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# A PRINTED VOLCANO SMOKE ANTENNA FOR UWB AND WLAN COMMUNICATIONS

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**Abstract**—A novel printed version of the classic volcano smoke antenna is presented and investigated in this article. The effects of some important parameters on the VSWR of the proposed antenna have been investigated in the design. The measured bandwidth of VSWR $< 2$ is from 1.80 to 14.35 GHz, which covers all UWB (3.1–10.6 GHz) and 2.4 GHz WLAN (2.4–2.4835 GHz) bands. Moreover, the antenna features near omnidirectional characteristics in the operation range and good radiation efficiency. A gain variation from 2.04 to 7.02 dBi (2–13 GHz) is obtained.

## 1. INTRODUCTION

UWB technology has recently attracted much attention for wireless communication, networking, detection radars and other applications. One of main issues in UWB systems is to design a compact and wideband antenna. The volcano smoke antenna is a conventional wideband antenna and it was originally designed by Kraus [1]. And there are also some recent investigations on this kind of antenna [2–5]. However, the classic volcano smoke antenna is a volumetric ultra-wide band antenna and its application is limited. Recently, several CPW-fed monopole antennas [6–8] have been introduced for UWB applications because of their characteristics of wide impedance bandwidth, compact and simple structure, low cost, omnidirectional radiation pattern, and ease of fabrication.

In this article, a novel printed version of the classic volcano smoke antenna is presented and some of important parameters have been investigated. The proposed antenna is a CPW-fed monopole antenna which is developed from the classic volcano smoke antenna. And the simulated and measured results show that it can be used in both UWB and WLAN communications. Details of the design and experimental results are presented and discussed in Section 2 and Section 3.

## 2. ANTENNA STRUCTURE AND DESIGN

The configuration of the printed volcano smoke antenna is shown in Figure 1. The antenna is printed on a substrate with the relative dielectric constant of 2.78 and the thickness of 0.8 mm. The antenna parameters are: $W = 46\,\text{mm}$, $L = 55\,\text{mm}$, $W_1 = 2.1\,\text{mm}$, $L_1 = 11\,\text{mm}$, $g = 0.35\,\text{mm}$, $h = 48\,\text{mm}$, $R_1 = 14\,\text{mm}$, $\theta = 72°$, $h_1 = 0.75\,\text{mm}$,

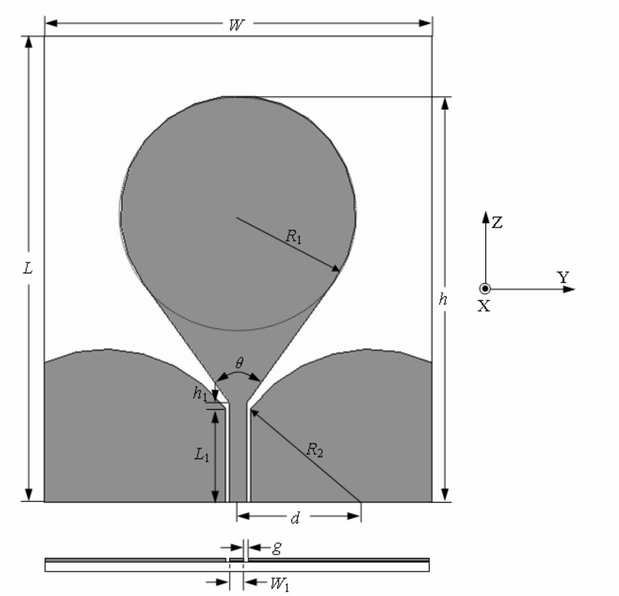


**Figure 1.** Geometry of the proposed antenna.

$R_2 = 18$ mm, $d = 15.7$ mm. The proposed antenna has CPW-type feed with signal line of length 11 mm and width 2.1 mm, and gap distance of 0.35 mm between the feed line and the two ground planes. The CPW line is excited by an SMA connector with a coax-to-CPW transition.

Among these parameters, the radius $R_1$ and angle $\theta$ of the radiator, as long as radius $R_2$ of two grounds are important factors for controlling impedance bandwidth. We have investigated the effects of these parameters on the VSWR of the proposed antennas using Ansoft HFSS commercial software. Figure 2 shows the simulated voltage standing wave ratio (VSWR) curves with parameter $h$. It is seen that the printed volcano smoke antenna has a good impedance matching in an ultra-wide frequency range. When the height of the radiator increases, its bandwidth is increased gradually, as shown in Figure 2. Considering the requirement of bandwidth for covering both WLAN-operating band and UWB-operating band, the case of $h = 48$ mm was selected as the constructed prototype.

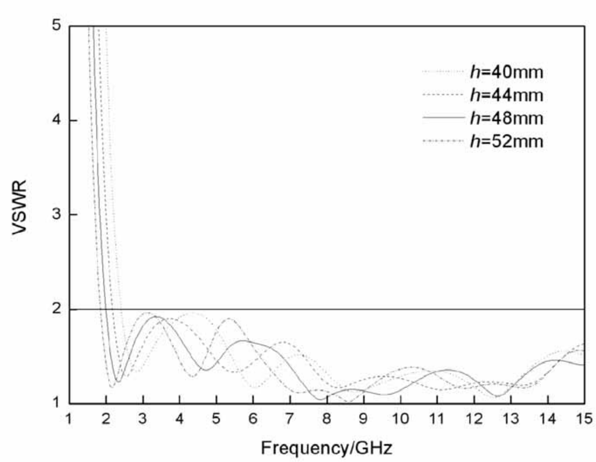


**Figure 2.** Simulated VSWR against frequency for antennas with various $h$. (other parameters: $W_1 = 2.1$ mm, $L_1 = 11$ mm, $g = 0.35$ mm, $\theta = 72°$, $h_1 = 0.75$ mm, $R_2 = 18$ mm, $d = 15.7$ mm).

Figure 3 and Figure 4 show the simulated VSWR of different angle $\theta$ of the radiator and radius $R_2$ of two grounds. It can be see that the angle $\theta$ and radius $R_2$ can be chosen in a broad range when the antenna can obtain effective impedance matching, that is the range of $\theta$ is about $72° \sim 90°$ and the range of $R_2$ is about $18 \sim 20$ mm. The biggest advantage of this geometry is that it can easily obtain ultra-wide band impedance matching.

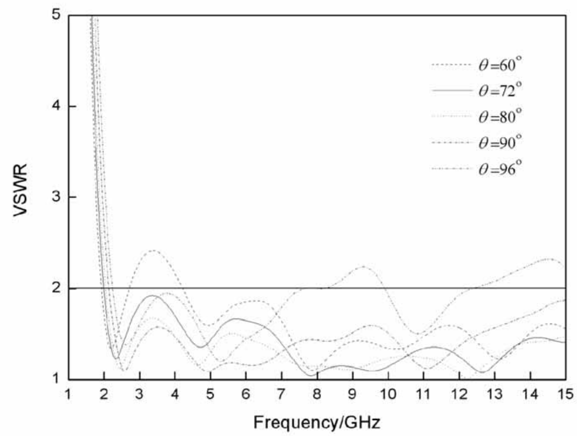


**Figure 3.** Simulated VSWR against frequency for antennas with various $\theta$. (other parameters: $W_1 = 2.1\,\text{mm}$, $L_1 = 11\,\text{mm}$, $g = 0.35\,\text{mm}$, $h = 48\,\text{mm}$, $h_1 = 0.75\,\text{mm}$, $R_2 = 18\,\text{mm}$, $d = 15.7\,\text{mm}$).

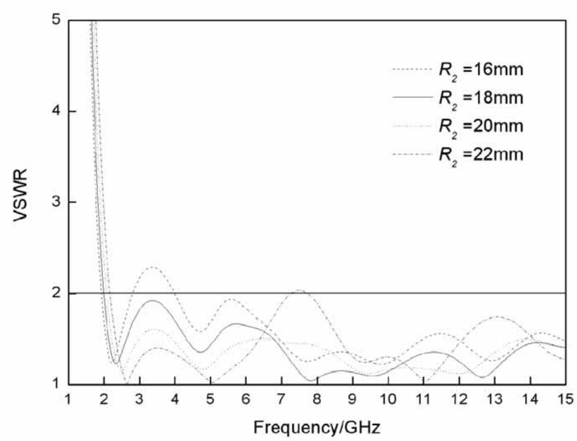


**Figure 4.** Simulated VSWR against frequency for antennas with various $R_2$. (other parameters: $W_1 = 2.1\,\text{mm}$, $L_1 = 11\,\text{mm}$, $g = 0.35\,\text{mm}$, $h = 48\,\text{mm}$, $R_1 = 14\,\text{mm}$, $\theta = 72°$, $h_1 = 0.75\,\text{mm}$).

## 3. SIMULATION AND MEASUREMENT

Finally, we choose that $h = 48\,\text{mm}$, $\theta = 72°$ and $R_2 = 18\,\text{mm}$. Other parameters are given in Figure 2. A test printed volcano smoke antenna

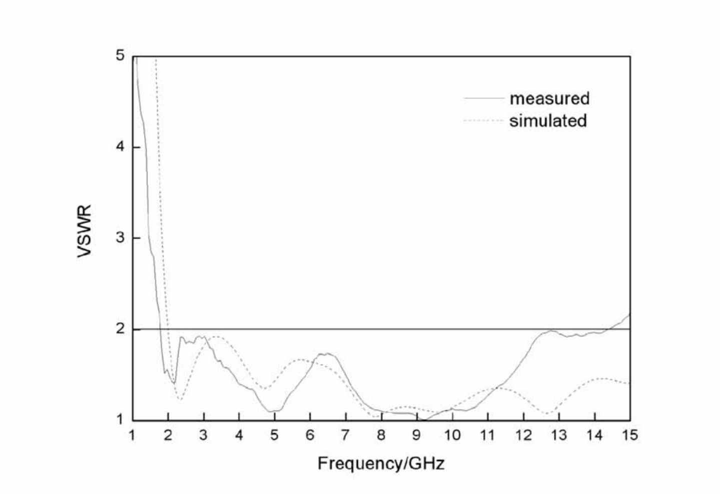


**Figure 5.** Measured and simulated VSWR of the proposed antenna.

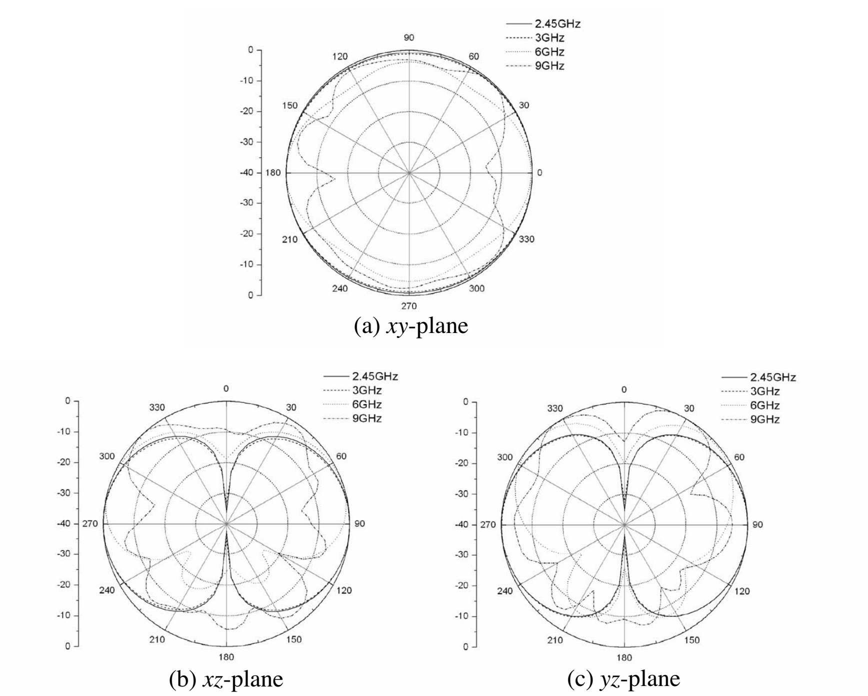


**Figure 6.** Simulated radiation patterns of proposed antenna at 2.45 GHz, 3 GHz, 6 GHz and 9 GHz in three orthogonal $x$-$y$, $x$-$z$, $y$-$z$ planes.

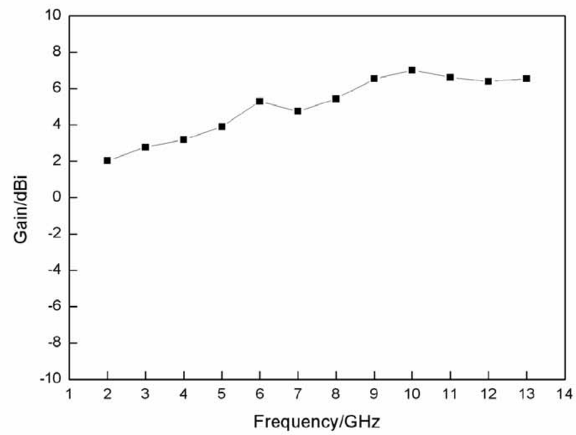


**Figure 7.** Simulated peak gain from 2 to 13 GHz.

was fabricated and the VSWR of the antenna was measured using the Agilent 8722ES Network Analyzer. As shown in Figure 5, the simulated bandwidth of VSWR $< 2$ is from 2.00 to 15.00 GHz, while the measured one is from 1.80 to 14.35 GHz. Both of them cover the UWB of 3.1–10.6 GHz for short wireless communications, and the WLAN of 2.4–2.4835 GHz for Wireless Local Area Network.

The simulated radiation patterns of proposed antenna at 2.45, 3, 6, and 9 GHz are shown in Figure 6. Figures 6(a)–6(c) show the $XY$-plane, $XZ$-plane, and $YZ$-plane patterns, respectively. Obviously, the antenna exhibits properties similar to those of a typical monopole antenna. The pattern in $XY$-plane is nearly omnidirectional over the entire operating bandwidth and suits UWB application. Figure 7 shows the simulated peak gain of the proposed antenna. It is evident that the range of antenna gain is about 2.04 to 7.02 dBi. The maximum simulated peak gain is 7.02 dBi at 10 GHz.

## 4. CONCLUSION

The new designed of printed volcano smoke antenna with modified parameters for both UWB and WLAN is successfully demonstrated. The proposed antenna has a planar structure that makes it easy to integrate with the circuits. The input match impedance for the printed volcano smoke antenna covers 1.80 to 14.35 GHz. This bandwidth covered all UWB (3.1–10.6 GHz) and 2.4 GHz WLAN (2.4–2.4835 GHz) bands. The antenna features nearly omnidirectional patterns in the $x$-$y$ plane. A gain variation from 2.04 to 7.02 dBi (2–13 GHz) is obtained.

## ACKNOWLEDGMENT

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