# *Frequency Reconfigurable Microstrip Patch Antenna for Wireless Applications*

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***Abstract-*** **A simple frequency reconfigurable microstrip patch antenna (MPA) having three PIN diode switches is proposed in this paper. The switches are essential for producing three reconfigurable frequency states and are placed below the patch in slot area. The simulation results show that the proposed antenna exhibits directional radiation patterns at all frequencies. The performance of the antenna is represented by the help of simulated reflection coefficient along with the radiation patterns. The proposed antenna is having the dimension of 60 mm × 68.5 mm with the reflection coefficient ($S_{11}$) value less than −20 dB and gain greater than 4.84 dB for all the states. The antenna is suitable for wireless applications.**

***Keywords*—Frequency reconfigurable, Microstrip patch antenna, PIN diodes.**

## I. INTRODUCTION

Adaptability and multi-functionality is the future of all communication systems. It is necessary for cost-efficient and reliable systems that will be used for complex problem solving. The reconfigurable antennas have achieved importance in multifunctional devices due to their multiband operation. These antennas have the ability of modifying their geometry and behavior in order to adapt to any sort of change in surrounding conditions. The MPAs are very popular for implementation of the above because of the planar geometry and well-defined ground plane above which integration of different switches, control circuitry, tunable materials can be possible. Currently, frequency reconfigurable antennas are major area of research due to multipurpose functionalities.

A frequency-reconfigurable microstrip patch antenna is proposed in [1] which employs switching of frequency in the range 1.98-3.59 GHz at nine different frequency bands. Similarly fabrication of a frequency reconfigurable MPA is accomplished for the production of six different frequencies with three switches [2] and a wideband to three narrow bands antenna with frequency reconfigurability is designed in [3]. A novel reconfigurable slot antenna is proposed in [4] which permits different bands of resonance frequency controlled electronically with the help of three switches to obtain seven different states. Two E-shaped antennas with different operational frequencies is presented in [5].

In this article, a frequency reconfigurable MPA is presented in which two slots are placed underneath the patch. The antenna structure has three switches which are placed in the lower slot of antenna in order to produce six different frequency bands.

The antenna can be used for cognitive radio systems where sensing and reconfigurability are key metrics of working. It can also be used for WiMAX applications with necessary modifications. The proposed antenna is low in cost, the substrate is easily available and there is flexibility in fabrication. It can put into practical use with the current form of technology in the world.

Antenna geometry and design of the proposed structure are presented in section II. Simulated results are shown in section III followed by the conclusion in section IV.

## II. ANTENNA DESIGN

The proposed antenna is designed and simulated using ANSYS HFSS vs 15. All the parameters are calculated using standard equations and lengths are varied by doing parametric analysis.

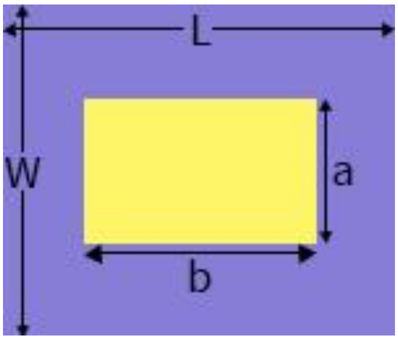


Figure 1: Structure of the proposed antenna (top view)

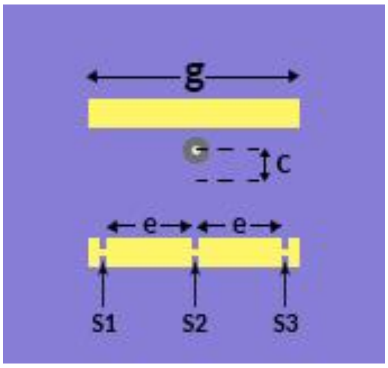


Figure 2: Structure of the proposed antenna (rear view)

Fig. 1 represents the front geometry and Fig. 2 shows the rear view of the proposed antenna. For design of the antenna low cost FR4 substrate with thickness 1.52 mm, permittivity 4.4 and loss-tangent (tan $\delta$) 0.002 are used. The proposed antenna is having width $W = 60$ mm and length $L = 68.5$ mm. The patch is having the dimension of $a = 20$ mm $\times$ $b = 28.5$ mm. The position of the feed point is at $c = 6$ mm from the center in order to achieve good return loss value. The ground plane is having a slot below the patch where $d = 14.8$ mm. The total length of the slot is $g = 27$ mm. Three switches, $S_1$ & $S_2$ and $S_2$ & $S_3$, are placed with a distance $e = 11.5$ mm apart from each other on the lower slot of the patch as shown in Fig.2.

The proposed structure with the slots yields six numbers of resonant frequency bands. The reconfiguration of frequency is possible due to the operating condition of switches. The patch acts as a radiator with frequency of resonance at 3.7 GHz, when all diodes are at ON condition. Similarly at OFF condition of all diodes, the patch behaves as a feed network to the slot with resonating frequency at 3.74 GHz. Here the switches provides a control on slot effective length, thus producing four other bands of frequency. The configuration of different switches is presented in Table-I. For representation of switch in the simulation environment, copper strip is used. ON condition resembles the presence of the copper strip whereas OFF state is represented by its absence.

TABLE I. CONFIGURATION OF SWITCHES

| Condition | Switch-$S_1$ | Switch-$S_2$ | Switch-$S_3$ |
|---|---|---|---|
| **State-D1** | Switch OFF | Switch OFF | Switch OFF |
| **State-D2** | Switch ON | Switch OFF | Switch OFF |
| **State-D3** | Switch ON | Switch OFF | Switch ON |
| **State-D4** | Switch OFF | Switch ON | Switch OFF |
| **State-D5** | Switch ON | Switch ON | Switch OFF |
| **State-D6** | Switch ON | Switch ON | Switch ON |

## III. Results & Discussion

The simulated reflection coefficient plots and the radiation patterns of the proposed antenna are shown from Fig. 3 to Fig 8 and Fig. 9 to Fig. 14.

As shown in Fig. 3 to Fig. 8, the simulated reflection coefficient, $S_{11}$ value is less than -10 dB at all frequency bands. It also shows that the proposed antenna is capable to operate with three different reconfigurable frequency bands.

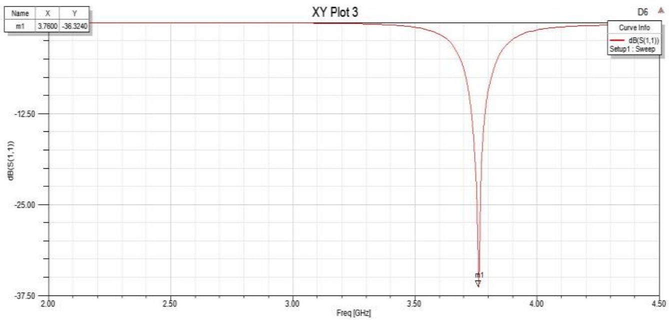


Figure 3. $S_{11}$ plot for D1 state

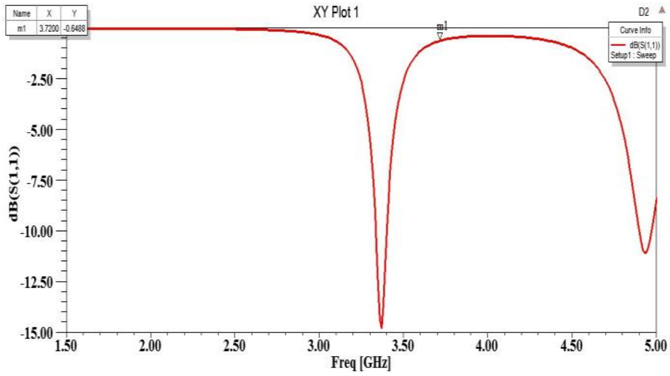


Figure 4. $S_{11}$ plot for D2 state

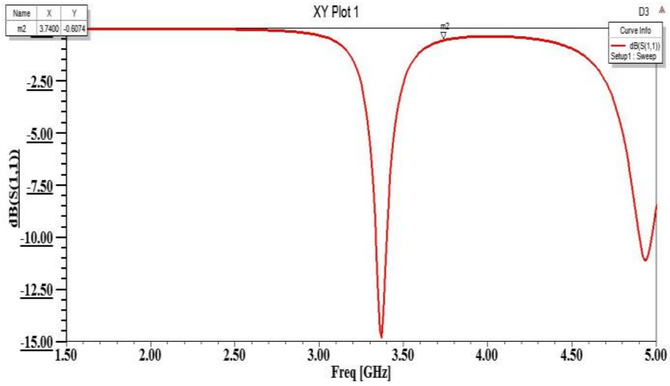


Figure 5. $S_{11}$ plot for D3 state

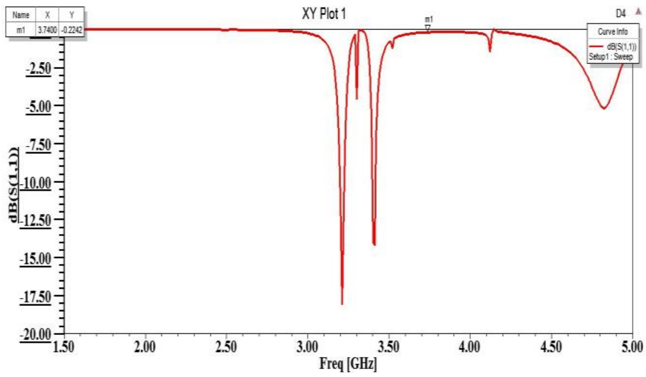


Figure 6. $S_{11}$ plot for D4 state

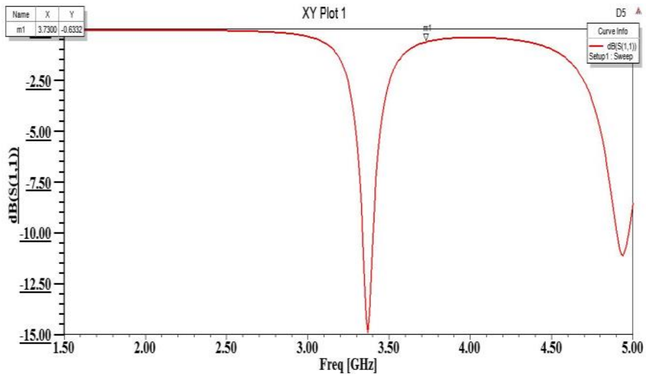


Figure 7. $S_{11}$ plot for D5 state

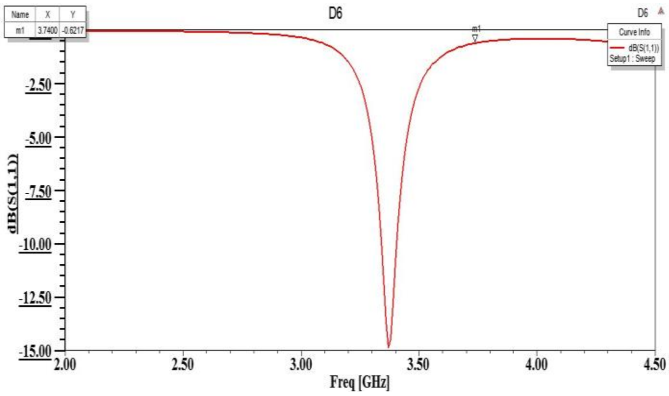


Figure 8. $S_{11}$ plot for D6 state

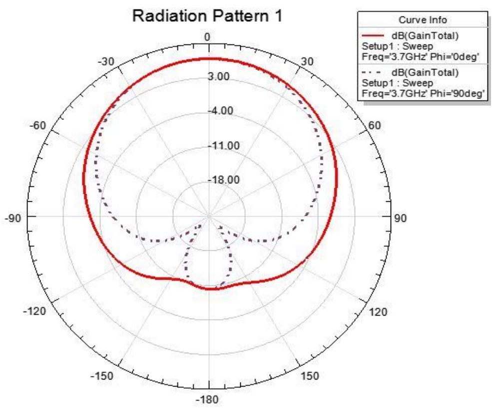


Figure 9. Radiation Pattern for D1 state

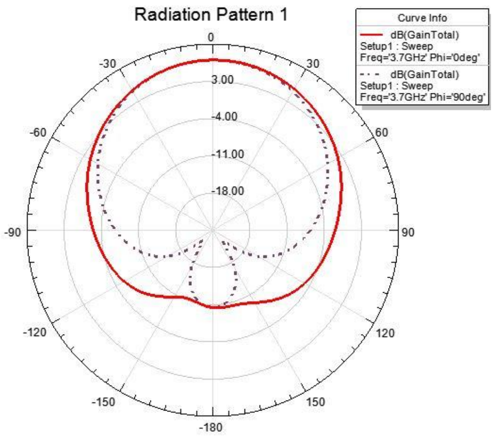


Figure 10. Radiation Pattern for D2 state

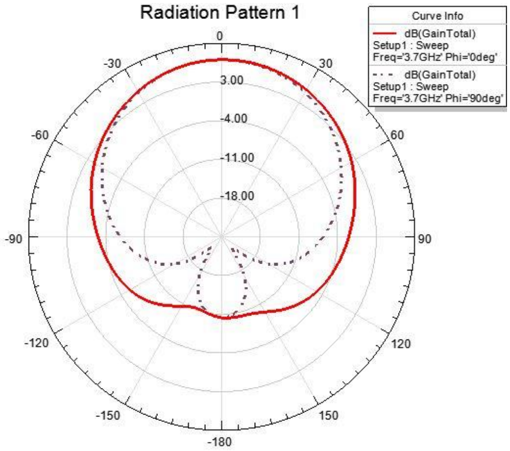


Figure 11. Radiation Pattern for D3 state

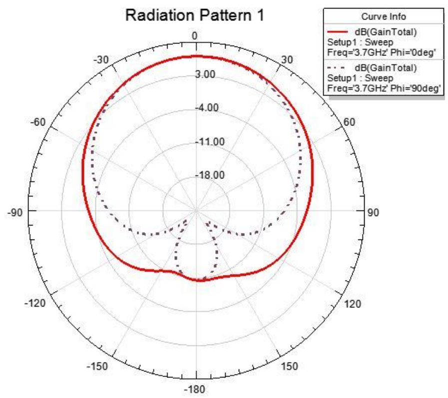


Figure 12. Radiation Pattern for D4 state

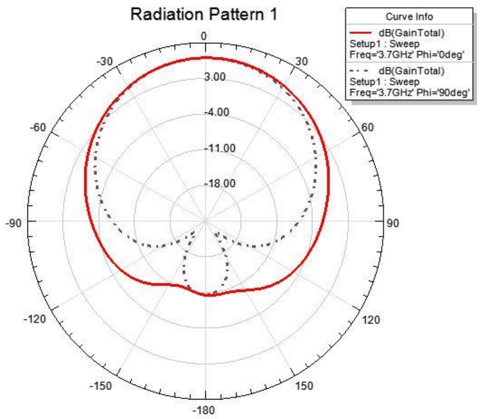


Figure 13. Radiation Pattern for D5 state

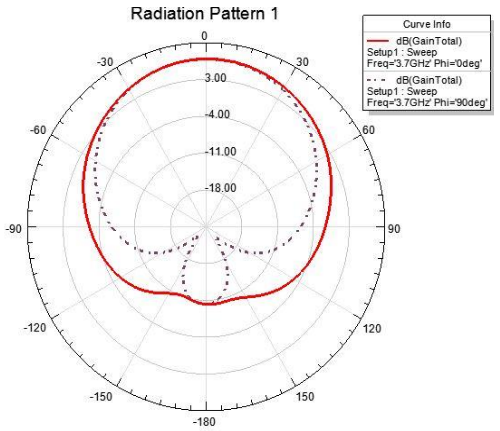


Figure 14. Radiation Pattern for D6 state

Fig. 9 to Fig. 14 show the radiation patterns for the proposed antenna. Different antenna parameters like gain, resonant frequency, reflection coefficient, radiation efficiency are studied and few of them are listed in the Table II.

TABLE II. ANTENNA PARAMETERS

| State | Gain (dB) | Frequency (GHz) | $S_{11}$ (dB) |
|---|---|---|---|
| **D1** | 5.84 | 3.73 | −34.93 |
| **D2** | 6.01 | 3.37 | −20.60 |
| **D3** | 4.84 | 3.37 | −41.25 |
| **D4** | 5.66 | 3.21 | −43.16 |
| **D5** | 5.68 | 3.37 | −38.98 |
| **D6** | 6.00 | 3.37 | −38.46 |

## IV. CONCLUSION

The proposed design can be operated in three frequencies by using three PIN diode switches. The simulation results show acceptable results for the proposed antenna with the reflection coefficient ($S_{11}$) value less than −20 dB and gain greater than 4.84 dB for all the states. The radiation patterns are directional at all frequencies. The radiation efficiency can be improved with the introduction of a metallic reflector plate beneath the antenna which is subject to further experimentation. The antenna can be useful for cognitive radio systems, WiMAX applications etc. Low cost, easy availability of the substrate and flexibility in fabrication makes the proposed structure suitable for wireless applications.

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