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A Compact Frequency Re-configurable antenna withEnhanced Bandwidth for WLAN applications

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Abstract: In this paper, A Compact Frequency Reconfigurable Antenna is presented for WLAN Applications. The proposed antenna consists of a Partial Ground Structure, Tuning Fork Shaped Patch and Two PIN Diodes are Integrated at the two corners of Forks to Obtain Frequency Re-Configurability. A 50-Ohm Microstrip Line is used to feed the antenna. FR-4 Epoxy Substrate is used in design with dielectric constant 4.4 and Loss Tangent 0.02. The total size of antenna is 21mm*13mm. the proposed antenna design and simulation carried out using HFSS simulator. The proposed antenna is having Two PIN Diodes to provide multiple Frequency bands in the range of 4-8Ghz using two PIN Diodes three possible conditions are achieved. The proposed Reconfigurable antenna can switch at multiple operating frequencies i.e., 5.14 Ghz, 8.60 Ghz (Both Diodes ON), 4.57 Ghz, 5.74 Ghz (One Diode ON and Other Diode OFF), And 5.86 Ghz (Both Diodes OFF) based on conditions provided by PIN Diodes. The Antenna Shows good characteristics at every operating frequency. The proposed antenna can work effectively for C-Band applications.

Keywords: WLAN, PIN Diodes, Tuning fork, Partial Ground Structure, Frequency Reconfigurable.

I. INTRODUCTION:

In wireless communication system requires the development in low profile antennas with high performance over a wide range of frequency spectrum. Now-a-days, with the help of reconfigurable antennas we can easily change its operating frequency, bandwidth, and polarization properties [1]. Basic principle behind the reconfigurability is to change the dimensions that is by changing the current distribution across the antenna withthe help of switches.

The effective length of the antenna is mainly used for determining the operating frequency. Adding tunable materials and switches means we are indirectly the changing its length, then we can say that frequency reconfiguration is obtained by controlling the effective length of the antenna [2]. By adding or removing some part we can be able to change the effective length of the antenna. By changing its antenna dimensions, we use PIN diodes because it has acceptable performance, ease of fabrication and less expensive so, we have usedPIN diodes which is model SMP1340-079 from skyware labs.inc. Instead of using varactor diodes and RF MEMS [3]. In this paper we designed a compact microstrip frequency reconfigurable patch antenna which exhibitsmultiple frequencies for multiple applications by changing the switches. Frequencies a $\lambda/6$ length slot has introduced both sides in order to enhance the gain [1]. This antenna has a tuning fork shaped full wavelength radiating strip which offers 1.41 GHz maximum impedance bandwidth covering the WiMAX/WLAN reconfigure the antenna to improve the performance and reduce the usage of several antennas. We have compared with different conventional quarter wave antenna dimensions and results which gives us 65% reduction in size and increase in bandwidth from 1GHz to 1.41GHz and this compact reconfigurability is possible using horn like structures in design.

In Section II presents the details of frequency reconfigurable antenna geometry and design for proposed antenna. In section III, presents a detail analysis of proposed antenna with returns plot, Radiation characteristics and current distribution to explain performance of the antennas. Finally, conclusions are given in section IV followed by acknowledgement and references.

II. ANTENNA GEOMETRY:

The geometry of the proposed compactmicrostrip monopole frequency reconfigurableantenna is shown in Fig.2. The antenna is imprinted on FR-4 epoxy substrate whose dielectric constant i.e; effective relativepermittivity $\varepsilon_{reff} = 4.4$ and contains thickness of 1.6mm and is fed with microstrip line. The proposed antenna has a symmetrical fork shaped radiation strip along with reconfigurable switches at 11.4mm from feed [4]. We have calculated the length of radiating element length by using the standard formula:

$$L_{eff} = \frac{c}{2 f_0 \sqrt{\varepsilon_{reff}}}$$

Here f_0 denotes lowest frequency at which VSWR =2 and c is the velocity of light.

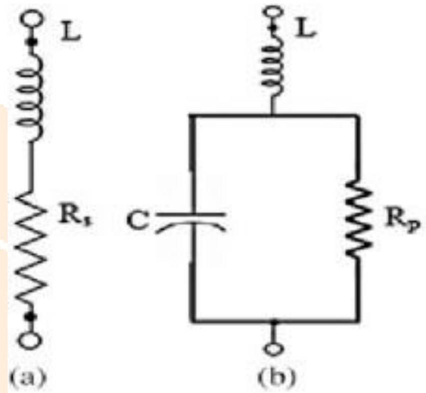


Fig 1. Equivalent circuits of PIN diode in ON and OFF states.

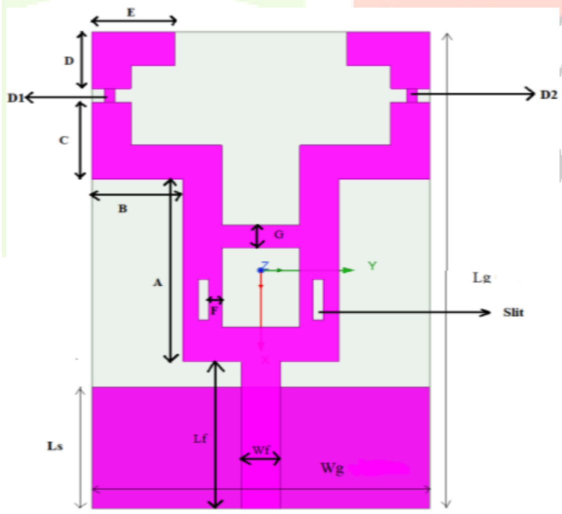


Fig 2. Proposed antenna Design.

In this design, two PIN diodes are used tochange the effective length of the antenna to achieve the frequency re-configurability. Basedon PIN diodes ON and OFF conditions. Whenthe PIN diode is kept ON, the RLC lumped parameters are assigned with resistance of Rs =0.85ohms, L = 0.7nH and When PIN diode is kept OFF, values are L = 0.7nH, Rs = 2K ohmsand C = 0.21pF. The proposed antenna can radiate at 4 different bands in which two conditions are identical dueto symmetry of antenna. The proposed frequency reconfigurable antenna detailed dimensions A = 8mm, B=3.5mm, C=3.4mm, D=2.5mm, E=3.2mm, F=0.6mm, G=1mm, Ls=5.35mm, Lg=21mm, Wg=13mm, Wf=1.5mm, Lf=6.5mm, Slit=1.8*0.4mm and D1, D2=0.6*0.4mm.

The Designed antenna is a very compact of dimensions 21*13mm. ANSYS HFSS tool is used to design and analyses the results. The radiating strip line of width 1.5mm and the feed line of width Wf = 1.5mm is optimized to achieve the greater impedance matching along with bandwidth [1]. The partial ground structure is optimized to enhance the return loss from negative value of 16dB to 30dB. The distance between two fork-shaped arms is optimized for less than quarter-wavelength such that the total length LTOT of the fork- shaped arm gives a full wavelength length. Small patches are introduced and assigned R, L and C characteristics which acts as a diodes of size 0.6*0.4mm which results in 3 different results.

III. RESULTS AND DISCUSSION:

The proposed antenna is simulated in HFSS, and results are drawn in which the returnloss is plotted which us shown in Fig. 3. Antenna radiates with nearly 92% efficiency inall cases when diodes are switched ON and OFF. Comparison of results is shown in below table 1.

Bandwidth is enhanced by 40% from regular antenna from [1] and reconfigurability is shown in Fig. 2. Where diode states decide the operating frequency. Antenna resonates at 5 different frequencies as shown in table with return loss less than -10dB whose power is radiated more than 97%. It offers nearly 30% bandwidth with VSWR=2 for the entire bandwidth in all cases.

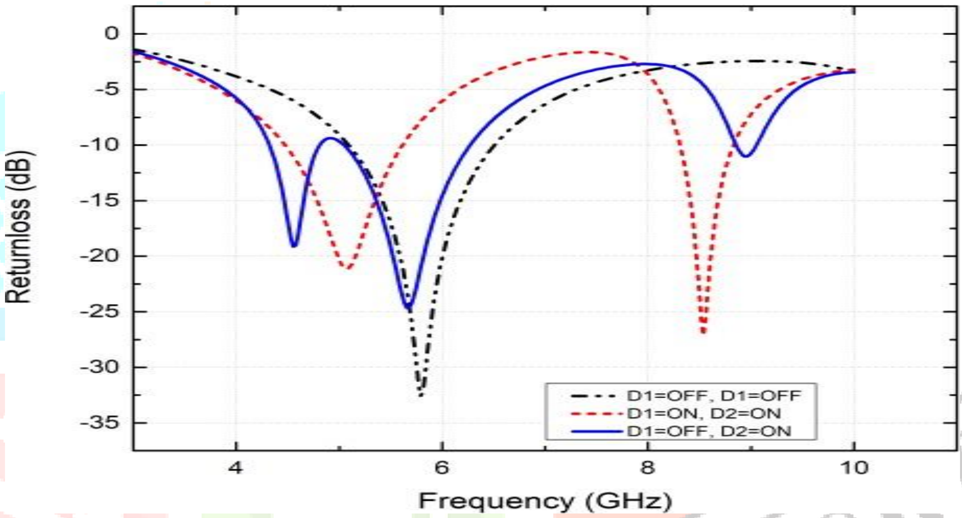
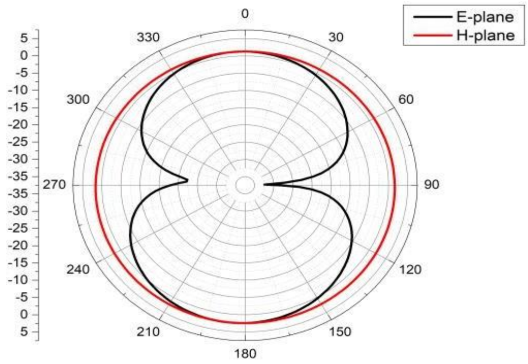


Fig 3. Return loss of Antenna.

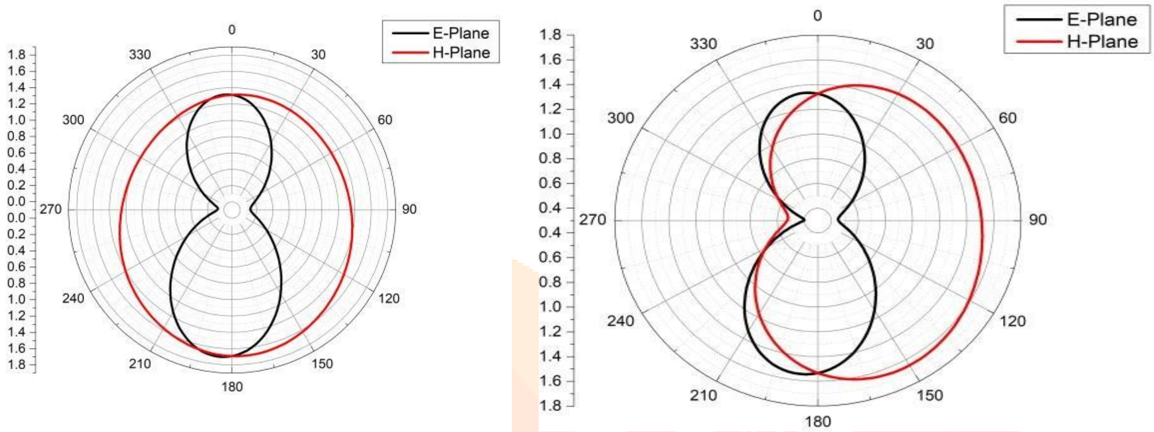
Table 1. Comparison of Results with Different Diode Cases.

PARAMETERS	D1=ON, D1=ON	D1=OFF, D2=ON	D1=OFF, D2=OFF
Operating Frequency	5.2Ghz,8.2Ghz	4.6Ghz, 5.65Ghz	5.8Ghz
Gain	1.81	1.693	1.66
Band Width (Ghz)	1.1GHz, 0.53GHz	0.47GHz, 1.22GHz	1.41GHz
Efficiency	95.58	92.84	92.16
VSWR	1.85,0.5	1.82,0.87	0.3

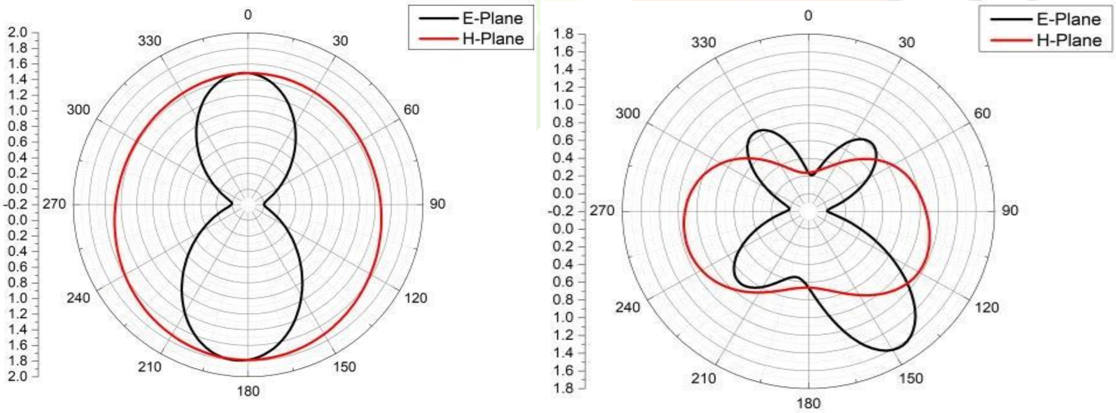
Simulated Radiation pattern is shown in Fig. 4 which is suitable to use in real-time applications, which has moderately directional radiation pattern. When the diodes are turned ON and OFF then the current distributed along the patchis changed which results in changing the effective length of antenna and gives out different resonant frequencies at different diodestates. The current distribution across the patchis shown in Fig. 4.



a). D1, D2=OFF Fr at 5.86 Ghz



(b). D1=on, D2=off Fr at 4.5775 Ghz and5.7475 Ghz



(c). D1, D2=on Fr at 5.14 Ghz and 8.605 Ghz

Fig. 4 Radiation Pattern

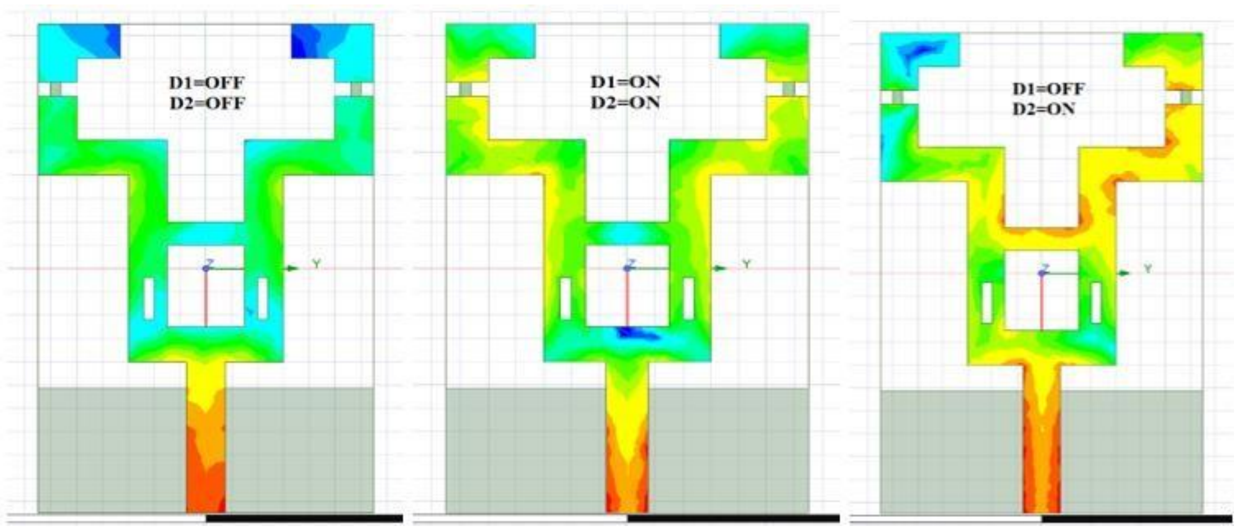


Fig. 5 Current Distribution.

The current distribution changes according to the diode's conditions, so that the emission of radiation also changes, and resonant frequency also changes.

IV. CONCLUSION:

A very compact frequency reconfigurable antenna is presented in this paper. The antenna elements are a partial ground, tuning fork shaped patch and two PIN diodes are integrated at the two corners of fork-shaped patch to obtain frequency re- configurability. FR-4 epoxy substrate is used todesign the antenna. The total size of antenna is 21mm x 13mm x 1.6mm. The proposed reconfigurable antenna can switch at multiple operating frequencies i.e., 5.14 GHz, 8.60 GHz(when both diodes ON), 4.57 GHz, 5.74 GHz (if one diode ON and other diode OFF), and 5.86 GHz (when both diodes OFF) based on conditions provided by PIN diodes. Two slits are provided over the patch for gain enhancement and a conductor strip attached in between the fork arms to enhance the impedance matching. The antenna has beenproposed, modelled, simulated, and analyzed with the help of Finite Element Method based simulator, HFSS. The proposed reconfigurableantenna shows moderate gain values 1.81 dB, 1.79 dB, 1.63 dB, 1.72dB and 1.74dB at resonant frequencies 5.14 GHz 8.60 GHz, 4.57GHz, 5.74 GHz, and 5.86 GHz respectively. The compact size and simple structure of the antenna validate that it is suitable for C-band applications.

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