International Journal of Academic Research and Development
ISSN: 2455-4197
Impact Factor: RJIF 5.22
www.academicsjournal.com
Volume 3; Special Issue 2; March 2018; Page No. 21-24

Design and analysis of frequency reconfigurable Microstrip patch antenna

Sanket Kalamkar[1], VP Bhope[2]
[1] Department of Electronics and Telecommunication Engineering, GH. Raisoni college of Engineering and Management, Ahmednagar, Maharashtra, India
[2] Professor, Savitribai Phule Pune University, Pune, Maharashtra, India

Abstract
A reconfigurable antenna is type of an antenna capable of modifying its frequency and radiation properties in a controlled manner. In order to provide a dynamical response, reconfigurable antennas integrate an inner mechanism (such as RF switches, varactors, mechanical actuators or tunable materials) that enable the intentional redistribution of the RF currents over the antenna surface and produce reversible modifications over its properties. Reconfigurable antennas differ from smart antennas because the reconfiguration mechanism lies inside the antenna rather than in an external beamforming network. The reconfiguration capability of reconfigurable antennas is used to maximize the antenna performance in a changing scenario or to satisfy changing operating requirements. In the proposed design a rectangular patch antenna with inverted 'U' shaped slot at the center frequency 9.5 GHz that can be reconfigured in the frequency range of 5.3- 5.7 GHz. PIN diodes are used for carrying out reconfiguration. The antenna is designed on FR4 substrate (εr= 4.4) of thickness (H) 0.8 mm. The proposed structure was simulated by using the High Frequency Structure Software (HFSS) ver 15.0. The simulated and experimentally measured return loss for different configuration are less than -10dB at resonance frequencies. The simulated results show the close agreement with proposed design.

Keywords: antenna, frequency reconfiguration, Microstrip patch, pin diode

1. Introduction

Reconfigurability when used in terms of antennas, is the capacity to change an individual radiator's fundamental operating characteristics through electrical, mechanical, or other means. Thus, under this definition, the traditional phasing of signals between elements in an array to achieve beam forming and beam steering does not make the antenna "reconfigurable" because the antenna's basic operating characteristics remain unchanged in this case. Ideally, reconfigurable antennas should be able to alter their operating frequencies, impedance bandwidths, polarizations, and radiation patterns independently to accommodate changing operating requirements. Reconfigurable microstrip antennas have the potential to add substantial degrees of freedom and functionality to mobile communication applications and electronic intelligence. This is achieved mainly by electronically reconfiguring the antenna parameters like radiation pattern, polarization or resonant frequency. In pattern reconfigurable microstrip antennas, operating frequency and bandwidth is maintained while changing radiation patterns. Manipulation of an antenna radiation pattern can be used to avoid noise sources or intentional jamming, improve security by directing Signals only towards intended users and serves as a switched diversity system. Polarization reconfigurable microstrip antennas are utilized mainly in frequency reuse for doubling the system capability in satellite communication systems. In this paper a frequency reconfigurable antenna will be discussed which will work in X band and C band.

2. Design of Antenna

An antenna with frequency reconfiguration is designed in the HFSS simulation software. Both Rectangular and U shaped patch element are designed using FR4 (εr=4.4) as a substrate while the height of the substrate is kept at 0.8 mm. The dimensions (Width x Length) of the microstrip patch elements were calculated at the center frequency of 9.57 GHz (rectangular) and 5.6 GHz (inverted U shaped patch by conventional design procedure based on transmission line theory of rectangular patch is given in [1]. The design of patch is simulated on High Frequency Structure Software (HFSS) ver 15.0. The below figure shows the design of an antenna in the HFSS

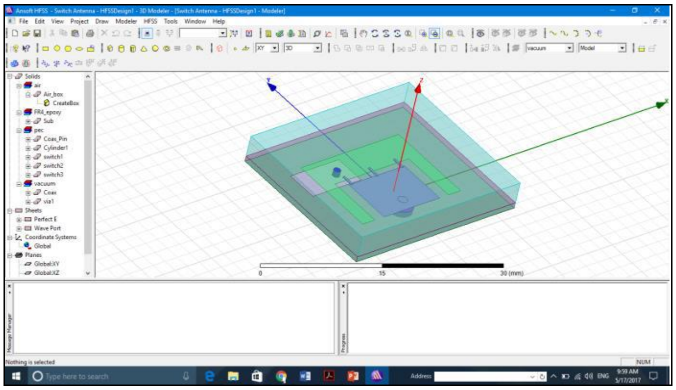


Fig 1: Simulation of antenna

Dimensions of Reconfigurable Antenna

Table 1

Parameters	Patch (9.57 GHz)	Patch (5.6 GHz)
Patch Dimensions		
Width	9.5 mm	16.3 mm
Length	7.2 mm	12.57 mm
Substrate / Ground Plane (Based on bigger patch)		
Width	25.9 mm	
Length	22.17 mm	
Height	0.8 mm	
Coaxial Feed		
Inner Radius	1.3 mm (from datasheet)	
Outer Radius	2.2 mm (from datasheet)	
Input impedance, Z_{in}	1283 Ω	
Edge impedance, Z_0	253 Ω	
Location along W, X_f	4.6 (from left edge of 9.57 GHz Patch)	
Location along L, Y_f	1.7 (from center of 9.57 GHz Patch)	

3. Frequency Reconfiguration

The designed antenna is capable of switching its frequency of operation among two frequencies viz. 9.57GHz (X band) and 5.6GHz (C band) to achieve these two different patch are make and break electrically to each other by using PIN diode, Three pin diodes (SMP1320-079 from Skyworks) are used here to achieve this reconfiguration. Figure 2 shows the how pin diodes are connected to patch antenna

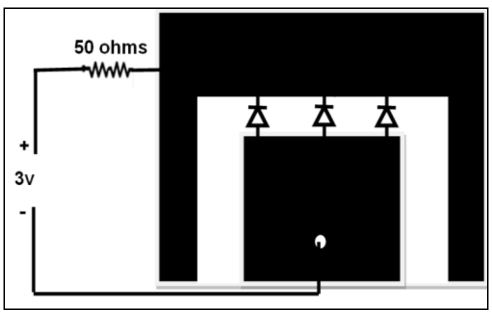
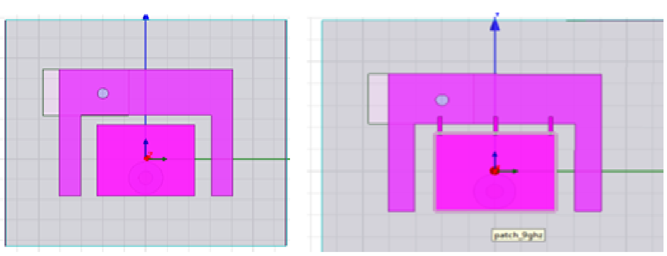


Fig 2: Switching Mechanism of reconfigurable antenna

4. Simulated Results

The antenna design has been simulated and the results are obtained for the same. The simulated return loss plots for two cases viz. when switches are ON state and switches are OFF state. The figure 3 shows the antenna with and without switches. The simulated return loss curve for all switches OFF condition shows resonant frequency at 9.57 GHz with -40 dB return loss and for all switches ON condition shows resonant frequency at 5.6 GHz with -30 dB return loss.



(a) Antenna without Switches (b) Antenna without Switches

Fig 3

Return loss of the antenna in both cases is plotted below in figure 4 and 5.Where the return loss for the 'switch OFF' condition shows around -40dB at frequency of the 9.57 GHz and for switch ON condition antenna gives the return loss of the -30dB at frequency of the 5.6 GHz.

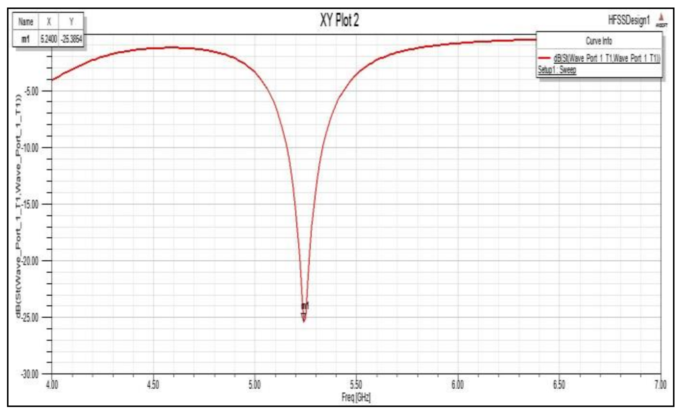


Fig 4: Simulated Return Loss when switch is OFF

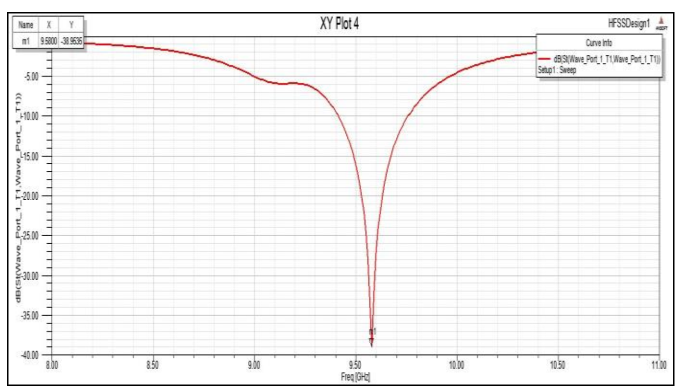


Fig 5: Simulated Return Loss when switch is ON

5. Measured Results

The antenna designed in HFSS is then fabricated on PCB of dielectric material FR4, the switches i.e. PIN diodes are soldered at appropriate places to form switching mechanism PIN diodes are biased with regulated power supply.

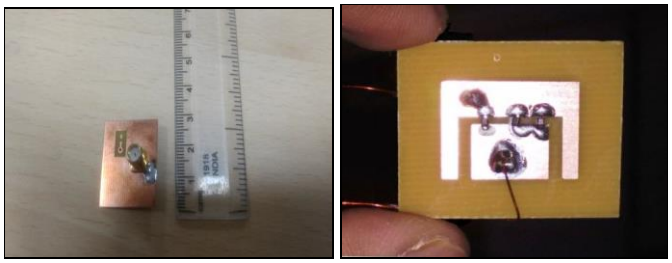


Fig 6: Fabricated antenna

Fabricated PIN diodes are powered with a DC power supply and at the same time there return loss is measured on VNA the measurement setup is shown below figure 7.

Fig 7: Antenna return loss measurement w. r. to voltage setup

Antenna with the PIN diodes is analyzed with FieldFox network analyzer (N9916A) Keysight make. Measured return losses for both frequencies are given in figure 8 and 9.

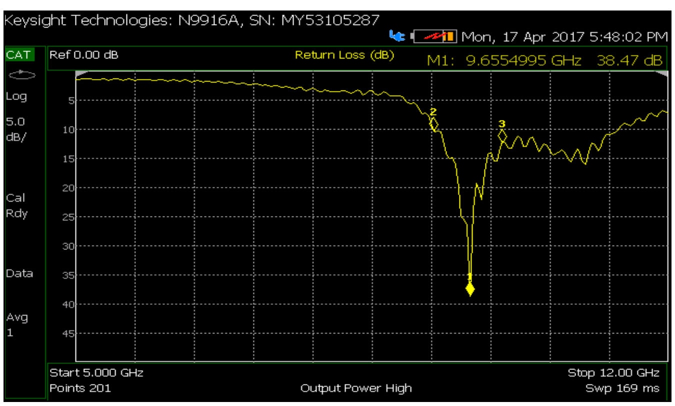


Fig 8: Measured Return Loss when switch is OFF

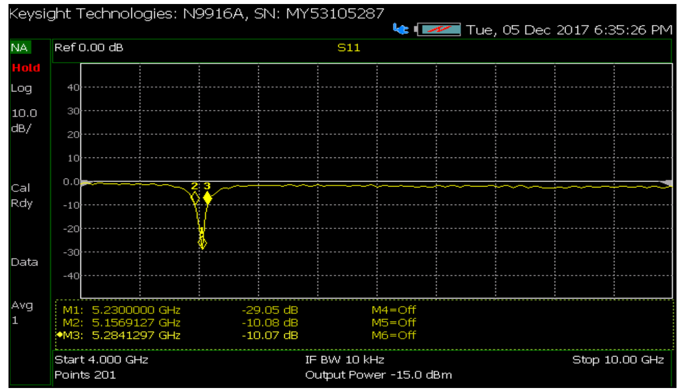


Fig 9: Measured Return Loss when switch is OFF

An antenna behavior with respect to PIN diode biasing voltages is also observed and plotted in figure 10.

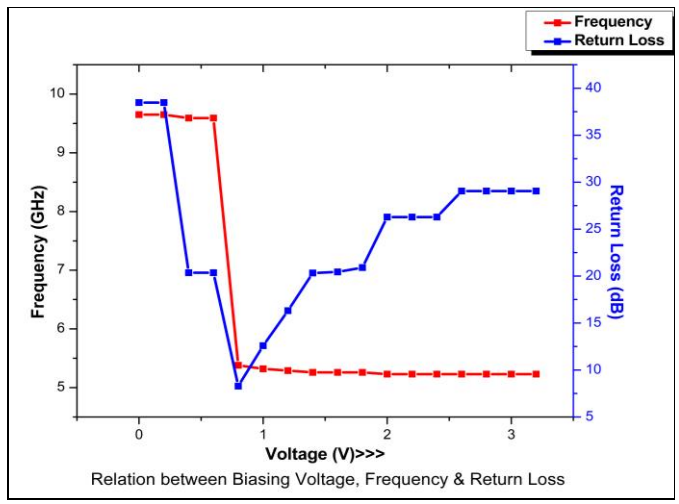


Fig 10: Return loss w. r. to Voltage

Simulated results are shown in figure 4 and figure 5 and the measured results are shown in the figure 8 and 9. Measured results are fairly matching to the simulated results, simulated design shows the return loss of -38.95dB at 9.58GHz, when switches are in OFF condition; while simulated return loss of -30dB at 5.65GHz when switches are in OFF. The measured results are as at switch OFF condition return loss is -38.47dB at frequency of 9.65GHz and return loss of -29dB at frequency of 5.23GHz when switches are in ON condition.

A comparative result summary of the both cases is shown in table 2

Table 2: Comparative Summary

Parameters	All Switches OFF		All Switches ON	
	Simulated	Measured	Simulated	Measured
Resonant Frequency (GHz)	9.58	9.65	5.65	5.23
Return Loss at Resonant Frequency	- 38.95 dB	- 38.47 dB	- 30 dB	- 29.05 dB
Lower -10 dB Frequency (GHz)	9.40	9.23	5.50	5.15
Upper -10 dB Frequency (GHz)	9.74	10.1	7.73	5.28
Bandwidth (MHz)	340	87	230	13

6. Conclusions

Few conditions can be taken into the considerations to riposte the slightly change in the frequency

- Shift in the result of few MHz is (20-40MHz approx.) is found in the measured results this can be due to fabrication as the fabrication in such accurate fashion is difficult to achieve.

- Location of the PIN diode as per design is not easy to locate and the manual soldering of PIN diode may also cause some loss.
- Parasitic elements in PIN diode also limits the switching capabilities of diode.

8. References

1. Balanis CA. Antenna Theory analysis and Design‖, John Wiley & Sons, New York, 1997.
2. Anamiya Bhattacharya, Rajeev, Jyoti. Frequency Reconfigurable Patch Antenna Using PIN Diode at X-Band IEEE 2nd International Conference on Recent Trends in Information Systems (ReTIS), 2015.
3. Yahya SH, Khraisat, Ahmad HN. Qubaia. Reconfigurable Antenna Design Progress in Electromagnetics Research Symposium Proceedings.
4. Jothi Chitra R, Nagarajan V. Frequency Reconfigurable Antenna Using PIN Diodes. 2014, 978-1-4799-2361-8/14/$31.00 ©2014 IEEE
5. Merrin P, Saravanan V. (17th & 18th March) Design of Reconfigurable Monopole Antenna using Pin Diodes for Implants 2nd IEEE International Conference on Engineering and Technology (ICETECH), Coimbatore, 2016.
6. Ramesh Garg P, Bhartia I, Bhal J, Ittipiboon A. Microstrip antenna Design handbook, Artech house, 2001.