2023 IEEE 11th Asia-Pacific Conference on Antennas and Propagation (APCAP) | 979-8-3503-2627-7/23/$31.00 ©2023 IEEE | DOI: 10.1109/APCAP59480.2023.10470024

An L-Band Reconfigurable Antenna Array Based on Bistable Glass Fiber Material

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***Abstract*-This paper introduces a reconfigurable antenna array operating in the L band. Firstly, a reconfigurable antenna unit is designed based on the bistable glass fiber material. By switching the two configurations of the antenna unit, the 90° pattern reconfiguration and polarization reconfiguration can be realized. Simulation results show that the -8 dB impedance matching bandwidth of the configuration I is from 0.95 GHz to 1.9 GHz with right-handed circular polarization (RHCP), and the bandwidth of the configuration II is from 0.9 GHz to 2.0 GHz with left-handed circular polarization (LHCP). Based on the antenna unit, an antenna array containing 2×2 units is designed. By controlling the switch of the units, radiation in ±*x* axis directions can be realized, and three polarization modes can be realized in both directions, including RHCP, LHCP and linear polarization (LP). The proposed antenna has the characteristic of multi-functional integration, and it is a novel reconfigurable antenna.**

***Keywords*-reconfigurable antenna, antenna array, circular polarization; bistable material**

I. Introduction

In recent years, reconfigurable antennas have received extensive attention because of their multifunction and flexibility [1-3]. In terms of the functions of reconfigurable antennas, they can be classified into frequency reconfigurable, pattern reconfigurable, polarization reconfigurable and hybrid reconfigurable antennas. In these studies, bistable glass fiber materials are considered for reconfigurable antenna due to their two stable configurations, which can be switched by actuators, and do not require continuous external force to maintain [4-6].

This paper proposes an L-band reconfigurable antenna based on bistable glass fiber materials, and adopts a gradient structure for feeding [7]. This multifunctional reconfigurable antenna is used as the antenna unit to form an antenna array. Both the antenna unit and the antenna array can achieve reconfigurable pattern and polarization.

II. Antenna Design

A. Antenna Unit

Fig. 1(a) shows the planar structure of the antenna unit. The substrate adopts a bistable glass fiber material with a permittivity of 4.9 and a loss tangent of 0.0014. The dimensions of the substrate are 392 mm×180 mm×0.49 mm. The proposed antenna includes radiation structure, matching patches and feed structure.

As shown in Fig. 1(b), configuration I is formed by curling the substate along the *x*-axis, which is a non-closed hollow cylindrical structure. In another case, as shown in Fig. 1(c), configuration II is formed by curling the substrate along the *y*-axis, which is a closed hollow cylindrical structure. Both configurations have structures similar to helical antennas, and can realize right-handed circular polarization (RHCP) and left-handed circular polarization (LHCP), respectively.

B. Antenna Array

The antenna units are formed into an array, its planar structure is shown in Fig. 2. The units are numbered 1, 2, 3, and 4 respectively. Unit 1 and unit 2 are on the same plane, while unit 3 and unit 4 are on the same plane, all parallel to the *x-z* plane.

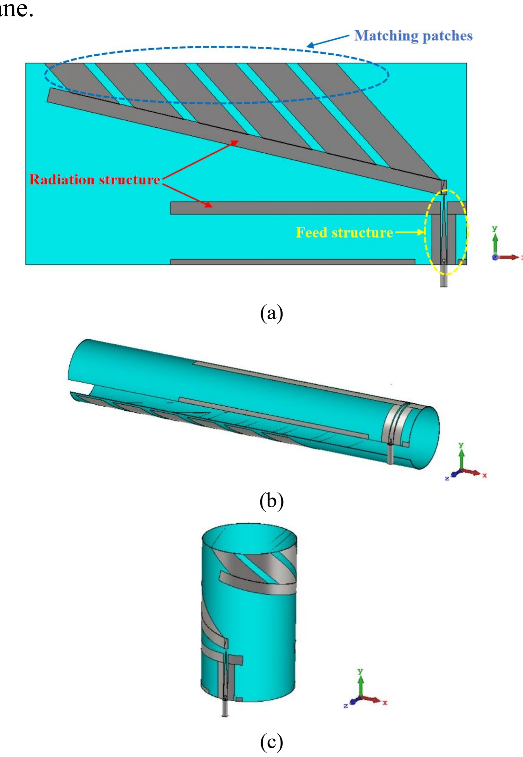


Fig. 1. Structure of the reconfigurable antenna unit. (a) Planar structure. (b) Configuration I. (c) Configuration II.

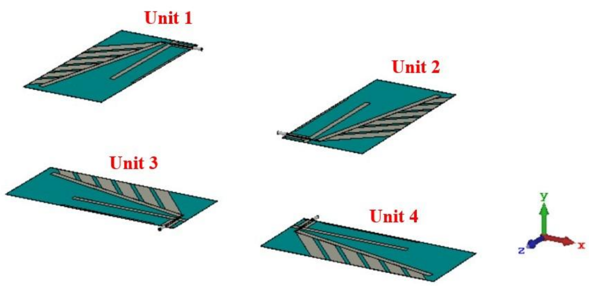


Fig. 2. Planar structure of antenna array

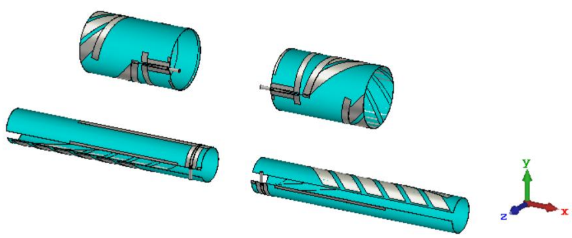


Fig. 3. Structure of reconfigurable antenna array.

As shown in Fig. 3, since each antenna unit has two configurations, when curling each unit along the *x*-axis, unit 1 and unit 2 are in configuration II, and unit 3 and unit 4 are in configuration I. Due to different polarization modes and radiation directions of two configurations, the antenna array can also achieve polarization reconfiguration and pattern reconfiguration, and have more radiation states than the unit.

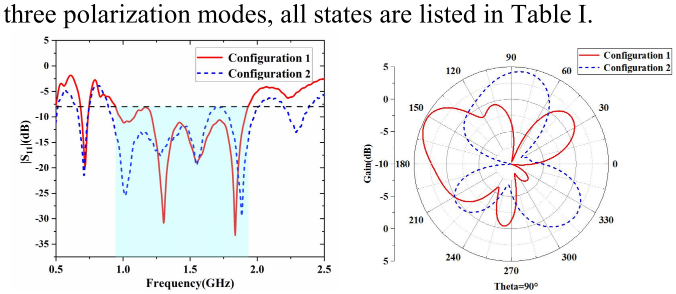
III. Simulation Results

A. Antenna Unit

Two configurations of the antenna unit are simulated. As shown in Fig. 4(a). The bandwidths of two configurations cover 0.95 GHz to 1.9 GHz. Fig. 4(b) shows the radiation patterns, configuration I has a gain of 2.3 dBi in the -*x* direction with RHCP modes and configuration II has a gain of 4.1 dBi in the +*y* direction with LHCP modes. Therefore, the antenna achieved a 90° reconfigurability of the pattern.

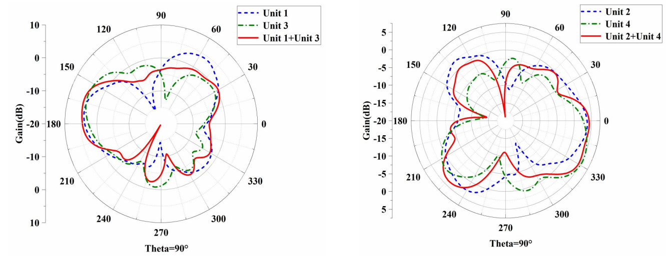
B. Antenna Array

Fig. 5 shows the radiation patterns of the antenna array when using different units. As shown in Fig. 5(a), when unit 1 or unit 3 works separately or both work together, the radiation in the -*x* direction can be realized. In contrast, when unit 2 or unit 4 works separately or both work together, the +*x* direction radiation can be achieved. Both radiation directions enable three polarization modes, all states are listed in Table I.



(a) (b)

Fig. 4. Simulated results of the antenna unit. (a) Simulated $|S_{11}|$. (b) Radiation patterns at 1.5 GHz.



(a) (b)

Fig. 5. Radiation patterns of the antenna array at 1.5 GHz.
(a) Radiation in the -*x* direction. (b) Radiation in the +*x* direction.

TABLE I
Different States of Antenna Array

State	Antenna(s) Used	Radiation Direction	Polarization Mode	Axial Ratio(dB)
1	Unit 1	-*x*	LHCP	5.5
2	Unit 3	-*x*	RHCP	5.3
3	Unit 1+Unit 3	-*x*	LP	40
4	Unit 2	+*x*	LHCP	5.2
5	Unit 4	+*x*	RHCP	3.8
6	Unit 2+Unit 4	+*x*	LP	40

IV. Conclusion

This paper introduces a reconfigurable antenna based on bistable glass fiber material and arrays it to achieve more radiation states. The simulation results show that the proposed antenna works in L-band, and antenna array can realize six radiation states. The designed antenna is multi-functional and has great application prospects.

Acknowledgment

The authors would like to thank CST Ltd. Germany, for providing the CST Training Center (Northeast China Region) at our university with a free package of CST MWS software.

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