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Reconfigurable Antenna (Circular Micro strip Patch Antenna) Using Varactor Diodes

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Abstract: An antenna that possesses the ability to modify its characteristics, such as operating frequency, polarization or radiation pattern, in real time condition is referred to as a reconfigurable antenna. Reconfigurable antennae have the potential to add substantial degrees of freedom and functionality to communication and phase array systems. Reconfigurable antennae can be simply used to reduce the number of antennae necessary for intended system function, but they can also be designed to serve much more complex roles[1]. In addition, reconfigurable antennae can be a cheaper alternative to traditional adaptive arrays or they can be incorporated into adaptive arrays to improve their performance by providing additional degrees of freedom. Reconfigurability in antennae allows us for spectrum reallocation in multi-band communication systems, dynamic spectrum management, reduces the number and size of antennae in a system. Generally reconfigurability can be obtained using following techniques: Tunable elements in the feeding networks, adaptive matching networks, phase shifters and tunable filters, tunable elements embedded such as PIN diodes, MEMS (switches, varactors, moveable parts) and optical switching in the radiating elements, mechanically moveable radiating elements [2].

The proposed reconfigurable Circular Patch antenna is a good candidate for X band communication. Circular Patch Antenna designed, simulated at 8.5 GHz successfully. The same antenna was made capable for frequency tuning by using varactor diode at optimized position and achieved from 6.5GHz to 8.2GHz in simulation and 7.6GHz to 8.6GHz and 10.4 to 11.6 GHz in practical. Three varactor diodes were used at optimized positions only for making the antenna tunable at different resonant frequencies without changing any other parameter and preventing the mode splitting [10]. The E-plane radiation pattern of designed antenna was found 22^0 offset with maximum power 6.4 dB. The Half Power Beam width was found 106^0. In this radiation pattern there were two side lobes and one back lobe which was came out 18.8 dB down from the one major lobe. The H-plane radiation pattern was found 0^0 offset with maximum power -6.2 dB and the half power beam width for this pattern was found 65.3^0.

Keywords: Micro strip antenna, s-parameter (S11), gain, radiation patterns.

I. INTRODUCTION

The evolution of wireless communication and mobile phone devices has revolutionized our life styles. Through the evolutionary process of development, various antennas have been developed for these applications. With the changing time the requirement of new small and multiband antennas are becoming even more challenging [3].

To fulfill such challenging demands, a constant and even thorough research is required for developing new antennas capable of operating in multiple bands with small size.

In this thesis, a new antenna is designed and developed to be used in fixed and reconfigurable terminals for wireless, mobile phone and cognitive radio applications to enhance the system capability [1]. This antenna offers smaller size, slim and independently controlled bands, in addition to the added functionality in the performance of wireless systems.

The proposed micro strip antenna has a circular geometry with micro strip feed. Satisfactory results are obtained by optimized geometrical parameters [4]. To achieve reconfigurable capability three varactor diodes are embedded by tuning the varactor diodes. The performance of proposed antenna is investigated in terms of return loss, gain and radiation pattern. Beside that the design of proposed antenna has low profile and small in size.

The work is divided into two phases. In the first phase the desired objectives are achieved using FEM based simulator CST Microwave studio and virtually the parameters are optimized to get best results.

After that we will fabricate prototype on GIL GML 1032 (Lossy) - Normal substrate and the prototype will be tested in laboratory to make a comparison with simulation results.

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II. ANTENNA STRUCTURE

A. *Conventional circular patch antenna:*

$$a = \frac{F}{\left\{1 + \frac{2h}{\pi \epsilon_{r} F}\left[\ln\left(\frac{\pi F}{2h}\right) + 1.7726\right]\right\}^{1/2}}$$

$$F = \frac{8.791 * 10^{9}}{f_{r}\sqrt{\epsilon_r}}$$

Therefore, for ϵ_r = 3.2, h= 0.762mm, f_r =8.5GHz the calculated radius of patch was 5.49mm.

First we have considered a simple circular patch antenna and tested its performance with available e.m. simulation tools (CST microwave studio) considering the parameters of RT Duroid (ϵ_r = 3.2, tanδ = 0.025, substrate thickness 'h' = 0.762 mm) with copper as its ground plane [9]. And antenna with inset feed with $\lambda/2$ impedance transformer of dc feed length 5.428 mm and width 1.83 mm. Transformer length 5.428 mm. and transformer width 0.45 mm. resonates at resonance frequencies 9.94 GHz and 10.28 GHz as shown in figure 1 and presents very narrow bandwidth.

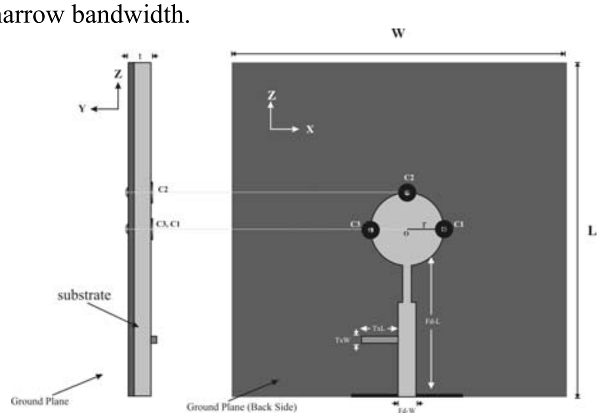

Figure 1. Simulated structure of Tuned Circular micro strip antenna using varactor diode

III. SIMULATED RESULTS

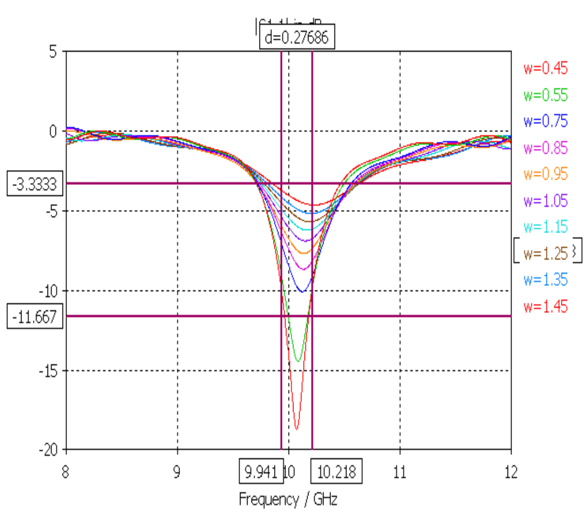

Figure 2. Quarter length transformer width variation.

The variation of junction capacitance with bias voltage is shown in figure 3

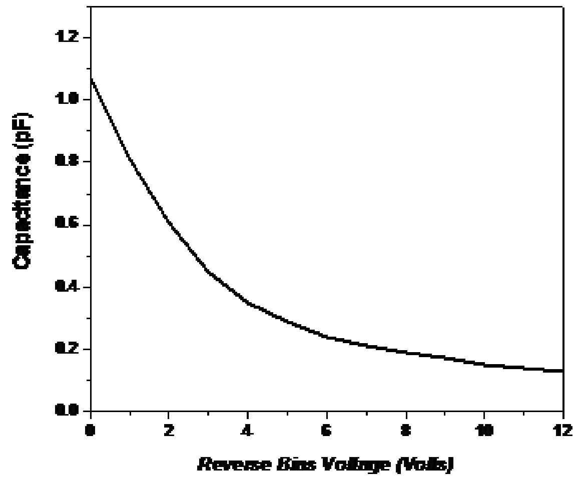

Figure 3. Junction Capacitance variation graph characterized

We therefore modified this patch antenna in several steps. In the first step, a circular patch antenna is designed of radius of 5.49 mm. The location, length and width of dc feed is optimized to achieve improved performance. In the next step, Modified circular patch is shorted with ground plane by three varactor diodes [6].

Three varactor diodes were used at optimized positions only for making the antenna reconfigurable at different resonant frequencies without changing any other parameter and preventing the mode splitting.

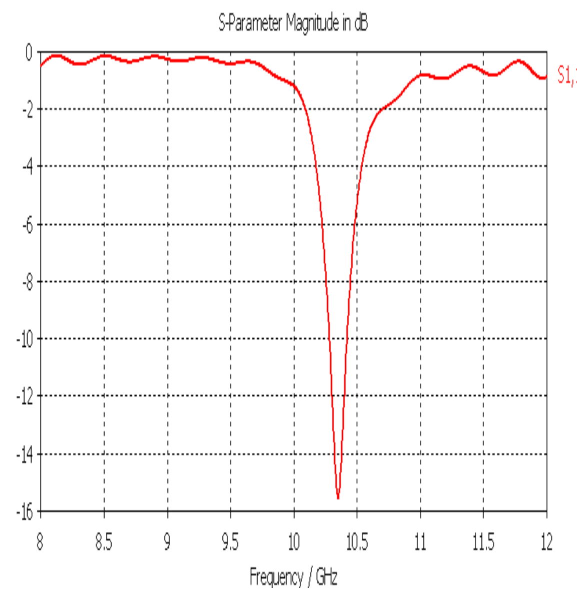

Figure 5. Tuned Circular antenna using varactor diode at no bias.

The DC biasing feed was designed in such a way to pass the DC only without affecting the performance and different parameters of the previously circular patch antenna designed at 8.5GHz.From figure 6 was found that the designed antenna was reconfigurable at different frequencies without changing other parameters such as impedance, polarization and pattern

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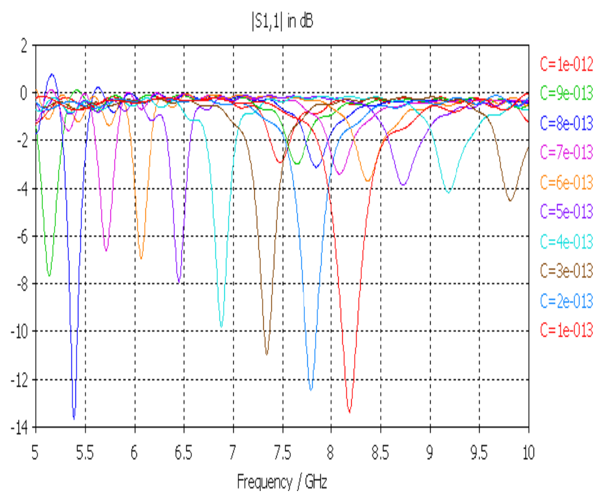

Figure 6. Return loss graph of different resonance frequencies at different capacitances is the capacitance of three varactors. Above is the S_{11} for five different values of C

The two dimensional E and H plane radiation patterns of antenna at two resonances are shown in figure 7(a) and 7(b).

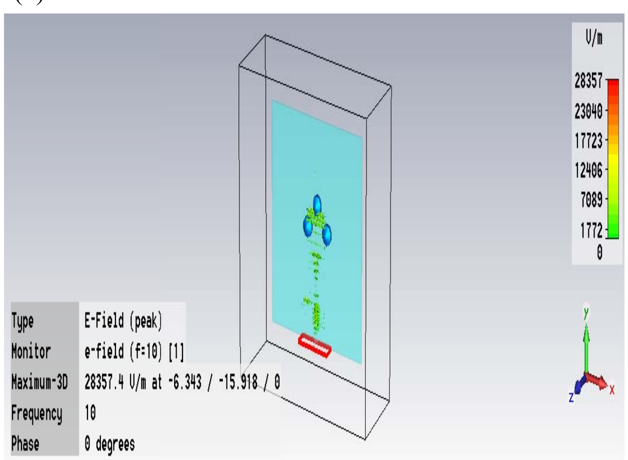

Figure 7(a) The E-field pattern of proposed antenna

Geometry suggests that this compact size antenna with little more improvements may be proved a suitable candidate for future generation communication systems.

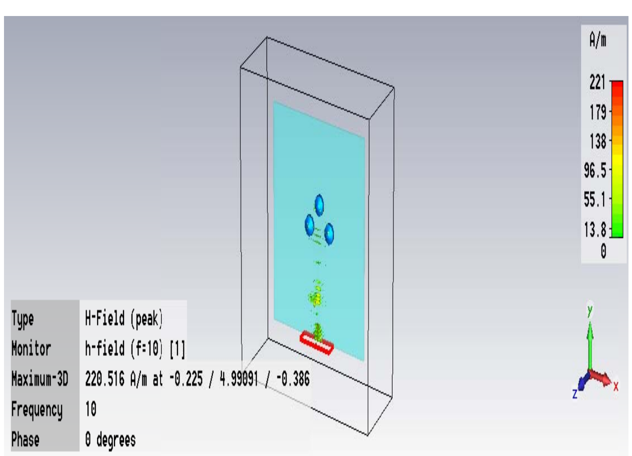

Figure 7(b) The H-field pattern of proposed antenna

IV. DISCUSSION AND CONCLUSIONS

Circular Patch Antenna designed, simulated at 8.5 GHz successfully. The same antenna was made capable for frequency tuning by using varactor diode at optimized position [11]. Due to the well known property of varactor diode that the capacitance of varactor diode is varied with the change in applied reverse bias voltage, applying proper reverse biasing to the varactor provide the different resonance frequencies of antenna achieved from 6.5GHz to 8.2GHz in simulation and 7.6GHz to 8.6GHz and 10.4 to 11.6 GHz in practical. Three varactor diodes were used at optimized positions only for making the antenna tunable at different resonant frequencies without changing any other parameter and preventing the mode splitting [7]. The DC biasing feed was designed in such a way to pass the DC only without affecting the performance and different parameters of the previously circular patch antenna designed at 8.5GHz. The E-plane radiation pattern of designed antenna was found 22^0 offset with maximum power 6.4 dB. The Half Power Beam width was found 106^0. In this radiation pattern there were two side lobes and one back lobe which was came out 18.8 dB down from the one major lobe. The H-plane radiation pattern was found 0^0 offset with maximum power -6.2 dB and the half power beam width for this pattern was found 65.3^0.

A circular patch antenna was designed and developed. The frequency tunability was introduced using varactor diodes. This proposed antenna comes in the category of frequency reconfigurable antenna [13]. This antenna is useful for X- band application from 11.2 to 11.7GHz.

In the future work one can introduce polarization reconfigurability or frequency and polarization reconfigurability simultaneously in the same antenna by putting the varactor diodes at specific locations at the edge of the circular patch.

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