# A Novel Dual-Band and Dual-Polarized Reconfigurable Reflectarray Antenna Element

Shun-Cheng Tian, Yu-Ying Zhao
School of Electronic Engineering
Xidian University
Xi'an, China
sctian@xidian.edu.cn

Long Li
School of Electronic Engineering
Xidian University
Xi'an, China
lilong@mail.xidian.edu.cn

***Abstract*—In this paper, a dual-band and dual-polarized element is proposed to design reconfigurable reflectarray antenna(RRA) to realize the frequency reconfigurable and beam-scanning characterristics, which is aimed at working in two polarization modes at different frequency. The element consists of two split-rings and two variodes. The dual-band and dual-polarized reflectarray element can achieve frequency agility characteristic between 4.2GHz and 6.5GHz at different polarization mode. Furthermore, the phase shift range of the element is more than 300 ° when the unit works at both 4.2GHz and 6.5GHz by changing the capacitance value of the variodes. Therefore, the cell is a good choice to the design of the reconfigurable plannar reflectarray antenna with the fast electric adjustable beam-scanning characteristic.**

***Keywords—reconfigurable; beam scanning; reconfigurable reflectarray antenna(RRA); variode; dual-band; dual-polarized***

## I. INTRODUCTION

Microstrip reflectarray antenna combines the advantages of parabolic antenna and phased array antenna and it has many advantages such as high gain, small volume, simple structure, low cost, easy processing, beam-scanning etc.. A planar microstrip reflectarray are composed of many passive elements. The antenna form 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 the phase compensation.

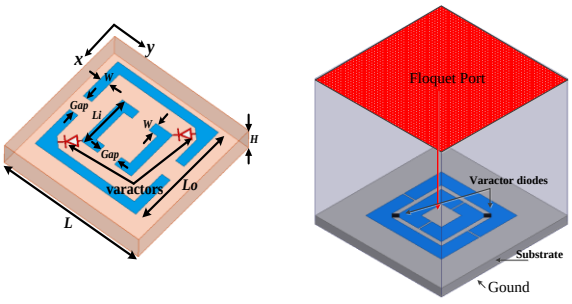
The planar microstrip reflectarray antenna usually work at single frequency and fixed beam in the main beam direction. It is necessary to introduce some reconfigurable technologies to meet additional requirements. Then the concept of reconfigurable reflectarray is proposed. Reconfigurable microstrip reflectarray has the characteristics of fast main beam scanning in 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 dual-band and dual-polarized reconfigurable reflectarray element.

## II. THE DUAL-BAND AND DUAL-POLARIZED ELEMENT

The dual-band and dual-polarized 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 1.2mm. The direction of the opening of the inner ring is rotated 90 ° compared with the outer one. The dual-band and dual-polarized reflectarray unit is loaded with two varactors between the two split-rings. 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. Numerical analysis and optimization of this unit have been done in HFSS 15.0. Floquet port and infinite periodic boundary conditions are adopted.

TABLE I. PARAMETERS OF THE NOVEL CELC ELEMENT

| Parameters | *mm* | Parameters | *mm* |
|---|---|---|---|
| L | 20 | W | 2.1 |
| Lo | 13.6 | H | 2 |
| Li | 8.4 | Gap | 0.2 |




(a) (b)

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

The reflection phase of the unit is controlled by adjusting the varactors. In order to simplify the design and simulation model, we use the lumped RLC to instead of the varactors and capacitance value is set from 0.63pF to 2.67pF. The element designed in this section makes the point by adjusting the capacitance of the varactor diodes not changing the structural parameters. When the polarization direction of electric field of the incident wave is along the X axis and the Y axis, the operating frequency is at 4.2GHz and 6.5GHz, respectively.

## III. Simulation Of The Element

The planar reflectarray antenna can achieve beam-scanning by adjust the phase shift of each element on the aperture. Then, the element phase shift characteristic is simulated and discussed. When the capacitance of varactor diodes change between 0.6pF-2.7pF, the phase shift characteristic of the element at case one is shown in Figure 2(a) and the phase shift range can reach $304°$ at $f = 4.2GHz$ when the polarization direction of electric field of the incident wave is along the X axis.

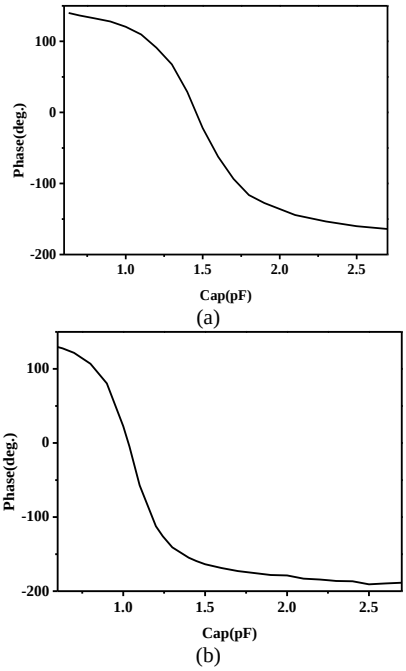



Fig. 2. The phase shift characteristics of the element: (a) At case one, (b) At case two.

Similarly, the phase shift characteristic of the element at case two is shown in Figure 2(b) and the phase shift range can reach $318°$ at $f = 6.5GHz$ when the element works at case two. From Fig.2, the phase shift of both case one and case two is more than $300°$. Therefore, the element can be used to design reconfigurable reflectarray antenna.

## IV. Conclusion

In this work, a dual-band and dual-polarized RRA element is presented which can operate at different frequencies between 4.2GHz and 6.5GHz when the polarization direction of electric field of the incident wave is along the X axis and the Y axis without changing the structure of it. Besides, through tuning the capacitances of the varactor diodes on the elements, the element can achieve more than $300°$ phase shift at 4.2GHz and 6.5GHz, respectively. As a result, it can be used to design reconfigurable reflectarray antenna with fast electric adjustable beam-scanning characteristic. The kind of the multifunctional fast electric adjustable RRA, which have notable potentials in offering interesting functionalities, may be given special attention in the radar and communication system to reduce the amount of antennas and the complexity of the system.

## 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).

## References

[1] Huang J, Encinar J A. Reflectarray Antennas[M] Handbook of Antenna Technologies. 2016:18-22.

[2] Munson R E, Haddad H A, Hanlen J W. Microstrip reflectarray for satellite communication and radar cross-section enhancement or reduction: US, US4684952[P]. 1987.

[3] Yu S, Li L, Kou N. One-Bit Digital Coding Broadband Reflectarray Based on Fuzzy Phase Control[J]. IEEE Antennas & Wireless Propagation Letters, 2017, PP(99):1-1.

[4] Misran N, Cahill R, Fusco V. Reflection phase response of microstrip stacked ring elements[J]. 2002, 38(8):356-357.

[5] Misran N, Cahill R, Fusco V F. Design optimisation of ring elements for broadband reflectarray antennas[J]. IEE Proceedings - Microwaves, Antennas and Propagation, 2004, 150(6):440-444.

[6] Bozzi M, Germani S, Perregrini L. Performance comparison of different element shapes used in printed reflectarrays[C]// Antennas and Propagation Society International Symposium. IEEE, 2003:294-297 vol.3.

[7] Martynyuk A E, Lopez J I M, Martynyuk N A. Spiraphase-type reflectarrays based on loaded ring slot resonators[J]. IEEE Transactions on Antennas & Propagation, 2004, 52(1):142-153.

[8] Cadoret D, Laisne A, Gillard R, et al. Design and measurement of new reflectarray antenna using microstrip patches loaded with slot[J]. 2012, 41(11):623-624.

[9] Chaharmir M R, Shaker J, Cuhaci M, et al. Broadband reflectarray antenna with double cross loops[J]. Electronics Letters, 2006, 42(2):65-66.

[10] Hasani H, Kamyab M, Mirkamali A. Low Cross-Polarization Reflectarray Antenna[J]. IEEE Transactions on Antennas & Propagation, 2011, 59(5):1752-1756.

[11] Encinar J A. Design of a dual frequency reflectarray using microstrip stacked patches of variable size[J]. Electronics Letters, 2002, 32(12):1049-1050.

[12] Nayeri P, Yang F, Elsherbeni A Z. Broadband Reflectarray Antennas Using Double-Layer Subwavelength Patch Elements[J]. IEEE Antennas & Wireless Propagation Letters, 2010, 9(1):1139-1142.

[13] Ethier J L T, Mcnamara D A, Chaharmir M R, et al. Reflectarray Design With Similarity-Shaped Fragmented Sub-Wavelength Elements[J]. IEEE Transactions on Antennas & Propagation, 2014, 62(9):4498-4509.

[14] Hum S V, Perruisseau-Carrier J. Reconfigurable Reflectarrays and Array Lenses for Dynamic Antenna Beam Control: A Review[J]. IEEE Transactions on Antennas & Propagation, 2014, 62(1):183-198.