Gain Characteristics Improvement of Broadband Circular Polarized Patch Antenna Using Artificial Ground Structure

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***Abstract* – Gain characteristics improvement of a broadband circularly polarized patch antenna using artificial ground structure is studied. The antenna has a simulated S_{11} bandwidth of 48.6% and axial ratio bandwidth of less than 3dB of 21.2%. However, gain characteristics of boresight direction decreases in the frequency range of 5.5GHz. In this paper, by modifying shapes of the ground plane, we attempted to keep the gain characteristics almost constant with respect to frequency.**

***Index Terms* — artificial ground structure, broadband, gain characteristics**

1. Introduction

Circularly polarized microstrip antennas have been widely used in many applications such as radars, satellite telecommunications and global positioning systems (GPS) because they have several advantages such as low profile, low cost and easy to fabricate. However, they have narrow bandwidth of S_{11} and axial ratio characteristics. Typically, they have only 10% and less in S_{11} characteristics, and 2% and less in axial ratio. Therefore, many techniques have been proposed to increase these bandwidths such as using stacked patches with truncating the opposite corners [1] and using an L-shaped probe with impedance matching networks [2]. But, these structures require relatively large antenna height and additional impedance matching networks that make it difficult to design and develop the printed antenna. The artificial ground (AG) structures [3] have been studied to solve these problems. By using the AG structure, bandwidth of S_{11} and Axial ratio characteristics can be increased 48.6%, 21.2%, respectively. However, gain characteristics of boresight direction in relation to frequency are reduced in a higher frequency range. In this paper, by extending ground plane of the antenna, we attempted to keep the gain characteristics constant with respect to frequency.

2. Design of the proposed antenna

The geometry of proposed antenna structure is shown in Fig. 1. A square patch element is truncated at opposite corners along the diagonal line to generate circular polarization at the center frequency of 6GHz as shown in Fig.1 (a). Fig. 1 (b) shows the AG Structure. The dielectric substrate of AG Structure is Rogers RT/Duroid 5880 with a permittivity of 2.2 and tan δ of 0.001. There are 6 × 4 unit cells on the dielectric substrate. The size of the unit cell is 4.2 mm × 9.25 mm. The size of the dielectric substrate and ground plane are width (grx) and length (gry) respectively. The AG structure depends sensitively on the bottom ground plane. The proposed antenna is a modified version of the antenna proposed in with a substrate and a ground plane which has a width (grx) of 39 mm and length (gry) of 40 mm. This antenna is fed with a SMA connector from the bottom of the Artificial Ground Structure. The thickness of the dielectric substrate of AG structure is 3.2 mm and the microstrip antenna is 1.6 mm. There is an air gap of 0.5 mm between these two layers.

3. Simulated results

The antenna structure is simulated by HFSS 16.0. As a result, the 3-dB axial ratio bandwidth gets wider (grx=40mm, gry=54mm) resulting in 32.33% (5.47 - 7.41 GHz) and 10-dB S_{11} bandwidth is 56.30 % (4.48 - 7.99 GHz) [4]. The axial ratio and S_{11} bandwidths increase by 11.93%, 7.70%, respectively compared to the case with gry=39mm. The average gain from 4GHz to 7GHz is 6.25dBic.

Fig.2 and Fig.3 show the axial ratio and gain characteristics with an increase in grx 40mm to 55mm with an interval of 5mm. When the length of grx increases from 40mm to 55mm, gain increases from 5.73 to 6.16dBic at 6GHz but the axial ratio deteriorates at 6GHz. Fig.4 and Fig5 show the axial ratio and gain characteristics when the length of grx increases from 44mm to 54mm with an interval of 5mm, gain increases from 5.73 to 7.01dBic at 6GHz. Axial ratio gets wider compared to the case with gry=39mm.

4. Conclusion

A gain characteristics improvement of circularly polarized microstrip antenna using rectangular AG Structure with rectangular unit cells has been presented. The length of the substrate and ground plane control the amplitude ratio, phase difference characteristics and gain characteristics. The S_{11} bandwidth of 56.30% (4.48 – 7.99 GHz) and the axial ratio bandwidth of 32.33% (5.47 – 7.41GHz) and

constant gain characteristics in the boresight direction have been obtained. The average gain is 6.25dBic.

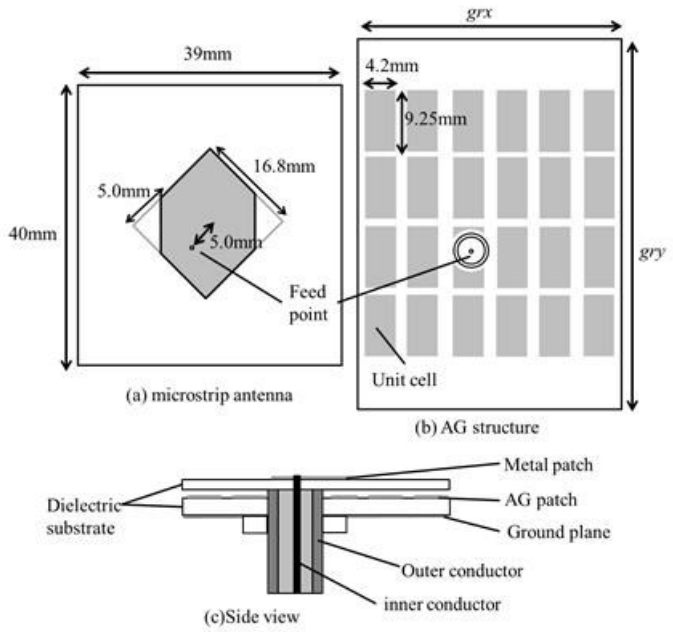

Fig. 1 antenna structure

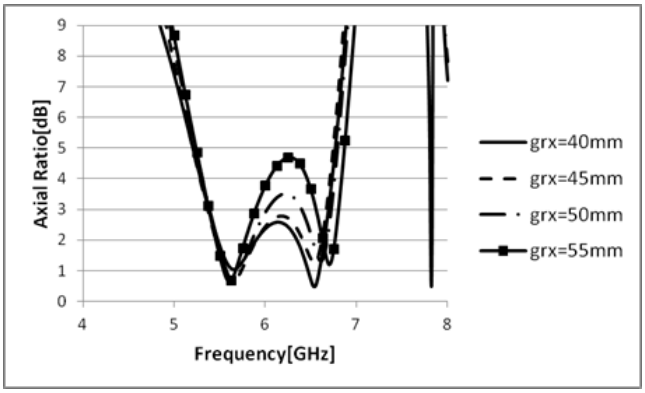

Fig.2 axial ratio (*grx*=40mm, 45mm, 50mm, 55mm)

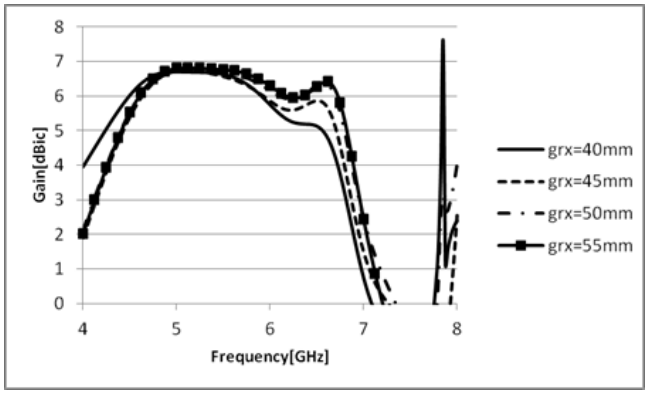

Fig.3 Gain (*grx*=40mm, 45mm, 50mm, 55mm)

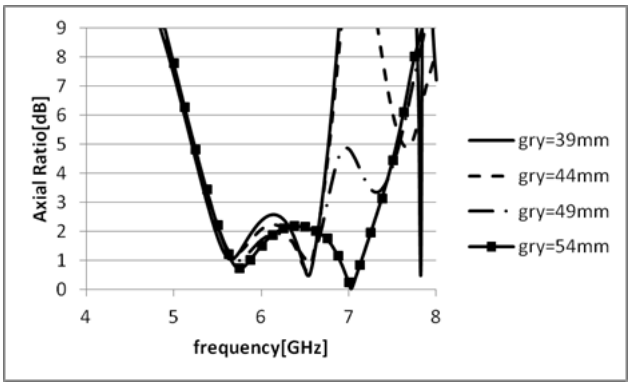

Fig.4 axial ratio (*gry*=39mm, 44mm, 49mm, 54mm)

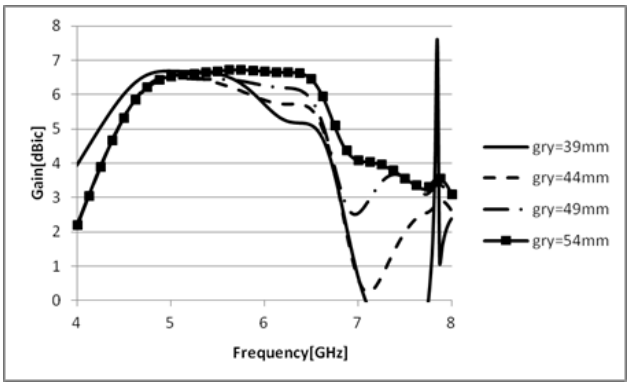

Fig.5 Gain (*gry*=39mm, 44mm, 49mm, 54mm)

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