Simulation of Proposed Miniaturized Reconfigurable Antenna for Wireless Communication

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Abstract
In recent years, there is a huge demand for reconfigurable antenna technique provides large bandwidth and wideband antennas to satisfy the increasing demands for wireless communication application. The frequency reconfiguration patch antennas that has extensively reduced the complexity in structure and thereby the antenna size. As frequency is inversely proportional to dimension of an antenna, the larger the length the smaller is the frequency of operation.

Keywords*-Reconfigurable antenna, PIN diodes, frequency reconfiguration, micro strip patch*

INTRODUCTION
In recent years, there is a huge demand for reconfigurable antenna technique provides large bandwidth and wideband antennas to satisfy the increasing demands for wireless communication application [1].

In communication system, it is difficult to provide a single antenna for different applications. Reconfigurable antenna is an antenna capable of modifying dynamically its frequency and radiation properties in a controlled manner [2]. Reconfigurability can be achieved by using RF PIN diodes, Varactor diode. Reconfigurable antennas can address complex system requirements by modifying their geometry and electrical behaviour, thereby adapting to changes in environmental conditions or system requirements (i.e. enhanced bandwidth, changes in operating frequency, polarization, and radiation pattern) [3].

This work deals with the design of concept of a miniaturized reconfigurable antenna, the most commonly used Micro-Strip Patch antennas are rectangular and circular patch antennas. These patch antennas provided different characteristics such as dual characteristics, circular polarizations, dual frequency operation, frequency agility, broadband width, feed line flexibility, beam scanning [4].

The proposed antenna operates in distinct wireless communication band between the frequency range (1.6 GHz to 5.8 GHz) [5]. Objectives of this work is to calculate overall performance of the reconfigurable antenna and to implement several functionalities on same antenna which is low profile and compact that could be easily integrated to movable devices [6]. To design a Multiband antenna by using switching configuration in reconfigurable antenna. As PIN diodes are used for switching purpose because they require lower biasing voltages. PIN diode operates in two modes the “ON” state, where the diode is forward biased and “OFF” state where the diode is not biased [7].

ANTENNA GEOMETRY
The antenna design (reference antenna for 2.5 GHz) is implemented in CST microwave studio 2014 and the structure is shown in fig. 1. Substrate material FR-4 (lossy) is used between ground and patch

with dielectric constant of 4.3. Patch has the dimension of 36.85 mm X 44.29 mm and it is fed with quarter wave transformer. On the patch slots are made as shown in fig. 2. To implement frequency reconfigurability a PIN diode (BAP50_02) is used as a switch. To design the antenna following formulae [8-10]

Antenna design

(1) Ground plane

(2) Substrate

- FR4 (Ɛr=4.4)
- Roger_RT Duroid(Ɛr=2.32)
- Quartz (Ɛr =3.8)
- Alumina (Ɛr =10)

(3) Patch

- Microstrip patch
- Microstrip slot patch
- Printed dipole patch

(4) Feed

- Microstrip line feed
- Coax feed
- Aperture feed
- Proximity feed

The antenna design is implemented in CST microwave studio 2014.The microstrip antenna consists of a very thin (t) metallic strip (patch) placed on a small fraction of a wavelength (h) above aground plane. The ground plane and a patch are separated by a dielectric with constant [11].

Substrate is used between ground and patch with dielectric constant. Patch is feed with the microstrip feed line. To implement frequency reconfigurability a PIN diode is used as a switch. To design the antenna following formulae were used:

To find the width of the patch,

$$W=\frac{c}{2fr}\sqrt{\frac{2}{\varepsilon r+1}} \qquad (1)$$

Where,

c = 3×10^8 m/s,

f_r =Resonating frequency and

Ɛr = dielectric constant.

Length of patch can be obtained by

$$L=L_{eff}-2\Delta L \qquad (2)$$

Where,

$$\Delta L=0.412h\left[\frac{(\varepsilon reff+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon reff-0.258)\left(\frac{W}{h}+0.8\right)}\right] \qquad (3)$$

$$\varepsilon_{reff}=\left(\frac{\varepsilon r+1}{2}\right)+\left(\frac{\varepsilon r-1}{2}\right)\left[1+12\left(\frac{h}{W}\right)\right]^{-1/2} \qquad (4)$$

$$Leff=\frac{c}{2fr}\sqrt{\frac{2}{\varepsilon reff}} \qquad (5)$$

The dimensions of substrate is given by

$L_{g=L+6h}$

$W_{g=W+6h}$

$$h=\frac{0.606\lambda}{\sqrt{\varepsilon r}}$$

Feed line length is given by

$$\text{Feedlength}(L_f)=\frac{\lambda_g}{4} \qquad (6)$$

Guided Wavelength

$$\lambda_g=\frac{\lambda}{\sqrt{\varepsilon reff}} \qquad (7)$$

Efficiency of antenna (η)

$$\eta=\frac{gain}{directivity}\times 100\%$$

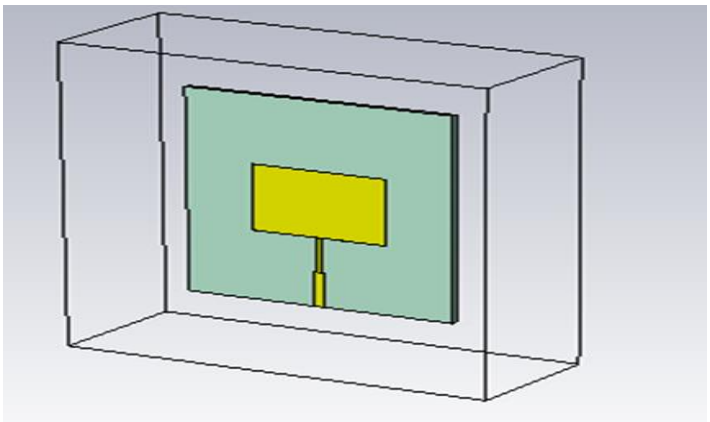

***Figure 1:** Microstrip Patch Antenna (reference antenna)*

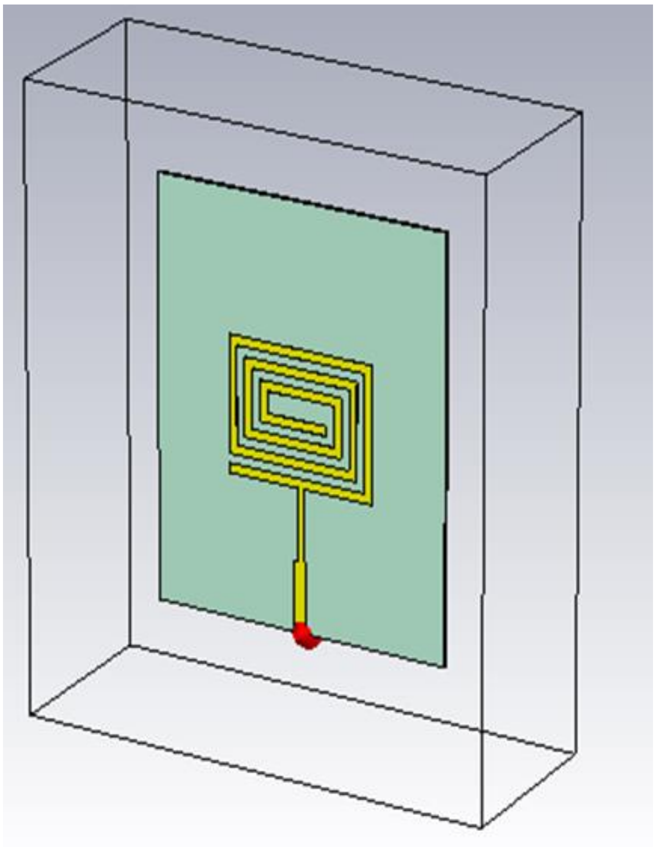

Figure 2: *Slotted Microstrip Patch Antenna*

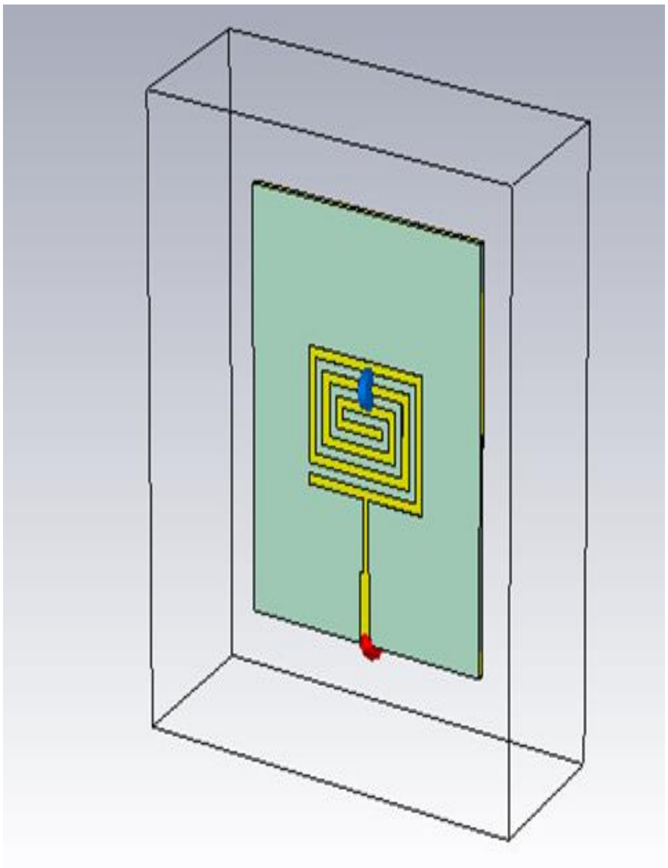

Figure 3: *The proposed antenna geometry*

The dimensions of various parameters used for designing antennas are provided in Table 1.

Table 1: *Different parameters value used for designing the reference antenna, slot antenna and proposed reconfigurable microstrip patch antenna*

Parameter List

Name /	Value	Description	Type
d_gap	2	diode gap	None
h	1.6	substrate height	None
L1	30.0129	diatance from subs	None
L2	2.2	gap between strip	None
L3	2.2	width of slot line	None
Lf	14.9985	feed length	None
Lg	88.5976	Substrate length	None
Lp	28.56	patch length	None
Lt	15.1144	transmission line le	None
t	0.035	copper thickness	None
Wf	3.1144	feed width	None
Wg	73.7154	substrate width	None

RESULTS AND DISCUSSIONS

Graph of return loss versus frequency for microstrip antenna (reference antenna) is shown in fig. 1. Microstrip antenna is radiating at 2.4808 GHz with a return loss of -20.72 dB. Fig.4

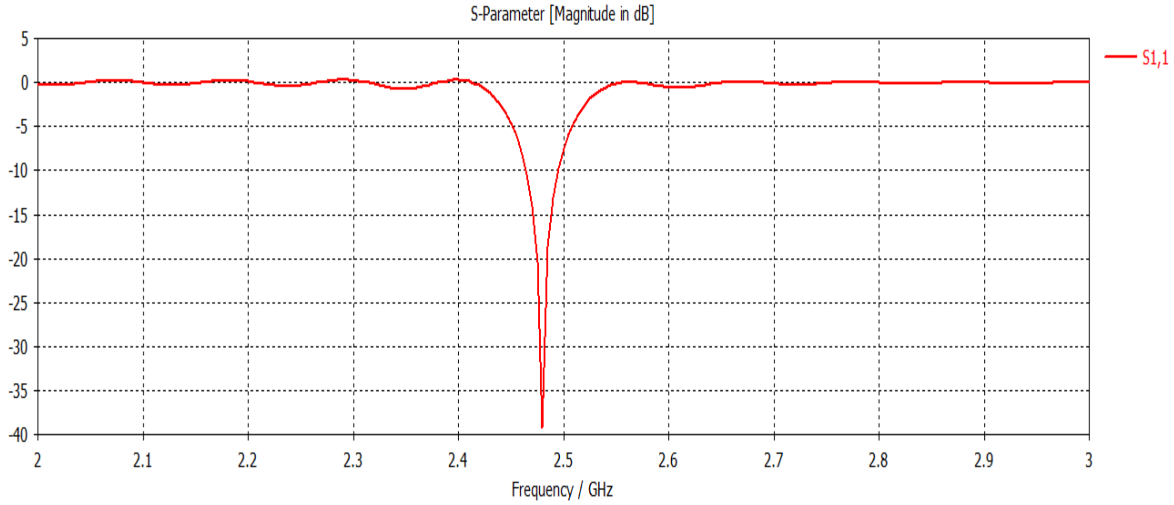

Figure 4: *Graph of Return Loss Vs frequency for reference Antenna*

Effect of Slots

Slots are made on to the patch as shown in fig. 2. The designed slotted antenna is radiating between 2.746 GHz to 5.9416 GHz as shown in fig. 5.

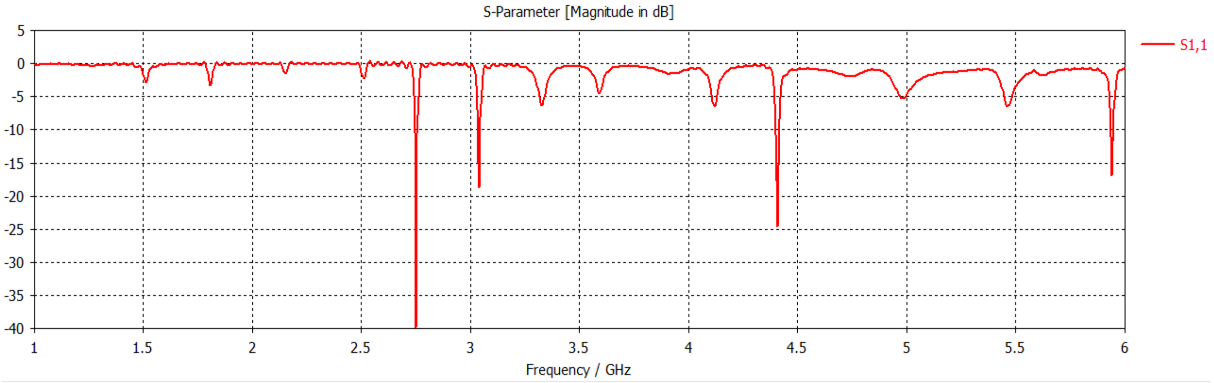

Figure 5: *Graph of Return loss Vs frequency for Slotted antenna*

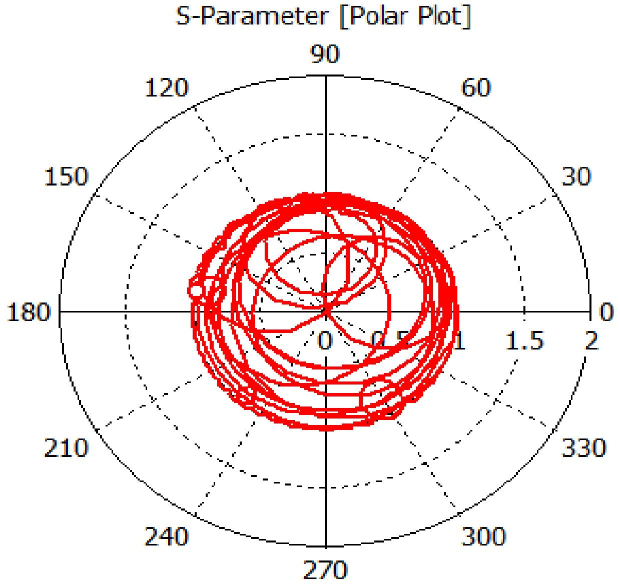

Figure 6: *Polar Diagram*

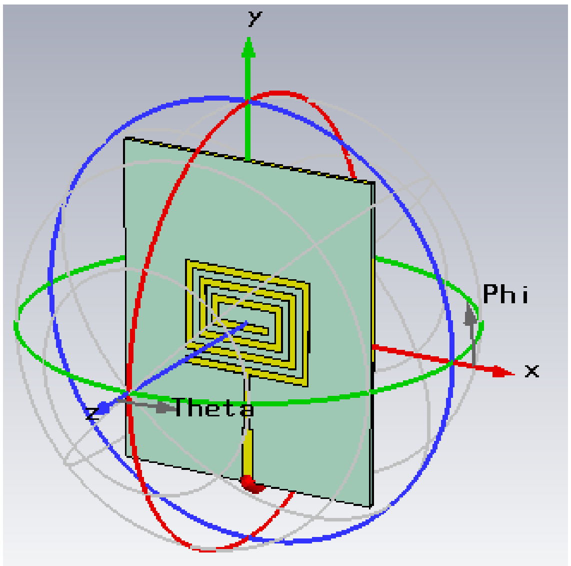

Figure 7: *Farfield*

Effect of PIN Diode

PIN Diode is inserted as shown in the fig. 3. For ON condition, the antenna is resonating at six different frequencies with wide bandwidth. For OFF condition, antenna operation is almost same as that of slotted antenna without a PIN Diode but with low return loss and improved bandwidth. When PIN diode is ON, length of the current path increases as compared to the OFF condition. Due to this antenna resonates at lower frequencies for ON condition and high frequencies for OFF condition. The return loss graphs for ON condition and OFF condition are shown

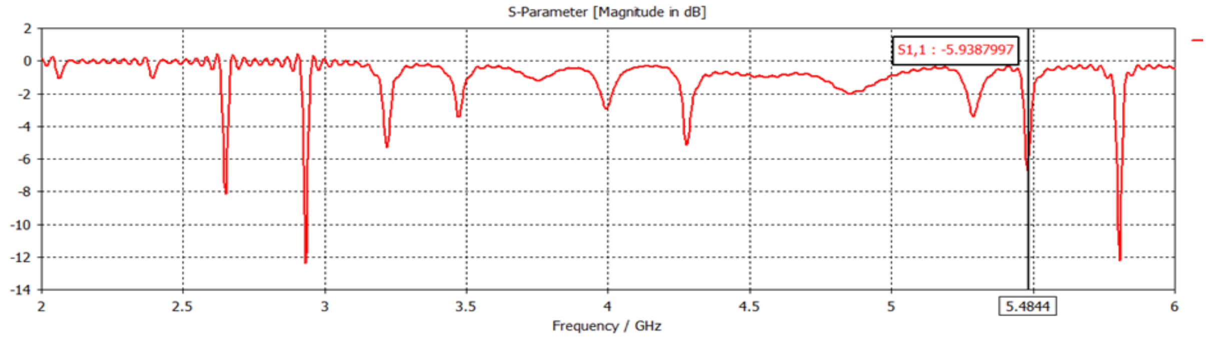

Figure 8: *Graph Return loss*

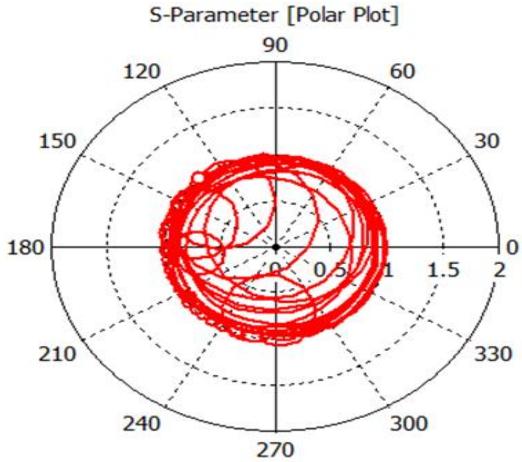

Figure 9: *Polar diagram*

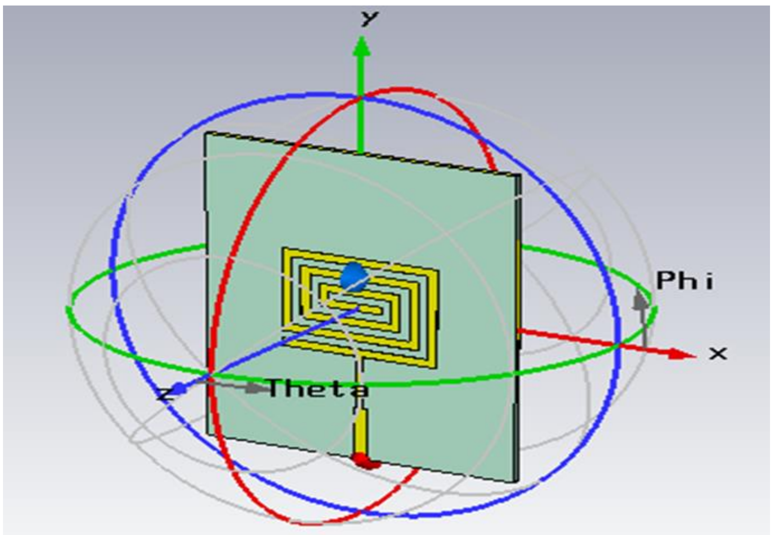

Figure 10: *Farfield*

CONCLUSION

The frequency reconfigurable antenna has been designed and simulated by computer simulation technology (CST) software. The simulation results show that by using PIN diode the antenna can be reconfigured for different frequencies such as 3.3528GHz, 4.0671GHz, 4.6818GHz, 5. 6039GHz.As a result, the proposed antenna is used for various multi frequency systems.

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