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# Wideband Dual-Polarized Vortex Beams Reflectarray Antenna with Independently Controllable Dual Modes

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**Abstract:** A wideband dual-polarized reflectarray is proposed to generate dual-mode vortex beams carrying OAM. The reflectarray unit is composed of a pair of orthogonal tightly coupled dipoles and delay lines. The dual-mode vortex beam is achieved by independently manipulating the orthogonally linearly polarized incident waves. The simulated results show that the dual-polarized vortex beams carrying +2 and -2 mode of orbital angular momentum are successfully generated from 5-8GHz. The orbital angular momentum mode bandwidth in this design is wider than other similar reports.

## INTRODUCTION

- **The orbital angular momentum (OAM) can be applied to wireless communication systems to improve channel capacity without consuming additional bandwidth. Due to the potential applications, OAM vortex beams have attracted considerable attention in recent years. However, dual-mode OAM vortex beam generator still suffers the narrow bandwidth.**
- **In this paper, a wideband dual-polarization dual-mode vortex beams reflectarray antenna is presented by employing tightly coupled dipole elements. The simulated results show that the two orthogonally linearly polarized vortex beams carrying +2 and -2 mode OAM are generated in a wide band from 5-8GHz.**

## WIDEBAND ELEMENT DESIGN

- **The structure diagram The configuration of the proposed element is shown in Fig.1. The element is composed of an elliptical dipole, a delay line and two metal surfaces. The dipole and the delay line is printed on the 0.5mm thick Rogers RO4350B substrate. The delay line is directly connected to the dipole with a length of l. The first metal surface is at the bottom, while the second metal surface is placed above the first one. A hole with the diameter D is made on the first metal surface to accommodate the phase delay line. Two dipoles are placed orthogonal to form an egg crate structure to provide dual-polarization capability.**

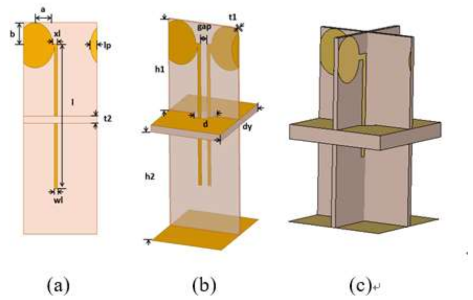



Figure 1. The Configuration of the presented element (a) Front view of single polarization element (b) Side View of single polarization element (c)Side view of dual-polarization element.

- **By varying the length l of the delay line, the required reflective phase shift for x- and y-polarized incidences could be achieved independently. The reflection amplitudes and phases versus different delay line lengths of the proposed element at 5-8GHz are shown in Fig.2.**

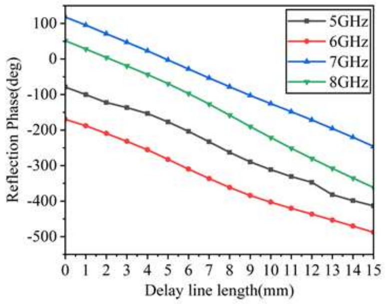



Figure 2. Reflective phases under different delay line lengths l at different frequencies.

- **As shown in Fig. 3, the reflective phase remains stable as the l2 changes, indicating that changing the y-directional delay line length l2 has negligible impact on the x-polarized reflective phases. It means that we can control the reflection phases of x- and y-polarized incidences independently.**

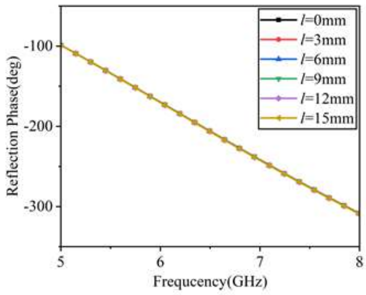



Figure 3. X-polarized reflective phases versus y-directional delay line length.

- **To generate normal vortex beam carrying determined OAM mode in a reflectarray, the phase compensation for the unit cell is calculated by:**

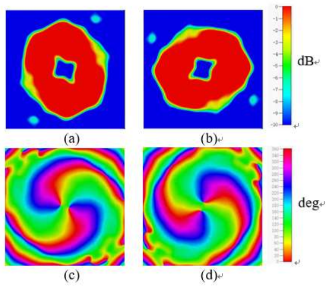
$$\varphi(x_i, y_i) = R_{i,j}k_0 + l\arctan(x_i/y_i)$$

- **where (xi,yi) is the position of the unit cell on the reflectarray, $R_{i,j}$ is the distance between the unit cell and the feed phase center, l is the desired OAM mode.**

Figure 4. Configuration of the proposed dual-mode reflectarray.

## RESULT

Figure 5. Simulated transverse E-field distributions of the dual-polarized dual-mode vortex beam on the observational planes at 7 GHz. (a) Magnitude distribution for l=+2. (b) Magnitude distribution for l=+2. (c) Phase distribution for l=-2. (d) Phase distribution for l=-2.




**A doughnut-shaped E-field magnitude distribution is observed on both x-polarized and y-polarized vortex beams from Fig. 5 (a) and (b). Meanwhile, the phase variation of 360° in opposite directions also conforms to the property of the OAM feature with l = +2 and l =-2, as shown in Fig. 5(c) and (d).**

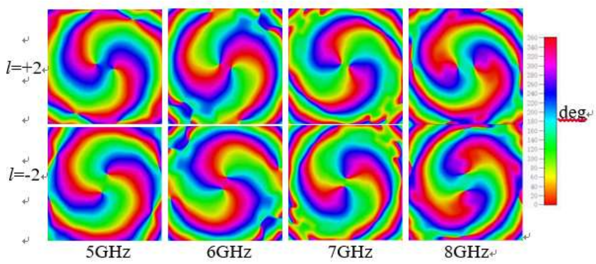



Figure 6. Simulated transverse E-field phase distribution for each mode at 5-8 GHz.

**We can conclude from Fig.6 that dual-mode OAM vortex beam is effectively generated in a 50% relative bandwidth(5-8GHz), which proves the effectiveness of the wideband vortex beam reflectarray design using tightly coupled dipoles.**