Dual-Mode Uniform Circular Array Antenna for OAM Communication

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Recently, orbital angular momentum (OAM) has been proposed to improve spectral efficiency in radio communications by multiplexing orthogonal OAM modes. To achieve OAM multiplexing, various antenna structures have been proposed. Two spiral phase plates with a beam splitter, a Cassegrain reflector antenna with a matrix feed, and two coplanar, alternately arranged uniform circular arrays (UCAs) were proposed to multiplex two or more OAM modes.

This paper presents a novel radial UCA for dual-mode OAM multiplexing. The proposed UCA generates two OAM modes (mode number $l = \pm 2$) simultaneously by using only one array. Fig. 1 shows the proposed UCA. Eight patch elements are radially and equally spaced on the *xy*-plane. An eight-dividing feeding network is designed to provide equal feeding levels and constant phase increments or decrements of 90° to the elements. The feeding network consists of two parts: two series feed lines and a 90° hybrid coupler. The series feed lines are printed on the same substrate of the patch elements, and then connected to the coupler behind the ground plane. Each series feed line distributes the signal from the coupler to four patch elements with a successive phase change of 180°. Another 180° phase change is given to the four patch elements (2, 4, 6, and 8) by moving the feed position to the opposite side compared to the other elements. Consequently, when a signal is input from the port A (B) of the coupler, the radiated fields from elements 1–8 have a sequential phase shift of –90° (+90°), and generate an OAM wave with $l = -2$ (+2).

A prototype has been fabricated and measured. The elements and feed lines are printed on a Taconic TLX-9 substrate with thickness of 1.57 mm, and a commercial 90° hybrid coupler (CMX55Q03 from RN2 Technologies Co.) is used. The UCA is well-matched at 5.2 GHz band, and the cross coupling between two modes is about –26 dB at 5.2 GHz. Like other OAM antennas, the UCA has a null at boresight ($\theta = 0°$). The peak gains are 6.9 dBi (at $\theta = 18°$) and 6.3 dBi (at $\theta = 19°$) for $l = -2$ and $l = +2$ respectively. A measurement of the dual-mode multiplexing has been carried out, and the results are shown in Fig. 2. The transmission coefficients at 5.2 GHz are –42.5 dB (–2 to –2 mode) and –59.4 dB (+2 to –2 mode), and the isolation between different mode channels is about 16.9 dB with a 1-m distance. Thus, the dual-mode multiplexing is successfully achieved.

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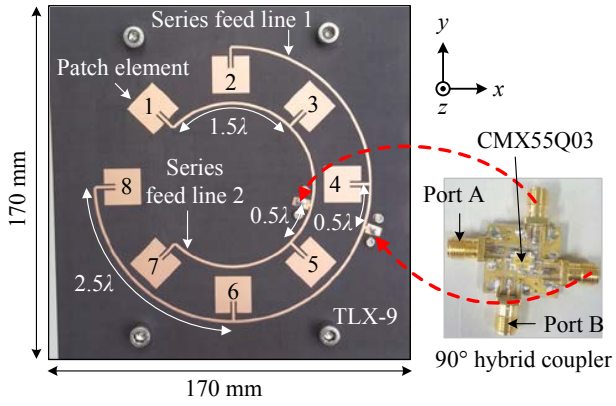

Figure 1. Antenna structure.

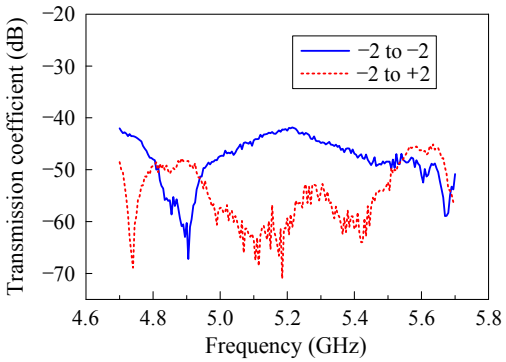

Figure 2. Measured transmission coefficients of the dual-mode multiplexing.