# Wideband Wearable Antenna Using Simple Feed Method

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#### 1. Introduction

Recently many kinds of wearable or fabric antennas are developed.[1]-[4] These antennas are the strong candidates of the external antennas for the recent small mobile terminals so as to get the better communication and propagation condition. For these applications, we had tried and developed the wideband wearable antenna in order to receive the digital television broadcasting as the first trial.[5] But its feed construction was complex and unsuitable as a general civilian demand product.

This time, we have tried to simplify the feed construction for the easy handling as a general civilian demand product. The simplified feed construction has been realized by using the snap buttons for dressmaking. This paper introduces the antenna using the simple feed construction and its performances in the free space and on the human body.

# 2. Target Application

The target application of this antenna is to receive the digital television broadcasting in Japan. Its frequency band is from 470MHz to 770MHz. In addition, it is available as the external antenna for the mobile terminal in 800/900MHz bands and the specified low-power radio, which is used at 422MHz in Japan and 446MHz in Europe as Personal Mobile Radio, if it can be cover the wider band from 422MHz to 960MHz.

The assumed usage situations are as the external antenna located in free space and the wearable antenna set on human body. Therefore this antenna had better achieve the good performance in both situations. In this case, the recommended return loss is less than -9.5dB (VSWR<2.0).

### 3. Antenna Construction

The photograph of the antenna is shown in Fig.1. The constructions of the antenna and the feed part are shown in Fig.2 and Fig.3.

This antenna consists of two right-angled triangular elements and the feed unit. Two triangular elements are made of the conductive fabric on the rectangular non-conductive fabric. The electrical conductivity of the conductive fabric is  $1.36\times10^4~\text{S/m}$ . Each triangular element is fixed on the rectangular fabric by the tread.

Two triangular elements are set symmetrically along the horizontal line and the upper element is slid to left. The length of the horizontal side of the triangular element is 0.25 wave length and the length of the perpendicular side is 0.17 wave length at the lowest target frequency which is 422MHz. The feed position of the upper element is set at a position of the distance of 0.11 wave length from the right apex in order to match the input impedance. [5]

The feed to the upper and lower elements is implemented by using a pair of the snap buttons for dressmaking. One of the pair of the snap buttons is also fixed on the feed point of the element by the thread. Other of the pair of the snap buttons is fixed on the printed circuit board by soldering. And it is connected to the coaxial cable.

Using the snap button for the element feeding can realize easy handling, which is connected and disconnected, for a general civilian user. Regarding the antenna design, the dimension of antenna is optimized by experiment and simulation. First the dimension of the antenna is adjusted roughly by experiment. After that, it is optimized by simulation using Moment Method. (Software:IE3D)

#### 4. Measured Performance

The measured return loss characteristics in the free space and on the human body are shown in Fig.4. The band whose return loss is less than -9.5dB is from 370MHz to 990MHz in both conditions. It covers the target application bands enough.

Next the radiation pattern in zx-plane at 470MHz is shown in Fig.5. In this plane, the pattern for  $E\theta$  is bi-directional and that for  $E\phi$  is omni-directional. The peak gain is -1.7dBd. These patterns include the coaxial cable loss of 0.5dB at 470MHz and therefore the peak gain without the coaxial cable loss is -1.2dBd.

The radiation patterns in xy-plane from 470MHz to 760MHz are shown from Fig.6 to Fig.8 when the antenna is located in the free space(a) and on the human body(b).

In the free space, the pattern for  $E\theta$  is approximately omni-directional and that of  $E\phi$  is bi-directional. For a change of frequency, most of pattern shapes do not change. But the pattern for  $E\theta$  at 760MHz in Fig.8(a) has the low gain area at 270 degrees direction and the omni-directional pattern shape is not maintained. The peak gain including the feed unit loss and the coaxial cable loss is -2.4dBd at 470MHz, -1.4dBd at 620MHz and -0.3dBd at 760MHz.

On the human body, the radiation toward the human body is lost. But the pattern shape and the front gain toward the free space is almost maintained. As one of its reason, it is considered this antenna has the better impedance matching under the conditions in the free space and on the human body.

From the above facts, this antenna is effective as the wearable antenna or the external antenna for the mobile terminal and the related wireless communication equipment.

## 5. Conclusion

The wideband wearable antenna using simple feed method has been successfully developed. This antenna is made of the conductive fabric and its simple feed is realized by using the snap buttons for dressmaking.

As its performances, it covers the wide band from 370MHz to 990MHz. So it is useful for the specified low-power radio in 422MHz band, receiving the digital television broadcasting from 470MHz to 770MHz in Japan and the mobile phone in 800/900MHz bands. Additionally, it is available in the free space and on the human body without degradation of performance.

Therefore this antenna is effective as the wearable antenna and the external antenna for the mobile terminal and the related wireless communication equipment.

As a next stage, it is planed the development of the antenna for higher band.

### References

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- [5] A. Kuramoto, "Wideband Wearable Antenna," ISAP2007, POS1-58, pp1086-1089, Niigata, Aug., 2007.

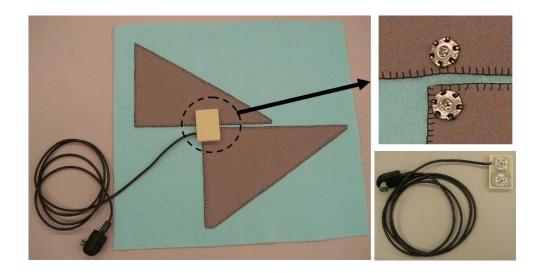


Figure 1: Photograph of antenna

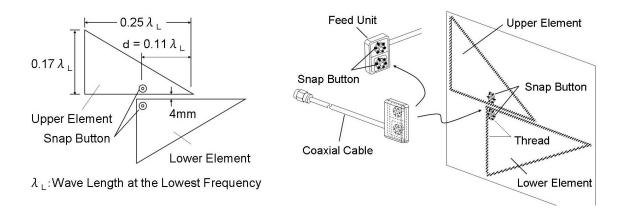


Figure 2: Construction of antenna

Figure 3: Construction of feed part

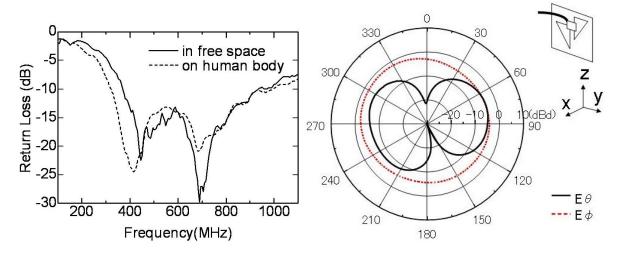


Figure 4: Return loss of antenna

Figure 5: Radiation pattern in zx-plane at 470MHz

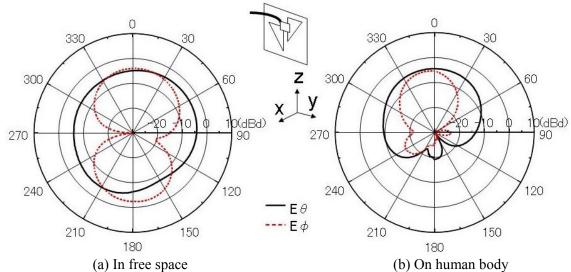


Figure 6: Radiation pattern in xy-plane at 470MHz

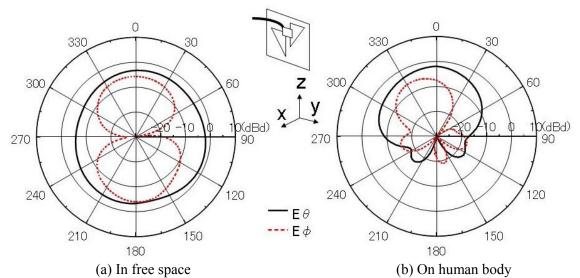


Figure 7: Radiation pattern in xy-plane at 620MHz

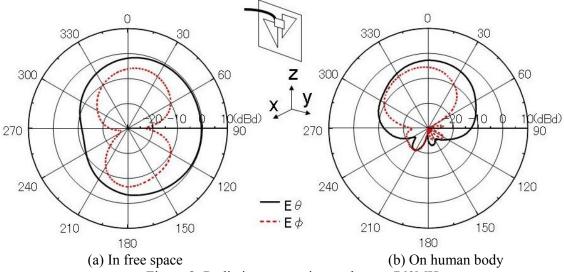


Figure 8: Radiation pattern in xy-plane at 760MHz