A shorted dual-polarized cross bowtie dipole antenna for mobile communication Systems

Wei-Jun Wu[1], Rong Fan[2], Zhi-Ya Zhang[3] ,Wei Zhang[1] and Qi Zhang[1]
[1]Science and Technology on Electromagnetic Compatibility Laboratory, China Ship Development and Design Center, Wuhan 430064, China and wj1218wu@126.com
[2]Xi'an Marine Equipment Engineering Research Academy Co.Ltd, Xi'an, Shaanxi 710071, China and frwsy@sohu.com

[3]National Key Laboratory of Science and Technology on Antennas and Microwaves, Xidian University, Xi'an, Shaanxi 710071, China and zhiyazhang@163.com

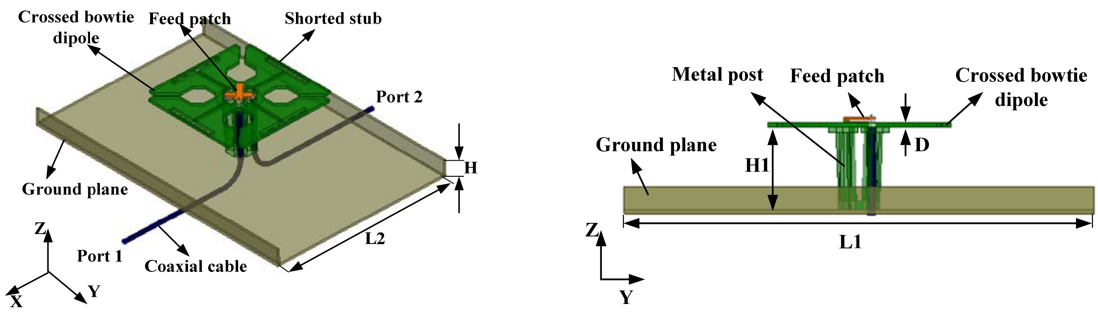
Abstract

A dual-polarized cross bowtie dipole antenna with shorted stubs for base station applications is presented. A pair of orthogonal cross bowtie dipoles with a rectangular ground plane is used to obtain the two linear polarizations. Besides two coaxial feeders and two shorted feed baluns, shorted stubs are introduced to improve the impendence matching and the isolation between the two orthogonal polarizations. A wideband impedance characteristics of about 27.6% for |S11|≤-10dB (+45^0 polarization) and |S22|≤-10dB (-45^0 polarization) is obtained. It is very suitable for potential base station applications in mobile communication such as DCS, PCS and UMTS, applications, etc.

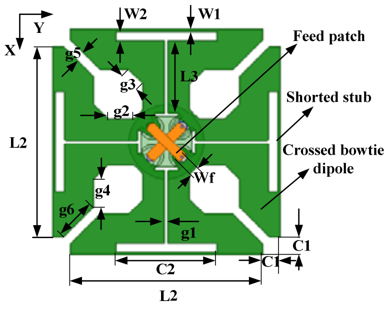
1. Introduction

With the increasing popularity of polarization diversity techniques in mobile communications, dual-polarized antennas have become more important and many dual-polarized antennas have been reported in many literatures [1-8]. For base station systems, the antenna has at least one cruciform radiating element module, which is aligned using dipoles radiators, patch radiators or slot radiators as radiators, at angles of +45^0 and -45^0 with respect to vertical or horizontal. With the rapid development of base station communications, antennas with wide impedance bandwidth become a necessary component in these systems. Many technologies were reported to broaden the impedance bandwidth. The stacked patch antennas with aperture coupled feed [3-4] can provide wider bandwidth but they involve structures with several layers, which will result in high cost and difficulty in adjustment. Patch elements fed with two probes with a relatively broad bandwidth [5–6] have been introduced, but the bandwidth is not wide enough to cover both the GSM1800 and UMTS bands. In [7-8], wideband dual-polarized printed dipole antennas are also designed. For simple structure and stable performance requirement, the cross metal dipole antenna is the usual choice. However, the impedance bandwidth performance of a traditional dipole antenna may not be good enough for the digital communication system (DCS,1710-1880 MHz), the personal communication system (PCS,1850-1990 MHz) and the universal mobile telecommunication system (UMTS, 1920-2170 MHz).

In this Letter, a dual-polarized cross bowtie dipole antenna with shorted stubs is proposed. Using the shorted stubs to effectively improve the impendence matching and the isolation between the two orthogonal polarizations at the whole band, the proposed antenna can achieve an operating bandwidth of about 27.6 % for |S11|≤-10dB (+45^0 polarization) and |S22|≤-10dB (-45^0 polarization) and better than 28dB for the isolation between the two polarizations. Details of the antenna design and theoretical results are presented.



(a) (b)



(c)

Figure 1 Geometry of proposed design: (a) 3D view; (b) Side view; (c) Detail view of cross bowtie dipole.

Table 1 Dimensions of proposed antenna

Parameters	*L1*	*L2*	*H*	*C1*	*C2*	*H1*	*dH*	*D*	*L3*
Values(mm)	*200*	*126*	*11.5*	*6*	*34.5*	*35*	*1.5*	*2*	*25*
Parameters	*W1*	*W2*	*Wf*	*g1*	*g2*	*g3*	*g4*	*g5*	*g6*
Values(mm)	*1*	*3*	*3.5*	*1.2*	*8.7*	*7*	*9.7*	*3.2*	*14.5*

2. Antenna design

The configuration of the dual-polarized cross bowtie dipole antenna and coordinate system are shown in Figure 1(a). The antenna mainly comprises a pair of cross bowtie dipoles, coaxial cable, feed patches, shorted stubs and a rectangular ground plane with dimension of L1×L2×H. With the large ground plane, the unidirectional radiation pattern and high front-to-back ratio of the antenna are obtained. The side view and the detail structures of the proposed antenna are shown in Figure 1(b) and (c). The cross dipole is a pair of bowtie dipoles whose centers are co-located and whose axes are orthogonal. Each dipole has a pair of bowtie arms. The height (H1) between the cross bowtie dipole and the ground plane is about a quarter of wavelength at the center frequency. The shorted stubs are employed on the end of the edge to improve the impedance matching in order to enhance the impedance bandwidth. The gap between the two dipoles is g1. The width and the length of the shorted stub are W1 and C2, respectively. The feed mechanism is designed into three parts, which include coaxial cable, feed patch and feed balun. The outer conductor of coaxial cable is connected to one arm of the bowtie dipole and the inner conductor is connected to the other arm of the bowtie dipole by a feed patch with the width (Wf). The outer conductor of the coaxial cable is also connected to the ground plane, which will connect one arm of the dipole to the ground. There is a shorting metal post at the symmetrical place with the coaxial feeder connecting the other arm of the dipole to the ground, which is called feed balun. The outer part of the coaxial feeder and the shorting metal post will produce a balun, which make the feed of the antenna good. The two orthogonal horizontal feed patches are staggered up and down. The distance between the two orthogonal feed patches is the parameter dH. It is noted that the distance can adjust the isolation between the two orthogonal polarizations. The designed and optimized antenna dimensions are given in Table 1.

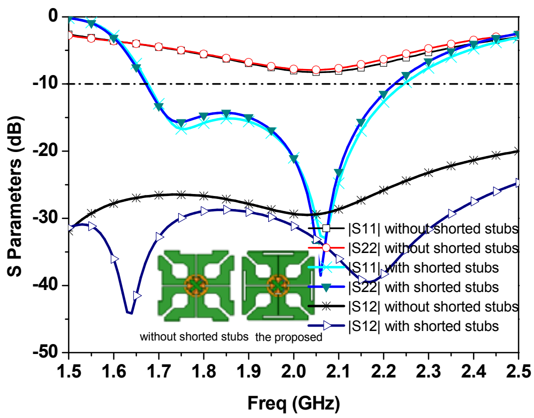


Figure 2 Comparison between simulated reflection coefficients and the isolation

Figure 2 shows the simulated reflection coefficients against frequency for the designed antenna. It can be observed that for |S11|≤ -10dB (Port1, +45^0 polarization) the impedance bandwidths are from 1.68 to 2.24 GHz and for |S22|≤ -10dB (Port2, -45^0 polarization) the impedance bandwidths are from 1.68 to 2.22 GHz, which clearly cover the required bandwidths of the DCS, PCS and UMTS applications. Meanwhile, to examine the effects of the shorted stubs to the antenna's matching condition, the simulated results of reflection coefficients for the case without the shorted stubs are also studied and plotted in Figure 2. Obviously, for the case of the antenna without the tuning stubs, it can be observed that the stubs have great effects on the impedance characteristics of the antenna, which the impedance bandwidth of the upper band is to deteriorate while moving off the tuning stubs. Figure 2 also presents the simulated isolation between the two orthogonal ports. The results show the isolation is improved at the whole band when with the shorted stubs and better than 28dB.

3. Simulated results

Figure 3 presents simulated S-parameters against the frequency for the proposed antenna. Obviously, wideband operations are obtained. For |S11|≤ -10dB (Port1, +45^0 polarization) the simulated impedance bandwidths are from 1.68 to 2.24 GHz and for |S22|≤ -10dB (Port2, -45^0 polarization) the simulated impedance bandwidths are from 1.68 to 2.22 GHz. In the figure, the simulated isolation between the two polarizations are also been given, which are better than 28dB over the entire bandwidth.

The simulated radiation patterns of the co-polarization and the cross-polarization for the proposed antenna in the XOZ-plane and YOZ-plane at 1.94 GHz are plotted in Figure 4. The half-power beamwidths in the XOZ-plane (the horizontal plane) are about $65^0 \pm 5^0$.

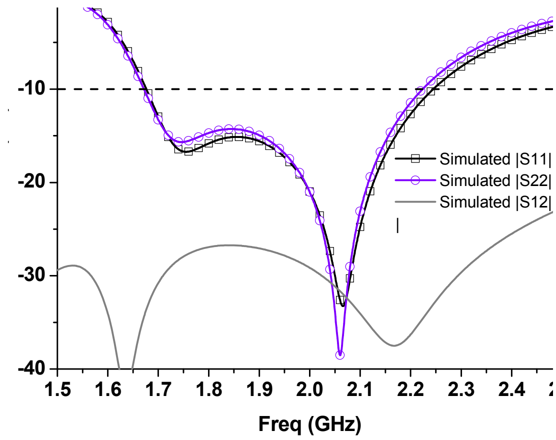


Figure 3 Simulated S-parameters of the proposed antenna.

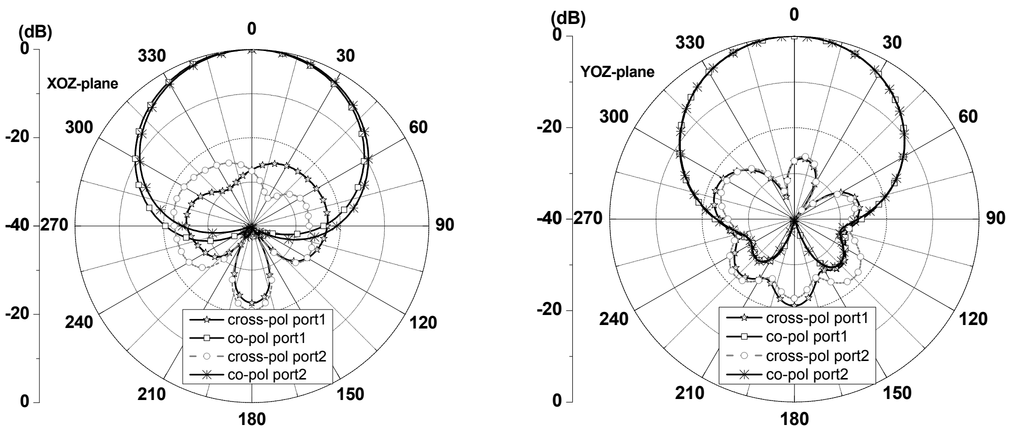


Figure 4 Simulated radiation patterns for the proposed antenna at 1.94GHz.

4. Conclusion

The wideband dual-polarized cross bowtie dipole antenna with shorted stubs is presented and investigated. Using the shorted stubs to achieve the other resonate point and effectively improve the impendence matching, the proposed antenna can achieve a wideband operating impendence characteristics. Stable unidirectional radiation patterns and high isolation between the two orthogonal polarizations, over the whole operating band are also provided. Due to these performances, the antenna has wide and potential applications for wireless communication system.

5. References

1. S. Hienonen, A. Lehto, and A. V. Raisanen1, “Compact wideband dual-polarized micostrip antenna,” *Microwave and optical technology letters* Vol. 28, No. 6, pp.396-398, March 2001.
2. Yang, S.-L.S.; Luk, Kwai-Man; Hau-Wah Lai; Kishk, A.A.; Lee, K.-F., “A dual-polarized antenna with pattern diversity, ” *IEEE Antennas and Propagation Magazine,* vol.50, pp.71-79, Aug. 2008
3. K. Ghorbani and R. B. Waterhouse, “Dual Polarized Wide-Band Aperture Stacked Patch Antennas,” *IEEE Trans. Antennas Propagat.*,vol.52, pp. 2171-2174, Aug. 2004.
4. M. Barba, “A High-Isolation, Wideband and Dual-Linear Polarization Patch Antenna,” *IEEE Trans. Antennas Propagat.*, vol.56, no.5, pp.1472-1476, 2008.
5. Lai, H.W., and Luk, K.M., “Wideband patch antenna with low cross-polarisation,” *Electron. Lett.*, vol.40, no.3, pp. 159–160, 2004.
6. Guo, Y.-X., Luk, K.-M., and Lee, K.-F., “Broadband dual polarization patch element for cellular-phone base stations,” *IEEE Trans. Antennas Propag.*, vol.50, no.2, pp. 251–253, 2002.
7. Shi-Gang Zhou, Peng-Khiang Tan, and Tan-Huat Chio, Low-Profile, “Wideband Dual-Polarized Antenna With High Isolation and Low Cross Polarization, *IEEE Antenna Wireless Propag. Lett*.,” vol.11, pp.1032–1035, 2012.
8. J.-Y. Deng, Y.-Z. Yin, K. Song, H. Gao and Q.-Zh. Liu, “Broadband double-tuned element with low profile for base station antennas,” *Electron. Lett.*, vol.46, no.3, pp.191–192, 2010.