Side Lobe Suppression by Various Conical Wall Edge of Multiband Spiral Antenna

Kyeong-Sik Min[1]
[1]Department of Radio Communication Engineering, Korea Maritime and Ocean University,
727, TAEJONG-RO, YEONGDO-GU, BUSAN, 49112, KOREA
ksmin@kmou.ac.kr

Abstract **– The various conical wall edge structure design of multiband spiral antenna for side lobe improvement is considered. The various edge shapes were designed and evaluated. The axial ratio of spiral antenna with a novel edge structure was not almost changed to compare with the conventional spiral antenna with only conical wall. The measured back lobes of spiral antenna with an elliptical dual edge and a rolled-up edge were remarkably improved. The gain at boresight was simultaneously increased.**

Index Terms **— Spiral Antenna, Multiband, Conical Wall Edge, Back Lobe Suppression, Elliptically Bended Edge, Rolled-up Edge. Circular Polarization**

1. Introduction

Circularly polarized multiband spiral antenna with conical wall and reflector has been proposed [1]. In order to realize a high gain, the optimum conical cavity wall as shown in Fig. 1 was also proposed by author's group [1]. A spiral antenna with the conical cavity wall [1] had been appeared the wide beam width and the high side lobe level. In order to realize the narrow beam width and high gain, the spiral antenna combined with a dielectric biconvex lens was proposed [2]. The narrow beam at the interested bands was realized by using biconvex lens. However, the side lobe problem was still remained and was not considered in ref. [2]. In order to suppress the side lobe which is included the back lobe, various conical cavity wall edge are proposed in this paper. The concept of elliptical edge design corresponds with an aperture-matched horn [3] design. This concept [3] had been proposed to eliminate the troublesome edge diffractions not by reducing the incident field on the aperture edges but by reducing the aperture diffraction. The method of ref. [3] is not completely agreed with the conical wall edge. Because a conical wall length is shorter than a horn length, edge diffraction of conical wall edge will be violently generated to compare with one of horn edge. Therefore, an optimal edge design suitable for conical wall is strongly required. The terminated edge of the conical wall which is practically identical short horn wall was designed.

2. Antenna Structure and Edge Design

Fig. 1 shows a spiral antenna structure with conical wall edge [1]. It is composed of a radiating plane, a ground plane with Archimedean slit, metal cap as a reflector and a conical cavity wall.

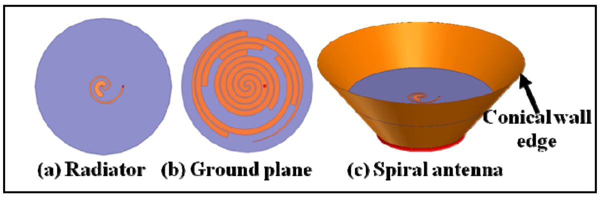

Fig. 1. Spiral antenna structure with conical cavity wall. [1].

In order to improve high back lobe caused by edge structure as shown in Fig. 1, various edge structure matched with conical wall as shown in Fig. 2 was designed and simulated for side lobe suppression.

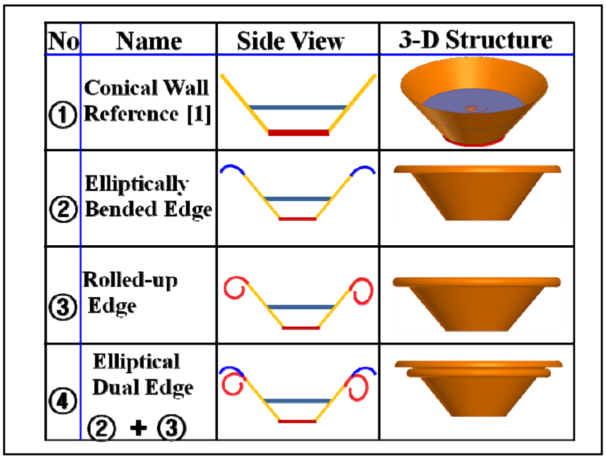

Fig. 2. Comparison of the edge structure for side lobe suppression.

An elliptically bended edge sharp of no. ② has similar with the aperture-matched horn edge of ref. [3]. Structure of no. ③ is intentionally designed well-matched with no. ①. Edge sharps of no. ② and no. ③ are perfectly different. An elliptical dual edge of no. ④ has a combined structure of no. ② and no. ③.

3. Simulation Result

Fig. 3 shows the simulated axial ratio with respect to various curved edge structure as shown in Fig. 2. One of the important targets in the edge design does not change the axial ratio even though edge sharp is changed to suppress the back lobe. Solid black line of no. ① appears the axial ratio without added edge. The axial ratio is kept by the optimum edge design even though edge sharp is changed or edge length is extended.

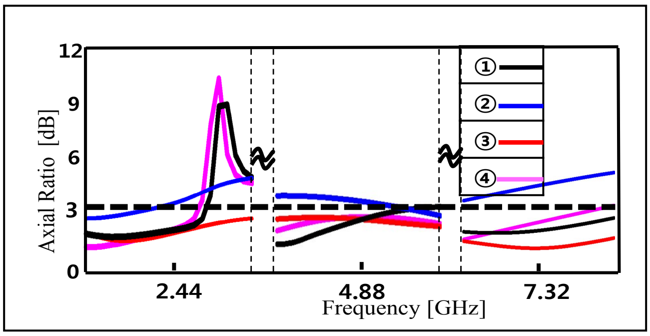

Fig. 3. Simulated axial ratio for 4 kinds of edge structure.

Fig.4 shows the simulated E-plane patterns for various edge structures at 4.88 GHz. In order to obtain a conical wall structure with improved back lobe without greatly sacrificing the size, axial ratio and cost, the conical wall without the curved edge in Fig. 2 is modified by attaching curved surface sections to the aperture edges so that the resulting junction is smooth to the touch. The back lobe patterns of ③ and ④ structure is remarkably improved about 3 dB to compare with one of ① structure without the curved edge. The boresight directivity gain of ④ structure appears higher about 0.3 dBi than gain of ③ structure as shown in Fig. 4.

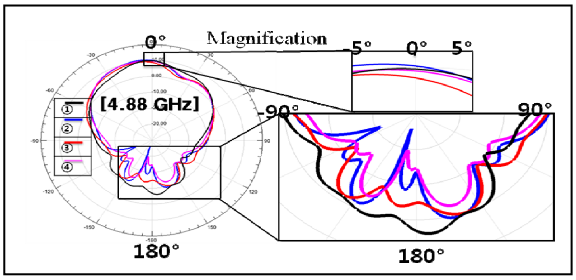

Fig. 4. Simulated E-plane patterns for various edge structures.

4. Experimental Results

Fig. 5 shows a photograph of a fabricated antenna of no. ④ as shown in Fig. 2.

Fig. 5 Photograph of a fabricated antenna of no. ④.

Fig. 6 shows the measured reflection coefficients with respect to various curved edge structure as shown in Fig. 2. Return loss level of – 10 dB below are observed at design frequency band. The return loss does not almost change even though the edge is added by the elliptically bended edge sharp.

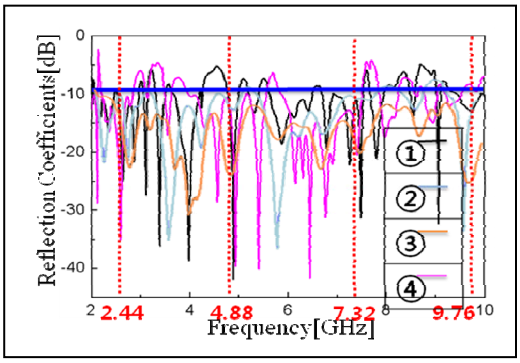

Fig. 6. Measured reflection coefficients with respect to various edge.

Fig. 7 shows the measured radiation pattern comparison between no. ① and no. ④ at 2.44 GHz and 4.88 GHz. The measured back lobe of no. ④ is remarkably reduced about 10 dB above at 2.44 GHz and 4.88 GHz. The measured gain of no. at a boresight ④ is increased about 0.4 dBi.

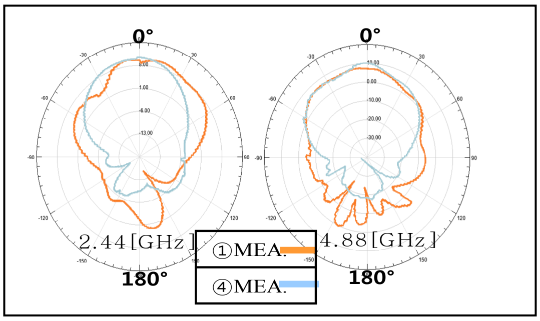

Fig. 7 Measured radiation pattern comparison between no. ① and no. ④.

5. Conclusion

Various conical wall edge design of spiral antenna for back lobe suppression was conducted. The axial ratio is maintained by the optimum edge design even though edge sharp and edge length are changed. The measured back lobe of no. ④ is remarkably reduced about 10 dB at 2.44 GHz and 4.88 GHz.

Acknowledgement

This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (No. 2013R1A1A2059944. The author would like to thank Mr. Dong-Hyun Yoon for their useful simulation support and technical assistance.

References

[1] Jae-Hwan Jeong, Kyeong-Sik Min and In-Hwan Kim, "Design for High Gain Spiral Antenna by Added Conical Cavity Wall", *The journal of KIEES*, Vol.13, No.3, pp. 165-172, Sep. 2013.

[2] Kyeong-Sik Min, "High Gain Antenna by Combination with Dielectric Biconvex Lens and Spiral Radiator", *IEEE AP-S/URSI 2015, pp.623-624, Vancouver, Canada,* July 19-24, 2015.

[3] Walter D. Burnside and C.W. Chuang, "an Aperture-Matched Horn Design," *IEEE Trans. AP*, Vol. AP-30, No. 4, Pp. 790 – 796, July 1982.