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Switchable Quadri-Polarization Diversity Aperture Coupling Patch Antenna

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Introduction

Recently, there has been a rising interest in polarization diversity in antenna design for wireless communication applications [1-4]. The polarization diversity is effective to counter the fading loss caused by multi-path effects and can be utilized to double the frequency spectrum to realize frequency reuse and extremely improving the communications capacity. This property has been applied in active read/write microwave tagging RFID systems successfully [5].

In nowadays, the pin-diodes provide more versatility in polarization diversity applications. We can reconfigure the antenna to operate in different excitation modes by controlling the on/off states of the pin-diodes in the antenna structures [5-10].

We propose a switchable polarization diversity antenna which owns quadric-polarization characteristic. By properly controlling the pin diodes in the on/off states, the antenna can generate a pair of dual-linear polarizations or a pair of circular polarizations.

Antenna Design

The geometry of the proposed antenna is shown in Fig. 1. The proposed antenna consists of two apertures on the ground plane fed by a pair of orthogonal microstrip feeding lines, a hybrid branch-line coupler, four pin-diodes, and a square patch. The antenna is designed to operate at 2.45GHz for the WLAN ISM-band (2400MHz~2483.5MHz) applications and microwave tagging RFID systems applications. The antenna was made by using an inexpensive FR-4 substrate of thickness 0.8 mm with a relative permittivity 4.4. As shown in Fig. 1(a), the antenna structure comes with the following layout parameters: the width of the square patch is Wp, the width of the slot is Lw, the length of the slot is Ls, the length from the open end of the feed line to the center of the slot is Lo, and width of the feed line is about 1.55 mm. Fig. 1(b) shows the side view of the proposed antenna. The substrate of the radiating patch and the substrate of the ground plane are also separated by an air layer of thickness h=1 mm [the supporting posts not shown in the figure]. The entire size of the proposed polarization diversity antenna is about 60 mm × 55 mm. The proposed antenna can provide quadri-polarization senses by switching the four pin-diodes embedded in the feeding network of the antenna shown in Fig. 1(a). When the antenna is excited from port 1 with D2 and D3 in the on state, D1 and D4 in the off state, we can obtain a linear polarization sense in the y-axis. While D3, D4 in the on state and D1, D2 in the off state, we can obtain a LHCP sense. All the different polarization states are listed in the Table 1.

To properly supply a DC bias for the pin-diodes, we need to design the RF chokes and the DC blocks. The DC blocks and the RF chokes can separate the DC signal and the RF signal in the feeding network efficiently such that unwanted interference can be prevented. The forward-bias of the pin-diode is VF = 0.95 Volt. The pin-diode model number is Infineon BAR50-02L.

Experimental Results

The return loss, the gain, and the radiation patterns of the proposed antenna have been simulated and measured for different states of the connecting pin-diodes. The feeding network of

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the proposed antenna is reconfigured according to different states of the four pin diodes. We carried out the simulations by using a commercial electromagnetic software, IE3D®. We utilized the equivalent lengths of metal tapes to represent the conducting pin-diodes. When the pin-diodes are in the off state, they are removed from the simulation [10].

Fig. 2 (a) and (b) show the simulated and measured S-parameters of the antenna. The measured results agree well with the simulated ones. In Fig. 2 (b), the measured operating bandwidth is about 9.60% in the linear polarization state. The measured operating bandwidth is about 3.67% in the left-hand circular polarization.

The measured linear polarization (y-axis) radiation patterns are shown in Fig.3. The maximum gains are about 3 dBi for E-plane and 3.4 dBi for H-plane in the main lobe. The measured LHCP radiation pattern is shown in the Fig.4. The maximum gain is about 3.2 dBi around the main lobe and the pattern demonstrates the proposed antenna is an excellent circular polarization antenna.

Conclusion

A switchable polarization diversity microstrip antenna is proposed for multi-polarization diversity applications. By switching the pin-diodes in the feeding network properly, the proposed antenna can be operated either in dual-linear polarizations sense or in dual-circular polarizations sense. Thus, the proposed antenna owns quadri-polarization diversity characteristic. Our experimental results validate that the design antenna has good performance in S-parameters, radiation pattern and axial ratio. Therefore, the switchable polarization diversity microstrip antenna can be a good candidate for future polarization diversity applications in the WLAN, microwave read/write tagging RFID system and MIMO communication systems.

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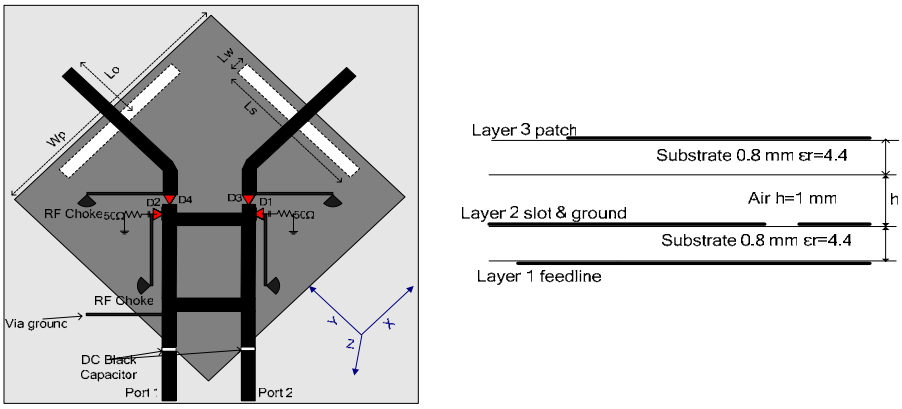
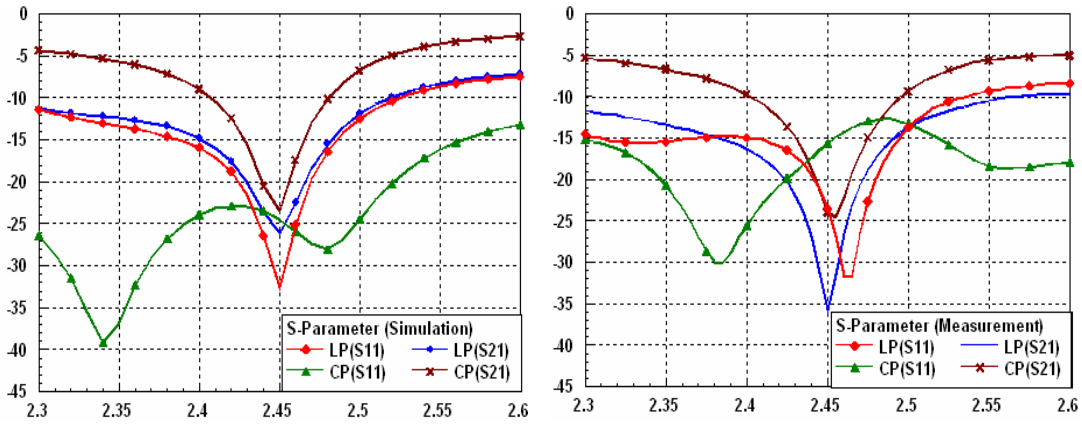


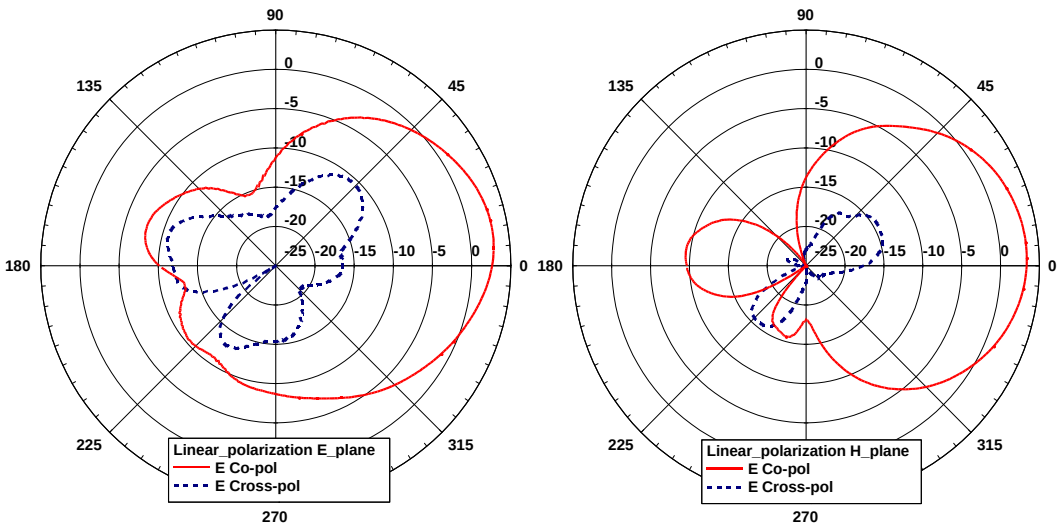
(a) Top view of proposed antenna (b) Side view of proposed antenna

Figure 1: Geometry of the switchable polarization antenna (a) Top view of the proposed antenna (Wp ≈ 1/2 λ, Lw = 1.15 mm, Ls = 22.5 mm, Lo= 6.5mm.) (b) Side view of the proposed antenna.



(a) (b)

Figure 2: Measured and simulated S-parameters of the proposed antenna (a) Simulation (b) Measurement



(a) (b)

Figure 3: Measured linear polarization radiation patterns of the antenna (a) E-plane (b) H-plane

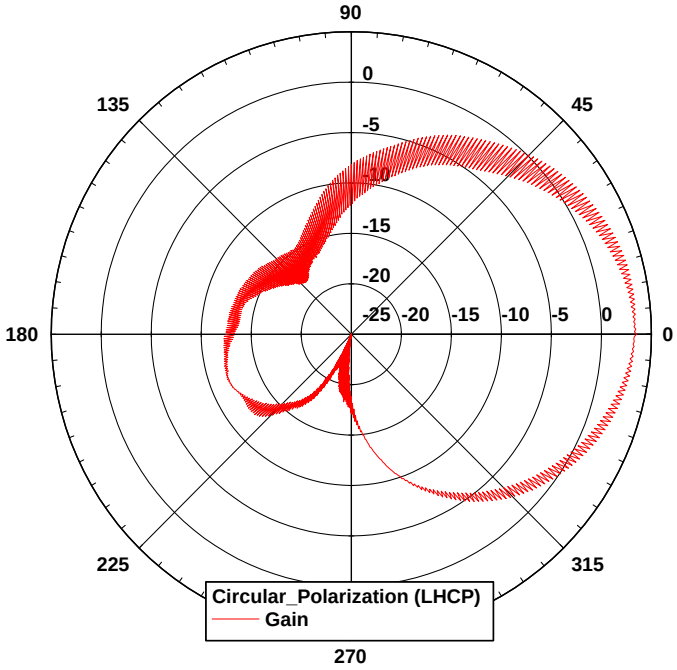


Figure 4: Measured left-hand circular polarization radiation patterns of the antenna

	Pin-Diode State	**Polarization Sense**
Antenna Excited from Port1	(D2,D3) ON ,(D1,D4) OFF	LP(y-axis)
	(D1,D4) ON ,(D2,D3) OFF	LP(x-axis)
	(D3,D4) ON ,(D1,D2) OFF	LHCP
Antenna Excited from Port2	(D2,D3) ON ,(D1,D4) OFF	LP(y-axis)
	(D1,D4) ON ,(D2,D3) OFF	LP(x-axis)
	(D3,D4) ON ,(D1,D2) OFF	RHCP

Table 1: Statuses of the proposed antenna