Fabrication of PIN Diode switchable antenna ON and OFF state with different frequencies

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***Abstract*— A novelette Microstrip patch antenna restructuring with the fabrication of adoptable switchable PIN diode ON and OFF conditions is recommended. The recommended antenna has an uncomplicated framework consists of inverted L-shaped slots that cut along the radiating edge of the reference patch antenna and a PIN diode is inserted between the slots. A PIN diode is fabricated with dielectric constants of substrate 3.2, the dimension of slot 0.40*14.70 mm2 and the length of the metallic strip diode 0.40mm. Simulated and fabricated diode results for diode ON and OFF state which are measured with both practical and ideal diodes. The OFF state resonant frequency is 5.598GHz and the measured frequency is 5.60GHz. Simulated and fabricated results are also checked for diode ON state. The ON state resonant frequency is 4.45GHz and the measured frequency is 4.59GHz. Antenna design simulation is done by using CST software**.

Keywords—Microstrip patch antenna, bandwidth, return loss, PIN diode.

I. INTRODUCTION

The newborn boom in the wireless communication industry, wireless data communication technology and cellular telephony, brought to the great market value for multiband antennas. Now-a-days microstrip patch antennas are widely used for commercial purposes. They can be anchored on the surface of aircrafts, satellites, automobiles, missiles, and even on the mobile phones also [1]. It is one of the most prominent content in the field of antenna. The most straight forward conductor alteration for microstrip patch antenna is in the change in length, which nominally results in the modification in running frequency. Many similar approaches to these alterations are based on the fundamental theory of the basic microstrip patch antenna operating in its initial resonating mode. These approximately have an adequate half wavelength, which is conditional by the dielectric constant and permeability of the substrate material. Various design techniques using defected ground structure (DGS) in the patch antenna have been suggested in previous publications [2-3]. Cavity model can be used to designed rectangular patch antenna [4]

If the number of resonant frequencies increases then the antennas counting also increases. So that in new born generation, there have been a substantial benefit in the unfolded growth of calibrate antennas receivable to their worldly good of adapting with change in environment and system requirements. A separate-out calibrated antenna would extinguish for the nine-folded antennas operation in assorted frequency bands. To accomplish configurability in the antenna, RF shifted devices alike PIN diodes, photoconductive levers, Micro Electro Mechanical System (MEMS) levers and FET's are demanded. Among the acquirable, RF levers and PIN diode levers are precise in microwave circuits utilization expected to its rapid switching execution speed, high current associability and duplicability.

PIN Diodes can be attached in series or in shunt connection. There is definite quantizes which promulgate us approximately the distinguishing attributes of a PIN diode lever. Isolation and Insertion loss are the two parametric quantities which stand for the linguistic presentation of a PIN diode. Victimization of PIN diodes for switching, individuation antenna can come across at two heterogeneous frequencies under distinguishable bias voltages. Isolation is a quantity of the microwave power through with the switch that is not delivered to the load, both from Attenuation Loss and Reflection Loss, when the switch is OFF. Insertion Loss is the transmission loss through with the energetic structure of a PIN diode switch. In forward biased instance (ON state), massive values of bias current and microwave current may flow with the switch architecture, inducing noteworthy ohmic loss. In reverse bias instance (OFF or Isolation state), only small value of discharge current flows through the switch [5-6].

If we require two dissimilar operational frequencies for two distinguishable utilizations, one frequency operates at T1 time and another frequency operates at T2 time, then we can design two antennas for such kind of practical applications. PIN diode switchable antenna can acclimatize dynamically their frequency of undercover operation. They are efficacious in situation where the nine-folded antennas are requisite that can be exchanged by switchable PIN antenna[7-8]

II. ANTENNA DESIGN SPECIFICATIONS

In this paper, the microstrip patch antenna is sketched to run at a centre frequency range of 5GHz with the output impedance of 50Ω using dielectric material GML = 1000 with Ɛo = 3.4, target loss (d) = 0.002 and thickness of 0.762mm[9-10].

A. PATCH DESIGN SPECIFICATIONS

1) The patch width is given as follows:

$$W=\frac{c}{2fr}\left(\frac{\varepsilon r+1}{2}\right)^{-0.5}$$

where, εr= Relative dielectric constant.

fr= Resonance frequency at which the rectangular microstrip antennas are to be deigned.

2) The actual length patch is given as follows:

$$L=\frac{c}{2fr\sqrt{\varepsilon_{eff}}}-2\Delta l$$

where, ε_{eff}= effective dielectric constant.

Δl = account of the fringing field at the edges.

B. DESIGN OF 50Ω FEED LINES

The characteristic ohmic resistance of the Microstrip line is given by:

$$Z=\sqrt{50R_{in}}$$

where, $R_{in}=\frac{120\lambda_{eff}}{2W_{patch}}$

III. FABRICATION OF PATCH ANTENNA

The Perception of the mask is printed on the substrate by using photolithography process.

Step 1. Clean the substrate properly, dries it exhaustively in front of the heat blower.

Step 2. Overlay the substrate with photo-resist material.

Step 3. Preheat the substrate in Dutch-oven at 98°C -100°C for 10 minutes.

Step 4. Align the mask on the substrate.

Step 5. Insulate the substrate to Ultra-Violet rays for 2 minutes.

Step 6. Keep the substrate in developer.

Step 7. Now keep the substrate in acetone and then dry in front of the heat blower.

Step 8. Apply dye on the substrate and then posts heat the substrate for 10 minutes.

Step 9. Protect the ground of substrate with tape.

Step 10. Allow the substrate for Etching in the solution of $FeCl_3$ and water, and finally we will get the desired pattern on the substrate.

The Fig.1 shows the simulated geometry of the patch antenna and the Fig.2 shows the facilitation antenna.

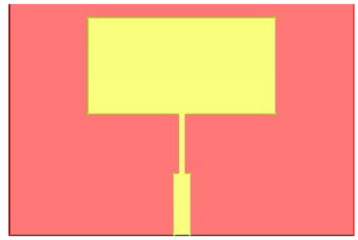

Fig.1 Simulated geometry of patch antenna

Fig.2 Photograph of the fabricated patch antenna

IV. **FABRICATION OF PIN ANTENNA**

This cross section created by mental act antenna. A microstrip antenna with metal sheet of inverted L-like structure is placed on the substrate layer which is shown in Fig. 3. This antenna structure is intentional victimization FR-4 substance having the comparative permittivity of 4.5 and the articulation is of 1.6 mm, which has been adverted from figure 3. Fig.4 and Fig.5 shows the design of ideal patch (OFF state) and design of ideal patch (ON state) respectively. The feeding proficiency used is microstrip feed line.

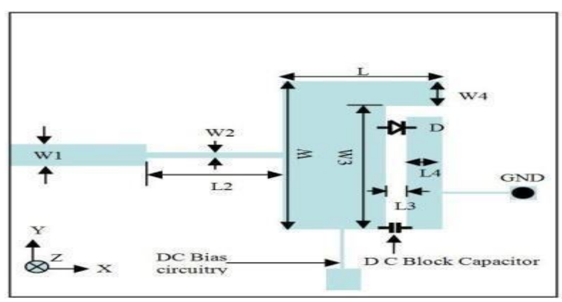

Fig.3 Design of patch

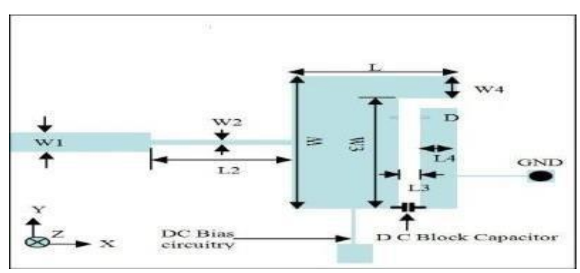

Fig.4 Design of Ideal patch (OFF State)

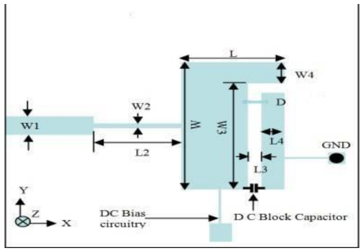

Fig.5 Design of Ideal patch (ON State)

At the radiating edge of patch reference, an up-side down L-shaped slot is cut and a PIN diode is inserted between the slots. The design parameters are shown in the below Table.1.

TABLE.1 **SIMULATION PARAMETERS OF PIN ANTENNA**

PARAMETERS	DIMENSIONS (mm)
W	20.70
L	15.80
W1	1.833
W2	0.3842
L2	8.00
L4	4.00
W3	17.70
W4	3.00
L3	0.40

IV.FINAL FABRICATION

Specifications:

Size of substrate =50.8 X 50.8mm^2

Thickness of Substrate =0.762 mm

Dielectric constant of Substrate = 3.2

Microstrip patch Width (W) = 20.70 mm

Microstrip patch Length (L) = 15.80 mm

Width of 50 Ω feed line (W1) = 1.83 mm

50 Ω feed line Length (L1) = 10 mm

λ/4 Transformer Line Width (W2) = 0.38mm

λ/4 Transformer Line Length (L2) = 8.0 mm

Dimensions of the slot = 0.40 x14.70 mm^2

Gap from non radiating edge (W4) = 3.00 mm

Gap from radiating edge (L4) = 4.00 mm

Ground plane dimensions = 50.80 x 50.80 mm^2

Length of metallic strip D (Diode) = 0.40mm

The functional execution of the antenna can be implicit by surface boundary current inside track in the patch. Two paths are accomplishable corresponding to the two states of the diode. In the foremost state, when the diode 'D' is in the reverse bias or OFF state, the surface current will flow along the slot. With this unitization antenna will emit at the resonate frequency. In the second state, the surface current in the antenna path will lead to the resonant frequency of antenna to supervisor than the acknowledgment frequency. The Fig.6 illustrates the final fabrication of PIN antenna[11-12].

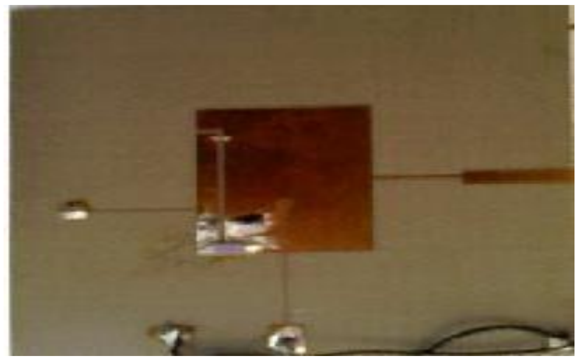
Fig.6 Fabrication of PIN antenna

V. RESULTS AND DISCUSSIONS

We decided to work on C-shape slot on reference patch. After getting the results of conventional microstrip patch antenna (5.0GHz), now we are converting switchable dual frequency antenna into an actual reconfigurable antenna which is achieved by a C-shaped slot cut on the reference patch. This gives the desired lower resonant frequency. A PIN diode is incorporated in the antenna structure as shown in the figure below. When the diode is switched ON (by applying proper bias), the antenna starts resonating at the higher frequency. The geometry of the nominated antenna is shown with C-shaped slot. The dimensions of the slot are L x W. The distance of the slot from non- radiating edge is denoted by W2 and the distance of the slot from radiating edge is denoted by L2[13-14].

VI.RETURN LOSS VARIATION WITH FREQUENCY

The return loss vs frequency plot is illustrated in Fig.7. The draw shows that the antenna achieved over 3GHz – 6GHz jointly corresponding to -10 dB, return loss are achieved. The return loss at 5.598GHz is -25.690dB. The return loss plot for OFF State patch is illustrated in Fig.8. The antenna has small running frequency band which ranges from 3 to 6GHz and corresponding to -10dB, the return loss is obtained[15]. The return loss of -25.690dB is achieved at resonant frequency of 5.598GHz. The return loss for ON state patch is illustrated in Fig. 9. The antenna has small- scale running relative frequency band which ranges from 3 to 6GHz and corresponding to -10dB, the return loss is obtained. The return loss of -13.08dB is acquired at reverberating frequency of about 4.445GHz.

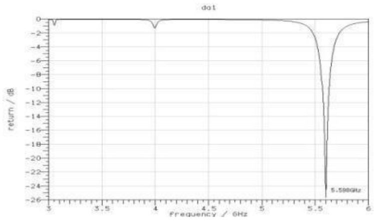

Fig. 7 Variation of return loss with frequency (OFF state)

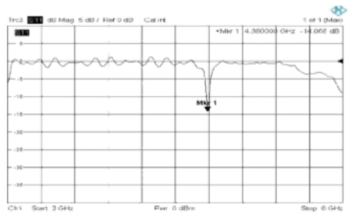

Fig. 8 Measured results for an Ideal Diode condition (OFF state)

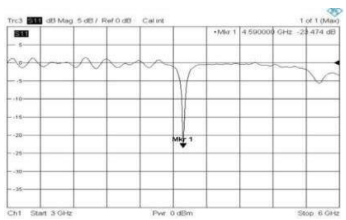

Fig. 9 Measured results for an ideal diode condition (ON state)

The simulated VSWR graph is illustrated in Fig. 10. The plot illustrate that antenna operates over 3GHz–6GHz respectively stand for at -10 dB, return loss are received. The return loss at 4.445GHz is -13.08dB.

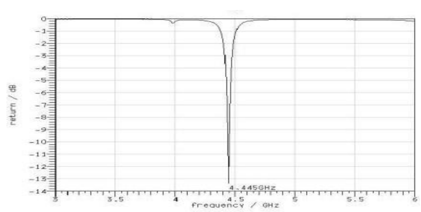

Fig. 10 Variation of return loss with frequency (ON state)

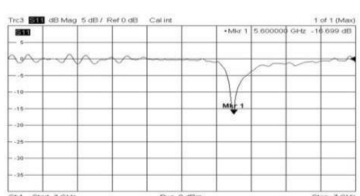

Fig. 11 Measured results for a Practical diode condition (OFF state)

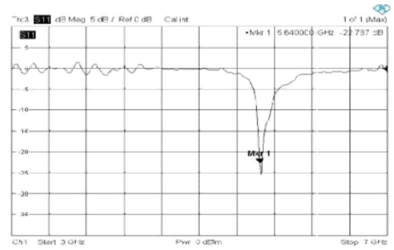

Fig. 12 Measured results for a Practical diode condition (ON state)

The return loss graph for OFF State patchis illustrated in Fig.11. The antenna has small-scale running frequency band which ranges from 3 to 7GHz and stand for at-10dB, the return loss is retrieved. The return loss of -16.699dB is acquired at reverberant frequency of 5.64GHz. The return loss for ON state patch is illustrated in Fig.12. The antenna has small running frequency band which ranges from 3 to 6GHz and corresponding to -10dB, the return loss is obtained. The return loss of -14.068dB is acquired at reverberant frequency of about 4.380GHz.

VII. CONCLUSION

Design and fabrication of PIN diode antenna having frequency re-configurability is progressed to dominant the bias voltage of the PIN diode and the fictitious antennas shows excellent unilateral contract between the simulated and the measured results.

COMPARISON OF SIMULATED AND MEASURED RESULT FOR TWO STATES

S. No	PARAMETER	SIMULATION RESULTS	MEASURED RESULTS	DEVIATION
1	Return loss	-25.690dB	-16.699dB	-8.991dB
2	Resonant frequency	5.598GHz	5.60GHz	0.002GHz

S. No	PARAMETER	SIMULATION RESULTS	MEASURED RESULTS	DEVIATION
1	Return loss	-13.08dB	-23.474dB	-10.394dB
2	Resonant frequency	4.445GHz	4.59GHz	0.145GHz

Compactness, easy fabrication and cost effective make the proposed antenna effectual for commercial message wireless communication utilization.

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