Design of Novel Reconfigurable Microstrip Patch Antenna for WLAN and WIMAX Application

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Abstract*—This paper presents a design of novel reconfigurable antenna for WLAN (wireless local area network) and WIMAX applications (wireless interoperability for Microwave access). The antenna consists of arbitrary shaped patch as a radiating element and a partial ground plane as a reflector. The frequency reconfiguration is carried out in this design using a PIN diode as a switch. The proposed antenna resonates at 5.8 GHz and 3.5 GHz under ON and OFF state of PIN diode respectively. The simulated -10 dB return loss under ON and OFF condition is observed as -27dB and -22 dB respectively. The simulated Gain is 5 dB for both the ON and OFF states. The antenna design is simulated using the ANSYS HFSS simulator. The design has a high gain and favorable radiation characteristics in the operating range which is required for WLAN and WIMAX requirements.

Keywords Microstrip patch, PIN diode, Reconfigurability, WLAN and WIMAX applications

I. INTRODUCTION

Antenna is a part of transmitting and receiving device designed to radiate electromagnetic wave and receive them back.so designing of an antenna plays an important in the communication systems. In this paper, instead of using multiple single antennas each operating at a single frequency requiring more space and making the design and fabrication more complex, we can perform the above operation using a single antenna that operates at multiple frequencies using the concept of dual band and optical switch making the design simpler and intentionally reducing the size of requirement with the desired characteristics of gain, efficiency in the operating fields. Over the past few years wireless communication is widely attracted towards the reconfigurable antenna [1]. Reconfigurable patch antenna can be used in variety of application because of its ease of availability, economical and its ability to integrate with planar and non-planar technologies like microwave circuit [2]. Frequency reconfigurable antenna allows frequency hopping which means changing the frequencies in the allocated spectrum according to the channel capacity and the users, on the other hand pattern reconfigurable antennas reduces the in band interference improving channel capability. The PIN diode is used for providing such reconfigurable property is explained in [3,4]. It acts as optical switch and which during ON and OFF state allows the antenna switch to different frequencies of operation. And as mentioned above the reconfigurable antennas tune the radiation pattern and frequency separately that individuality makes the system to reduces the noise, electronic jamming and prevent unwanted use of energy. During off state it resonates at 3.5GHz whereas, when the diode is on the antenna operates at 5.8GHz.

Hence it is possible to get multiple frequency operation using the switch by varying the on and off states of PIN diode. But in most of the designs we can see that the frequency reconfiguration states are limited to few mainly due to the limitation of structure size, in addition to this using of lumped or microstrip based matches the narrowband antenna primary frequency possibly by adding an extra circuitry. In this paper we explain the design parameters and also the values that we obtained under different condition with the simulation results we achieved. The results show how the antenna changes its frequency bands.

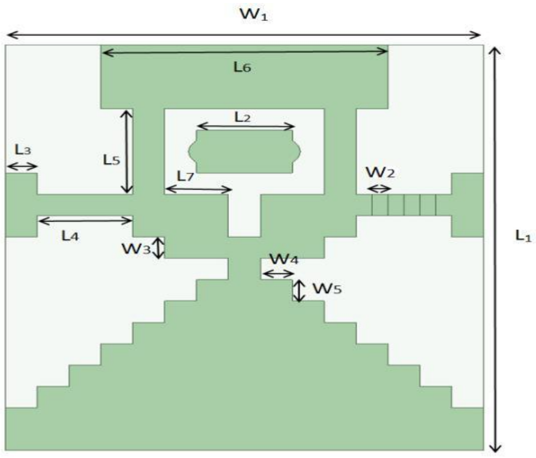
II. LITERATURE SURVEY

The literature survey here is completely based on the earlier work on the microstrip patch antenna. And the study reveals that there are many benefits of using the microstrip patch antenna includes light weight, low cost, low profile, easy to fabricate, fast integration with outside, and high portability[5]. While it is having several advantages, it also suffers from fundamental disadvantages such as small bandwidth, low gain that impact on the antenna efficiency. One of the simplest method to improve the band width is to increase the thickness of substrate but by doing so the efficiency of antenna is reduced because large amount of input power is dissipated in the resistor thereby the total available power for radiation by antenna reduces[6]. Another suitable method is to decrease the height of the structure but causes reduced impedance bandwidth. Thus, numerous other techniques suggest to have high dielectric permittivity but these are poorly chosen for antenna bandwidth. Since magnetic substrates are having wider bandwidth, magneto-dielectric substrate are most widely used for miniaturization

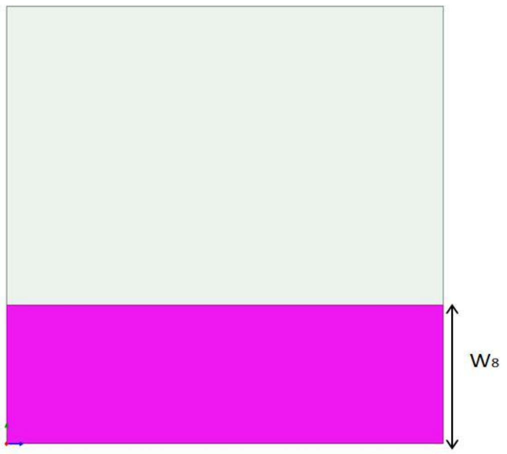
[7]. All the above specified methods and techniques are used to boost up the properties of microstrip patch antenna and however there exists a relation between gain, bandwidth and structure of microstrip antenna [8].

III. ANTENNA DESIGN

The basic design of an antenna is shown in the figure 1.The radiating patch is placed on the substrate of FR4 epoxy with permittivity value of 4.4 and with the height of 1.6mm. The partial ground plane of the antenna is placed on the other side of the substrate. The feeding is provided by a microstrip line of thickness of 2mm and with the impedance matching of 50 ohm. The PIN diode is used for the purpose of switching action and it is placed at the starting point of the patch. The value of lumped components R, L, and C are changed accordingly to operate the PIN diode in OFF and ON state. A lumped port is used for the excitation purpose and the design parameters of each box is specified explained in design methodology. The patch and microstrip line are assigned as a perfect electric conductors and the microstrip patch antenna radiates along the width of the patch because of fringing effect.



(a)



(b)

Figure 1(a) Front view of the proposed design (b) Rear view of the proposed design

Table 1. Dimensions of the proposed design

S.No	Parameters	Values (in mm)
1.	L1XW1	38X30
2.	W2	1
3.	W3	2
4.	W4	2
5.	W5	2
6.	W8	9
7.	L2	6
8.	L3	2
9.	L4	6
10.	L5	8
11.	L6	18
12.	L7	4

A. Design Methodology

The dimension of the antenna structure is 30*38*1.6mm^3. The PIN diode is designed using four conducting sheets and the sheets are assigned as lumped RLC. The two sheets on either sides are assigned with the capacitors of 1uf and theremaining two sheets are assigned with the resistor, inductor and capacitor values of ideal PIN diode with respect to ON and OFF situation. The performance of the switch as On and Off case is explained using the equivalent circuits of PIN diode. PIN Diode consists of an undoped intrinsic region in between the p-type and n-type semiconductor and acts as a variable resistance. The equivalent circuit of the ON and OFF states of PIN diode is explained using the figure 2.

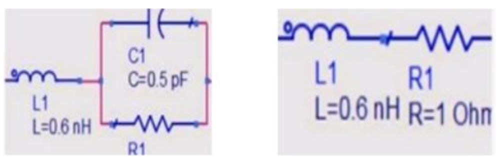
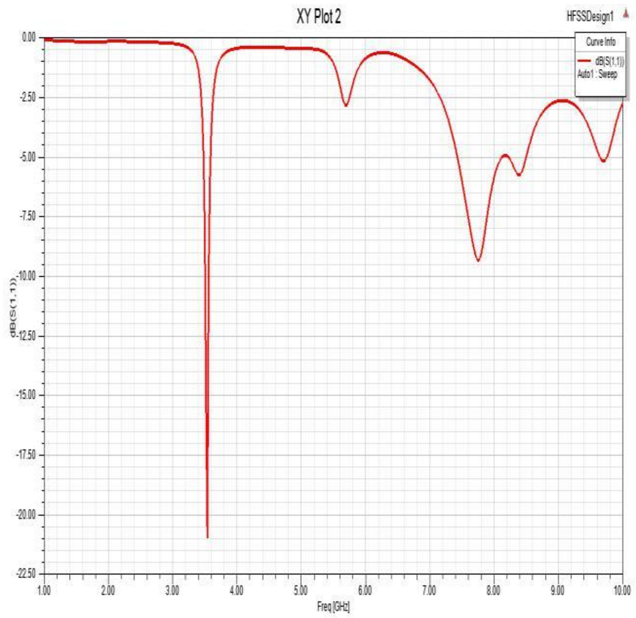


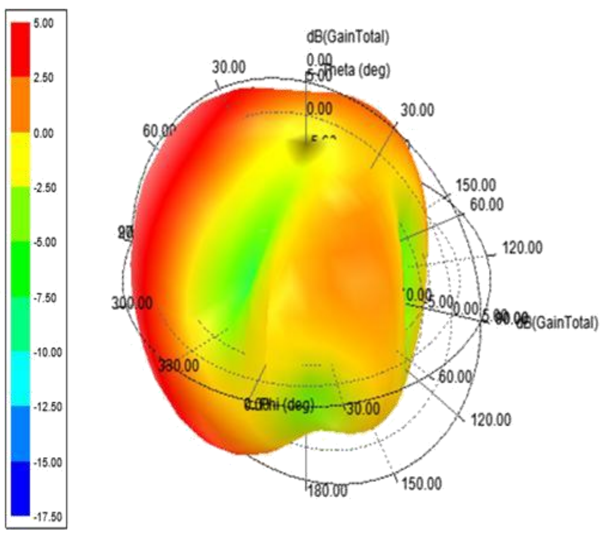
Figure 2: Equivalent circuits of PIN Diode

Considering the ON state, the resistor and inductor are in series hence the middle sheets are assigned with the above r and l values, coming to the OFF there exists a parallel combination of resistor and capacitor in series with the inductor as shown in the above figure hence providing the values accordingly for changing the switch condition. In On state the value of resistance is very small providing a low resistance patch and develops a short circuit path whereas in off state the large value of resistance is given which does provide the path for current flow [7,8].

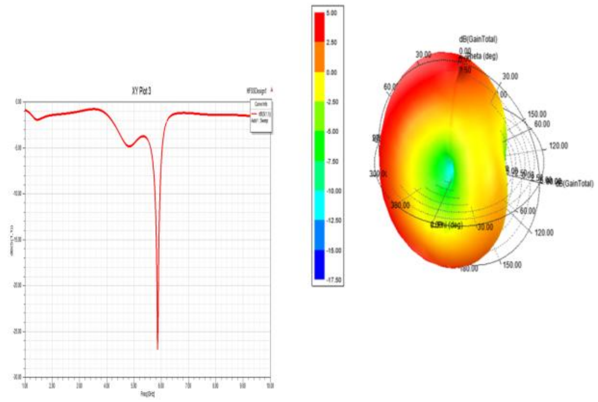
IV. RESULTS

Figure 2 Simulated Return Loss of the proposed design (a) ON state (b) OFF state. The results are evaluated during ON and OFF state separately along with the fundamental parameters such as gain, radiation pattern and the return loss at the desired operating frequency bands with the values and finally a comparison plot is shown on a single figure representing the frequency reconfiguration property.





(a)



(b)

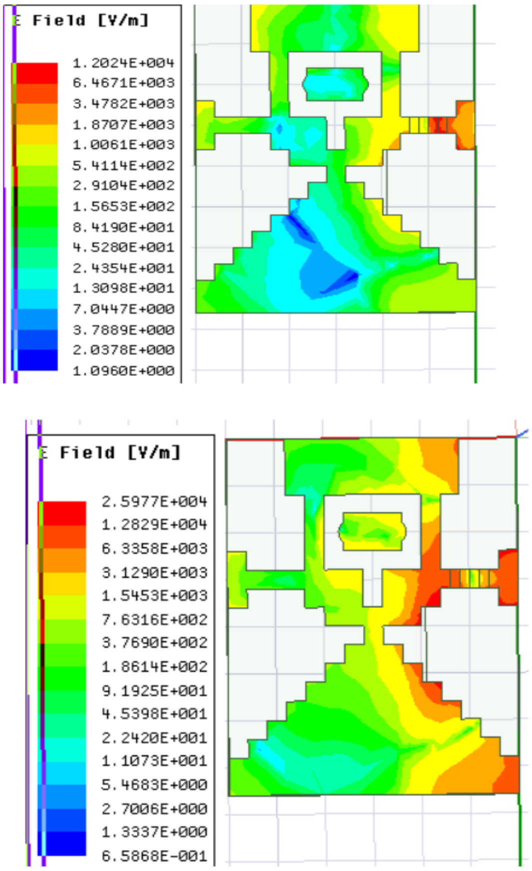
Figure 3 3D Gain of the proposed antenna (a) ON state (b) OFF state

Table 2 Performance analysis of the proposed design

S.No	Parameters	ON State	OFF State
1	Frequency (in GHz)	5.8	3.5
2	S11 (in db)	-26	-22
3	Gain (in db)	5	5
4	Impedance Bandwidth (in MHz)	200	70

The antenna radiates at 5.8GHz in ON state and the values of S11 obtained are given as -26 db indicating 90% of the power is being radiated and with the 10 db bandwidth of 200 MHz. In the OFF State antenna radiates at 3.5GHz with the S11 value of -22 db also with 10db bandwidth of 70 MHz. The summary of the performance is tabulated in the table 2. Further extending the explanation, the distribution of field intensity is also explained in this paper.

Figure 4(a) represents the electric field intensity in Off state and form that we can explain that surface current density is more in upper and lower regions hence those are the regions responsible for resonance at 3.5GHz likewise figure 4(b) explains the surface current density in On state and it show that the current density is high in lower region and the lower region is responsible for the resonance at 5.8GHz.



(b)

Figure 4 Electric field intensity in (a) ON and (b) OFF state

V. CONCLUSION

In this paper, we have designed an antenna that works for wireless applications and the concept we used here is reconfigurability with a PIN Diode and the results obtained are advantageous with the gain value of 5dB and the return loss obtained is very small, the simulation results prove that the characteristics obtained are in accordance with the requirements. The antenna proposed is applicable for multi band applications for wireless communication systems.

REFERENCES

[1] Recent Developments of Reconfigurable Antennas for Current and Future Wireless Communication System.January 2019 Electronics 8(2):128DOI: 10.3390/electronics 8020128

[2] Sakshi Gupta, Preeti Khera, Sukhwinder Singh Dhillon, Anupama Marwaha Dual Band U-Slotted Microstrip Patch Antenna for C band and X band Radar Applications 5th International Conference on Computational Intelligence and Communication Networks, 2013 IEEE.

[3] Abdulraheem, Y.I.; Oguntala, G.A.; Abdullah, A.S.; Mohammed, H.J.; Ali, R.A.; Abd-Alhameed, R.A.; Noras, J.M. Design of frequency reconfigurable multiband compact antenna using two PIN diodes for WLAN/WiMAX applications. IET Microw. Antennas Propag. 2017, 11, 1098 1105.

[4] M. Borhani, P. Rezaei, and A. Valuate, Design of a reconfigurable miniaturized microstrip antenna for switchable multiband systems, IEEE Antennas and Wireless Propagation Letters, vol. 15, pp. 822 825, 2016.

[5] Tanish Narang; Shubhangi jain; Microstrip Patch Antenna- A Historical Perpective of the Development ,Conference on Advances in Communication and Control Systems 2013 (CAC2S 2013).

[6] Girish Kumar, K.P. Ray, Broadband microstrip antennas , Aretch House 2003.

[7] El Maleky, O., Abdelouahab, F. B., Essaaidi, M., & bdelfatah, N., (2017), Miniature design of T-Shaped frequency econfigurable antenna for S-Band Application using Switching Technique , international Journal of Electrical and Computer Engineering IJECE), vol. 7, no. 5, pp. 2426-2433.

[8] Ismail, M. F., Rahim, M. K. A., & Majid, H. A., (2016,December), The Investigation of PIN Diode Switch onReconfigurable Antenna , In RF and Microwave Conference(RFM), 2011 IEEE International, pp. 234-237, IEEE.