Wideband Circularly Polarized Crossed Dipole Antenna with Parasitic Elements

Lijun Zhang, Baohua Sun
National Laboratory of Antennas and Microwave Technology
Xidian University
Xi'an, Shaanxi, People's Republic of China
lijunZhang326@163.com

***Abstract*—A wideband circularly polarized crossed dipole antenna with parasitic elements is proposed. A vacant-quarter printed ring is used to realize circular polarization. There are two rectangular patches and two arrow-shaped patches loaded on the two sides of the substrate, respectively. The parasitic elements are designed to optimize circular polarization characteristics and generate a new resonance. An inverted cylindrical cavity-backed reflector is used to control the radiation pattern and acquire high gain .The impedance bandwidth is 107% (0.96-3.12 GHz). And the 3-dB axial ratio operation bandwidth is 97%(1.08-3.12 GHz). The average gain during the operation band is 6.8 dBi.**

Keywords—crossed dipole; circular polarization; parasitic element; cavity-backed reflector

I. INTRODUCTION

Circular polarization has many advantages that it can mitigate polarization mismatch and suppress multipath effect. This facilitates the positioning of the transmitting and receiving antennas. Due to these advantages, circularly polarized antennas are applied to many modern wireless communication systems. Extensive research on miniaturization, wide bandwidth, low profile, high gain are conducted. Circular polarization can be generated by two electric field components with equal magnitude and quadrature phase. ME(magnetoelectric) dipole is first proposed by Wong and Luk in 2006[1]. ME dipole consists of a planar E-dipole and a vertically oriented M-dipole. The M-dipole and E-dipole are placed orthogonally. Crossed-dipole is a simple way to achieve circular polarization. A vacant-quarter printed ring is employed at the feeding port to get a 90 degree phase difference [2]-[3]. Metamaterial is also applied to circularly polarized antennas. Artificial magnetic conductor increases the bandwidth by 20 percent[4]. The ME dipole loading metamaterial is proposed to achieve low profile[5].But they has complex structures. The four arms of the crossed dipole are of different lengths and types to reduce size[6]. The other method is to use wider planar dipoles, such as rectangular and bowtie dipoles[7]. These methods only can broaden bandwidth limitly.

In this paper, a wideband circularly polarized crossed-dipole antenna with parasitic elements is proposed. The parasitic patches are loaded on the different side with the dipole arms. In this way, the impedance and AR bandwidth can be enhanced greatly. An inverted cylindrical cavity-backed reflector is used to control the radiation pattern and acquire high gain. The return loss better than 10dB is from 0.96 to 3.12 GHz. And the 3-dB AR bandwidth is from 1.08 to 3.12GHz.

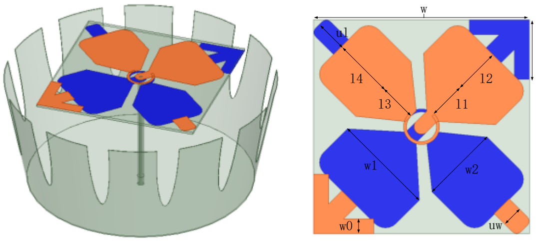
II. ANTENNA CONGIFURATION AND ANALYSIS

A. Antenna configuration

Fig. 1 depicts the geometry of the proposed antenna. An inverted cylindrical cavity reflector is used here with size of 120*120*50mm^3 . Two pairs of dipoles are respactively located at the top and bottom side of the substrate with thickness of h=1mm and relative permittivity of ε_r=2.2. The radius of the center feed ring is r. The upper patches are yellow and the bottom patches are blue. A vacant-quarter printed ring is used to realize circular polarization. The parasitic patches are loaded at the end of the dipole arms on the backside . The inner and outer conductors of the feeding coaxial line are connected to two pairs of dipoles, respectively. The outer conductor of the feeding cable is connected to the cylindrical cavity which is used as a reflector to provide unidirectional pattern. All parameters are listed in Table I.

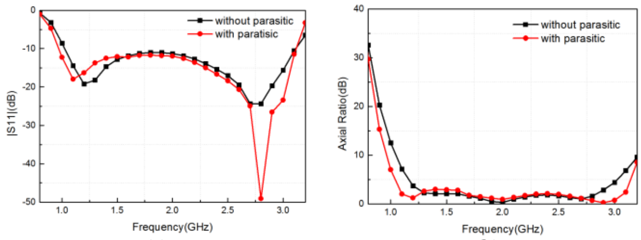
B. Antenna analysis

To figure out the mechanism, the crossed dipole with and without parasitic patches are compared. It can be seen that the patches increase the AR bandwidth by 17% in Fig. 2. The parasitic patches extend the current path, creating a new axial ratio minimum point at lower frequency. So the bandwidth is improved. An inverted cavity reflector is used here. Compared to a conventional plane ground, the cavity with smaller volume can achieve the same effect. Fig. 3 shows the reflection coefficient and axial ratio using different reflectors. There are three situations: a normal cylindrical cavity, an inverted cylindrical cavity and the proposed cylinder cavity. It is found that the proposed cavity reflector has slight impact on impedance bandwidth. But it significantly improve the axial ratio bandwidth. This is due to the slot will influence the current distribution and change the electric field.



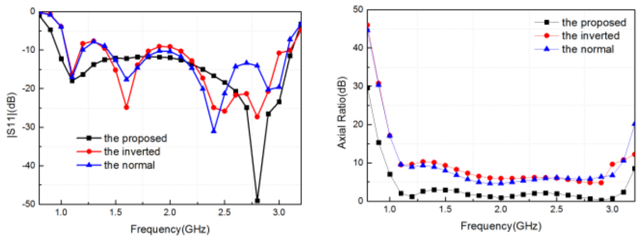
(a) (b)

Fig. 1 Antenna configuration (a) 3D view (b) Top view



(a) (b)

Fig. 2 Antenna results (a) |S11| (b) Axial Raito



(a) (b)

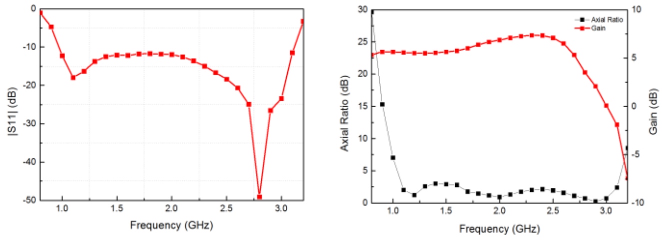
Fig. 3 Antenna results (a) |S11| (b) Axial Raito

TABLE I

parameter	Value(mm)	parameter	Value(mm)
L1	13	uw	7
L2	16	ul	10.6
L3	13	W0	5
L4	20	L0	20
W1	34	hg	50
W2	26		

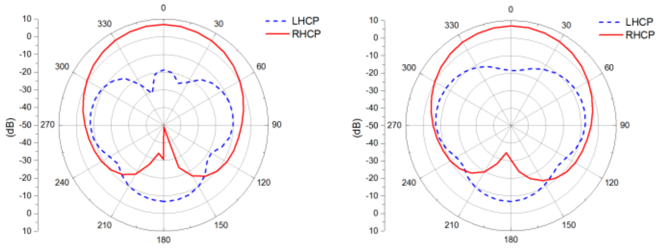
III. Antenna Simulation Results

This crossed dipole antenna has great wideband characteristics. It can be seen from Fig. 4(a) that the 10 dB impedance bandwidth is about 107%, from 0.96 to 3.12 GHz. The 3 dB axial ratio bandwidth is 97%, from 1.08 to 3.12 GHz. The gain with little variation from 1.08 to 2.6 GHz can be observed from Fig. 4(b). The cavity reflector can suppress the back radiation and enhance the gain. The radiation pattern at the frequency of 2 GHz is shown in Fig. 5. It can be seen that a very stable broadside radiation pattern is obtained .



(a) (b)

Fig. 4 Antenna results (a) |S11| (b) Axial Ratio and Gain



(a)yoz (b)xoz

Fig. 5 2GHz Radiation pattern (a) yoz (b) xoz

IV. Conclusion

In this paper, a wideband crossed dipole with parasitic elements is proposed. The gradient radiator patch has wider bandwidth than liner patch. The parasitic patches improve the axial ratio bandwidth by 17%. The introduction of an inverted cylindrical cavity with slots contributes to unidirectional radiation pattern and high gain. The proposed broadband antenna can be applied to many applications.

References

[1] Luk, Kwai Man, and W. Wang, A new wideband unidirectional antenna element," Int. j. microw. Opt. technol, 2006.

[2] J. W. Baik, K. J. Lee, W. S. Yoon, T. H. Lee and Y. S. Kim, "Circularly polarized printed crossed dipole antennas with broadband axial ratio," in *Electronics Letters*, vol. 44, no. 13, pp. 785-786, June 19 2008.

[3] S. W. Qu, C. H. Chan and Q. Xue, "Wideband and High-Gain Composite Cavity-Backed Crossed Triangular Bowtie Dipoles for Circularly Polarized Radiation," in *IEEE Transactions on Antennas and Propagation*, vol. 58, no. 10, pp. 3157-3164, Oct. 2010.

[4] K. Agarwal, Nasimuddin and A. Alphones, "Wideband Circularly Polarized AMC Reflector Backed Aperture Antenna," in *IEEE Transactions on Antennas and Propagation*, vol. 61, no. 3, pp. 1456-1461, March 2013.

[5] M. Li, K. M. Luk, L. Ge and K. Zhang, "Miniaturization of Magnetoelectric Dipole Antenna by Using Metamaterial Loading," in *IEEE Transactions on Antennas and Propagation*, vol. 64, no. 11, pp. 4914-4918, Nov. 2016.

[6] S. X. Ta, H. Choo, I. Park and R. W. Ziolkowski, "Multi-Band, Wide-Beam, Circularly Polarized, Crossed, Asymmetrically Barbed Dipole Antennas for GPS Applications," in *IEEE Transactions on Antennas and Propagation*, vol. 61, no. 11, pp. 5771-5775, Nov. 2013.

[7] H. H. Tran and I. Park, "Wideband Circularly Polarized Cavity-Backed Asymmetric Crossed Bowtie Dipole Antenna," in *IEEE Antennas and Wireless Propagation Letters*, vol. 15, pp. 358-361, 2016.