Design of A Frequency Reconfigurable Planar Reflectarray Antenna Element

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***Abstract*—In this paper, a frequency agility element is proposed to design a planar reflectarray antenna to realize the frequency reconfigurable and beam-scanning characteristics. The element consists of two split-rings, two group of PIN diodes and one group of variodes. By controlling the states of the two group of PIN diodes on the spit-rings, the reflectarray element can achieve frequency agility characteristic between 4.6GHz and 5.8GHz. Furthermore, the phase shift range of the element is greater than 310° when the unit works at the frequency of both 4.6GHz and 5.8GHz by changing the capacitance value of the variodes. Therefore, the cell is ideal for the design of the reconfigurable planar reflectarray antenna with the fast electric adjustable beam-scanning characteristic.**

Keywords—planar reflectarray antenna; reconfigurable; beam scanning; variode; PIN diode

I. Introduction

Microstrip reflectarray antenna combines the advantages of parabolic antenna and phased array antenna, which has many advantages such as high gain, small volume, simple structure, low cost, easy processing, and beam-scanning, etc. A planar microstrip reflectarray is composed of many passive elements. The antenna forms a main beam in a certain direction eventually by reflecting the incident wave from the electromagnetic radiation source because the elements on the antenna can supply phase compensation.

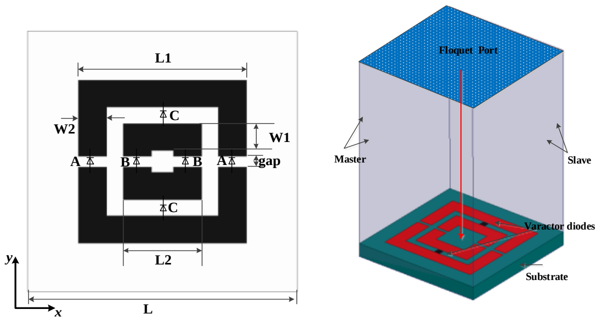
The planar microstrip reflectarray antenna usually works at single frequency and fixed beam in the main beam direction. It is necessary to introduce some reconfigurable technologies to meet additional requirements. Then the concept of reconfigurable reflectarray is proposed. Because the reconfigurable microstrip reflectarray has the characteristics of fast main beam scanning in an accurate direction. Therefore, the reconfigurable microstrip reflectarray is a strong candidate in the beamforming application. In this paper, double split-rings resonator structure is proposed to design a reconfigurable reflectarray.

II. Design Of The Frequency Agility Element

The frequency agility reflectarray element adopts double split-rings resonator structure, as shown in Figure 1 (a). The upper of the substrate is etched with double split-rings resonator, the lower is the metal floor and the thickness is 2mm. The dielectric constant of the dielectric substrate is 2.65. Specific structure parameters are shown in Table I. Figure 1(b) shows the simulation model in the HFSS with the infinite periodic boundary.

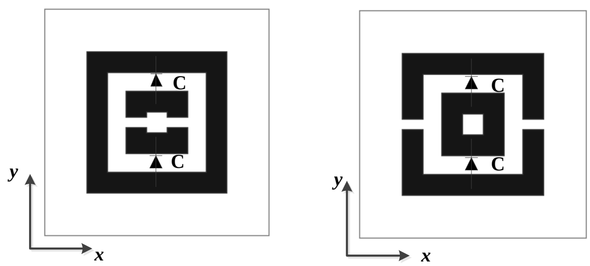
TABLE I. Parameters Of The Novel CELC Element

Parameters	*mm*	Parameters	*mm*
L	20	W1	2
L1	12	W2	2
L2	7	Gap	0.5



(a) (b)

Fig. 1. The reflectarray unit element: (a) Geometry of the reflectarray unit element, (b) The simulation model.



(a) (b)

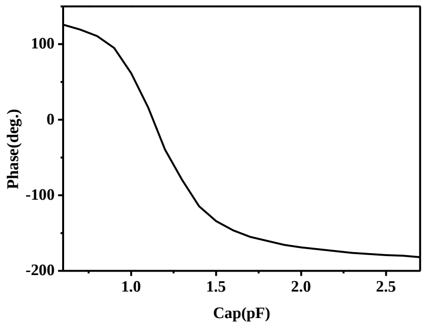
Fig. 2. The element working states: (a) At case one, (b) At case two.

The reflectarray unit is loaded with three groups of diodes, Group A and group B at the openings of two rings are PIN diodes and group C is varactors between the two split-rings. The reflection phase of the unit is controlled by adjusting the group C varactors and the working frequency is determined by the work states of the group A and group B PIN diodes.

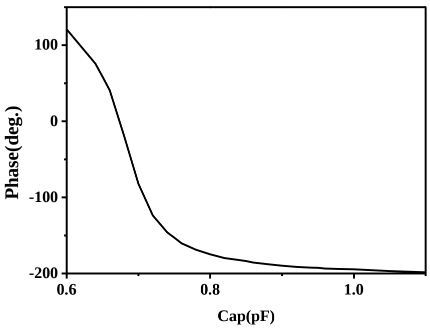
In order to simplify the design and simulation model, we use the lumped RLC equivalent to the group C varactors and capacitance value is set from 0.63pF to 2.67pF. When the group B between the inner ring opening is on and the group A at the outer is off, the working state of the reflectarray element is set to case one; on the contrary, the working state of the unit is set to case two, which are shown in Fig. 2(a) and Fig. 2(b), respectively.

III. Simulation Of The Element

The planar reflectarray antenna achieves beam-scanning by adjusting the phase shift of each element on the aperture. And the element phase shift characteristic is simulated and discussed as follows. When the capacitances of varactor diodes change between 0.6pF-2.7pF, the phase shift characteristic of the element at case one is shown in Figure 3(a) and the phase shift range can reach 310° at $f = 4.6GHz$ when the element works at case one.



(a)



(b)

Fig. 3. The phase shift characteristics of the element: (a) At case one, (b) At case two.

Similarly, the phase shift characteristic of the element at case two is shown in Figure 3(b) and the phase shift range can reach 320° at $f = 5.8GHz$ when the element works at case two. From Fig.3, the phase shift of both case one and case two are more than 310°. Therefore, the element can be used to design reconfigurable microstrip reflectarray antenna.

IV. Conclusion

In this work, by controlling the states of PIN diodes, the reflectarray element can operate at different frequencies between 4.6GHz and 5.8GHz without changing its structure. Besides, by tuning the capacitances of the varactor diodes on the element, it can achieve more than 310° phase shift at 4.6GHz and 5.8GHz, respectively. So it can be used to design reconfigurable planar reflectarray antenna with fast electric adjustable beam-scanning characteristic.

Acknowledgment

This work is supported by National Natural Science Foundation of China under Contract No. 51477126, Technology Innovation Research Project of the CETC, AreoSpace T.T.&C. Innovation Program, and Fundamental Research Funds for the Central Universities (K5051202051).

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