

Design and Analysis of Frequency Reconfigurable Dual-Band Microstrip Patch Antenna for Wireless Communication

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ABSTRACT

With the enhancement in the world of wireless communications, the need for multipurpose devices has increased. This need can be fulfilled with reconfigurable antennas. In this paper, frequency reconfigurable microstrip patch antenna is presented. In this design it makes use of two patches with same shapes in order to tune for multiple frequencies. The antenna design make use of micro strip feeding technique, PIN diode is used for switching between the patches to tune for different frequencies. The antenna is capable of resonating at a frequency of 2.4574GHz and 5.907GHz, when On State. It will generate a frequency 3.296GHz. When OFF state. This antenna is simulated and measured using CST 2018 software.

Keywords

Antenna, Reconfigurability, PIN Diode, Microstrip and CST.

1. INTRODUCTION

Reconfigurability can be achieved in different categories like frequency, polarization and radiation pattern reconfigurations. This change is obtained by redistributing the antenna currents, thus, altering the electromagnetic fields of the antenna's effective aperture. Regarding the adjustable parameters of the antennas, reconfigurable antennas can be divided into many sub-categories which include frequency reconfigurable antenna, pattern reconfigurable antenna, polarization reconfigurable antenna, frequency-polarization hybrid reconfigurable antenna and frequency-pattern hybrid reconfigurable antenna among which frequency reconfigurable antennas are found more in the literature.

1.1 Advantages of Reconfigurable Antennas

Right now, wireless communication necessity is expanded and the band of the frequency is limited. We likewise limit the measure of the electronic gadgets so we are going to design an antenna which are spread multi-band frequency. The reconfigurable antenna has numerous advantages which are shown below:-

- (i) Have a multiband reconfigurable antenna in a single terminal for different applications.
- (ii) Easy to fabricate and integrate on ICs and switching devices.
- (iii) Size of that type of antenna is very small.
- (iv) Planar reconfigurable antenna has a decent capacity of reconfiguration.

Microstrip patch antennas can be fed by a variety of methods. These methods can be classified into two categories-

contacting and non-contacting. In the contacting method, the RF power is fed directly to the radiating patch using a connecting element such as a Microstrip line. In the non-contacting scheme, electromagnetic field coupling is done to transfer power between the Microstrip line and the radiating patch. The four most popular feed techniques used are the Microstrip line, coaxial probe (both contacting schemes), aperture coupling and proximity coupling (both non-contacting schemes). In this design we used contacting feed such as Microstrip Line Feed. In this type of feed technique, a conducting strip is connected directly to the edge of the Microstrip patch. The conducting strip is smaller in width as compared to the patch and this kind of feed arrangement has the advantage that the feed can be etched on the same substrate to provide a planar structure. However as the thickness of the dielectric substrate being used, increases the surface waves and also spurious feed radiation, which hampers the bandwidth of the antenna. The feed radiation also leads to undesired cross polarized radiation. This method is advantageous due to its simple planar structure. In this paper, a reconfigurable rectangular patch antenna using PIN diodes is presented to provide multiple- frequency operation for various applications.

2. ANTENNA DESIGN CALCULATION

An interactive theoretical and experimental design approach was utilized to optimize the structure of the antenna. Optimize means to correct and re-correct the dimension of the structure and location of the feed and number of slots in the geometry. The research methodology to simplify the design and development procedures –

2.1 Design/Simulation Stage

- 1) Microstrip patch antenna design for desired radiation pattern and polarization
- 2) Microstrip fed microstrip patch antenna to characterize its parameters
- 3) Microstrip fed microstrip patch antenna for desired input impedance and radiation pattern, Number of bands and bandwidth improvement techniques are implemented.

2.2 Design and Basic Parameter

It is very important to identify the basic aspects and fundamental parameter along with the specification of the presented antenna configuration much before the validation process of design. This is important for us to make sure that the simulation process is carried out correctly without any error.

2.3 Design Procedure for proposed Patch Antenna

During the Procedure for proposed design patch antenna of the project, the design methodology used will be as shown in figure 1.

Steps required for calculating width (W) and Length (L) of a conventional rectangular microstrip patch antenna

Step 1. Initially, select the desired resonant frequency, thickness and dielectric constant of the substrate.

Step 2. Obtain Width (W) of the patch by giving the value of ϵ_r and f_0 .

Step 3. Obtain Length (L) of the patch after determining ΔL and ϵ_r .

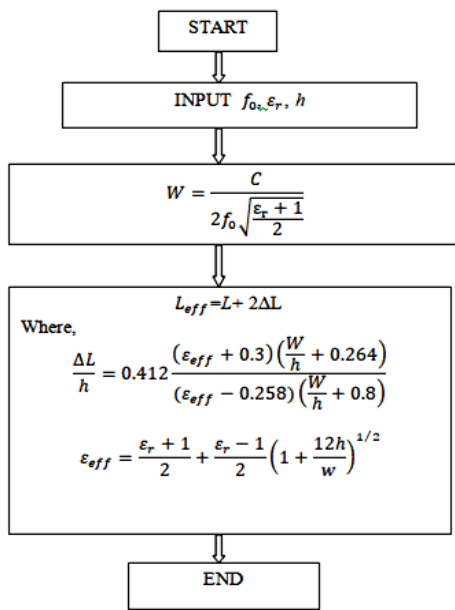


Figure 1: Flow chart

It is also possible to determine the inset length of the patch by taking the resonant frequency f_0 , width W and length L of the patch as input.

3. PROPOSED DESIGN

To design of frequency reconfigurable microstrip patch antenna use pure copper material for ground and design and FR4 material for substrate.

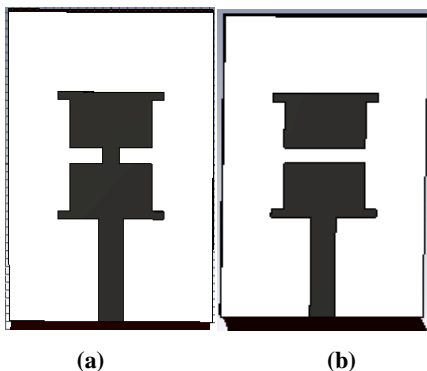


Figure 2: Proposed design (a) ON state (b) OFF state

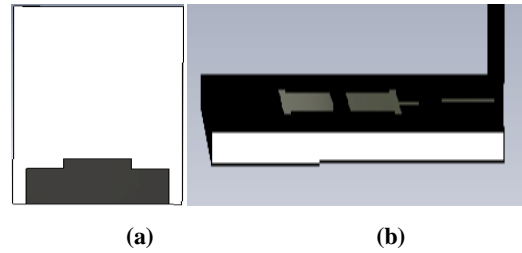


Figure 3: Proposed design (a) Ground (b) Side view

4. SIMULATION RESULT

Case-I: When Diode Connected or On State

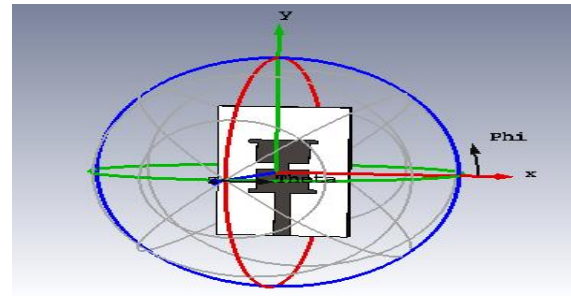


Figure 4: Simulation of proposed antenna ON state

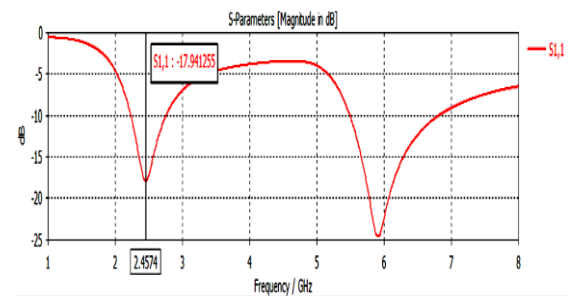


Figure 5: S11 or Return loss of band -I

In figure 5, showing returns loss for band-I in ON state. Return loss is -17.94 which resonant frequency is 2.457GHz.

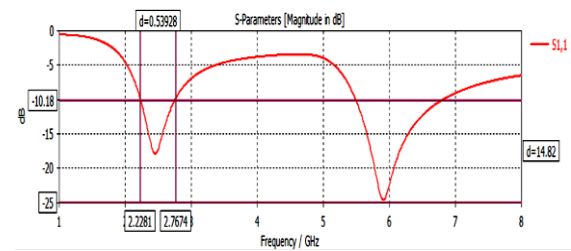


Figure 6: Bandwidth for band-I

In figure 6, showing bandwidth for band-I in ON state. Bandwidth is 539MHz (2.767GHz-2.281GHz).

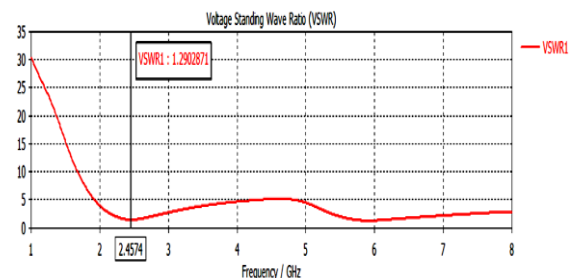


Figure 7: Voltage standing wave ratio for band-I

In figure 7, showing VSWR for band-I in ON state.

Value of VSWR is 1.29 at resonant frequency.

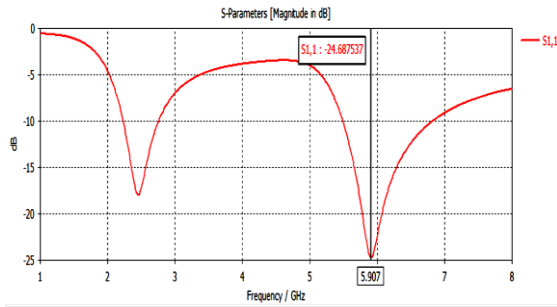


Figure 8: S11 or Return loss of band-II

In figure 8, showing returns loss for band-II in ON state. Return loss is -24.68 which resonant frequency is 5.907GHz.

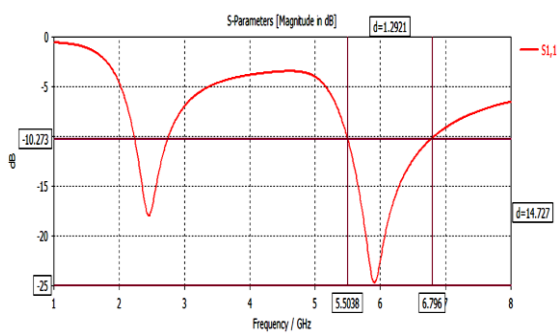


Figure 9: Bandwidth for band-II

In figure 9, showing bandwidth for band-II in ON state. Bandwidth is 1292MHz (6.796GHz-5.503GHz).

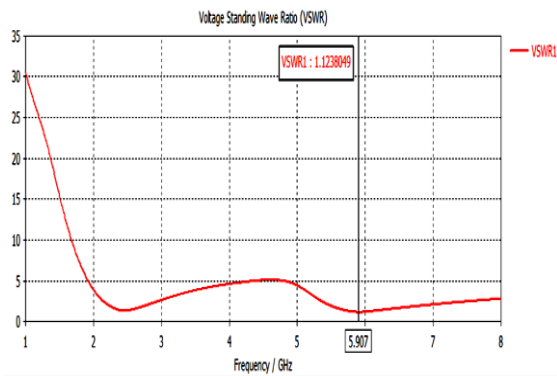
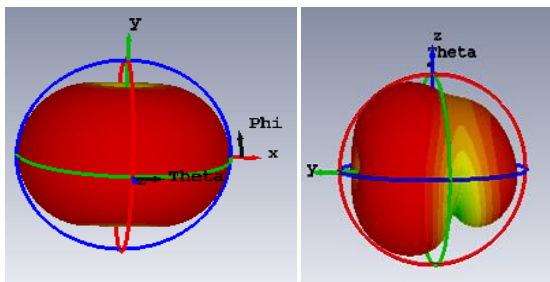


Figure 10: Voltage standing wave ratio for band-II

In figure 10, showing VSWR for band-I in ON state. Value of VSWR is 1.12 at resonant frequency.



(a) (b)

Figure 11: Radiation Pattern (a) band-I (b) band-II

Case-II: When Diode Not Connected or Off State

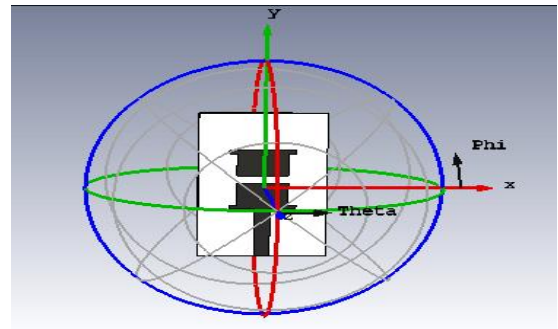


Figure 12: Simulation of proposed antenna OFF state

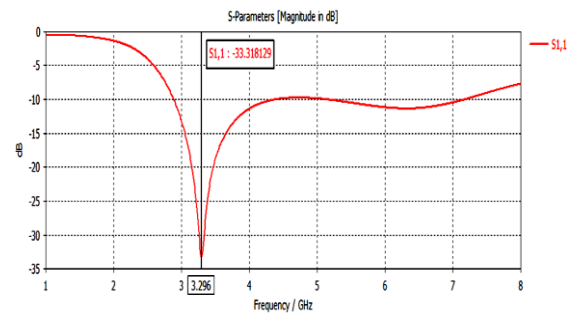


Figure 13: S11 or Return loss

In figure 13, showing return loss for band-I in OFF state. Return loss is -33.31 which resonant frequency is 3.296GHz.

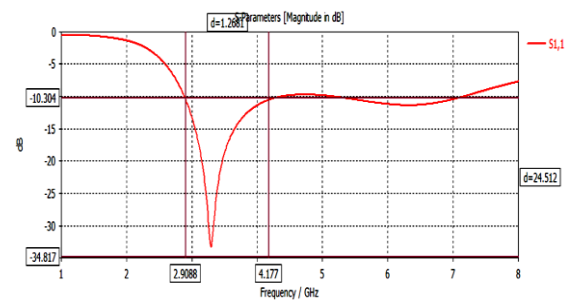


Figure 14: Bandwidth

In figure 14, showing bandwidth for band-I in OFF state. Bandwidth is 1268MHz (4.177GHz-2.9088GHz).

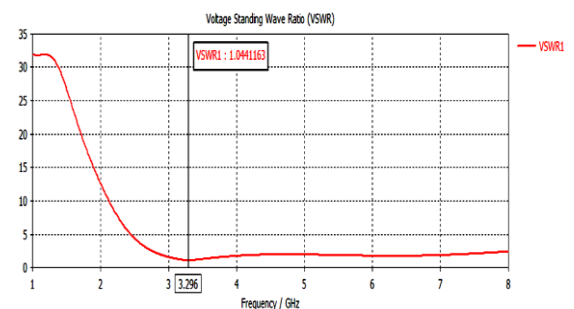


Figure 15: Voltage standing wave ratio

In figure 15, showing VSWR for band-I in ON state. Value of VSWR is 1.044 at resonant frequency.

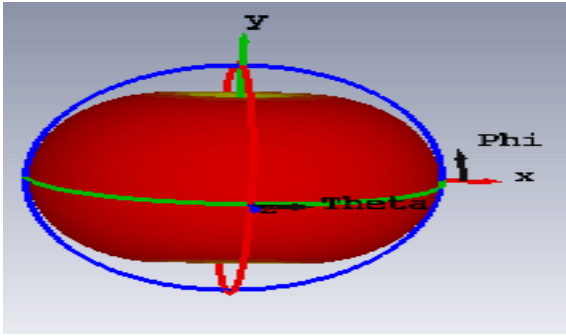


Figure 16: Radiation Pattern

B. Ijaz proposed antenna resonates at center frequency of 2.4 GHz and 4.25 GHz when RF PIN diodes are switched OFF. However, RF PIN diodes ON state resulted in 1.84 and 3.66 GHz frequency bands. The 1.84 and 2.45 GHz bands are controlled by altering the electrical length of inverted L-shaped resonator. Whereas, C-shaped radiator is used to resonate the proposed antenna at 3.66 GHz and 4.56 GHz frequency bands. Overall, the simulation and measurement results showed a good agreement.

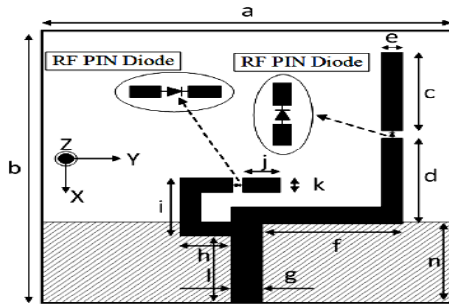


Figure 17: Antenna design[1]

Table 2: Result summary of Designed Antenna

Sr. No.	Parameter	Value(ON)		Value(OFF)
1	S11 or Return Loss (dB)	-17.94	-24.68	-33.31
2	Band Width (MHz)	539	1292	1268
3	VSWR	1.29	1.12	1.044
4	Resonant Frequency(GHz)	2.457	5.907	3.296
5	Power stimulated.	0.5 W	0.5 W	0.5 W

Table 2 is showing the simulation results in CST. In which return loss, VSWR, resonant frequency, bandwidth and total power simulated are showing.

Table –3: Comparison of previous and proposed design

Sr No	Parameter	Previous Design				Proposed Design		
		ON		OFF		ON		OFF
	Band	I	II	I	II	I	II	I
1	S11 or Return loss (dB)	-17	-26	-27	-27	-17.94	-24.68	-33.31

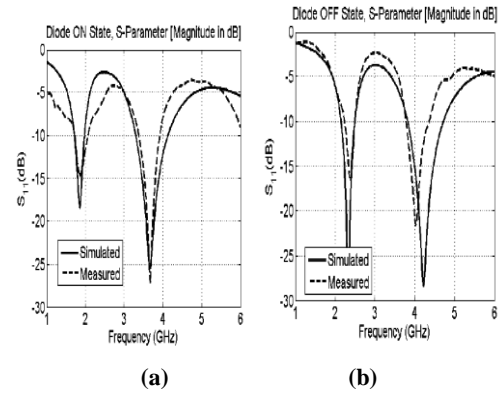


Figure 18: Simulated result (a) ON state (b) OFF state [1]

Table 1: Design parameters for Designed antenna

Sr. No.	Parameter	Values
1	Frequency(f_r)	1-8 GHz
2	Dielectric constant(ϵ_r)	4.4 / FR4
3	Substrate Height(h)	1.6 mm
4	Line Impedance	50 Ω
5	Plane	39mm \times 25mm \times 1.6mm
6	Tangent Loss	0.06

2	Resonant Frequency (GHz)	1.84	3.66	2.4	4.25	2.457	5.907	3.296	
3	Bandwidth (MHz)	275	550	200	625	539	1292	1268	
4	VSWR	1.2	1.12	1.22	1.15	1.29	1.12	1.044	
5	Dimension	47 mm x40 mm x 1.6mm				39mm × 25mm × 1.6mm			
6	Application	Wireless C band, WLAN, Wi-Fi				Wireless C band, WLAN, Wi-Fi			

Table 3 is showing comparison of proposed and previous design in terms of return loss, resonant frequency

5. CONCLUSION

Different reconfigurable antennas are used in various wireless applications such as cognitive radio, space, satellite communication and mobile radio etc. Proposed antenna give better results in term of bandwidth, return loss. It is achieved 2 times more than bandwidth with min return loss then previous results. Maximum bandwidth achievement is 1292MHz in ON state and 1268 in OFF state with 5.907GHz and 3.296GHz respectively. Therefore all frequency range lies in C band and upper band so proposed antenna will be More useful in wireless, WLAN communication with frequency reconfiguration functions.

6. REFERENCES

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