Measurement of a slot antenna backed by a half cylindrical cavity made of conductive textiles

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Abstract - **Reflection and radiation characteristics of a slot antenna backed by a half cylindrical cavity made of conductive textiles have been measured. Two conductive textile sheets and conductive threads configured a post-wall structure forming a cavity of a thin half-cylinder. The antenna was designed for the operation frequency around 2.45 GHz. The reflection and radiation characteristics were measured in the cases that it was planar and bent on a spherical surface, and they were compared with those of a rectangular cavity which has already been reported. As a result, the radiation characteristics did not change much by bending, and the operating band in the reflection characteristics was less shifted by bending than the slot antenna backed by a rectangular cavity. Its height was the same and its surface area decreased into 0.6 times of the rectangular cavity.**

Index Terms — **Slot antenna, Conductive textile, Cavity, Wearable device, Half cylinder.**

1. Introduction

Recent years wearable devices have been paid much attention, which include not only wearable computers but also so called smart devices and personal assistant devices. Wireless communication function is essential to such devices and they need to configure wireless networks between wearable on-body nodes or between on-body and off-body nodes. One example of their applications is a personal health monitoring system using a body area network of sensor nodes.

Wearable devices should be thin, light, and flexible. A lot of wearable antennas have been proposed so far, most of which are made of textiles [1]-[8]. Our research group have been studying cavity-backed slot antennas (CBSAs) using conductive textile sheets [7][8]. The conductive threads used in our study include aluminum and are not fine metallic wires or filaments, but made by means of a traditional technology and have been used as ornamental yarn for clothes for hundreds years. First, we utilized a rectangular cavity of textiles that was an envelope type. A post-wall structure was then applied to the backed cavity. In this study we have tried a half cylindrical shape and a smaller size of the antenna was fabricated than the previous ones.

2. Half Cylindrical Cavity-Backed Slot Antenna

The operation frequency of a CBSA is considered to be close to the resonant frequency of the backed cavity. The resonance of a cylindrical cavity is first considered before the structure of the half cylindrical cavity-backed slot antenna is explained. When the height of the cylinder is much smaller than the radius, i.e. forming a disk-typed cavity, uniform field distributions can be assumed in the height direction. The cross section normal to the top and bottom circles and including the central axis of the cylinder is considered as a magnetic wall. The resonant frequency and field distributions do not change if it is divided into two half-cylindrical parts by this magnetic wall. So, the disk type cylinder can be thereby modified into a half-cylinder with a narrow aperture. The aperture works as a radiating slot and is directing sideways, which was reported by Kaufmann, et al. [6]. The radiating aperture is close to the human body when the antenna is worn as a wearable antenna. To avoid radiation toward the body side we have modified the cavity such that the aperture is on the top surface rather than the side, and then it is a cavity-backed slot antenna shown in Fig. 1.

Considering the resonance of the original circular cylinder, the first zero of the Bessel function of the first kind of order zero was used to estimate the approximate size of the cavity. And then the sizes in Fig. 1 were obtained by a finite-element method base simulation software (ANSYS HFSS).

Two sheets of conductive textiles as parallel plates were sandwiching polyethylene foam sheets of 2.5 mm thickness, and they were stitched with a bundle of two conductive threads having the diameter of 150 μm. The stitching conductive threads formed arrays of vias working as post-walls. The slot was made by getting rid of the conductive threads on the upper textile. On the antenna, a feed line crossed on the slot for electromagnetic coupling and then was connected to a tuning stub line that was a microstrip line on a PTFE substrate [8]. Since it was preferable to use a flexible feed line, the substrate was a thin film whose thickness was 0.5 mm. The stub line was an open-ended microstrip line.

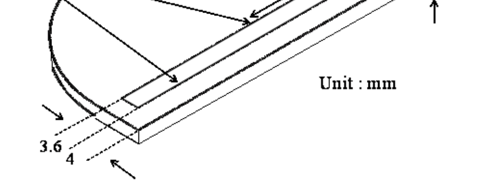


Fig.1. Slot antenna backed by a half cylindrical cavity.

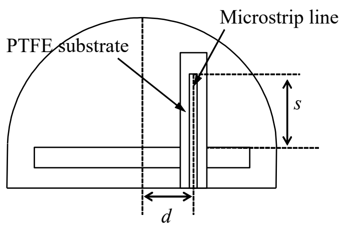


Fig.2. Offset *d* and stub length *s*.

The offset position from the center of the slot and the length of the stub line were tuned to match the impedances of the feeder and the antenna as shown in Fig. 2.

3. Reflection Characteristics

The reflection and radiation characteristics were measured for the flat and bending cases. The roundly bending case was carried out by setting the antenna on the surface of a polystyrene foam in a spherical shape. The radius of curvature was set to *rc* = 225 mm since we assumed the curved surface of a shoulder blade or upper buttocks. The offset position of the feeder and the stub length were 25 and 19 mm, respectively.

Figure 3 shows the reflection characteristics. The bandwidth was 162 MHz for the flat antenna and became narrower to 147 MHz for the bending case. The center frequency was lower by about 30 MHz. They were compared with those of the antenna with a rectangular cavity. In the previous report [8], the bandwidth was 230 MHz for the flat antenna and became narrower to 162 MHz for the bending case. The center frequency was lower by about 110 MHz. Thus the bandwidth and the center frequency of the proposed antenna were less changed by bending than the slot antenna backed by a rectangular cavity.

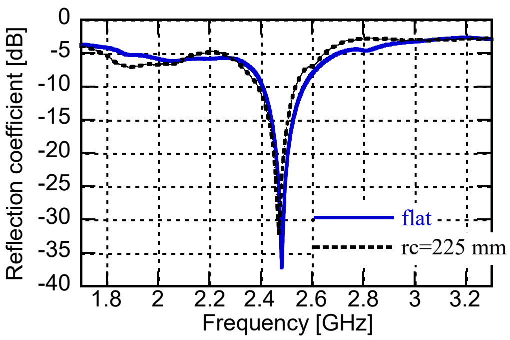
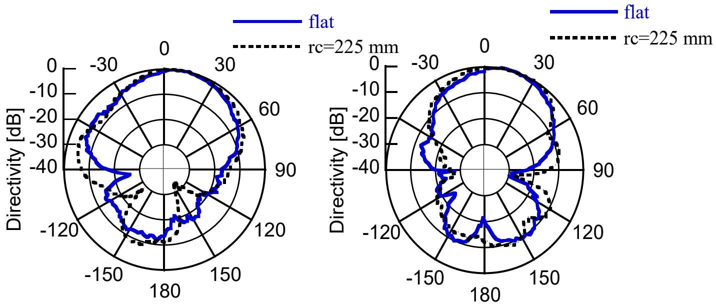


Fig.3. Reflection characteristics.

4. Radiation Characteristics

Next, the radiation patterns will be shown. The fabricated CBSA was used as a receiving antenna, and the transmitting antenna was a double-ridged waveguide antenna (Lindgren, model 3115). The distance of the two antennas was 2.5 m, and the frequency was chosen as 2.49 GHz. The variation in the radiation patterns by being bent were shown in Fig.4 (a) and (b) for E- and H-plane characteristics, respectively.



(a) E-plane pattern (b) H-plane pattern

Fig. 4. Radiation characteristics.

In the E-plane radiation, several dB changes appeared in the backward and side directions where the radiation was not strong. On the other hand the front side patterns in both E- and H-planes changed little by bending.

5. Conclusion

We fabricated a slot antenna backed by a half cylindrical cavity made of conductive textiles and the reflection and radiation characteristics were measured in the cases that it was planar and bent on a spherical surface.

As a result, the reflection and radiation characteristics were less changed by bending than the slot antenna backed by a rectangular cavity. Thus, this flexible antenna could hold the characteristics of the flat case even when it was bent on a spherical surface. Its surface area decreased into 0.6 times of that of the rectangular cavity while it was the same height.

Acknowledgment

This work was supported by a Grant-in-Aid for Scientific Research (C) from Japan Society for the Promotion of Science: JSPS KAKENHI Grant Number 26420356.

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