Compact Printed Monopole Antenna with Extremely Wide Bandwidth

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Abstract

A compact printed monopole antenna with an extremely wide bandwidth (EWB) is proposed, which is composed of a hollowed elliptical monopole patch and a trapeziform ground plane, both printed on the same side of a substrate, and is fed by a tapered CPW feeder in the middle of the ground plane. The experimental results demonstrate that this antenna achieves a measured impedance bandwidth from 0.44GHz to 10.6GHz (24.1:1) for VSWR≤2, and exhibits a nearly omnidirectional radiation pattern, while its area is only about $0.20\lambda_l \times 0.13\lambda_l$, where λ_l is the wavelength of the lowest operating frequency.

1 Introduction

Recently some updated designs with a bandwidth ratio of more than 10:1 have been proposed, which mainly include two types. One is based on the tapered traveling-wave structures such as the 'cobra' structure [1]. But these structures are somewhat large. Another type is the specially designed monopole antenna, e.g. the planar inverted cone antenna (PICA) [2] and the leaf-shaped monopole antenna [3]. However these planar monopole antennas need a perpendicular ground plane, resulting in an increase of antenna volume and the inconvenience of integrating with monolithic microwave integrated circuits.

In the meantime, some planar ultra-wideband monopole antennas, without a perpendicular ground plane, have been proposed [4-7]. In [4], a printed elliptic monopole juxtaposed with a ground plane in a single substrate is presented. It is designed for UWB communications with an impedance bandwidth ratio of about 4:1 and an area of $0.34\lambda_l \times 0.19\lambda_l$. In [6]、[7], an rectangular monopole antenna and an elliptical monopole antenna are proposed respectively, achieving a VSWR≤2 bandwidth of 0.79～9.16 GHz, 0.41～8.86 GHz, respectively.

In this paper, a novel hollowed printed monopole antennas is introduced, which provides measured impedance bandwidth of 0.44～10.6 GHz with a compact size. The proposed antenna design and its simulated and experimental results are presented and discussed.

2 Antenna design

An examination in the current distribution of the CPW-fed elliptical patch antenna reveals that, at all frequencies of its operating bandwidth, the surface currents of the monopole patch mostly concentrated on the bottom periphery of the patch close to the feed, while those on the upper periphery and around the center of the patch are of very low current density, as shown in Figure 1. From this observation, a circular hollow of radius r is cut out from the elliptical patch to eliminate the region of low current density, resulting in the proposed antenna, as shown in Figure 2.

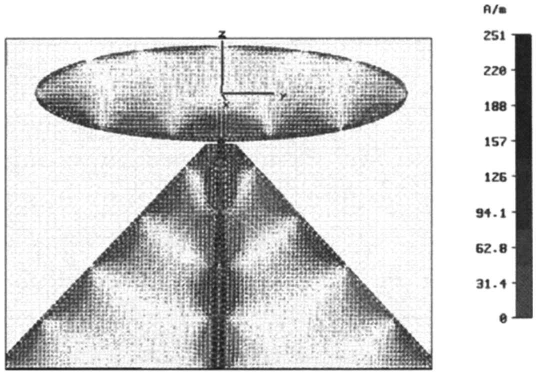


Figure 1 Current distribution of CPW-fed elliptical patch antenna (f=6GHz)

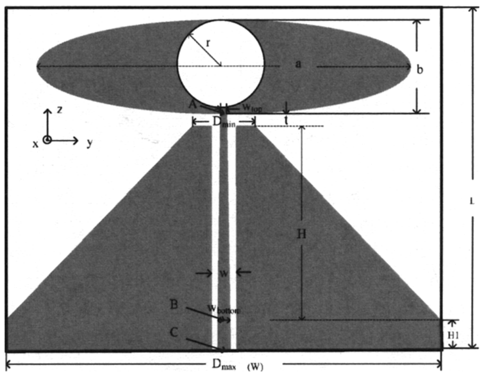


Figure 2 Geometry of proposed antenna

The proposed antenna consists of a hollowed elliptical monopole and a trapeziform ground plane with a spacing t between them. Both the monopole and the ground plane are etched on a substrate of thickness h=1.524 mm and relative permittivity $\varepsilon_r = 3.48$. The hollowed elliptical monopole is fed by a tapered CPW feeder in the middle of the ground, where the total gap width g is fixed to 3.0 mm, but the top width of the central strip is w_{top}=1.0 mm for 100Ω characteristic impedance at point A and the bottom width w_{bottom}=2.6 mm for 50Ω impedance at point C, while the width w between points A and B is linearly tapered, and that between points B and C is uniform.

3 Simulated and experimental results

By using CST Microwave Studio software [8] based on the finite integration technology method, the characteristics of the proposed antenna were computed and its parameters were optimized.

The optimized antenna was fabricated and the VSWR was measured using the Agilent 8722ES network analyzer. The measured VSWR is compared with the calculated by CST, as shown in Figure 3.

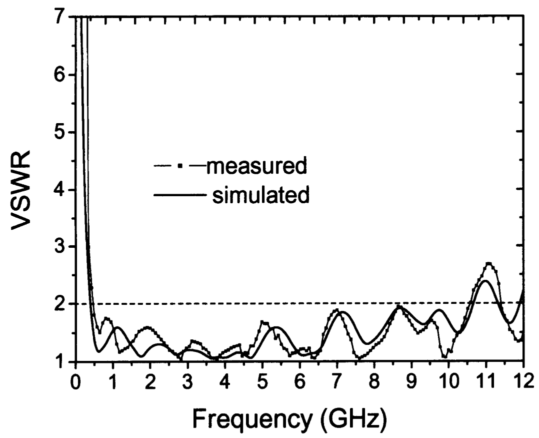
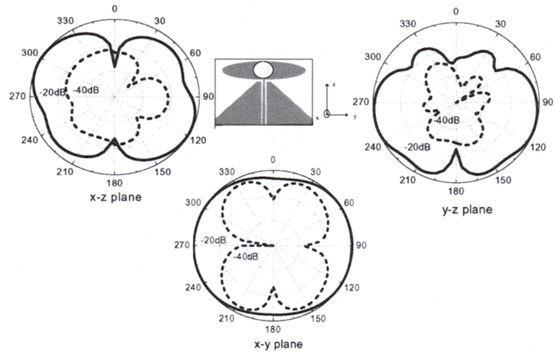


Figure3 Measured and simulated VSWR
(Parameters: a=120mm, b=30mm, r=14mm, D_{max}=140 mm, H=50mm)

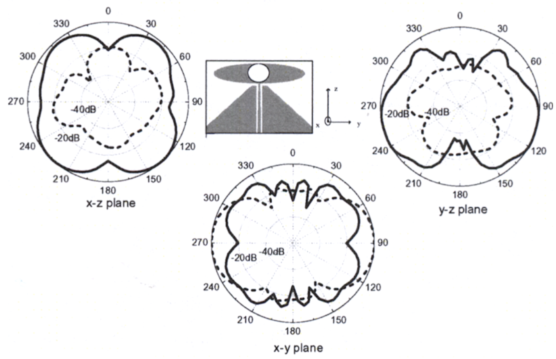
The simulated VSWR ≤ 2 bandwidth covers a frequency range from 0.39 to 10.70 GHz, while the measured ratio impedance bandwidth covers a frequency range from 0.44 to 10.6 GHz with a ratio bandwidth of 24.1:1, showing good agreement between both. There is a slight discrepancy between the simulation and the experiment, due mainly to the effect of a SMA connector in addition to errors in the processing. That SMA connector is not accounted for in the simulation but was used in the experiment. In addition, It is noted that the antenna has a compact dimension of only about $0.20\lambda_l \times 0.13\lambda_l$ (λ_l——the wavelength of the lowest operations frequency).

The simulated radiation patterns of the antenna at 3, 6 and 9 GHz are shown in Figure 4. It is seen that this antenna has nearly omni-directional radiation characteristics, while the cross-polarization level rises with the frequency increase owing to the horizontal components of surface currents. The variation of radiation pattern with frequency is not drastic.

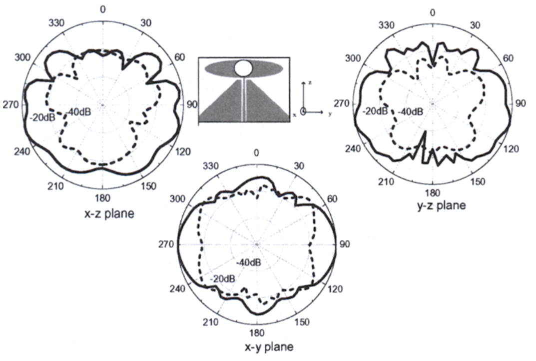
Figure 5 displays the simulated gain characteristics of the antenna with the measured one of Ref. [7]. It is seen that the gain of this hollow elliptical antenna is close to that of an elliptical antenna [7]. The gain increases with frequency in general within the operating bandwidth of the antenna. For the frequency higher than 4GHz, the gain is larger than 3dB, up to about 6dB.



(a) f=3GHz



(b) f=6GHz



(c) f=9GHz

Figure4 Simulated radiation patterns

(solid line—co-polar; dotted line—cross-polar)

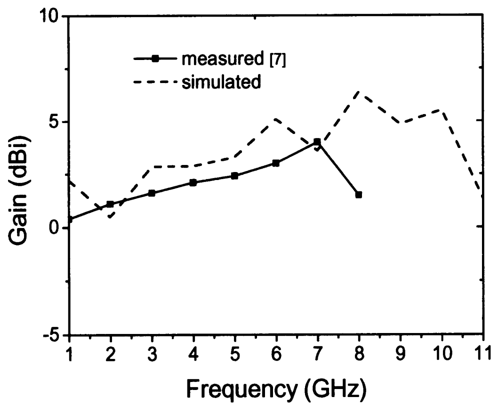


Figure5 Gain

4 Conclusions

A compact EWB hollowed elliptical planar monopole antenna is presented. By combining three techniques, a hollowed elliptical monopole patch, a trapeziform ground plane and a tapered CPW feeder, the hollowed elliptical monopole antenna has achieved a measured ratio bandwidth of 24.1:1 for VSWR≤2 and exhibited a nearly omnidirectional radiation pattern, while its area is only about $0.20\lambda_l \times 0.13\lambda_l$. This antenna has a simple structure, compact size and low cost, therefore it will be an attractive candidate for various military and civil EWB applications.

Acknowledgements

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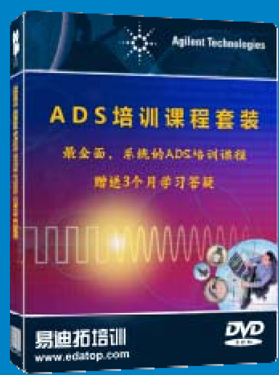

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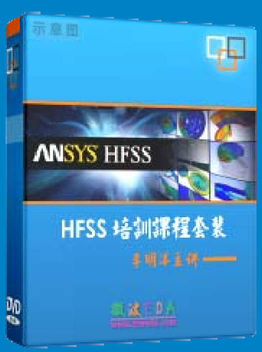

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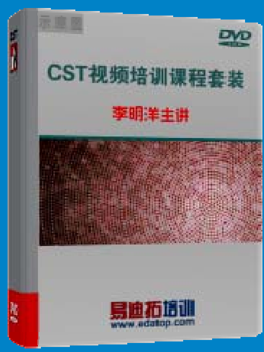

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