Antenna polarisation adjustment for microstrip patch antennas using parasitic elements

Gangil Byun and Hosung Choo

A novel and simple approach to adjust the polarisation properties of a microstrip patch antenna in the entire axial ratio (AR) range is proposed. The proposed antenna consists of a radiating patch and a parasitic strip separated into two parts, and the separated strip is placed at the outer perimeter of the patch for capacitive coupling. This structure enables the antenna to induce opposite-direction currents on the strip, which allows flexible polarisation adjustment by moving the separated positions of the strip. For evaluation, two antennas with linear and circular polarisations are fabricated, and their performance is measured in a full anechoic chamber. The results prove that the proposed approach is suitable for flexible AR adjustment without a significant degradation of the matching characteristics and the design complexity.

Introduction: In wireless communications systems, antennas are used to transmit and receive radio waves with particular polarisations: vertical or horizontal polarisation is usually adopted in ground communications, while circular polarisation is often applied to satellite signal reception [1]. To provide such a wide range of polarisations, a microstrip patch antenna has been a suitable candidate in various practical applications because its polarisation axis can be rotated by changing the feed position. In addition, circular polarisation is easily achieved by applying asymmetric antenna structures with corner truncation [2] and slot insertion [3–5]; however, previous studies are limited to obtaining a specific polarisation without an in-depth concern for the entire AR range from AR = 1 (RHC) to AR = 1 (LHC), which includes linear and various elliptical polarisations.

Proposed approach: Fig. 1 shows the geometry of the proposed microstrip patch antenna, polarisation adjusted using parameter \( \phi_{AR} \).

In this Letter, we propose a novel and simple approach to adjust the polarisation properties of a microstrip patch antenna for flexible AR control. The proposed antenna consists of a radiating patch and a parasitic strip that is separated into two parts having the same length. The strip is placed at the outer perimeter of the radiating patch to induce an opposite-direction current by capacitive coupling, and the coupling strength is adjusted by the distance between the strip and the radiating patch. This structure enables the antenna to achieve a flexible capability of polarisation adjustment in the entire AR range because the current distribution of the patch can be controlled by varying the separated positions of the strip. To verify the suitability of the proposed approach, two antennas with different polarisations were fabricated, and their radiation gains, patterns and ARs were measured in a full anechoic chamber. The results confirm that the entire AR range can be achieved by the proposed approach without a significant increase in design complexity.

Effects of parameter \( \phi_{AR} \) on AR and resonant frequency

Fig. 3 shows variations of the RHC gain in the bore-sight direction and the reflection coefficient according to \( \phi_{AR} \). The RHC gain is increased from 18.3 to 4.8 dBic, and the reflection coefficients are less than −16.2 dB, which implies that varying \( \phi_{AR} \) affects only the AR without degradation of the matching characteristics of the antenna.

Fabrication and measurement: To evaluate its feasibility, the proposed antenna was applied for a global positioning system operating in the L-band. Two sample antennas were chosen among the existing antennas in the AR range shown in Fig. 2 and were fabricated on a ceramic substrate from Taconic (50 × 50 mm, \( \varepsilon_r = 9 \), \( \tan\delta = 0.002 \)). Figs. 4a and b present the chosen sample antennas with linear and RHC polarisations, which are denoted as Ant. 1 and Ant. 2, respectively. Their design parameters are \( w_p = 27.8 \) mm, \( w_s = 2 \) mm, \( h = 7.5 \) mm, \( d_1 = 1.1 \) mm, and \( d_2 = 5 \) mm, with a substrate height of 7.85 mm. The separated positions of Ant. 1 are symmetrically placed at \( \phi_{AR} = 0^\circ \), while those of Ant. 2 are slightly rotated by \( \phi_{AR} = 17.5^\circ \).
The fabricated antennas were mounted on a circular ground plate with a diameter of 10 cm to measure the radiation characteristics, such as bore-sight gain, AR and radiation patterns in a full anechoic chamber.

Fig. 5a shows that the RHC gain of Ant. 1 is 1.7 dBic and that of Ant. 2 is 4.9 dBic at 1.55 GHz, which means that the gain is increased by about 3 dB because of the polarisation change. The polarisation change can also be verified in Fig. 5b, which shows the ARs of Ant. 1 and Ant. 2. Ant. 2 has an AR value of 0.6 dB at 1.54 GHz with a 3 dB AR bandwidth of 28 MHz from 1.527 to 1.555 GHz, while the AR of Ant. 1 is greater than 40 dB.

Fig. 6 presents measured the radiation patterns of Ant. 1 and Ant. 2 at 1.55 GHz. Ant. 1 exhibits half-power beamwidths of 131° and 138°, and those of Ant. 2 are 144° and 132° in the zx- and zy-planes, respectively. Owing to their different polarisation properties, the cross-polarisation level of Ant. 2 is increased by 15.3 dB at θ = 0°, compared with Ant. 1. These results demonstrate that flexible adjustment for the entire AR range can be achieved by applying the proposed approach without a loss of radiation efficiency.

Conclusion: We have proposed a novel and simple approach for flexible polarisation adjustment in the entire AR range. We placed the parasitic strip at the outer perimeter of the radiating patch for capacitive coupling and adjusted the separated positions of the strip to change the antenna polarisation in the entire AR range. We then fabricated two sample antennas with different ARs to evaluate the feasibility of the proposed approach through measurement. The results confirmed that the AR could be varied from 40 dB to 0.6 dB and vice-versa without significant degradation of reflection coefficients and radiation efficiency.

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