In the past, the authors have been studying the appropriate evaluation considering the influence of absorption and blockage of the human body on radio wave propagation characteristics in vehicles such as within office, train, car, and aircraft, by applying large-scale FDTD analysis method [1]. This paper evaluates radio wave propagation characteristics by beam-type WPT in 915 MHz bands in a typical office environment. Evaluation examples show for propagation loss increase due to the presence/absence of human body blockage.



Figure 1. Human body model used for numerical analysis.

2 Numerical model for indoor propagation characteristics evaluation for Beam-Type WPT

Figure 1 shows a numerical human. This numerical human modeled an adult male based on the Japanese's average size was developed by the National Institute of Information and Communications Technology (NICT) [2]. This paper will place some human body models in an office room model [3,4] and evaluate human body blockage's impact on the propagation characteristics.

3 915 MHz band propagation characteristics considering human blockage

Figure 2 shows an example situation for indoor propagation estimation used in this paper. Here, the transmitter's installation position of beam-type WPT is depicted with a red marker, and the arrangement of the human is shown. The transmitter is installed so that the antenna broadside direction is toward the v-axis direction and located at a position 1 m from the floor and 20 cm away from the wall. Figure 3 compares cumulative probabilities obtained from power density distributions on an evaluation area in the simulated office room. Based on our numerical simulations and statistical analyses, we found that the field intensity emitted from one transmitter is about 3-8 dB lower, and the coverage ratio receivable area might be decreased by 13 % due to human blockage. We intend to conduct other estimations that consider different indoor propagation models, more humans, and new beam-type WPT transmitters, including multiple antennas.

4 Conclusions

This paper presented an example of evaluation on the effect of human body blockage on radio wave propagation characteristics of beam-type WPT in an indoor environment. We obtained electromagnetic field distribution with high resolution for the whole coverage area by using FDTD simulation. Based on statistical evaluations, we discussed the influence of human body blockage on propagation characteristics in the office environment at 915 MHz bands. In the future, there will also be further investigations regarding safety issues for human exposure.



Figure 2. A numerical model for propagation characteristics and safety guideline compliance estimation inside small office including humans.



Figure 3. Degradation of coverage ratio of receivable area for a beam-type WPT transmitter due to the human blockage.

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6 References

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