Tiny Circularly Polarized Printed Slot Antenna for UWB Usage

Majid Shokri[1] , Ch. Ghobadi[1] and J.Nourinia[1] , Hamed Shirzad[2], S.Asiaban[2] and Zh.Amiri[2]

1. Department of Electrical and Electronic Engineering, Urmia University, Urmia, West-Azarbayjan, Iran
2. Department of Electrical and electronic engineering, Urmia Branch, Islamic Azad, University Urmia, West-Azarbayjan, Iran

Abstract: This letter offers a wideband circularly polarized square slot antenna (CPSSA) fed by coplanar waveguide (CPW), with a compact size of only 25 mm (length) ×25mm (width) × 0.8 mm (height). The proposed antenna provides impedance bandwidth of 2.86–10.95 GHz (117%) with VSWR ≤ 2, and its CP bandwidth is larger than 47.5% that covers 5.05-8.20 GHz which is obtained by embedding two inverted-L grounded strips around two opposite corners whereas the impedance bandwidth can be greatly improved through the tuning stubs. The simulated and measured results of the proposed antenna have been discussed to verify its characteristics.
[Majid Shokri, Ch. Ghobadi and J.Nourinia, Hamed Shirzad, S.Asiaban and Zh. Amiri. **Tiny Circularly Polarized Printed Slot Antenna for UWB Usage.** *Rep Opinion* 2012;4(10):21-24]. (ISSN: 1553-9873). http://www.sciencepub.net/report. 6

Key Words: slot antenna, circular polarization

1. Introduction

Due to attractive properties of printed slot antennas namely wide impedance BW, low profile, and easy fabrication, with various feeding techniques, they have attracted much attention in circular polarization (CP) applications [1]. Recently, various geometries of broadband CP slot antennas have been reported to overcome the narrow impedance and axial-ratio bandwidths (ARBWs) while , both right-hand CP and the left-hand CP are achieved simultaneously with various techniques as follows: embedding two inverted-L grounded strips around two opposite corners of the slot with vertical tuning stub [1], inserting a lightning-shaped feed line and inverted-L grounded strips [2], embedding a T-shaped grounded metallic strip that is perpendicular to the axial direction of the coplanar waveguide (CPW) feed line [3], utilizing a spiral slot in the ground plane [4], utilizing the embedded arc-shaped grounded metallic strip for circular and linear polarization [5]. In this Letter, a tiny, yet structurally simpler, circularly polarized square slot antenna (CPSSA) for UWB systems with the combination of the technique introduced in [1] and a crescent shaped patch is presented. The measurements indicate that it has an impedance bandwidth (BW) of 2.86–10.95 GHz (3.83:1, 117%), which is three times wider than previous square slot antenna structures [2–3].

2. **Antenna design**

Fig. 1 exhibits the geometry of the proposed single-layer CPW-fed CPSS antenna. As it is shown, the proposed antenna consists of a square ground plane, two equal size inverted-L-shaped strips around two opposite corners, a tuning circle stub embedded in the feeding structure and a crescent main patch clung to the feed line (all units are in mm). The proposed CPS antenna is printed on a commercially cheap FR4 substrate with a loss tangent of 0.024, permittivity of 4.4 and tiny dimensions of 25 mm (length) ×25mm (width) × 0.8 mm (height). To achieve 50Ω characteristic impedance, the width and length of the coplanar waveguide (CPW) feed line is 3.1 mm and 11.4 mm, respectively, and the width of the gap between the feed line and the ground plane is 0.3 mm. The size of the inverted-L-shaped strips are; a=5mm and b=4mm and the radius and center point of circles1, 2 and3 are reported in table1.

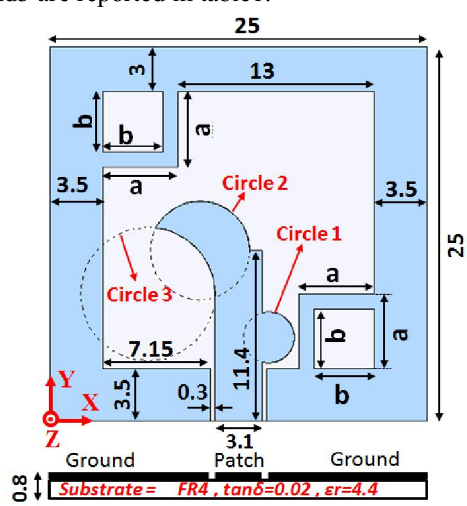


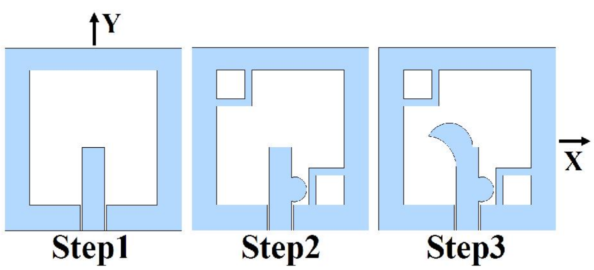
Fig. 1 Geometry of proposed CPW-fed CPSSA (all dimensions in mm)

Table 1: Radius and position of circless1, 2 and 3

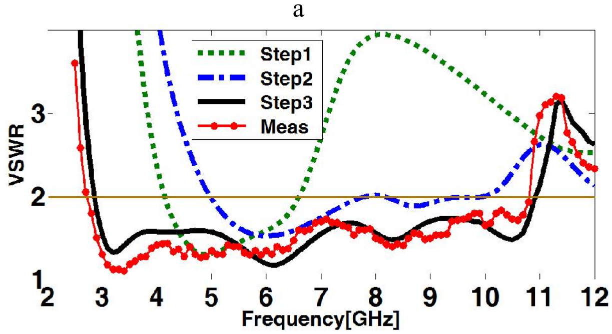
	Circle1	Circle2	Circle3
Radius	R1=1.7mm	R2=3.3mm	R3=4.46mm
Center position	X1=14.5mm Y1=5.6mm Z1=0.8mm	X2=10mm Y2=11.4mm Z2=0.8mm	X3=6.5mm Y3=8.8mm Z3=0.8mm

Other dimensions are shown in Fig1. In the designing of the antenna three steps are accomplished; the first step includes only a single strip and ground plane, the second one consists two inverted-L grounded strips around two opposite corners and a metal circle clung to feed line and the last one encompasses crescent shaped main patch (a part of circle 2). In the Fig.2 a three steps of designing the antenna is seen and VSWR curves of them and measurement VSWR of the proposed antenna are depicted in Fig.2 b.

Mainly two objects have been considered with in the design: one for enhancing the impedance bandwidth and the other for producing and expanding the CP bandwidth which is principally related to inverted-L-shaped strips around two opposite corners. The measured and simulated results of three prototypes of CPSSA, parametric studies on: inverted-L-shaped strips, the size of the radius and center position of stub and patch syndetic to feed line, and finally the measured radiation pattern of the offered antenna will be discussed in next section.



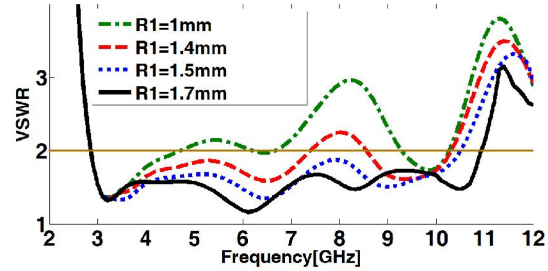
a



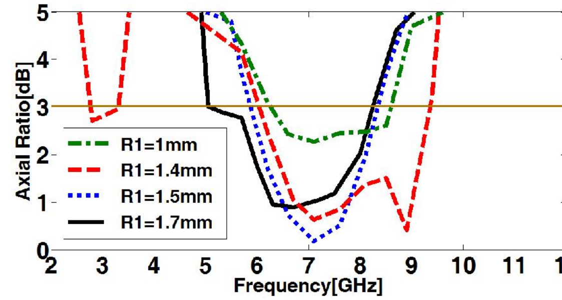
b

Fig. 2 antenna designing steps, VSWR of antenna steps

a) Three steps of designing the antenna
b) VSWR curves of the antenna designing steps and measurement vswr results



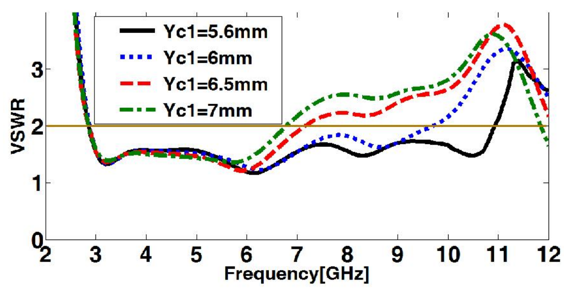
a



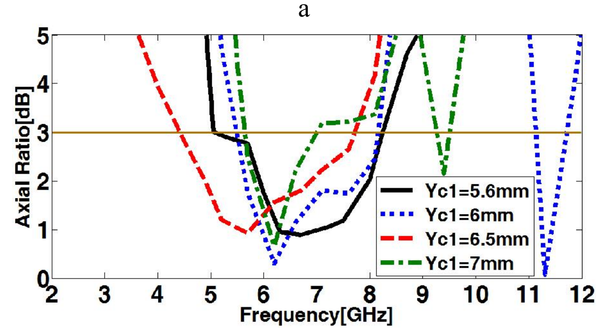
b

Fig. 3 VSWR and CP axial ratios of various value of R1 (radius of circle1)

a) VSWR curves of different values of R1
b) CP axial ratios of different values of R1



a



b

Fig.4 VSWR and CP axial ratios of various value of Yc1 (vertical center position of circle1)

a) VSWR curves of different values of Yc1
b) CP axial ratios of different values of Yc1

3. **RESULTS AND DISCUSSION**

In this article two objects have been tracked: one enhancing the impedance BW and the other producing and expanding the CPBW. As shown in Fig. 2 a and Fig. 2 b for achieving the objects, three steps from CPSSA design techniques have been traversed namely: firstly adopting a square GND plane and a rectangular feed line, secondly embedding a circular stub to the feed line and inverted-L metal strips to ground and at last appending a crescent shape main patch to feed line. From the figures it is clear that adopting the techniques the impedance BW increases step by step and close correspondence between measured and simulated VSWR of the optimized antenna (named as Step3) is a considerable point plotted in the Fig. 2 b and it is also understood from the figure that the measured impedance bandwidth for the antenna has an operating frequency range from 2.86 GHz to 10.95 GHz. The simulated VSWR and CP axial ratio curves for two various CPSSA parameters, R1 and Yc1 (radius of circle1 and its vertical center position respectively) are plotted in Fig.3 and Fig.4. A tuning circular stub (perpendicular to the feed line) which is built by expanding a circular metal with R1 (radius of circle1) =1.7mm, Yc1 (its vertical center position) =5.6mm and Xc1 (its horizontal center position) =14.5mm structural features, is added in the rectangular feeding to broaden the impedance BW. Our parametric simulations indicate that the radius and vertical position of the tuning stub has important affect on improving the impedance BW. From the numerical results in Fig. 3 a, it is gotten that the impedance bandwidth is expanded at the upper frequency as R1 increases from 1mm to 1.7mm, meanwhile broader impedance BW is earned by taking a smaller Yc1 parameter among its values shown in Fig.4 a. On the other hand, as shown in Fig.3 b and Fig.4 b, the optimum values of R1 and Yc1 which simultaneously leads to the widest impedance BW and satisfying CPBW, covering 5GHz-6GHz (IEEE 802.11a), are 1.7mm and 5.6mm respectively. Due to numerical results which were accomplished by using the Ansoft High Frequency Structure Simulator (HFSS), the combination of two inverted-L-shaped strips, made of two arms (a and b as shown in Fig. 1), to GND has a great effect on both impedance and CP BWs as discussed in Fig 5. It means that increasing a and b (3mm and 2mm to 5mm and 4 mm) will yield not only to additional impedance BW but also a wider CPBW, associated with AR≤ 3 dB, is taken which covers 5150–5350/5725–5825MHz (specified by IEEE 802.11a) bands for wireless standard technologies. Fig.6 indicates the close correspondence between the measured and simulated curves of gain and AR for the proposed antenna with optimized values presented in Fig.1 and in Table1. As plotted in Fig.6, the ARBW of the suggested antenna is from 5050MHz to 8200MHz (47.5%) and its gain is acceptable. Fig.7 shows the simulated normalized RHCP and LHCP radiation patterns of the offered CPSSA at 5.5GHz and 7.3GHz. We have simulated the time-varying surface current distribution on proposed antenna at 6.8GHz, at the minimum point of AR. The simulation results of surface current distribution for the antenna are shown in Fig.8. It is observed that the surface current distribution in 180° and 270° are equal in magnitude and opposite in phase of 0° and 90°. If the current rotates in the clockwise/counter clockwise (CW/CCW) direction, the antenna can radiate the right/left hand circular polarization (RHCP/LHCP). The proposed CP slot antenna is able to generate an RHCP in the +z direction, whereas an LHCP is produced in the –z direction. The suggested antenna with optimal structure, as shown in Fig. 9, was fabricated and tested in the Antenna Measurement Laboratory at Iran Telecommunication Research Center (ITRC).

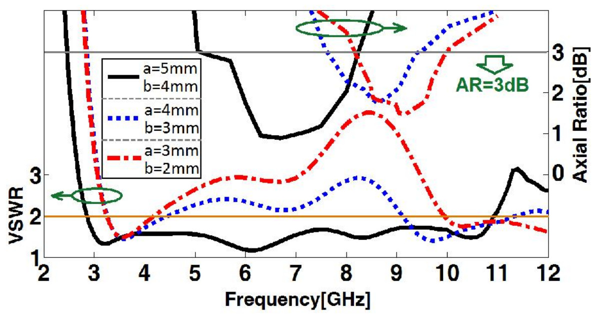


Fig.5 VSWR and CP axial ratios of various values of a and b (arms of the inverted-L-strips)

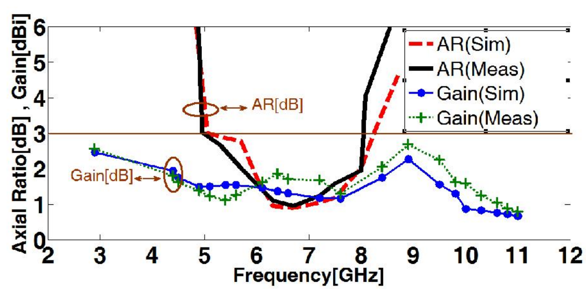


Fig. 6 Measured and simulated CP axial ratios and gain of the proposed antenna

4. Discussion

This paper presents circularly polarized square slot antenna (CPSSA) fed by coplanar waveguide (CPW) with a crescent shaped patch. All of the important parameters that are determinant in antenna characteristics were depicted one by one while keeping the others fixed. At last the antenna's features namely: current distributions, gain level, radiation patterns and agreement between numerical and experimental results acknowledge that this radiator is a good candidate for

5150–5350/5725–5825MHz (specified by IEEE 802.11a) bands for wireless standard technologies with CP coverage.

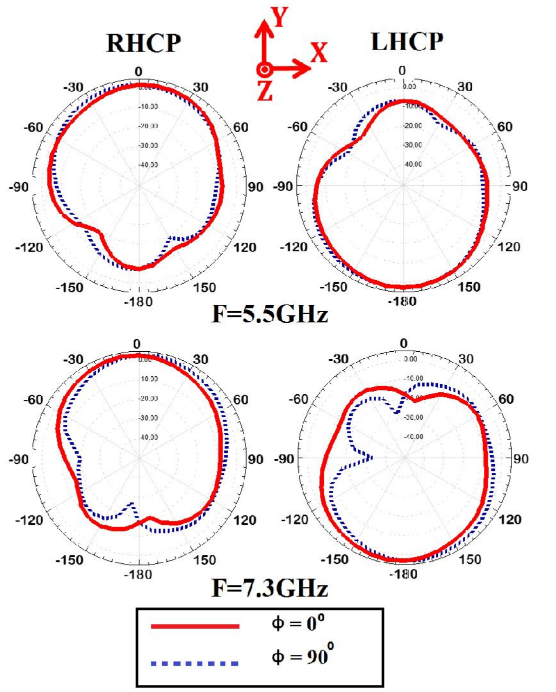
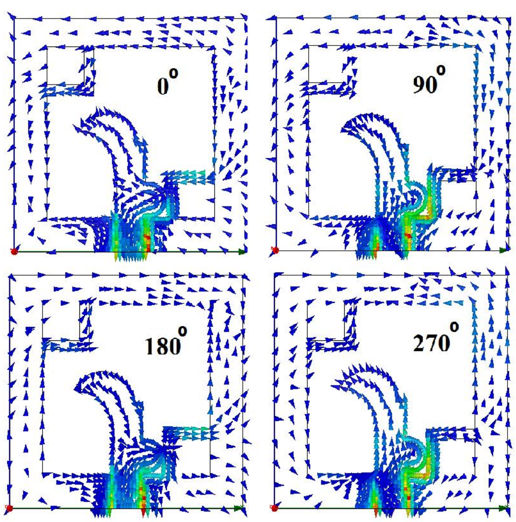


Fig. 7 Simulated radiation patterns of the proposed antenna at 5.5GHz and 7.3GHz



°Fig. 8 Distribution of the surface current on the feed and ground plane of the CPSSA antenna at 6.8 GHz in 0°, 90°, 180°, and 270

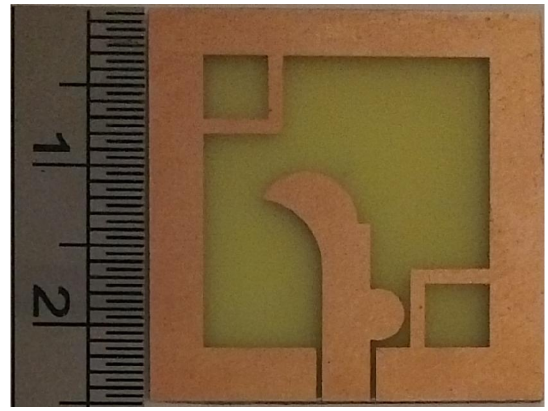


Fig. 9 Photograph of the realized antenna.

References

[1] Javad Pourahmadazar, Ch. Ghobadi, J. Nourinia, Nader Felegari, and Hamed Shirzad, Broadband CPW-Fed Circularly Polarized Square Slot Antenna with Inverted-L Strips for UWB Applications. IEEE Antenna Wireless Propag. Lett., vol. 10, pp. 369—372, 2011.

[2] Jia-Yi sze, C-I. G. Hsu, Z-W.Chen, and C-C Chang, Broadband CPW-fed circularly polarized square slot antenna whit lightening shaped feed line and inverted-L grounded strips. IEEE Trans Antenna Propag., vol. 58, no .3, pp. 973—977, Mar. 2010.

[3] J-Y. Sze, K-L. Wong, and C-C . Huang," Coplanar waveguide-fed square slot antenna for broadband circularly polarized radiation". IEEE Trans. Antenna Propag., vol. 51,no. 8, pp. 2141—2144,Aug 2003.

[4] C. Chen and E.K.N. Yung," Dual-band dual-sense circularly- polarized CPW-fed slot antenna with two spiral slots loaded," IEEE Trans Antenna Propag., vol. 57, no. 6, pp. 1829—1833, Jun 2009.

[5] M.-J. Chiang, T.-F. Hung, and S.-S. Bor., "Dual-band circular slot antenna design for circularly and linearly polarized operations," Microw.Opt. Technol. Lett., vol. 52, no. 12, pp. 2717–2721, Dec. 2010.

9/6/2012