A Compact Circularly Polarized Subdivided Microstrip Patch Antenna

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***Abstract*—A compact circularly polarized subdivided microstrip patch antenna is proposed. The antenna is composed of the interconnection of four corner patches alternating with four strips and a fifth central patch. It presents the very small size of $0.28\lambda_g$ by $0.28\lambda_g$ at resonance (5.85 GHz), which represents a surface reduction of 60% compared with a conventional microstrip square patch antenna. The proposed antenna exhibits a gain of 4.3 dBi to 5 dBi and an axial ratio lower than 1.8 dB in the range of its bandwidth, which is of 30 MHz.**

***Index Terms*—Circular polarization (cp), microstrip antenna.**

I. Introduction

MICROSTRIP antennas have been extensively studied for both commercial and military applications, due to their low-profile, lightweight, low cost and easy integration with monolithic circuits [1], [2]. One such antenna, the circularly polarized microstrip patch antenna is often exploited in mobile terrestrial and satellite communication terminals [3]. In order to fulfill the need of high performance devices for mobile communication systems, there is a great need for more compact circuits and antennas. In this context, several methods have been suggested to reduce the size of microstrip antennas. They include loading the antenna with a high dielectric constant substrate [4], short-circuiting the patch to ground plane [5], modifying the geometry of the patch [6]–[8], and other techniques that combine these three methods [9]. Recently, a compact linearly polarized antenna, which consists of the interconnection of four corner patches alternating with four strips and a fifth central patch was developed in the authors' group [10]. This antenna structure exhibits a very compact size and lends itself well to circular polarization because the narrow strips from the center pad can be used for orthogonal feeding. We present the performance of the antenna for both a right- and left hand circularly polarized (RHCP and LHCP) subdivided microstrip patch antenna. Thanks to its compactness and circular polarization, the proposed antenna represents an interesting alternative for mobile communication.

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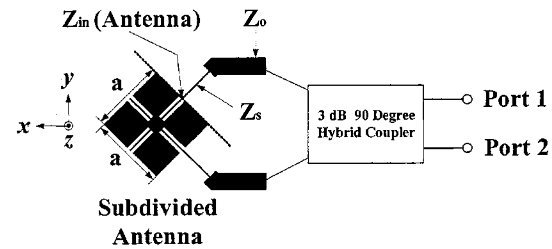

Fig. 1. Proposed compact circularly polarized subdivided microstrip square patch antenna connected to a 3-dB 90 degree coupler (Z_{in} (Antenna) $= 509\ \Omega$, $Z_o = 50\ \Omega$, $Z_s = 176\ \Omega$, $a = 410$ mi l).

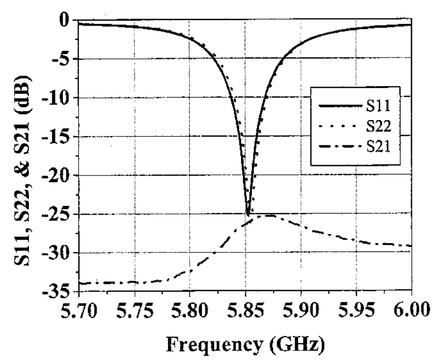

Fig. 2. Measured insertion and return losses of the antenna.

II. Compact Circularly Polarized Subdivided Microstrip Patch Antenna Design

The proposed circularly polarized subdivided microstrip patch antenna and its feeding coupler are shown in Fig. 1. The quadrature (90°) hybrid (3 dB) coupler generates orthogonal modes for circular polarization. The input impedance of the subdivided antenna is very high ($Z_{in} = 509\ \Omega$). In order to match the antenna to the 50 Ω lines of the coupler, two narrow 176 Ω lines have been introduced as impedance transformers. In a conventional microstrip patch antenna, the resonance frequency is related to the length a of the patch as $a \approx \lambda/2$. The resonance frequency in the proposed antenna is significantly lowered by the subdivided nature of the metal geometry, which introduces longer current paths along its contours, and simultaneously by the strong inductive/capacitive loadings associated with the branch/gap elements. These effects result in an antenna of a much more compact size than its conventional counterpart, as it will be demonstrated in the next section.

The antenna is mounted on an RT/Duroid 5870 substrate with dielectric constant of 2.33 and thickness of 31 mil. The overall dimension a, defined in Fig. 1, of the antenna structure is $a =$ 410 mil.

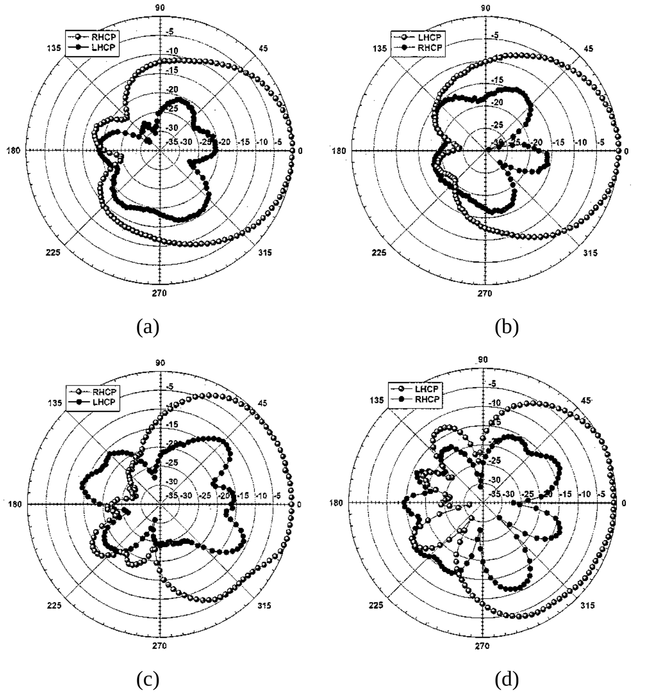

Fig. 3. Measured normalized radiation patterns for RHCP and LHCP for both identical and opposite polarizations for the transmitter and receiver (a) RHCP, y–z plane, (b) LHCP, y–z plane, (c) RHCP, x–z plane, and (d) LHCP, x–z plane.

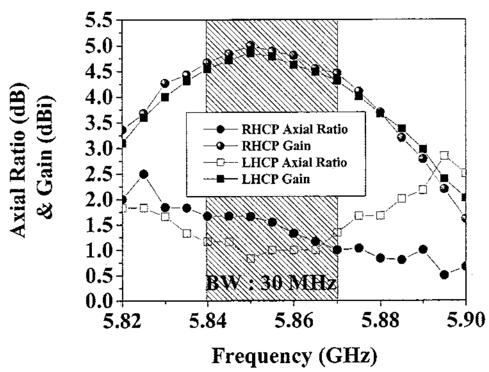

Fig. 4. Measured axial ratio and gain (the bandwidth of 30 MHz corresponds to the −10 dB isolation frequency range shown in Fig. 2).

III. Results and Discussion

Fig. 2 shows the measured insertion and return losses of the antenna, which represent the matching at each port and the isolation between the two ports, respectively. In the range from 5.84 GHz to 5.87 GHz, the antenna exhibits return losses lower than −10 dB and an insertion loss lower than −25 dB, which represents good matching and isolation characteristics. Fig. 3 presents the normalized radiation patterns for RHCP and LHCP in the y–z- and x–z planes at 5.85 GHz. It can be seen that the isolations from the undesired opposite polarization are lager than −10 dB. Fig. 4 shows the axial ratios and gains for RHCP and LHCP. The bandwidth of 30 MHz in Fig. 4 corresponds to the −10 dB isolation bandwidth in Fig. 2. In this frequency range, the gain of the antenna varies between 4.3 dBi and 5 dBi and the axial ratio is lower than 1.8 dB. The antenna exhibits the compact overall size of $0.28\lambda_g \times 0.28\lambda_g$, which corresponds to a surface reduction of about 60% in comparison with a conventional microstrip square patch antenna.

IV. Conclusion

A compact circularly polarized subdivided microstrip patch antenna has been proposed and demonstrated. The antenna is characterized by a size reduction of 60% when compared to a conventional microstrip square patch antenna. This structure should find applications in compact phased arrays due to its small size and integration of the feedline in the plane of the antenna.

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