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E-plane Beam Width Reconfigurable Dipole Antenna with Tunable Parasitic Strip

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***Abstract*—A 3-dB E-plane beam width (EPBW) reconfigurable dipole antenna is proposed in this paper. By introducing a tunable C-shape strip, the EPBW of the dipole antenna can switch in three different modes: narrow, middle and wide. Three pairs of PIN diodes are used for controlling. The beam width tuning range can be tuned by the position of two slots on the C-shape strip. This antenna is working at 2.6 GHz with overlap 10-dB band width of 4.8%. The 3-dB EPBW of the three modes are 77.6^o, 90.7^o and 168.3^o. The antenna has low profile and simple structure for fabrication. The simulation shows good results of impedance matching and radiating.**

***Index Terms*—antenna, dipole, reconfigurable.**

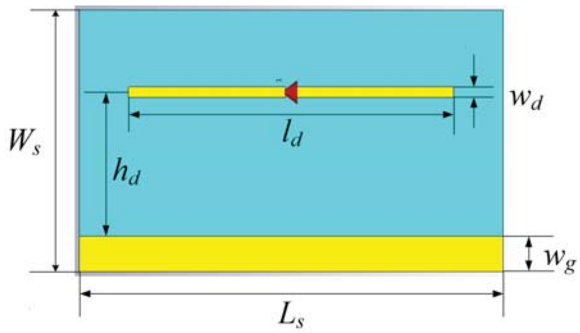
I. Introduction

In the city communication system, the users may concentrate in a small area, like office, and then distribute in a large area, like home, regularly. For covering most of the users dynamically, beam width reconfigurable antenna is required. When the users are concentrated, the narrow beam mode can provide higher gain in this limit area which means larger channel capacity for more terminals. When the users are distributed, wide beam width mode can provide wide coverage in the space. Even the gain is lower, since there are less users in each small area, the channel capacity is still enough. One way to realize the beam width reconfigurable antenna is adding parasitic antenna elements beside the active element [1]. By controlling the couple from active element to parasitic element, the effective radiating aperture changes as well. If the antenna structure is fixed, the beam width tuning is realized by reconfigurable ground plane by induce different reflection [2]. In [3], two identical monopole antennas combined with reconfigurable ground plane is illustrated to realize one narrow and one wide beam width. In [4] and [5], the beam width reconfiguration is obtained in one antenna element. Some parasitic parts are introduced to change the phase distribution of the active element. Compare with [1]- [3], [4] and [5] provides more compact size but they still have 3D structures.

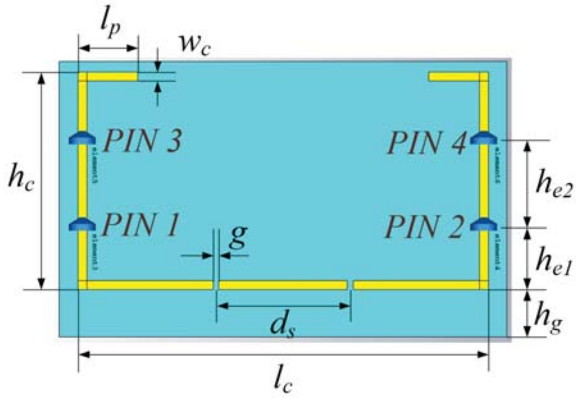
In this paper, the beam width reconfigurable is realized by a tunable strip behind a dipole antenna. The beam width tuning range is decided by the position of two slots. Four PIN diodes are introduced to control the current magnitude on the strip, therefore control the beam width. Full wave simulations are conducted to perform the design at 2.6 GHz frequency band. The paper is organized as follow: section II describes the operational principle. Section III discusses the antenna desigh details and performances. Conclusions and references are described in section IV.

II. Operational Principle

The antenna configuration is show in Figure 1. All structures are printed on the substrate with dielectric 2.2



(a) Top side view



(b) Bottom side view

Fig. 1: Antenna Configuration

and thickness 0.78 mm. On the top side of the substrate, as shown in Figure 1(a), there is a dipole antenna and a strip for reflecting. On the bottom side in Figure 1(b), there is a C-shape strip with two slots and four PIN diodes. Surface current on the reflecting strip couples to the C-shape strip through their parallel parts. As the current magnitude and phase changes on the vertical part of the C strip, the E-plane half power beam width changes as well. When the current becomes stronger, the beam width becomes wider. Therefore, four PIN diodes are set on the vertical part of the C strip to cut it into different lengths. When all PIN diodes are off, the current is in the lowest magnitude, as shown in Figure 2(a), which has lowest influence on the dipole. In this case, the dipole antenna has narrowest half power beam width in E-plane. When all PIN diodes are on, as shown in Figure 2(c), the current is in the highest level and has highest influence on the dipole. In this case, the dipole antenna has widest beam width. When the PIN diodes 1 and 2 are on, 3 and 4 are off, as shown in Figure 2(b), the current magnitude and beam width is in the middle stage. The current magnitude on the dipole in Figure 2(a), (b) and (c) is different, because the phase difference between C strip

TABLE I: Structure Parameters

W_s	37	w_d	1.5	d_s	18	h_d	25	l_d	46
l_s	60	l_c	55	g	0.8	l_p	8	w_c	1.2
w_g	5	h_c	29.2	h_g	6.4	h_{e1}	8.4	h_{e2}	11.6

TABLE II: Working Modes and PIN Diodes States

	PIN 1 and PIN 2	PIN 3 and PIN 4	Beam Width State
Mode 1	off	off	Narrow
Mode 2	on	off	Middle
Mode 3	on	on	Wide

and dipole changes. In Figure 2(a), they are almost the same phase, but in Figure 2(c), they have a phase difference of nearly 90^o. The slots on the horizontal part of the C strip shows apparent influence on the widest beam width but little effect on the narrowest beam width. When the two slots get closer to the center, the widest beam width becomes wider, which means the beam width tuning range gets larger, but the side lobe level and impedance matching becomes worse.

III. Antenna Design and Performance

According to the previous discussion, the beam width reconfigurable dipole antenna can be realized. All structure parameters are shown in Table I. The working modes and PIN diodes states are shown in Table II. The PIN diode type is MAGP907 from MACOM which has total capacitance of 0.025 pF and series resistance of 5.2Ω. The S-parameters of the three working modes are shown in Figure 3. Good impedance matching is achieved at 2.6 GHz with 5% overlap band width of the three modes. The radiation patterns in E-plane of the three modes are shown in Figure 4. The half power beam width is 78^o, 91^o and 170^o respectively. If more PIN diodes are used on the C strip, smaller and more tuning steps can be achieved. Considering about the fabrication simplicity, this paper just gives an example of three modes. Figure 5 shows the influence of the slots position on the horizontal part of C strip. When they get closer, the minimum beam width increases only 2^o, as shown in Figure 5(a), but the maximum beam width increases 80^o, as shown in Figure 5(b). Therefore, the beam width tuning range can be controlled. Smaller tuning range leads to lower side lobe and wider overlap frequency band while the wider tuning band has the opposite property.

IV. Conclusion

This paper gives an idea about half power beam width reconfigurable in E-plane of a dipole antenna. The design methodology is to introduce a parasitic strip around the dipole antenna. As the length of this strip changes, the coupling current changes as well, which leads to beam width reconfigurability. The achieved beam width tuning range is from 78^o to 170^o. The proposed antenna is compact and simple to be fabricated in practical application.

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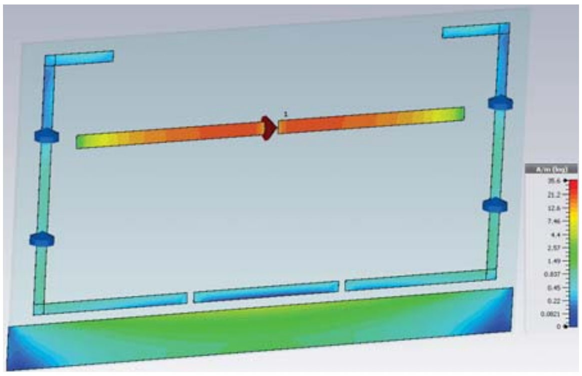
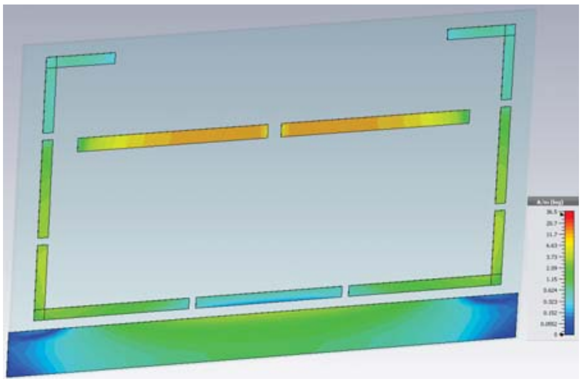
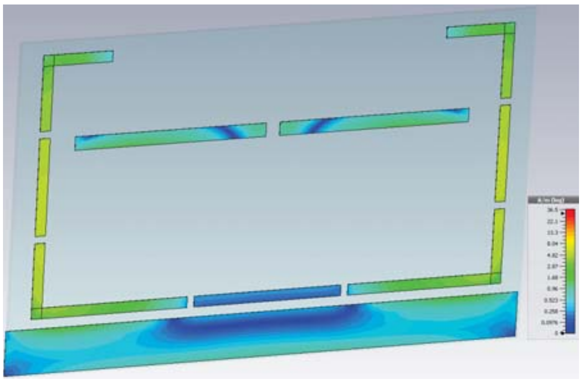


(a) All PIN diodes off



(b) PIN diodes 1 and 2 are on, 3 and 4 are off



(c) All PIN diodes on

Fig. 2: Current Distribution

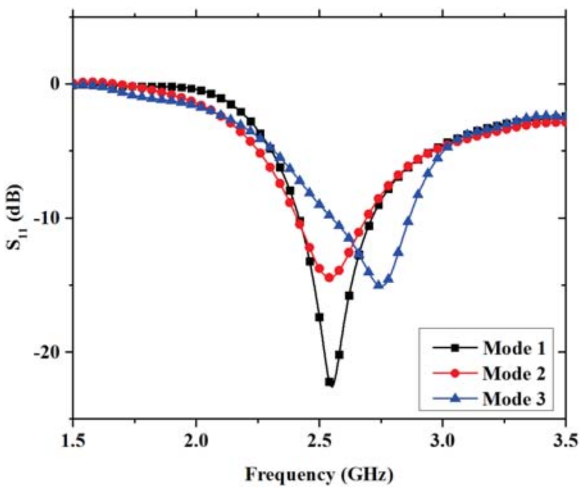


Fig. 3: S-parameters

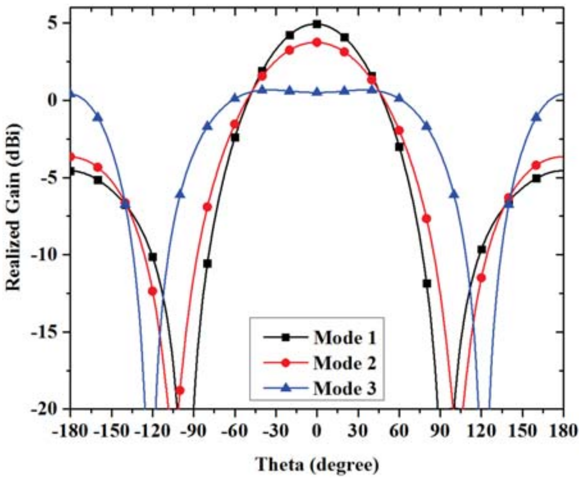
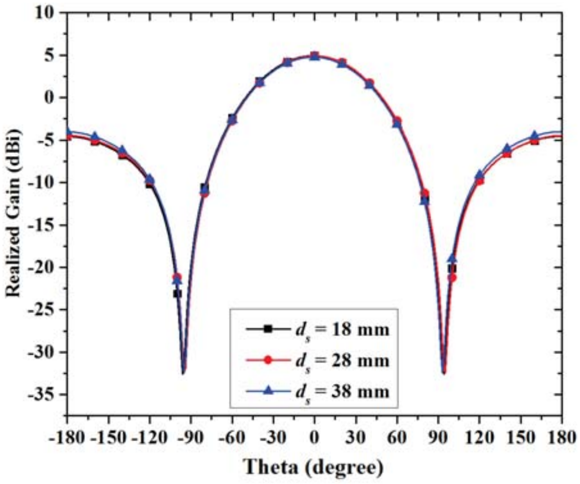
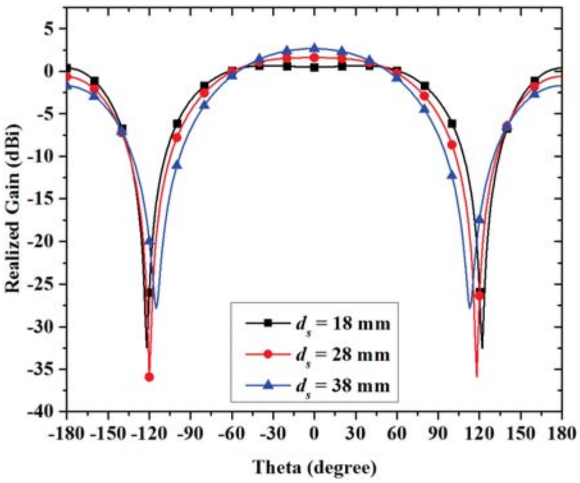


Fig. 4: E-plane Radiation Patterns



(a) Minimum beam width state



(b) Maximum beam width state

Fig. 5: Influence of the Slots Position

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