A NOVEL FREQUENCY RECONFIGURABLE SLOT ANTENNA

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ABSTRACT
A novel frequency reconfigurable slot antenna is designed for cognitive radio system. In cognitive radio system the two antennas are required one is a wideband antenna and another is frequency reconfigurable antenna. In this work a frequency reconfigurable slot antenna is designed between the switchable frequency range i.e 7.34-7.96 GHz at eight different frequency band and capable to operate single frequency at a time. The proposed antenna has a microstrip patch and a slot etched out in a ground plane. To achieve frequency agility, the effective length of the slot is altered by use of three p-i-n diodes which are placed within the slot at predetermined positions. Results such as return losses, gain, bandwidth and radiation patterns are presented in this paper.

KEYWORDS: *Cognitive radio, PIN diode, multi frequency-agile antenna, L- slot antenna.*

I. INTRODUCTION

It has been observed that, there is a rapid evolution in telecommunication sector in the recent past years due to proper utilization of electromagnetic spectrum. So for proper utilization of spectrum, a cognitive radio system are designed .To fullfill the requirement of cognitive radio system the two antennas are required i.e. a wideband antenna and a frequency reconfigurable antenna. The reconfigurable antennas has a unique property of reconfigurability in radiation pattern, polarization or frequency such as in [1][2] without altering the dimensions of the antenna. A single antenna can be configured to generate several frequencies having desired bandwidth, radiation patterns & Gain. In [3], a frequency reconfigurable microstrip patch-slot antenna is described, and the antenna is capable to agile at eight different working frequencies between 1.98 and 3.59 GHz. The reconfigurable rotated-T slot antenna for cognitive radio systems is described in [4], in which the antenna can operate at eight adjacent frequencies between 6.0-10.6 GHz. Similarly, in [5], the antenna is able to reconfigure for 16 different frequencies within a wide bandwidth from 0.8 to 3.0 GHz .Many researchers use a varactor diodes, RF PIN diode, RF MEMs and FETs as a switch for reconfigurability function. To achieve this function the dimension of the radiating structure is altered by using these switches, which changes the path length of current distribution due to which the antenna acquires the particular frequency band. The PIN diodes are widely used for this purpose as it offer advantages such as easy fabrication, inexpensive & have acceptable characteristics. Several antenna designs based on Slots cut on Ground Plane has proposed in open literature as slots provide numerous advantages. Impedance bandwidth can be altered by modifying the both the dimensions and the position of slots cut out from the ground plane [6]. Slots which are positioned below a radiating patch are known to have increased its bandwidth and are also helpful in decreasing the overall size of antenna [7]. Certain slot shapes are also know to have reduced the Antenna Size, such as L Shaped slot or T-Shaped Slots cut out from Ground plane have been known to have reduced antenna Size[8]. By warping the slot shapes, the slots can be made to occupy relatively lesser area on the Antenna surface, thereby further decreasing the size of Antenna.
In [9], improvement in efficiency and Bandwidth is analyzed with a slot cut out on the ground plane. Antennas based on different slot shapes have been proposed by various researchers. Annular Ring Slot Antenna (ASA) which provides re-configurability for both frequency & radiation pattern by

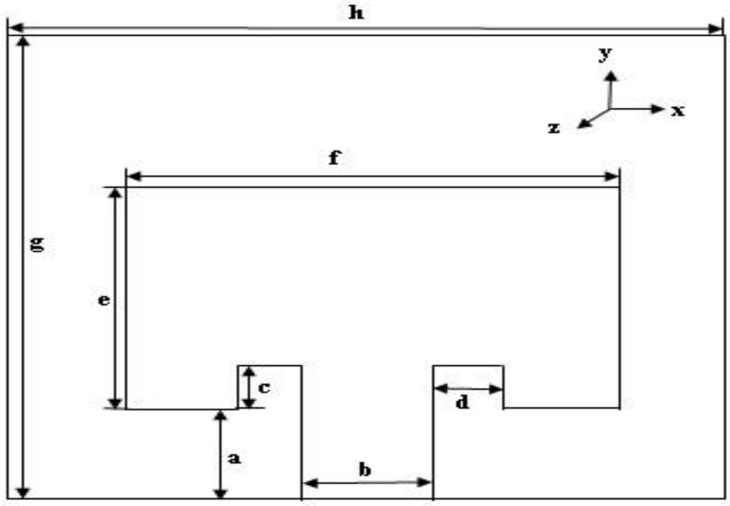
altering the Circular Slot length by use of PIN diodes has been shown in [10]. Similarly, the length of L shaped Slot [11], U Shaped slot [12], H shaped [13] has been altered by use of switches (MEMS, PIN diodes or varactor) to achieve frequency agility. In [14-15], a simple way to achieve the antenna agility is by selectively switching in or out some parts of antenna structure.

In this article, a novel frequency reconfigurable slot antenna is presented. The antenna consists of a microstrip patch and a slot etched out in the ground plane. To achieve frequency agility the three p-i-n diode are placed into the slot. The antenna guarantees an overall of $2^3=8$ different states with single resonance frequency at a time between 7.34-7.96 GHz using three switches (RF p-i-n diode). During simulation a 2×1 mm^2 metal strip is used instead of RF p-i-n diode. The volume of the antenna is compact with a dimension of 35.4×53.95 mm^2.

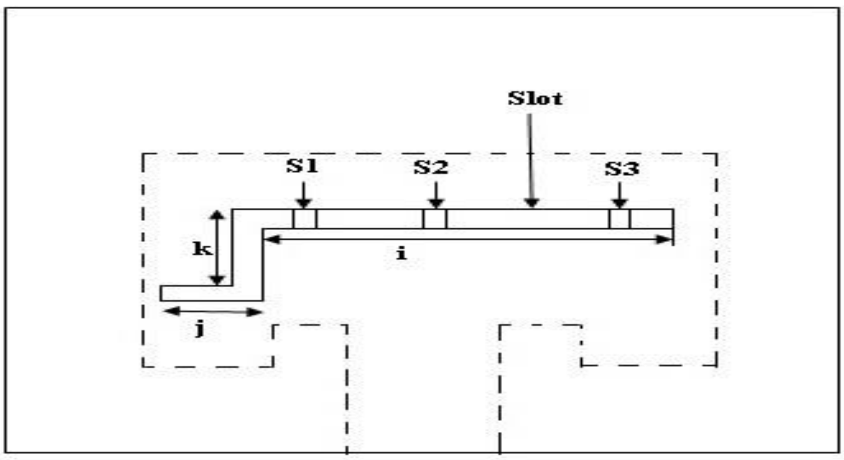
In this work, Section II explains the geometry of design and its dimensions with the help of figure and table respectively. Similarly the results such as return loss, bandwidth and radiation pattern of different states are discussed in section III and then work is concluded with future scope.

II. DESIGN AND CONFIGURATION

In this section, the construction of proposed antenna is presented. The geometry of the proposed antenna is shown in Figure 1.The antenna is constructed on a Rogers RT/ duriod 5880(tm) substrate with Ɛr 2.2, height 0.51mm and δ is 0.0009. By changing effective length of the slot by using metal strips, the different resonance frequency can be obtained.



(a)



(b)

Figure 1. Geometry of the proposed antenna (a) Top view (b) Bottom view.

The dimensions of the proposed antenna are shown in table 1.

Table1. Dimensions of proposed antenna

S.NO	PARAMETERS	VALUES(IN MM)
1.	Feed length (a)	16.614
2.	Feed width (b)	1.571
3.	Inset distance (c)	5.543
4.	Inset gap (d)	0.786
5.	Patch dimension (e)	18.15
6.	Patch dimension (f)	21.56
7.	Substrate dimension(g)	53.95
8.	Substrate dimension (h)	35.4
9.	Slot length (i)	16
10.	Slot length (j)	5
11.	Slot length (k)	5

III. RESULT AND DISCUSSION

The simulated return loss results v/s resonance frequencies of different states are shown in Figure 2. The simulated return loss of these states is less than -10 dB at different frequency band.

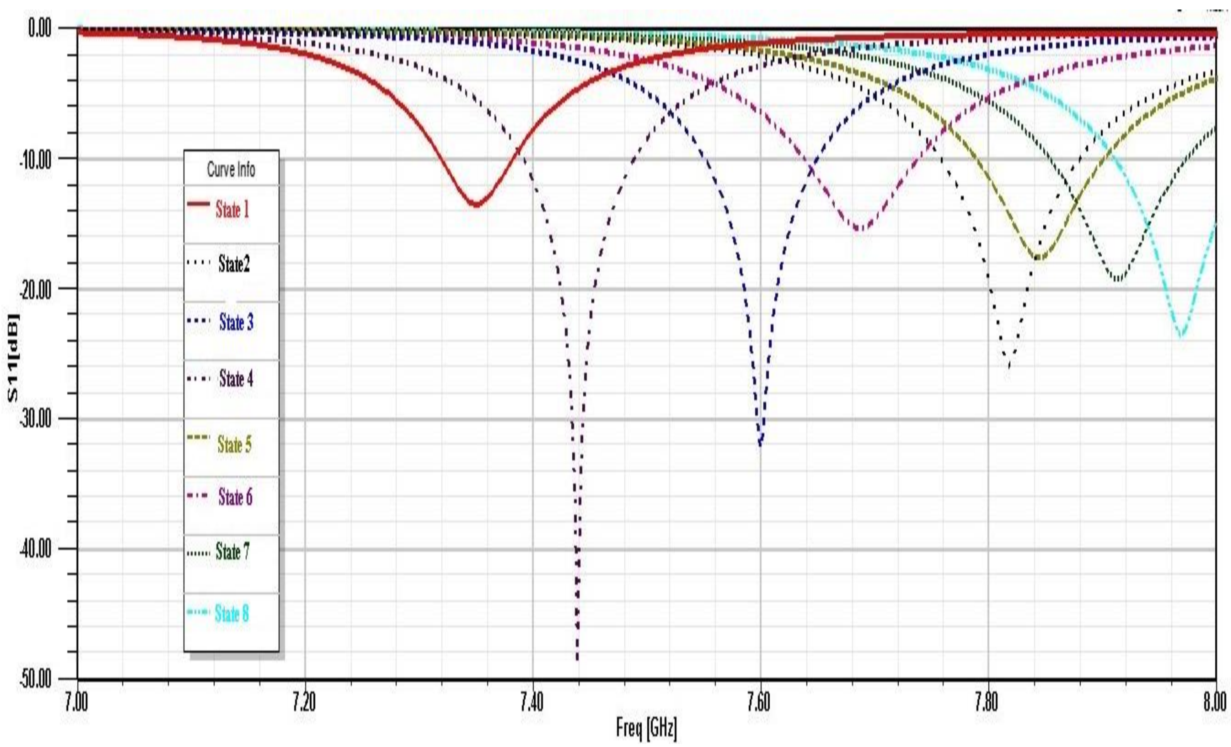


Fig.2. Simulated S11 results

The simulation performance of the frequency-agile slot antenna of various states is summarizes in Table 2.

Table2. States of each switch with correspondent resonance frequency and bandwidth

States	S1	S2	S3	Resonance frequency(GHz)	Bandwidth(MHz)
State1	Off	off	off	7.34	50
State2	On	off	off	7.81	110
State3	Off	on	off	7.59	90
State4	Off	off	on	7.43	100
State5	On	on	off	7.84	120
State6	Off	on	on	7.68	100
State7	On	off	on	7.91	120
State8	On	on	on	7.96	120

The E-plane and H-plane radiation pattern of proposed antenna of various states at the different resonant frequencies are shown in Figure 3 to Figure 10.

Curve info.	
Solid line: E-plane	Dotted line: H-plane

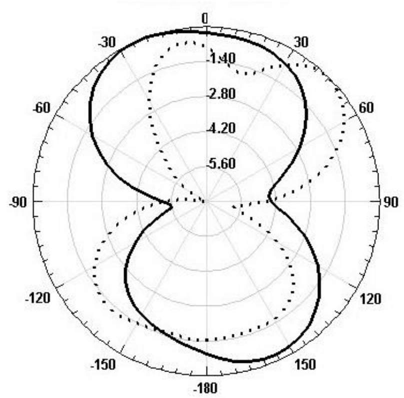


Figure 3.State 1

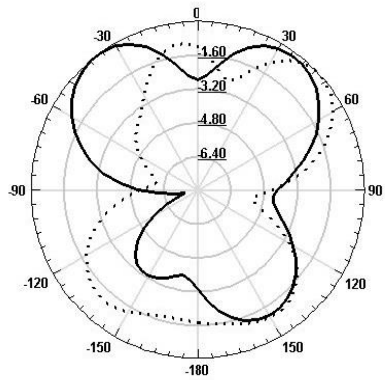


Figure 4. State 2

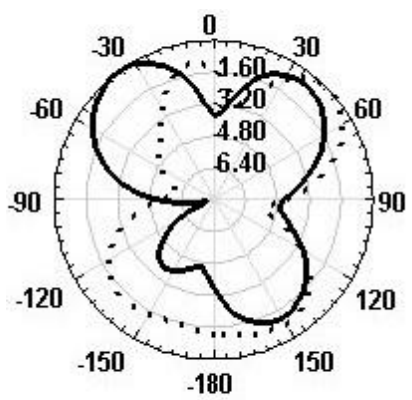


Figure 5.State 3

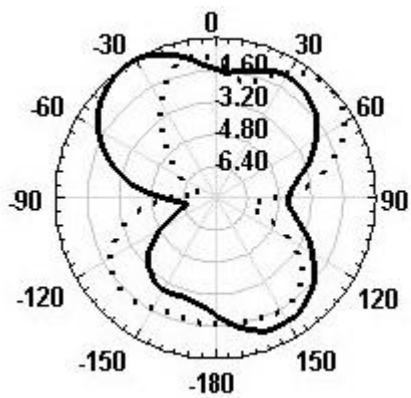


Figure 6. State 4

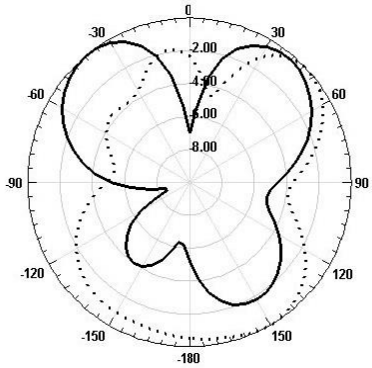


Figure 7.State 5

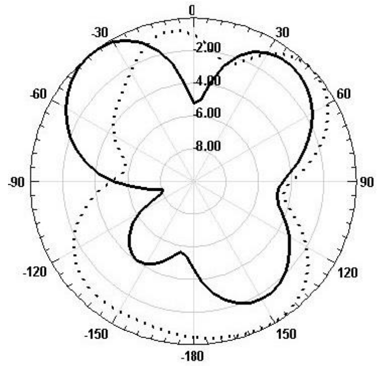


Figure 8. State 6

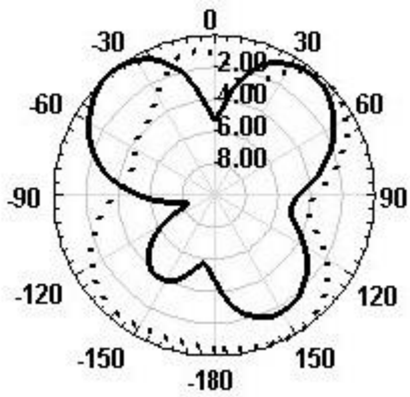


Figure 9. State 7

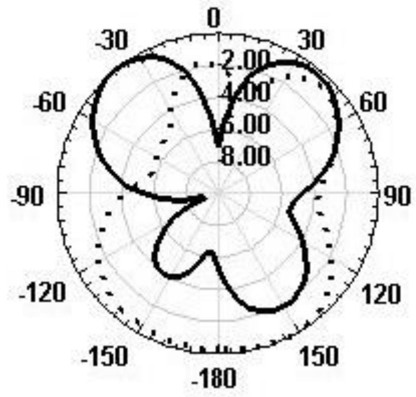


Figure 10.State 8

Figure 3-10 shows that the radiation patterns are nearly omnidirectional and the antenna is capable to operate at eight different frequencies .This shows that the antenna is fit for cognitive radio system because to make the design more demanding for cognitive radio system, the antenna should be compact and has nearly omnidirectional radiation patterns. The gain of the proposed antenna varies from 2 to 6.8 dBi.

IV. CONCLUSIONS

A novel multi frequency reconfigurable slot antenna has been presented. The proposed antenna is capable to reconfigure at eight different frequencies of 7.34-7.96 GHz by using three PIN diodes that are built into the ground plane slot .The slot antenna has nearly omnidirectional radiation pattern in the E-plane and H-plane at each of its eight frequency sub-bands. This shows that the proposed antenna is capable for cognitive radio application.

V. FUTURE WORK

To improve the losses in RF switch, the antenna can be designed with RF MEMS switches and also the frequency band of the antenna can be increased with the help of different design configurations.

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