A High Gain Monopolar Patch Antenna with Low Profile

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Abstract –A low profile monopolar patch antenna with conical beam radiation pattern and high gain performance is presented in this paper. The antenna has a simple structure which consists of a monopolar patch, a ground and a set of shorting pins. To enhance the gain performance, the antenna is designed to operate with TM_{03} mode and TM_{04} mode. The proposed antenna operates from 2.41 to 2.51 GHz for the VSWR ⩽ 2 and has the maximum gain of 11 dBi. Most important, the antenna is low profile which only has the height of $0.03\lambda_0$.

Index Terms **— low profile, monopolar antenna, high gain, high order mode antenna**

I. INTRODUCTION

Conical beam antennas are widely used in the wireless communication system. The conventional method to realize conical beam radiation pattern is by adopting a monopole, which is easy fabrication and low cost. However, the high profile of a conventional monopole antenna would limit its application in the wireless communication system.

To reduce the thickness of the monopole antenna, several techniques are proposed in [1]-[5]. A circular patch antenna was present in [1] to achieve a monopole-like radiation pattern with low profile. However, the impedance bandwidth of this antenna is narrow. To solve this problem, multi-modes technique is adopted in [2]-[5] to widen the bandwidth of circular patch antenna. In [2], two modes of a circular patch and a ring are used to achieve a wide bandwidth. Beside, TM_{01} and TM_{02} modes are excited by adding some conductive vias in [3]-[5] to realize low profile and wideband. However, the gains of these antennas are not high enough.

To further enhance the gain of the conical beam antenna, a hemitorus lens-reflector is adopted in [6] to realize a high gain performance with 12 dBi. But the profile of the antenna is very high. Array antenna is utilized in [7] to obtain a high gain of 9 dBi. But a complex feeding network is required. Another array antenna without individual feeding network is proposed in [8] by using four SIW cavities to enhance the gain up to 7.5 dBi. Besides, an open-ended coaxial waveguide [9] and multi-aperture rings are also utilized to achieve high gain performance [10].

In this paper, we proposed a microstrip monopolar patch antenna with low profile and high gain performance. The antenna consists of a circular patch, a circular ground and a set of shorting pins. The antenna has a similar configuration with the antenna presented in [3]. However, this antenna is designed to operate in TM_{03} mode and TM_{04} mode to obtain a high gain performance, which is different from the antenna in [3]. This type of antenna can produce a monopole-like radiation pattern with low profile and high gain characteristics.

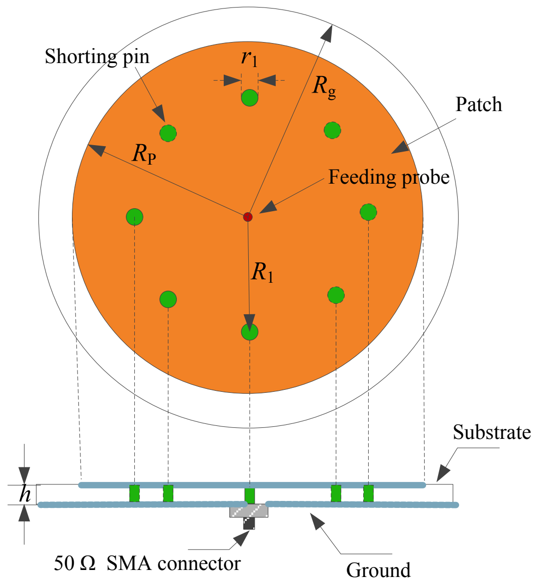


Fig. 1 Configuration of the proposed antenna

II. ANTENNA DESIGN

A. Configuration

Fig.1 shows the configuration of the proposed Antenna. The antenna has a simple structure with a substrate, a circular patch, a ground plane and 16 shorting pins. The substrate has a dielectric constant of 2.33 and loss tangent of 0.0012. Other parameters of the prototype are given by h =3.96 mm, R_1 =71.9 mm, R_g =160 mm, R_p =128 mm, r_1 =3.2 mm. The antenna is fed at the center of the patch by a coaxial fed probe with a 50 Ω SMA connector, which can generate a conical radiation pattern at the vertical plane and omni-directional pattern at the azimuth plane. The circular patch can generated a TM_{03} mode, while the shorting pins are used to produce a TM_{04} mode. By adjusting the size of the patch and the position of the shorting pins, the frequency of the two modes can be moved closely to 2.45 GHz to enhance the impedance bandwidth of the antenna.

B. *Simulation Result*

Fig. 2 depicts the simulated voltage standing wave ratio and gain versus frequency. It can be found that the antenna has impedance bandwidth for the VSWR ≤ 2 from 2.41 to 2.51 GHz. The gain varies from 10 dBi to 11 dBi, which is

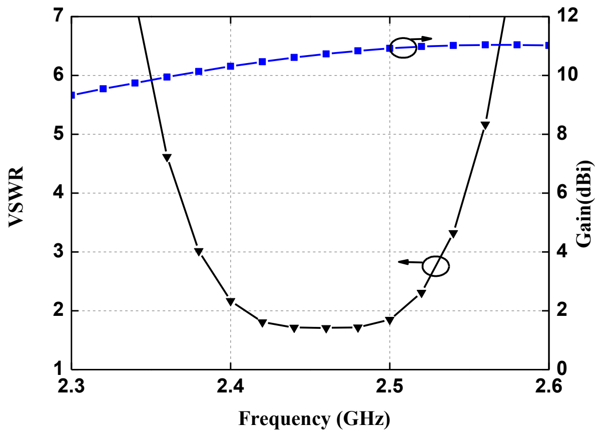
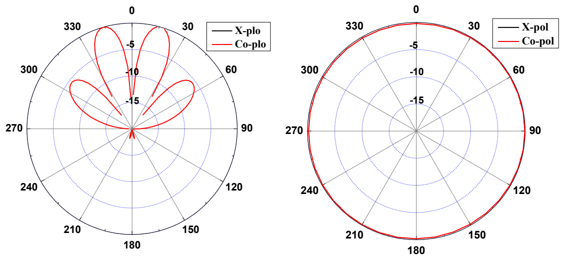


Fig. 2 VSWR and gain of the antenna



(a) (b)

Fig. 3 Antenna patterns at 2.45 GHz (a) Vertical plane, $\phi = 0^{o}$. (b) Azimuth plane

higher than the proposed antenna in [3]. Figure3 shows the simulated radiation pattern at 2.45 GHz. It can be found that the antenna has a conical radiation pattern and an omnidirectional pattern in vertical plane and azimuth plane, respectively. In addition, the cross polarization level is about 30 dB lower than the co-polarization level for both the vertical and the azimuth planes.

A comparison of the proposed antenna and other designs are shown in Table I. It can be found the gain in this work is 5dB higher than that proposed in [3]. The thicknesses of the two antennas are similar. But the impedance bandwidth in [3] is much wider than that in this work. This is because the input impedances of TM_{03} and TM_{04} modes are much higher than that of TM_{01} and TM_{02} modes. Beside, this antenna has much lower profile when compare with other high gain designs.

III. CONCLUSION

This paper presented a circular monopolar patch antenna with conical radiation pattern. By adopting a set of shorting pins and center-fed techniques, the TM_{03} and TM_{04} modes can be excited. When adjusting the size of the patch and the shoring pins position, the frequency of two modes can be moved closed to 2.4GHz to obtain a good impedance matching. Moreover, the peak gain can reach to 11 dBi. Beside, this antenna also has a low profile with only $0.03\lambda_0$. With these characteristics, the proposed antenna is suitable for 2.4 GHz wireless communications.

TABLE I
PERFORMANCE OF CONICAL BEAM ANTENNAS

Ref.	techniques for enhancing the gain	Thickness	bandwidth	Max. Gain
[3]	TM_{01} and TM_{02} mode	0.024 λ_0	18%	6 dBi
[6]	Hemitorus lens-reflector	5 λ_0	1%	12 dBi
[8]	SIW array	$0.09\lambda_0$	3.5%	7.5 dBi.
[9]	Open-ended coaxial waveguide	$0.3\lambda_0$	40%	7.5 dBi
[10]	Concentric coaxial apertures	$0.25\lambda_0$	40%	12 dBi
This work	TM_{03} and TM_{04} mode	$0.03\lambda_0$	4%	11 dBi

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