

## **Study of Frequency and Polarization Reconfigurable on Square Patch Antenna**

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### **Abstract**

A frequency tuning with polarization microstrip patch antenna design with varactor diode is presented. The frequency reconfigurability is achieved by varying the varactor diode capacitance. The proposed square patch antenna has the impedance 2.13 GHz to 2.29 GHz by varying the capacitance value between 0.07pF to 0.57pF. The Right handed circular polarization (RHCP) and Left handed circular polarization (LHCP) are realized by keeping two coaxial feed with  $\pm 90^\circ$  time phase difference. The radiation patterns are remains same on varying of frequency. The bias line is used at the top of the substrate to connect DC power supply in order to control the varactor diode.

**Keywords—** Varactor diode, Circular Patch, Probe feed, Frequency reconfiguration.

### **INTRODUCTION**

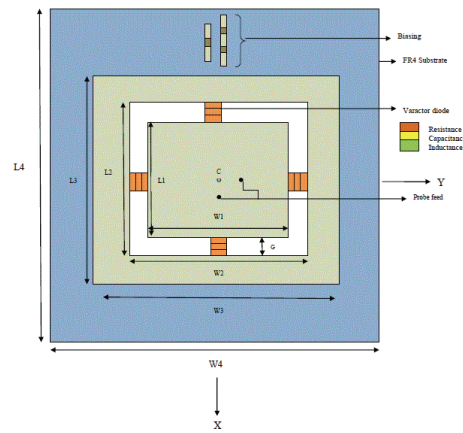
Due to requirement of integrating multiple wireless standards into a single wireless unit, reconfigurable antenna has attached a lot of attention. Reconfigurable antenna provides a single antenna that can be used for multiple applications. Reconfigurable antenna can be classified into four types such as Frequency, polarization, radiation and multiple reconfigurable antennas [1]. Compared to other antennas, reconfigurable antennas have more advantages and better prospects. They are light in weight, smaller in dimension and lower in price. Moreover, the reconfigurable antenna reduces the complexity of hardware and cost of the system. Reconfigurable antennas are controlled by PIN diodes, MEMS or varactors diodes [2]-[6]. These diodes provide either ON or OFF mode mechanism to change the resonance of the antenna. Thus, the current distribution will be changed over the volume of the antenna and results in the reconfigurability. The frequency reconfigurable Bow –Tie antenna developed for the application of Bluetooth, Wimax, WLAN achieved by embedding positive-intrinsic-

negative (PIN) diode over the bow-tie arms. The effective electric length of the antenna can be changed leading to an electrically tunable operating band [7]. A frequency reconfigurable U-slot micro strip patch antenna is presented to reduce the crosstalk from adjacent channels in multichannel system and implemented by placing a variable chip capacitor (trimmer) and an inductor at antenna input as to vary the antenna impedance matching frequency [8]. The polarization reconfigurable mechanism is the time varying direction and relative magnitude of the electric field vector either linear, Left handed circular polarization, Right handed circular polarization based on  $\pm 90$  phase difference. If the path of electric field vector is back and forth along a line it is said to be linear polarized wave. A left hand circular polarized wave is one in which the wave rotates counter clockwise whereas right hand circular polarized wave exhibits clockwise motion. A reconfigurable microstrip antenna for switchable polarization [9] is proposed by corner truncated square radiating patch and independent biased PIN diode to form linear polarization,  $\phi=45^\circ$  LHCP and  $\phi=90^\circ$  RHCP. It forms solution to the problem of changing in impedance, in which polarization diversity counter the effect of fading in communication. Reconfigurable rhombus shaped patch antenna with Y-shaped feed for polarization diversity [10] is proposed by modes on rhombus shape patch antenna in which the antenna become asymmetrical structure. It form LHCP in which electric current rotate clockwise and RHCP in which electric current rotate in counter clockwise when one diode ON and another OFF. Both diodes in OFF or ON then exhibit symmetric and form linear where the frequency remains constant.

In this paper a frequency reconfigurable varactor diode loaded microstrip antenna with simultaneous polarization reconfiguration is presented for square patch. The proposed have the impedance bandwidth (-10dB) of 2.13GHz to 2.29GHz frequency for square patch. By varying the capacitance of varactor diode reconfigurability is achieved. A dual coaxial feed is located on X and Y axis of the patch to form circular polarization and excite a mode ( $TM_{01}$ ). The proposed antenna is simulated using Ansys/Ansoft HFSS v15 which is a full wave analysis tool.

## **SQUARE PATCH ANTENNA GEOMETRY**

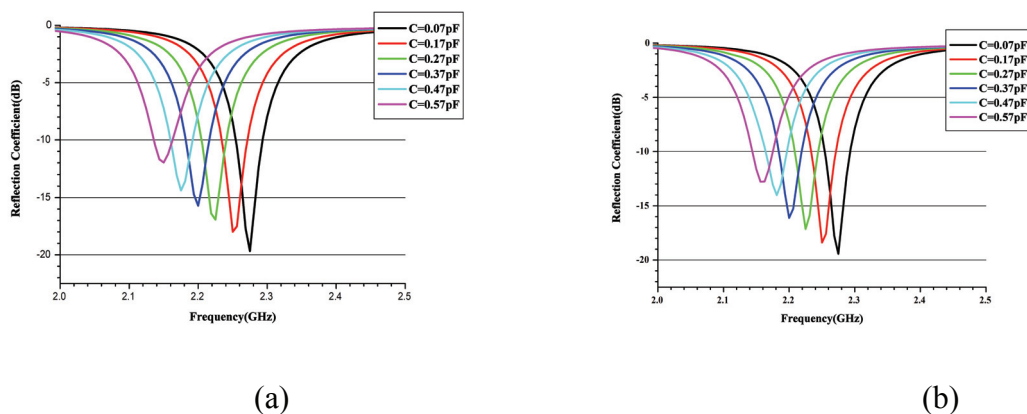
The geometry of proposed antenna is shows in Figure 5. It is built on  $100 \times 100 \text{ mm}^2$  substrate FR4\_epoxy (Relative permittivity  $\epsilon_r=4.4$  of dielectric constant 0.02) with a thickness 1.6 mm. The antenna is fed using a  $50 \Omega$  co-axial connector and the feed point is  $x = 5 \text{ mm}$ ,  $y = 0 \text{ mm}$  in X axis and  $x=0$ ,  $y=5\text{mm}$  in Y axis. The proposed antenna has square patch of  $L1=W1=30$ ,  $L2=W2=32$ ,  $L3=W3=40$  and the design equation is given in [11]. The gap between inner square patch and outer patch is  $G=2\text{mm}$ . The square patch is connected to the outer patch through varactor diode, placed on gap. The varactor diode is a bridge between the patch. The varactor diode is connected with DC-blocking capacitors which are part of the biasing network. The bias line along with resistor and inductor are placed on top of the substrate at a distance from the patch to prevent antenna performance. The variable capacitor is in series with capacitance of patch is connected. By varying varactor diode capacitance, resonant frequency of the antenna is varying.



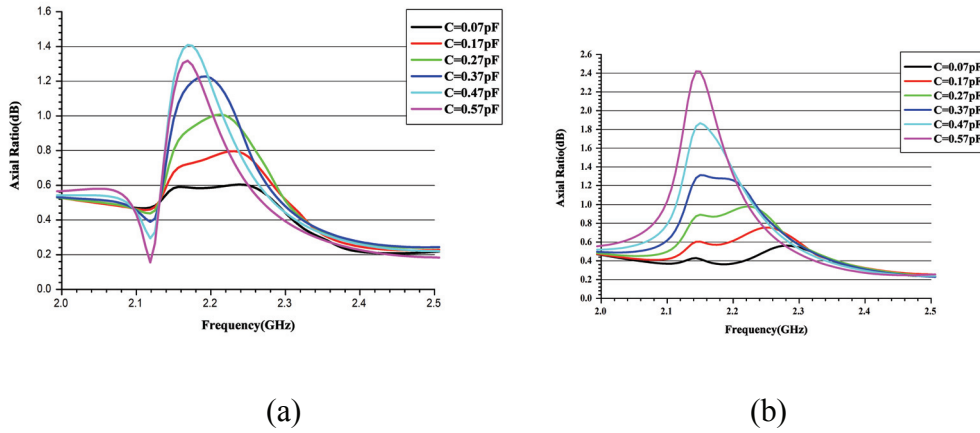
**Figure 1: Geometry of the Antenna Top View. The parameter of the antenna are  $L1=W1=30$ ,  $L2=W2=32$ ,  $L3=W3=40$ ,  $L4=W4=100$ mm,  $G=2$ mm.**

### RESULTS AND DISCUSSION

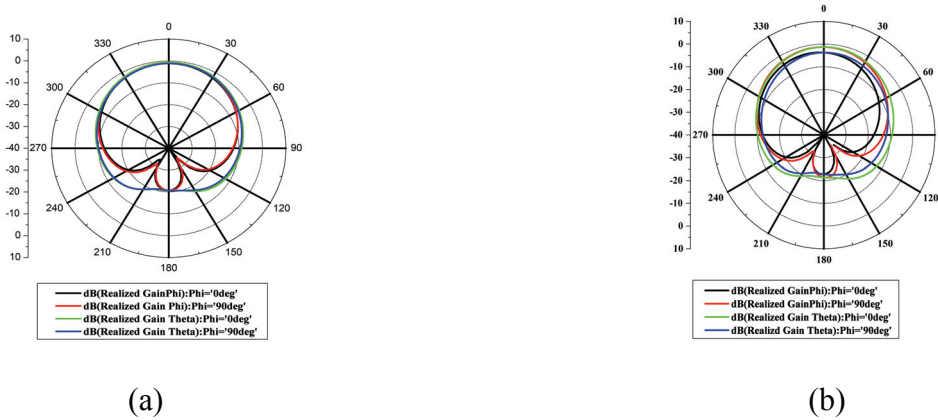
By varying the capacitor value, the frequency is tuned and resonating upto 2.26 GHz band. Figure 2 shows the reflection coefficient ( $S_{11}$ ) of proposed antenna. It can be seen that by varying the capacitance from 0.07pF to 0.57 pF, the resonant frequency of the patch is controlled from 2.26GHz to 2.15 GHz. In addition it shows the compactness of the proposed antenna. Figure 3 shows the axial ratio of the square patch in which impedance bandwidth(-10dB) of frequency are below 1dB on varying of different capacitance value and it proves that the antenna is resonating in circular polarization in good performance. Figure 4 shows the radiation pattern of proposed antenna at 2.15 GHz and 2.26 GHz. It is observed that radiation pattern remains almost invariant as frequency is varied.



**Figure 2: Reflection coefficient (i)  $S_{11}$  (ii)  $S_{22}$  for ideal different capacitance value (0.07 pF to 0.57 pF) considering packaging parasitic components and bias network components.**



**Figure 3: Axial Ratio of square patch (a) LHCP (b) RHCP**



**Figure 4: Radiation Pattern for two different Capacitance value (a) C=0.07pF at 2.26GHz (b) C=0.57pF at 2.15GHz**

It is observed that the frequency variation is from 2.15 GHz to 2.2642 GHz for the varactor capacitance values. It can be predicted that the antenna efficiency and realized gain would be affected also which are not shown here for the sake of brevity. From the Skyworks manufacture data sheet for varactor diode, packaging inductance and resistance is given as  $L_p=0.7nH$  and  $R_p=4.8\Omega$  [SMV2019 from Skyworks]. The inductor and capacitor of DC blocking Network are given as  $L_p=0.287nH$  and  $R_p=0.2\Omega$  respectively.

## CONCLUSION

In this paper a varactor diode loaded frequency and polarization reconfigurable antenna is designed and simulated. The Varactor diode is placed between the inner patch and outer ring. The bias line has been placed above the substrate with some distance to prevent the diode. The simulation result shows that the antenna is capable of tuning its resonant frequency from 2.26 GHz to 2.15 GHz for varying capacitance value. The axial ratio shows the antenna provides good circular polarization. The radiation pattern remains almost invariant as frequency is varied. The proposed antenna has great advantage for frequency reconfigurability.

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