Dual Band Re-Configurable Pin Diode Based Microstrip Patch Antenna with and without Slot

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Abstract — *This paper is a comparative study of a rectangular microstrip patch antenna and a rectangular slotted reconfigurable microstrip patch antenna with pin diode. Antenna 1 has rectangular patch and Antenna 2 has a slot and a pin diode between slotted areas of the rectangular patch. The analysis is based on the antenna parameters such as return loss, VSWR, gain, directivity and radiation pattern and the operating frequency. As per IEEE standard, the designed antennas are applicable for k and Ka band application. The design and simulation has been done by using Ansoft HFSS software with substrate FR4_epoxy, which has dielectric constant 4.4 and tangent loss 0.02. The analysis shows that the values of antenna parameters change with the change in the geometry of the patch such as introducing slots and pin diode. The designed antenna has the operating frequencies of 19.35 GHz, 19.94 GHz, 27.04 GHz and 28.22 GHz and return loss of -27.85 dB, -23.26 dB, -33.05 dB, -25.86 dB and stable radiation pattern, omnidirectional and circular polarization at these operating frequencies.*

Keywords — *Rectangular Patch, Re-configurable, Pin diode, Microstrip Patch Antenna, HFSS.*

I. INTRODUCTION

Antenna is defined as the interface between the current moving in the conductor of the antenna terminals and electromagnetic waves traveling in the space, simply a device for receiving or transmitting radio waves. Among the various types of antenna such as wire antenna, aperture antenna, reflector antenna and lens antenna etc., microstrip patch antenna has drawn the attention of many researchers and has become very popular in recent time [1], [2]. Especially for airborne RADAR, microwave links for backhaul purpose, satellite communication, satellite and radar are mainly needed for weather forecast, airport traffic control and automatic application [3]. Microstrip patch antennas are popularly known by different names like printed antenna, microstrip antenna or in short patch antenna. The configuration of microstrip patch antenna may vary as per the application and desired operating frequencies band. It consists of the radiating patch at the upper side and ground plane at the lower side of dielectric substrate material [4]. The conducting material of the patch can be either Copper (Cu) or Gold (Ag) and can be in any shape like rectangular, square, circular, elliptical, pentagonal, hexagonal and flexible in shape and type of substrate material [5]. Microstrip patch antenna must have low relative permittivity to increase the fringe fields which are responsible for the radiation mechanism of the antenna [6]. Microstrip patch antenna has attractive features among others like small size, low weight, low manufacturing cost, ease of fabrication, ease of being integrated on the circuit and has dominant characteristics such as low profile, low radiation loss, multi band frequency, integration with microwave integrated circuit and comfortable to planer and non-planer surfaces [7],[8]. Microstrip feeding technique is one of the feeding type commonly used because of its simplicity and edge of integration conducting type of feeding technique in which RF power is directly attached with the radiating patch [9]. Slots in the radiating microstrip patch can be helpful for the changes in the values of the antenna parameters and to obtain the desired operating frequencies [10].

In recent time, frequency reconfigurable antenna has great demand especially for wireless communication because of its dynamic ability to adjust for different antenna parameters like return loss, VSWR, gain, directivity, polarization, radiation characteristics and also for operating frequencies re-configurability, which can be achieved by using pin diode as a switch (ON-OFF) mode [11]. Apart from the antenna parameters and operating frequency re-configurability, re- configurable antenna also has many features like multipurpose functions, size miniaturization, low cost, compact size, similar radiation characteristics, proper gain [12],[13]. The key advantages of using re- configurable antenna is that, it can reduce the hardware complexities, size, number of components and number of antenna required for the same purpose as single antenna can perform for more than single band of frequencies with frequency re- configurability function [14].

II. ANTENNA DESIGN

The microstrip patch antennas have been proposed, designed and simulated by using Ansoft HFSS software with the substrate of dimension 20mm*15mm*1.6mm having dielectric constant 4.4 and tangent loss 0.02. the first structure is just simple having rectangular patch of dimension 8mm*6mm at position (6,5,1.6) and then the rectangular patch is cut with one slot of dimension 8mm*1mm at position (6,8,1.6) in between the slot at the center pin diode in introduced as switch (ON-OFF) mode. Furthermore, it is worth monitoring that the configuration of the pin diode improves the antenna parameters and operating frequencies. The microstrip patch antennas have been excited by microstrip feed line technique at the feeding position (9, 0 and 1.6) which is directly connected with the radiating patch. Figure 1(a) shows the top and side view of rectangular microstrip patch antenna as reference antenna which operates at the resonance frequencies of 19.94 GHz and 27. 04 GHz. Figure 1(b) shows the top and side view of slotted rectangular reconfigurable microstrip patch antenna with pin diode, which operates at the resonant frequencies of 19.35 GHz and 28.22 GHz and also the values for return loss, VSWR, gain, directivity, radiation pattern, electric field current distributions are measured.

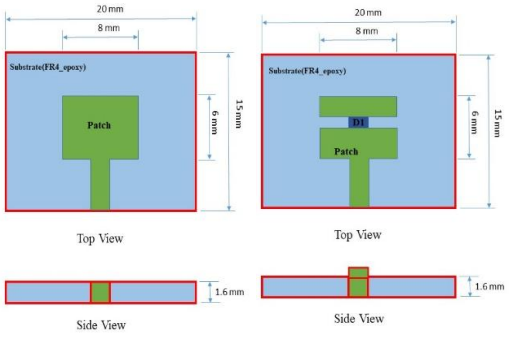

Fig. 1 (a) Antenna 1 Fig. 2 (b) Antenna 2

III. RESULT AND DISCUSSION

The result obtained from the simulation of these antennas with different configuration is discussed in this section.

The operating frequencies of rectangular microstrip patch antenna is 19. 94 GHz and 27.04 GHz, at these resonant frequencies the measured values for return loss are -23.26 dB and -33.04 dB, VSWR 1.2 and 0.39, gain 2.94 and 1.73 also directivity are 3.47 and 2.84, from the E-field current distribution and radiation pattern it has been also observed that, the designed antenna produces omnidirectional radiation and stable radiation pattern throughout the whole operating frequencies with circular polarization. The detailed description of achieved antenna parameters are summarized in the Table 1 and figure shows the graph obtained for frequency verses return loss, VSWR, gain, directivity, radiation pattern and current distribution respectively.

TABLE 1 OBSERVED VALUES FOR ANTENNA 1.

Frequency [GHz]	Return loss	VSWR	Gain	Direct ivity
19.94	-23.26	1.2	2.94	3.48
27.04	-33.05	0.39	1.73	2.84

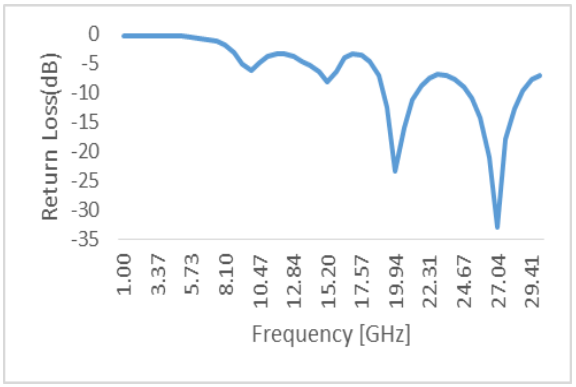

Fig. 2 (a) Frequency vs Return Loss

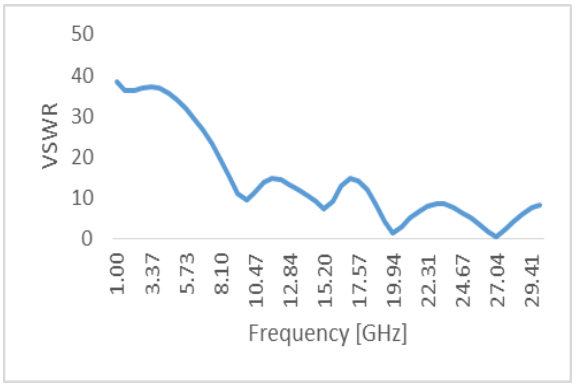

Fig. 2 (b) Frequency vs VSWR

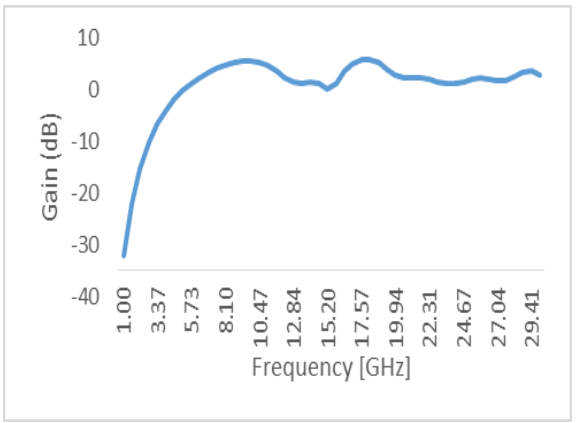

Fig. 2 (c) Frequency vs Gain

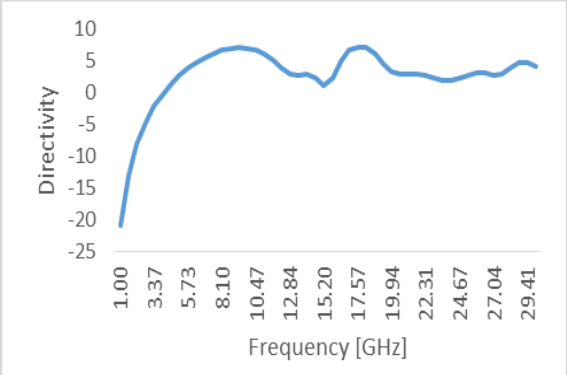

Fig. 2 (d) Frequency vs Directivity

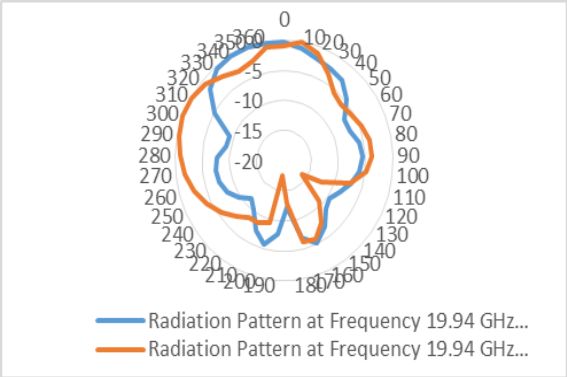

Fig. 2 (e) Radiation Pattern at Frequency 19.94 GHz for E-field at phi '0deg' and H-field at phi '90deg'

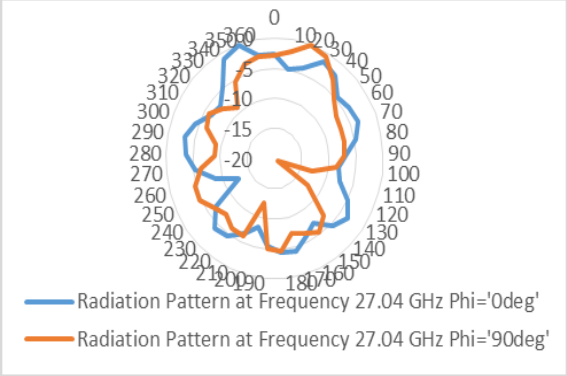

Fig. 2 (f) Radiation Pattern at Frequency 27.04 GHz for E-field at phi '0deg' and H-field at phi '90deg'

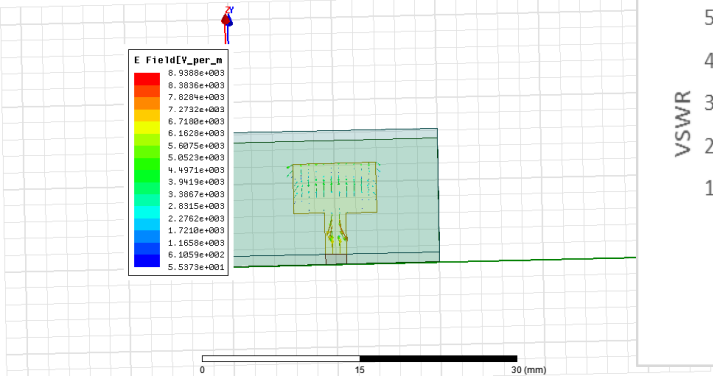

Fig. 2 (g) E-Field current distribution for antenna 1 at resonant frequency.

The result obtained from the simulation for this slotted rectangular microstrip patch antenna with pin diode for re-configurability is discussed in this section.

This antenna operation is based on the performance of pin diode as switch (ON-OFF) mode, which operates at the resonant frequencies of 19.35 GHz and 28.22 GHz when the pin diode is ON and OFF. The detailed description of achieved antenna parameters for diode ON and OFF mode are summarized in the Table 2 and figure shows the graph obtained for frequency verses return loss, VSWR, gain, directivity, radiation pattern and current distribution respectively.

TABLE 2 OBSERVED VALUES FOR ANTENNA 2.

Diode OFF				
Frequency [GHz]	Return loss	VSWR	Gain	Direct ivity
19.35	-27.85	0.7	2.26	2.83
28.22	-25.87	0.88	4.83	6.09
Diode ON				
Frequency [GHz]	Return loss	VSWR	Gain	Direct ivity
19.35	-26.87	0.79	3.56	4.12
28.22	-20.57	1.63	2.74	4.59

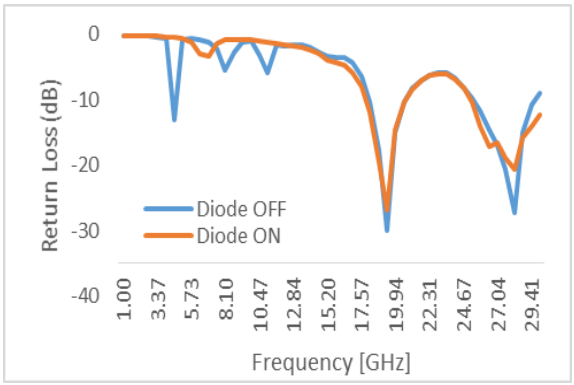

Fig. 3 (a) Frequency vs Return Loss

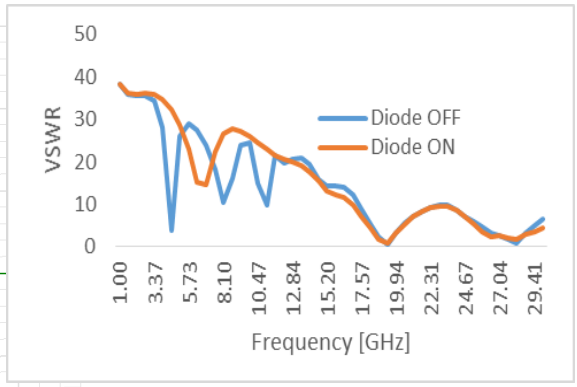

Fig. 3 (b) Frequency vs VSWR

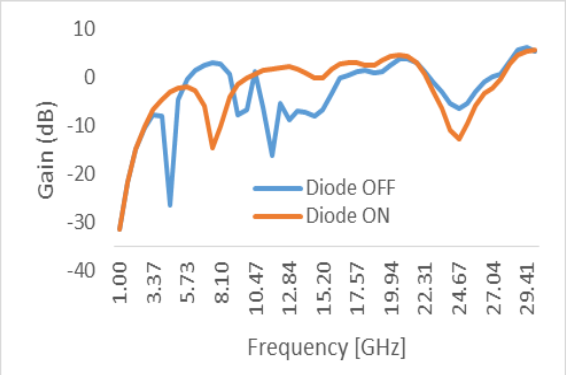

Fig. 3 (c) Frequency vs Gain

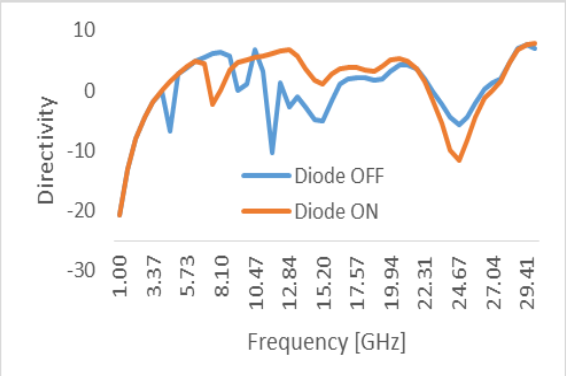

Fig. 3 (d) Frequency vs Directivity

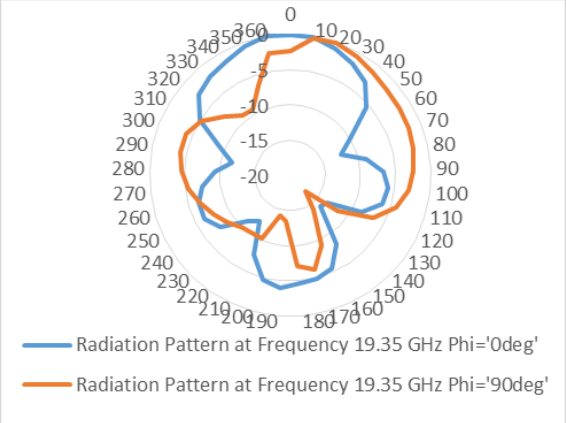

Fig. 3 (e) Radiation Pattern at Frequency 19.35 GHz for E-field at phi '0deg' and H-field at phi '90deg'

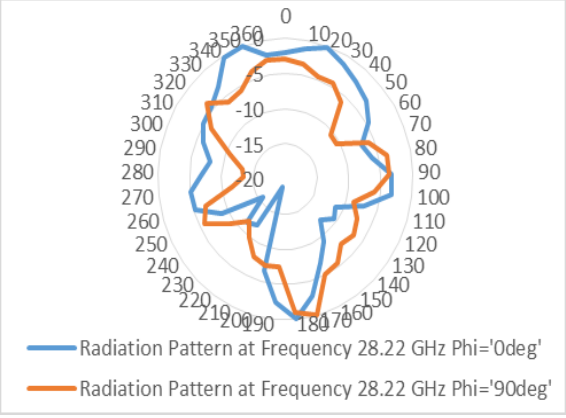

Fig. 3 (f) Radiation Pattern at Frequency 28.22 GHz for E-field at phi '0deg' and H-field at phi '90deg'

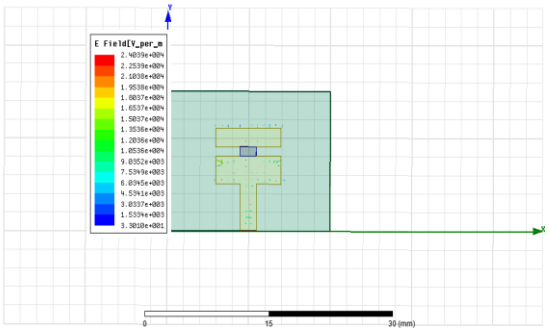

Fig. 3 (g) E-Field current distribution for antenna 2 at resonant frequency.

IV. CONCLUSIONS

Rectangular microstrip patch antenna and slotted rectangular microstrip patch antenna with pin diode for frequency re-configurability has been proposed in this paper. Design and simulation was done by using Ansoft HFSS software with FR4_epoxy substrate. The results have been observed and compared. Both the antennas have good antenna parameters such as return loss, VSWR, gain, directivity and radiation pattern. It has also been observed that use of pin diode as switch has been fruitful for re-configurability of antenna parameters and operating frequencies. Moreover, from the E-field current distribution and radiation pattern it has also been observed that, the designed antenna produces omnidirectional radiation and stable radiation pattern throughout the operating frequencies with circular polarization. The designed antennas may find their application in the field of airborne RADAR, microwave links for microwave backhaul purpose and satellite communication.

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