A Wideband Microstrip Monopolar Patch Antenna with Compact Size

Kai Xu Wang, and Hang Wong, Jun Xiang
Information and Communication Technology Centre, Shenzhen Research Institute and
State Key Laboratory of Millimeter Waves, Department of Electronic Engineering,
City University of Hong Kong, Kowloon, Hong Kong

Abstract –A compact monopolar patch antenna is presented in this paper. The antenna has a wide bandwidth and a monopole-like radiation pattern. To reduce the whole size of the antenna, a substrate with high dielectric constant is adopted. Besides, three types of shorting pins and a triangle slot are added to the patch to widen the impedance bandwidth. The proposed antenna operates from 2.29 to 2.59 GHz for the reflection coefficient ⩽ -10 dB and has the maximum gain of 3.5 dBi. Most important, the antenna is low profile which only has the height of 0.048 λ_0.

Index Terms **— low profile, monopolar antenna, wide bandwidth, compact size**

I. INTRODUCTION

Monopole antennas are widely applied in the wireless communication system since their wide impedance bands, conical radiation patterns and simple structures. However, the height of a conventional monopole antenna is almost a quarter wavelengths, which would limit its application in the wireless communication system.

To solve this problem, several techniques are proposed to reduce the profile of monopole antennas [1]-[7]. A center-fed circular patch antenna was present in [1] to generate a monopole-like radiation pattern with low profile. However, it's bandwidth is narrow. A wide-band circular patch antenna with conical-pattern radiation was reported in [2] by utilizing an L-shaped probe feeding. In [3], a circular patch fed by a top-loaded monopole was proposed to enhance the impedance bandwidth. Unfortunately, their thickness are still too high for some applications. To decrease the profile and widen the impedance bandwidth of the monopole antenna, a circular patch-ring antenna was proposed in [4] by using the mode of the circular patch and a mode of the ring. Beside, two circular patch antennas with a set of conductive vias were present in [5] [6] to realize low profile and wideband. However, these antennas have a large radius. One of the techniques to reduce the radius of the patch antenna is by adopting a high dielectric constant substrate. However, it would result in narrow bandwidths. Especial for the antenna in [5], the high dielectric constant substrate would lead to high input impedance.

In this paper, we proposed a broadband microstrip monopolar patch antenna with low profile and small size.

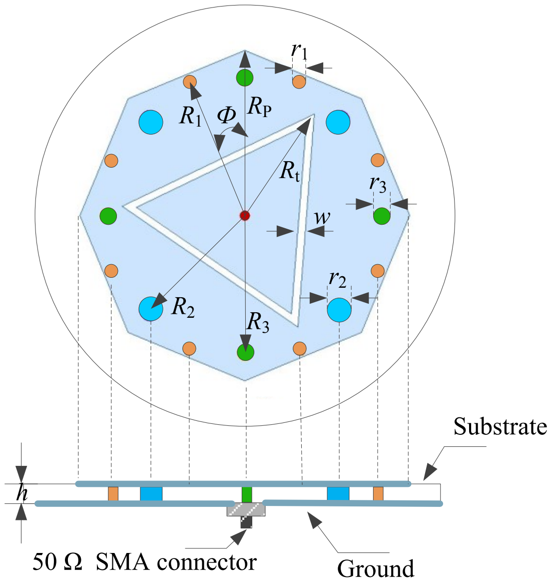


Fig. 1 Configuration of the proposed antenna

TABLE I
DETAIL DIMENSION OF PROPOSED ANTENNA

Parameters	R_1	R_2	R_3	r_1	r_2
value/mm	30.8	28.4	29	0.3	2.1
Parameters	h	w	R_P	Φ	$r3$
value/mm	6	0.5	34.9	22.5	0.7

The antenna consists of an octagonal patch antenna and three set of conductive vias. A triangle slot is cut from the patch to enhance the impedance bandwidth. This type of antenna can produce a monopole-like radiation pattern with compact size and wide impedance bandwidth characteristics.

II. ANTENNA DESIGN

A. Configuration

Fig.1 shows the configuration of the proposed Antenna. The antenna consists of an octagonal patch， three different sets of shorting pins, and a ground plane. A coaxial fed probe with a 50 Ω SMA connector is located at the center of the patch to excite this antenna to generate conical radiation pattern at the vertical plane and omni-directional at the horizontal plane. Three sets of shorting pins with different radii and different locations which are used to adjust the impedances of two resonant modes [7]. While the triangle slot are used to further improve the impedance response in order to obtain the wide bandwidth characteristic. The substrate of RT/duroid6010 with a dielectric constant of 10.2 is used (thickness of 6 mm). The other parameters of the antenna are shown in table I.

B. Simulation Result

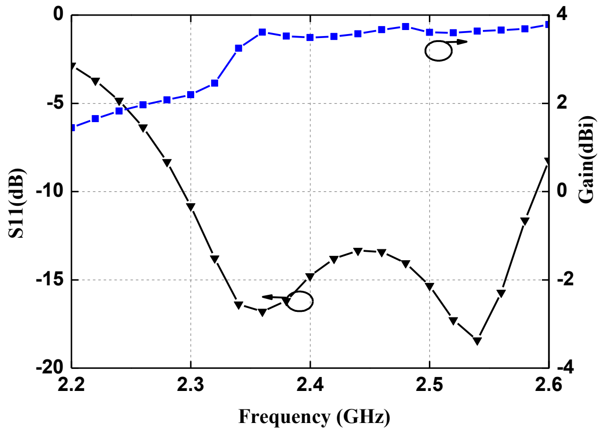
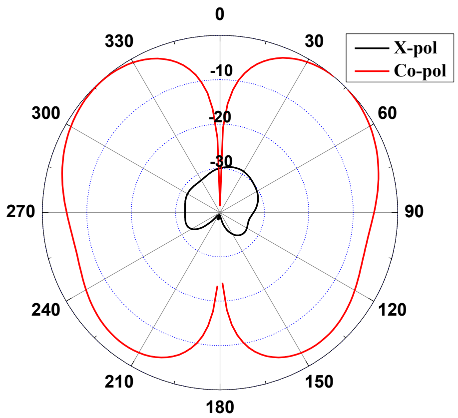
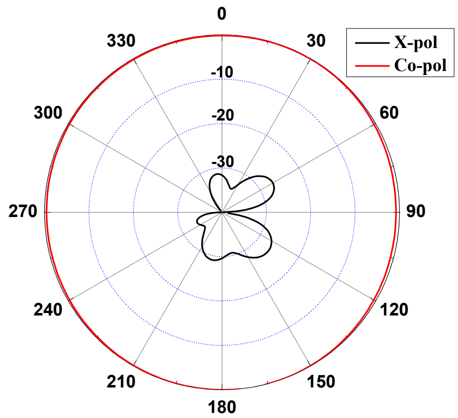


Fig. 2 Reflection coefficient



(a)



(b)

Fig. 3 Antenna patterns (a) Vertical plane, $\phi = 0^{o}$. (b) Horizontal plane

Fig. 2 depicts the simulated reflection coefficient and gain versus frequency. It can be found that the antenna has impedance bandwidth of 12.5% for the reflection coefficient ≤ -10 dB from 2.29 to 2.59 GHz. The gain varies from 2 dBi to 3.5 dBi. Figure3 shows the simulated pattern at 2.4 GHz. It can be found that the antenna has a conical radiation pattern as displayed in Fig.3 (a). As shown in the horizontal plane, the radiation pattern of the antenna is omnidirectional. In addition, the cross polarization level is about 26 dB lower than the co-polarization level for both the vertical and the horizontal planes.

III. CONCLUSION

This paper demonstrated an octagonal monopolar patch antenna with conical radiation pattern. By adopting a high dielectric constant substrate, the antenna can be design with compact size. Moreover, three sets of shorting pins are utilized to generate two resonator modes and a triangle slot is etched on the patch to reduce the input impedance to realize a wide impedance band. With these characteristics, the proposed antenna is suitable for wireless communications.

ACKNOWLEDGMENT

This project was supported in part by the Research Grants Council of the Hong Kong SAR, China (Project No. CityU 138413) and the Fundamental Research Program of Shenzhen City under grant No. JCYJ20140509155229810.

REFERENCES

[1] L. Economou and R. J. Langley, "Patch antenna equivalent to simple monopole," *Electron. Lett*., vol. 33, no. 9, pp. 727–728, Apr. 1997.

[2] Y.-X. Guo, M. Y. W. Chia, Z. N. Chen, and K.-M. Luk, "Wide-band L-probe fed circular patch antenna for conical-pattern radiation," *IEEE Trans. Antennas Propagat*., vol. 52, no. 4, pp. 1115–1116, Apr. 2004.

[3] K. W. Chin, K. F. Tong, and K.-M. Luk, "Wideband circular patch antenna operated at TM_{01} mode," *Electron. Lett,* vol. 35, no. 24, pp.2070–2071, Nov. 1999.

[4] A. Al-Zoubi, F. Yang, and A. Kishk, "A broadband center-fed circular patch-ring antenna with a monopole like radiation pattern," *IEEE Trans. Antennas Propagat*., vol. 57, no. 3, pp. 789–792, Mar. 2009.

[5] J. H. Liu, Q. Xue, H. Wong, and H. W. Lai, "Design and analysis of a low-profile and broadband microstrip monopolar patch antenna," *IEEE Trans. Antennas and Propagat*., vol. 61, no. 1, pp. 11-18, Jan. 2013..

[6] J. H. Liu, S. Y. Zheng, Y. X. Li and Y. L. Long, "Broadband monopolar microstrip patch antenna with shorting vias and coupled ring," *IEEE Antennas Wireless Propag. Lett*., vol. 13, pp. 39-42, 2014..

[7] H. Wong, K. K. So and X. Gao, "Bandwidth enhancement of a monopolar patch antenna with V-shaped slot for car-to-car and WLAN communications," *Accepted for IEEE Trans. Vehicular Technology.*