Design of Microstrip Patch Antennas with Parasitic Elements for Minimized Polarization Mismatch

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***Abstract*—This paper proposes the design of microstrip patch antennas to minimize the polarization mismatch. The proposed antenna consists of a circular radiating patch and multiple parasitic elements. The number, length, and angular positions of the parasitic elements are adjusted to vary the antenna polarization as well as the orientation of the main axis. To demonstrate the feasibility, we design two sample antennas with different axial ratios and the orientation angles. The first sample antenna has linear polarization with a orientation angle of 0°, and the second sample antenna is elliptically polarized with a orientation angle of 5°. The results prove that the proposed antenna can adjust the polarization in the entire range of the axial ratio with the capability of rotating the orientation angle.**

Keywords—Antennas, antenna polarization, polarization mismatch.

I. INTRODUCTION

In recent wireless communications systems, antenna polarization has become an important design factor to maximize the reception capability. However, this performance is easily degraded by multipath effects causing the polarization mismatch. Thus, there have been a lot of efforts to minimize the polarization mismatch using various approaches [1]−[3]. Although reconfigurable antenna structures have been proposed to adjust polarization properties, the design complexity is increased significantly due to the use of additional pin diodes with DC bias circuits [4]. In [5], the axial ratio (AR) can be adaptively adjusted by simply rotating the parasitic element; however, the paper deals with only a single polarization adjustment and does not provide an in-depth consideration of changing the orientation of the main axis, which is denoted as orientation angle.

In this paper, we propose the design of a microstrip patch antenna to adjust the orientation angle and the axial ratio. The proposed antenna consists of a circular radiating patch and parasitic elements surrounding the patch. The number, length, and angular positions of these parasitic elements are varied to adjust the orientation angle and the axial ratio, which includes the right-hand circular (RHC), left-hand circular (LHC), linear, and elliptical polarizations. To demonstrate the feasibility, two sample antennas with different polarization characteristics are designed, and their polarization properties are compared with each other. The results prove that the proposed antenna is capable of rotating the orientation angles, and its axial ratio can also be adjusted in the entire AR range without a significant increase in design complexity.

II. PROPOSED ANTENNA GEOMETRY

Fig. 1 shows the geometry of the proposed antenna structure. The circular patch has a diameter of d and is designed to be approximately a half effective wavelength at its operating frequency. The radiating patch is surrounded by N parasitic elements, and the i^{th} element is designed by the width w, length l_i, and angular position ϕ_i. The feeding point l_f and the substrate height h are also taken into account as design parameters to maintain good impedance matching characteristics.

TABLE I. DESIGN PARAMETERS OF THE ANTENNA

Parameters	d	w	g	h	l_f	# of parasitic elements
Ant. 1	35	1.8	1.1	4.7	7.1	22
Ant. 2						7

Unit: mm

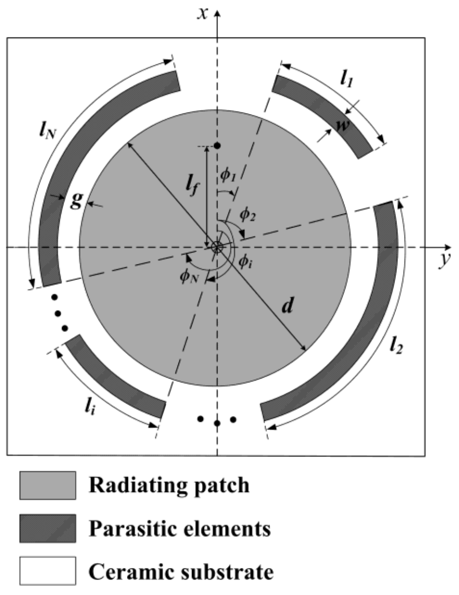

Fig. 1. Geometry of the proposed antenna.

Fig. 2 presents the bore-sight gain of the two sample antennas operating at 1.575 GHz, and its detailed parameters are listed in Table 1. The first sample antenna (Ant. 1) has linear polarization with the orientation angle of 0°, and the total gain and the axial ratio of Ant. 1 are 4.9 dBi and 40 dB, respectively. The second sample antenna (Ant. 2) is elliptically polarized with the axial ratio of 4.9 dB, and its orientation angle is changed to 5°. Although the total gains of Ant. 1 and Ant. 2 are similar with each other, the RHCP gain of Ant. 2 is increased from 1.9 dBic to 4.8 dBic at 1.575 GHz due to the change of the polarization properties. Thus, we can verify that the proposed antenna is capable of adjusting both the orientation angle and the axial ratio.

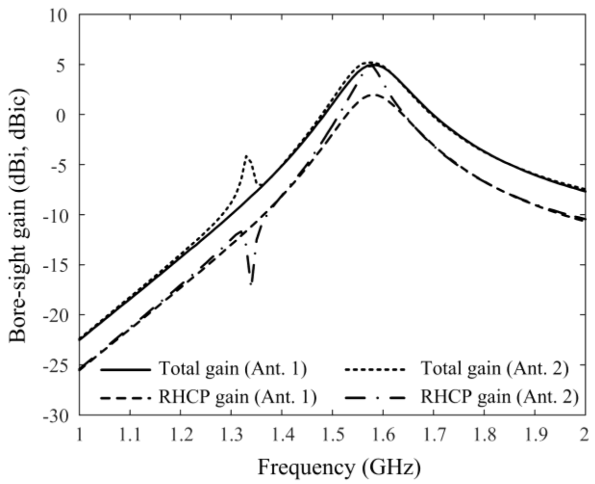

Fig. 2. Comparisons of bore-sight gains between Ant. 1 and Ant. 2.

III. Conclusion

We proposed the design of microstrip patch antennas with parasitic elements to adjust the polarization properties. In this structure, the circular radiating patch is surrounded by multiple parasitic elements, and the number, length, and angular positions of these parasitic elements were adjusted to vary the orientation angle and the axial ratio. Ant. 1 is linearly polarized with the orientation angle of 0°, and Ant. 2 has elliptical polarization with the orientation angle of 5°. Due to the change of the polarization, the RHCP gain of Ant. 2 was improved by 2.9 dB compared to Ant. 1. The results verified that the proposed antenna was able to adjust orientation angle and axial ratio by tuning the parasitic elements.

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