A cpw-fed dual-beam shorted-patch antenna

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Abstract: In this paper, a compact dual-beam shorted-patch antenna is presented for wireless communications at 5.8 GHz. A short-end coplanar waveguide (CPW) feed line integrated on the ground plane is adopted in the structure to provide dual beam characteristic. The metal via array is applied in order to adjust the resonant frequency. The simulated results dual-beam radiation in the E-plane has maxima at +45° and 135°. The measured radiation pattern is dual-beam and the peak gain is 6.11 dBi at 5.8 GHz.

Keywords: dual-beam antenna, coplanar waveguide feed, via array

Classification: Microwave and millimeter-wave devices, circuits, and modules

References

[1] C. A. Balanis: Antenna Theory Analysis and Design (Wiley, USA, 2016) 4th ed. 783.
[2] T. Chen and Y. Lin: “Dual-beam microstrip leaky-wave array excited by aperture-coupling method,” IEEE Trans. Antennas Propag. 51 (2003) 2496 (DOI: 10.1109/TAP.2003.816312).
[3] C. Chen, et al.: “Wideband symmetrical cross-shaped probe dual-beam microstrip patch antenna,” IEEE Antennas Wireless Propag. Lett. 14 (2015) 622 (DOI: 10.1109/LAWP.2014.2375371).
[4] S. Liu, et al.: “Single-feed dual-band single/dualbeam u-slot antenna for wireless communication application,” IEEE Trans. Antennas Propag. 63 (2015) 3759 (DOI: 10.1109/TAP.2015.2438331).
[5] K. Carver and J. Mink: “Microstrip antenna technology,” IEEE Trans. Antennas Propag. 29 (1981) 2 (DOI: 10.1109/TAP.1981.1142523).
[6] J. M. Floch, et al.: “Design of dual beam printed dipole antenna,” The 5th European Conference on Antennas and Propagation (2011) 1109.
[7] S. Samree, et al.: “Dual beam Yagi patch antenna,” 2015 IEEE International Symposium on Antennas and Propagation & USNC/URSI National Radio Science Meeting (2015) 2247 (DOI: 10.1109/APS.2015.7305512).
[8] D. Misman, et al.: “Design of dual beam meander line antenna,” The 5th European Conference on Antennas and Propagation (2011) 576.
[9] C. J. Deng, et al.: “All-metallic dual-beam antenna with a low profile,” 2017 IEEE International Symposium on Antennas and Propagation & USNC/
1 Introduction

Low profile is an indispensable indicator of antenna in high-performance aircraft, spacecraft, satellite, and missile applications for its easy integration. Presently there are many military and commercial applications, such as mobile radio and wireless communications, they all need small size, low profile and dual beam antenna [1]. Owing to simple feed network and high gain characteristics, leaky wave antennas (LWAs) are applied in dual beam designs [2]. However, the length of LWAs is relatively large. To reduce the antenna volume, microstrip antennas have been widely used in many modern communication systems [3, 4, 5]. By using cross-shaped probe feeding technique, a wideband symmetrical dual-beam microstrip antenna is proposed and investigated in [3]. But the structure of the antenna is more complex, and two layers of substrates are needed. A dual beam printed dipole antenna is presented [6]. The dipole is composed with one reflector and one director. By combining two dipole antennas, dual beam characteristic is obtained. But the size of the antenna is 195 x 80 mm². The antenna in [7] utilized two reflectors that provides directional pattern in two perpendicular directions. By adding parasitic element, a meander line antenna is investigated [8]. The antenna can produce double beam radiation pattern. Unfortunately, the size of these antennas is very large. In [9], all-metallic dual-beam antenna with a low profile is presented. According to the asymmetric arrangement of shorting strips, dual beam operation can be achieved. It is not suitable to integrate into the RF front end since there are two shorting walls in the design of the antenna. A U-slot microstrip antenna operating at the TM02 mode is presented to attain radiation beams [10]. Nevertheless, the normalized radiation patterns in yz plane are not symmetrical.

In this paper, a novel dual-beam shorted-patch antenna with a low profile is proposed and designed. The metal via array is employed in order to adjust the resonant frequency. Owing to symmetric coupling feed structure, TM20 mode can be excited. The working frequency is 5.80 GHz, which is applied in WLAN band (5.725–5.825 GHz). Both simulation and experiment studies support the fact that the proposed antenna can achieve dual-beam and high gain performances.

2 Antenna design and analysis

2.1 Antenna structure

The geometry of the proposed antenna is depicted in Fig. 1, which is printed on a TLF-35A substrate with a relative dielectric constant of 3.42, dielectric loss tangent of 0.0022, and thickness of 1.0 mm. It has a dimension of 60 x 45 mm² with radiation plane dimension of 30 x 20 mm². It consists of a rectangular patch, a
coplanar waveguide (CPW) feed line integrated on the ground plane, and a metal via array. A SMA connector is used to feed the ground plane, and is placed at x-axis. The antenna elements are simulated in ANSYS HFSS full wave simulator [11]. The optimized parameters of the antennas are given in Table I.

![Antenna geometry](image)

**Fig. 1.** Geometry of the proposed antenna. (a) Top view. (b) Bottom view.

| Parameter | Value (mm) |
|-----------|------------|
| L         | 60         |
| W         | 45         |
| D₁        | 2.2        |
| D₂        | 2          |
| Lₛ        | 21         |
| Lₘw       | 20         |
| Lₚ        | 30         |
| D         | 1          |
| d         | 0.2        |
| a         | 17.3       |
| b         | 10         |
| h         | 1          |

**Table 1.** Detailed dimensions of the proposed antenna

### 2.2 Current distribution and parametric study

Fig. 2 shows the surface current at the TM₂₀ mode with symmetrical feed coupling structure. It is shown that the directions of currents at the up and down parts are opposite. Due to the existence of a metal via array, the left edge of the surface current has a little offset. Simulation results of the reflection coefficients at different values of these parameters are shown in Fig. 3. More importantly, the other
parameters are kept unchanged as the values in Table I, when a particular parameter is investigated. In Fig. 3(a), the resonant frequency is controlled by $a$. Fig. 3(b) shows that, $b$ has the similar influence on the reflection coefficients of the antenna. The ANSYS HFSS full wave simulator was used in the study.

![Fig. 2. Surface current distributions at 5.8 GHz.](image)

![Fig. 3. Simulated reflection coefficients for different (a) $a$, (b) $b$.](image)

### 3 Simulation and experimental results

To verify the results of the simulated design, the photo of the proposed antenna prototype is shown in Fig. 4. The measured and simulated reflection coefficients are...
presented in Fig. 5. The measured results are obtained by ROHDE & SCHWARZ ZVA8 vector network analyzer. The reflection coefficient is $-14.85$ dB at 5.8 GHz, and the reflection coefficients less than $-10$ dB range from 5.78 to 5.82 GHz. They show a good agreement between simulation and measurement results.

Fig. 6 shows the simulated total gain in the whole space at 5.8 GHz. Dual-beam is produced. The simulated dual-beam radiation in the $E$-plane has maxima at $+45^\circ$ and $135^\circ$. The simulated peak gain is about 6.13 dBi. The proposed antenna is measured in the anechoic chamber (SATIMO-SG24). Fig. 7 depicts the measured co- and cross-polarized radiation patterns at 5.8 GHz, in $E$-plane (xz-plane). It can be concluded that two beams are symmetric.

![Photograph of the fabricated antenna. (a) Top view. (b) Bottom view.](image)

Fig. 4. Photograph of the fabricated antenna. (a) Top view. (b) Bottom view.

![Simulated and measured reflection coefficients of the proposed antenna.](image)

Fig. 5. Simulated and measured reflection coefficients of the proposed antenna.
4 Conclusion

A novel dual-beam patch antenna based on symmetric coupling feed structure technology has been presented in this paper. The measured peak gain is 6.11 dBi at 5.8 GHz. Moreover, the measured radiation efficiency of the antenna is 71% at 5.8 GHz. More importantly, the proposed antenna has the characteristics of the low profile, high gain, and easy fabrication. Hence, the proposed antenna is a promising candidate in modern wireless communication systems.

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