

A new method for reducing the input impedance of the archimedean spiral antenna

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This paper presents an Archimedean spiral antenna (ASA) and explores the radiation characteristics of the ASA. We propose a parallel Archimedean spiral antenna (PASA). The proposed antenna can maintain the radiation characters with a half input impedance compared with the ordinary ASA. The characteristics of the antennas such as VSWR, realized gain, radiation patterns are given. From the simulation results, we can see that this method can successfully reduce the input impedance of the ASA.

Keywords: Archimedean Spiral Antenna, Input Impedance, Parallel Connection.

1. Introduction

For the antenna engineer, an antenna that belongs to the class of frequency-independent antennas is an obvious for achieving a large operational bandwidth. The Archimedean spiral antenna (ASA) is a classical frequency-independent antenna [1]. Several papers have been published on the topic of spiral antennas [2-5]. For its prominent features like consistent input impedance and invariable circularly polarized radiation, it is widely used in high-speed wireless communication, high-resolution radar and airborne applications [6,7]. It is also has some disadvantages such as bidirectional radiation, larger size, and input impedance is not equal to $50\ \Omega$ [8]. Many researchers have done many experiments to enhance the spiral antenna's radiation performances and very little was found on the input impedance [9-11]. This paper proposed a method to enhance the ASA's radiation performance of input impedance reduction.

2. Archimedean Spiral Antenna Design

Fig. 1(a) shows the structure of the ASA. Fig. 1(b) is the simulated model in free-space. The Archimedean spiral curves r_1 and r_2 , represent the inner and

outer contour for one arm of the spiral antenna, and the seconde arm is the mirror image of the first arm. a is the spiral constant. The arm width is w .

The Archimedean spiral curves employed in this design can be described by the equation:

$$r_1 = r_{01} + a\varphi \quad (1)$$

$$r_2 = r_{02} + a\varphi \quad (2)$$

where r_{01} and r_{02} are the inner and outer radii of the spiral curves. In this design, $r_{01} = 0.1mm$ and $r_{02} = 0.4mm$.

The arm width

$$w = r_{01} - r_{02} \quad (3)$$

The spiral constant

$$a = \frac{2(r_{02} - r_{01})}{\pi} \quad (4)$$

The range of φ from φ_{st} to φ_{end} representing the starting and ending angle of the spiral curves. In this design $\varphi_{st}=0$, $\varphi_{end}=2\pi \times 7$ rad.

This conventional Archimedean spiral antenna is self-complementary (the line width is equal to the gap), and therefore exhibits, according the Babine's principle, a free-space impedance of about 189Ω .

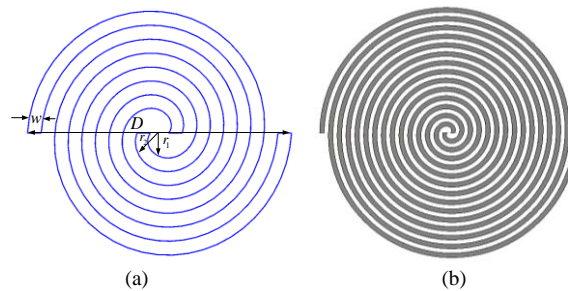


Fig. 1 The geometry of the ASA in free-space (a) structure of the ASA (b) simulated model

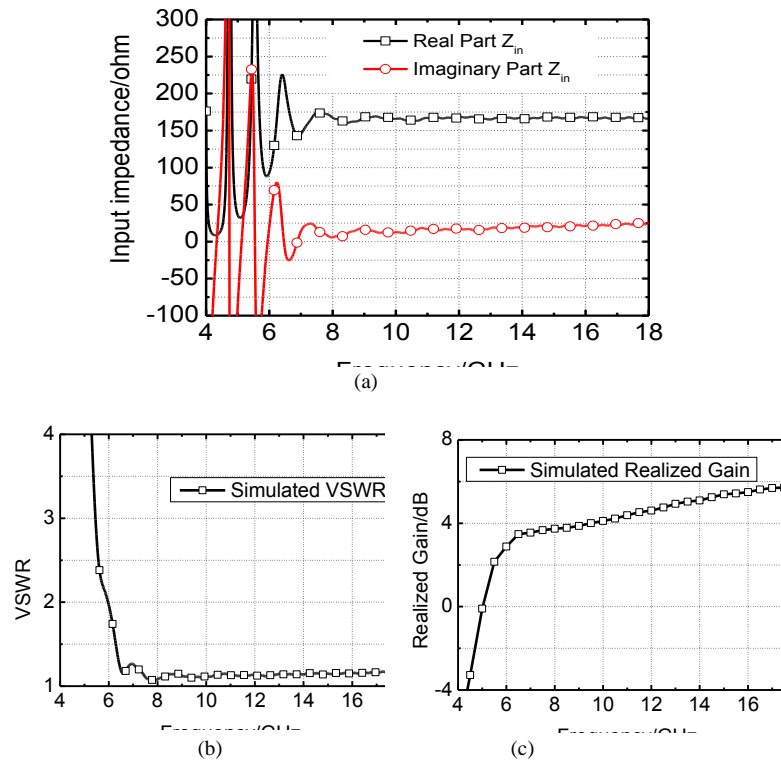


Fig. 2 Simulated results of the ASA (a) Input impedance (b) VSWR (c) Realized gain

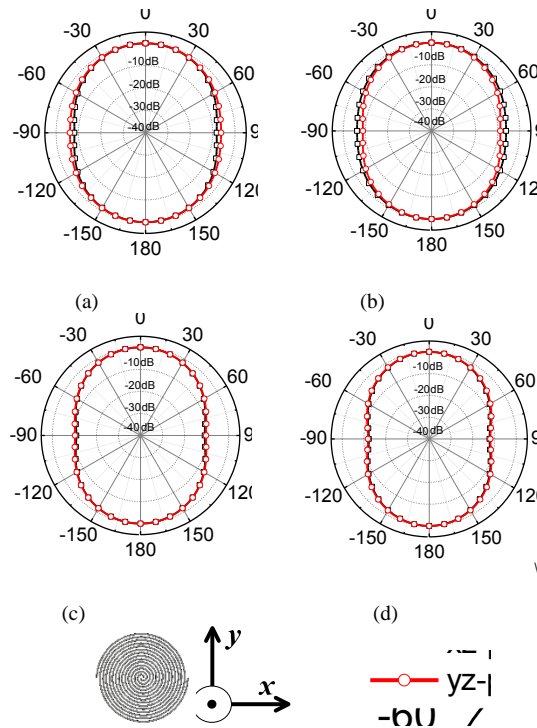


Fig. 3 Simulated radiation pattern of the ASA (a) $f=6\text{GHz}$ (b) $f=10\text{GHz}$ (c) $f=14\text{GHz}$ (d) $f=18\text{GHz}$

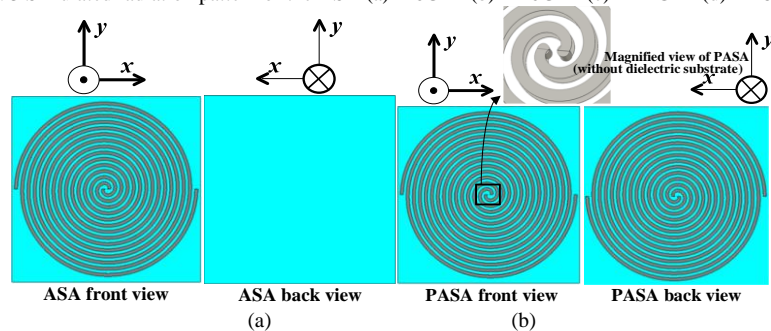


Fig. 4 Model of the ASA with a dielectric substrate and PASA with a dielectric substrate. (a) Case 1
(b) Case 2

3. Archimedean Spiral Antenna with Low Input Impedance

We construct and simulated the radiation characteristics of the ASA on above section. But the ASA is usually printed on a dielectric substrate. In this paper we present a method to reduce the input impedance of the ASA. For validating the

method, we consider two cases for the ASA. The ASA with a substrate which is shown in Fig. 4(a) (denoted as Case 1), a same ASA printed on the ASA with a substrate which means there are two ASAs printed both on and beneath the substrate is shown in Fig. 4(b). Two ASAs are connected with a small PEC column, we can also say that the two ASAs are parallel connection. We can call this antenna as parallel Archimedean spiral antenna (PASA). Fig. 4(b) shows the proposed antenna PASA (denoted as Case 2).

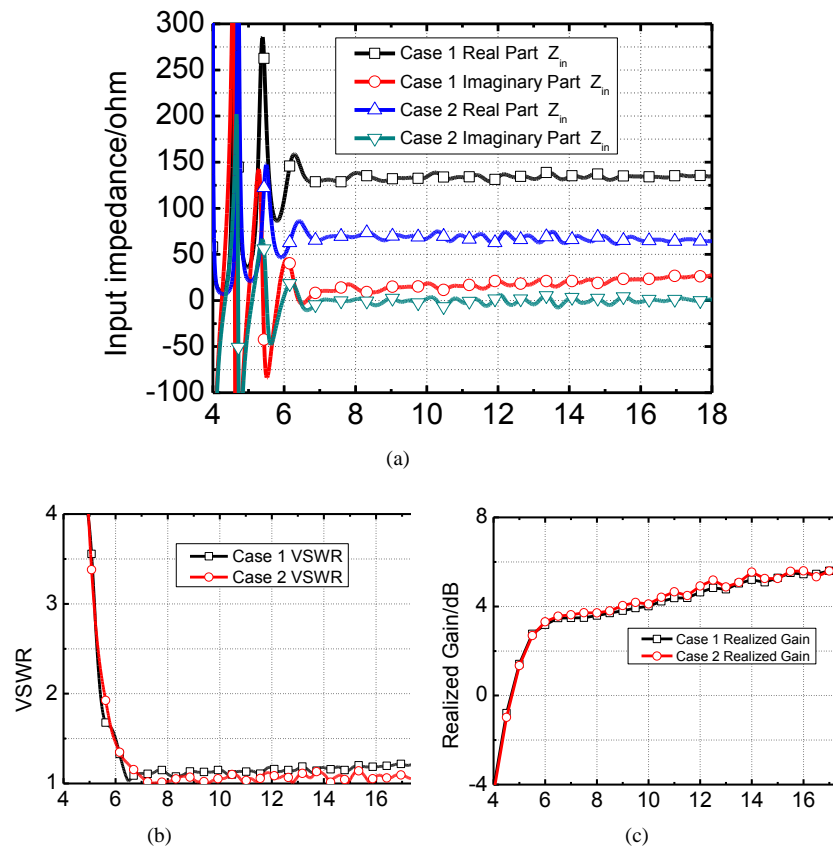


Fig. 5 Simulated results of the ASA and PASA (a) Input impedance (b) VSWR (c) Realized gain

Fig.5 (a) shows the simulated input impedance of above two cases. From the figure we can see that the input impedance in Case 1 is lower than the ASA in free-space due to the loaded of the dielectric substrate. The input impedance in Case 2 is about half of the input impedance in Case 1. This simulation results

validate the effect of the proposed antenna PASA in reducing the input impedance of the ASA.

Fig. 5(b) shows the simulated VSWR. Fig. 5(c) shows the simulated realized gain. Fig. 6 shows the radiation pattern. From the results we can see that there is little difference in radiation performances between Case 1 and Case 2.

It is confirmed by simulation that using the way we proposed in this paper can successfully reduce the input impedance of the ASA. When using the low input impedance ASA, it is easier for engineers to design a balun for the ASA. Also it can facilitate the miniaturization of the ASA.

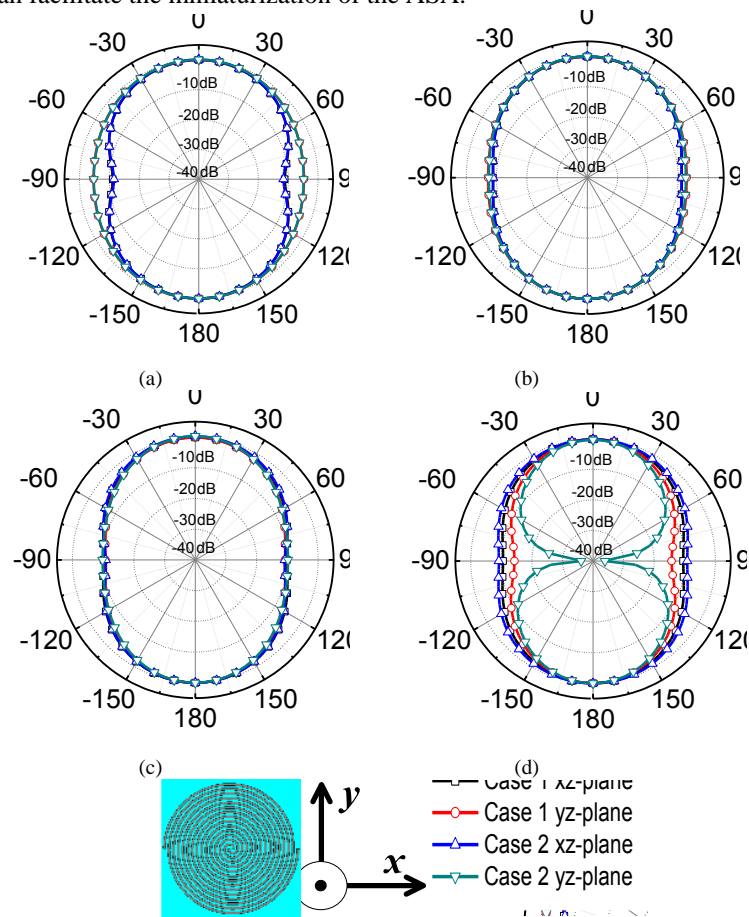


Figure 6 Simulated radiation pattern of the ASA and PASA (a) $f=6\text{GHz}$ (b) $f=10\text{GHz}$ (c) $f=14\text{GHz}$ (d) $f=18\text{GHz}$

4. Conclusion

A new method for the reduction of the Archimedean spiral antenna (ASA) input impedance is proposed in this paper. A model of the parallel Archimedean spiral antenna (PASA) is constructed and simulated. Simulated results shows the effect of the method for the input impedance reduction of the ASA. This method should be very useful in the design of the ASA.

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