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RECONFIGURABLE PLANAR INVERTED-F ANTENNA WITH TRI-BAND OPERATION

SANEH SURYA PHADTE, DR. H. G. VIRANI

Dept. of Electronics and Telecommunication Engineering, Goa College of Engineering, Farmagudi, Ponda, Goa.

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Abstract: In this article, a tri band Planar inverted-F antenna with an electronically controlled ground slot enabling reconfigurability is proposed. To minimize its size, the radiator is folded to occupy an area of about 10 X 40mm^2. Next, a ground slot is introduced. The slot is loaded with 2 pairs of PIN diode switches with simple biasing circuits to vary its resonant frequency. The designed antenna has tri band operation. Two frequencies 1.5GHz and 2.4GHz keeping constant the third frequency reconfigured according to the pin diode connections getting 3 separate frequencies for 3 configurations 2GHz, 2.1 GHz and 2.2 GHz. The frequency reconfiguration is carried out by switching the diodes on/off states.

Keywords: Ground slot, PIN diode

Corresponding Author: MR. SANEH SURYA PHADTE

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INTRODUCTION

Recent years have observed the demand for reconfigurable antennas. This trend has been driven by many newly emerging wireless services. With multiband capability, reconfigurable antennas can utilize more efficiently radio frequency spectrum, facilitating a better access to wireless services in modern radio transceivers. Various methods have been reported in the literature to achieve reconfigurable antennas. These are generally divided into two main categories: the frequency tuneable and pattern diversity antennas. For frequency tuneable antennas, much attention has been given to reconfigurable slot antenna designs [1-2] due to the flexibility of slots in integrating electronic switches. The frequency tuning characteristics of a slot antenna can be achieved by changing the slot effective length [2] or by switching the connection between the feed and the ground [4]. Apart from using ground slots, frequency reconfigurability can also be achieved by changing the induced current distribution [4] or varying the ground plane electrical length [4] supporting a patch antenna. For pattern diversity antennas, reconfigurability can be obtained by adjusting the physical configuration of the antenna radiator to produce tuneable radiation patterns.

Most of frequency reconfigurable slot antennas generate only single operating bands at a particular reconfigurable mode. Although many conventional multiband techniques exist such as multi-mode resonator or multi-resonator [5], they are difficult to implement in reconfigurable slot antennas. Recently, a coplanar inverted-F antenna (CIFA) with ground slots has been reported in [5]. It is capable to generate a new higher-band resonance from a ground slot without affecting its original resonance of the patch radiator.

This article provides a new solution to achieve a reconfigurable antenna capable of generating multiband operation at each reconfigurable mode. By means of length-tunable ground slot, a new reconfigurable planar inverted-F antenna achieves tri-band operation at three different modes. The generated frequency bands cover several popular wireless services including GPS, UMTS and WLAN or BLUETOOTH.

I. Antenna Design

The antenna has a simple structure fed by 0.5mm radius using probe feed technique. The dielectric material selected for the design is FR-4 which has dielectric constant of 4.4 and height of dielectric substrate (h) = 1.6 mm. A microstrip radiator of width L2= 2mm is designed in IE3D. The radiator is fed by a 50ohms microstrip feedline of width Wf = 3mm and placed Wd = 6mm from the antenna edge. It occupies a small area of Lr = 10mm X Wg = 40 mm, one end of the radiator is folded twice with L1= 3mm and W1 = 26mm to form the configuration shown in

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Figure 1. To form an inverted-F antenna, other end of the radiator is grounded through a via. This is to compensate the large capacitance introduced from the coupling of the folded arm to the ground. The gap between the Lg = 90mm X Wg = 40mm ground plane supporting the antenna and the feedline to the shorting strip G = 4mm are the other parameters. The chosen ground plane size is typical for many wireless transceivers such as a mobile phone.

Following the technique in [5], a slot is introduced in the ground. The ground slot is placed Ld = 5mm from the ground top edge and has a dimension of Ls = 3mm Ws = 26mm as shown in Figure 2(a).

In order to achieve an electronically variable (reconfigurable) slot length, two identical 1mm X 1mm conducting pads (P1 and P2) and two pairs of PIN diode switches are introduced in the ground slot as presented in Figure 2(a) and Figure 2(b) respectively. The gap d = 1mm in Figure 2(b) is chosen to allow uniform decrease of the slot effective length, thus allowing uniform increase in the excited resonant frequency. All final dimensions are achieved through optimization using parametric study in IE3D.

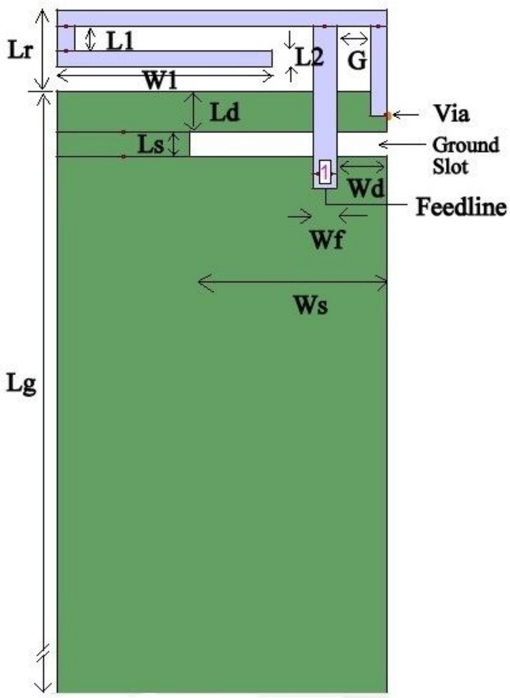

Fig. 1 Proposed Antenna

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A. Reconfigurable Ground Slot

Following the technique in [3], a slot is introduced in the ground. The ground slot is placed Ld = 5mm from the ground top edge and has a dimension of Ls = 3mm X Ws = 26mm as shown in Figure 1(a).

In order to achieve an electronically variable (reconfigurable) slot length, two identical 1mm X 1mm conducting pads (P1 and P2) and two pairs of PIN diode switches are introduced in the ground slot as presented in Figure 1(b) and Figure 2 respectively. The gap d = 1mm in Figure 1(b) is chosen to allow uniform decrease of the slot effective length, thus allowing uniform increase in the excited resonant frequency. All final dimensions are achieved through optimization using parametric study in IE3D

The switches are designed to operate in three diode pairs. The switch states at each mode are given in Table 1. From the table, the ON-state indicates the diode is forward biased while the OFF-state indicates it is reverse biased. Figure 3 shows the simulation model of the ground slot in each mode. For simulation simplicity, the ON-state diode is represented by a 1mm X 1mm PEC. In this case, the effect of the PIN diode forward biased resistance is neglected. The PEC is removed to represent the OFF-state diode.

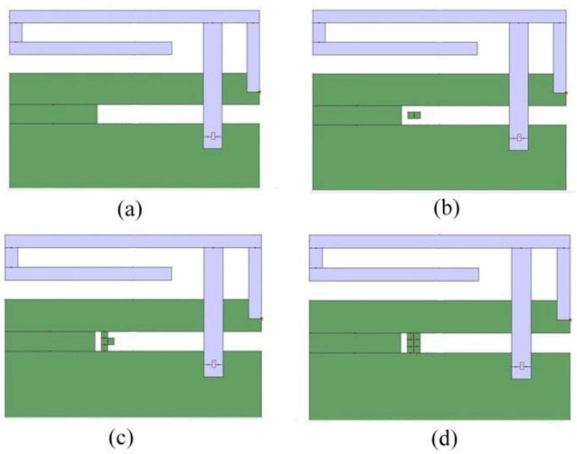

Fig.2 (a) Ground slot (b) Mode 0 (c) Mode 1 (d) Mode 2

II. Simulation Results

The Figures 3(a)-3(c) show the return loss from the simulation model.

The practical circuit realization suffers with the mismatch between the available source power and the power delivered. This mismatch is known as return loss.

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Return loss = -20log (Ʈin)

where 'Ʈin' is input reflection coefficient. In the Mode 0 the return loss of the antenna is obtained as -26.20 dB at 1.5GHz, -12.02 dB at 2GHz and -14.55 dB at 2.4 GHz. It has a bandwidth of 140MHz, 70MHz and 120MHz respectively (the total bandwidth coverage at 10 dB return loss). In the Mode 1 the return loss of the antenna is obtained as -14.75 dB at 1.5GHz, -16.52 dB at 2.1GHz and -19.40 dB at 2.4 GHz. It has a bandwidth of 70MHz, 110MHz and 200MHz respectively (the total bandwidth coverage at 10 dB return loss). In the Mode 2 the return loss of the antenna is obtained as -10.05 dB at 1.5GHz, -9.75 dB at 2.2GHz and -20.75 dB at 2.4 GHz. It has a bandwidth of 100MHz, 2000MHz and 500MHz respectively (the total bandwidth coverage at 6 dB return loss). So the designed antenna offers good gain and minimum losses at the specified frequency. The return losses of the antenna for all three modes are shown in Figs 3 (a), 3 (b) and 3(c).

It is observed that spacing of the diodes, results in a nearly uniform increase in resonant frequency at each ascending mode. The simulated results show that the proposed reconfigurable antenna has tri band operation. Two frequencies 1.5GHz and 2.4GHz keeping constant the third frequency reconfigured according to the pin diode connections getting 3 separate frequencies for 3 configurations 2GHz, 2.1 GHz and 2.2 GHz. As a result, the proposed antenna can be considered as a good candidate for wireless services application such as GPS, UMTS and LAN or BLUETOOTH

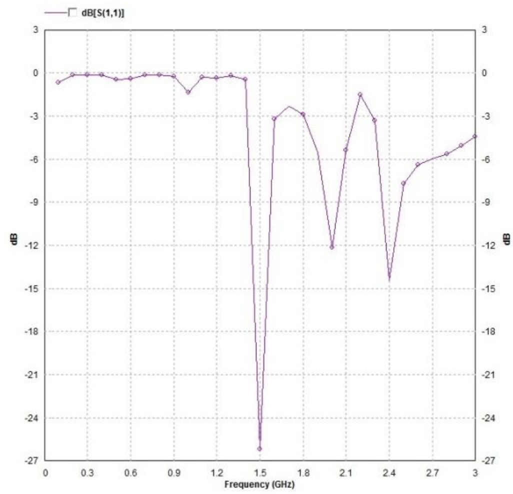

Fig. 3(a) Mode 0 Return loss

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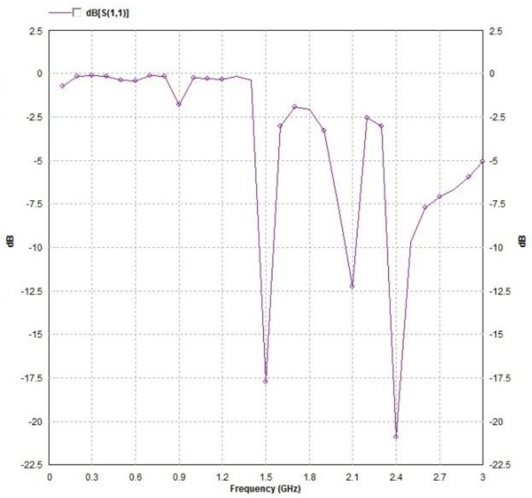

Fig. 3(b) Mode 1 Return loss

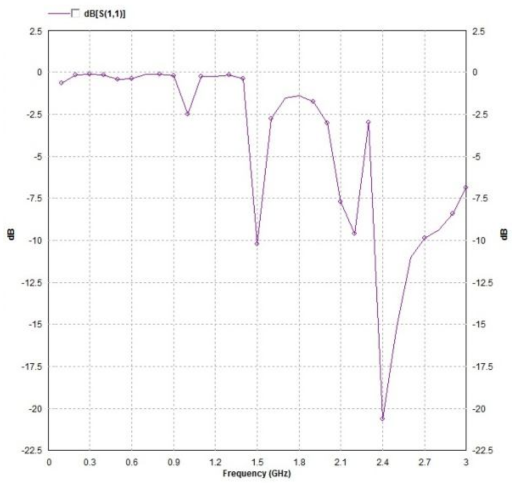

Fig. 3(c) Mode 2 Return loss

III. CONCLUSION

In this article, a new frequency reconfigurable coplanar inverted-F antenna employing a tuneable ground slot has been presented. Using two pairs of PIN diode switches in the ground slot, it has been demonstrated that the antenna can excite new resonant frequencies at each of its three switching modes. The obtained experimental results show that the proposed antenna

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can cover several popular wireless services including GPS, UMTS and BLUTOOTH or LAN produces nearly omni-directional radiation patterns with good efficiency.

The proposed slot tuneable antenna concept should be of interest to the designers of reconfigurable antennas for multiband wireless transceivers

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