The Electrode structure to reduce channel loss for Human Body Communication Using Human Body as Transmission Medium

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Introduction

Recently the human body communication which uses a human body as a transmission medium has been proposed [1]. In the human body communication, a data from one device is transmitted to another device through human body. The human body communication has an advantage that the devices can communicate conveniently without an additional wire.

In the previous paper [2][3], when onbody communication system is designed, voltage transfer system is designed to maximize the voltage of received signal over that of transmitted signal. In this viewpoint of signal loss, the optimized transmitter for human body communication has two electrodes: a signal electrode and a ground electrode. The signal electrode which is attached to human body feeds a transmitting signal into human body and the ground electrode is connected to the ground level of transmitter circuit. The signal loss is dependent on the fact that the ground electrode is attached to human body or not. The signal loss decreases as the ground electrode is attached to human body because the absolute strength of electric field and power flow around human body increase[4]. But from the viewpoint of power transfer system, this electrode structure makes very inefficient performance because the ground electrode in the transmitter increases the power loss of body (=lossy dielectric material) unnecessarily.

In this paper, the electrode structure to reduce channel loss in lossy dielectric material from the viewpoint of power transfer system is presented. Under the assumption that Human body is lossy dielectric material at 5 MHz, the channel loss of the proposed structure is calculated using EM simulator. Moreover, the simulation results of proposed structure is compared with that of previous structure.

Simulation Model

A biological tissue-equivalent phantom has been used in the measurement of previous paper [2], and in the previous papers [2][3], the simulation model for human body has been composed of muscle tissue. In this paper, this model (εr = 308.26, σ=0.59 s/mat 5 MHz) is also used. Fig. 3 shows the simulation model for human body. In the experimental setup of Fig. 1, the signal from transmitter passes through arms mainly, so the human body is modeled simply as rectangular parallelepiped of arm shape[2]. The distance between transmitting and receiving points is 150cm due to the distance between the point on the right wrist and the point on the left wrist. As a first step, the effects of ground electrode on channel loss have been simulated at a transmission distance of 150 cm. As a next step, the optimization of the electrode structure is performed using EM simulator. Main parameters of the optimization are the size of electrode and ground, the load between the electrode attached to arms and the ground in the receiver.

Fig. 1 shows the simulation model for human body and Case Ⅰ, Ⅱ models with/without ground electrode in the transmitter. In the applications of the signal from transmitter passes through arms mainly, the human body is modeled simply as rectangular parallelepiped of arm shape, composed of muscle tissue. CST MWS 5.1 is used as a EM simulator.

Channel loss

The channel loss is defined to evaluate the performance of human body communication from the viewpoint of power transfer system. In the simulation model, the voltage and current of discrete port and the load are known. The transmitted power Pt is the power generated by voltage source, and the receiver power Pr is the received power at the load. In this paper, the Pr/Pt is defined as the channel loss. This criterion can evaluate the power loss of human body communication.

Simulation results and Analysis

As a first step, the effects of ground electrode on channel loss have been simulated at a transmission distance of 150 cm. Table Ⅰ shows the simulation results for the presence of the ground electrode in the transmitter (Case Ⅰ, Ⅱ) excited by voltage source(3V). As mentioned in the previous paper [2][3], the signal loss decreases as the ground electrode is attached to human body. However, as shown in Table Ⅰ, the channel loss increases because the ground electrode in the transmitter increases the power loss in the body. So, from the viewpoint of power transfer system, the transmitter with the ground electrode makes very bad efficiency. Fig. 2,3 show the power flow calculated along curve1,2,3 in Fig. 3. Curve1 is the line passing vertically through the transmitting point A. Fig. 2(b) shows the transmitter without the ground electrode (Case Ⅱ) excites the power flow of surface-wave in the air more largely in comparison with the transmitter in Case Ⅰ. While Curve2 inside the body shows the path of power flow inside lossy dielectric material, Curve3 outside the body shows the path of the surface-wave power in air. Fig. 3(a) shows that in case of surface-wave power in the air, the pattern of the power flow in Case Ⅰ is almost similar to that of the power flow in Case Ⅱ, but Fig. 3(b) shows power flow near the transmitter in Case Ⅰ drops more steeply than the power flow in Case Ⅱ. Therefore, the electrode in Case Ⅰ causing large power-loss in the body is inefficient structure in comparison with the electrode in Case Ⅱ.

As a next step, the optimization of the electrode structure was performed using EM simulator. As the results of optimization, it is gainful to maximize the size of ground and signal electrode. As shown in Fig. 4, the electrode structure having the wristband type is presented to optimize this conditions. The load(=1kohm) in the receiver is also determined to decrease the channel loss.

Conclusion

In this paper, the electrode structure to reduce channel loss for human body communication was presented and these results were analyzed by EM simulation and compared with the previous structures [4]. The signal loss decreases as the ground electrode is attached to human body, but the channel loss increases. Based on these calculation results, the electrode structure having the wristband type to reduce power loss efficiently was proposed.

References:

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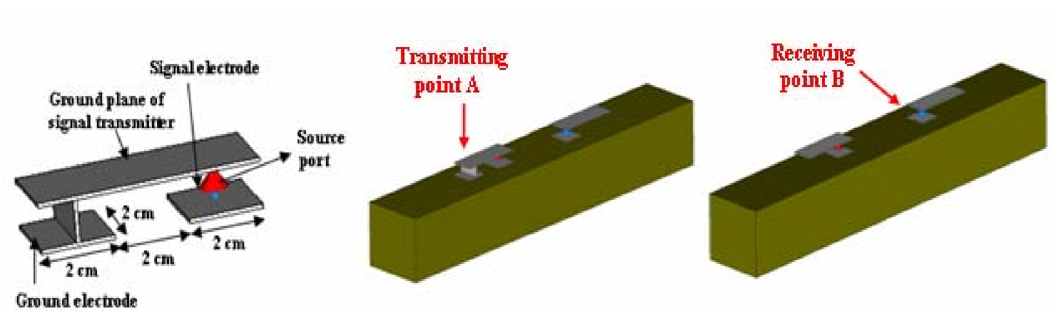
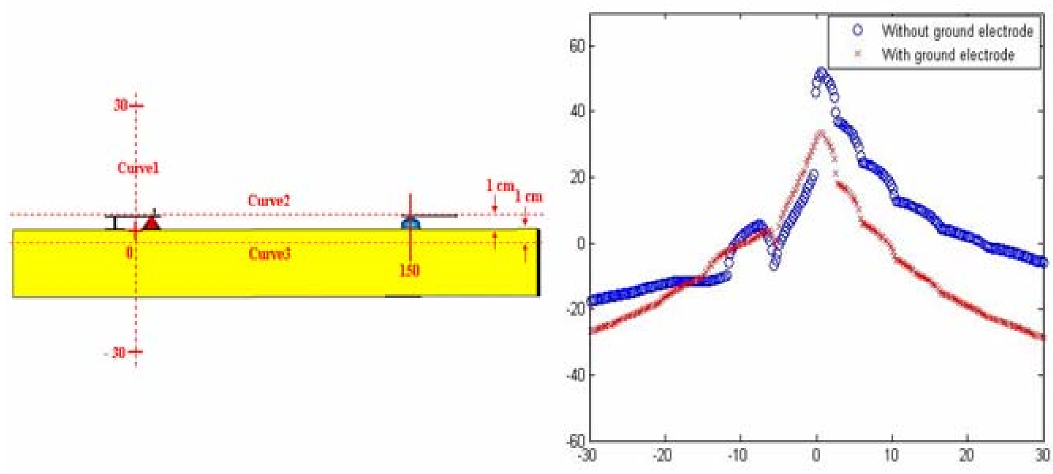


(a) (b)-Case Ⅰ (c)-Case Ⅱ

Fig. 1. (a) The electrode structure with ground electrode in the transmitter, Simulation models (b) with, (c) without ground electrode in the transmitter.

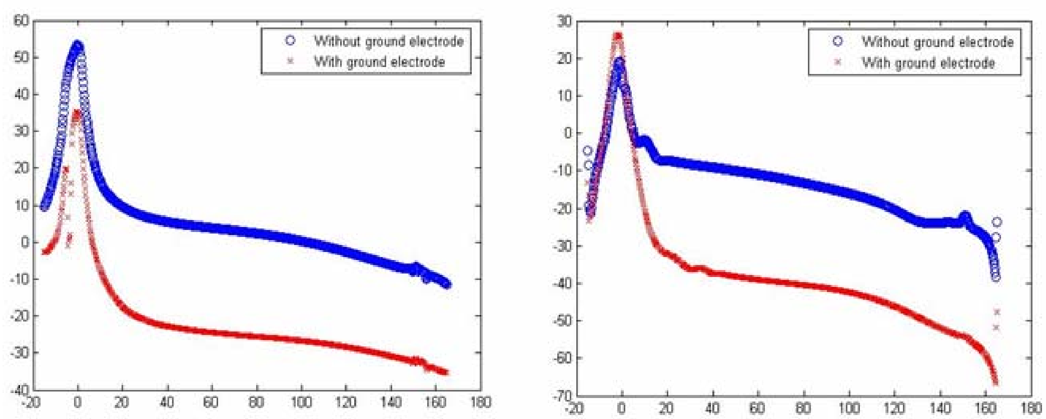
Transmitter	Vt (dB)	Pt (dBm)	Vr (dB)	Pr (dBm)	Signal loss (dB)	Channel loss (dB)
Case Ⅰ	9.5 (=3V)	18.8	-41.6	-75.0	**-51.**	**-93.8**
Case Ⅱ	9.5	-22.8	-60.1	-85.1	**-69.6**	**-62.3**
Proposed	**9.5**	**-6.9**	**-50.9**	**-53.9**	**-60.4**	**-47**

TableⅠ. The signal and channel loss of Case Ⅰ, Ⅱ, proposed structure



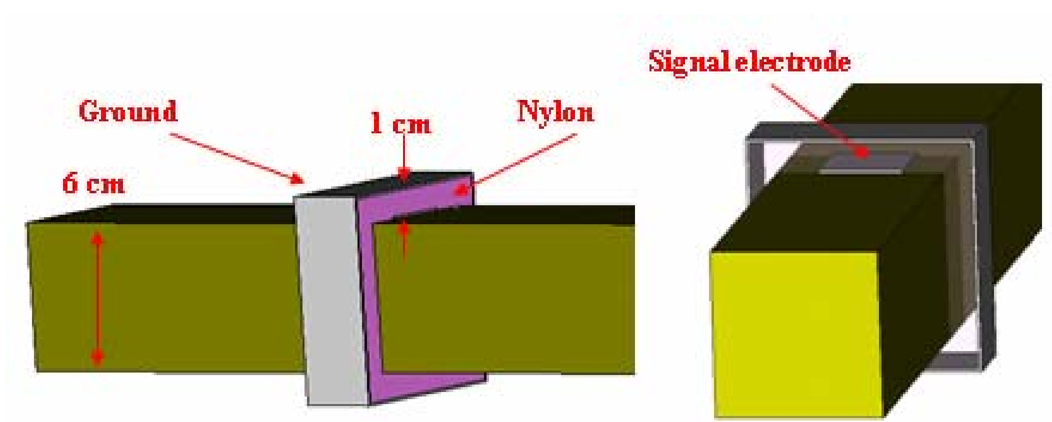
(a) (b)

Fig. 2. (a) Curve1,2,3 in the simulation model, (b) Power flow along Curve1



(a) (b)

Fig. 3. Power flow along (a) Curve2 in the air, (b) Curve3 in the body



(a) (b)

Fig. 4. (a) side view, (b) front view of the proposed electrode structure