Circularly Polarized V-Shaped Patch Antenna for RFID Application

Yongsheng Pan, Yuandan Dong, Zhan Wang
School of Electronic Science and Engineering
University of Electronic Science and Technology of China
Chengdu, China
2015020907011@std.uestc.edu.cn, ydong@uestc.edu.cn, zhanwang7323@163.com

***Abstract* — A circularly polarized (CP) V-shaped patch antenna is proposed. Different from normal patch antennas, the suggested antenna employs a 3-dimentional V-shaped patch as the radiator. Two wings of the V-shaped patch gradually change antenna height and provide the impedance taper, therefore increases the bandwidth. The bottom of the "V" avoid large inductive reactance introduced by long feed probes. And a metal screw shorted to the ground has been added to significantly improve the impedance matching and CP performance. Good agreement has been observed between simulation and measurement. Measured results show that this antenna has an impedance bandwidth ($|S_{11}|$ < -10 dB) of 22 %, and a 3 dB AR bandwidth of 4.4 %, gain is around 8 dBi with a 915 MHz center frequency. Overall, the proposed antenna is very suitable for RFID applications.**

***Keywords* — circular polarization; patch antenna; RFID applications; V-shaped patch;**

I. INTRODUCTION

Circularly polarized (CP) antennas can reduce the loss caused by the polarization mismatch, and have been widely used in applications such as RFID reader. For single-fed microstrip antennas, circular polarization is usually achieved by cutting slots or truncating patch corner [1]. However, the 3 dB AR bandwidth of these approaches are usually less than 1 % [2]. This is caused by the conflict between quality factor (Q) of the antenna and the inductive reactance of the feeding probe. Thick substrate could decrease the Q and increase bandwidth, but it requires longer feeding probe, thus introducing larger inductive reactance, making it difficult to match [3].

Inspired by the wedge-shaped structure in [4] and linearly polarized V-shaped antenna in [5], the proposed antenna solved this conflict by using an asymmetrical V-shaped patch. Two wings of the V-shaped patch are equal to a thick substrate, which could decrease the Q and increase the bandwidth of the antenna. And the bottom of the "V" shortened the feeding probe height resulting in a decreased inductance, making it easier to match. By using an asymmetrical structure, two orthogonally polarized modes with slightly different center frequency were generated, which can achieve circular polarization. A metal screw shorted to the ground is placed around λ/4 away from the feeding probe to neutralize the inductance of the feed probe, which can significantly optimize the impedance matching and axial ratio (AR) performance.

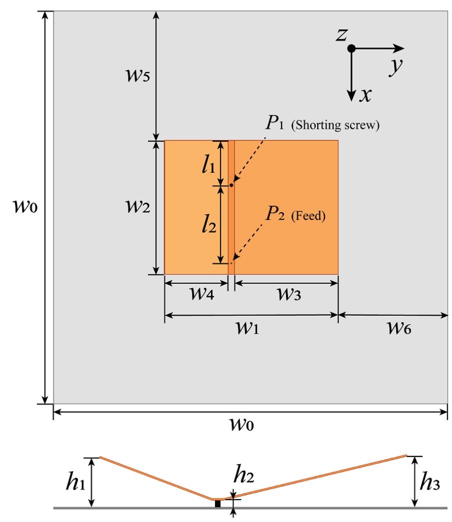


Fig. 1. Geometry of proposed V-shaped patch antenna

TABLE I. PARAMETER LIST（UNIT：MM）

Parameter	w_0	w_1	w_2	w_3	w_4	w_5	w_6	l_1	l_2	h_1	h_2	h_3
Dimensions	400	176.1	136.4	105.1	64.3	131.8	111.2	45.6	79.4	28.3	4	29.3

II. STRUCTURE

The structure of the proposed antenna is shown in Fig. 1. It consists of a ground plane, a V-shaped patch, a feeding probe (P_2 in Fig. 1), a shorting screw (P_1) and other mechanical structure. Dimensions of this antenna were optimized using ANSYS HFSS and a genetic algorithm. The final parameters are shown in Table I.

The structure is easy and low cost to fabricate. Patch and ground plane are made of aluminum plate, the patch is 0.5 mm thick and the ground plane is 1 mm thick. The "V" shape of the patch is achieved by a simple, low-cost bending process. The substrate of this antenna is air, so dielectric losses are eliminated. Shorting screw P_1 is a M3 screw made of stainless steel. It's mounted between the patch and the ground to optimize impedance matching and provide extra mechanical strength to the structure. In order to fix the position of the V-shaped patch, four polyamide hex threaded pillar were added to the corner of the patch. The fabricated antenna is shown in Fig. 2.

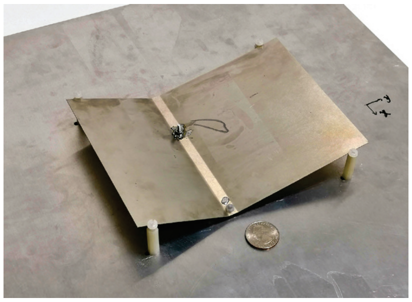
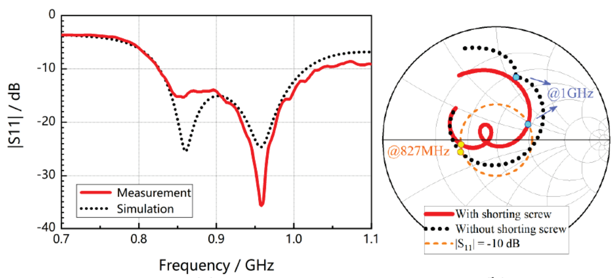


Fig. 2. Photo of the fabricated V-shaped aluminum antenna.



(a) (b)

Fig. 3. (a) Simulated and measured reflection coefficient of the proposed antenna, and (b) Simulated impedance with or without shorting screw.

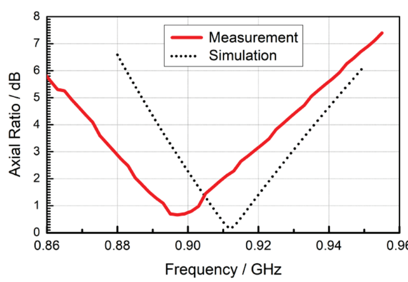


Fig. 4. Simulated and measured axial ratio.

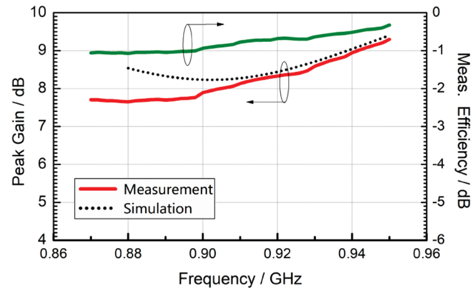
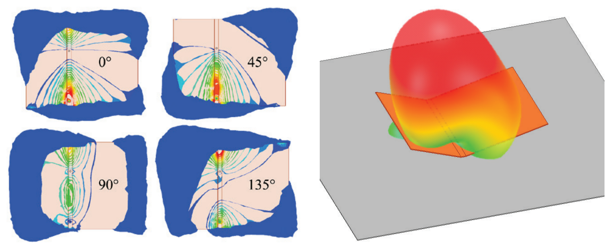
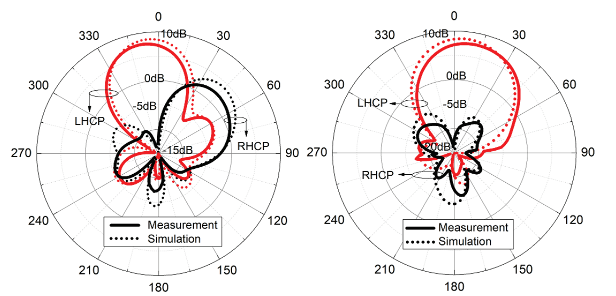


Fig. 5. Simulated and measured peak gain and efficiency.



(a) (b)

Fig. 6. (a) Simulated E field vs phase and (b) 3D radiation pattern.



(a) (b)

Fig. 7. Simulated and measured radiation patterns at 915MHz (a) XOZ-plane. (b) YOZ-plane.

III. Simulated and Measured Results

Simulated and measured results are shown in Fig. 3 to Fig. 7. Measured impedance bandwidth ($|S_{11}| < -10$ dB) is 204 MHz (826-1030 MHz), that is 22 % for the center frequency of 915 MHz, the effect of the shorting screw is shown in Fig. 3 (b). By introducing the screw which is equivalent to a shunt inductor, extra resonance is generated which improves the matching and CP performance. Axial ratio were measured at +Z-direction, and 3 dB AR bandwidth is 40 MHz (879-919 MHz) or 4.4 %, which shows that the V-shaped patch can effectively increase the bandwidth. Realized gain around center frequency is about 8 dBi. And measured efficiency is more than 90 %, which reflects the advantages of all-metal structure. Radiation patterns are shown in Fig. 6 (b) and Fig. 7, the direction of the peak gain is slightly off center (about 6°), which may be due to the asymmetrical structure. Noting that the deflection of the gain is more in XOZ-plane, which means that the asymmetry of the "V" is not the main factor.

IV. Conclusion

A circularly polarized V-shaped patch antenna is proposed, fabricated and tested. Numerical analysis and measurements were used to evaluate this antenna. Simulated and measured results show good agreement. By using the V-shaped patch with a shorting screw, this antenna reached an impedance bandwidth ($|S_{11}| < -10$ dB) of 22 %, and a 3 dB AR bandwidth of 4.4 %. With an all-metal structure, 90 % efficiency and 8 dBi gain are achieved, yet the cost and processing difficulty were very small, making it very suitable for RFID reader application.

References

[1] James, James R., Peter S. Hall, and Colin Wood. *Microstrip antenna: theory and design*. No. 12. Iet, 1981.

[2] Sharma, P. C., and K. C. Gupta. "Analysis and optimized design of single feed circularly polarized microstrip antennas." *IEEE Transactions on Antennas and Propagation* 31.6 (1983): 949-955.

[3] Chen, Wei, Kai‐Fong Lee, and R. Q. Lee. "Input impedance of coaxially fed rectangular microstrip antenna on electrically thick substrate." *Microwave and Optical Technology Letters* 6.6 (1993): 387-390.

[4] Jo, Young-Mio. "Broad band patch antennas using a wedge-shaped air dielectric substrate," *IEEE Antennas and Propagation Society International Symposium. 1999.* 932-935 vol.2.

[5] Tang, Chia-Luan, Jyh-Ying Chiou, and, and Kin-Lu Wong. "Broadband dual-frequency V-shape patch antenna." *Microwave and Optical Technology Letters* 25.2 (2000): 121-123.