# A Probe Fed Reconfigurable Micro Strip Antenna - (PFRMSA) Structure for Cognitive Radio Applications

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*Abstract* – A novel probe fed reconfigurable micro strip antenna(PFRMSA)is proposed in this paper. A U-slot has been etched in the radiating square patch. The slot length is altered by switching ON and OFF by using three RF PIN diodes. To realize the reconfiguration characteristics in the antenna three switch configurations are used. There are three modes of the antenna The antenna has been simulated with HFSS software. The simulated return loss and radiation results are tabulated in this paper. As the results show, from 3.85 to 7.05 GHz, the antenna can operate at 5.2, 3.8,and 7.4 GHz different frequencies with similar radiation patterns. The antenna has flat gain flatness with the maximum gain being 5 dBi over the whole range. The measured results and simulated results shows good agreement for acceptable performance and can be used in Cognitive Radio applications.

***Keywords***-SDR, RF switch, Probe-feeding, Frequency reconfigurable, Micro strip Antenna.

## I. INTRODUCTION

Frequency reconfigurable micro strip antennas are gaining importance due to their advantages such as multiband ability, reconfigurablity, and compactness in modern wireless systems. Various methods have been reported in the recent literature to achieve frequency reconfiguration in the antenna structure, such as tuning the antenna using PIN diode switches [1-2], varying the electrical length of the ground plane [3] of a patch antenna. In [4] the induced electric current distribution is changed. The reconfigurable operating frequencies [5] obtained by switching different feeding location. Several reconfigurable antenna designs [5, 6] has been reported for the flexibility of integrating electronic switches.

In this paper, a probe fed frequency reconfigurable micro strip patch antenna is proposed and investigated. The reconfiguration has been carried by etched a U-slot into the Patch. The frequency modulation characteristic has been realized by switching three RF PIN diodes on the radiating slot using ON and OFF configurations.

The geometrics of the antenna and the results will be explained in next sections. The full-wave electromagnetic simulation and analysis for the proposed antenna has been performed using ANSYS HFSS, which is based on the Finite Element Method to compute a 3-D full-wave frequency domain electromagnetic field and S-parameters. Return loss, radiation pattern and the gain of the micro strip antenna are simulated and the simulated results are verified with the measured results and compared. The antenna shows similar radiation pattern and gain at different desired operating frequencies.

*Cognitive Radio*

The concept of Cognitive Radio (CR) appeared as a new paradigm in 1999, with the potential of its application to Software Defined Radio (SDR) and reconfigurable radio over wireless networks [8]. It describes the situation in which intelligent radio devices and associated network entities communicate in such a manner that they are able to adjust their operating parameters according to the needs of the user/network, while learning from the experience at the same time. Such a concept that attempts to mimic human cognition and reasoning has created a huge excitement in the wireless community, igniting discussions that lead to a plethora of theoretical and practical research work together with standardization and regulation activities. With the advent of 4G wireless networks, technological areas like multiple input multiple output (MIMO) system, co-operative communications, multi hop communications have taken centre-stage. Due to the scarce spectrum available to meet all the functionalities in the modern wireless devices it has become imperative to design a frequency reconfigurable antenna to increase the spectrum efficiency [9]. Currently, multiband antennas, which are designed to address more than one band/service at a time, are the most practical and affordable On the other hand, wireless systems are evolving toward multi functionality. A reconfigurable antenna that has switchable fundamental parameters, such as operating frequency, bandwidth, radiation pattern, and polarization, is a well-deserved criterion for providing multi functionality.

## II. ANTENNA DESIGN

### A. *Antenna Geometry*

The geometry and the dimensions of the proposed micro strip antenna are shown in the Fig. 1. It is a micro strip antenna with a U-slot on the radiating patch. The antenna has been designed on a PCB with the relative permittivity of the dielectric substrate with Er=2.2, loss tangent tanδ= 0.001, thickness h ~~¼ 3~~ mm and surface area is 31*31 $mm^2$.

The frequency reconfigurablity characteristic is obtained using three RF-PIN diodes have been used as RF switches to alter the effective electrical length of the antenna. PIN diode1, 2 and PIN diode3 have been inserted in the U-slot gap of the patch. By switching the diodes ON and OFF, the resonating frequencies of the antenna have been controlled. Three modes are realized using the switches. A coaxial fed or probe feeding is used to feed the antenna at the center of the radiating patch. The outer conductor of the coaxial cable is connected to the ground plane, and the center conductor is extended up to the patch antenna for impedance matching at 50Ω point. Detailed dimensional parameters of the antenna are shown in Table I.

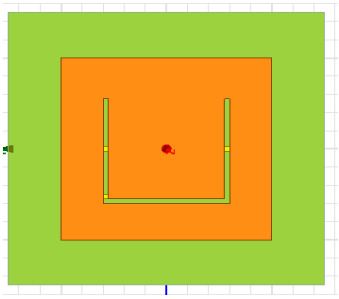

Fig1: The geometry of the proposed antenna structure(Top View)

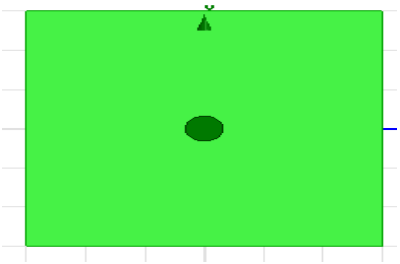

Fig2: The geometry of the proposed antenna structure(Bottom View~~)~~

The top view and bottom view of the proposed antenna are shown in the figure 1, 2.

Fig3a : Fabricated Antenna Top view (000 State)

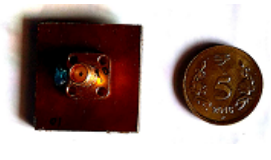

Fig3b : Fabricated Antenna Bottom view (000 State)

Fig4a : Fabricated Antenna Top view (111 State)

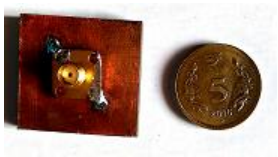

Fig4b : Fabricated Antenna Bottom view (111 State)

### B. *RF Switch Modeling*

The PIN diode is modeled using lumped parasitic elements R, L, and C in Fig 4a-b. The values are used from the datasheet of the PIN diode SMP 1320.The parasitic values from the data sheet are[10].

L = 1.5 nH , $R_S$=0.9 Ω , $R_P$=1.5 KΩ, $C_T$= 0.23 pF.


Fig4a: The electrical equivalent circuit of RF PIN diode(ON state)

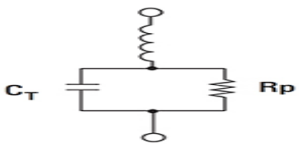


Fig4b: The electrical equivalent circuit of RF PIN diode(OFF state)

## III. EXPERIMENTAL SETUP, SIMULATION AND MEASUREMENT

The antenna was simulated using the HFSS tool and return loss, VSWR, and radiation pattern were measured for acceptable performance. The antenna is fed through a coaxial probe with an SMA of 50 ohm impedance.. The measurement set up for testing the performance of designed antenna is shown in Fig. 5. The proposed Micro strip antenna geometry is designed & simulated using HFSS software to

obtain various parameters like return loss, voltage standing wave ratio (VSWR), bandwidth, gain and radiation pattern. The designed antenna is tested using VNA ZVK (10 MHz-10 GHz) tool.

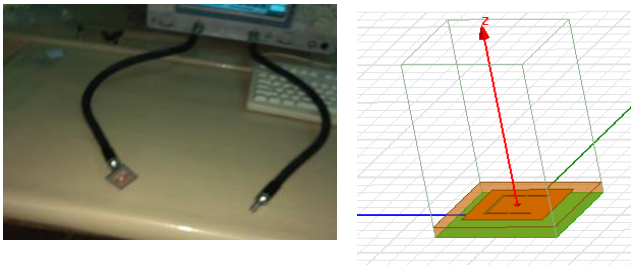

Fig5: Measurement setup and simulation setup of the antenna.

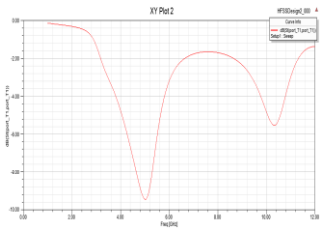

Fig6a: Return Loss when switches are in **000** state

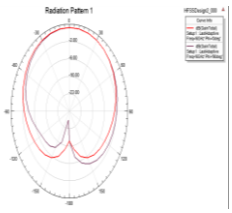

Fig6b: Radiation pattern when all switches in 000 state

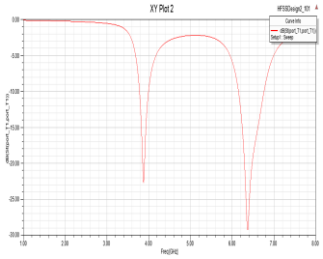

Fig7a: Return Loss when switches are in 101state.

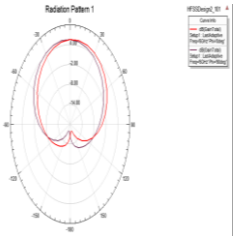

Fig6b: Radiation pattern when switches are in 101 state

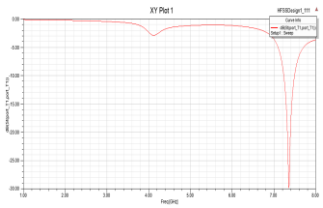

Fig8a: Return Loss when switches are in 111 state.

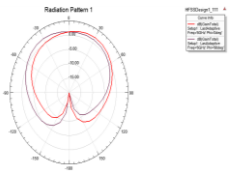

Fig8b: Radiation pattern when switches are in 111

There were three modes of operation of the antenna. The three switches in the radiating patch of the U-slot were altered to achieve the desired resonant frequency and band width. The antenna operates in the S,C, and X microwave bands. The 3D polar plot of -radiation is given in fig 9.

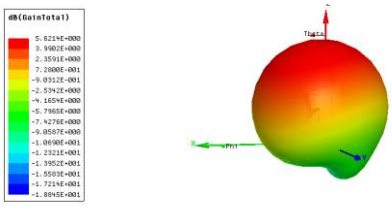

Fig 9: 3D-Polar plot of the antenna

In mode-1, 2, and 3 antenna operates as a transmitting antenna with desired resonant bands as mentioned in the Table-I.

TABLE I: Result Analysis

| | Switch State (SW1,SW2,SW3) | Resonant frequency fr1 | Resonant frequency fr2 |
|---|---|---|---|
| Mode-1 | 0,0,0 | 5.23 GHz | 10.4 GHz |
| Mode-2 | 1,0,1 | 3.8 GHz | 6.4 GHz |
| Mode-3 | 1,1,1 | 7.4 GHz | – |

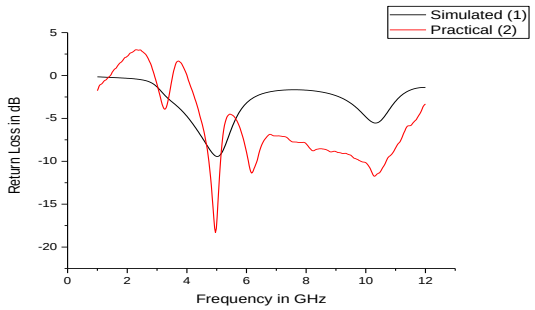


Fig 10a: Comparison of Return loss in Switch State 000

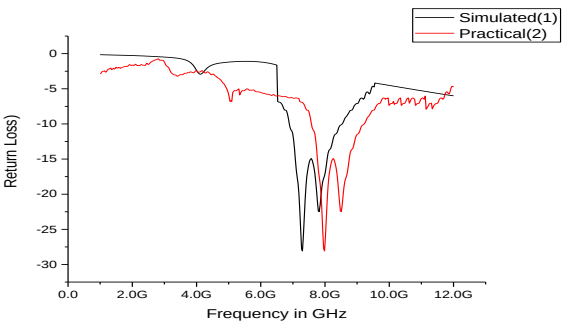


Fig 10b: Comparison of return loss in Switch State 111

The Comparison of simulated and measured return loss

were done and plotted in the figures 10a-b.The simulation results were compared with the measured results for acceptable performance. The variations were attributed to the parasitic elements in the PIN diode modeling and the fabrication pitch tolerance variations

## IV. CONCLUSION

Design concept of micro strip patch etched U- slot antenna with three PIN diodes switches has been proposed in this article. The radiation performances of the antenna have been studied by using EM software and presented in this paper. As the results show that the proposed antenna has advantages such as reconfigurable frequency, stable radiation patterns, flat gain, compact size, etc., so it can be used for other wireless communications system.

Acceptable agreements between simulated and measured results are obtained for the S-parameters of the antenna. Future works can include optical diode or RF MEMS RF switch to further miniaturize and for modern wireless applications.

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## REFERENCES

[1] Sheta AF, Mahmoud SF,A widely tunable compact patch antenna. *IEEE Antenna & Wireless Propagation Lett*ers 7:pp 40–42.

[2] E. S. Jo *et al*., "A frequency reconfigurable slot dipole antenna using surface PIN diodes," *2017 International Symposium on Antennas and Propagation (ISAP)*, Phuket, 2017, pp. 1-2.

[3] Byun SB, Lee JA, Lim JH, Yun TY (2007) Reconfigurable ground-slotted patch antenna using PIN diode switching

[4] Lai ML, Wu TY, Hsieh JC, Wang CH, Jeng SK (2009) Design of reconfigurable antennas based on an L-shape slot and PIN diodes for compact wireless devices. IET Microw Anten Propag 3(1):47–54.

[5] P. Tilanthe and P. C. Sharma, "A new dual band frequency reconfigurable antenna," *2009 International Conference on Emerging Trends in Electronic and Photonic Devices & Systems*, Varanasi, 2009, pp. 310-312.

[6] S. Danesh, M. R. Kamarudin, T. A. Rahman, M. Abedian and M. Khalily A wideband frequency reconfigurable rectangular dielectric resonator antenna , (2016).

R. M. C. Cleetus and G. J. Bala, "Frequency reconfigurable antennas: A review," *2017 International Conference on Signal Processing and Communication (ICSPC)*, Coimbatore, 2017, pp.160-164.

[7] FCC Spectrum Policy Task Force, Washington, DC, "Report of the Spectrum Efficiency Working Group," Tech. Rep., 2002.

[8] Venkataraman, Hrishikesh, Muntean, Gabriel-Miro,Cognitive Radio and its Application for Next Generation Cellular and Wireless Networks, Lecture Notes in Electrical Engineering,2012 ,Springer.Publishers.

[9] Pandit, Shweta, Singh, Ghanshyam, Spectrum Sharing in Cognitive Radio Networks,Medium Access Control based approach.2017,Springer Publishers.

[10] .Datasheet of the SMP 1320 www.skyworksinc.com/Product/476/SMP1320_Series