A Frequency Tunable Wideband Circularly Polarized Antenna

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***Abstract*—A wideband frequency tunable circularly polarized (CP) crossed dipole antenna with a wide beamwidth is presented. The proposed antenna consists of two crossed dipoles, four screws, and a modified cavity. By replacing the screws, the proposed antenna can work in different frequency bands. The simulated results show the tunable impedance bandwidth for VSWR ⩽ 2 is 57% from 1.19 GHz to 2.14 GHz and the 3-dB axial ratio (AR) band is covered from 1.27 GHz to 1.92 GHz (41%). The 3-dB AR beamwidth and half power beamwidth are more than 120° at the operating frequencies. Thus, the designed antenna is a promising candidate for modern wireless communication system.**

***Index Terms*—Circularly polarized (CP), crossed dipole, modified cavity, tunable impedance bandwidth, wide beamwidth.**

I. Introduction

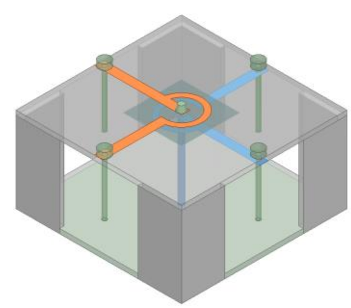
Since the circularly polarized (CP) antennas have been proposed in 1940's [1], [2], CP antennas are becoming a useful technology for various wireless communication systems including global positioning systems (GPS) [3], radio frequency identification (RFID) systems [4], wireless local network (WLAN) [5] and so on. Compared with linearly polarized (LP) antennas, CP antennas can not only receive polarized incoming waves in any direction, but also can reduce polarization mismatch, suppress multi-path interference and counter Faraday rotation effect of the ionosphere, so as to provide a stable link between the receiving antenna and transmitting antenna [6]. With the development of the modern communication systems, CP antennas with wide 3-dB axial ratio (AR) beamwidth and half power beamwidth (HPBW) are highly required [7].

In current years, the researches on crossed dipole antennas and arrays have attracted many attentions [8]. By employing two crossed dipoles, this kind of antennas can provide a wide operation bandwidth [9]. Meanwhile, the crossed dipole antennas with a cavity can further facilitate the realization of wide AR beamwidth, wide HPBW and unidirectional circularly polarization patterns. However, these kind antennas often have relatively narrow AR bandwidth or cannot maintain wide 3-dB AR beamwidth and HPBW across the operating band [10], [11].

In this paper, a frequency tunable wideband circularly polarized crossed dipole antenna is proposed. Four screws are loaded on the dipole arms to extend the current path and enhance the circularly polarized performance. Meanwhile, by replacing the screws with different lengths, a wide tunable operation band can be obtained. The proposed antenna is numerically analyzed and optimized by using HFSS software. The antenna configuration is shown in section II, the simulated results are given in section III, section IV is the conclusion.

II. Antenna Configuration

The geometry of the proposed antenna is shown in Fig. 1. The antenna consists of two crossed dipoles, four identical screws and a special cavity. The arms at the top side of the substrate are connected to the inner conductor of the coaxial cable whereas the outer conductor is connected to the arms at the bottom side. The crossed dipoles are fabricated on Arlon AD255A substrate with a relative permittivity of ε_r = 2.55, a loss tangent of tan δ = 0.0015. The square patch clamped in the substrate is the ground of the sequential phased feed network. The cavity is composed of a metal ground plane and four metal supports which are sequentially placed at the corner of the ground plane.



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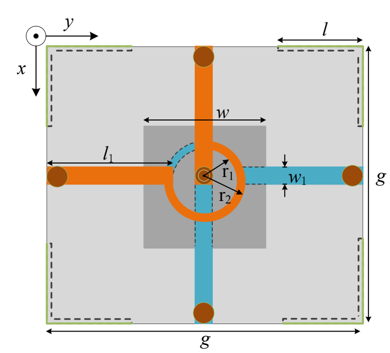

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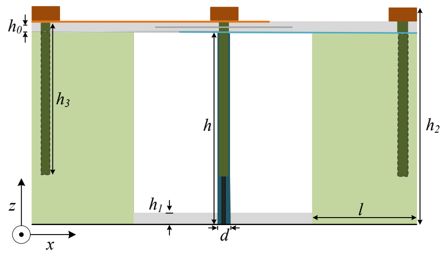


(c)

Fig.1. Geometry of the proposed antenna. (a) 3D view. (b) Top view. (c) Side view.

As we know, the length of the dipole arms is about 0.5 λ_0 (λ_0 is the wavelength at the operating frequency), a longer dipole length will lead to a lower working frequency. A conventional crossed-dipole antenna with thin arms often suffers from narrow axial bandwidth, insufficient HPBW and AR beamwidth. Therefore, four screws are loaded on the dipole arms to adjust the working frequency band. The dipole with the screws loaded act as a bent dipole, the z-directional current is formed, which is beneficial for the improvement of the HPBW and AR beamwidth. Furthermore, a modified cavity with four vertical metal walls are introduced. By adjusting the distance between the metal walls and screws, coupling current will be generated on the metal walls, the circularly performance at low elevation angle will be further enhanced. Then, a wide 3-dB AR bandwidth is obtained.

III. Simulated Results

Since a conventional crossed dipole antenna can only provide wide 3-dB AR beamwidth and HPBW in a narrow operation bandwidth, hence to maintain a stable circularly polarized performance across a wide bandwidth, a crossed dipole antenna with different screws is discussed.

To illustrate the influence of the length of the screws on antenna performance, two antenna states are discussed. In state 1, h_3 = 17 mm, in state 2, h_3 = 23 mm, the other parameters in two states are the same. The parameters are chosen as follows: l = 15 mm; g = 57 mm; w = 20 mm; l_1 = 23 mm; w_1 = 3 mm; r_1 = 5.3 mm; r_2 = 7.1 mm; h_0 = 1.6 mm; h_1 = 1.6 mm; h_2 = 31.6 mm; h = 28 mm; d = 2 mm.

Fig. 2 and Fig. 3 show the simulated VSWR and broadside AR of the proposed antenna. It can be seen that the tunable impedance bandwidth is 57% from 1.19 GHz to 2.14 GHz, the tunable AR bandwidth is 41% from 1.27 GHz to 1.92 GHz. Fig. 4 shows the simulated AR variation over the elevation (θ) angles at the center frequencies of the AR bandwidth in state 1 and 2. The results show that the antenna has wide 3-dB AR beam width, which are around 129° at 1.45 GHz and around 127° at 1.75 GHz.

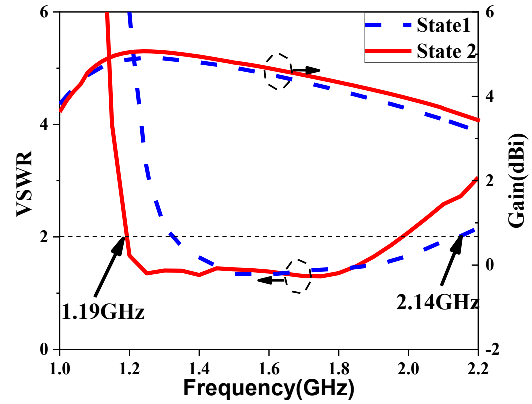


Fig.2. Simulated VSWR and Gain of the proposed antenna.

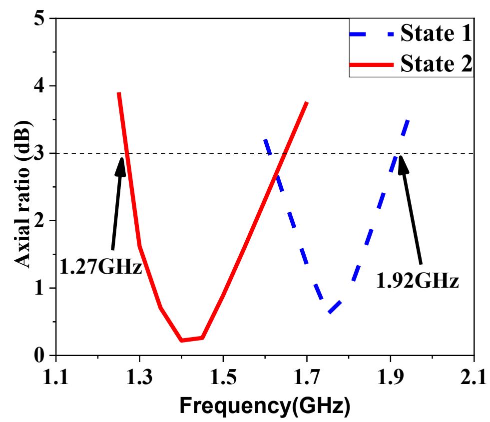
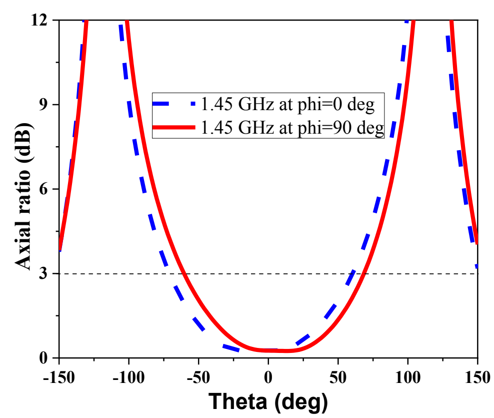


Fig. 3. Simulated axial ratio of the proposed antenna.



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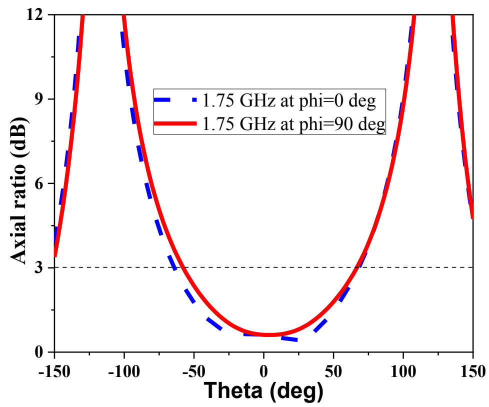
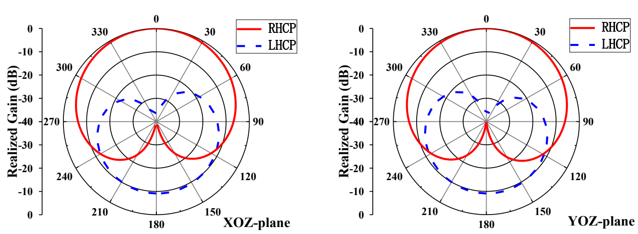


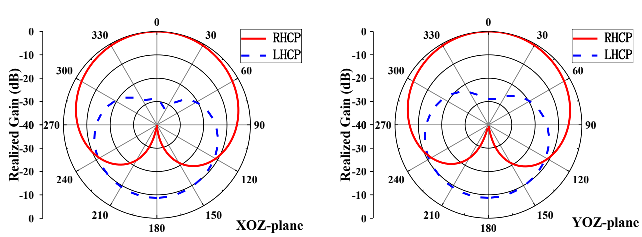
(b)

Fig. 4. Simulated AR versus elevation (θ) angles in XOZ-plane and YOZ-plane. (a) at 1.45 GHz. (b) at 1.75 GHz.

The simulated normalized radiation patterns are shown in Figs. 5–6. It can be seen that the right-handed CP (RHCP) is achieved in both frequency bands. Meanwhile, the cross-polarization ratio is greater than 25 dB. Fig. 5 shows the simulated radiation pattern for the two principal planes of the antenna at 1.45 GHz in state 1 and 1.75 GHz in state 2. It is observed that the radiation patterns are very stable at two states. The HPBW is 122° in XOZ-plane and 124° in YOZ-plane at 1.45 GHz, at 1.75 GHz, the HPBW is 126° in both planes. From above content also can know,the realized gain is 4.5 dBi and 4.4 dBi at 1.45 GHz and 1.75 GHz.



(a)



(b)

Fig. 5. Simulated radiation patterns. (a) at 1.45 GHz. (b) at 1.75 GHz.

IV. Conclusion And Future Work

A frequency tunable wideband circularly polarization antenna has been discussed. The simulated results show the antenna have a tunable impedance of 57% and a tunable AR bandwidth of 41%. The proposed antenna achieves wide AR beamwidth of around 128° and wide HPBW of more than 120° at the working frequencies. This means that the proposed frequency tunable antenna can easily achieves good circular polarization performance in a wide frequency band. The future work for this study will include reducing profile height, fabricating, and measuring, *etc.*

Acknowledgment

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