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Frequency reconfigurable antenna and polarization reconfigurable antenna for wireless communication

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Abstract: A frequency reconfigurable microstrip patch antenna and polarization reconfigurable microstrip patch antenna is presented in this paper. The patch is resonating at 2.4GHz. The frequency reconfigurable antenna is capable of switching to nine different frequencies from 1.98GHz to 2.4GHz using PIN diodes or Varactors. The paper demonstrated this switching operation using copper strips as substitutes for active elements. The design, switching table and results are presented. The polarization reconfigurable antenna able to switch between vertical polarization to horizontal polarization. HFSS simulation software is being used to provide software results. Parameters like gain, S_{11} (Return loss) and radiation pattern is demonstrated. The fabricated antennas are tested in a well equipped lab on a network analyzer to verify software results.

Keywords: *R*econfiguration, Return Loss, VSWR, Radiation Pattern.

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I. INTRODUCTION

Communication between two distant points has been a constant challenge for mankind to finally wireless communication through electromagnetic signals. This evolution represents a constant effort to improve the quality and effectiveness of distant communication with ever-evolving techniques to enhance the delivery of contents. Wireless handheld devices are the most representative model of these efforts. In this regard, the antenna community often has an important role to play. The focused is given on designing low-profile, small and multiband antennas together with multiple antenna systems capable of satisfying the strict demands of emergent multifunction wireless devices. The complexity of handheld antenna is continuously increasing, not only by the pressure of the market needs but also by the requiring efficient antennas capable of radiating as much power as possible in free-space conditions. Antennas have always been the part that makes a wireless device wireless. Antennas have traditionally been external, connectorized components. Antennas for mobile devices have evolved since their introduction from Whips to Retractable to Stubbles to Embedded. Antennas are slowly becoming more and more integral, as more devices are adding wireless capability. Consumers are demanding more from their wireless devices and expected as smaller, more functionality, more signal strength and improved performance.

By using 'X' shape antenna Co polarization obtained is less than cross polarization. The return loss between -19.20dB to -45.47dB is achieved with this design [1].. In Ref. [2] monopole antenna offers -6dB return loss, 3.4 to 4.1dBi Gain and Omni directional radiation pattern. Kothari, et al. [3] presented Meander antenna design offering Return loss <-40dB, Gain 2.6dBi, Impedance Bandwidth 23.8% and Directivity as 2.6dBi in which two shapes are used for antenna design i.e. rectangle and triangle. With rectangular microstrip patch antenna Return loss -15dB, VSWR 1.42,2.4dBi Directivity and 1.49% Bandwidth improvement is achieved whereas with triangular microstrip patch antenna -13dB return loss, 1.86 VSWR, 6.2dBi Directivity and 0.92% Bandwidth is achieved. In Ref. [4] spiral shape microstrip patch antenna is used. It gives -5.5dB Return loss. Its -5dB bandwidth is greater than 45MHz, and path loss is from 57.69dB to 69.22dB. Lopez, et al. [5] presented 3 shapes for microstrip patch antenna-Rectangular, Triangle and circle. Rectangular microstrip patch antenna with return loss -40dB and Gain 6.7dB is presented. Triangle shape antenna gives S11 as -35dB and gain as 6.3dB. The circular antenna offers -30dB return loss and 6.2 dB gain. The overall return loss variation is 10dB and Gain variation 0.5dB is obtained by this design. Less mutual coupling of the order of -15dB and average Impedance bandwidth of the order -10dB is achieved with the help of two Cup shape antennas connected orthogonally [6]. Rectangular shape wide band antenna design is indicated in this paper. Peak gain 0dBi, S21 -15dB and VSWR 2:1 is offered by this antenna. The unwanted frequencies are rejected with the help of pin shape notch in the antenna design itself [6]. A simple circular shape antenna designed is presented here. The result shows S11 of the order -25db, less gain of order -30dB and 0 to -25dB Co and cross polarization [7]. A compact meander shape antenna is presented in this paper. The feed technique of antenna is varied to study the effect on the antenna parameters here. By changing feeding technique, high Return loss -46.69dB, Less VSWR of the order 1.08, Omni directional radiation pattern and 8.1dBi Gain is achieved in this paper [8]. Most of researchers used traditional shapes like square , circle, triangle and 'V' [4,6,8,9] and few uses Monopole [2], Spiral [5], Meander [3] and X[1] for antenna used in handheld devices. Researchers uses Parameters like Return loss and Peak Gain [1-9], Co and/or Cross Polarization [1, 7, 8, 9], Path loss [5] for evaluation of antenna.

From literature review it is observed that antenna used in portable devices is narrow band which will not able to handle more than 2 to 3 applications efficiently. Some of the researchers used multi band antenna for portable device which uses notches to reject unwanted frequencies. To fulfil the requirement of portable device antenna, parameter diversity using single antenna can serve the purpose. Thus, utilization of polarization and frequency reconfiguration and identification of reconfiguration technique for portable devices.

II. METHODOLOGY

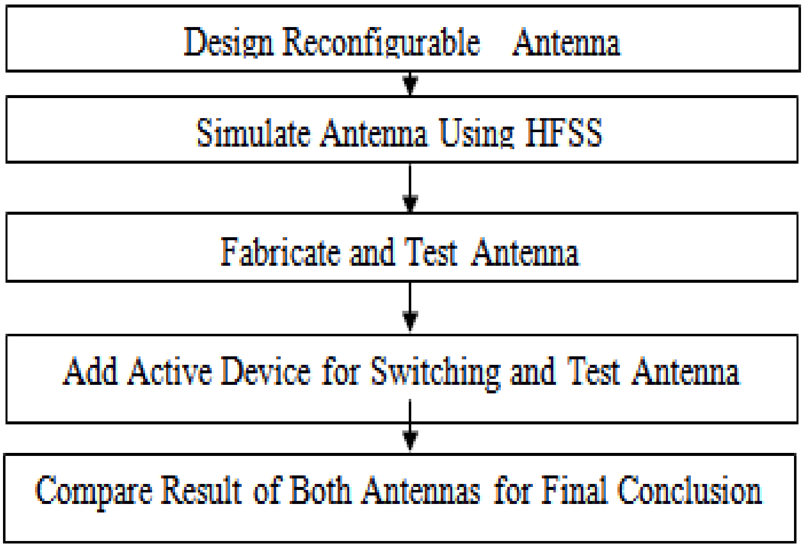


Figure 1: Block diagram of design of antenna system

The various steps involved in design of antenna system [Fig.1] are as follows:
1. Design E shape and Meander shape Microstrip antenna.
2. Simulate using HFSS and optimized the design to get Return Loss less than -10dB.
3. Fabricate antenna on FR4 substrate and test antenna on Vector Network Analyzer for following parameters-
   a. Return Loss
   b. SWR
   c. Radiation Pattern.
4. Apply reconfiguration technique to passive antenna.
5. Test antenna on Vector Network Analyzer.

2.1 Design of Antenna Frequency Reconfigurable Antenna

Table 1: Summary of Design Parameters of frequency reconfigurable antenna

Sr.No.	Parameter	Specification
1	ε_r	4.8
2	W	39.32mm
3	ε_{reff}	4.26
4	L_{eff}	32.44mm
5	ΔL	1.37mm
6	L	29.76mm

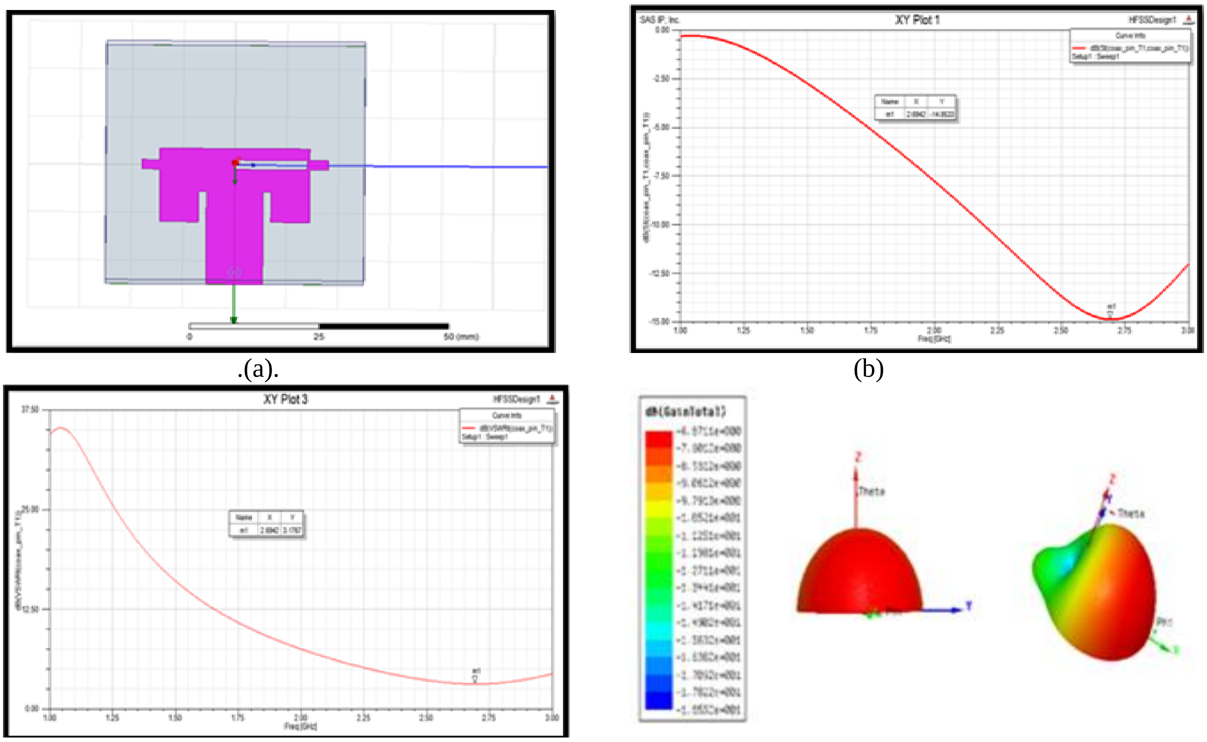
Table 2: Summary of Design Parameters of Polarization reconfigurable antenna

Sr.No.	Parameter	Specification
1	S	7mm
2	D	1.2mm
3	W	0.8mm

The frequency reconfigurable antenna and polarization reconfigurable antenna is designed as per parameters stated in Table 1 and Table 2. These designed parameters are used to simulate and optimize the antenna design. Simulation software HFSS (High Frequency Structure Simulator) is used for simulation and optimization of antenna design. The optimization is done by selecting proper position of feed point for both the antennas.

III. PERFORMANCE EVALUATION

3.1 Frequency Reconfigurable antenna



.(a). (b)

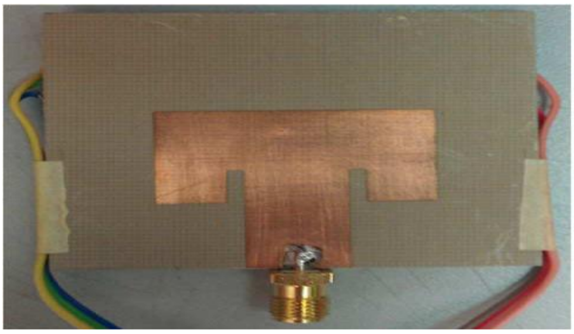
.(c) (d)

Figure 2: (*a).Structure of frequency reconfigurable antenna, (b) Return Loss, (c) VSWR, (d) Radiation Pattern of reconfigurable antenna.*

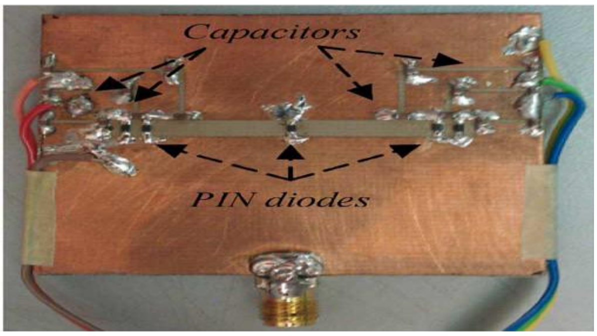
The frequency reconfigurable antenna uses ' E' shape structure as shown in Fig. 2(a). The feed is given at the center location and simulated on HFSS. The antenna shown in Fig. 2(a) shows the slot in the radiating patch. The Frequency Reconfiguration is obtained by changing the length of slot. The frequency offered by antenna is a function of length and the overall length depends on the slot length. The return loss of -14dB is achieved as shown in Fig. 2(b).The VSWR (Voltage standing wave ratio) is of the order 3.2 is obtained as shown in Fig. 2(c). The radiation pattern of antenna is Omni directional as shown in Fig. 2(d).

3.2 Structure of fabricated antenna and Experimental Results

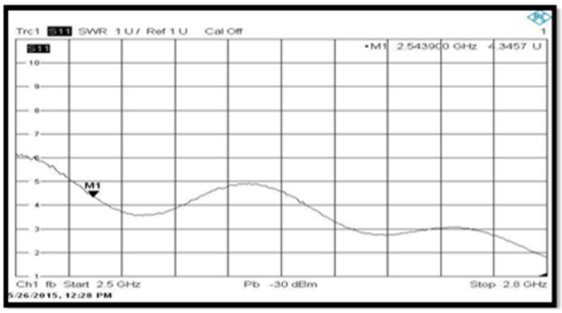
Fig. 3 (a) shows E shape antenna which is fabricated on FR4 substrate with permittivity $\varepsilon_r = 4.8$ and thickness of substrate is 1.6 mm. Fig. 3(b) shows PIN diodes used for switching purpose helps to vary the frequency. Fig.3 (c) shows SWR of antenna equal to 3.21 which are fairly close to the simulation result. Fig. 3(d) shows Omni directional radiation pattern and gain is equal to -47dBm.



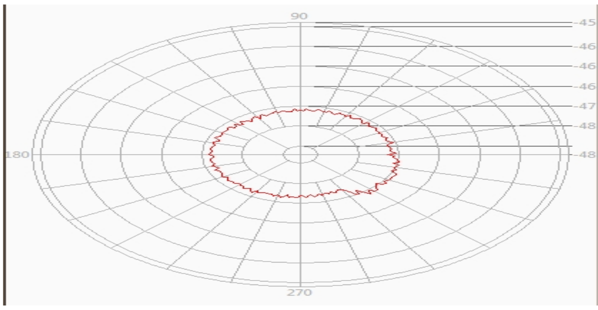
.(a)



(b)



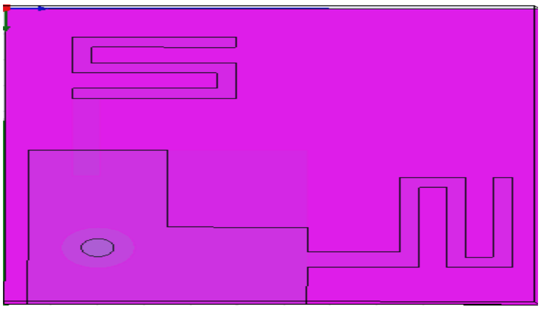
. (c)



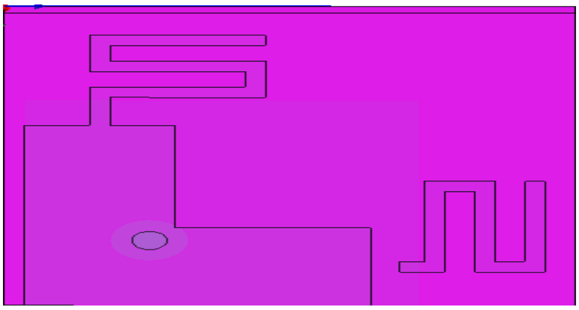
(d)

Figure 3 : (a).Fabricated Structure of frequency reconfigurable antenna, (b) Arrangement of PIN diodes, (c) VSWR, (d) Radiation Pattern of frequency reconfigurable antenna.

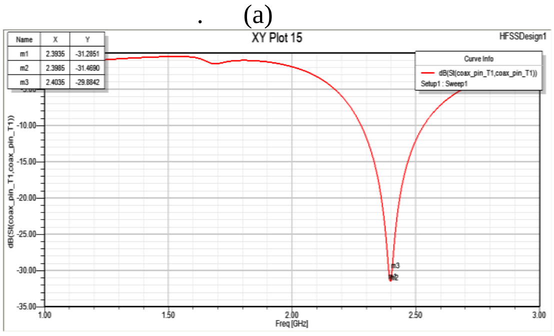
3.3 Polarization Reconfigurable antenna-



. (a)



(b)

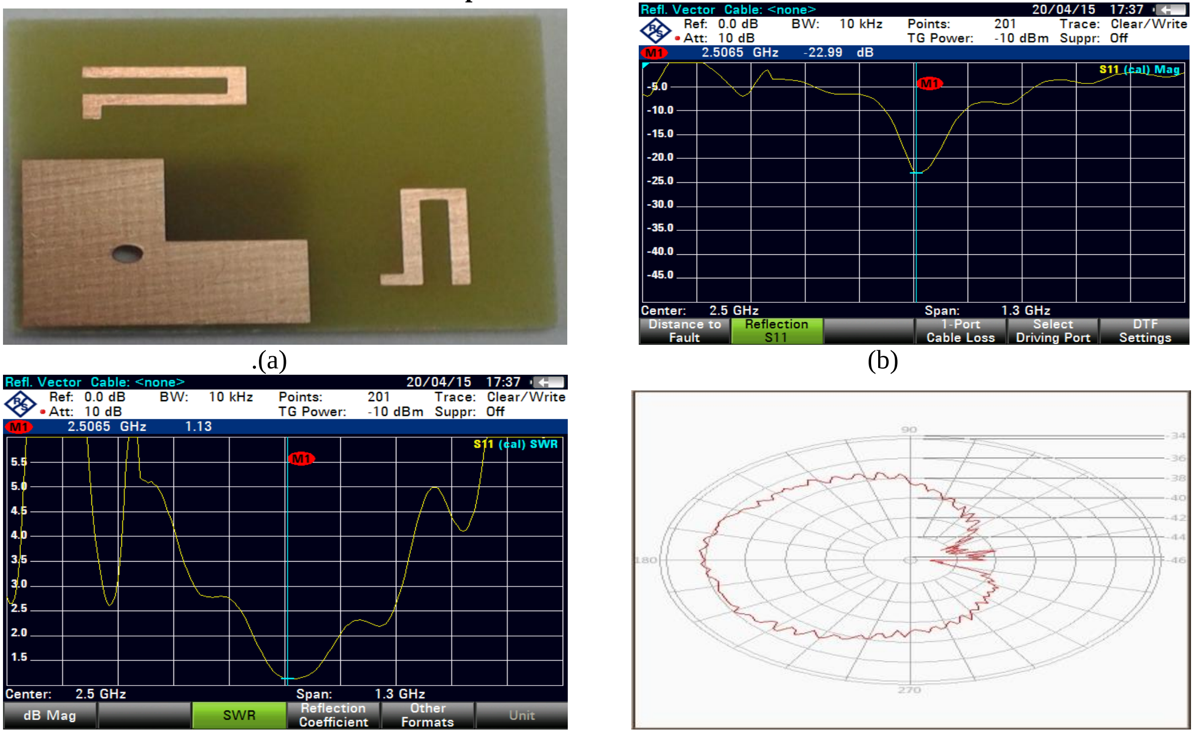


.(c) (d)

Figure 4: (a) Structure of polarization reconfigurable horizontal antenna, (b) Structure of polarization reconfigurable vertical antenna, (c) Return Loss, (d) Radiation Pattern of reconfigurable antenna.

Fig. 4 (a-b) shows meander shape horizontal and vertical polarization reconfigurable antenna. In this design two meander antennas are placed orthogonally and at a time only one antenna comes into effect. Fig. 4 (c) shows low return loss of -20.20dB and Fig. 4(d) shows Omni directional radiation pattern in the horizontal plane. Depending upon the selection of antenna, the radiation pattern shifts from vertical to horizontal plane.

3.4 Fabricated antenna structure and Experimental Results



.(a) (b)

.(c) (d)

Figure 5: (a).Fabricated Structure of Polarization reconfigurable antenna, (b) Return loss, (c) VSWR, (d) Radiation Pattern of polarization reconfigurable antenna.

Fig. 5 (a) shows polarization reconfigurable antenna fabricated on FR4 substrate. Here two antennas are placed orthogonally and feed is given to antenna and polarization is varied by using switching between vertical to horizontal antenna. Fig. 5 (b) shows -22.99 dB return loss when any of the antennas is switched ON. Fig. 5 (c) shows very low SWR of the order 1.13. Fig. 5(d) offers Omni radiation pattern with gain equal to -36dBm.

Table 3: Summary of Result

Antenna	Frequency Reconfigurable		Polarization Reconfigurable	
	Simulation Result	Experimental Result	Simulation Result	Experimental Result
Gain	0.9dB	.6dB	2.8dB	2.6dB
Return loss	-14dB	-14.84dB	-29.88dB	-22.99dB
VSWR	3.2	3.21	1.05	1.13
Radiation Pattern	Omni Directional	Omni directional	Omni directional	Omni directional

Table 3 shows comparison of simulation and experimental results of frequency reconfigurable antenna and polarization reconfigurable antenna. From Table 3 it is seen that the simulation and experimental results shows closed math for both types of reconfigurations.

IV. CONCLUSION

The polarization reconfigurable antenna and frequency reconfigurable antenna are simulated, fabricated and tested in laboratory on VNA (vector network analyser). From the Table 3 it is observed that, the Polarization Reconfigurable antenna-Return loss (-22.99dB) which is less than frequency reconfigurable antenna, VSWR of Polarization reconfigurable antenna (1.13) is less than frequency reconfigurable antenna. Gain (2.6dB) of polarization reconfigurable antenna is higher than frequency reconfigurable antenna. Thus, from obtained results it is concluded that Polarization Reconfigurable antenna is better than Frequency Reconfigurable antenna and can be used in portable device for wireless communication.

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