POS1-23

Application of single point feeded wide band circularly polarized coplanar antenna

#Kanya Hirabayashi [1], Masanobu Kominami [2]

[1] Glass Business Planning & Development Department, Central Glass Co., Ltd
1510 Ohkuchi-cho Matsusaka-city Mie Japan, kanya.hirabayashi@cgco.co.jp

[2] Osaka Electro-Communication University
18-8 Hatsu-cho Neyagawa-city Osaka 572-0833 Japan, kominami@isc.osakac.ac.jp

1. Introduction

In the communication of vehicles or mobile phones, the radio wave comes from any direction with variety of polarization. Therefore, the antenna which has omni-directional and polarization independence characteristics is required. In addition, good design and a low cost are required. As a glass antenna is produced by printing method, which is suitable for mass-production, a glass antenna has advantage in the shape and the cost to the roof antenna. However, since a glass antenna is constructed on a glass surface, it couldn't apply multilayer structure like a MSA. Therefore, it is difficult to design for a circular polarization antenna, which is required under the multipath propagation environment. There are varieties of polarizations such a multipath field.

The antenna which has broadband circular polarization characteristics with single point feeded has been proposed, such as stacked MSA [1], [2], combined a micro strip line and L shape monopole antenna element [3] . Moreover, modified slot loop antenna on the glass sheet has been proposed as a single point feed circular polarization antenna [4].

This paper describes the study of single point feeded circularly polarized coplanar antenna. Moreover, beam tilt application is proposed.

2. Antenna details and principle of the operation

The features of the proposed antenna is a slot which locates the upper end of a rectangular ground plain, and an L shape antenna element connects to the slot around the its center position. The Feeding point is the end of the slot, indicated as F in Fig. 1. The total length of L shape element, L1 + L2, and slot length are equivalent to 1/2λ, and a bending point is a center of the L shape element. The antenna pattern is shown in Fig. 1, which is constructed on the +z-axis side of a glass sheet. The frequency range which has the axial ratio 3 dB or less is 2.07 to 3.08 GHz, and bandwidth ratio is 39.2%. This shows that the proposed antenna generate a circular polarization over the very wide range. In Chapter 3, the details explain.

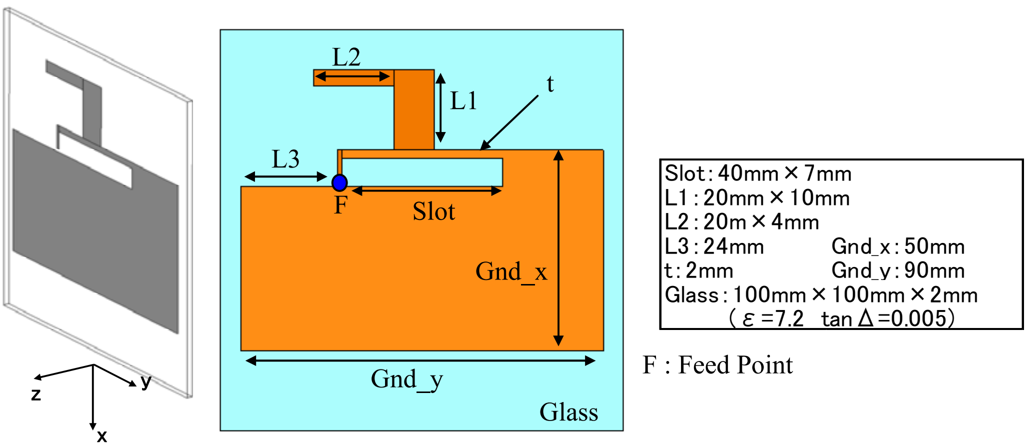
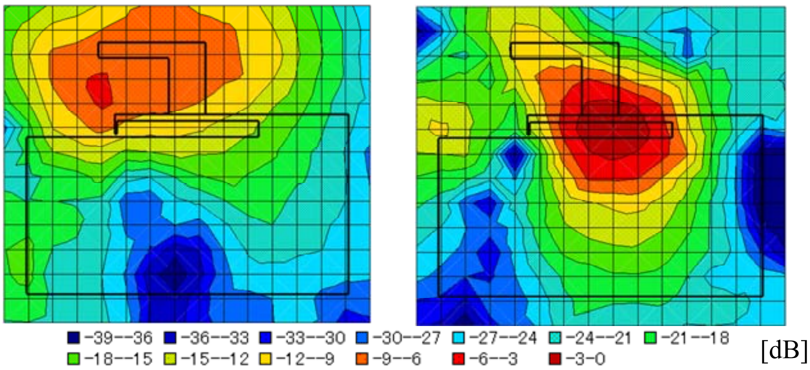
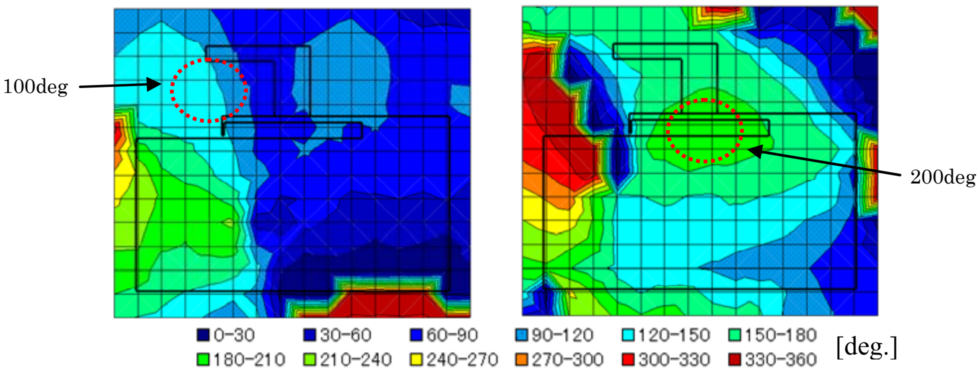


Fig.1 Antenna coordination of single point feeded circularly polarized coplanar antenna.

In order to verify the circular polarization generation principal of the proposed antenna, the X component and Y component of the electric field strength and the phase were obtained by numerical calculation. Evaluation frequency was 2.3 GHz which is the center of the bandwidth.
The observation position of electric field defined at 13 mm -z-axis, back side of the antenna. The strength of the electric field in X component is shown in Fig. 2 (a), and the strength of a Y component is shown in Fig. 2 (b). The evaluated value is normalized by its maximum electric field strength as 0 dB. The phase in X component of the electric field is shown in Fig. 3 (a), and the direction of the Y component is shown in Fig. 3 (b). The maximum strength of the X component electric field is observed near the slot, and the phase is about 200 degree at that point. The maximum strength of electric field of Y component is about -5dB and it generated near the L shape element, phase difference is about 100 degree. Compared the electric field of Y and X components, difference of the electric field strength is about 5 dB; phase difference is about 100 degree. Therefore, generation of the circular polarization is confirmed.



(a) Y component (b) X component
Fig.2 Strength of electric field near the antenna



(a) Y component (b) X component
Fig.3 Phase of Electric field near the antenna

3. Antenna Performance

A frequency characteristic, directional characteristic, and impedance characteristic are studied. The reference antenna is crossing dipole antenna (XDP) shown in Fig. 4. XDP generates circular polarization wave by adjusting the length of the crossing antenna element slightly. The antenna conductor in this study is formed on the z-axis side of a glass sheet. The radio wave comes from the - z-axis direction in a frequency characteristic study.

The frequency characteristic of an axial ratio is shown in Fig. 5 (a), and the frequency characteristic of a gain is shown in Fig. 5 (b). The red lines in figures show the calculated value of XDP, green lines show the calculated value of this antenna, and blue lines show the measured value of this antenna. The frequency characteristic of the axial ratio shows broadband compared with XDP. The frequency range which an axial ratio is 3 dB or less is 2.23 to 2.31 GHz in XDP, and bandwidth ratio is 3.5%. The proposed antenna is 2.07 to 3.08 GHz, and bandwidth ratio is 39.2%. Antenna gain is approximately equal between XDP and the proposed antenna.

The accuracy of the calculated value of the proposed antenna is examined. In Fig. 5, the calculated value and the experimental value show the similar tendency, and it seems that the calculated value is appropriate.

Fig. 6 (a) and (b) show the directional characteristics of XZ plane and YZ plane under the frequency of 2.3 GHz. The solid lines show the calculation result of the proposed antenna and dashed lines show the reference antenna, XDP. The maximum radiation direction of the proposed antenna is -150 degree in XZ plane, and 150 degrees in YZ plane. Due to the proposed antenna shape is asymmetric, the direction of maximum radiation biased a little against XDP's direction.

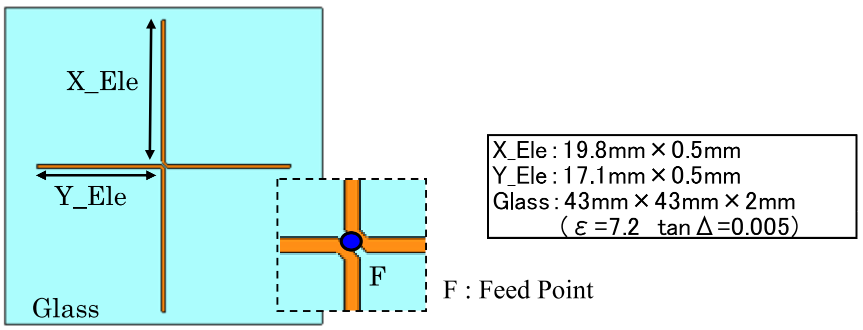
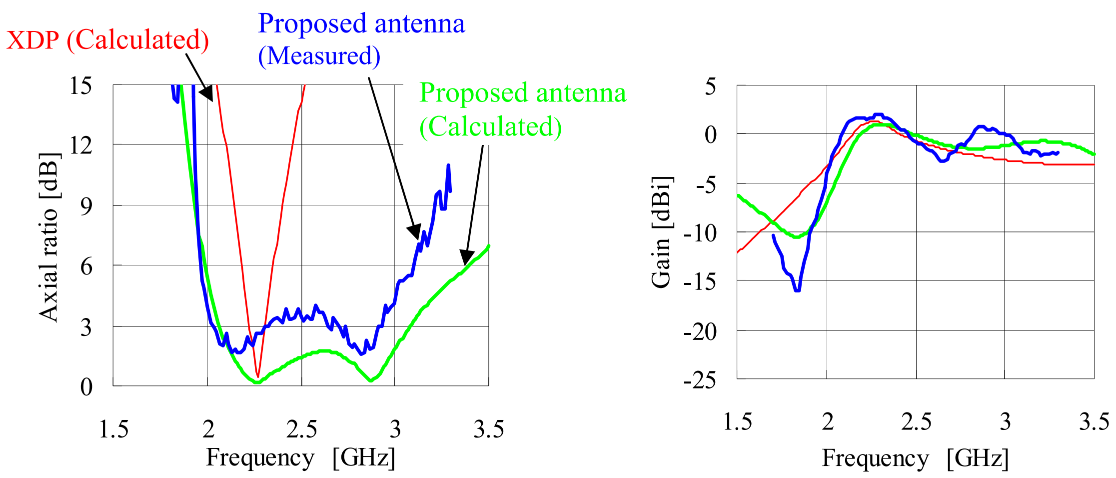
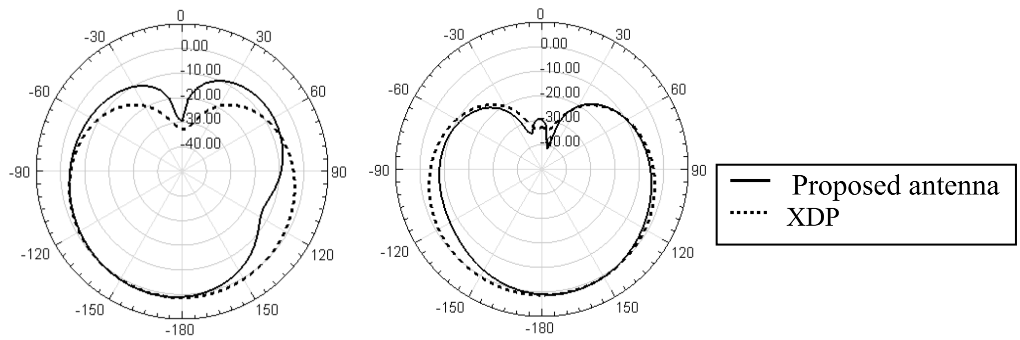


Fig.4 XDP constructed on the glass sheet.



(a) Axial ratio (b) Gain

Fig.5 Frequency characteristic



(a) XZ Plane (b)YZ Plane

Fig.6 Directional characteristics

4. Application

The proposed antenna is applied to the direction control, beam tilt. The antenna pattern is shown in Fig.7. Two proposed antennas are placed on the glass sheet shown in Fig.7. In order to control in the direction of Y-axis, these antennas are connected together by a coplanar line, and feed phase controls by adjusting the position of the feed position of the coaxial cable.

The simulation and the experiment proceed. An experimental result is shown in Fig.8. In order to feed by 50 ohms coaxial cable, the impedance of the coplanar line is determined as 100 ohms. The ratio of the slot width and signal line width is set to 2.5:1. [5][6] As the feed point shifts left in 8 mm, the antenna gain of -30 degree in zy plane is improved about 4 dB. This applied antenna is suitable for the front window of a car, and then the radio wave which comes from the front is efficiently received.

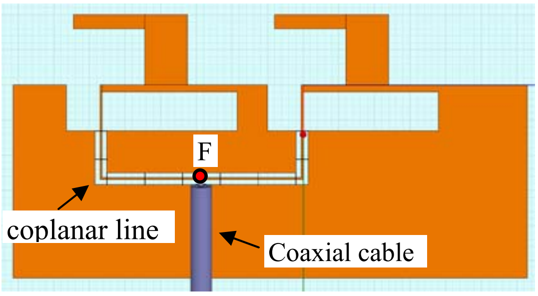


Fig.7 Array of the proposed antenna
(F : Feed point)

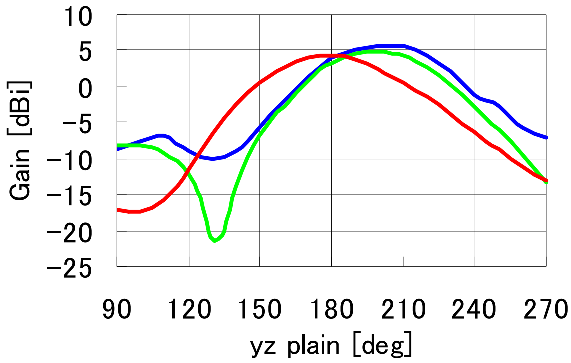


Fig.8 Directional characteristics in yz-plane
: Feed point at the center of coplanar line
: Feed point shifts left in 8mm.
: Measured shifts left in 8mm.

5. Conclusion

The single point feed broadband circular polarization antenna constructed on the glass sheet is examined. The fundamental principal of circular polarization generation is studied by observing the strength and the phase of the electric field of X component and Y component. Moreover, two antennas are placed on the glass sheet and connected together by the coplanar line as an example of application. It is confirmed that the direction of a beam can change by adjusting the position of the feed point.

References

[1]T.Nakamura, T.Fukusako, "Broadband Design of Circularly Polarized Microstrip Patch Antenna Using Artificial Ground Structure With Rectangular Unit Cells" IEEE Transactions on Microwave Theory and Techniques, Vol.59, No.6, pp.2103-2110, June 2011.

[2]T.Noro, Y.Kazama, M.Takahashi, K.Ito, "Circularly Polarized Patch Antennas Combining Different Shaped Linealy Polarized Elements" IEICE Transactions on communication, Vol.J91-B No.5 pp.595-604, May 2008

[3]X.L.Bao, M.J.Ammann, P.McEvoy, "Microstrip-Fed Wideband Circularly Polarized Printed Antenna" IEEE Transactions on Microwave Theory and Techniques, Vol.58, No.10, pp.3150-3156, October 2010.

[4]K.Hirabayashi, M.Takahashi, M.Kominami," Development of Single point feed circularly polarized coplanar antenna", IEEJ Transactions on Electronics, Information and Systems, Vol. 131, No. 12, pp.2123-2130, December 2011

[5]G.Ghione, C.U. Naldi, "Coplanar Waveguides for MMIC Applications: Effect of Upper Shielding, Conductor Backing, Finite-Extent Ground Planes, and Line-to-Line Coupling," IEEE Transactions on Microwave Theory and Techniques, Vol.35, No.3, pp.260-267, March 1987.

[6] K. C. Gupta, R. Garg, I. J. Bahl, and P. Bhartia, Microstrip Lines and Slotlines, 2nd ed.Artech House, Inc., 1996.