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Design and Optimization of a Cone-Shaped Monopole Antenna

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ABSTRACT

In this article, a new structure is proposed for a monopole antenna in the range of 2-18 GHz. This structure is composed of a grounded plane as well as a cone connected to the core of a coaxial cable. The all parameters of antenna are investigated comprehensively for the new structure. A hemisphere is added to the antenna for optimization. After the comprehensive analysis of the new structure via HFSS software, it is found that the all parameters of antenna besides VSWR and radiation pattern are improved. Simple building and low price are the advantages of this antenna.
KEYWORDS: ultra-wideband, monopole antenna, cone-shaped antenna, bandwidth, radiation pattern

1) INTRODUCTION

Monopole antenna are used in a wide frequency range in airy and ground telecommunication systems, and their electrical properties depend on the monopole element and the ground plane [1]. Daily progress in different applications of mobile telecommunication systems such as local wireless networks, short-pulsed radars and sound-channels caused to use monopole antennas in these systems [2]. In recent years, numerous studies have been done on the above antennas due to notable physical properties like low price, light weight, simple and symmetric structure, their satisfactory functioning in a wide frequency bandwidth, polarization and good radiation characteristics in the operational frequency range [3]. In addition, they are used in medical applications like hypothermia cancer treatment and cardiac ablation catheter [4]. In general, different shapes of wideband monopole antenna are introduced. For example, one of these antennas in Ref. [2] is an eyesight monopole antenna over a flat plane with a frequency bandwidth of 3-20 GHz, which is similar to tear-antennas in UWB applications [5]. Design and analysis of a model of v-shaped wideband monopole antenna is proposed in the Ref. [3]. Recently, flat monopoles are proposed and used for wideband schemes [6-9] but their radiation pattern is not wholly directional due to their asymmetric structures [5,10].

In this article, a model of funnel antenna which is located on a cone conductor over a flat ground plane is investigated. The proposed antenna has a suitable frequency bandwidth of 2.5-18 GHz which meets UWB applications, however its radiation pattern has distortion for frequencies bigger than 18 GHz. To solve this problem, it will be resolved via adding a hemisphere conductor on the antenna structure. Adding the hemisphere to the VSWR structure of 2-20 GHz antenna the pattern is improved. The proposed optimized antenna has a wider bandwidth and better radiation pattern in the operational band. The functioning of antenna is investigated via HFSS software and its results are simulated.

2) The Antenna Structure:

Figure 1 shows the wideband monopole antenna. This antenna is composed of a cone which is located on a limited circular flat ground plane. The cone is conductor and feed by a 50 Ohmian coaxial cable. The height of the cone part, the radius of the ground plane and the radius of the top and bottom spout of the cone are optimized. The shield of the coaxial cable is connected to the ground, and the inner conductor is linked to the small spout of the cone which is 0.5 mm above the ground plane. VSWR and the radiation pattern of antenna is 46 mm for the radius of ground plane, the big radius of the cone is 35 mm, the small radius of the cone is 1.69 mm and the height of the cone is 15 mm. The thickness of the cone is given 0.2 mm.

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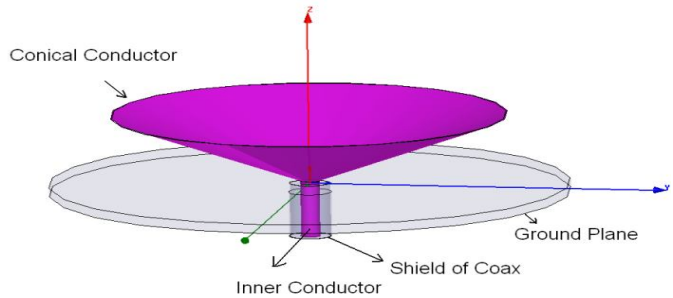


Figure 1 The structure of proposed antenna

ground radius=46(mm) upper radius=35 (mm)
height cone=15(mm) Lower radius=1.69(mm)

3)The Simulation Results:

Here, we show the results of wideband cone-shaped antenna via HFSS software. The VSWR of proposed antenna is demonstrated in the Fig. 2. We see that the antenna has a bandwidth in the frequency range of 2.5-18 GHz which is suitable for wideband systems.

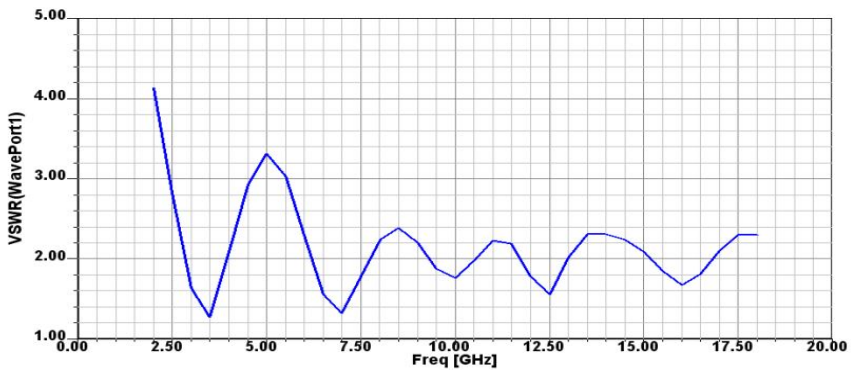
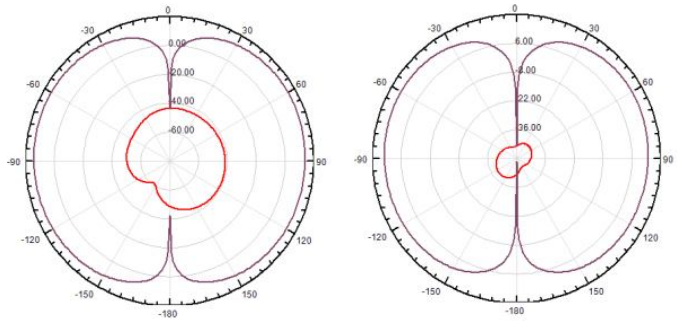


Figure 2 The VSWR of the proposed antenna

The radiation patterns around the cross-polarization and co-polarization of the antenna are shown in the Fig. 3 for the frequency range of 2.5-10-18 GHz in y-z and x-z planes. We see that this antenna has good radiation properties in its bandwidth, low cross-polarization and small side lobes. Although the bandwidth of the cone-shaped antenna is wide but the proficiency of this antenna is almost constant and is about 1.5db. However, the radiation pattern encounters distortion in high frequencies.



(b) (a)

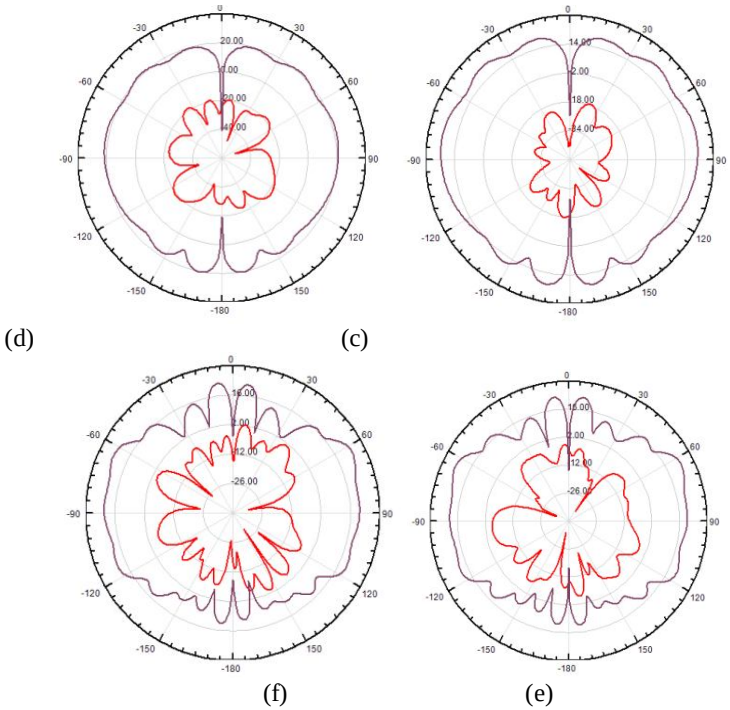


Fig. 3 The radiation pattern of proposed antenna at frequency 2 GHz (a) xz plane (b) yz plane. At frequency 10 GHz (c) xz plane (d)yz plane. At 18 GHz (e) xz plane (f) yz plane

Co-polar
Cross- polar

The gain of the cone-shaped monopole antenna is shown in the Fig. 4. The gain is low for this structure and has no a sensible change.

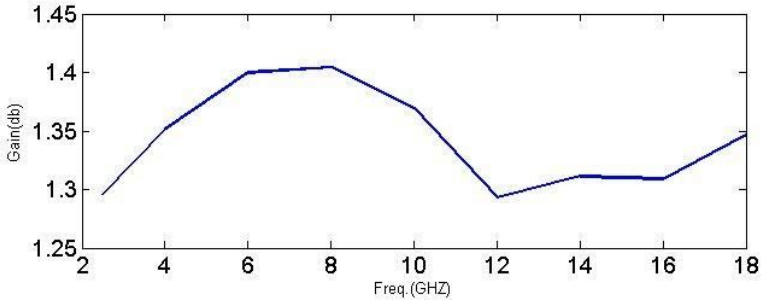


Figure 4 The gain of cone-shaped monopole antenna

4) The Optimized Antenna

Considering the previous results, a solid conductive hemisphere is used on the cone part of the antenna for optimization. The structure is shown in the Fig. 5. The radius of the hemisphere is equal to the radius of the top of spout of the cone which overlay. The hemisphere and cone are conductors. The conductive cone is located 0.5 mm above the plane. The inner conductor of coaxial cable is located 0.5 mm above the ground plane and is connected to the bottom of the cone. The outer part of that is connected to the ground. To have suitable wideband applications, the VSWR and radiation pattern of antenna are optimized in high frequencies by changing the antenna parameters.

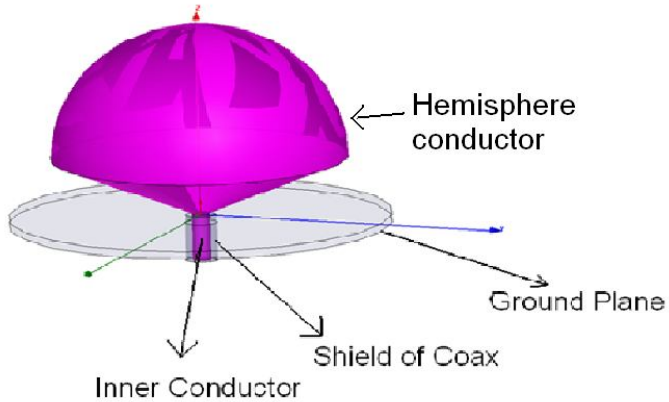


Figure 5. The structure of optimized antenna
5upper radius=35 (mm) ground radius=45(mm) Sphere radius=35(mm)
Lower radius=2(mm) height cone=15(mm)

5) The Simulation Results for Optimized Antenna

In this part the simulation results of wideband cone-shaped monopole antenna are shown. The results are simulated via HFSS software. The Fig. 5 shows the optimized mentioned antenna. The proposed antenna in Fig. 1 has VSWR<2.5 and the proposed antenna in the Fig. 5 has VSWR<2. The bandwidth of the optimized antenna is 2-20 GHz. The VSWR of antenna remains smaller than 2 for frequencies higher than 20 GHz, and the radiation patterns of antenna has a good functioning in its bandwidth to the frequency 20 GHz.

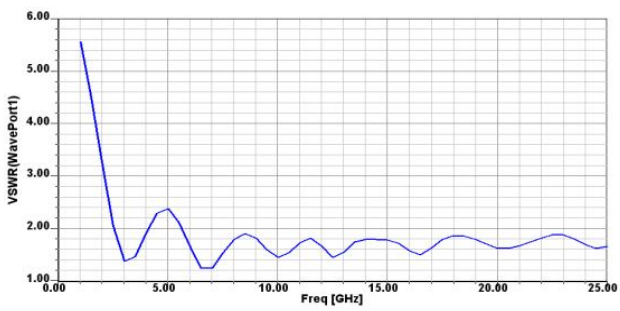
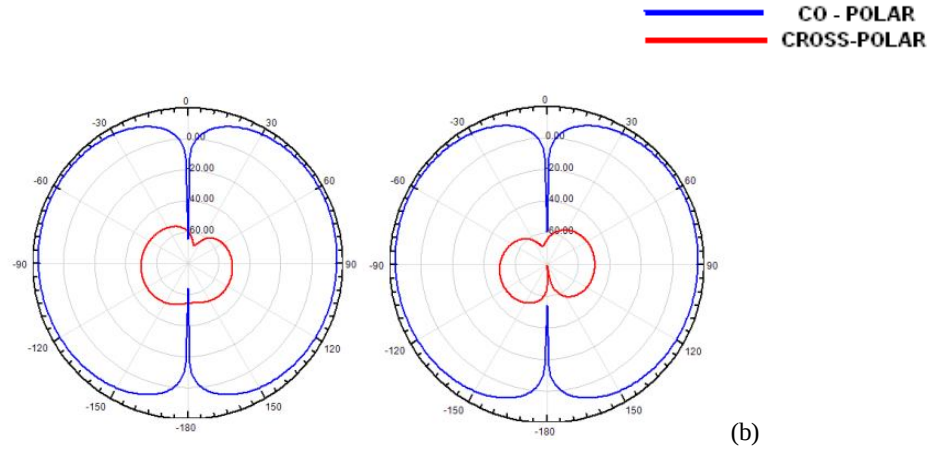


Figure 6. The VSWR of the optimized antenna
Sphere radius=35(mm ,) upper cone radius=35 (mm) , (ground radius=45(mm)
Lower cone radius=2(mm), height cone=15(mm)

The cross-polarization and co-polarization radiation patterns around the antenna for frequencies 2-20GHz are plotted in the E-plane and H-plane. The simulations are done via HFSS software.



(a) (b)

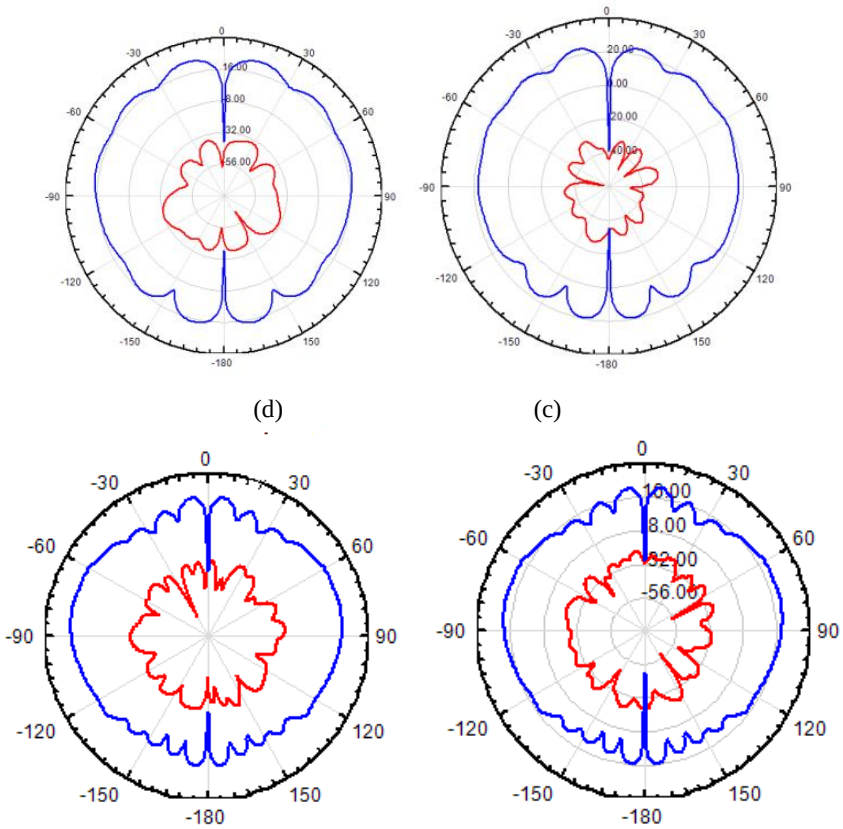


Figure 7. The radiation pattern of proposed antenna at frequency 2 GHz (a) xz plane (b) yz plane. At frequency 10 GHz (c) xz plane (d)yz plane. At 20 GHz (e) xz plane (f) yz plane

The gain of the optimized antenna is shown in the Fig. 8. The maximum gain of the antenna is obtained at 6 GHz.

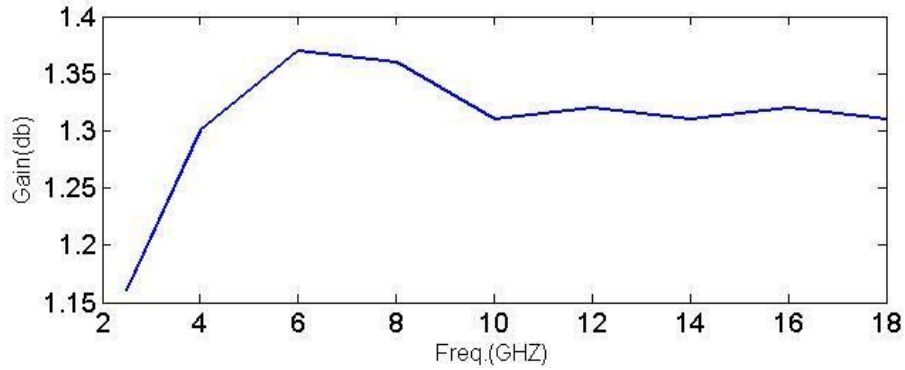


Figure 8. The gain of cone-shaped monopole antenna

6) Conclusion

In this article, a model of cone-shaped monopole antenna besides its optimized version are investigated. These antenna have wide bandwidths in which the optimized one has a wider bandwidth and the radiation pattern has a lower distortion at higher frequencies. The normal antenna has a bandwidth of 2.4-18 GHz but the optimized one has a bandwidth of 2-20 GHz. The proposed antenna are suitable for UWB applications.

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