Influence of Parasitic Elements on Characteristics and Design of ESPAR Antenna

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Abstract

In this paper the influence of parasitic elements on characteristics and design of the electronically steerable passive array radiator (ESPAR) antenna is analyzed and discussed. Simulated results of three types of simplified ESPAR antennas are compared. Through the comparison, it is found that if the parasitic element is open to the ground, it has no effect to the radiation characteristics of ESPAR antenna. So the existence of the parasitic elements, which are open to the ground, can be neglected. Only parasitic elements shorted to the ground need to be considered in the design of the ESPAR antenna.

1. Introduction

Recent developments in the field of wireless communications and near field measurement such as radar cross section (RCS) measurement etc., have demanded for new design techniques in coming up with transmitting and receiving antennas. Antennas implemented for application in the Industrial, Scientific and Medical (ISM) band, specifically, in wireless local area network (WLAN) and continuous wave radar cross section (RCS) measurement, should possess directivity to cover a desirable area when radiating and provide ample rejection of unwanted interfering signals when receiving. It is therefore paramount to design antennas capable of forming specific radiation patterns, where the main lobe gain can be increased while minimizing radiations on unwanted directions and consequently improving the overall signal-to-interference ratio (SIR). The improvement in the SIR will address signal error problems commonly encountered in some real application systems.

The ESPAR antenna is an appropriate device that offers versatility through its beam steering with simple structures and low implementation cost [1] [2]. It has been investigated due to its low cost, stable performance, simple structure and small analog beam forming. Up to now, many kinds of ESPAR antenna array have been constructed from dipole elements without a ground plane, or from monopole elements with a ground plane. Various expected radiation pattern with certain fixed peak direction can be achieved by changing the values of loads connected to the parasitic elements. Usually ESPAR antenna array consists of one central active elements and N loaded parasitic elements. A central active element is surrounded by N loaded parasitic elements symmetrically. Each parasitic element is connected to some optional loads to form expected radiation pattern. [3, 4].

The continuous wave radar cross section (RCS) measurement needs to track moving target. Owing to ESPAR antenna's effectivity in suppressing interference through its beam/null steering capabilities, the ESPAR antenna can be used in the design of continuous wave radar cross section (RCS) measurement. In this paper, a design of a simplified monopole ESPAR antenna has been designed and analyzed. Then simulated results of three types of simplified ESPAR antennas, including a monopole antenna with a parasitic element shorted to the ground, open to the ground and without a parasitic element, are compared. Finally through the comparison, a design rule of the simplified monopole ESPAR antenna is given.

2. Simplified Monopole ESPAR Antenna Design

In Fig.1, the configuration of a seven-element switched parasitic antenna array is illustrated. The antenna array is formed by a central active element and six parasitic elements. The active monopole element, excited by a coaxial line, is located at the center of a perfectly conducting, circular ground of radius 0.5 wavelengths. Six parasitic monopole elements are placed around the active element symmetrically. All the seven monopole elements with the same configuration are arranged on a finite circular ground. The distance between the active and parasitic element is optimized to a certain value L, much shorter than 0.25 wavelengths, to achieve better impedance matching. The length

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of the seven elements is 0.25wavelengths all. All of the parasitic elements are connected to the circular ground plane via diode switches.

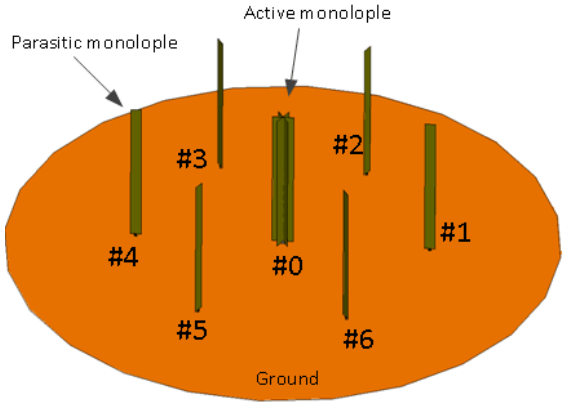


Fig.1. Simplified Monopole ESPAR Antenna

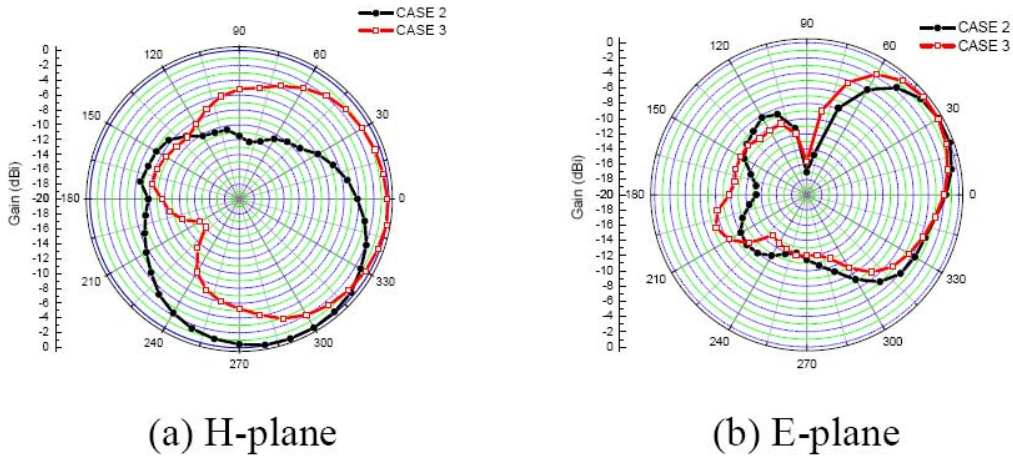


Fig.2. Simulated H plane and E Plane radiation pattern of case 2 and case 3

Fig.2 shows the simulated H plane and E Plane radiation pattern of case2 and case3. Case 2 and case3 stand for that the 2nd and the 3rd parasitic monopole are connected to the ground sequentially. It can be seen from Fig.2 that the maximum radiation direction can be changed. Through controlling different parasitic monopoles shorted to the ground, the radiation pattern can realize scanning in the azimuth plane.

3. Analysis of Characteristics of Parasitic Elements in ESPAR

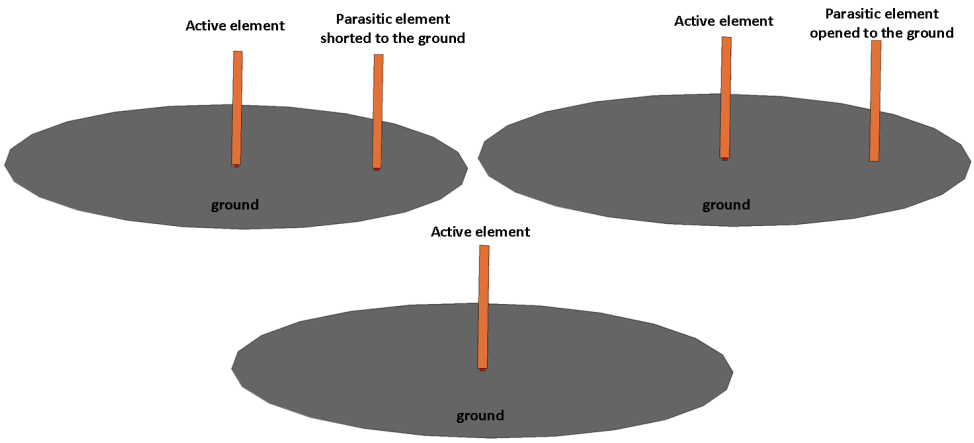
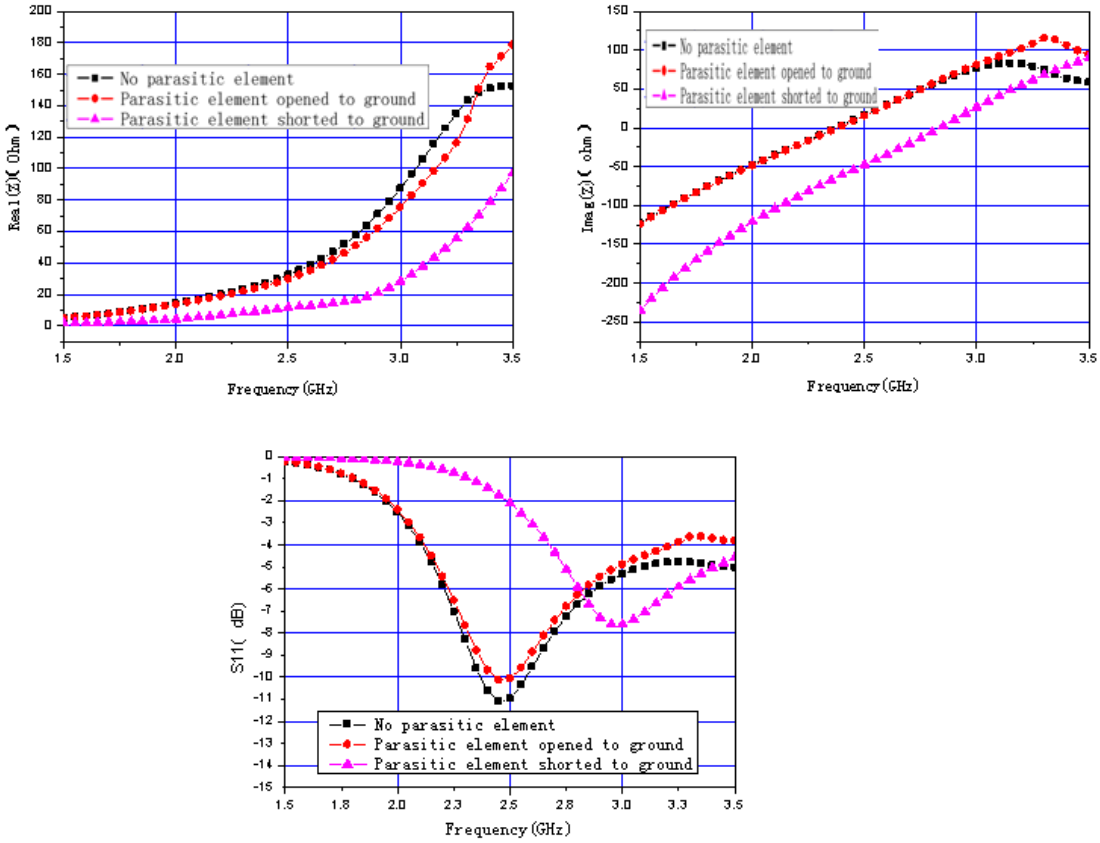
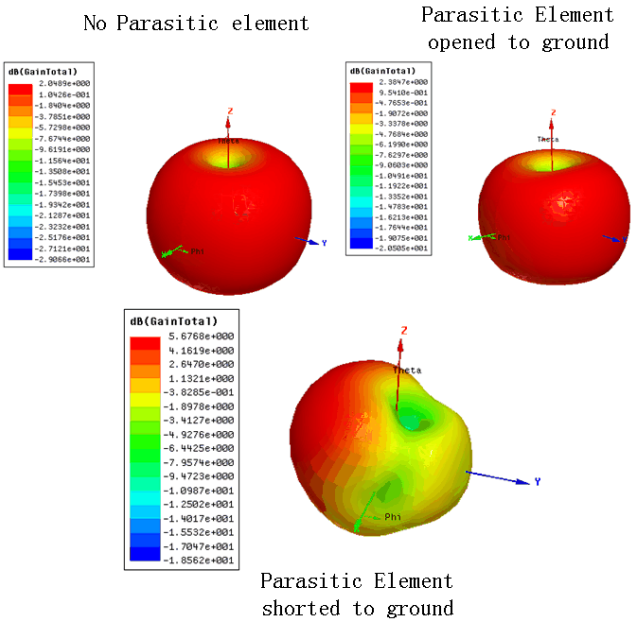


Fig. 3 Three types of simplified monopole ESPAR antenna

In the design of the simplified monopole ESPAR antenna, there is a key point about the characteristic of the parasitic elements in the design of ESPAR antenna. Fig. 3 shows three types of antennas, including a monopole antenna with a parasitic element shorted to the ground, opened to the ground and without a parasitic element.



(a) Comparison of input impedance and S11



(b) Comparison of radiation pattern

Fig. 4 Performance comparison of three types of simplified monopole ESPAR antenna

Through the comparison of simulated results, including the input impedance of antenna, the S11 parameter and the radiation pattern, in Fig. 4, it can be find that when the distance between parasitic and active elements is a quarter wavelength, the simulated performance of the antennas with a parasitic element opened to the ground and without a

parasitic element are almost the same, but different from the antenna with a parasitic elements shorted to the ground. So in the design of the simplified monopole ESPAR antenna, the parasitic elements opened to the ground can be neglected. Only the parasitic elements shorted to the ground should be considered.

4. Conclusion

In this paper, a simplified monopole ESPAR antenna has been designed. It can realize radiation steering in the azimuth plane through controlling different parasitic elements shored to the ground. Finally, the comparison of simulated performance of three types of ESPAR antennas is given. A design rule is summarized that the parasitic elements opened to the ground have no effect to the active element and need not to be considered in the design

5. Acknowledgments

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6. References

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