Design and Simulation of Reconfigurable Monopolar Antenna for Wi-Fi Application

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Abstract— A concept of reconfigurable monopolar antenna for Wi-Fi applications are introduced in this paper. The design utilizes circular patch for lower band. Normally, long rectangular patch antennas with compact structure and high gain have been used, but recently the antennas with circular patch are preferred and are excited with dominant mode and are integrated with a monopole antenna. Two PIN diodes are placed on the left and right side of the patch results in wide variety of RF switch topologies. Based on the switching state of PIN diode, antenna is capable of operating at different modes. By adjusting the feed position it is easy to obtain input matching. It offers 8% of higher bandwidth. Measurement results show that the reconfigurable monopolar antenna achieves frequency for lower band 2.4GHz. . In addition, the antenna yields narrow bandwidth with minimum variation in gain, hence used for 4G and 5G technologies.

Keywords – Patch **antenna, Monopolar antenna, WI-FI, PIN diode, Reconfigurable antenna, HFSS.**

I. INTRODUCTION

Mobile communication has become an important part of our daily life. Due to rapid growth of technology, the requirement of an antenna with less height for mobile phones contributes a huge challenge [1] – [2]. Antenna plays a vital role in many devices for the purpose of point to point communication with increased gain and reduced wave interference [3]. One of the most growing technologies is considered to be wireless technology. This wireless technology uses radio waves for transmitting information without wires and cables. Nowadays, many of the systems operates in two or more frequency bands that may requires dual- or triple-band operation of fundamentally narrowband [4] - [5] that places a great demands on designs of an antenna. A proposed concept explains the designing of a reconfigurable monopolar antenna for low band frequency of Wi-Fi.

In mobile phones it is possible to have two Wi-Fi antennas, one for 2.4GHz and one for 5GHz band, although this is less common. As it has the highest frequency on mobile devices, the Wi-Fi antenna will be the smallest antenna. Monopole antennas are widely used in wireless communication system, since they can provide omnidirectional radiation patterns [6][7] with better efficiency.

Monopole antennas are half the size of their dipole counterparts, and hence are attractive when smaller antenna is needed [8]. It can handle communication in any direction except straight up above to antenna which results in poor radiation. In order to overcome this drawback, bandwidth enhancement should be done with the help of reconfigurable antenna.

With effectively increasing the system capacity and linking quality a reconfigurable antenna [7] – [9] can change its radiating characteristics dynamically. Mostly, reconfigurable antennas were developed for wireless technologies [10] - [14]. When compared to broadband antennas, reconfigurable antenna offers many advantages, such as compact size, similar radiation patterns for all designed frequency bands, and frequency selectivity [15]. This paper explains the designing of reconfigurable monopolar antenna for Wi-Fi applications with the lower band frequency of 2.4GHz.

II. DEVELOPMENT

The antenna parameters are simulated using the ANSYS HFSS simulator. HFSS stands for **High Frequency Structure Simulator.** It is one of the several commercial tools used for antenna design and the design of complex RF electronic circuit elements including filters, transmission lines and packaging. HFSS is the full wave 3D electromagnetic high frequency structure simulator. It is based on frequency domain FEM (Finite Element Method) simulation technology. HFSS integrates solid modeling simulation and visualization in common environment. It divides complete structure in tetrahedral mesh then boundary conditions are applied Maxwell's equations inside the structure is solved using finite element method.

III. SIMULATION SETUP OF ANTENNA CONFIGURATION

Here Figure 1 shows the antenna configuration that was constructed with a grounded substrate. Circular Patch is a low profile antenna that is light weight and inexpensive is placed on the substrate. The ground plane should extend beyond the edges of the patch by atleast 2 to 3 times the board of thickness for proper operation.

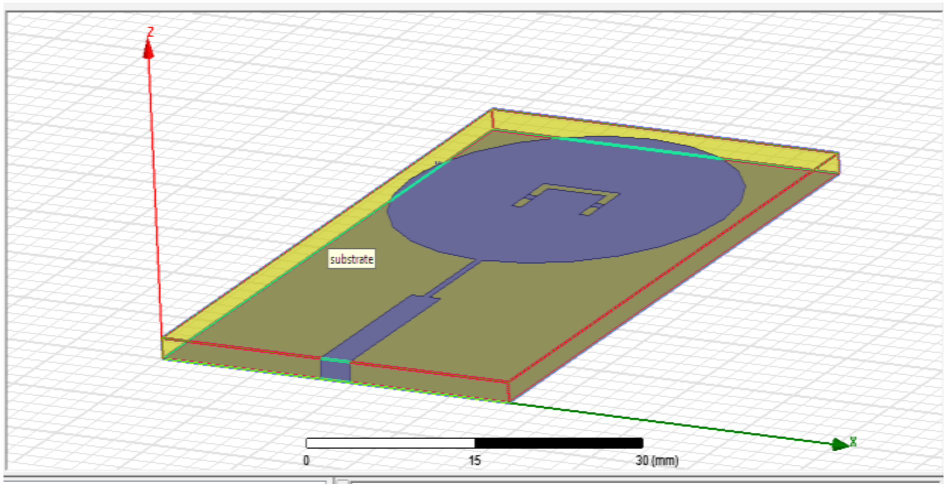

Figure 1. Both PIN Diodes are in ON state

If a ground plane is too small that will result in a reduced front to back ratio. Making the ground plane larger increase the gain and efficiency. Two PIN diodes are placed on the patch which acts as a switch that performs ON and OFF operation.

The Figure 1 contains the ground plane, patch, and substrate and the feedline is connected to patch. The line feed is one of the most common techniques used for feeding microstrip patch antenna. In this type of feeding technique, a conducting strip is connected directly to the edge of circular patch. The conducting strip is smaller in width as compared to patch. Hence this is an easy feeding technique, since it provides ease of fabrication and simplicity in modeling as well as impedance matching.

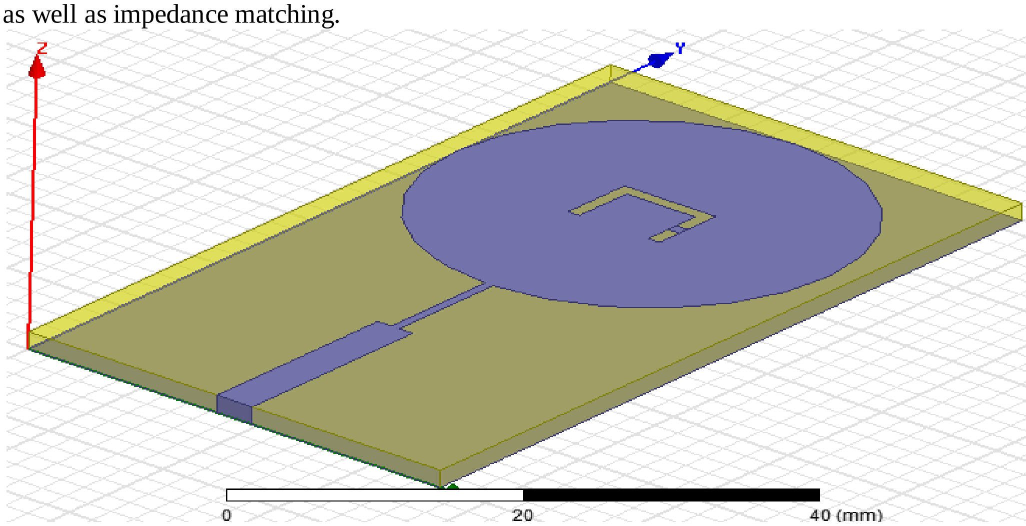

Figure 2. Right PIN Diode Switch Is In ON State

This type of feeding technique results in undesirable cross polarization effects. Figure 2 and Figure 3 illustrates the design configurations where PIN diode on the right in ON state in Figure 2 and PIN diode on the left side is in ON state in Figure 3 Feed line is a transmission line that connects antenna with transmitter and receiver particularly with transmitting antenna, the feed line is critical component and that must be adjusted to work correctly with the antenna and transmitter.

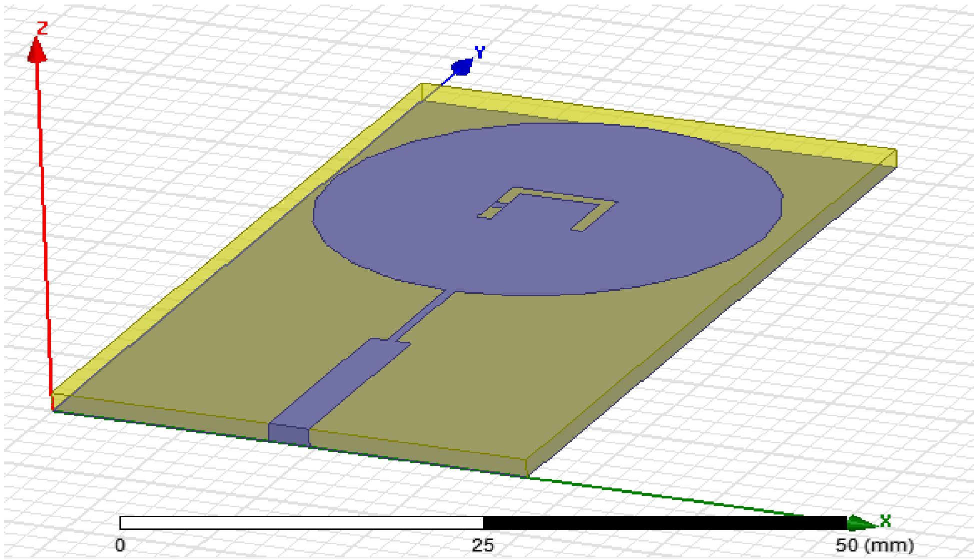

Figure 3. Left PIN Diode Switch Is In ON State

Figure 1 and Figure 4 indicates both PIN diode in ON state and OFF state respectively.

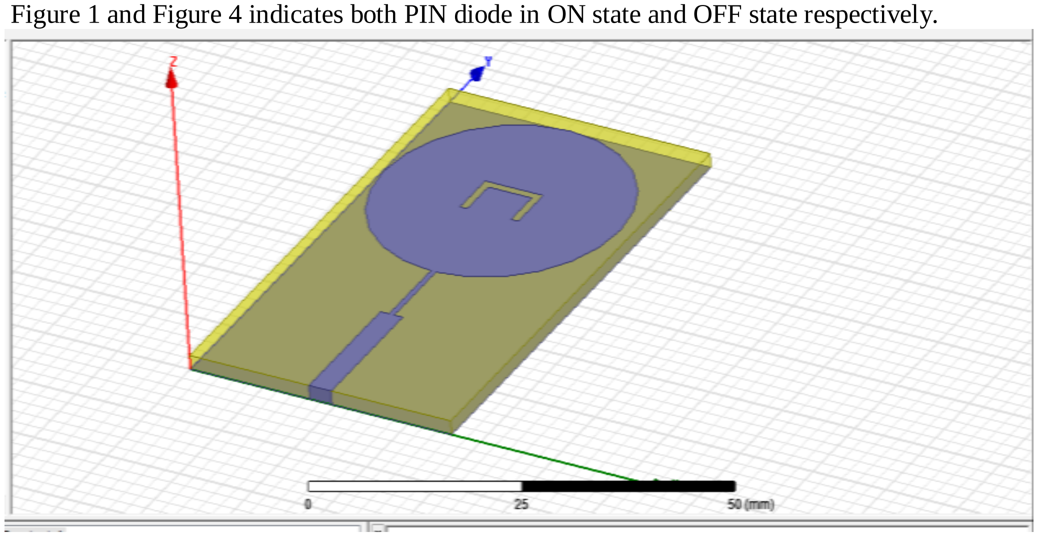

Figure 4. Both PIN Diodes are in OFF State

IV. VALIDATION AND RESULTS

Figure 5 shows that XY Plot output for left and right PIN diodes are in ON state. It gives the results in peak point which denotes the narrow bandwidth and gives the accurate frequency value. We obtain a very low return loss of -28.0812dB at a bandwidth of 85MHz.

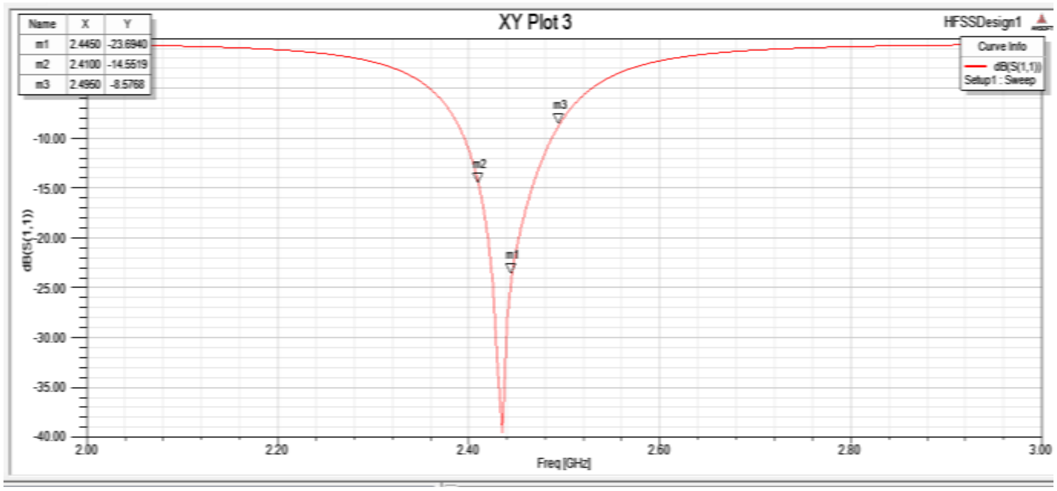

Figure 5. XY Plot for Both PIN Diodes are ON State

Return loss = -28.0812dB
Bandwidth = (2.4950-2.4100) GHz = 85MHz
Figure 6 shows that XY Plot output for right PIN diode is ON state. It gives the results in peak point which denotes the narrow bandwidth and gives the accurate frequency value. We obtain a very low return loss of -27.5148dB at a bandwidth of 90MHz.

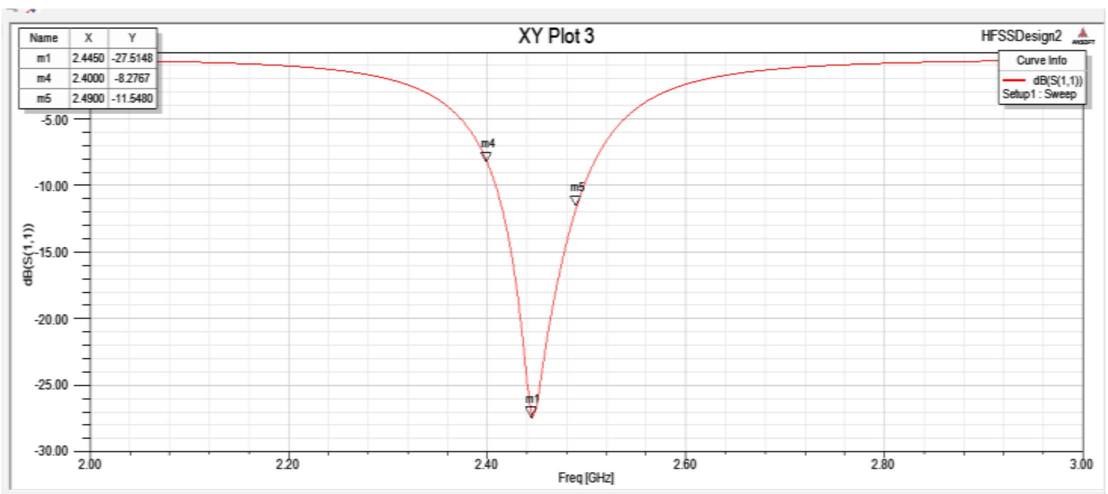

Figure 6. XY Plot for Right PIN Diode ON State

Return Loss = -27.5148 dB
Bandwidth = (2.4900 - 2.4000) GHz = 90MHz

Figure 7 shows that XY Plot output for left PIN diode is ON state. It gives the results in peak point which denotes the narrow bandwidth and gives the accurate frequency value. We obtain a very low return loss of -18.0635dB at a bandwidth of 60MHz.

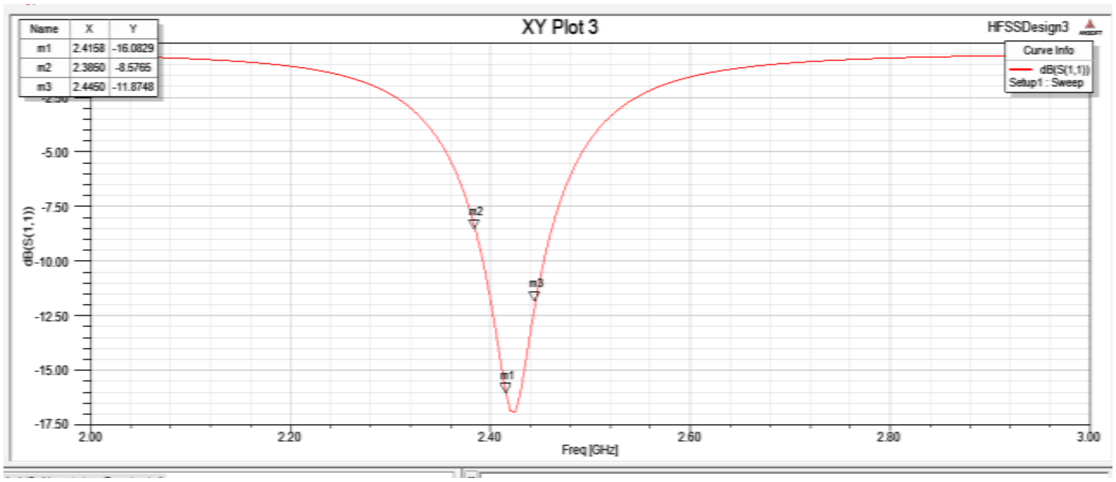

Figure 7. XY Plot for Left PIN Diode ON State

Return loss = -18.0635dB
Bandwidth = (2.4450-2.3850)GHz = 60MHz

Figure 8 shows that XY Plot output for left and right PIN diodes are OFF state. It gives the results in peak point which denotes the narrow bandwidth and gives the accurate frequency value. We obtain a very low return loss of -14.6333dB at a bandwidth of 60MHz .

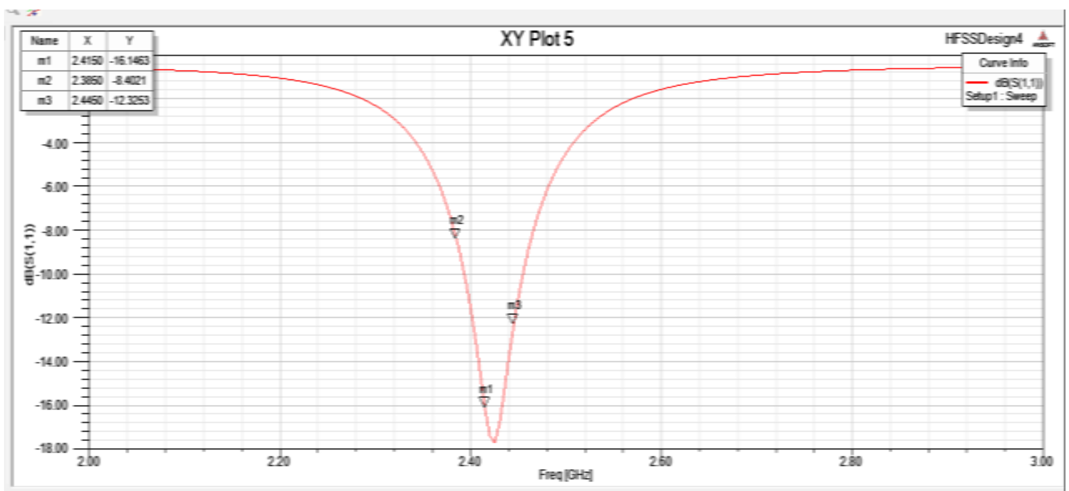

Figure 8. XY Plot for Both Diodes are OFF State

Return Loss = -14.6333 dB
Bandwidth = (2.4450 – 2.3850) GHz = 60MHz

The directivity and gain of an antenna are important measure of its performance as a transmitting system. The maximum gain results up to 2dB. When bandwidth and gain is taken into consideration, it clearly shows that the property of narrow bandwidth.

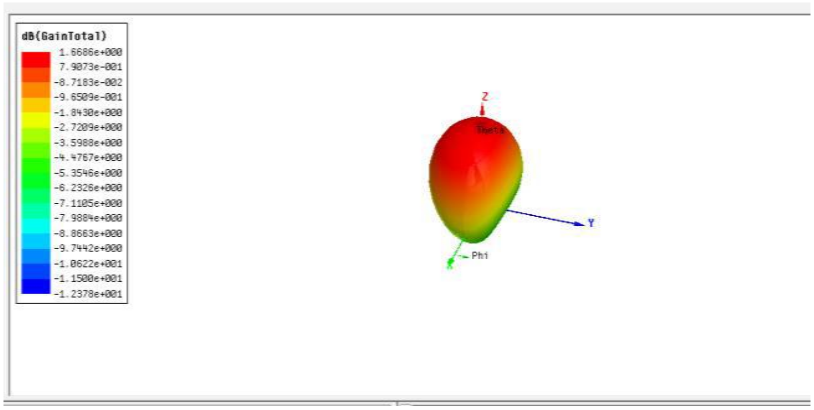

Figure 9. 3D Polar plot for Both PIN Diodes are ON State

Gain = 1.6686dB
The left and right PIN Diodes are yield 1.6686dB in ON state which offers narrow bandwidth due to decrease in gain.

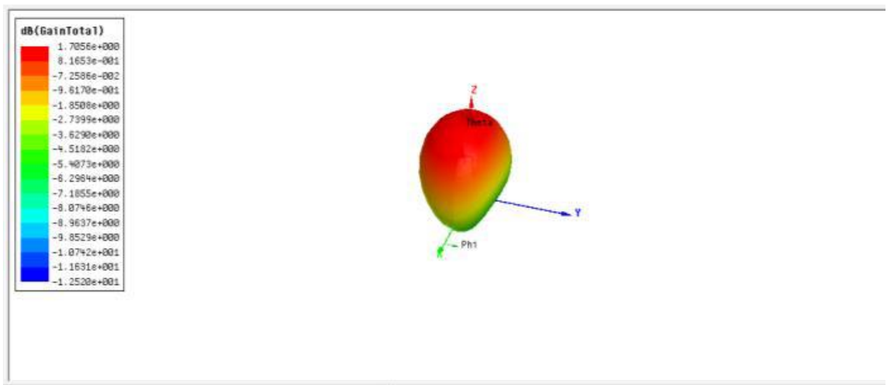

Figure 10. 3D Polar Plot for Right PIN Diode ON State

Gain = 1.7056dB
The right PIN Diode yield 1.7056dB in ON state which offers narrow bandwidth due to decrease in gain.

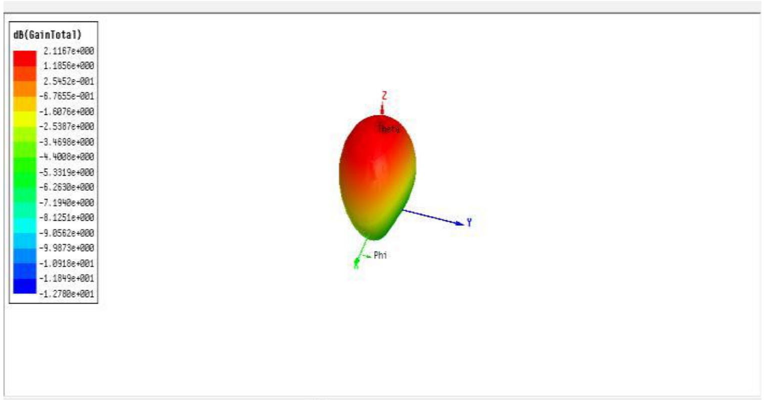

Figure 11. 3D Polar Plot for Left PIN Diode ON State

Gain = 2.1032dB
The left PIN Diode yield 2.1032dB in ON state which offers narrow bandwidth due to decrease in gain.

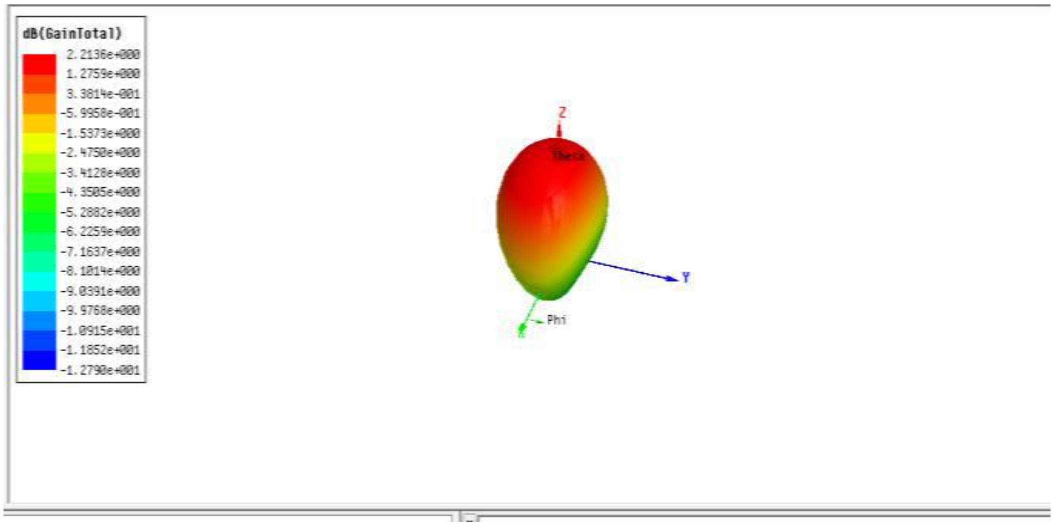

Figure 12. 3D Polar Plot for Both PIN Diodes are OFF State

Gain = 2.1224dB

The left and right PIN Diodes are yield 2.1224dB in OFF state which offers narrow bandwidth due to decrease in gain.

Impedance matching is the practice of designing the input impedance of electrical load or the output impedance of its corresponding signal source to maximize the power transfer or minimize signal reflection from load. As this impedance matching is done using smith chart.

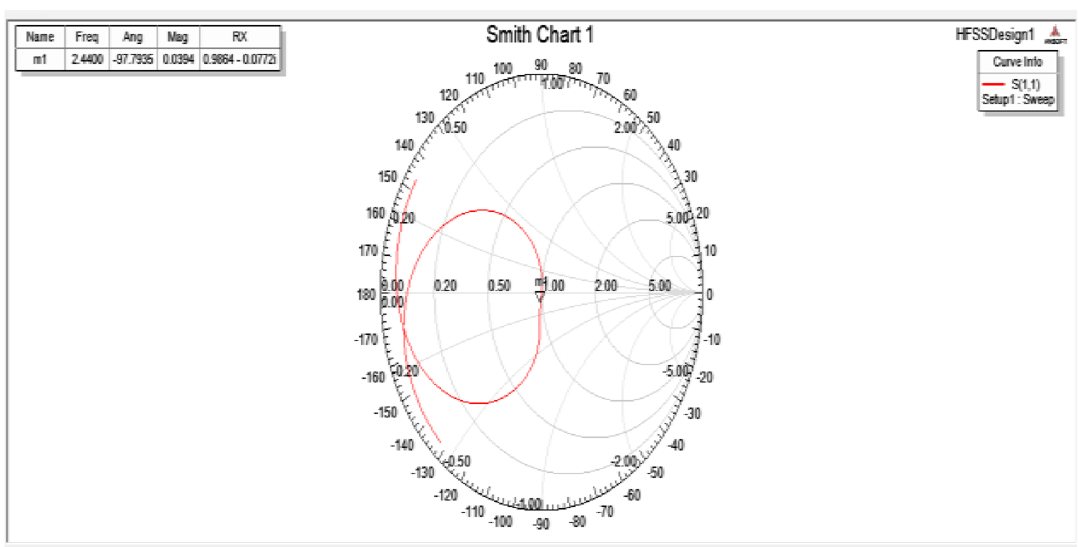

Figure 13. Smith Chart for Both PIN Diodes are ON State

Impedance Matching = 0.9864 * 50 = 49.32 Ω

Using smith chart, we are analyzing whether impedance is perfectly matched are not. In the result, if the impedance value is nearly equal to 50ohm after multiplying the factor 50 with the impedance value, then the impedance is perfectly matched.

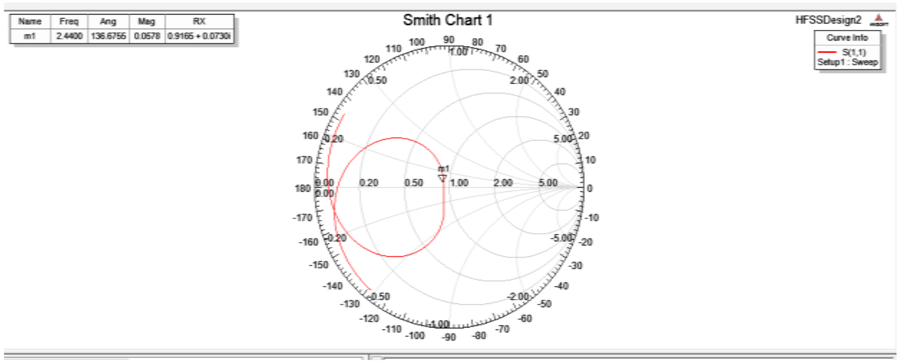

Figure 14. Smith Chart for Right PIN Diode ON state

Impedance Matching = 0.9165 * 50 = 45.825 Ω

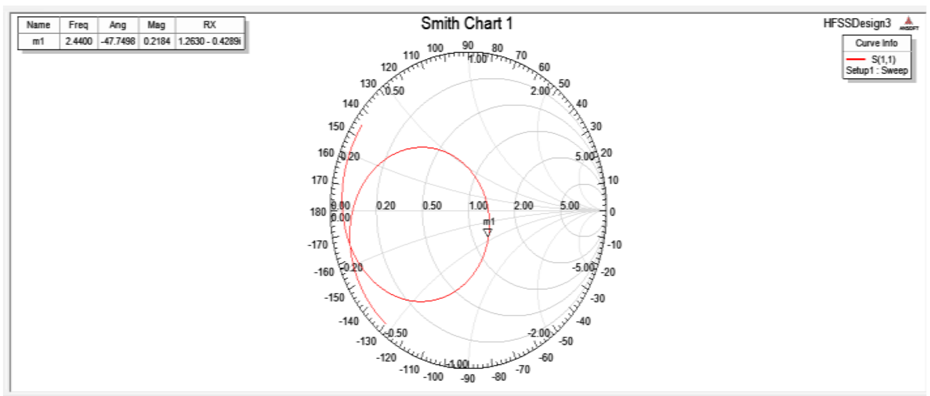

Figure 15. Smith Chart for Left PIN Diode ON state

Impedance Matching = 1.1088 * 50 = 55.44 Ω

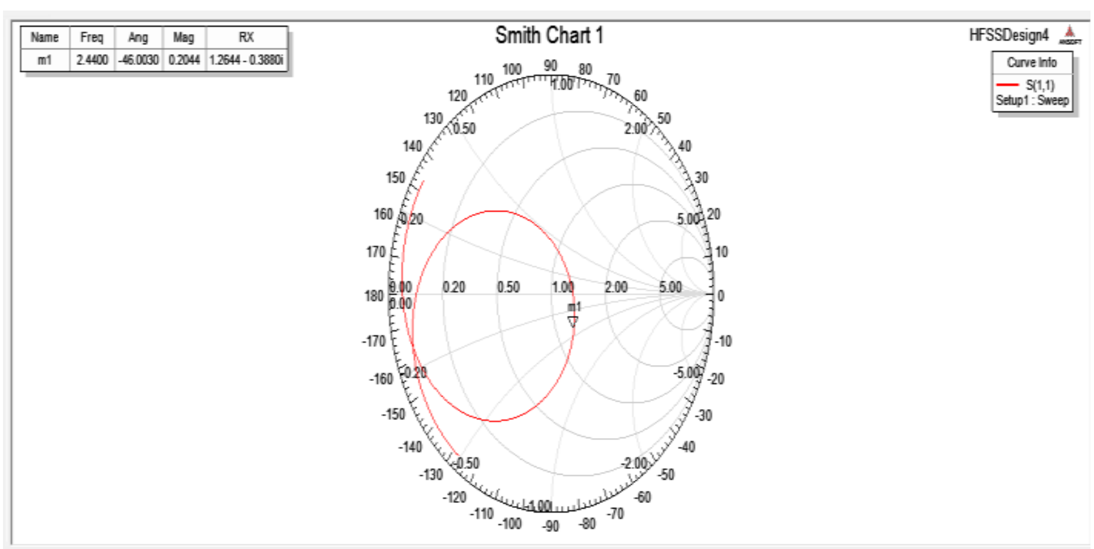

Figure 16. Smith Chart for Both PIN Diodes are OFF state

Impedance Matching = 1.2939 * 50 = 64.695 Ω

A **radiation pattern** defines the variation of the power radiated by an antenna as a function of the direction away from the antenna. Figure 17 shows the radiation pattern plotted graphically.

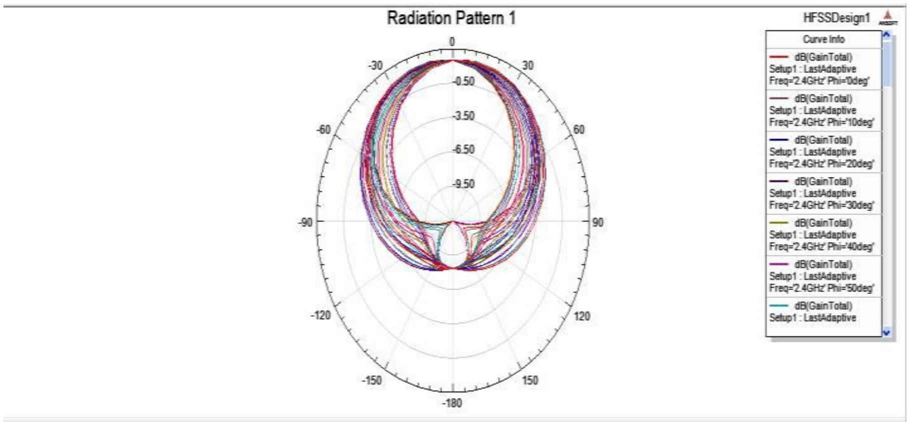

Figure 17. Radiation Pattern for Both PIN Diodes are ON state

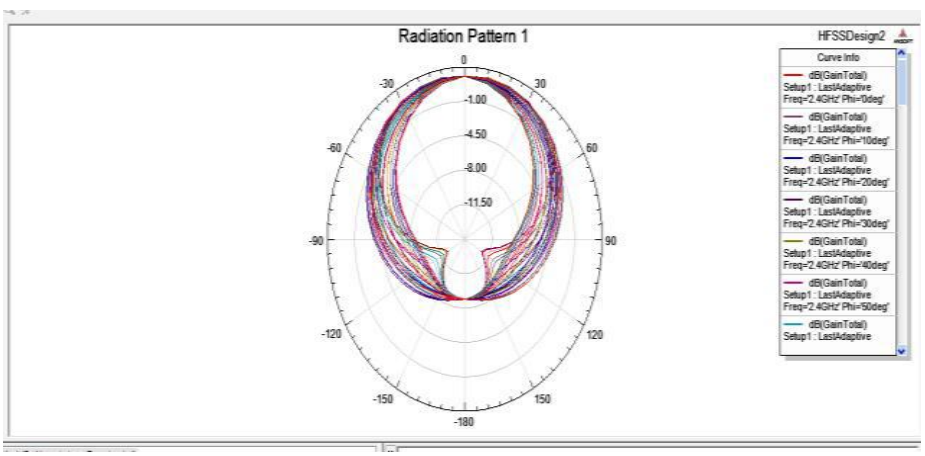

Figure 18. Radiation Pattern for Right PIN Diode ON state

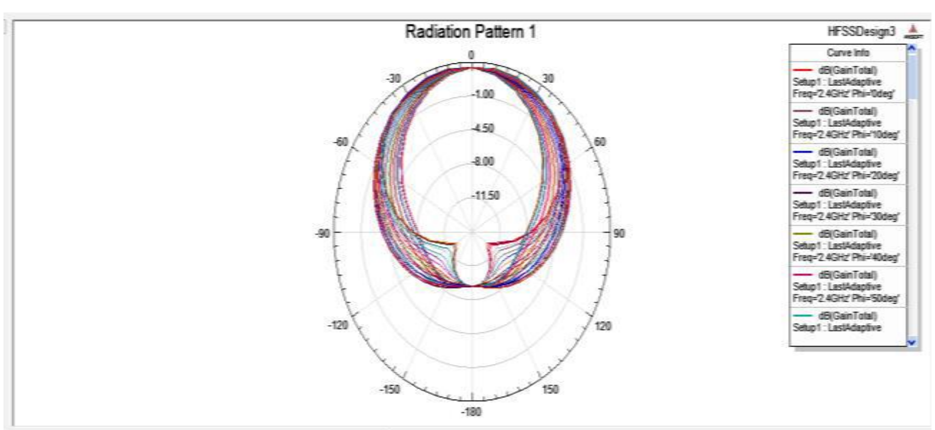

Figure 19. Radiation Pattern for Left PIN Diode ON

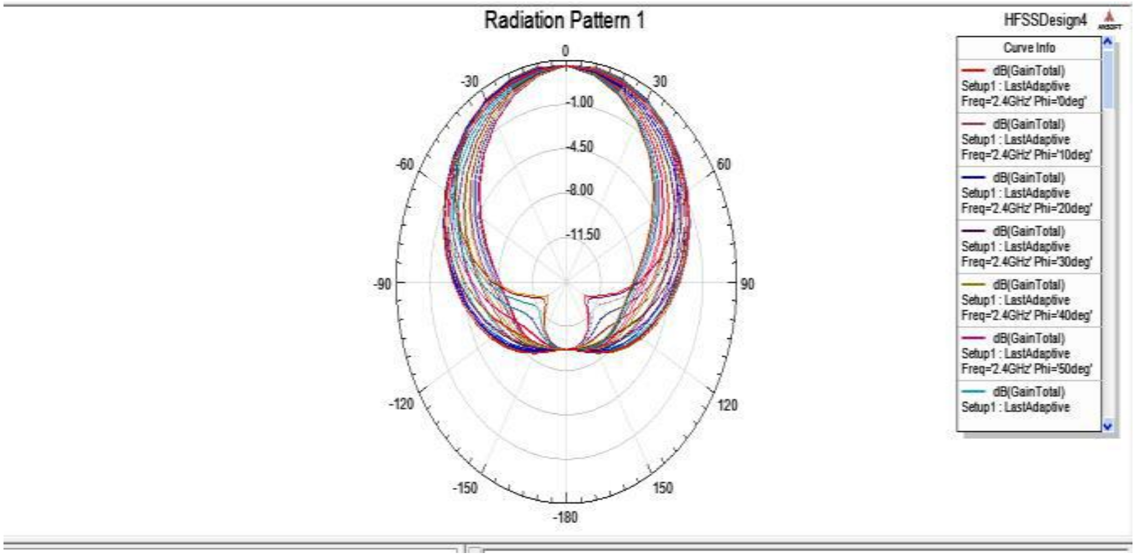

Figure 20. Radiation Pattern for Both PIN Diodes are OFF state

PIN Diode state	Return loss (dB)	Gain (dB)	Impedance matching (Ω)	Bandwidth (MHz)
Both are ON	-28.0812	1.6686	49.32	85
Right ON Left OFF	-27.5148	1.7056	45.825	90
Right OFF Left ON	-18.0635	2.1032	55.44	60
Both are OFF	-14.6333	2.1224	64.695	60

Table 1. Comparison with antenna parameters

V. CONCLUSION

Finally the concept of reconfigurable monopolar antenna for Wi-Fi has been demonstrated. The resonant frequency is determined at the lower band by using reconfigurable monopolar antenna for ON and OFF process two PN diodes are used that acts as a switch which are placed right and left side of circular patch. The proposed method is designed for the lower frequency of Wi-Fi at 2.4GHz. The comparison of antenna parameters has been illustrated. Next the future process will be continued in fabricating for lower band of Wi-Fi.

VI. REFERENCES

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