

Novel Circularly Polarized Substrate Integrated Waveguide Slot Antenna By Using A Polarizer Technique

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Abstract

circularly-polarized antenna is built based on new SIW(substrate integrated waveguide) structure which contains cavity-backed resonator and a conventional polarized ring with two square slits in inner and outer ring that differ 90° at position and is proposed for right-handed circular polarization (RHCP) and fabricated in two separate layers. A broadband impedance bandwidth of 13.9% and a RHCP axial ratio of 0.5GHz have been obtained under the condition of less than $VSWR \leq 2$ and axial ratio ≤ 3 dB, respectively.

Keywords: circularly-polarized, cavity-backed, RHCP, SIW

Introduction

To provide better mobility and weather penetration, circular polarization is widely used in current radar and satellite wireless communication systems.

Circular polarization is formed by two orthogonal filed components with two identical amplitudes but with 90° of phase difference.

In recent years, there has been a rapid development in wireless communication technologies. The demand for high performance and a small size has also increased steadily. To meet this demand, microstrip antennas, which have low weight, a low-profile, a compact size, and many commercial advantages, are used in many of applications. The substrate integrated waveguide (SIW), also called the laminated waveguide [1] or the post-wall waveguide [2], is composed of two rows of conductive cylinders on a printed circuit board (PCB). The Via holes are embedded in a substrate that connect two

parallel metal plates. Therefore, a synthetic rectangular metallic waveguide filled with dielectric material is constructed in the planar form, thus allowing complete integration with other planar transmission-line circuits (such as micro-strip or coplanar waveguides) on the same substrate [3]. The advantage of SIW is that it is low-loss, compact in volume, low-profile, and can make a simple integration with other planar circuits. Therefore, research into SIW circuits and antennas is gaining interest. For instance, a low-profile, cavity-backed planar SIW slot antenna is presented in [4]. Because of the back cavity, it has 5.4 dBi gained with 1.7% bandwidth, a slotted leaky-wave antenna was implemented in the SIW technology [5]. In this device, leakage occurs on the periodic structure of transverse slots on top of the SIW. This leaky-wave antenna provides a beam-scanning range from broadside to end fire. An SIW feeding network is used in a 4x4array in a Yagi antenna [6]. In addition,

the SIW technology has been applied to realize circularly polarized (CP) antennas. In [7], a SIW cavity-backed, crossed-slot antenna is presented. The CP wave is generated in the TE_{12} mode. The CP operation is realized by different lengths of the two arms of the crossed slot to create a 90 phase difference. A low-profile, cavity-backed planar slot CP antenna has been developed using a half-mode substrate integrated waveguide (HMSIW) technique [8]. The CP wave is generated in the TE_{12} mode.

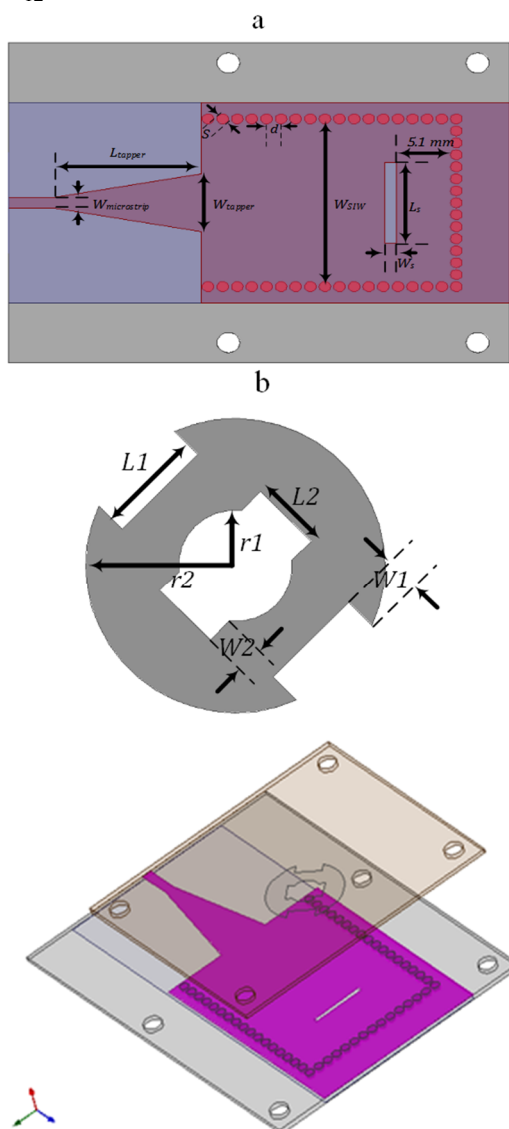


Fig. 1. Proposed antenna configuration
 a bottom layer b top layer c two layered
 A 90° phase difference is achieved by the incorporated microstrip line in which two

orthogonal quarter-wavelength patch modes are excited. ACP SIW antenna was designed using a quarter-mode substrate integrated waveguide (QMSIW) technique [9]. The CP wave is generated in TE_{22} mode. A 90 phase difference is achieved by adjusting the length of the two edges of the QMSIW cavity. Results and discussion of proposed antenna are presented in the following section.

Antenna Configuration

We considered the proposed cavity-backed slot antenna using SIW technology as shown in Fig. 1. The proposed antenna is mainly composed of three parts: a conventional polarized ring with two square slits inside and out of ring, a SIW-based cavity-backed resonator and a slot antenna, respectively. The total occupied area is $32(W) \times 43(L)$ mm² in Fig. 1a with FR4 substrate which has thickness (h) of 0.5 mm, relative permittivity of 3.8, and loss tangent of 0.022. The optimized parameter values for generating CP are listed in Table 1. In order to attain CP a ring with two square slits inside and out of it is used that have 90° difference at position on FR4 substrate with 0.5mm thickness and 4.4 relative permittivity as shown in Fig. 1b. The ring is located in a distance of 1 mm from lower substrate and the distance between the two substrates is filled with air.

Table 1: Design parameter values of proposed antenna

Parameter(s)	Value	Parameter(s)	value
L_s	8 mm	L_{tapper}	12.6 mm
W_s	1 mm	r_1	1.6 mm
W_{siw}	16.8 mm	r_2	4.2 mm
d	1.259 mm	L_1	3 mm
s	1 mm	L_2	2 mm
W_{tapper}	5.85 mm	W_1	0.923 mm
$W_{microstrip}$	1.1 mm	W_2	0.751 mm

Experimental results and discussion

A measured return loss of the proposed antenna is shown in Fig. 2, which shows a good agreement between data and the simulated results, using commercially available software (HFSS). Photograph of the fabricated antenna is shown in Fig. 4. It can be evaluated from Fig. 2 that the input impedance bandwidths are 13.9% from 11.4to 13.1GHz. From Fig. 3, which shows the gain and axial ratio (AR), it is seen that the proposed antenna has 8.75 dBic as maximum gain within 11 to 13 GHz, a very stable 3 dB gain bandwidth of 0.5 GHz, and axial ratio bandwidth of 2.3% from 11.7to 12.3 GHz for less than 3dB. The measured radiation patterns in two orthogonal cutting planes shown in Fig. 5 imply that the proposed antenna satisfies the RHCP generation with a lower cross-polarization at the broad sight direction.

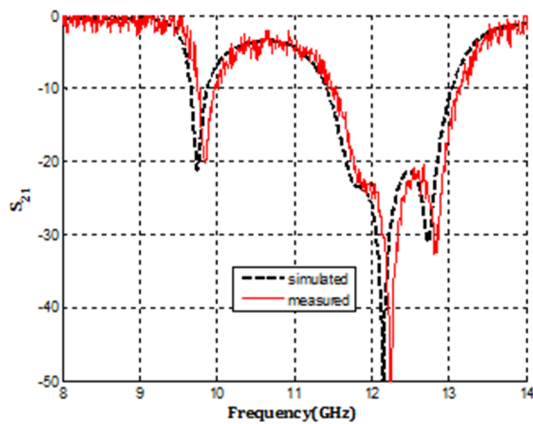


Fig. 2. Simulated and experimental return loss characteristics with photograph of fabricated antenna.

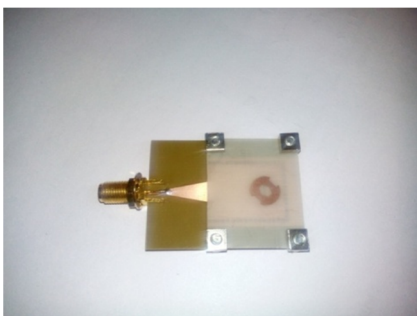


Fig. 3. Photograph of the fabricated antenna

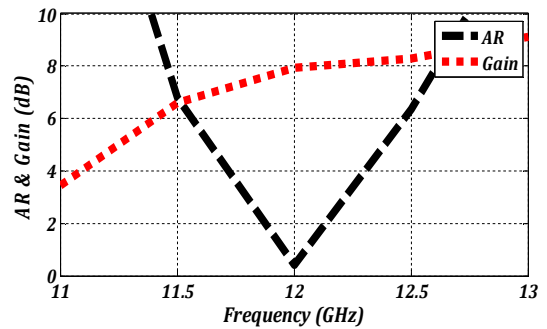


Fig.4.Gain and axial ratio characteristics against frequency

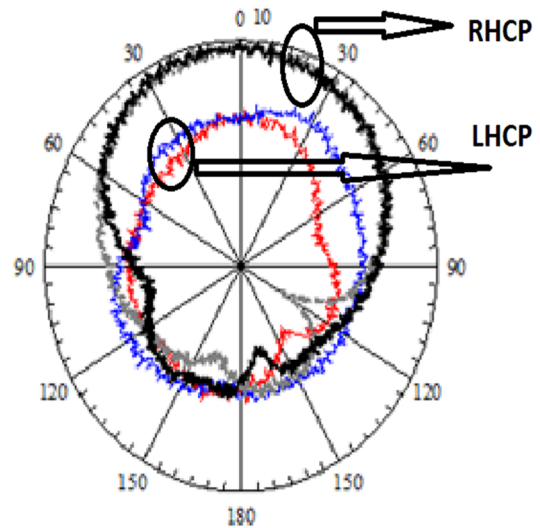


Fig.5. RHCP- and LHCP radiated patterns at 12 GHz

Conclusion

A novel two-layered SIW-fed slot antenna embedded in a cavity-backed resonator is proposed, that has a unified impedance matching network inside the SIW feeding structure. In addition, the RHCP characteristic has been easily accomplished by employing a cover layer on cavity back resonator. It is expected that the proposed structure can be applied to the phased array antenna for high-speed data communication in satellite systems.

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