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Invited Paper

Radiated Noise Cancelling by Capacitance Around Floor Electrode in Intra-Body Communication

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Abstract. This paper describes a radiated noise cancelling method in intra-body communication by changing additional capacitances around a floor electrode. The additional capacitances are used between the floor electrode and earth ground. The signal to noise ratio is estimated by using an equivalent circuit. The maximum signal to noise ratio is obtained by changing the capacitances, where the radiated noises on signal and ground electrodes of the floor electrode are cancelled. We confirmed that the signal to noise ratio can be controlled by changing the additional capacitances.

1. Introduction

Intra-body communication (IBC) [1] uses a human body as a transmission path. A communication trigger is generated by natural human actions: stepping or touching. The transmission path model was studied by using capacitances [1]-[3]. IBC suffers from radiated environmental noises [4]. It is necessary to study an influence of the radiated environmental noises on the communication performance. We try to use additional capacitances around a floor electrode for reducing the radiated environmental noises.

2. Transmission Path of Signal and Noise

The transmission paths of signal and noise are shown in Fig. 1. A person (=human body) with a wearable transmitter stands on the floor electrode including a signal and ground electrode. A signal from the wearable transmitter propagates to the floor electrode. A noise is radiated from an electric light. The radiated noise propagates to the floor electrode through three transmission paths.

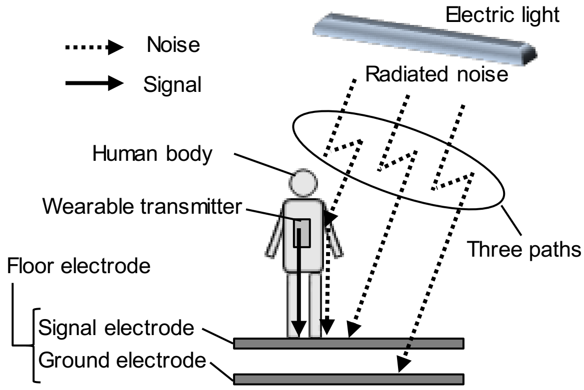

Fig. 1. Transmission paths of signal and noise in IBC.

3. Signal Strength Simulation

Fig. 2 shows an equivalent circuit of the person standing on the floor electrode without the wearable transmitter and the electric light. The capacitances except for C_{esg} were decided from our previous work [5]. The C_{esg} of 60.6 pF was calculated from a size of the electrodes and a distance between the signal and ground electrode. The size of the electrode is 365 mm × 365 mm × 0.1 mm, and the distance is 20 mm. We defined four nodes: human body node HB, signal electrode node SE, ground electrode node GE, and earth ground node EG.

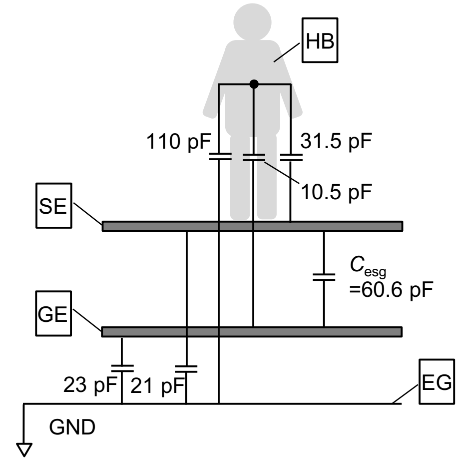

Fig. 2. Equivalent circuit without wearable transmitter and electric light.

Fig. 3 shows an equivalent circuit using the wearable transmitter with an internal impedance of 1 kΩ. The equivalent circuit of a human body and the floor electrode in Fig. 2 is expressed by a bold solid line box including four nodes: HB, SE, GE, and EG. The additional capacitances of C_{adg} and C_{ads} are also shown in Fig. 3. C_{adg} is connected between GE and EG. C_{ads} is connected between SE and EG. C_{adg} and C_{ads} are variable capacitances. The capacitances among the wearable transmitter and the four nodes were decided from our previous work [5].

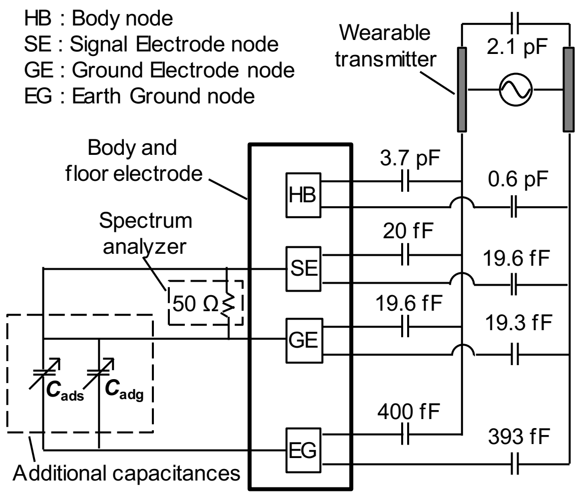

Fig. 3. Equivalent circuit of signal transmission path.

C_{adg}/C_{ads} dependence of received signal voltage between SE and GE with a 50-Ω load resistance are shown in Fig. 4. The parameter of C_{adg} was changed at 100 pF (●), 1000 pF (▲), and 10000 pF (■). The characteristics of the received signal voltage at C_{adg} of 100 pF and 1000 pF increase sharp-monotonically.

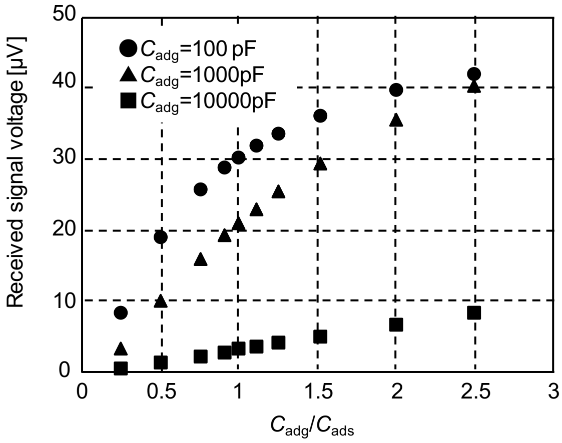

Fig. 4. C_{adg}/C_{ads} dependences of received signal voltage.

4. Radiated Noise Simulation

Fig. 5 shows an equivalent circuit with the electric light. The radiated noise from the electric light propagates to SE and GE. C_{tss} includes not only a capacitance between SE and the noise source by the electric light but also a capacitance through the human body. A capacitance of 0.1 pF between the noise source and EG was decided from our previous work [5]. The C_{tss} of 472 fF and C_{tsg} of 468 fF were calculated from the size of the electrode and distance between a ceiling and the floor electrode. The size of the electrode is 365 mm × 365 mm × 0.1 mm. The distances between the ceiling and signal electrode at C_{tss} and C_{tsg} are 2.5 m and 2.52 m, respectively.

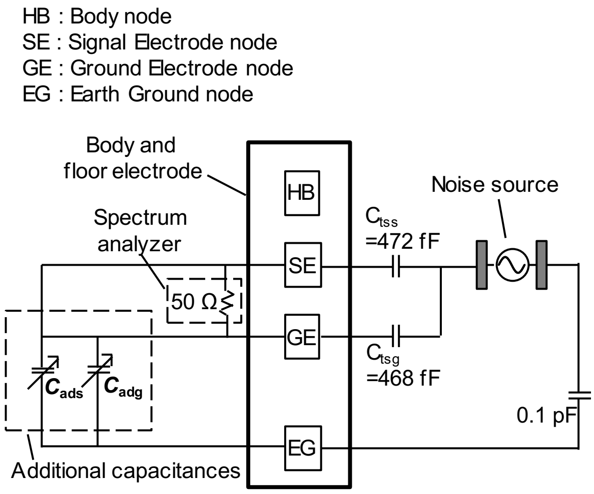

Fig. 5. Equivalent circuit of radiated noise transmission path.

C_{adg}/C_{ads} dependences of the received signal voltage between SE and GE with the 50-Ω load resistance are shown in Fig. 6. The parameter of C_{adg} was changed at 100 pF (●), 1000 pF (▲), and 10000 pF (■). The characteristics have a minimum value of the received noise voltage at around C_{adg}/C_{ads} of 1 where is independent of C_{adg}. The sharp characteristics are shown at C_{adg} of 100 pF and 1000 pF.

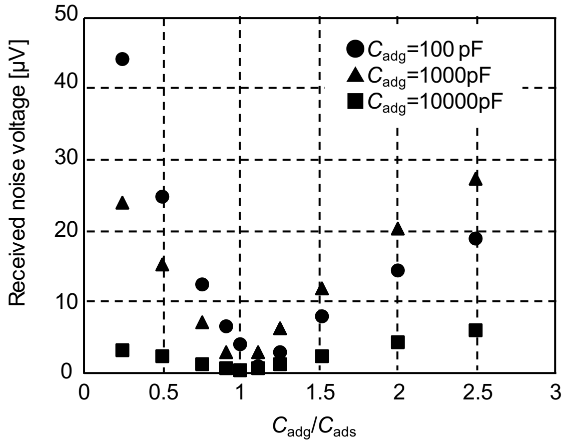

Fig. 6. C_{adg}/C_{ads} dependences of received noise voltage.

5. Signal to Noise Ratio Simulation

The signal to noise ratio characteristics from Fig. 4 and Fig. 6 are shown in Fig. 7. We found that a maximum signal to noise ratio is obtained at around C_{adg}/C_{ads} of 1. This result indicates that the signal to noise ratio is sensitive around at C_{adg}/C_{ads} of 1. It is confirmed that the maximum signal to noise ratio can be automatically obtained by adjusting C_{adg}/C_{ads} to around 1.

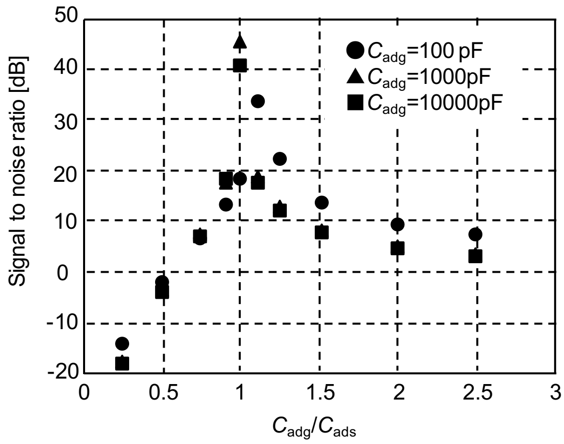

Fig. 7. C_{adg}/C_{ads} dependences of signal to noise ratio.

6. Conclusion

We tried to use additional capacitances around a floor electrode for reducing radiated environmental noises in intra-body communication. It was confirmed that a maximum signal to noise ratio can be automatically obtained by adjusting the capacitances. This means that the radiated environmental noises can be cancelled by the additional capacitances between the floor electrode and earth ground.

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References

[1] T. G. Zimmerman, "Personal area networks: Near-field intrabody communication", ***IBM Systems Journal***, Vol. 35, No. 3-4, pp. 609-617, 1996.

[2] M. Shinagawa, J. Katsuyama, K. Matsumoto, S. Hasegawa, R. Sugiyama, Y. Kado, "Noise analysis for intra-body communication based on parasitic capacitance measurement", ***Measurement, ELSEVIER***, Vol. 51, pp. 206-213, 2014.

[3] N. Haga, K. Motojima, M. Shinagawa, Y. Kado, "A note on signal paths in intrabody communication channels", ***IEICE Electronics Express***, Vol. 12, No. 12, pp. 1-6, 2015.

[4] Y. Hayashida, M. Hasegawa, A. Suzuki, M. Sinagawa, Y. Kado, N. Haga, "Radiated noise analysis via human body for intra-body communication", ***Measurement, ELSEVIER***, Vol. 89, pp. 159-165, 2016.

[5] R. Sugiyama, Y. Hayashida, J. Katsuyama, K. Matsumoto, Y. Ido, M. Shinagawa, Y. Kado, "Signal Analysis of Wearable Transmitter for Intra-body Communication", ***BodyNets'13 Proceedings of the 8th International Conference on Body Area Networks***, pp. 449-452, 2013.