Design of a Compact Wideband Spiral Antenna for WLAN Applications

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Abstract: The commercial software WIPL-D is used to optimize the design of a spiral antenna for WLAN applications. The spiral is designed for operation from 5 GHz to 6 GHz, with an average gain of 5 dB. In order to increase the bandwidth of the antenna and enhance the radiation pattern, V-Shaped ground plane is used, and an inductive element is added in series with the source. A bandwidth of 24% is achieved.

Keywords: WLAN, Spiral Antenna, WIPL-D

1. Introduction

The frequency independent antennas were introduced by Rumsey [1]. Later, many wideband antennas such as log-periodic dipole antenna (LPDA) and equiangular spiral antennas were studied based on the same theory [2-4]. The design of spiral antennas in top of a ground plane is studied before [5, 6]. In this work, the commercial software WIPL-D [7] is used to design a traditional spiral antenna in top of aground plane to operate in the 5 GHz to 6 GHz frequency range. WIPL-D allows the modeling of arbitrary metallic and dielectric 3D structures with wires and plates very easily. It uses higher order basis functions and the Method of Moments (MoM) to provide highly efficient analysis in a very short time. To better match the spiral antenna and to enhance the radiation pattern, the ground plane is changed to a V-shape. The depth of the V-shaped ground plane is optimized using WIPL-D to achieve the appropriate radiation pattern. This configuration leads to a constant imaginary part for the input impedance of the antenna across the band. An inductive element is also added in series with the source in order to match the capacitive part of the input impedance.

2. Spiral Antenna Over a Flat Ground Plane

WIPL-D is used to optimize the design of a conventional spiral antenna on top of a flat ground plane. The main goal is to achieve a compact size antenna to work for WLAN applications between 5 and 6 GHz. Figure 1 shows the geometry of a traditional spiral antenna with a ground plane width W = 30 mm, L = 25 mm spiral strips width of d = 2 mm, and the separation distance between the plane of the spiral and the ground plane h is 4.666 mm. Figure 2 shows the results of the return loss of the antenna compared with FDTD simulation. The difference between the results came from the discretization in the FDTD. Figure 3 shows the real and imaginary parts of the input impedance, and Fig. 4 shows the gain pattern at 5.3 GHz

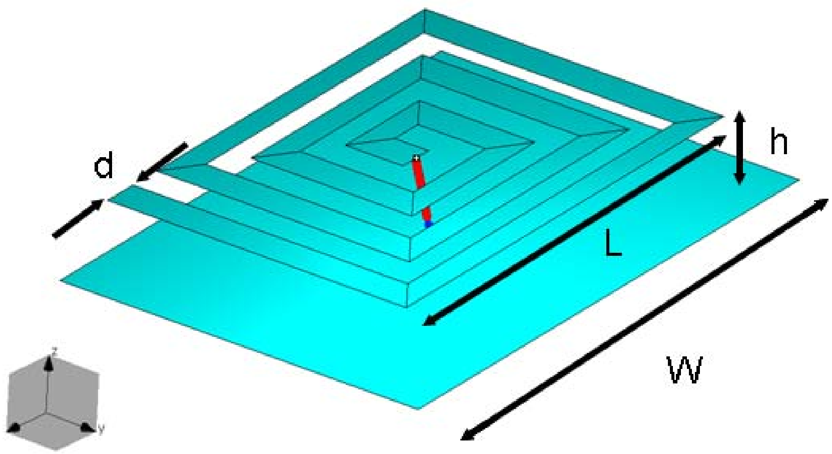


Fig. 1. The traditional spiral antenna geometry.

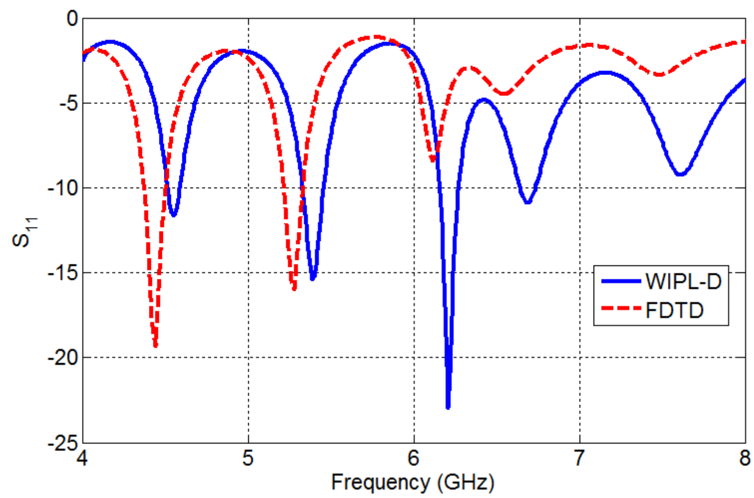


Fig. 2. The return loss of the traditional spiral antenna.

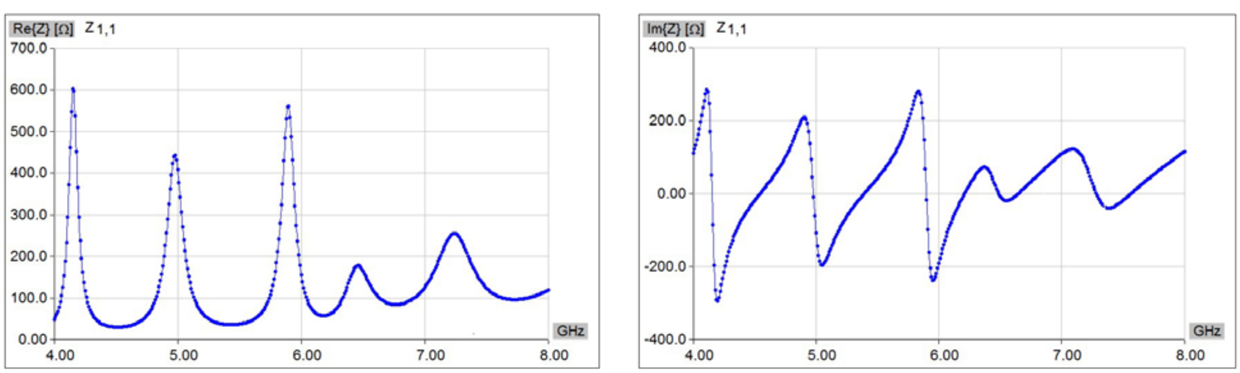


Fig. 3. The input impedance of the traditional spiral antenna.

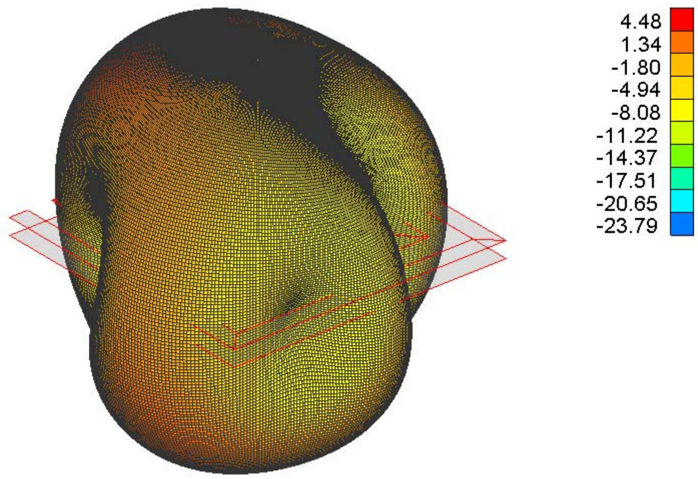


Fig. 4. The gain of the traditional spiral antenna at 5.3 GHz.

3. Spiral Antenna Over a V-Shaped Ground Plane

In order to enhance the radiation pattern of the antenna, a V-shaped ground plane is added in place of the flat ground plane as shown in Fig. 5. The size of the spiral is the same as the spiral on the flat ground plane. The depth of the ground plane is optimized using WIPL-D to get the minimum variation in the imaginary part of the input impedance. The return loss and the input impedance for a V-shaped ground plane of depth 25 mm are shown in Figs. 6 and 7. In Fig. 7, the imaginary part of the input impedance is around 60Ω in the range between 5 and 6 GHz, while the real part is around 70Ω. To achieve a better match, an inductive element of +j60Ω will be added in series with the source. Figure 8 shows the return loss of the antenna in the presence of an inductor of 2 *nH* in series with the source. Figure 9 shows the gain pattern of the antenna. The effect of the V-shape ground plane can be seen in reducing the back radiation of the antenna, and in the hemispherical shape for the forward radiation. In Fig.10, the maximum gain of the antenna in the z direction is plotted with respect to frequency.

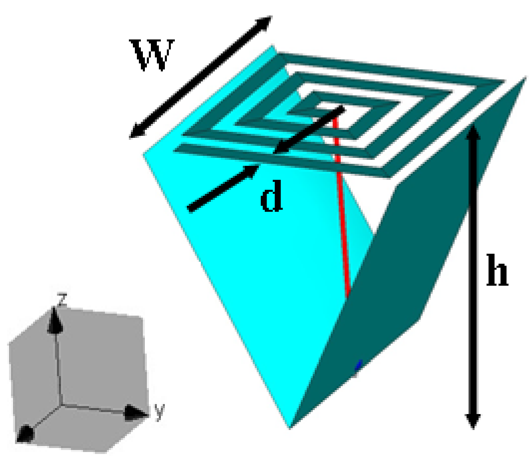


Fig. 5. The geometry of the spiral antenna on top of a V-shaped ground plane.

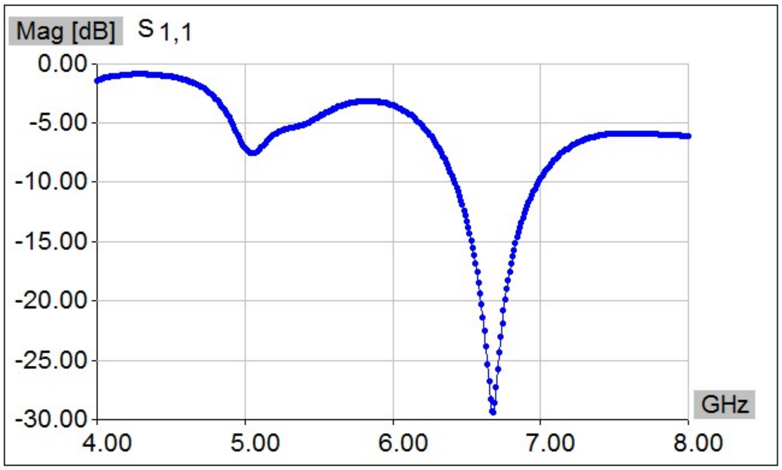
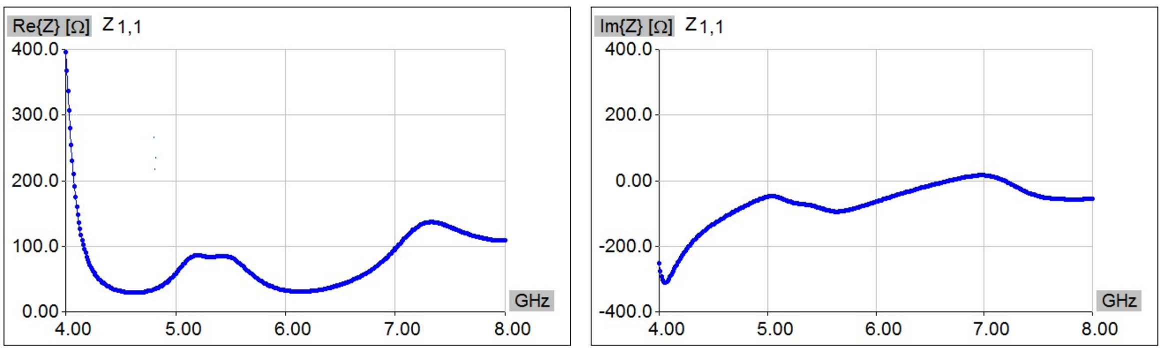


Fig. 6. The return loss of the spiral antenna on top of a V-shaped ground plane.



(a) (b)

Fig. 7. The input impedance of the spiral antenna on top of a V-shaped ground plane. (a) real part, (b) imaginary part.

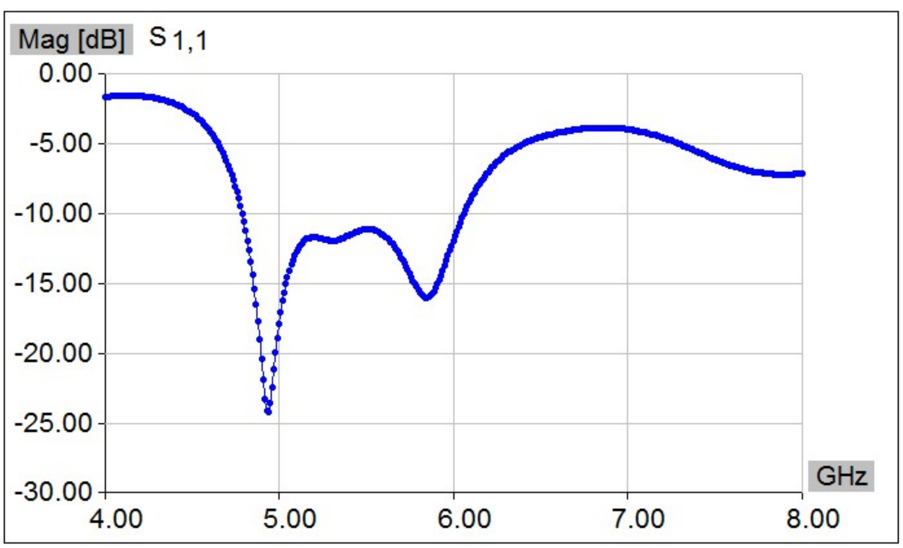


Fig. 8. The return loss of the spiral antenna on top of a V-shaped ground plane and with matching inductive element.

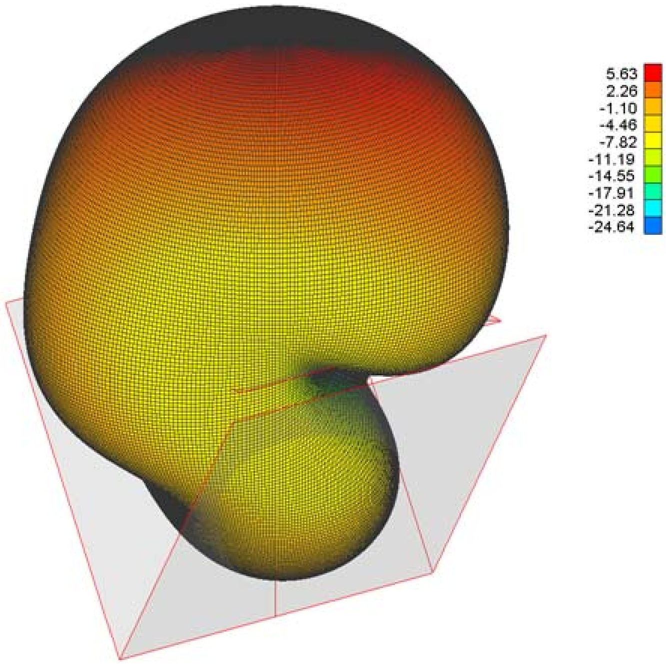


Fig. 9. The gain pattern of the spiral antenna with V-shaped ground plane at 5GHz.

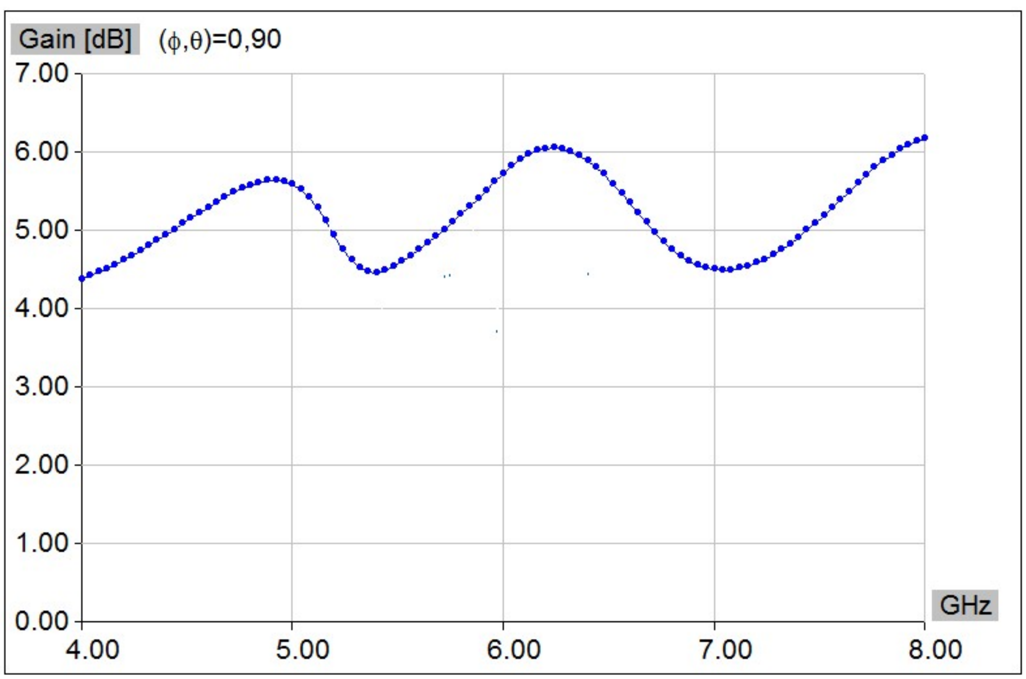


Fig. 10. The maximum gain of the spiral antenna with V-shaped ground plane.

4. Conclusion

A new design for a spiral antenna was introduced. A large bandwidth of about 24% with return loss less than -10 dB and average gain of 5 dB was achieved. The commercial software WIPL-D was used to optimize the dimensions of the ground plane to achieve the desired bandwidth and gain of the antenna. The software is well suited for optimization because of its short execution time when no dielectric materials presented. Typically, one execution of the structure takes only couple of minuets.

5. References

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