Two Element Monopole Wearable Antenna Suppressed Radiation in Human Body Direction

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1. Introduction

Recently, many kinds of wearable fabric antennas for GPS reception have been developed [1], [2]. On the other hand, the wideband antenna application for receiving digital television broadcasting wave from 470 MHz to 770 MHz in Japan is required for mobile terminals. To fulfil this requirement, many kinds of wearable fabric antennas have been developed as an external antenna. [3]-[5]. However, in these antennas, the radiation level to the human body the direction was very high. So, the antenna characteristic was influenced from the human body. Therefore, it is required to suppress the radiation level in human body direction.

In this paper, new wideband wearable antenna suppressed radiation in human body direction for digital television reception is proposed. Details of the simulated results of the proposed antenna are presented and discussed.

2. Proposed antenna 1

The proposed antenna 1 is shown in Fig.1. This proposed planar monopole antenna consisted of two rectangular radiating monopole elements, the transmission line to connect between the antenna element and the rectangular ground plane. To achieve the unidirectional radiation pattern, the antenna space S_2 was about 0.25 wave length. The phase difference of each antenna #1and #2 was generated about 90 degrees.

3. Simulated results of antenna 1

Fig.2 shows the simulated VSWR as parameters of S_1 and S_2. The transmission line length $S_1$and the radiating element length S_2 were same and these lengths were designed about 0.25 wave length as a middle frequency which was 620MHz. This antenna was simulated by Finite Element Method (HFSS). At 0.227 wave length (110mm) shown in the black line, the VSWR of the high region frequency was over than 2. On the other hand, 0.207 wave length (100mm) shown in the green line, the VSWR of the low region frequency was over than 2. From these results, the VSWR less than 2 was obtained from 470 to 770MHz at 0.217 wave length (105mm).

Fig.3(a) and Fig.3(b) show the simulated radiation patterns of the proposed antenna1 when the length of the transmission line and the radiation element was 0.217 wave length(105mm). Simulated frequencies were 470, 620 and 770MHz in consideration of the lowest frequency, middle frequency, and the highest frequency. In the X-Y plane, the radiation gain in direction of 180 degrees was about -10dBi. On the other hand, the radiation gain in direction of 0 degrees was about 3 dBi at 770MHz. In the X-Z plane, the radiation gain in direction of 270 degrees was about -20dBi as well as in X-Y plane. And the radiation gain in direction of 90 degrees was about 3 dBi. From these results, it was confirmed that the proposed antenna 1 can be suppressed the electric wave of the constant direction. Therefore, it is preferable to set up the suppressed direction in the human body.

Fig.4 shows the simulated antenna gains as a parameter of S_2 in the direction of 0 degrees. Fig.5 shows the simulated VSWR of the proposed antenna 1 as a parameter of S_2. The length S_1 of antenna element was fixed at 0.207 wave length (105 mm) and the transmission line length S_2 was changed. But the gains in the low frequency were low, but the gain in the high frequency was high. And in the low frequency, the antenna gain increases by decreasing the transmission line length S_2. But the VSWR was deteriorated by decreasing the transmission line length S_2.. Therefore, the good results of VSWR and gain were obtained at the length S_2 of transmission line was about 0.19 wave length (90 mm).

4. Proposed antenna 2 and simulated result

The proposed taper antenna 2 was shown in Fig.6. As well as in Fig.1, this antenna consisted of two radiating monopole elements, the transmission line to connect between the antenna element and the rectangular ground plane. To miniaturize the antenna size, the shape of the monopole antenna element was transformed from the rectangular to the taper configuration. Moreover, each parameter of the antenna was optimized by simulation. The sizes of the antenna 2 were 160×205.5[mm].

Fig.7 shows the simulated VSWR of the proposed antenna 2 shown in Fig.6. The parameter S_6 of the taper element was changed. In the low frequency, more wideband performance was obtained by resonance frequency shifts to low frequency when the parameter of the taper element was longer. On the other hand, the VSWR was not varied in the high frequency. From this result, the widest wideband was obtained when the length S_6 of the taper element was 20[mm].

5. Proposed antenna 3 and simulated result

The proposed antenna 3 was shown in Fig.8. The antenna size was reduced to about 85 percent compared with the antenna 2 as shown in Fig.6. The sizes of the antenna 3 is 136×174[mm].

Fig.9 shows the simulated VSWR of the proposed antenna 2 and 3 shown in Fig.6 and Fig.8, respectively. The black line was the antenna 2 and the red line was the antenna 3 after size reduction. From these results, the frequency band of the VSWR less than 2 was shifts high frequency by miniaturizing the antenna size. Therefore, the proposed antenna 3 was obtained most wideband.

6. Conclusion

This paper describes two element monopole wearable fabric antenna suppressed radiation in human body direction. The proposed wearable antenna 3 covers wide bandwidth the VSWR less than2 from 470 to 770MHz in the condition that the proposed antenna 3 was in the free space. In addition, the proposed antenna 3 was filled good wideband performance even if the antenna size was miniaturized. As a next stage, it is necessary to measure the VSWR and radiation pattern in the free space and with human body.

References

[1] K. Ogawa et al., "A shoulder mounted planar antenna for mobile radio application," IEEE Trans. On Vehicular Technology, vol.49, May 2000.
[2] M. Tanaka, J.H. Jang, "Wearable Microstrip Antenna," IEEE AP-S, International Symposium, Columbus, Ohio, USA, vol.2, pp704-707, June 2003.
[3] C. Cibin et al., "A Flexible Wearable Antenna," IEEE AP-S, Internal Symposium, Monterey, CA, USA, vol.4, pp3589-3592, June 2004.
[4] Pekka Salonen, Jaehoon Kim, Yahya Rahmat-Samii, "Dual-Band E-Shaped Patch Wearable Textile Antenna," IEEE AP-S International Symposium, Washington, D.C., USA, vol.1A, pp466-469, July 2005.
[5] A. Kuramoto, "Wideband Wearable Antenna," ISAP2007, POS1-58, pp1086-1089, Niigata, Aug., 2007.

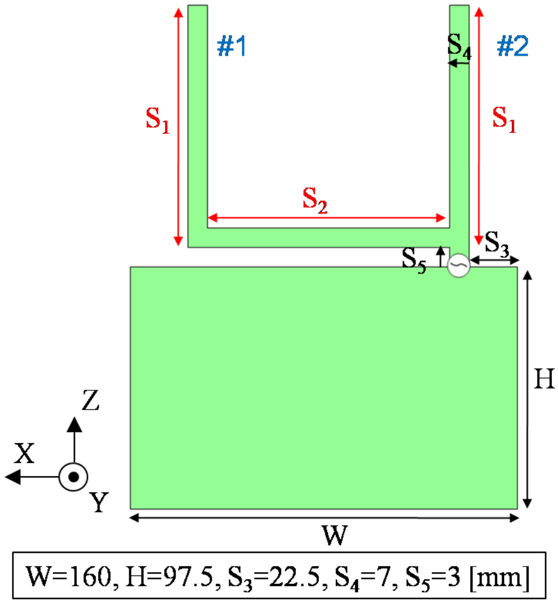


Fig.1 The proposed antenna 1.

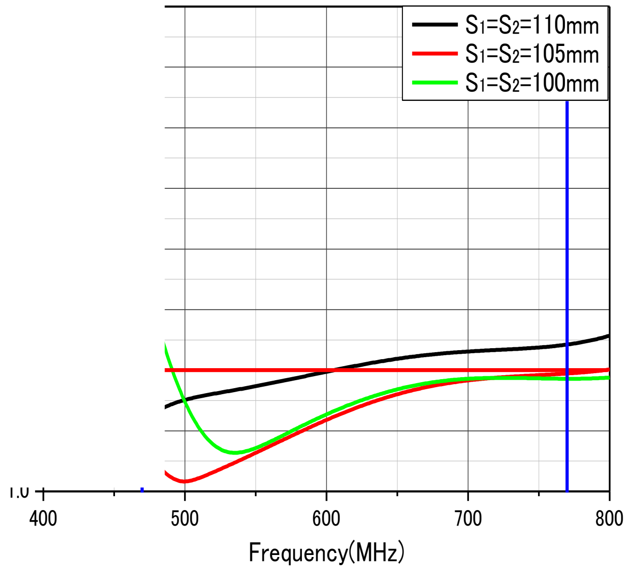
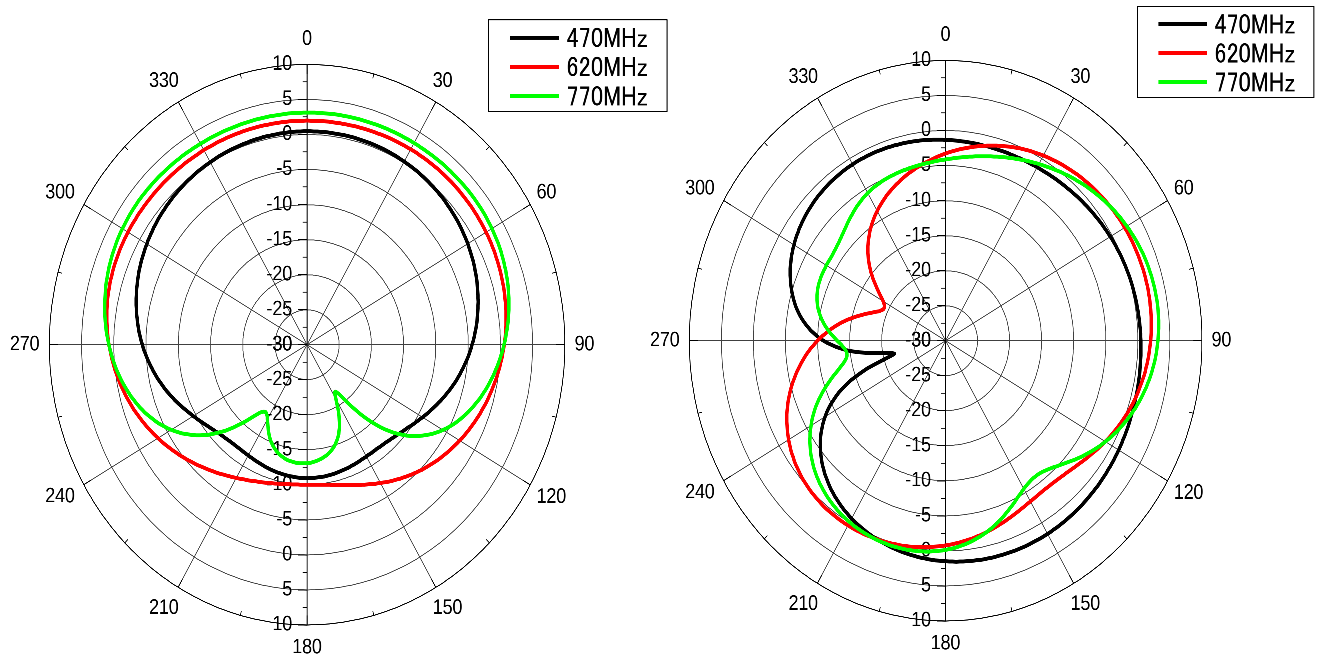


Fig.2 Simulated VSWR as parameters of S_1 and S_2.



(a) X-Y plane (b) X-Z plane

Fig.3 Simulated radiation patterns of the proposed antenna 1.

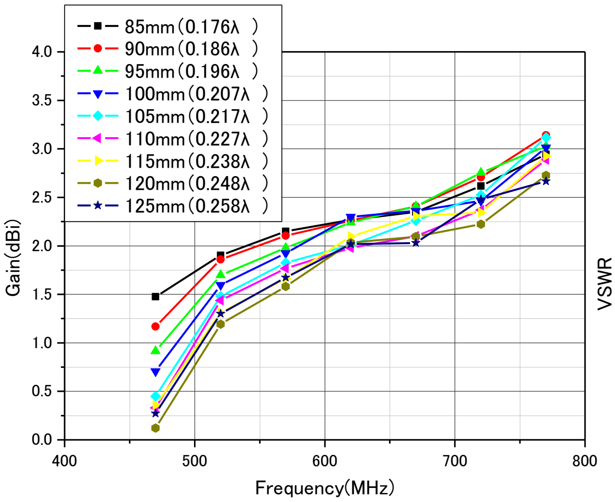


Fig.4 Simulated antenna gains as a parameter of S_2.

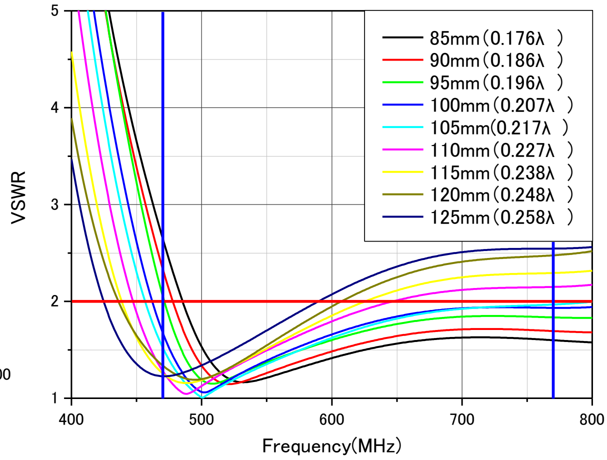
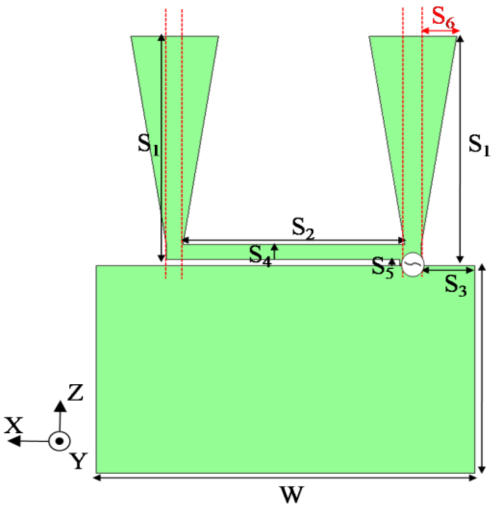


Fig.5 Simulated VSWR as a parameter of S_2.



W=160, H=97.5, S_1=105, S_2=105→90
S_3=22.5, S_4=7, S_5=3 [mm]

Fig.6 The proposed taper antenna 2.

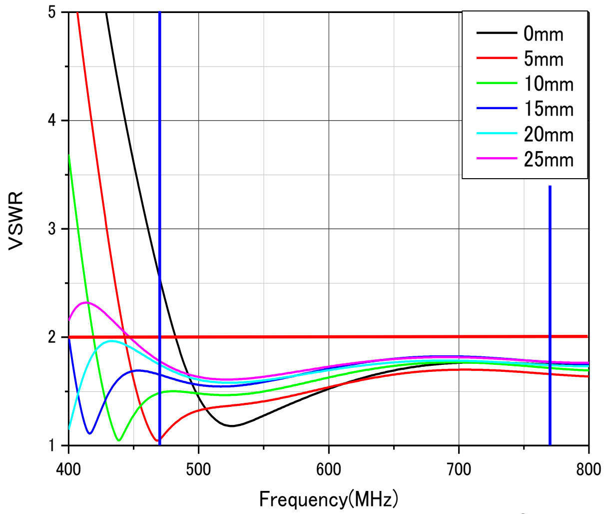
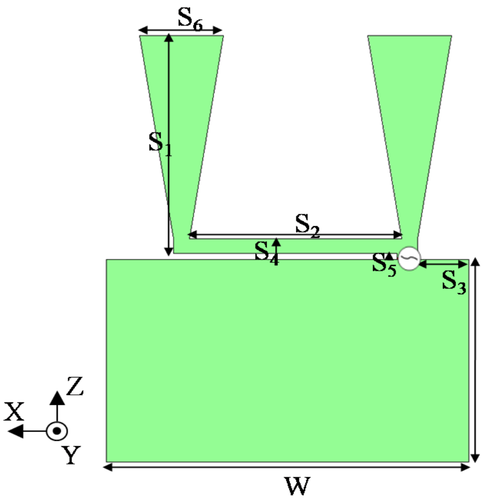


Fig.7 Simulated VSWR as a parameter of S_6.



W=136, H=82, S_1=89, S_2=80,
S_3=19, S_4=6, S_5=3, S_6=40 [mm]

Fig.8 The proposed miniaturized antenna 3.

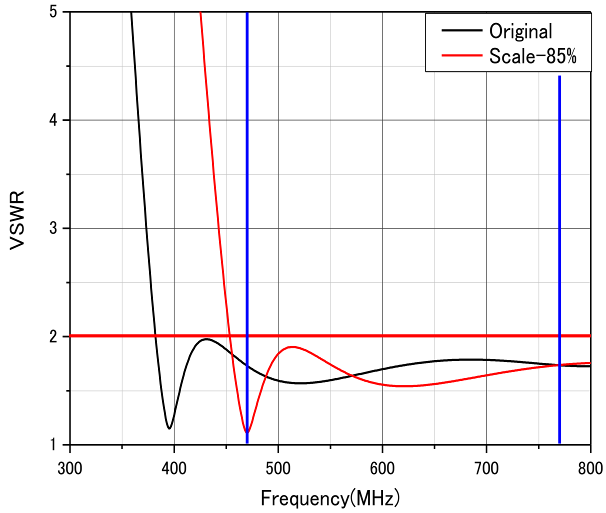


Fig.9 Simulated VSWR.