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Research paper

Reconfiguration of Circular Microstrip Patch Antenna for Wireless Applications

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Abstract

Reconfigurable antennas provide a possible solution to solve the related problems using the ability to switch frequency, patterns and polarization. This paper represents a possible application in wireless communication using reconfigurable Microstrip patch antenna. The dielectric substrate of proposed circular Microstrip patch antenna is fabricated with FR 4 epoxy and patch design 40x40x1.6mm. This work provides a methodology to design reconfigurable antennas with PIN diode switch. The frequency reconfiguration achieved by PIN diodes At the range of 3 GHZ to 6.9 GHZ the frequency reconfigurability is realized. To resonate the antenna at various frequencies PIN diode is used. Simulation of Ansoft HFSS software is used to compute the gain, axial ratio, radiation pattern, and return loss of proposed antenna. The structure of circular patch antenna achieves an enhanced wide bandwidth. The results show a better frequency reconfiguration.

Keywords: *Ansoft HFSS, circular patch microstrip Antenna, PIN diode, frequency reconfiguration, FR 4 Epoxy, wide bandwidth.*

1. Introduction

The antenna is the important component in the construction of every wireless communication system. Antenna plays a part of transmitting or receiving system it is designed to radiate or receive electromagnetic waves. Microstrip patch antenna is attractive due to their light weight, conformability and low cost. It consist of a radiating patch on one sideof a dielectric substrate and ground at in the other side. The dielectric substrate is made up of FR 4 epoxy. The patch, ground and transmission line feed is made up of copper.

Reconfigurable antennas are used to cover different wireless channels over a wide frequency range for the best of our requirement a circular patch antenna can be used. It is light weight, low cost and it is more useful as a communicating antenna. Reconfigurability can be achieved by using diverse types of switches like FET, PIN-Diode and varactor diode, among them PIN –Diode is being mostly used due to its high switching speed. Communications systems require faster data transmission and better spectrum usage according to user's priorities.

In this paper circular shaped patches are used which are connected by two PIN-Diode switches to attain reconfigurability. Frequency reconfiguration is achieved by changing the switch condition based on the requirement.

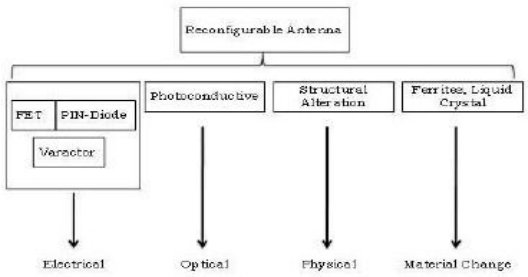


Figure 1: Reconfiguration of implementation of antennas

2. Reconfigurable Circular Shaped Patch Antenna Concept

Antenna Design

The proposed patch antenna is made up of FR4 substrate material that has relative permittivity 4.4 and loss tangent 0.02. PIN diodes are introduced for frequency reconfiguration. The resonating mode can be manipulated by turning ON and OFF switches. The design of the proposed antenna is shown in Figure 2 represents the PIN diode switch (S1 and S2). The dimensions for the design are shown in Table 1 and the substrate thickness is taken to be 1.6 mm. Transmission line is used as a feed to the antenna with an input impedance of 50 ohms.

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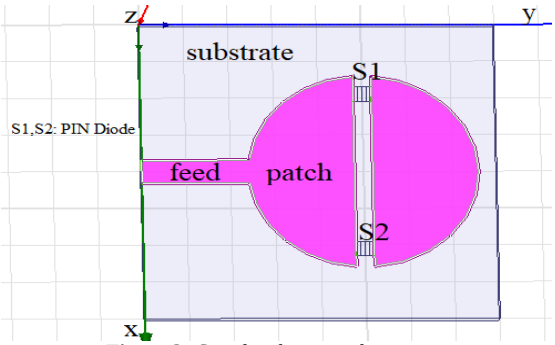


Figure 2: Circular shape patch antenna

PIN Diode Switch

The PIN diode switch is famous in microwave circuits due to its fast Switching times . It can operate at speeds orders of magnitude faster than mechanical switches. Switching speeds of less than 100 ns are typical. The slot is incorporated in to the patch and the P-I-N diode is introduced in between the patch. While ON and OFF the P-I-N diodes frequency reconfiguration is achieved.

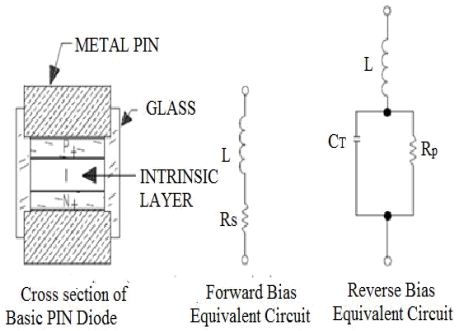


Figure 3: PIN diode cross section and its circuit equivalents

Table 1: Dimensions of the Proposed Design

L_g	40mm
W_g	40mm
L1	3.2mm
W1	15mm
L_f	15mm
W_f	3.2mm

3. Comparisons of Proposed Methods

The antenna has two PIN diode switches and when compared with existing methods the power consumption is less and simulation time is less. Reconfigurability is achieved by PIN diodes at different frequencies. Dimensions are less comparatively with other devices. Low cost compared to existing system because only two switches are used. Totally nine resonant frequencies are obtained at different switching states.

4. Simulation Results

The antenna is simulated by Ansoft HFSS software. Figure 2 shows three-dimensional view of proposed structure. The antenna Reconfigurability is implemented by using two switches S1 and S2 which incorporated between the patches. The circuit model for on and off state of the PIN diode is shown in Figure 3. In case of ON state both resistor and inductor are in series connection and in case of OFF state, resistor and capacitor are parallel to each other and in turn series with the inductor. The obtained reflection coefficient result shows that proposed antenna is able to resonate at different frequencies with switch conditions as summarized in Table 2. Figure 4 shows the reflection coefficient results at different switching conditions. When all the switches are closed the transmit frequency is at two frequencies i.e. 4.4 GHz and 5.92 GHz with return loss of -22.89 dB and -27.32 dB respectively. When all the switches are in "ON" state the transmit frequency is at two frequencies i.e. 3.02 GHz and 5.81 GHz with the return loss of -27.66 dB and -30.32 dB respectively. When S1 is in "ON" state and S2 in "OFF" state the transmit frequency is at dual frequencies i.e. 3.85GHz and 5.91 GHz with the return loss of -26.08 dB and -29.18 dB respectively. When S1 is in "OFF" state and S2 in "ON" state the transmit frequency is at dual frequencies i.e. 3.9 GHz and 5.99 GHz with the return loss of -26.19 dB and -29.98 dB respectively as shown in figure 4.

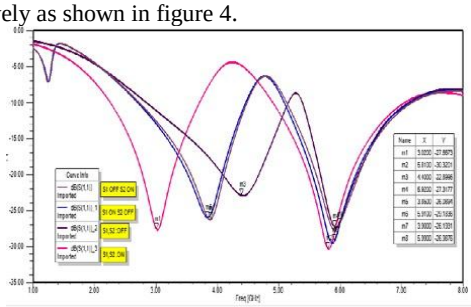
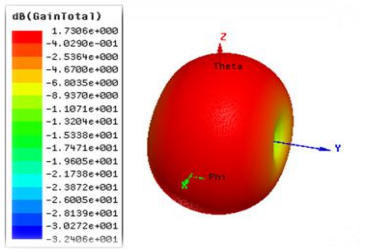


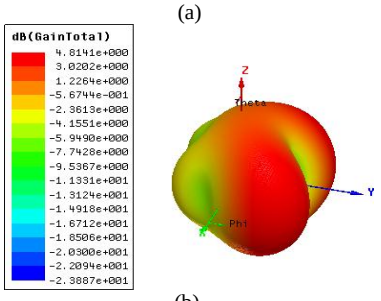
Figure 4: Return loss plot for switching condition

5. Gain

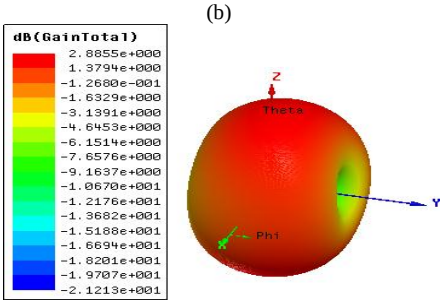
The Gain plot of the proposed structure is obtained and shown in Figure 6.1.; the antenna gain can be compensated for using high power input in transmitter and high power irradiation in receiver. Figure 6.1 shows the radiation patterns for several operational frequencies in wireless applications. The calculated radiation patters at 4.4, 5.92, 3.02, 5.81, 3.85, 5.91, 3.9, 5.99 GHz are shown in Fig. 6.1 We can see that in general the designed antenna has quite good radiation patterns. However, some distortion might occur for several operational frequencies due to slightly miss matching condition.



(a)



(b)



(c)

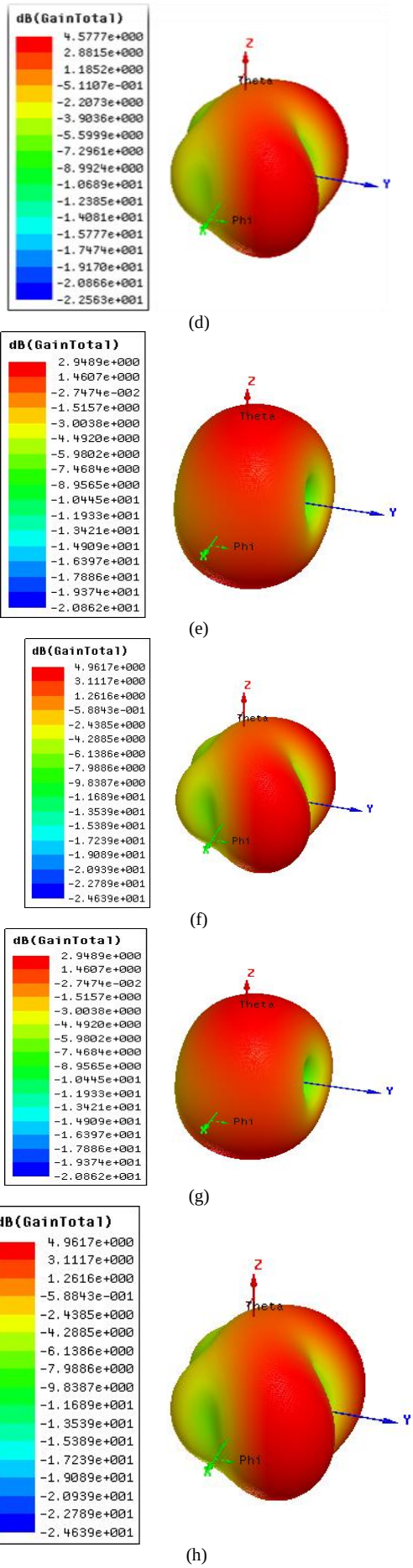
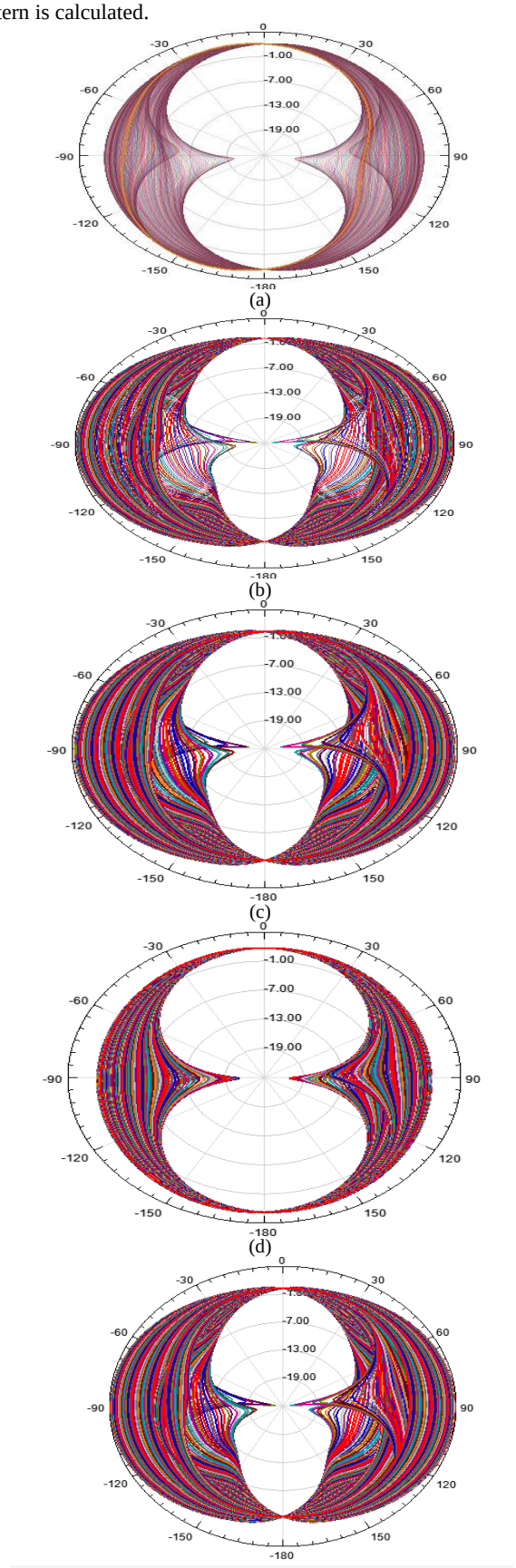


Figure 5: 3D Gain of the proposed antenna at (a) 4.4 GHZ, (b) 5.92 GHZ, (c) 3.02 GHZ, (d) 5.81 GHZ, (e) 3.85GHZ, (f) 5.91 GHZ, (g) 3.9 GHZ, (h) 5.99 GHZ

6. Radiation pattern

A power radiated by an antenna is known as radiation pattern. The radiation pattern of an antenna is a plot of the far-field radiation from the antenna. By using HFSS software the far-field radiation pattern is calculated.



(a) (b) (c) (d) (e)

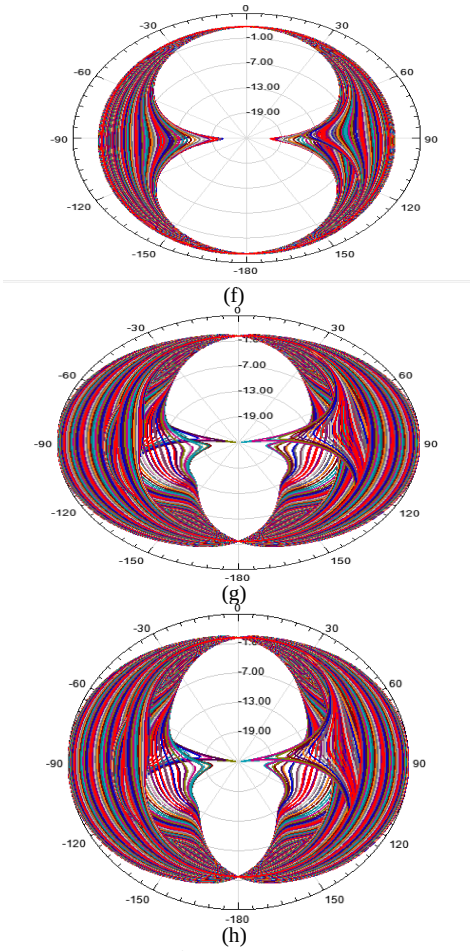


Figure 6: Radiation pattern of the proposed antenna At (a) 4.4 GHz (b) 5.92 GHz (c) 3.02 GHz (d) 5.81GHz (e) 3.85 GHz (f) 5.91 GHz (g) 3.9 GHZ (h) 5.99 GHZ

Table 2: Switch Condition and Transmit Frequency

Switch Condition	Transmit Frequency
All switches closed	4.4 GHZ, 5.92 GHZ
All switches open	3.02 GHZ, 5.81 GHZ
S1 ON and S2 OFF	3.85 GHZ, 5.91 GHZ
S1 OFF and S2 ON	3.9 GHZ, 5.99 GHZ

7. Conclusion

The design of Microstrip patch antenna and simulation is done by HFSS simulation tool. Using the switches between patches the reconfigurability is achieved at various frequencies. At 4 GHZ to 8 GHZ the frequency reconfigurability is achieved. This result shows better agreement with frequency reconfiguration for various applications.

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