Multi-linear polarization reconfigurable center-fed circular patch antenna with shorting posts

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***Abstract*—In this paper, a novel multi-linear polarization reconfigurable antenna with shorting posts, which can achieve four linear polarizations ($0°$, $45°$, $90°$, $135°$), has been proposed. By switching the diodes between two groups of shorting posts, four linear polarizations can be realized. The dimensions of the proposed antenna are about $0.56\lambda\times$ $0.56\lambda\times0.07\lambda$ at 2.4 GHz. The measured results agree well with the simulated ones.**

I. Introduction

Polarization reconfigurable antennas have received increasing attentions due to their advantages in enhancing the performance of many wireless communication systems[1]. To date, various kinds of polarization switching have been proposed, such as switching between two linear polarizations (LPs) [2], or between two circular polarizations (CPs) [3], or between LPs and CPs [4]. In [5], two orthogonal LPs and two orthogonal CPs were realized by reconfiguring four transmission modes on a feed network.

Despite the success, previous designs were mainly focused on the polarization reconfiguration between two LPs, CPs, or among LPs and CPs. Very few papers have been reported to achieve the switch among multi-linear polarizations. As is known, for conformal array applications, element antennas with multi-liner polarization reconfigurability are highly desired, as they can improve the gain of the array by rotating the polarizations [6]. One interesting design was proposed in [7], where six linear polarizations with $30°$ rotation have been obtained. The antenna used 12 PIN diodes with measured gains about 3.5 dBi. In [8], [9], four linear polarizations with $30°$ rotation were achieved by reconfiguring four slot radiators. However, the large dimensions of the antenna (around $1.22\lambda\times1.22\lambda\times0.26\lambda$ at 2.45 GHz) may make it inconvenient to be applied in the antenna array.

In this paper, a novel multi-linear polarization reconfigurable antenna with shorting posts is proposed. Four diodes are placed between two groups of shorting posts to achieve the four linear polarizations ($0°, 45°, 90°, 135°$). The proposed antenna has a simple DC biasing network. The antenna dimensions are about $0.56\lambda\times$ $0.56\lambda\times0.07\lambda$ at 2.4 GHz. For all these four polarization states, the measured S11 agree well with the simulated ones, and the measured gains are more than 4.8 dBi.

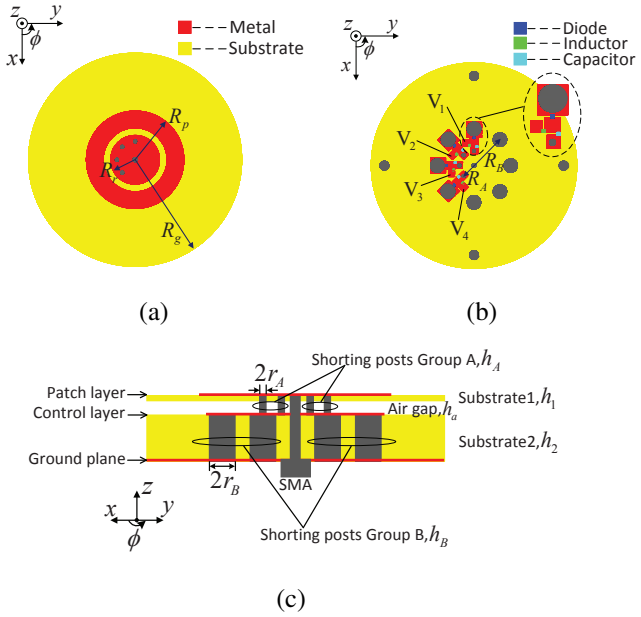
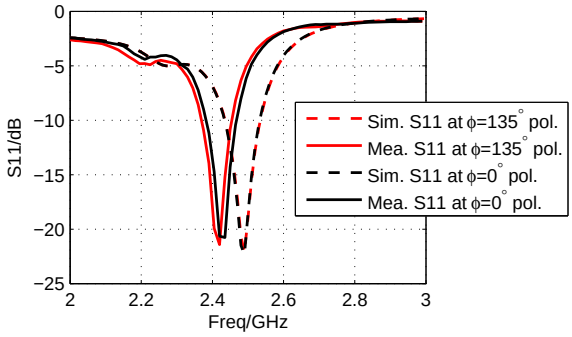


Fig. 1. Geometry of the reconfigurable multi-polarization antenna with shorting posts: (a) top view of the patch layer, (b) top view of the control layer, and (c) side view.

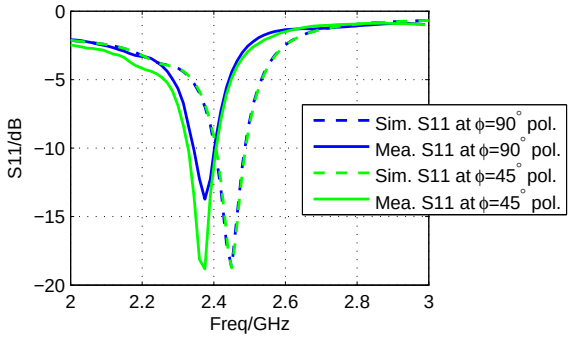
II. Antenna Configuration and Performance

Geometry of the proposed multi-linear polarization reconfigurable antenna with shorting posts is shown in Fig. 1. Two substrates that are Substrate 1 and Substrate 2 are used, and an air gap is introduced between them. Both these two substrates are Rogers RT/Duriod 5880 laminate with the radii of 35 mm. For Substrate 1, patch layer is etched on the top, and the bottom metal is removed. On the patch layer, an annular-ring-slot patch with a radius of 16 mm is etched. For Substrate 2, a control layer is etched on the top, and ground plane is placed on the bottom. Shorting posts group A with four shorting posts at a $45°$ rotation is drilled through the patch layer to the control layer. Shorting posts group B with eight shorting posts at a $45°$ rotation is drilled through the Substrate 2. Among these eight shorting posts, four shorting posts are connected to Shorting posts group A by placing four diodes, while the other four shorting posts are used for impedance match. The feeding pin is located in the center with a radius of 0.65 mm.

Four linear polarizations can be realized by switching four

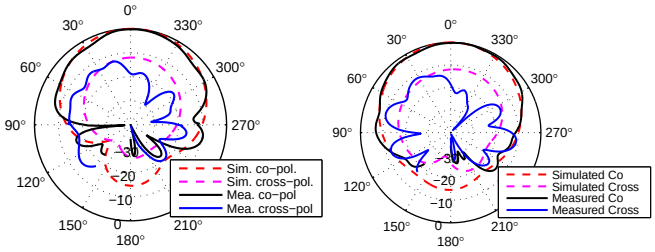


(a)



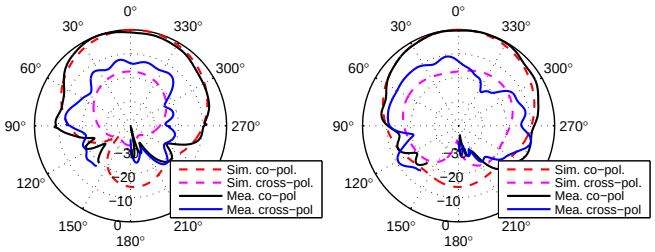
(b)

Fig. 2. Simulated and measured reflection coefficients at: (a) $\phi = 0°$ and $\phi = 45°$, (b) $\phi = 90°$ and $\phi = 135°$ polarizations.



(a) (b)

Fig. 3. $\phi = 0°$ polarization simulated and measured radiation patterns at 2.4 GHz. (a) E plane, and (b) H plane.



(a) (b)

Fig. 4. $\phi = 45°$ polarization simulated and measured radiation patterns at 2.4 GHz. (a) E plane, and (b) H plane.

diodes between the shorting posts group A and group B. For example, to obtain $0°$ polarization state, the diode located on the x-axis needs turning ON, while the other three diodes are OFF. The beam lead PIN diode DSM8100-000 is chosen. Four inductors (47 nH) are used in the DC feed network to choke the RF signal while maintaining the DC continuity. Meanwhile, four capacitors (27 pF) are employed to block the DC signal.

A simulation model is set up and an antenna prototype has been fabricated. Due to the antenna's symmetrical structure, $0°$ polarization and $135°$ polarization states have same S11 and radiations patterns, as well as $45°$ polarization and $90°$ polarization states. The simulated and measured S11 are shown in Fig. 2 a) and (b). As can be seen, the measured S11 shift towards to the lower frequency compared to the simulated ones. This can be attributed to variations in PIN diodes parameters from values given in manufacturers data sheets and the inaccuracies in the fabrication process. For all four polarization states, the measured S11 are overlapped from 2.39 GHz to 2.41 GHz. Fig. 3(a) and (b) show the simulated and measured radiation patterns. The measured patterns agree well with the simulated ones, and can achieve realized gains more than 4.8 dBi.

III. Conclusion

In this paper, a center-fed circular patch antenna with shorting posts,which can be reconfigured to obtain four horizontal linear polarizations at a $45°$ interval is proposed. Four diodes are placed between two groups of shorting posts to achieve the polarization reconfiguration. The measured S11 for all four polarization states are overlapped from 2.39 GHz to 2.41 GHz, and the measured gains are more than 4.8 dBi.

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