

Super wideband characteristics of monopolar patch antenna

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Published in *The Journal of Engineering*; Received on 23rd October 2013; Accepted on 4th November 2013

Abstract: A simple method of acquiring super wideband characteristics for monopolar patch antenna is proposed. Through adopting a modified cone as feeding and radiating structure, the monopolar patch antenna can reach the impedance bandwidth of more than 1:23.4 for voltage standing wave ratio (VSWR) ≤ 2 . In the whole operating band, the antenna has the like-monopole omnidirectional radiation patterns and the peak gains of 3.8–8.7 dB. Meanwhile, the height of the antenna is just $0.074\lambda_c$, and the diameter of the radiated body is $0.205\lambda_c$, which is smaller than other ultra-wideband omnidirectional antenna.

1 Introduction

In the field of wireless communications, the omnidirectional antenna has been widely used because of its null-free coverage in azimuth plane. As the development of multi-band operation and compact volume on variety communication systems, such as indoor base stations, it is demanded the omnidirectional antenna has the characters of wideband and miniaturisation. As is known to all, monopole is the classic antenna to realise omnidirectional communication, but it is characterised by nearly a-quarter-wave-length height and narrow-band operation.

In 1993, Delaveaud *et al.* [1] proposed monopolar patch antenna, which had very low profile of 0.058λ and like-monopole radiation

pattern (RP), but the impedance bandwidth (VSWR ≤ 2) was merely 3%. The designing thought was adding patch on the top of monopole and shorting the patch to the ground. Then, most of the related researches concentrated on the methods of enhancing bandwidth of the monopolar patch antenna [2–7]. In 2005, Lau *et al.* [2] presented a kind of monopolar patch antenna whose impedance bandwidth reached 138% (1:7.4). In his designing, the feeding structure under the patch adopted four orthogonally combining truncated trapezoidal plates, and the shorting structure was four symmetrical shorting wires. The height and diameter of the radiation body were $0.087\lambda_c$ and $0.246\lambda_c$ separately, where λ_c is lower cutoff frequency for VSWR ≤ 2 . After that, Lau improved the feeding structure further on above antenna, and a super impedance wideband of more than 1:26 was reached [3]. During this period, there were some other developments on the structure of monopolar patch antennas, such as changing the sharp and type of the feeding structure [4, 5], cutting ring slot on the patch [6] and adding sleeve under the patch [7], whose heights were all below $0.1\lambda_c$ and diameters were all in 0.24 – $0.4\lambda_c$. To sum up, all these methods could enhance impedance bandwidth to some degree, but none of them could overwhelm Lau's bandwidth. Actually, all the present researches are adopting different structures under the patch to

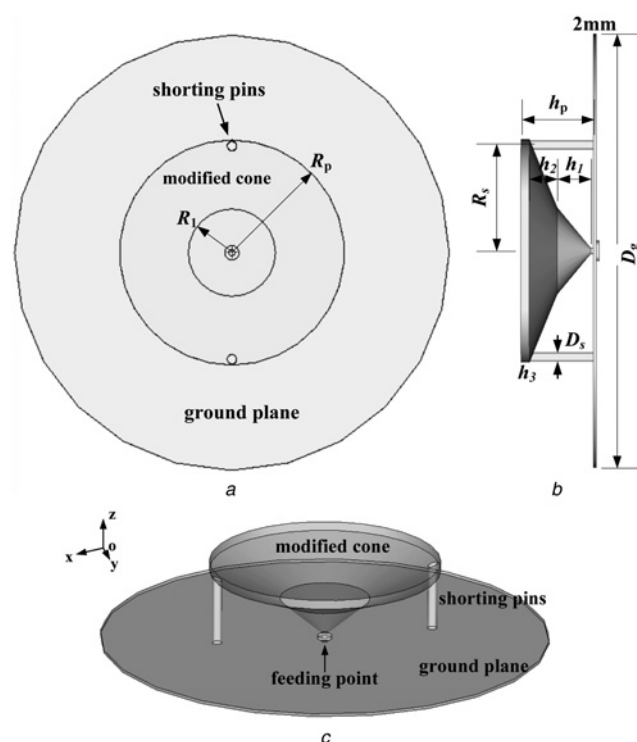


Fig. 1 Geometry of the proposed antenna

a Top view
b Side view
c 3D view

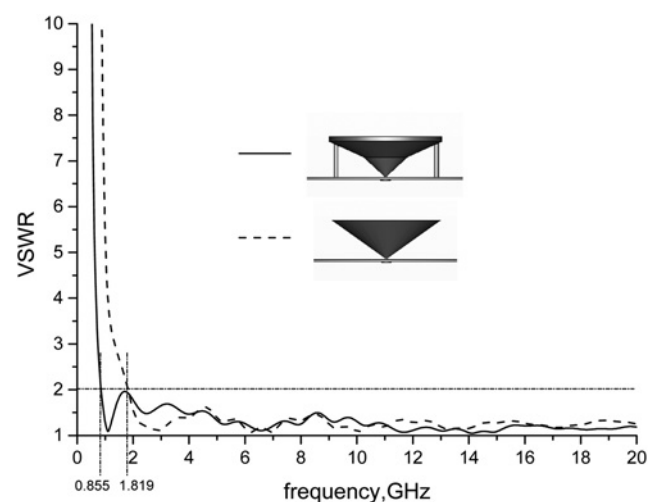


Fig. 2 Measured VSWR of the proposed antenna and mono-conical antenna

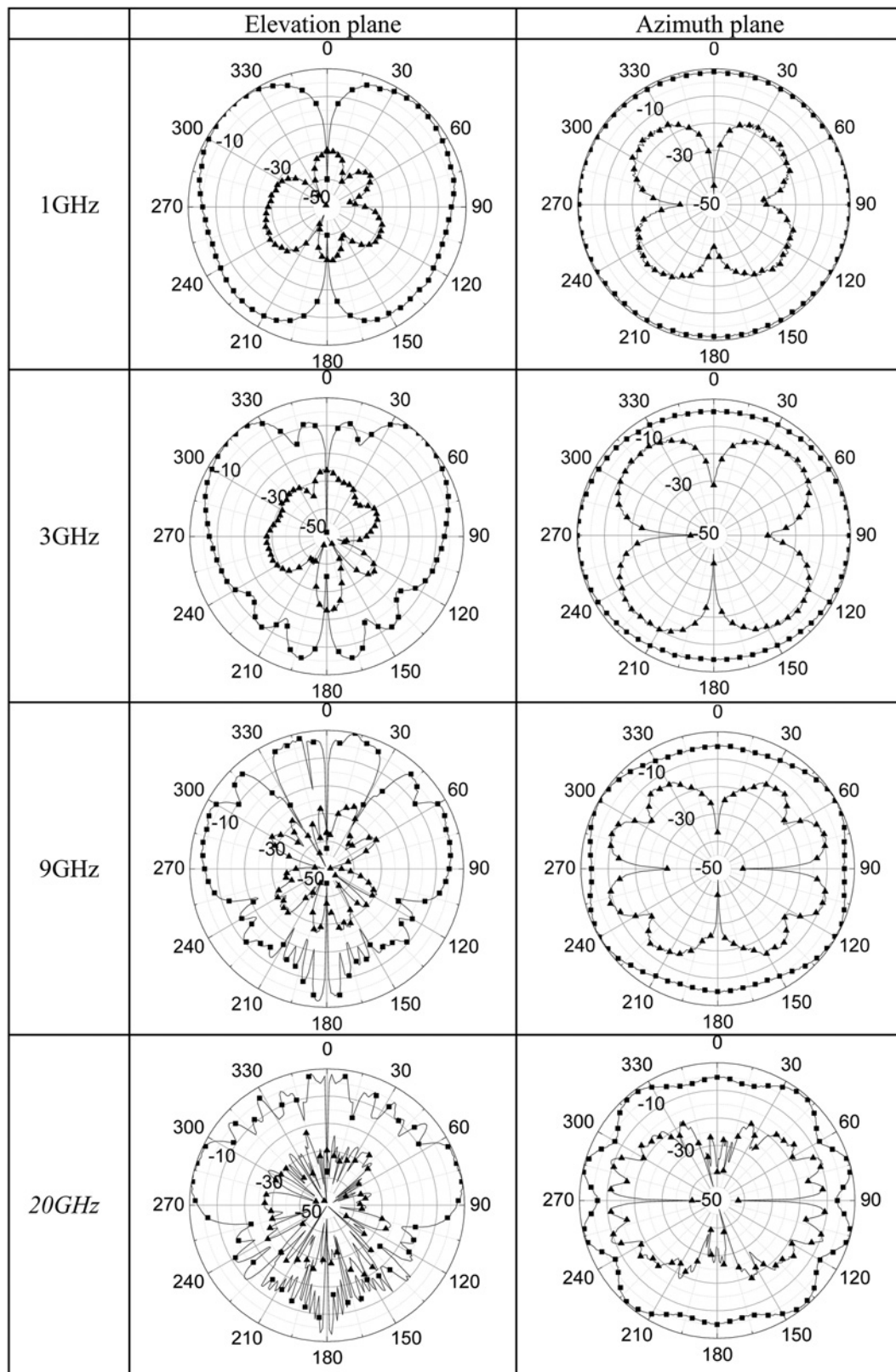


Fig. 3 Measured RPs (dB)
 ■ – co-pol and ▲ – cross-pol

broaden impedance bandwidth or decrease the lower cutoff frequency, because decreasing lower cutoff frequency implies reducing antenna dimensions.

In other words, it is an interesting and challenging problem that how to use the simplest structure obtains the best performances

Table 1 Ripple level and peak gains against frequency

Frequency, GHz	1	3	9	20
Ripple level, dB	1.1	4.2	5.0	6.6
Peak gain, dB	3.8	6.3	5.0	8.7

under the specified external sizes. However, all the present methods almost increase the complexity of antenna structure when broadening bandwidth. Under the inspiration of literature [3], we propose a novel method to realise super bandwidth for monopolar patch antenna. Comparing with other monopolar patch antennas, the proposed antenna has simpler structure and smaller sizes.

2 Antenna design

The design process is illustrated as follows. Fig. 1 shows the geometry of the proposed antenna. Firstly, an inverted cone and a ground plane form a basic mono-conical antenna, whose VSWR possesses the high-pass feature and the lower cutoff frequency is determined just by the sizes of the cone. The bottom of the inverted cone lies at the centre of the circular ground plane and connects to the inner conductor of a coaxial connector. Secondly, two shorting pins are used to ground the cone. The two pins are distributed symmetrically at both sides of the cone axis. Grounding the cone could reduce the lower cutoff frequency obviously. However, the pins will lead to the deterioration of impedance matching at lower-frequency band. So thirdly, we divide the inverted cone into two components from the waist. The lower cone with a smaller cone angle mainly decides the impedance characteristic of the upper-frequency band, whereas the upper truncated cone with a larger cone angle mainly decides the impedance characteristic of the lower-frequency band. This modified process helps to reduce the lower cutoff frequency further and improve the impedance matching. Through the steps above, an original omnidirectional antenna with super wideband and low profile can be obtained by the simple structure. The diameter of the ground plane is decided as 296 mm ($0.84\lambda_c$ at 855 MHz) and the thickness is 2 mm . Through the optimisation for structural parameters, the height of the cone h_p is $0.074\lambda_c$ (26 mm) and the diameter $2R_p$ is $0.205\lambda_c$ (72 mm), which are further smaller than other present wideband monopolar patch antennas. The other sizes in Fig. 1 are: $h_1 = 12\text{ mm}$, $h_2 = 10\text{ mm}$, $h_3 = 3\text{ mm}$, $R_1 = 14\text{ mm}$, $D_s = 3\text{ mm}$ and $R_s = 32.4\text{ mm}$. All the parameter values are optimised by electromagnetic simulation software computer simulation technology (CST).

3 Results and analysis

According to the structures and sizes above, a prototype of the proposed antenna was fabricated and measured to confirm the design method. Fig. 2 shows the measured VSWR curves up to 20 GHz . From the figure, the lower cutoff frequency of the proposed antenna for $\text{VSWR} \leq 2$ reaches 855 MHz . Since mono-conical antenna also possesses ultra-wideband feature, we show the VSWR of a mono-conical antenna with same dimensions as comparison, whose lower cutoff frequency is 1.819 GHz . It is implied this antenna is obviously smaller in size. The final impedance bandwidth of the proposed antenna is more than $1:23.4$.

The RPs and gains were also measured. The RPs were obtained in elevation plane (xoz -plane) and azimuth plane (parallel xoy -plane

cutting the peak gain) at $1, 3, 9$ and 20 GHz . Fig. 3 shows the measured results. The co-polarised RPs suggest that the proposed antenna possesses like-monopole radiation in the whole frequency band. As the frequency increases, the maximum direction in elevation plane changes from high-elevation angle to low ones. Additionally, the co-polarised ripple level in azimuth plane also increases. Table 1 lists the ripple level values. Actually, the ripple is caused by the asymmetric shorting structure and varies with its electrical sizes, but the maximum ripple level is not more than 6.6 dB , which is much smaller than 10 dB in [3]. The peak gains are also given in Table 1. As the frequency rises, the peak gain basically increases from 3.8 to 8.7 dB .

4 Conclusions

The method of designing super-wideband monopolar patch antenna is presented and confirmed through an antenna case. The impedance bandwidth of the antenna for $\text{VSWR} \leq 2$ is more than $1:23.4$ ($0.855\text{--}20\text{ GHz}$). The height and diameter of the antenna are merely $0.074\lambda_c$ and $0.205\lambda_c$, which is smaller than other present ultra-wideband monopolar patch antenna. The measured results show that the antenna also has well like-monopole RPs in the whole band, the gains are in $3.8\text{--}8.7\text{ dB}$, and the ripple levels in azimuth plane are not more than 6.6 dB . This simple and small antenna almost covers all the digital communication bands and could satisfy many compact and multi-band omnidirectional communication systems.

5 Acknowledgments

This work was supported by the Fundamental Research Funds for the Central Universities under grant number K5051202006, PRC.

6 References

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