Wideband Linear Polarization Reconfigurable Magneto-electric Dipole Antenna

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Abstract **– A Linear polarization reconfigurable magneto-electric dipole antenna is presented. Antenna reconfigurability is achieved by using a novel cross-dipole feed with four bent arms and four PIN diodes. By controlling the states of the diodes, the antenna operation can be switched between two orthogonal linear polarizations. Superior antenna performance such as wide operating bandwidth, stable gain and symmetric patterns are observed.**

Index Terms **— Polarization reconfigurable antenna, Magneto-electric dipole, cross dipole, novel feeding technique.**

1. Introduction

Antennas with polarization diversity show attractiveness in improving channel capacity and combating multi-path effects [1]. Polarization reconfigurable antennas, which can provide switchable polarization state, receive many interests nowadays. With the large amount of commercially available PIN diodes, it is convenient and cost-effective for engineers to design reconfigurable antennas. However, most of the reported polarization reconfigurable antennas are based on microstrip patch antennas, which, as a result, usually show a relatively narrow operating bandwidth [2]-[4]. The magneto-electric (ME) dipole antenna, as a new kind of complementary antenna, exhibits many superior features such as wide operating bandwidth, stable gain and symmetrical radiation pattern [5]. Unfortunately, conventional feeding techniques for the ME dipole like the L-probe feeding and the coaxial feed prevent themselves from developing towards polarization reconfigurable capability. The cross-dipole, on the other hand, has been widely designed as a radiating element for dual-polarized and circularly polarized applications [6]. Taking advantage of the symmetric structure of the cross-dipole, the polarization reconfigurable ME dipole antenna can be realized using the cross-dipole as the feed. In this paper, a polarization reconfigurable ME dipole antenna adopting cross-dipole as the feed is proposed. The antenna shows a wide impedance bandwidth and stable relatively high gain. It can find its potential application in modern wireless communication system.

2. Design Configuration

The proposed polarization reconfigurable ME dipole antenna, as depicted in Fig. 1, consists of four horizontal patches, eight vertical metallic posts, a cross-dipole feed, one dielectric substrate and a box-shaped reflector. The vertical posts and horizontal patches construct two horizontal electric dipoles and two vertical oriented shorted patches acting as magnetic dipoles, as we consider the structure in one direction, i.e., *y*-direction. One dielectric substrate with low relative permittivity is used to accommodate the horizontal parts of cross-dipole arms and the patches. A box-shaped reflector is designed to suppress back radiation. The cross-dipole with each of its four arms bent and inserted with a PIN diode (Bar50-02V from Infineon Technologies) is utilized to excite the antenna. Two opposite cross-dipole arms can be turned on, electrically connected to the central pad, by controlling bias voltages of the four diodes. Thus, the selected pair of opposite arms become the primary feeding structure that couples energy from the coaxial cable into the ME dipole while the other pair of arms are electrically disconnected from central pad. Therefore, the proposed antenna can be configured to operate in one pre-determined polarization state. The ON/OFF states of the four PIN diodes depicted in Fig. 1 and the corresponding polarization of the antenna are listed in table I.

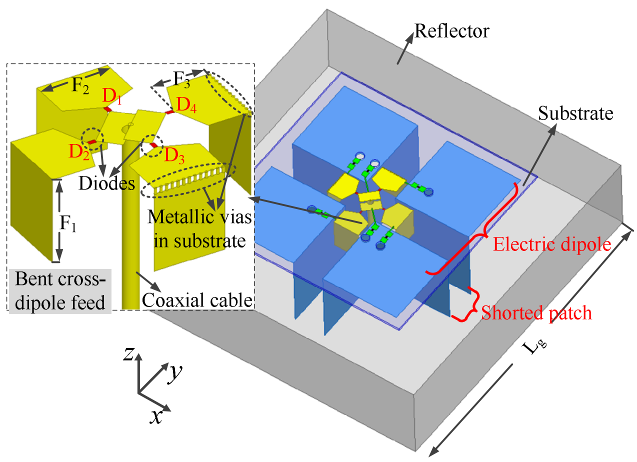
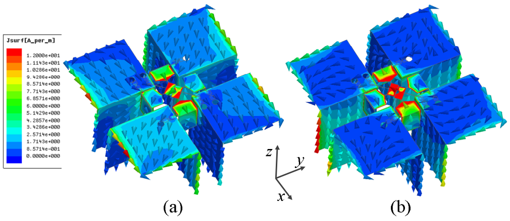


Fig. 1. Geometry of the polarization reconfigurable ME dipole antenna.

TABLE I
OPERATION MODES OF THE PROPOSED POLARIZATION RECONFIGURABLE ME DIPOLE ANTENNA AT DIFFERENT DIODE STATES

D_1	D_2	D_3	D_4	Polarization
ON	OFF	ON	OFF	*x*-polarization
OFF	ON	OFF	ON	*y*-polarization



(a) (b)

Fig. 2. Current distributions on the proposed antenna at different times: (a) t = 0 and (b) t = T/4.

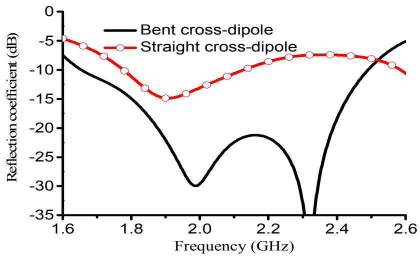


Fig. 3. Simulated reflection coefficients for bent and straight cross-dipole feed with other parameters optimized.

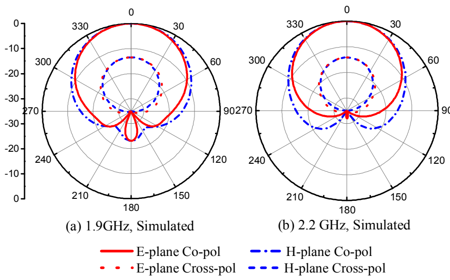
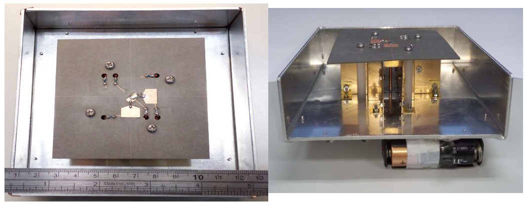


Fig. 4. Simulated radiation patterns of the proposed antenna.

3. Antenna Performance

The antenna is designed and optimized by using finite element method (FEM)-based EM software. To better understand the antenna performance, current distributions of the polarization reconfigurable ME dipole antenna is shown in Fig. 2. As can be seen, at the time of t = 0, horizontal currents are found to be maximum, indicating that the electric dipole is excited. And at the time of t = T/4, where T is a period of time, horizontal currents are minimized while vertical currents reach their maximum, which addresses an equivalent magnetic dipole. The above analysis indicates that the electric dipole and magnetic dipole are excited successfully with in-phase radiations. Therefore, the proposed antenna properly demonstrate the ME dipole concept.

It is found that an effective way to achieve good impedance matching of the antenna is to make the arms of the cross-dipole bent instead of straight. Simulated reflection coefficients of both proposed antenna with bent and straight cross-dipole arms are illustrated in Fig. 3 respectively. Simulated results show that wide impedance bandwidth (S_{11} < -14 dB or SWR < 1.5) of 30.5% covering 1.8 GHz to 2.45 GHz is achieved for both polarizations. Radiation patterns are symmetric and back radiation level lower than -20 dB is achieved as depicted in Fig. 4.



(a) (b)

Fig. 5. Photos of the antenna prototype: (a) top view and (b) side view.

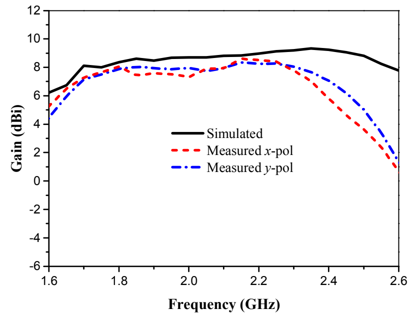


Fig. 6. Measured and simulated gain of the proposed antenna.

In order to verify the aforementioned methodology, an antenna prototype is fabricated as shown in Fig. 5. Measurement of the antenna is then conducted with Agilent N5230A network analyzer and SATIMO near-field measurement system. Fig. 6 illustrates the simulated and measured antenna gains. The antenna gain remains stable with a variation less than 1.2 dB across the whole operating frequency range for both polarizations.

4. Conclusion

A cross-dipole with four bent arms and integrated with four diodes has been designed to excite the ME dipole antenna. The proposed antenna can be configured to switch between two orthogonal polarizations by controlling the bias voltages. Wide impedance bandwidth, symmetrical radiation patterns and stable gain are achieved. The proposed design can find its potential use in modern 2G, 3G and 4G LTE wireless communication systems.

References

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