

An OAM Mode Reconfigurable Antenna

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Abstract—For the purpose of utilizing orbital angular momentum (OAM) carrying beams, multiple OAM beams should be generated preferably by a single antenna. In this paper, an OAM mode reconfigurable antenna is proposed. The proposed antenna can be used to transmit mode 1 and mode -1 OAM beams respectively by controlling PIN diodes on the feeding network. The simulation results such as return loss, near-field and far-field phase patterns, radiation patterns of two operating states for mode 1 and mode -1 are given. The proposed antenna can serve as a candidate for increasing the link capacity at 2.4 GHz.

Index Terms—Orbital angular momentum (OAM), reconfigurable antenna.

1. Introduction

In 2014, it was found that orbital angular momentum carrying beams can be used to improve channel capacity in the near-field zone line-of-sight (LOS) link [1]. OAM-carrying beams can be generated by spiral phase plate [1], helicoidal parabolic reflector [2], circular travelling-wave antenna [3] and uniform circular array (UCA) [4]. However, a single antenna to transmit multiple OAM modes has not yet been investigated.

In order to transmit different OAM beams by a single antenna for capacity improvement, we combine the concepts of OAM beams multiplexing with reconfigurable antenna. In this paper, an OAM mode reconfigurable antenna is proposed, which can be used to transmit or receive mode 1 and mode -1 OAM beams by controlling the PIN diodes. Therefore, the proposed antenna can be used to provide two independent channels in the near-field zone LOS link at 2.4 GHz WiFi band.

2. OAM Mode Reconfigurable Antenna

Uniform circular array (UCA) with successive phase shifting is a classic planar structure to generate arbitrary OAM modes [4]. Here we design a four-elements UCA with reconfigurable feeding network to provide two kinds of phase shifting for mode 1 and mode -1 OAM beams generation. Fig.1 shows the principle of the feeding network and the element placement for two operating states. The 90 degrees phase shifting is obtained by the microstrip line extension while the 180 degrees phase shifting is achieved by simply flipping the element [5]. As a result, a 0-90-180-270 phase shifting for mode 1 can be obtained, which is shown in Fig.1 (a). On the other hand, the 270-180-90-0 phase shifting for mode -1 can be obtained by mirroring the structure in Fig.1 (a), which is demonstrated in Fig.1 (b). According to the principle illustrated above, the configuration of the OAM mode reconfigurable antenna is illustrated in Fig.2.

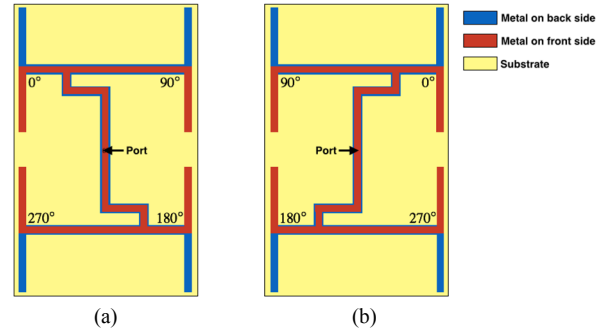


Fig. 1. Feeding networks for generation of OAM beams with different modes: (a) Mode 1, (b) Mode -1.

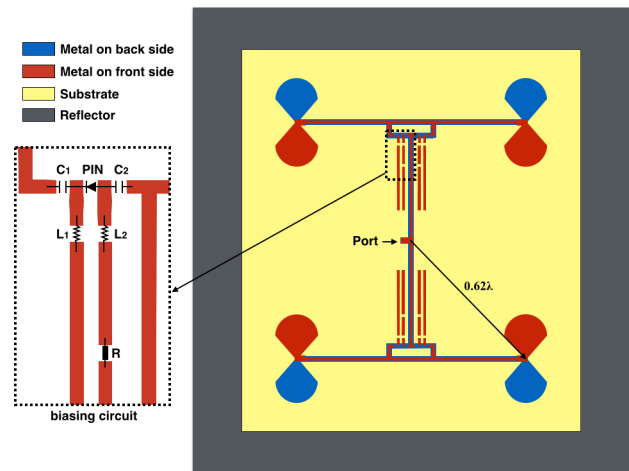


Fig. 2. The configuration of the OAM mode reconfigurable antenna.

The broadband radiator leaf-like dipoles are used for easier matching. Here we use 4 biasing circuits to control 4 PIN diodes; one of the biasing circuits is shown in Fig. 2. By controlling the direct-current (DC) power, the proposed configuration can be used to realize the two operating states which illustrated in Fig. 1; thus mode 1 and mode -1 OAM beams can be generated by the proposed configuration.

3. Simulation Results

According to the configuration illustrated above, a simulation model is built. In our simulation, ADS is used to design the biasing circuit and HFSS is used to design the antenna. A metallic reflector is placed $\lambda/4$ beneath the antenna array on one hand for gain improvement and on the other hand for avoiding the interference caused by the biasing line. Let us denote the PIN diodes' states as state 1 and state 2 for mode 1 and mode -1, respectively.

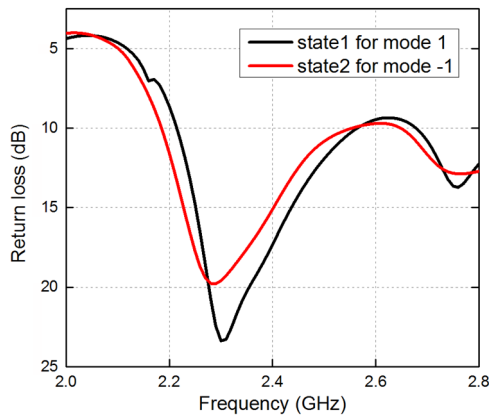


Fig. 3. Return loss of state 1 for mode 1 and state 2 for mode -1.

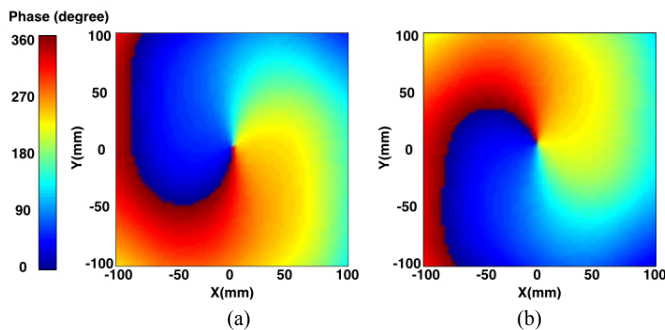


Fig. 4. Near-field E-field phase: (a) state 1 for mode 1, (b) state 2 for mode -1.

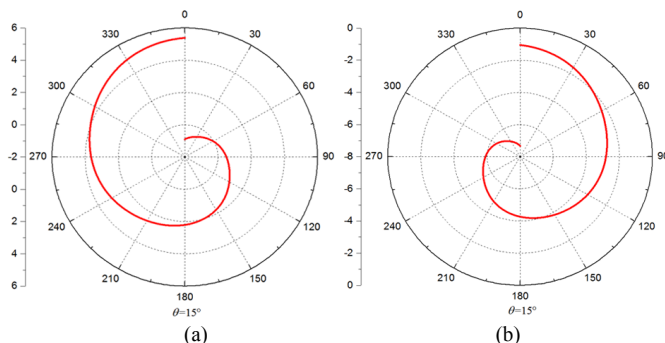


Fig. 5. Far-field E-field phase versus φ , at 2.4 GHz and $\theta=15^\circ$ of two states: (a) State 1 for mode 1, (b) State 2 for mode -1.

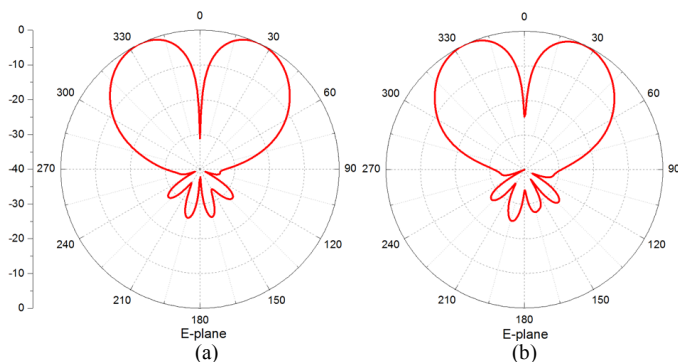


Fig. 6. Normalized radiation patterns at E-plane: (a) State 1 for mode 1, (b) State 2 for mode -1.

The simulation results of the proposed antenna such as return loss, near-field rotational phase front, far-field phase and radiation pattern of two working states are shown in Fig. 3-6. Slight differences for simulation results between two states are due to the asymmetrical of the feeding line for two states (see Fig. 2). It is implied from the simulation results that good OAM beam of mode 1 and mode -1 can be generated by the proposed antenna at 2.4 GHz.

4. Conclusion

An OAM mode reconfigurable antenna is proposed. Through controlling the operating states of the PIN diodes, OAM beams with mode 1 and mode -1 can be generated. The proposed antenna can serve as a candidate for providing two independent channels, which have different rotation phase fronts. Thus the proposed OAM mode reconfigurable antenna can be used to increase the channel capacity in near-field zone LOS link at 2.4 GHz.

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References

- [1] Y. Yan *et al.*, "High-capacity millimetre-wave communications with orbital angular momentum multiplexing," *Nature Commun.*, vol. 5, no. 4876, Sep. 2014.
- [2] Fabrizio Tamburini *et al.*, "Encoding many channels on the same frequency through radio vorticity: first experimental test", *New J. Phys.*, vol. 14, no. 3, p. 03301, 2012.
- [3] Shilie Zheng *et al.*, "Transmission characteristics of a twisted radio wave based on circular travelling-wave antenna", *IEEE Trans on Antenn and Propag*, vol. 63, no. 4, pp.1530-1536, April. 2015.
- [4] S. M. Mohammadi *et al.*, "Orbital angular momentum in radio – a system study", *IEEE Trans on Antenn and Propag*, vol. 58, no. 2, pp.565-572, Feb. 2010.
- [5] Bai, Q., Tennant, A., and Allen, B., "Experimental circular phased array for generating OAM radio beams", *Electron. Lett.*, vol. 51, no. 61, pp. 442-443, Mar 2015.