24-GHz Circularly Polarized Substrate Integrated Waveguide-Fed Patch Antenna

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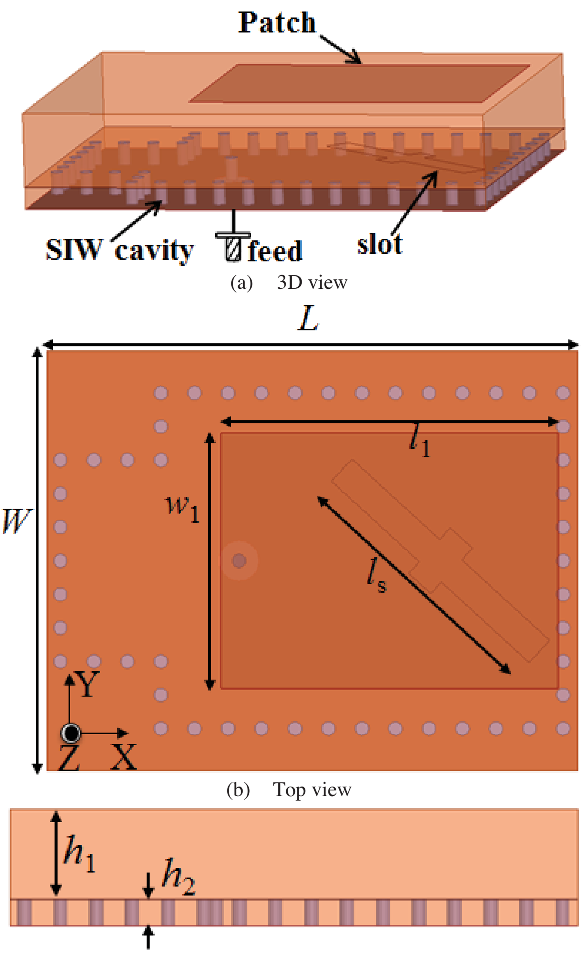
***Abstract*-This paper has presented the design of a 24-GHz patch antenna with characteristics of good circular polarization, simple structure and easy fabrication. The printed antenna consists of two layers of substrates with the lower one for achieving a short-ended substrate integrated waveguide (SIW) and the upper one for supporting the rectangular radiating patch. The left-handed circularly polarized wave has been obtained by etching a 45° rotated cross-shaped slot on the broad wall of the SIW. The obtained results can confirm that the proposed antenna has achieved an impedance bandwidth ($|S_{11}| \leq$ -10 dB) of 23.1-25.3GHz and the 3-dB axial ratio bandwidth of 23.2-24.7GHz.**

Keywords: SIW, circularly polarized antenna, patch antenna

I. Introduction

The researches on circularly polarized antennas have been extensively implemented in the literature as they have more advantages compared with linearly polarized antennas [1]. One is that circularly polarized antennas can reduce the "Faraday rotation" effects caused by the ionosphere, which is important in satellite communications. The other is that they can effectively reduce multipath interferences or fading in various applications including wireless local area networks (WLANs) and radio frequency identification devices (RFIDs).

Planar or printed circularly polarized antennas are preferred as they can be easily fabricated and integrated with RF-end circuits. Planar feeding circuits including CPW, stripline, and microstrip have been developed for designing circularly polarized antennas. Recently, SIW-fed circularly polarized antennas and arrays have been proposed and studied in [2-4]. The SIW-fed aperture-coupled magneto-electric dipole antenna can generate circularly polarized radiation at 60GHz. The multi-layer structure is fabricated by using PCB technology [2]. In [3], the SIW-fed aperture coupled two-arm spiral antenna has been proposed as the element for achieving a circularly polarized array. Furthermore, a sequential-rotational array has been developed to achieve wideband performance. The 3dB axial ratio bandwidth achieves more than 18.8%. The SIW-fed circularly polarized LTCC antenna array at 60GHz has also been proposed in [4]. The axial ratio bandwidth is enlarged by positioning a slot-coupled rotated strip above a transverse slot etched on the broad wall of an SIW. Moreover, the mutual coupling between the elements of the array has been reduced by introducing a metal-topped via fence around strip.



(a) 3D view

(b) Top view

(c) Side view

Figure 1. Geometry of the proposed SIW-fed circularly polarized antenna.

In this paper, a SIW-fed patch antenna with circular polarization is proposed. The antenna is designed to operate at 24GHz and features characteristics of good circularly polarized performance and easy fabrication. The rest of the paper is organized as follows: the configuration, design and results of the proposed circularly polarized antenna are demonstrated in Section II, a conclusion is drawn in Section III.

II. Antenna Design

Figure 1 presents the geometry of the SIW-fed circularly polarized patch antenna. The antenna is designed by stacking two substrates with thicknesses of h_1 and h_2, respectively. A short-ended section of SIW is designed and optimized in the lower substrate to feed the antenna while the rectangular radiating patch is printed on the upper substrate. A 45° rotated cross-shaped slot is etched on the top ground plane of the SIW to excite the left-handed circular polarization. It is worthwhile to mention that, the right-handed circularly polarized wave can be generated by rotating the slot along the opposite direction. The design, simulation and optimization of the proposed antenna are carried out using HFSS15.0. The simulated results of reflection coefficient and axial ratio value at boresight are shown in Figure 2. It shows that the proposed antenna has an impedance bandwidth from 23.1 to 25.3 GHz for $|S_{11}|\leq$ -10 dB and axial ratio bandwidth from 23.2 to 24.7 GHz for AR $\leq$ 3 dB. Figure 3 presents the simulated LHCP and RHCP radiation patterns in both XoZ and YoZ planes at 24GHz. As observed, the presented structure radiates LHCP in the +Z direction. The simulated realized gain at boresight is illustrated in Figure 4. The obtained realized gain at boresight is around 8.2dBi at 24GHz.

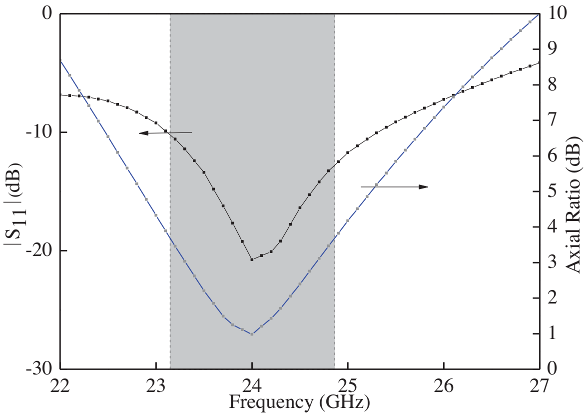


Figure 2. Simulated results of reflection coefficient and axial ratio of the proposed antenna.

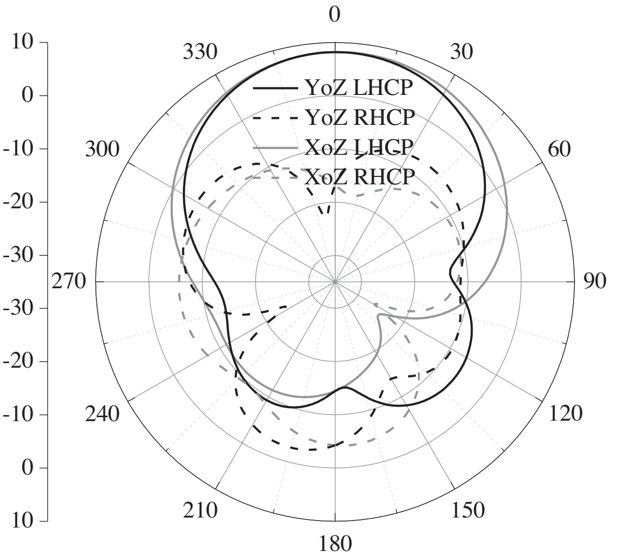


Figure 3. Simulated LHCP and RHCP radiation patterns in two principal planes at 24 GHz.

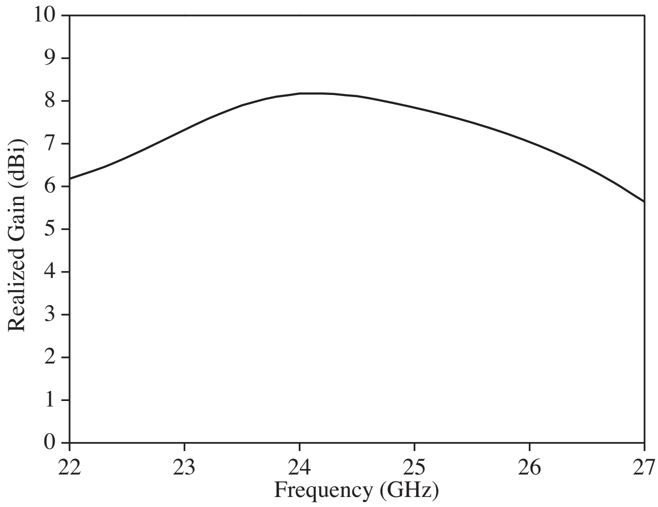


Figure 4. Simulated realized gain at boresight.

III. CONCLUSION

The design of a SIW-fed patch antenna operating at 24GHz has been designed and investigated for achieving circular polarization in this paper. Simulated results show that the 10-dB impedance and 3-dB AR bandwidths of the proposed antenna are 23.1-25.3GHz and 23.2-24.7GHz, respectively. In addition, the realized antenna gain at 24GHz is above 8dBi.

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