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The Development of Human Body Parts Model for Wireless Communication Device Testing

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1.Introduction

Recently, the wireless equipments such as game machines, audio equipments and cellular phones have come to overflow in surroundings. The performance of these equipments strongly depends on an electromagnetic environment at the set up location. However, a lot of portable wireless communication devices are not designed considering the influence that the human body part such as operator's hands gives to the performance of those equipments. For instance, the influence of operator's hand causes deterioration of radiation directivity, antenna transmission efficiency and frequency response etc. Because the reproducibility of the testing is low, it is insufficient to evaluate the influence of operator's hand on the performance of wireless communication equipments by the real human body.
Therefore, the approximation human body that can be used to evaluate operation of radio equipment is needed. In this report, the development of the artificial approximative human body with the synthetic material that can be used to the realistic situation of the wireless equipments testing is described. Concretely, the influence that the component of human's hand (for instance, skin, muscle, and bone, etc.) caused wireless equipments performance was analyzed by the numerical analysis. To evaluate a realistic wireless device performance, the model of simple shape that approximated actual human hand (hereafter, it is called the hand phantom) is designed referring to the above-mentioned result. Finally, the comparison result of the wireless device performance evaluation by hand phantom and actual human is shown, and the utility of hand phantom is proven.

2. Analysis of human's hand

2.1 Measurement of person hands data

The development requirement for phantom is consolidated in the following two items.

1. Creation of the simplest phantom shape that influence of human's hand can be simulated
2. Creation of phantom structure of excellent operativeness by which influence of human's hand can be simulated

The goal of item 1. is not production of anatomized artificial arm. The creation of an approximate canonical model for the real human body influence on the microwave is intended.
The target of item 2 is frame structure development for the improvement of the phantom handling performance. In an actual testing environment, it is demanded that phantom be able to maintain a steady situation for DUT (Device Under Testing). The frame structure development for phantom is a requirement to satisfy that demand. However, it is necessary to avoid giving impact of the frame structure different from the real human body to the microwave.
First of all, it is necessary to measure the influence that the real human hand confers to the microwave as the reference data. At the next step, the impact which hand phantom model of the prototype gives the microwave is measured. The difference between the measurement data with hand phantom model and the reference data is assumed to be an index for the phantom model redesign. When the above-mentioned step is repeated, the phantom model that satisfies requirement item 1 and 2 is completed.

2.2 Measurement system

Fig. 1 shows the system which measures the influence which real human hand confers to the microwave radiated from the antenna.
The reference data for the impact of human hand to the micro wave radiation is collected by this

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system. To prevent the microwave exposure to other parts of the human body, the electromagnetic absorption wall is installed. A basic half wave length dipole antenna is used for the probe (see Fig.2). The measurement frequency is set to 2GHz. The distance between the antenna and human hand is set to 5mm.

2.3 Result

Fig. 3 shows the radiation pattern at 2GHz. Strong backward blockage of about -25dB is recognized around 160 and 240 degrees. These null patterns are an impact which human hand gave the microwave. The measured results of the dipole antenna's input property are shown in Fig. 4. It is confirmed that human hand hardly influenced the dipole antenna's input property. Therefore, it is thought that the effect of backward blockage occupies the hand's impact for microwave.

3. Phantom model design

3.1 Analysis

In this chapter, the prototype hand phantom influence to microwave and the reference data in chapter 2 are compared. To give priority to reproducibility, the hand phantom adopted a numeric model. A numerical model for FDTD method (finite-difference time-domain method) is simple hexahedron as shown in Fig.5. The size is adopted from human body standard data (width of hands, thickness, and length seen by the third finger). Electric properties use the value indicated by FCC. Two kinds (the type with built-in the frame and the shell exterior type) were assumed as a frame structure for Phantom. The built-in type frame is described as the endoskeleton model and the shell exterior type is described as the exoskeleton model, respectively. The thickness of the bone is uniformly assumed to be 4mm.

Table 1 Electric properties of hand tissue

	Permittivity	Conductivity
Bone	15.37	0.48
Muscle	54.17	1.51

3.2 Analysis result

The analytical results are shown in the Fig.6 with measured one. The endoskeleton model is nearer the reference data than the exoskeleton model. However, the difference of both models is about 2dB, and neither is an insufficient quality. The model correction is necessary.

3.3 Re-design model

As for an actual palm, the thickness of the edge is thicker than that of the palm center. Therefore, the hand edge shape is transformed. Re-design model is shape to shorten exoskeleton, and add the hexahedron to phantom edge, (see Fig. 7).

The numerical analysis result of backward blockage effect by re-design model is shown in Fig. 8 with the reference data.

Fig.8 shows an analytical result of uses this model and the comparison with the human body data. Backward blockage effect is brought close to the reference data by adding a simple structure. It could be confirmed to trace the human body by combining simple shape. The development of Phantom that can maintain the RF device is advanced based on these examinations.

4. Conclusion

In this report, the reference data for the impact of human hand to the microwave radiation was collected. Thereafter, the influence to microwave with prototype hand phantom and the real human's hand were compared. As a result, it could be confirmed to trace the human body by combining simple shape. The development of phantom that can maintain the RF device is advanced based on these examinations.
At the next stage, phantom for the cellular phone maintenance will be developed.

5. References

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[2] K. S. Kunz and R. J. Lubbers, “Finite difference time domain method for electromagnetics.” Boca Raton, FL: CRC Press, 1993.

[3] FCC Dielectric Properties of Body Tissues at RF and Microwave Frequencies
http://www.fcc.gov/fcc-bin/dielec.sh

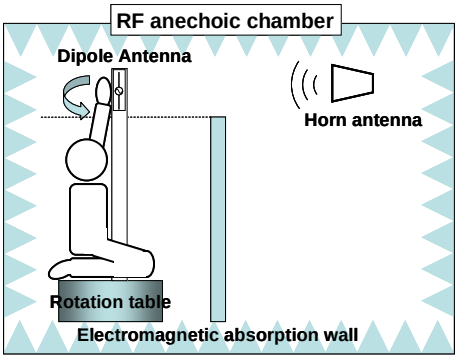

Fig.1 Measurement system

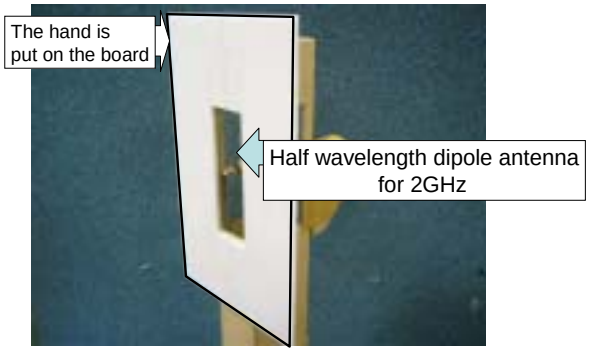

Fig.2 Probe structure

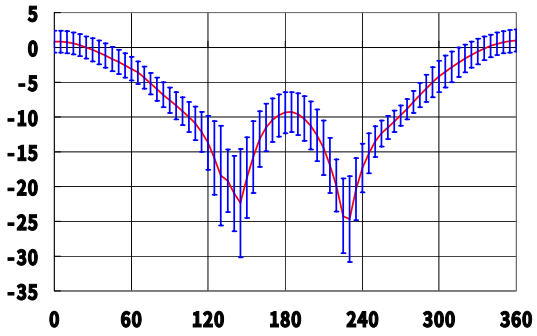

Fig.3 Radiation pattern

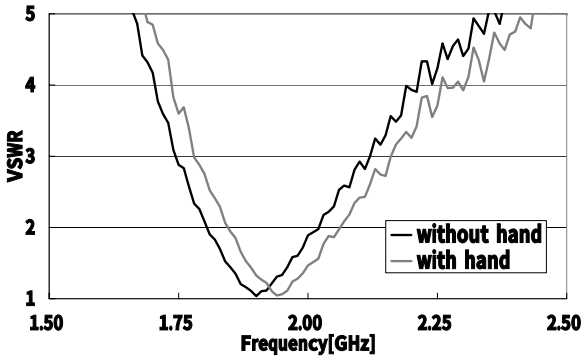

Fig.4 VSWR for dipole antenna

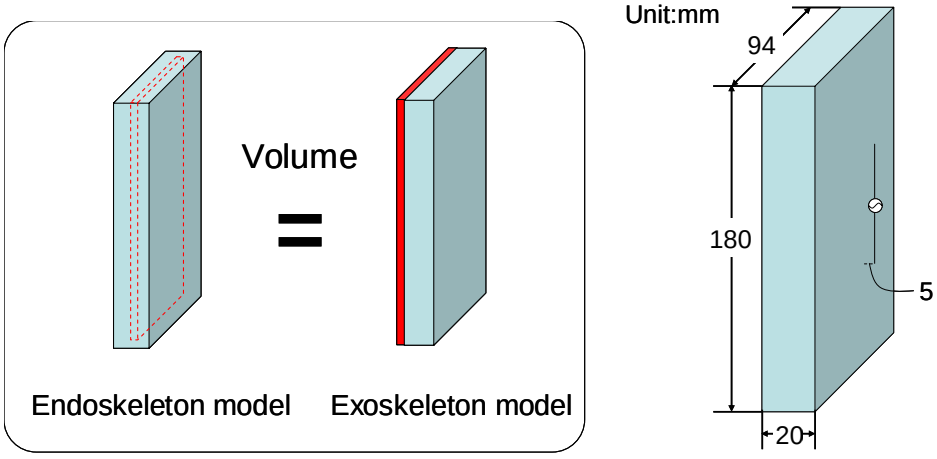

Fig.5 Analysis model

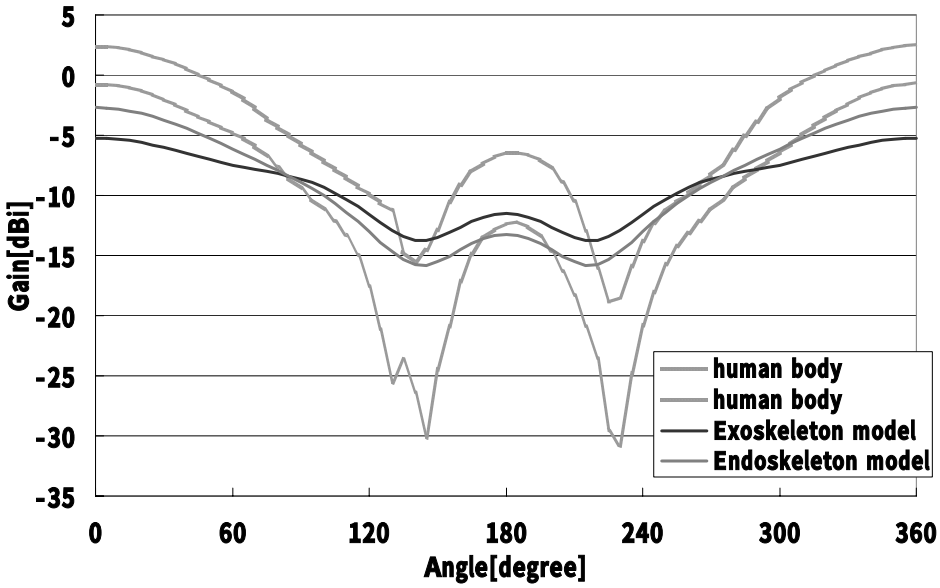

Fig.6 Analysis result

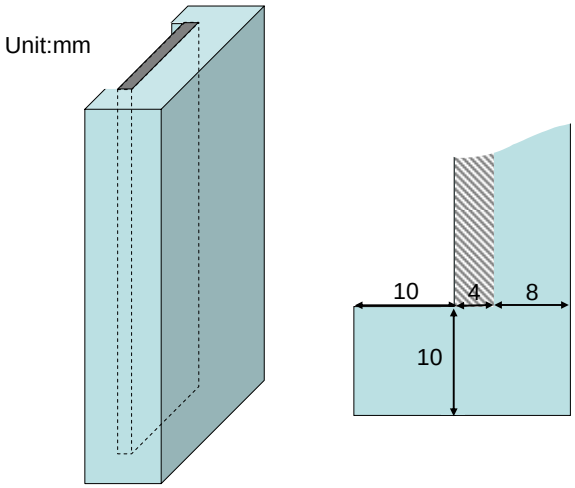

Fig.7 New analysis model

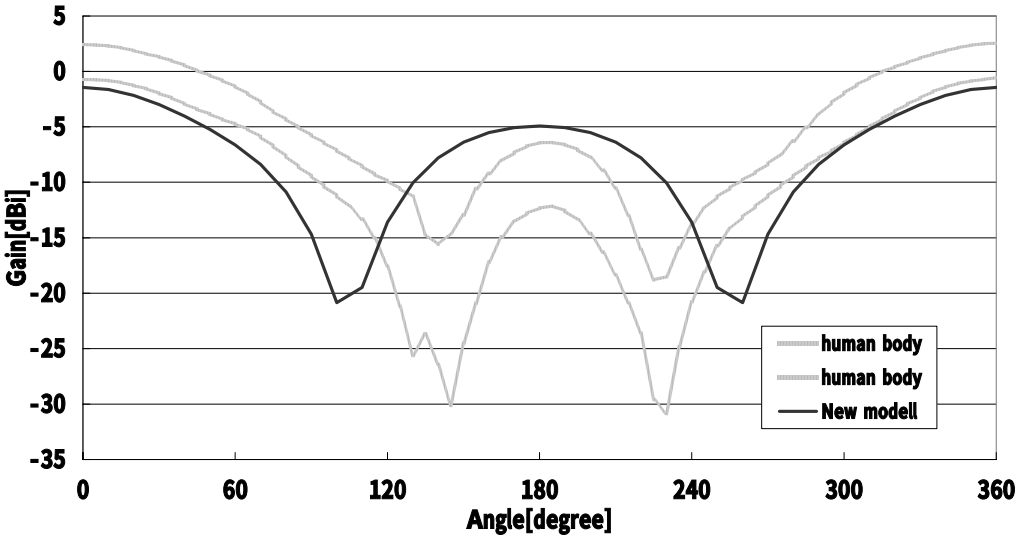

Fig.8 New model result