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Development of Human Centric Antenna system for Digital Terrestrial Broadcasting

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1. Introduction

In 2011, Digital terrestrial broadcasting system (@470-710 MHz band) was replaced analog TV broadcasting in Japan. It has the merit such as being able to transmit a clear picture and sound, to provide the EPG (Electronic Program Guide) and data broadcasting service to the portable equipment. Therefore, those systems have been gathering attention as a new information medium. Especially, the performance enhancement of the antenna installed in the RF device becomes the requirement for the receivable coverage improvement.

To solve this problem, it is possible to use wearable antenna [1]-[3]. This has the advantage whose restriction of the size is less than built-in type antenna for the RF device. On the other hand, the antenna is installed near the human bodies. Therefore, it is necessary to consider the existence of the human body in the antenna design. In addition, the antenna should be shape that does not disturb the human usual activity.

In this report, the antenna loading to the human head is attempted. Concretely, it is investigated to set up the antenna on headband.

2. Basic structure of wearable antenna

Basic structure of wearable antenna is shown in Fig.1 and 2. Moreover, the optimized antenna shape parameter is shown in Table 1 and Table 2. A basic antenna is constructed with the metal headband and half of the broadband planar antenna element [4]. The entire antenna element is supported by the rubber substrate of 3mm in thickness. The notches are inserted in the antenna element, and profile has been lowered. In addition, the adjustment fin for the impedance matching is set up between ground plane and the antenna element.

Because the wearable antenna is used near the human body, the consideration of human body effect is indispensable for the optimization. Accordingly, the shape of each element is designed so that the antenna performance might become the best in near the loss dielectric sphere of 200 mm in the diameter. In the antenna design, FDTD method is used [5]. The cell size is set to 1 mm in X, Y and Z directions. As for the dielectric property of loss dielectric sphere, constant of brain tissue in FCC (Federal Communications Commission) database [6] is adopted. The headband as a ground plane is located around the dielectric sphere as an approximate human head. To acquire sensitivity to horizontal polarization, antenna element has been established with 60-degree angle from the centre.

3. Calculation results

Calculated input properties are shown in Fig.3. Practical using frequency is about between 500 MHz and 550 MHz. Detail input properties in these frequencies are VSWR=3.1 at 500MHz and VSWR=1.7 at 550MHz, respectively. Input property in the band used for digital terrestrial broadcasting requires VSWR less than 3.0. Therefore, it is thought that the antenna design requirement is approximately satisfied regardless of the presence of the approximation human head.

In addition, the radiation pattern at 600 MHz is shown in Fig. 4 and 5. Vertical polarization has achieved a high gain in all directions. On the other hand, in horizontal polarization has achieved a sufficiently high gain of the antenna in the forward and backward.

On the other hand, it is worried that the amount of the microwave exposure to the human head increases when wearable antenna is used. Hence, SAR (Specific Absorption Rate) in human head with this antenna is evaluated. The exposure frequency is set to 600MHz. SAR with the half wavelength dipole antenna located at the headband position is also evaluated for the comparison. The maximum value of 10g-averaged SAR with this antenna is 0.84 W/kg. In contrast, maximum 10g-averaged SAR with the half wavelength dipole antenna is 4.7 W/kg. Therefore, it is considered a low impact on the human head.

4. Measurement results

The antenna's radiation properties are measured in a radio anechoic chamber. The prototype antenna is attached on the dummy human body (phantom) shown in Fig. 7 because of the practical performance evaluation.

Input property of prototype antenna is shown in Fig.3 for the comparison with the design data.

According to Fig.3, input property in the band used for digital terrestrial broadcasting satisfies VSWR less than 3.0 in calculation and measurement.

The actual gain in maximum radiation direction as a function of frequencies is shown in Fig.4. The gain transition of the calculated data with loss dielectric sphere and the experimental gain that uses phantom shows good agreement.

In addition, measurements of the radiation pattern are shown in Fig.5 and Fig.6. Radiation pattern is sufficiently higher than the common built-in antenna has been confirmed. It is the usefulness of this antenna in the terrestrial digital broadcasting has been verified.

5. Conclusion

In this study, we propose a practical way of small antennas for digital terrestrial TV broadcasting can be attached to the human head. This antenna shows a good agreement for VSWR and radiation pattern by analysis and experience. This antenna is a low effect on the human body, and realized the high gain and broadband. Using this antenna structure will be considered also apply to other frequencies or applications.

References

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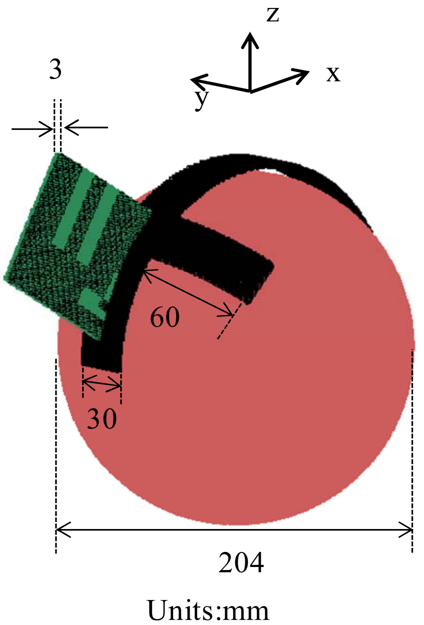

Fig.1 Simulated wearable antenna model

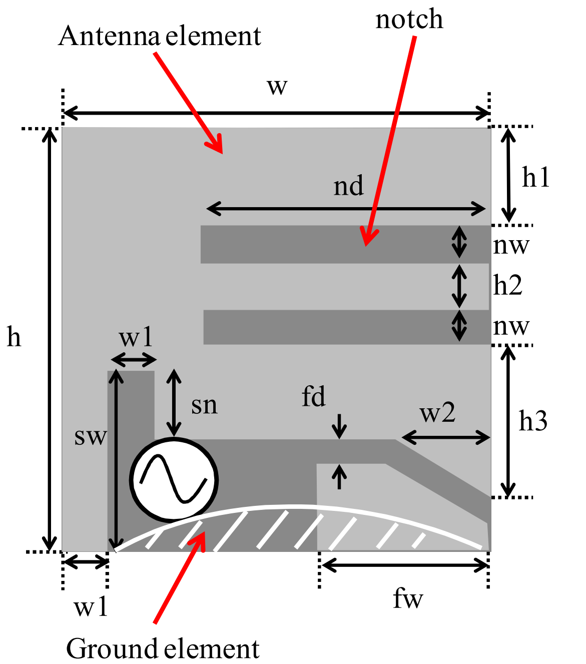

Fig.2 Details of the antenna element

Table 1 Electric parameters

	ε_r	ε_{er}	σ [S/m]
Brain	47.49		0.661
Substrate(Cal.)	3.000	1.481	0.00840
Substrate(Exp.)	3.453		0.00840

Table 2 Antenna element parameters

	Length[mm]
w	80
h	85
nd	48
nw	10
sw	24
h1	21
h2	12
h3	27
fd	1.4
fw	34
sn	16
w1	11
w2	17

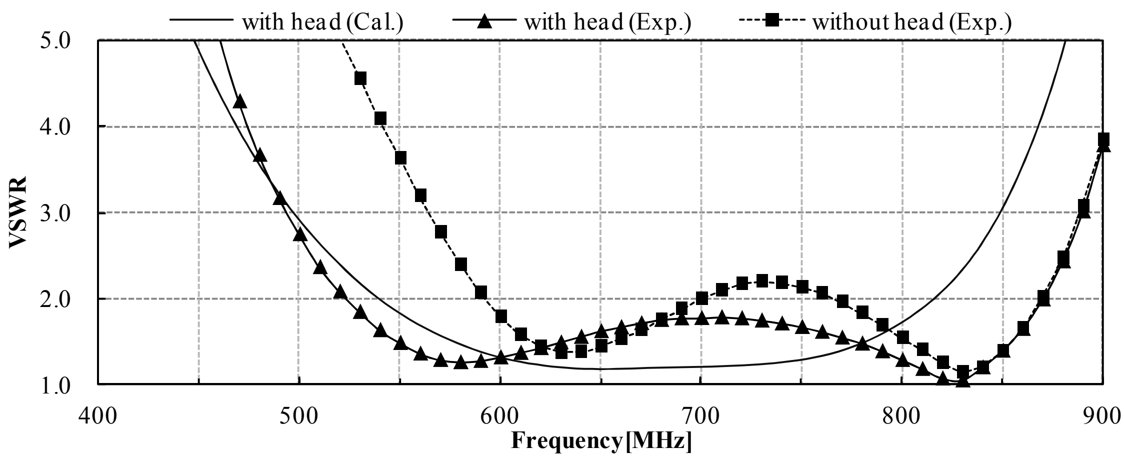

Fig.3 VSWR

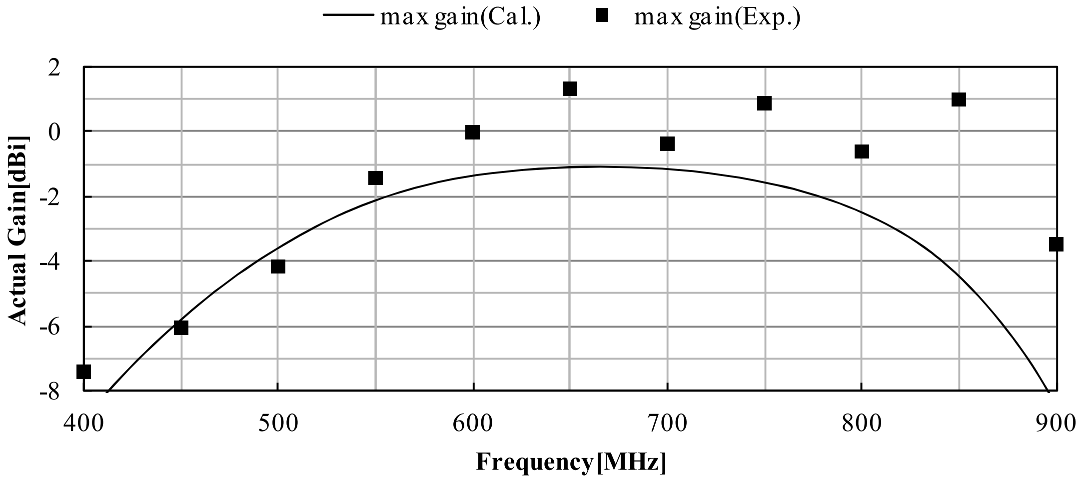

Fig.4 Gain vs. Frequency

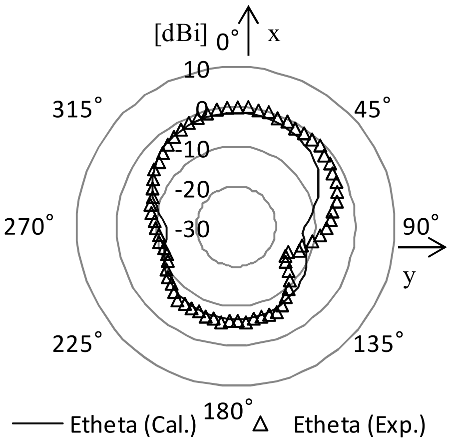

Fig.5 Radiation pattern (vertical,@600 MHz)

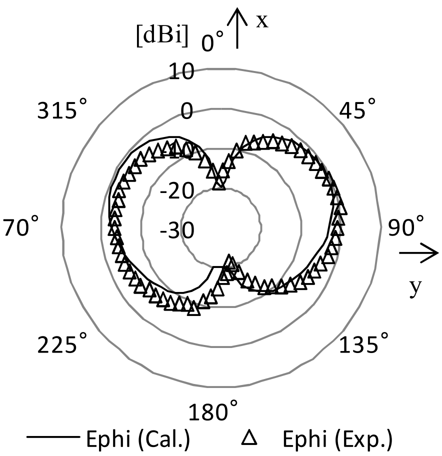

Fig.6 Radiation pattern (horizontal,@600 MHz)

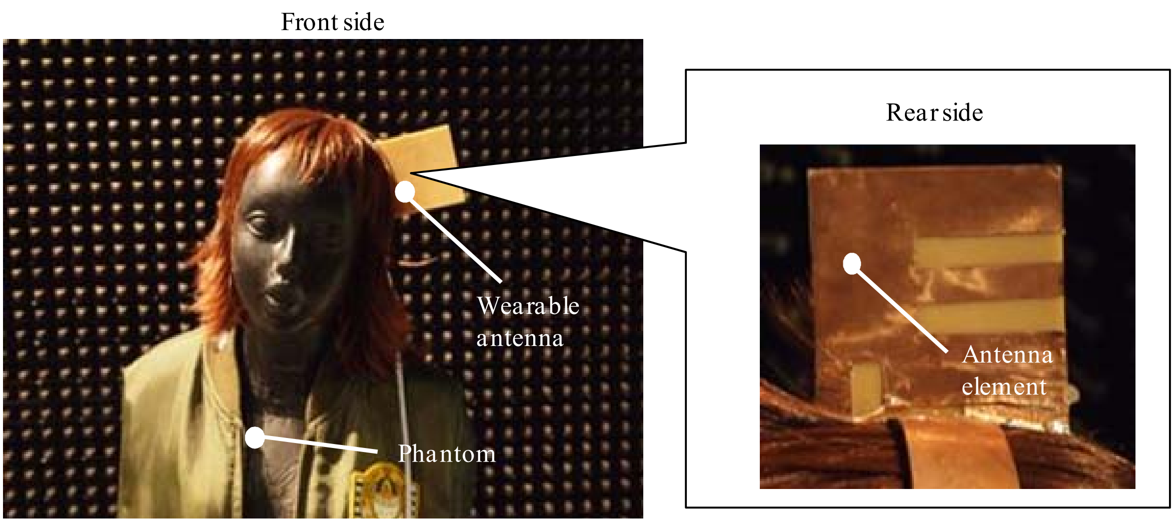

Fig.7 State of the measurement