WEARABLE PATCH ANTENNA

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Abstract

We report a flexible and light-weight wearable patch antenna that can be sewn into clothing and hats. This antenna is a microstrip antenna composed of felt and a conductive woven fabric. The characteristics of the test antenna were evaluated, and it was found that this antenna operates normally as a microstrip antenna, and is practical and feasible for communication.

1. Introduction

The microstrip antenna is being used as a representative antenna for mobile and satellite communication. Though the microstrip antenna has features such as planes and relatively high gain (about 7dBi), it is general to fabricate them by using a hard substrate. However, those substrates are limited in shape and mounting placement for fixing such an antenna to clothing or hats [1]. Therefore, we propose a flexible and light antenna.

This antenna was fabricated using a flexible conductive woven fabric and felt; therefore, it can be easily sewn in clothing or hats. Its purpose is to be used for satellite communication, or to monitor the position of aged people who have wandered. In this paper, the structure of the antenna is described, and its characteristics are evaluated.

2. Structure of the antenna.

Figure 1 is a photograph of the antenna, and structure of the antenna is shown in Fig. 2. In Fig. 1, the left side shows the antenna wound around an arm and right side shows how the antenna bends.

The antenna's frequency is 2.5 GHz, and its polarization is linear. The patch and the ground are a conductive woven fabric, and the dielectric part is common felt. The feed method is pin feed for simplicity. The conductive woven fabric is usually used as an electromagnetic shielding material. Its thickness is 0.125 mm, the surface density is 72g/m^2, and the surface resistance is 0.05Ω/sq. The felt is a commercially available material with a thickness of about 1 mm; the estimated dielectric constant of the felt is 1.43.

Fig. 1 Photograph of wearable patch antenna

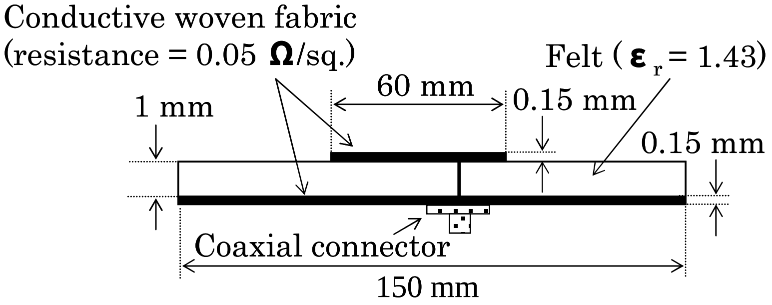
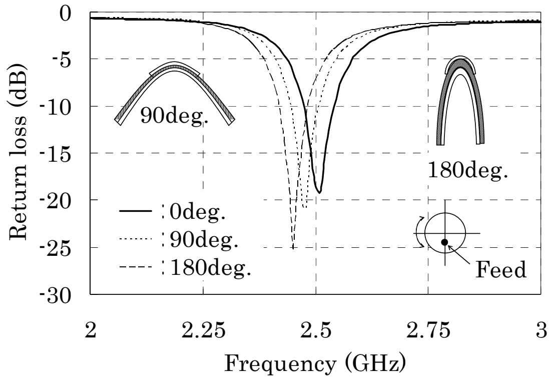


Fig. 2 Structure of wearable patch antenna

To use the conductive woven fabric, we measured its return loss and transmission loss. We put the woven fabric between two coaxial/waveguide adapters (for 1.7 GHz—2.6 GHz), and we measured return and transmission loss by using a network analyzer. At frequency 2.5 GHz, the return loss and transmission loss were 0.03 dB and 74 dB, respectively. This measurement showed that the woven cloth could possibly be used as an electric conductor.

3. Experiments and Results



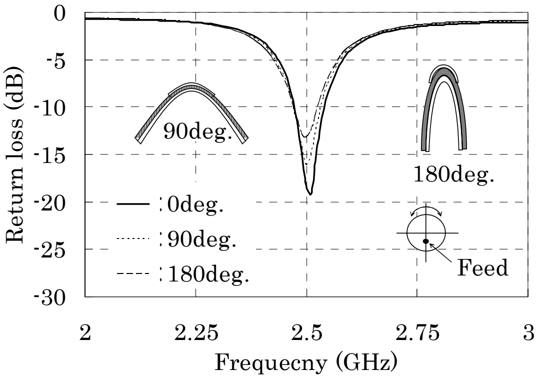


Fig. 3 Return loss when bending the E-plane

Fig. 4 Return loss when bending the H-plane

In order to examine antenna characteristics, we measured the return loss and gain of a test antenna. The return loss is shown in Fig. 3. In Fig. 3, the return loss when bending the antenna is also shown. In Fig. 3, 0 deg. is when the antenna is not bent, and 90 deg. is when the E-plane is bent to a V-shape at the center of the patch antenna, and 180 deg. shows the E-plane bent to a U-shape at the center of the antenna. Figure 4 shows the return loss when bending the H-plane of the antenna center.

In the conditions shown in Fig. 3 and Fig. 4, the fundamental return loss was about -20 dB, and the fundamental resonant frequency was 2.505 GHz. As the E-plane or the H-plane was bent, the fundamental resonant frequency moved to about 25 MHz or 5 MHz, respectively. Clearly bending the H plane shifted the resonant frequency less than bending the E-plane.

Table. 1 Antenna gain when bending H-plane and E-plane

	0 deg.	90 deg.	180 deg.
H-plane	6.51dBi	5.28dBi	4.5dBi
E-plane	6.51dBi	4.98dBi	4.12dBi

Next, the measurement results for the gain when bending the E- or H-plane are shown in Table 1. The measurement frequency for all was 2.505 GHz. Similarly to the return loss, the gain when bending the E-plane also dropped further than that when bending the H-plane. The gain for 180 deg. bending of the E-plane dropped most from the fundamental gain, and the gain degradation was 2.4 dB.

The radiation patterns when bending the E-plane and H-plane are shown in Fig. 5 and Fig. 6, respectively. The measurement frequency was also 2.505 GHz for the graphs of both radiation patterns. When either the E- or H-plane was bent, the width of the main

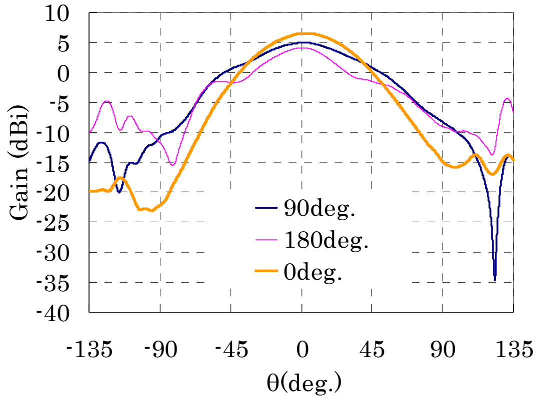


Fig. 5 Radiation pattern when bending E-plane

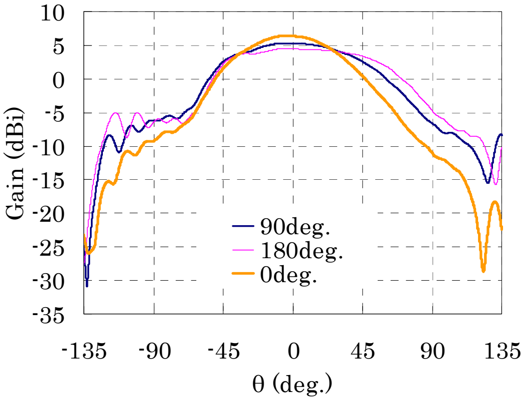


Fig. 6 Radiation pattern when bending H-plane

beam tended to widen. As the E-plane was bent, the energy of the main beam tended to move to the side lobe.

From the results illustrated above, we found that the bend direction of the patch antenna depended on the current flow direction, and that the degradation depended on the density of the current distribution.

4. Conclusion

In this paper, we described a wearable patch antenna to be sewn in clothing and hats, and reported the testing and evaluation of its characteristics. Experimental results showed clearly that the gain of this antenna is almost equivalent to that of a conventional patch antenna when the antenna was not bent. It was also clear that the gain drop of about 2.4 dB when bending the E-plane 180 deg. was the largest. When the antenna is actually used on clothing and hats, the antenna seems to be practical and feasible as a patch antenna. Moreover, if a gain degradation of about 2 dB is acceptable, the antenna seems to be usable even if it is bent slightly.

In future work, we will study a feed method, not obstructing coaxial connector for wearing the antenna, and an antenna array (Fig. 7) sewn into clothing and hats.

Fig. 7 Antenna array on the hat

Reference

[1] P. J. Massey, "GSM fabric antenna for mobile phones integrated within clothing," 2001 IEEE Antennas and Propagation Symposium Digest, pp. 452-455.