Input impedance characteristics of fixed type of transceivers in intra-body communication

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1. Introduction

As electronic devices become smaller, people may begin to "wear" electronic devices instead of carrying them [1]. A communication method which uses human body as part of the transmission medium, which will be called "intra-body communication" hereafter, may become a new Man-Machine interface because transmission path is established only when the user touches another device. Studies on intra-body communication originated from Zimmerman's pioneering work on intra-body transmission were carried out at MIT in 1995 [2]. And intra-body communication is one of the promising data transmission methods for constructing Body Area Network (BAN) or Body-centric Network (BCN). Since electrical signal propagates mainly through the human body, power consumption is smaller and transmission is less susceptive to eavesdropping [3], [4].

Fig.1 shows communication form of the intra-body communication, (a) Intra-person, (b) Among several people, and (c) Between person and fixed type of device. As shown in Fig.1 (c), a fixed type of the transceiver can be the other side of the wearable type of the transceiver in intra-body communication.

An electrode is a key device in intra-body communication system since electrodes are analogous to antennas in airborne wireless communication system. Therefore, the input impedance characteristics of the electrodes are one of important issues. However, nobody has addressed the

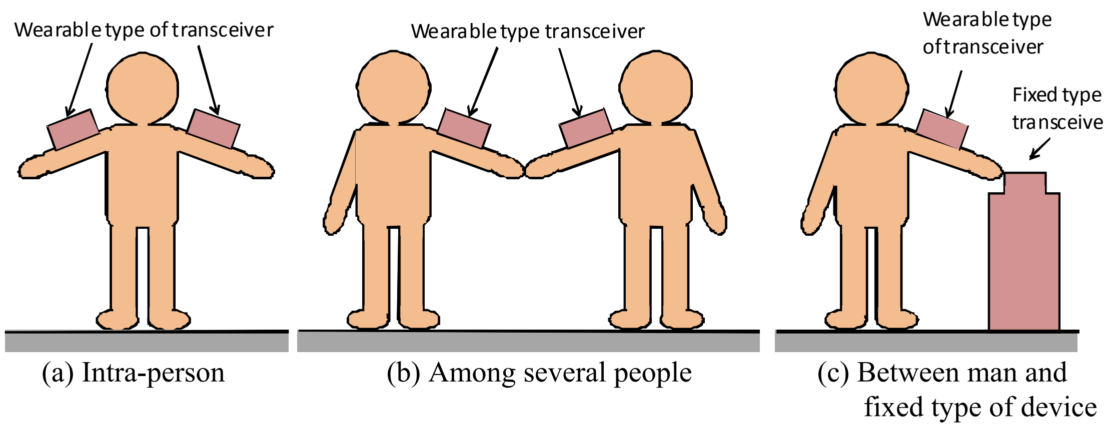


Fig. 1 Communication form of the intra-body communication

issues on the impedance characteristics of the fixed type of the transceivers, although there are a few study reports which are related to wearable type [5].

In this paper, we focus on the fixed type of the transceivers in intra-body communication and investigate the input impedance characteristics of electrodes.

2. Model

Fig. 2 shows the configurations of the intra-body communication system for electromagnetic field analyses. As shown in Fig. 2, fixed type of the transceiver consists of a rectangular parallelepiped metal housing made of aluminium, and the electrode is placed 10 mm above the top of the metal housing. And a simple whole body model which is designed by considering an average human body size of Japanese adult males [6], consisting of several elliptic cylinders, is used for electromagnetic field analyses. Electrical characteristics of muscle tissue are applied to the human body model in the electromagnetic field analyses. The electrical characteristics are obtained from an

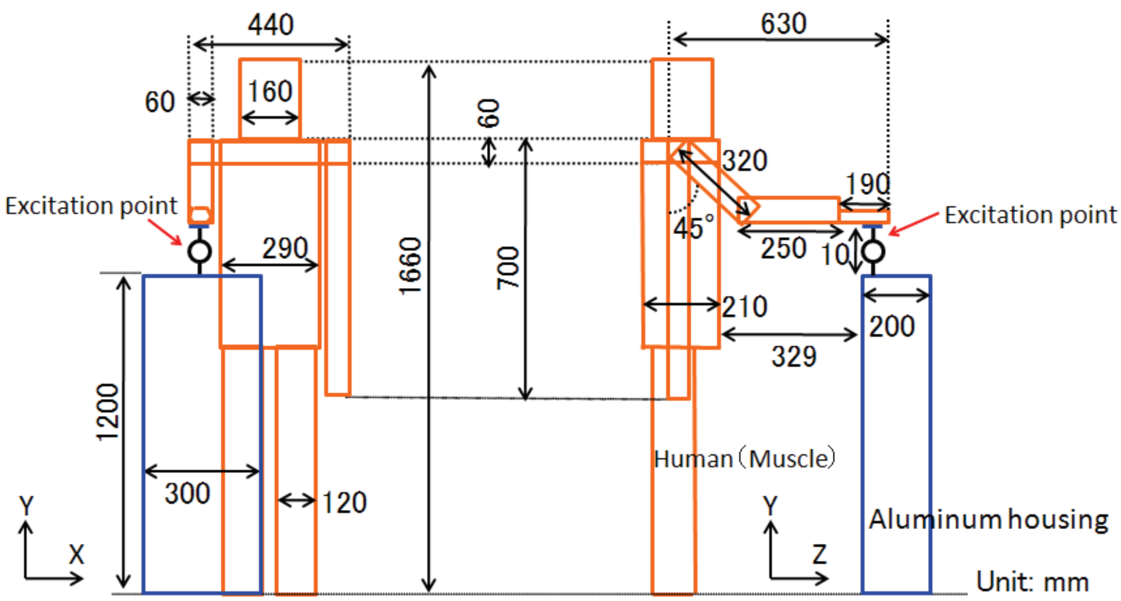


Fig. 2 Configurations of the model for electromagnetic field analysis

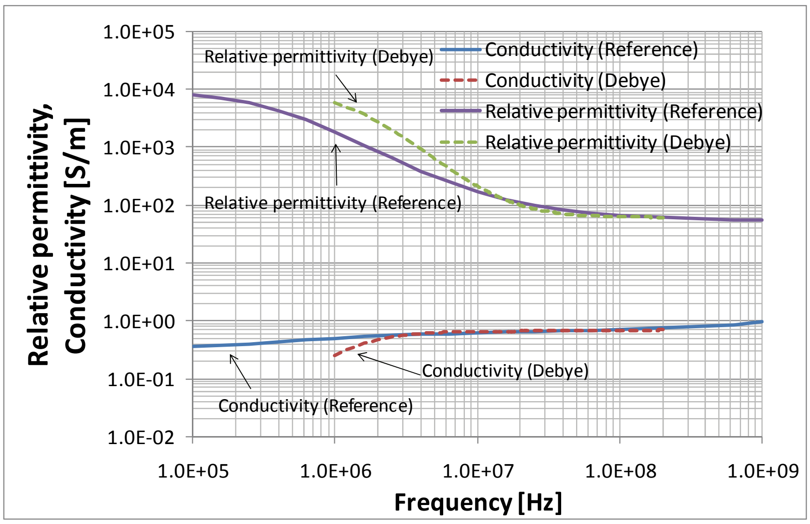
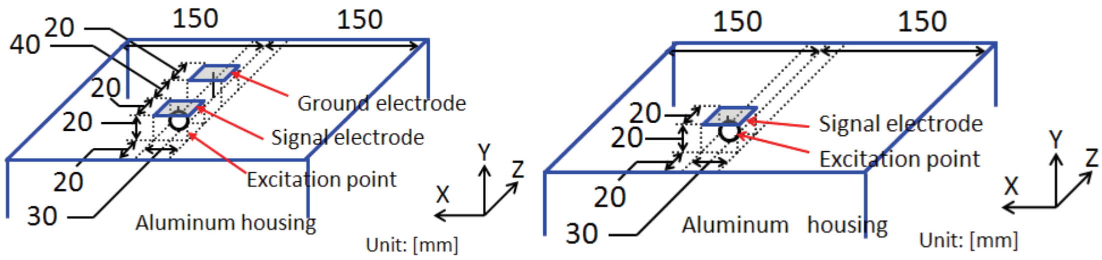


Fig. 3 Electrical characteristics of muscle tissue at each frequency as Debye type of frequency dependent dispersion medium



(a) 1-electrode model (b) 2-electrode model

Fig. 4 Arrangement of electrodes on top of fixed type of transceiver

approximation, defining the material/tissue as Debye type of frequency dependent dispersion medium as shown in Fig. 3. The referenced electrical characteristics in Fig. 3 are values from a database of Dielectric Properties of Body Tissues [7]. Although slight difference is seen between values from the reference and the Debye approximation, the reason is that it is difficult to fit the characteristics to real ones by the approximation since the electrical characteristics of human body is varied precipitously in lower frequency.

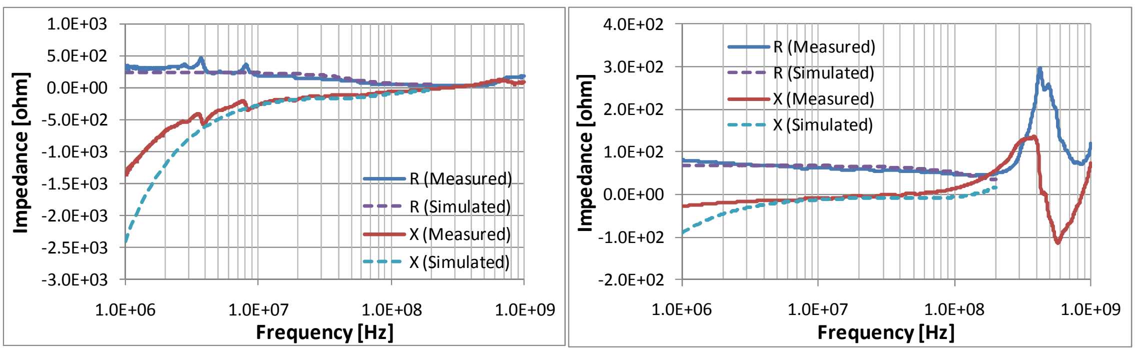
Fig. 4 shows the arrangement of electrodes on the top of the fixed type of transceiver in detail. The tip of the arm touches the electrodes on the fixed type of the transceiver as shown in Fig. 2. In the case of 2-electrode model shown in Fig. 4 (b), both electrodes of signal and ground are touched by a palm.

3. Impedance Characteristics

Fig. 5 shows input impedance characteristics of the fixed type of transceivers, obtained from experiments in a frequency range of 1MHz to 1GHz, and from electromagnetic field analyses in a frequency range of 1 MHz to 200 MHz. A male human subject with 30 years old, 165 cm-body height and 60 kg-body weight was examined in the experiments.

As shown in Fig. 5, impedance characteristics obtained from analyses based on TLM method and experiments that a male human subject with 30 years old, 165 cm-body height and 60 kg-body weight was examined, were agreed well each other in a frequency range above 5 MHz. In a frequency range below 5 MHz, the impedance characteristics are slightly different from each other, but those show the same tendency. Therefore, it shows a validity of the electromagnetic field analyses. It is thought that the slight difference below 5 MHz is caused by the electrical characteristic difference between the human body and the employed Debye type of frequency dependent dispersion medium as shown in Fig. 3.

In a frequency range below 100 MHz, the resistive components showed almost constant values



(a) 1-electrode model (b) 2-electrode model

Fig. 5 Input impedance characteristics of electrode of the fixed type of transceivers of around 200 ohm in 1-electrode model and around 60 ohm in 2-electrode model, respectively. The reactive component in 2-electrode model showed almost zero in the all frequencies. On the other hand, the absolute value of reactive component in 1-electrode model increases as frequency decreases.

From the view point of input impedance characteristics shown in Fig. 5, it is easier for 2-electrode model to feed with a feeding source of 50 ohm compared with 1-electrode model.

Some ripples are confirmed at 4 MHz and 8 MHz in Fig. 5 (a) obtained from experiments. It is caused by the internal reflection of the employed cable in experiments, since the observed frequency positions of ripples are changed if different length of the cable is employed.

4. Conclusion

In this paper, we focused on the fixed type of the transceivers in intra-body communication and investigated the input impedance characteristics of the electrodes for the transceivers.

Impedance characteristics obtained from analyses based on TLM method and experiments that a male human subject with 30 years old, 165 cm-body height and 60 kg-body weight was examined, were agreed well each other.

In a frequency range below 100 MHz, the resistive components showed almost constant values of around 200 ohm in 1-electrode model and around 60 ohm in 2-electrode model, respectively. The reactive component in 2-electrode model showed almost zero in the all frequencies. On the other hand, the absolute value of reactive component in 1-electrode model increased as frequency decreased.

Therefore, it is easier for 2-electrode model to feed with a feeding source of 50 ohm compared with 1-electrode model.

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