# Design of a Wideband Planar Volcano-smoke Slot Antenna (PVSA) for Wireless Communications

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**Abstract:** This paper presents a novel antenna design, referred to as the planar volcano-smoke slot antenna (PVSA), useful for wideband wireless communication applications. The antenna is a planar slot with an appearance reminiscent of a volcanic crater and puff of smoke, and is fed by a coplanar waveguide (CPW) to achieve wide bandwidth. A coax-to-CPW transition, which is crucial for achieving wide bandwidth performance, is modeled and introduced into the antenna, and the effect of slot variations on antenna bandwidth is investigated. It is demonstrated that the optimized PVSA has an impedance bandwidth of 125% (for a VSWR < 2) at the center frequency of 3.7 GHz.

## 1. Introduction

Recently, there has been a great deal of interest in the design of wideband antennas for wireless communication applications because of continuously expanding range of wireless telecommunication services and related applications for voice and data transmission. For instance, to realize a high data rate of wireless transmission it is necessary to use a wideband antenna [1], which should exhibit a good impedance match and radiation pattern over a wide frequency range.

In the past, a whole host of wideband antennas, such as Vivaldis, log-periodics and spirals, have been developed for numerous communication-related applications. One particular example of a very wideband antenna, which has an appearance reminiscent of a volcanic crater and puff of smoke, is designed by gradually tapering the inner and outer conductors of a coaxial transmission line [2]. Recently, slot antennas fed by coplanar waveguide (CPW) have been used for microwave and millimeter wave applications because they offer low-profile geometries and wide bandwidth [3-4].

In this paper, the design and optimization of the PVSA are presented. A coax-to-CPW transition is incorporated into the PVSA to match it to a 50 Ω input impedance. To investigate the effect of slot variations on antenna bandwidth, three designs with different slots are modeled and fabricated. The input reflection characteristics and radiation patterns of three designs are compared for both simulated and measured results.

## 2. Planar volcano-smoke slot antenna design

We begin our discussion by describing the design of a PVSA antenna fed by a coax-to-CPW transition. This type of slot provides a smooth, gradual transition from the feed line to the radiating element and a nearly constant input impedance over a relatively wide bandwidth [1]. Figure 1 shows the geometry of the PVSA. It consists of a shaped patch antenna with dimensions of 130mm×130mm an inner island, a ground conductor, and a coax-to-CPW transition. In previous research, the performance of a PVSA fed by a CPW feed line was investigated and a 96.5Ω resistance was used for the simulation as a reference load over the entire frequency range, to determine the return loss of the antenna [3]. However, in this paper, a coax-to-CPW transition is

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introduced to match a $50\,\Omega$ input impedance, which is more desirable. The widths of the upper and lower parts of the slot are 38mm and 0.5mm, respectively, and the slot width increases gradually. The width and length of the inner conductor are 18.5mm and 81mm, respectively, and the ground conductor of the slot is connected to the ground plane of the coax. The antenna is numerically modeled by using the MoM, and the simulated and measured S11 characteristics are compared in Fig. 2. An S11 characteristic better than –10dB (for a VSWR < 2) is achieved from 1.4 GHz to 7 GHz in the MoM simulation, while it covers the frequency range of 1.4 GHz to 6 GHz in the measurement result. The radiation patterns of the PVSA have been measured and are shown in Figs. 3 and 4 for 2 and 4 GHz, for the two principal cuts ($\phi$=0° and $\phi$=90°). We note that the pattern is symmetric for the $\phi$=0° cut, while it is tilted forward for the $\phi$=90°. In addition, a study of the current distribution on the antenna shows that the currents are concentrated along the slot.

Next, we investigate the effect of slot variations on the antenna bandwidth. Three designs, including the original one described above, are simulated and fabricated for this purpose. Two other designs are shown in Figs. 5 (a) and (c), while the original design is presented in Fig. 5 (b). The dimensions of the inner conductor and the overall antenna remain the same for all three cases. The size of the upper part of the slot is 42mm and the area of the slot is wider than that of the original one for the design-A (Fig. 5 (a)), while it is 26mm and the area of the slot is narrower compared to the original one for Design-B (see Fig. 5 (c)). The simulated and measured S11 characteristics for the three designs are displayed in Fig. 6 for the sake of comparison. We observe that the frequency band shifts to lower for the wider slot case, while it moves to higher frequencies for the narrower slot case. The measured S11 characteristics show that the original design has the widest bandwidth among the three.

## 3. Conclusions

In this paper, we have presented a compact wideband planar volcano-smoke slot antenna for wireless communications. The broadband nature of the antenna stems from the choice of its shape, and a coax-to-CPW transition used to match the antenna to 50Ω over a very wide bandwidth (1.4 to 6 GHz). It is conjectured that the antenna size could be reduced by placing it over a dielectric substrate, though at the cost of sacrificing its bandwidth somewhat.

## References

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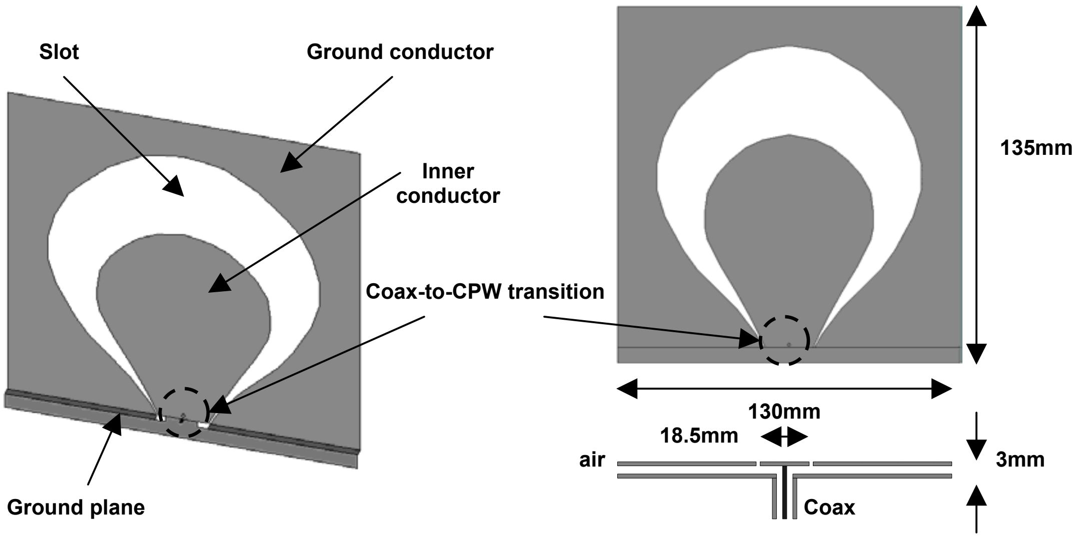


(a) (b)

Fig. 1 Geometry of a planar volcano-smoke slot antenna (PVSA): (a) 3D view; and (b) top and side views.

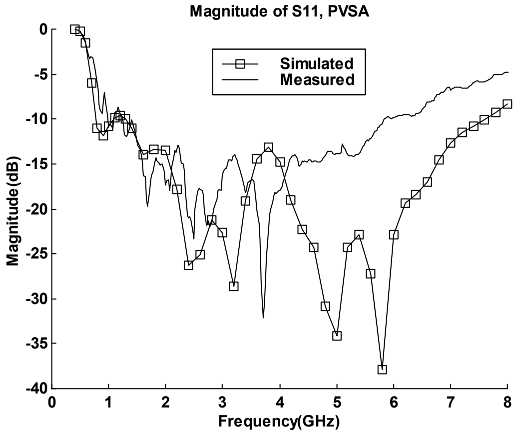
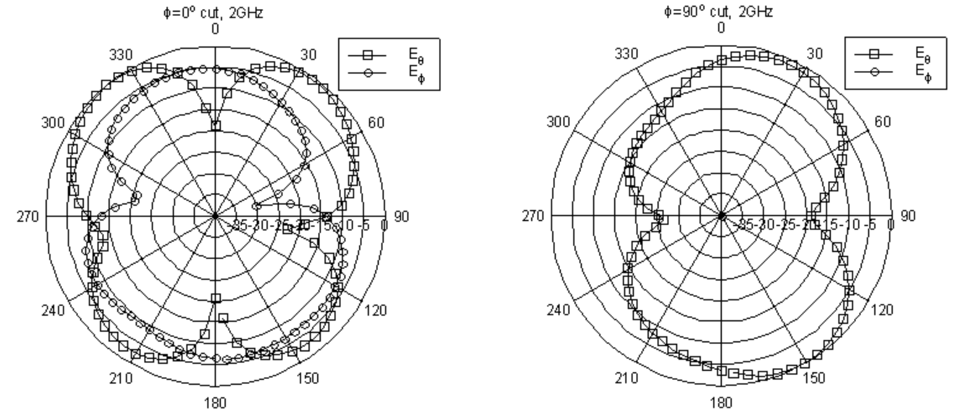
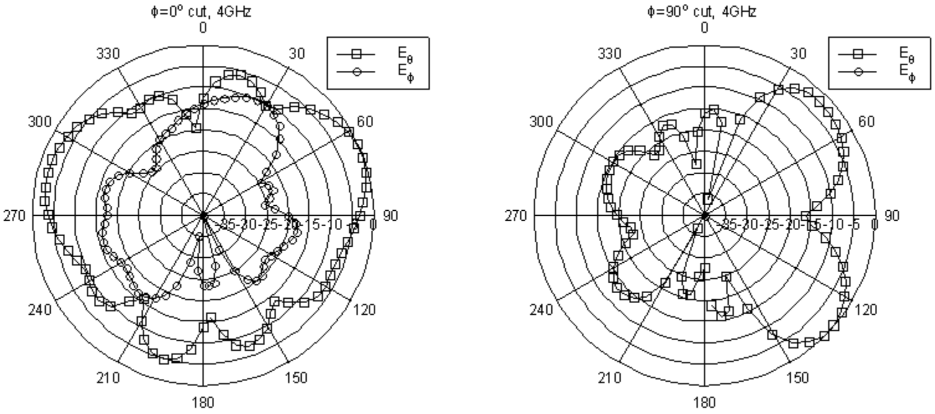


Fig. 2. Comparison of simulated and measured S11 characteristics of the PVSA.



(a) (b)

Fig. 3. Radiation patterns of the PVSA at 2GHz: (a) ϕ=0° cut; and (b) ϕ=90° cut.

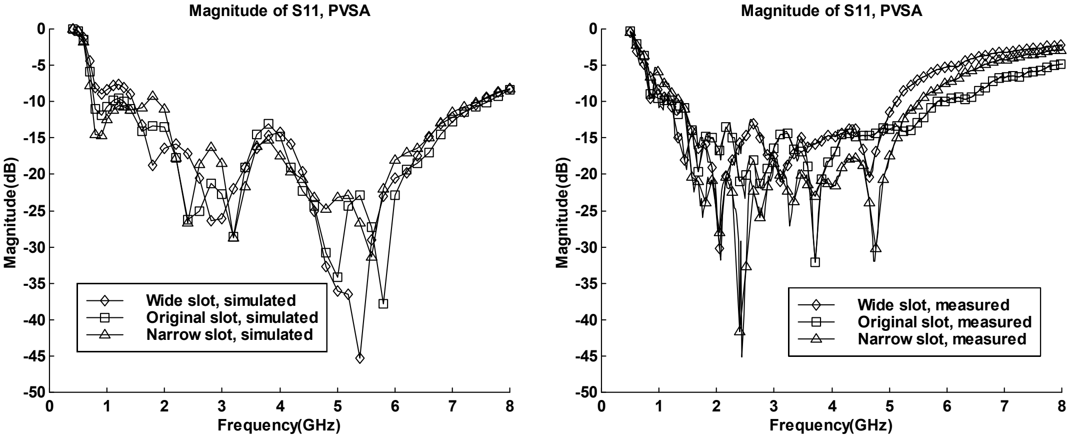


(a) (b)

Fig. 4. Radiation patterns of the PVSA at 4GHz: (a) ϕ=0° cut; and (b) ϕ=90° cut.

(a) (b) (c)

Fig. 5. Geometries of three PVSA designs: (a) design-A (wider slot); (b) original design; and (c) design-B (narrower slot).



(a) (b)

Fig. 6. Comparison of S11 characteristic for three PVSA designs: (a) simulated; and (b) measured.