A Novel Small Size CPW-fed Circular Polarized Antenna

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Abstract— **A novel design of a circularly polarized CPW-fed antenna for WiMAX/WLAN application is presented. The antenna consists of a CPW-feed structure, two square slots around both sides of the feed and two interleaved parasitic resonance strips inserted within each of the square slots. The proposed antenna gives circular polarization at the centre frequency of 2385 MHz with 3 dB axial ratio bandwidth of about 3.77% and impedance bandwidth of 13.39%. The designed antenna has a small size of 30×40 mm^2.**

I. Introduction

The Circularly polarized (CP) antennas are now receiving much attention in the wireless communication, due to their ability to provide better mobility and weather penetration than the linearly polarized antennas.

Many designs for CP antennas have been reported in the published literature. A fractal boundary circularly polarized single feed microstrip antenna has been proposed in [1], which provides 3 dB axial ratio bandwidth of about 1.6% and impedance bandwidth of 6.2% at the centre frequency of 2510 MHz. In [2] an aperture-coupled asymmetrical C-shaped slot microstrip antenna for circular polarization is reported. This antenna is fed at the centre using an aperture coupling to obtain a CP operation and provides measured 3 dB axial ratio bandwidth around 3.3% and 10 dB return loss bandwidth of 16.0% with an overall substrate size of 60×60 mm^2. A circular polarized microstrip patch antenna with complementary split ring resonator has been described in [3] that provides 27.2 MHz or about 0.7% 3dB axial ratio bandwidth with respect to the centre frequency at 4.18 GHz.

Recently, coplanar waveguide (CPW)-fed antenna has received considerable attention due to its preferable characteristics, such as low radiation loss, no need for drilling and easy fabrication. As such, the CPW-fed CP antenna has attracted more attention recently. A circular patch antenna fed by a coplanar waveguide line has been reported to produce circular polarisation at 5.8 GHz with impedance bandwidth of about 3.6% and CP bandwidth for AR < 3 dB of 63 MHz (1%) [4]. In [5] a CPW-fed circular polarized antenna is described. In that structure, by etching a longitudinal slot at the middle point of a stair-shaped slot and tuning the geometrical parameters, two orthogonal electric fields with quadrature phase difference result in a circularly-polarized wave, the dimension of which is 40×60 mm^2. In [6] an asymmetric CPW-fed CP square slot antenna is proposed with an overall size of 60×60 mm^2 and operates at 2.2 GHz.

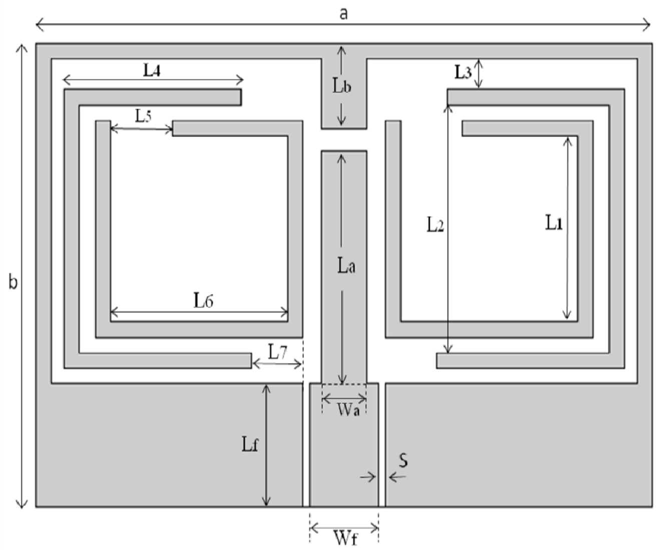

Fig. 1: A small size CPW-fed circular polarized antenna

In this paper, a novel small size CPW-fed circular polarized antenna is proposed. The proposed antenna is compact and occupies an area of 40 × 30 mm^2 and provides circular polarization at the centre frequency of 2385 MHz with 3dB axial ratio bandwidth of about 3.77% and impedance bandwidth of 13.39%. This antenna has a novel structure with parasitic radiating elements and square slots in the ground. The antenna structure is simulated through the commercially available software packages of Ansoft HFSS.

II. ANTENNA DESIGN

The geometry of the proposed CPW-fed CP antenna is illustrated in Fig. 1. The overall antenna size is 30 × 40 × 1.6 mm^3 which is about 0.359λ × 0.479λ × 0.019λ at 2.4 GHz. An

TABLE I
GEOMETRICAL PARAMETERS OF THE PROPOSED ANTENNA

Parameter	a	b	Wf	Lf	S	Wa	La	Lb	L1	L2	L3	L4	L5	L6	L7
Unit (mm)	40	30	4.5	8	0.4	3	15	5.5	12	16	2	11.5	4	11.5	3.35

FR4 substrate with relative permittivity of 4.4 is used. Table I gives the dimension of this antenna.

The proposed antenna consists of a CPW-feed structure with two square slots along both sides of the feed. This feeding arrangement provides the required current for feeding the radiating strip elements. The CPW-feed structure contains a 50 Ω transmission line that is connected to a protruded strip of length La and width Wa. Through this strip feed, current is coupled to another strip, having the same strip width and placed in front of the strip feed, effectively creating two square slots.

To obtain the circular polarization radiation two orthogonal fields with quadrature phase difference are needed. The radiating strip elements consist of two interleaved parasitic resonance paths each of width 1 mm and separated from each other by 1 mm. As seen in Fig.1 the outer resonance strip is in the shape of a C and is fed effectively through the coupling from the edges of the slot. The other resonance strip within the previous C shaped strip has an open square ring geometry and is fed by the C-shaped strip and the protruded strip. These two interleaved strips effectively provide two near orthogonal current paths with some phase difference between them. To provide a good AR one can also place the above interleaved strips on the second square slot. It has been noticed that with the presence of the C-shaped strip (within the two slots) a resonance at 2.5 GHz takes place while the AR is poor. Placement of the other open square strip within the two slots, makes the resonance frequency changes slightly to 2.4 GHz, while the AR is improved. The presence of the second slot and strips makes the structure symmetric and provides a better radiation patterns. The C shaped strip has a length of about $\lambda_g/2$ at 2.4 GHz.

The variation of the electric field with time can be employed to explain the cp radiation. Fig. 3 shows the electric field at the resonance frequency for ωt=0, 45, 90, 135 and 180 degree. It can be observed that the maximum electric field at 0 deg is in y direction and at 45 deg the x direction component of electric field increases. Then at 90 deg the total electric field rotates to x direction effectively. At 135 deg the x direction component of electric field decreases and then at 180 deg it turns into –y direction. Thus the required orthogonal direction electric field with a 90 phase shift for the CP radiation is provided and the electric field rotates like a left-handed circularly polarized (LHCP) wave.

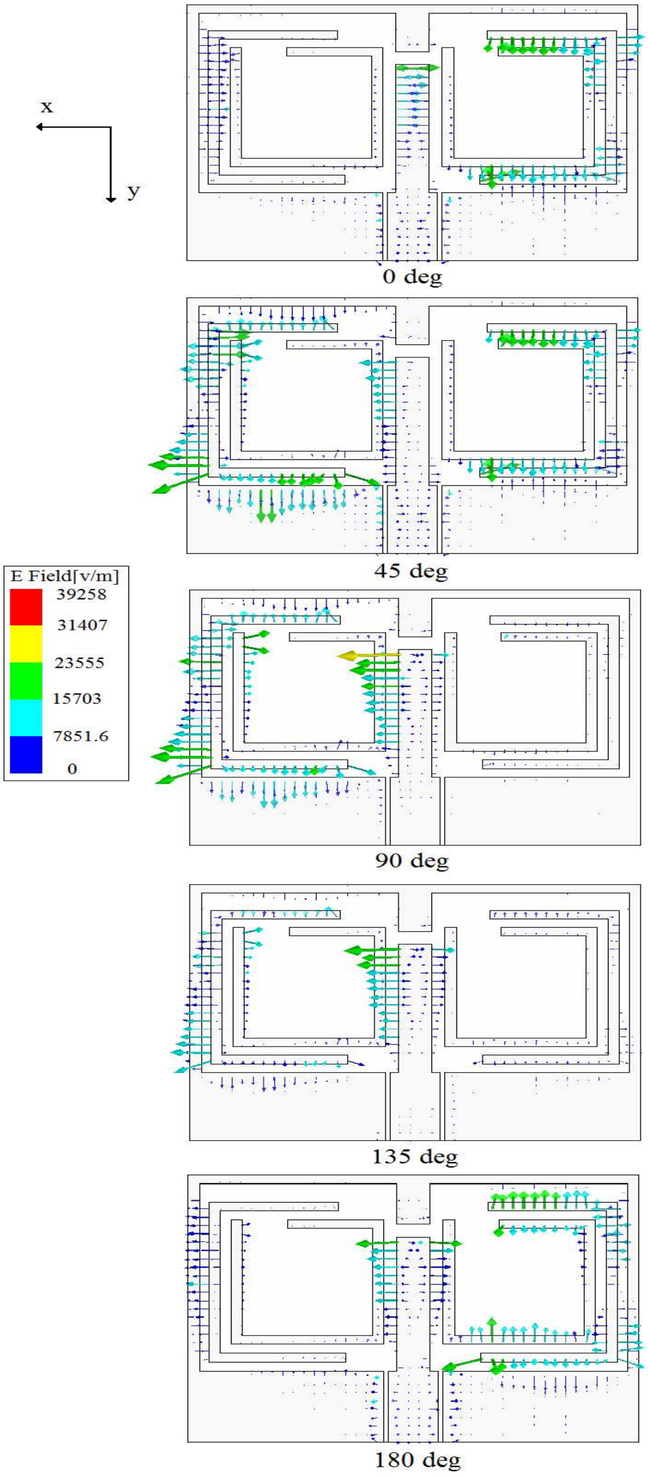

Fig. 2: Simulated electric field of the proposed antenna at the resonance frequency for ωt=0, 45, 90, 135 and 180 degree.

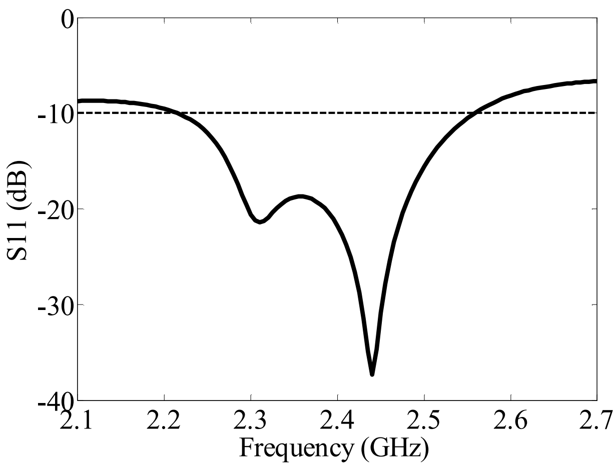

Fig. 3: Reflection coefficient of the proposed antenna

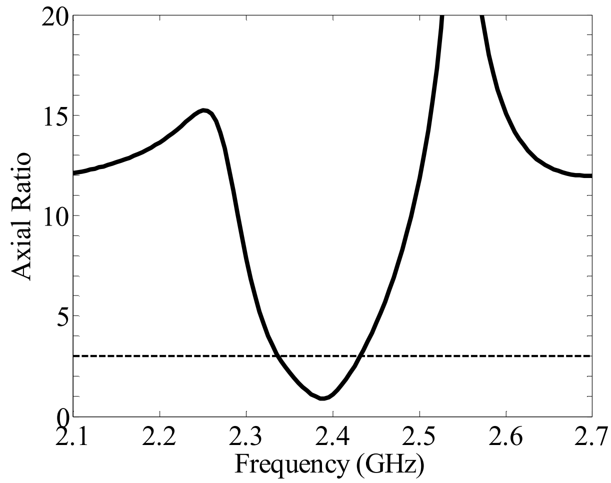

Fig. 4: Axial Ratio of the proposed antenna

III. RESULT

The proposed circular polarized antenna is simulated by HFSS software, and the antenna characteristics such as reflection coefficient, axial ratio and radiation pattern will be presented in this section.

Fig. 3 shows the reflection coefficient of the designed antenna. It can be seen that the proposed antenna based on -10 dB reflection coefficient provides a bandwidth of 320 MHz or 13.39 % with respect to the centre frequency at 2390MHz which covers 2.4 GHz WiMAX/WLAN application.

The axial ratio spectrum of the proposed antenna at the broadside direction is shown in Fig. 4. As can be seen the 3 dB axial ratio bandwidth of 90 MHz or about 3.8% with respect to the centre frequency at 2385 MHz is achieved.

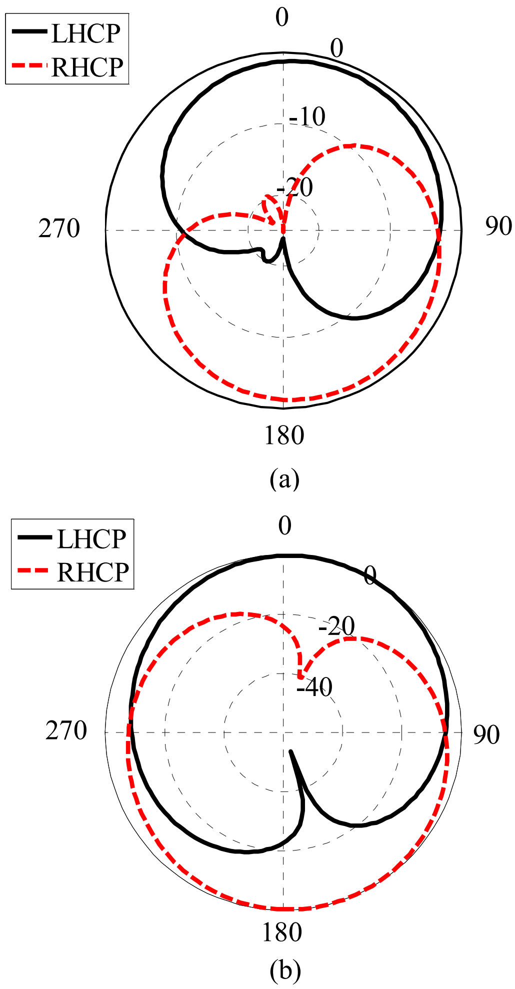

Fig. 5: LHCP and RHCP radiation patterns of the proposed antenna at 2.4 GHz: (a) H-plane; (b) E-plane.

Fig. 5 shows the LHCP and RHCP radiation patterns of the proposed antenna at 2.4 GHz. It can be seen that in the bore sight direction, cross-polarization is 24 dB lower than the co-polarization and the 3 dB AR beamwidths of the antenna is around 80 degrees.

IV. CONCLUSIONS

A novel small size CPW-fed circular polarized antenna is presented. The overall antenna dimensions are about 0.359λ × 0.479λ × 0.019λ at 2.4 GHz on an inexpensive FR4 substrate with 1.6 mm thickness and relative permittivity of 4.4. The proposed antenna gives circular polarization at the centre frequency of 2385 MHz with 3 dB axial ratio bandwidth of 90 MHz or about 3.77%. The -10 dB reflection coefficient bandwidth is around 320 MHz or 13.39 % with respect to the centre frequency at 2390 MHz. The antenna provides LHCP radiation pattern with the 3 dB AR beamwidths of around 80 degrees.

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