

Printed Volcano Smoke Antenna

Introduction

This application note represents a Printed Volcano Smoke Antenna, modeled and simulated in WIPL-D Pro CAD. The simulations were performed from 1 to 15 GHz, with the results of interest being return loss, VSWR, and radiation pattern (RP). The proposed antenna is suitable for applications in both WLAN and UWB bands.

WIPL-D Pro CAD is a user-friendly software, allowing users more flexibility with demanding antenna models. This application note highlights the advantages of the Symmetry feature, which enables setting up to three symmetry planes to a model, in order to shorten simulation time without compromising the accuracy of the results.

Model description

The model consists of a printed radiating patch, a coplanar waveguide (CPW), and a coaxial cable fed by a coaxial port. The model is symmetrical in yOz plane: therefore, only half of the model is shown in Fig. 1. The total dimensions of the antenna are 55 mm x 46 mm, excluding the coaxial cable. The antenna is printed on a substrate with $\epsilon_r=2.78$ and a height of 0.8 mm.

The radiating patch (radius $R1$, angle θ) is connected to the coaxial cable via a 50Ω CPW signal line (length $L1$). The two CPW ground planes (radius $R2$) are separated from the 50Ω CPW signal line by a distance g . The impedance of the coaxial cable is set to be 50Ω , in order to minimize transmission loss between the coaxial cable and the CPW signal line. The detailed view of the feeding area is presented in Fig. 2. The model dimensions are listed in Table 1 [1].

Table 1. Model dimensions

Parameter	Value
L_{sub}	55 mm
W_{sub}	46 mm
H_{sub}	0.8 mm
$R1$	14 mm
θ	72°
$L1$	11 mm
$R2$	18 mm
g	0.16 mm

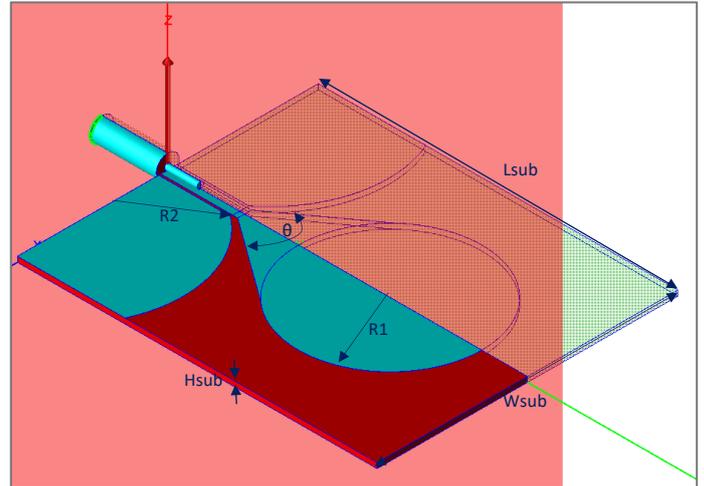


Figure 1. Printed Volcano Smoke Antenna in WIPL-D Pro CAD

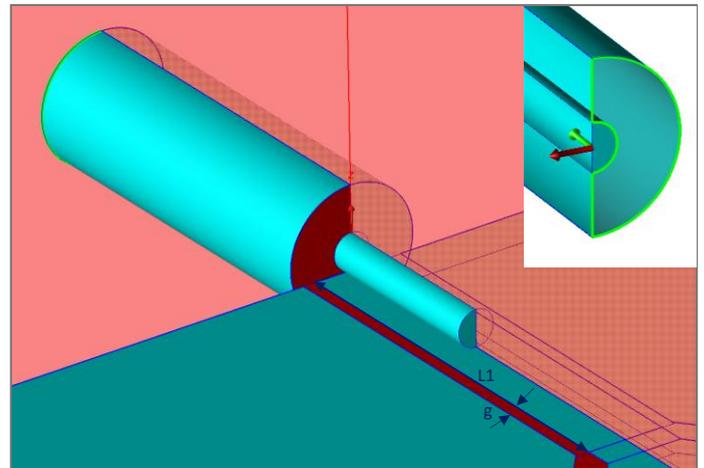


Figure 2. Feeding of the antenna

Simulation and results

To verify the impact of the Symmetry feature on the accuracy of the results, two antenna models are made and simulated, and their results are compared. The first model is a model of the antenna with symmetry ("Half model"). The second model is the model of the antenna without symmetry ("Full model").

The return loss, VSWR, and RP are observed from 1 GHz to 15 GHz, in 29 frequency points. The proposed antenna is well-matched from 1.9 GHz to 15 GHz (Fig. 3). Within this range, the VSWR remains below 2 (Fig. 4). Particularly, the return loss at WLAN frequency (2.44 GHz) is 14 dB, while VSWR is equal to 1.5.

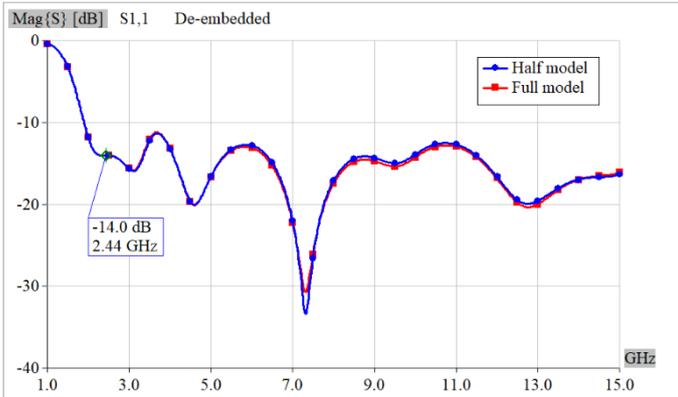


Figure 3. Return loss

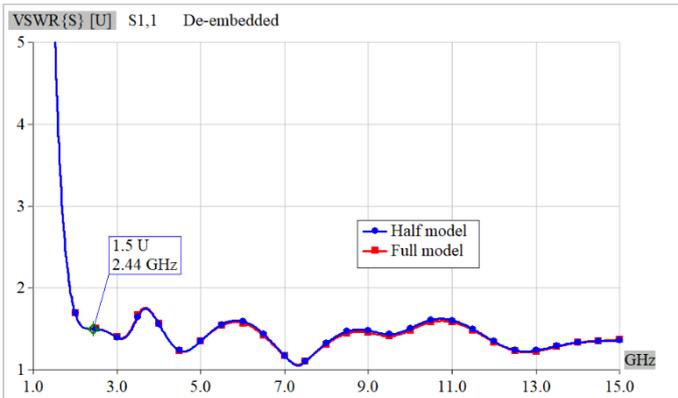


Figure 4. VSWR

As can be seen in Fig. 3-4, the results of the model with symmetry (“Half model”) and the model without symmetry (“Full model”) are almost identical. That confirms that the Symmetry feature has no impact on the accuracy of the results. The minor differences in results can be attributed to a significant difference in the number of unknowns between these two models.

The full RP is calculated in 37 x 37 directions (Phi x Theta), and presented only for the model with symmetry. The Theta-cut is observed in two cases: for Phi = 0 (Fig. 5), and Phi = 90° (Fig. 6). The Theta angle is assigned from xOy plane, so Theta = 90° corresponds to the positive part of the z-axis.

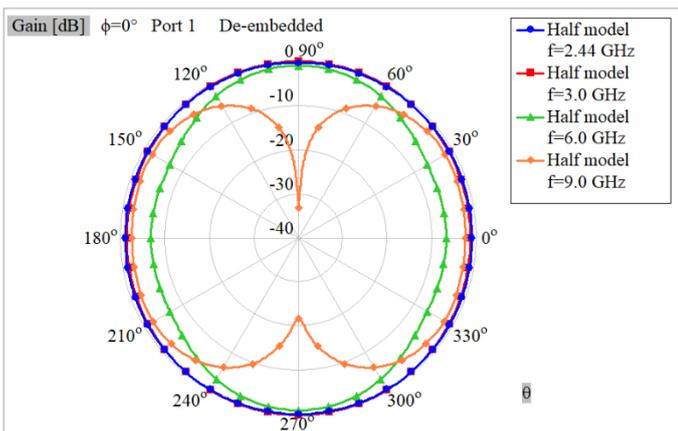


Figure 5. RP (Theta cut, Phi = 0)

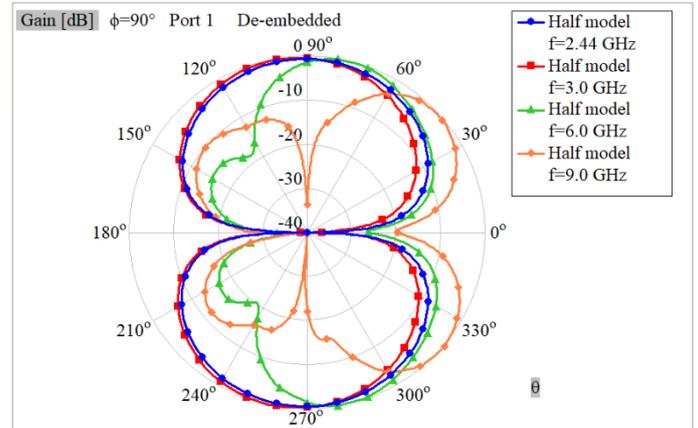


Figure 6. RP (Theta cut, Phi = 90°)

As previously stated, the model is symmetrical only in the yOz plane; therefore, only one symmetry plane can be assigned. In general, if the model is symmetrical, the type of symmetry is chosen based on the symmetry of the excitation. In this case, the excitation (coaxial port) is also symmetrical to yOz plane, so the “Symmetry” is chosen.

The model with symmetry (“Half model”) and the model without symmetry (“Full model”) were simulated, and their simulation times are compared to evaluate the efficiency of the Symmetry feature. The simulations were performed on a workstation with the following specifications: Intel(R) Core(TM) i7-7700 CPU @ 3.60GHz, while the GPU used for simulation is NVIDIA GeForce GTX 1080. The required number of unknowns and simulation time for each model are given in Table 2.

Table 2. Measured simulation time

Model	Number of unknowns	Simulation time [s]
Half model	5,778	394.20
Full model	11,837	867.24

The symmetry option allows users to fasten the simulation time by reducing the number of unknowns. As shown in Table 1, the model with symmetry (“Half model”) requires approximately half of the unknowns compared to the model without symmetry (“Full model”). Although the number of unknowns is significantly reduced, the accuracy of the results has not been affected (Fig. 3-4). Furthermore, the simulation times in Table 2 demonstrate the high efficiency of the symmetry option, with the “Half model” completing simulations 54% faster than the “Full model”.

[1] G.-P. Gao, X.-X. Yang, J.-S. Zhang, J.-X. Xiao, “A printed Volcano Smoke Antenna for UWB and WLAN communications”, Progress In Electromagnetics Research Letters, Vol. 4, 55–61, 2008