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Multiband Reconfigurable Slotted Microstrip Patch Antenna

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Abstract: In this paper, a compact frequency reconfigurable slotted microstrip patch antenna is proposed to operate at different frequency bands. These operating frequency bands are3.08GHz, 6.29GHz, 3.16GHz, 5.3GHz, 6.3GHz, 7.1GHz, 6.29GHz, 4.17GHz and 6.31GHz at four different states. The proposed antenna is a single layer microstrip patch antenna consists of four slots and controlled by PIN Diodes. In such antennas, the resonance frequencies can be control by adjusting the mode of the PIN diodes either in on state or off state. The proposed reconfigurable antenna is very useful for different recent communication applications.
Keywords: reconfigurable microstrip patch antenna; frequency reconfigurable; PIN diode switches

Introduction

In today's globe development, communication and wireless system more on demands the use of antennas proficient in accessing services in several frequency bands, by using a single antenna device sometimes [1]. In recent times, these reconfigurable antennas have received a large amount of awareness for their applications in wireless communications, electronic observation and countermeasures, by adapting their properties to get selectivity in frequency, bandwidth, polarization and gain[2]. These reconfigurable rectangular antennas offer more advantages of resourceful use of electromagnetic spectrum, compact size and frequency selectivity which is very useful for eliminating the effects of co-site interference in comparison of the broadband antennas. The Reconfigurability technique is used to enhance the performance of the antenna, and this technique is applied on microstrip patch antennas. For such type of antennas, the shape and placement of switches are very important. In wireless systems, Microstrip patch antennas are used for providing reconfigurability because these antennas have some major advantages. light weight, easiness in integration with RF switches and their fabrication cost is also low. But these more basic printed antenna designs have the disadvantage. i.e. their impedance bandwidth characteristics is narrow.

To achieve the frequency selectivity by changing the states of the switch or PIN diode which is added to the designed antenna.[3]-[8] The PIN diode includes many functions on the reconfigurable antenna. In this paper, for reconfigurable multi-frequency operation, a PIN diode controlled switching technique is presented [9]-[12]. The proposed design is simple, systematic, single feed and reconfigurable. The performance and a comprehensive parametric study of a reconfigurable rectangular microstrip patch antenna which have operating frequency of 3-8GHz have been studied and evaluated to understand the various effects of PIN diode switches state (ON and OFF) and parameters of slots. This reconfigurable rectangular microstrip patch antenna is designed for wireless (WLAN) application which is operating on multiband frequencies. The initial antenna is a conventional of microstrip antenna in which four slots are added on to the patch. This is also known as OFF mode. While the another is known as ON mode in which PIN diode switches are added to the two slots. The proposed microstrip patch antenna is simulated using CST Microwave Studio[13].

Antenna design and configuration

(A)A dual band printed antenna design:

The step by step evolution of the proposed printed antenna is shown in Fig. 1 (a) to (c).Initially a conventional patch antenna is designed which is a microstrip patch antenna having a ground plane as shown in Fig. 1(a) i.e. Antenna I.This antenna resonates at frequencies 3.8GHz,6.2GHz and 6.8GHz. By inserting the two slots on the patch, antenna resonates at two frequencies 6.2GHz and 6.7GHz as shown in Fig 1(b) i.e. Antenna II.Similarly two more slots are etched on the bottom side of the patch, which behaves as quad band antenna and resonates at 3.1 GHz, 5.3GHz,6.2GHz and 6.9GHz frequencies as shown in Fig. 1(c) i.e. Antenna III. The proposed designs are simulated in CST Microwave Studio. S-parameters of all the steps are shown in Fig. 2(a)-(c).

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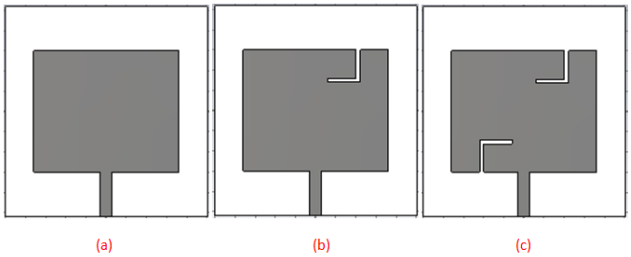
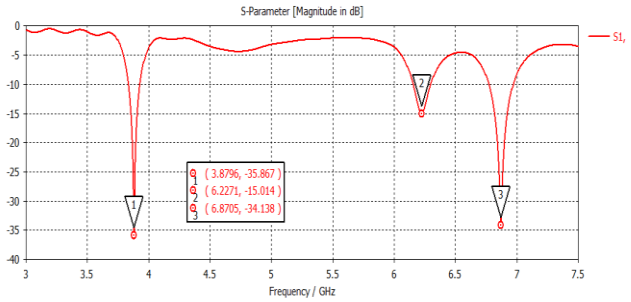
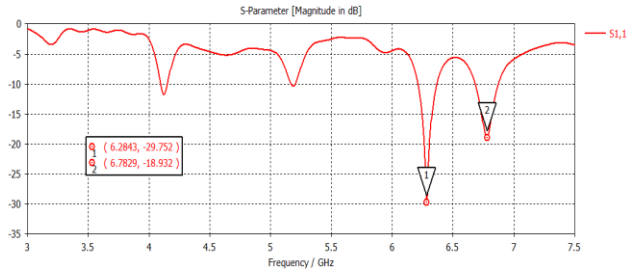


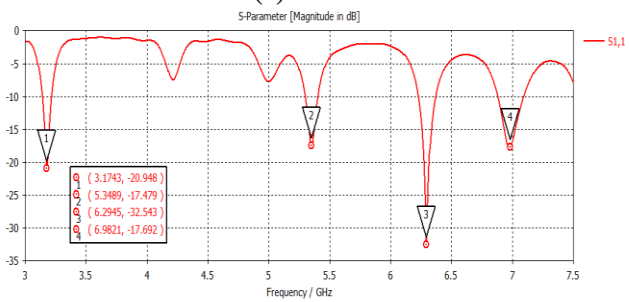
Fig1: Step by step evolution of the proposed Antenna: (a) Antenna I (b) Antenna II (c) Antenna III



(a)



(b)



(c)

Fig2: S11 parameters for different configurations of step by step proposed antennas of Fig1.

B. Design of reconfigurable printed antenna:

The proposed reconfigurable antenna with two PIN diodes is shown In Fig 3.The proposed reconfigurable antenna is designed on a low-cost substrate FR-4. The dielectric constant of the substrate is 4.3,loss tangent is 0.025 and the thickness of the substrate is 1.2 mm. In this paper, the overall size of the proposed microstrip antenna is 50 x 52mm^2. To make sure that antenna impedance should be 50Ω, the size of the feed line of the antenna is adjusted. The size of the slots which are designed on the patch of the antenna may also affect the antenna impedance. A PIN diode D1 is inserted between the slots which are on the upper right side of the patch and another PIN diode D2 is inserted between the slots which are on lower left side of the patch. By changing the biasing states (ON/OFF) of both the diodes, then switchable functionality with quad modes is achieved. The structure is simulated using CST Microwave Studio and diodes are replaced as metal strip for the ease of simulation. The metal strip with the dimension of 1mm x 1mm is connected. If switch is in ON state condition (denoted as 1 in Table 2), the metal strip is connected on the antenna and if switch is in OFF

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state condition (denoted as 0 in Table2) then the metal strip is disconnected. After optimization on CST Microwave Studio, the dimensions of the proposed printed antenna and evolution are shown in Table I.

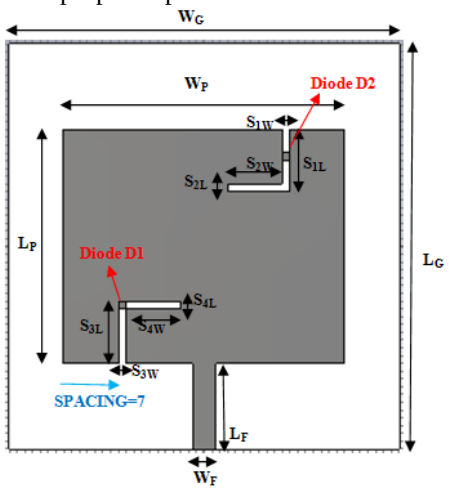

Fig. 3. Configuration of the proposed reconfigurable slotted printed antenna with labelled parameters

TABLE I . OPTIMIZED PARAMETERS OF PROPOSED ANTENNA

Parameters	W_G	L_G	W_P	L_P	W_F	L_F	S_{1L}
Unit (mm)	50	52	36	30	3	11	8
Parameters	S_{1W}	S_{2L}	S_{2W}	S_{3L}	S_{3W}	S_{4L}	S_{4W}
Unit (mm)	1	1	7	8	1	1	7

Result and discussion

The proposed compact printed quadband reconfigurable slotted patch antenna results have been presented in this section.The parametric analysis has been done for the placement of diodes D1 and D2 in x and y direction as shown in Fig. 4. Different combinations of diodes D1 and D2 in ON and OFF states with their S11 parameters are shown in Fig. 5. For mode 1, the antenna provides dual band functionalitywhen both diodes are in OFF state which has impedance bandwidths of 273MHz(3.048–3.321GHz), 231MHz(5.235GHz-5.466GHz), 461MHz (6.778GHz-7.239GHz) and 316 MHz(6.154–6.470 GHz). It is visible from the results shown in Fig 4, when the state of the switches changes from one state to another state,frequencybands shiftalso changes. For mode2,the antenna provides quad band functionality when diode D2 is in ON state and diode D1 is in OFF state which is resonating at 3.16 GHz, 5.23GHz, 6.29GHz, and 7.10GHz which have impedance bandwidth of 149GHz(3.09-3.240GHz), 265GHz (5.112-5.377GHz), 382GHz (6.161-6.543GHz), and 196GHz (7.010-7.206GHz) similarly for mode 3,the antenna provides single band functionality when diode D1 is in ON state and diode D2 is in OFF state and resonate at 6.29 GHz frequency which has impedance bandwidth of 312GHz (6.170– 6.482GHz) and 399MHz(6.756GHz-7.155GHz).And for mode 4, when both diodes are in ON state and resonates at3.14GHz and 6.29GHz which have impedance bandwidth of 273GHz (3.048-3.321GHz) and 316GHz (6.154-6.470GHz).All the combination modes of the two diodes are illustrated in Table II.

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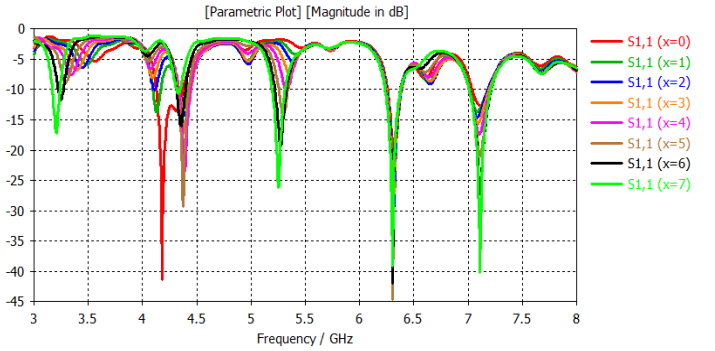
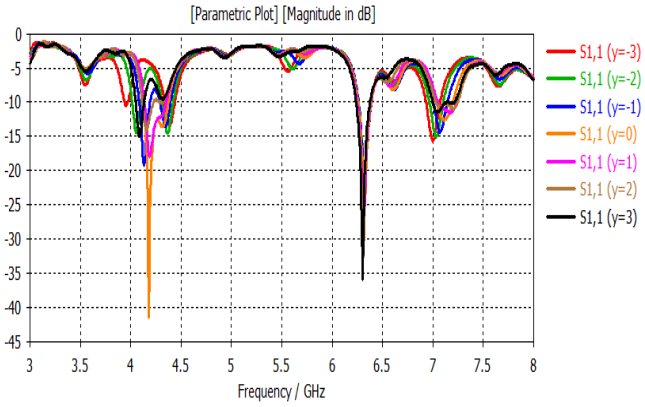
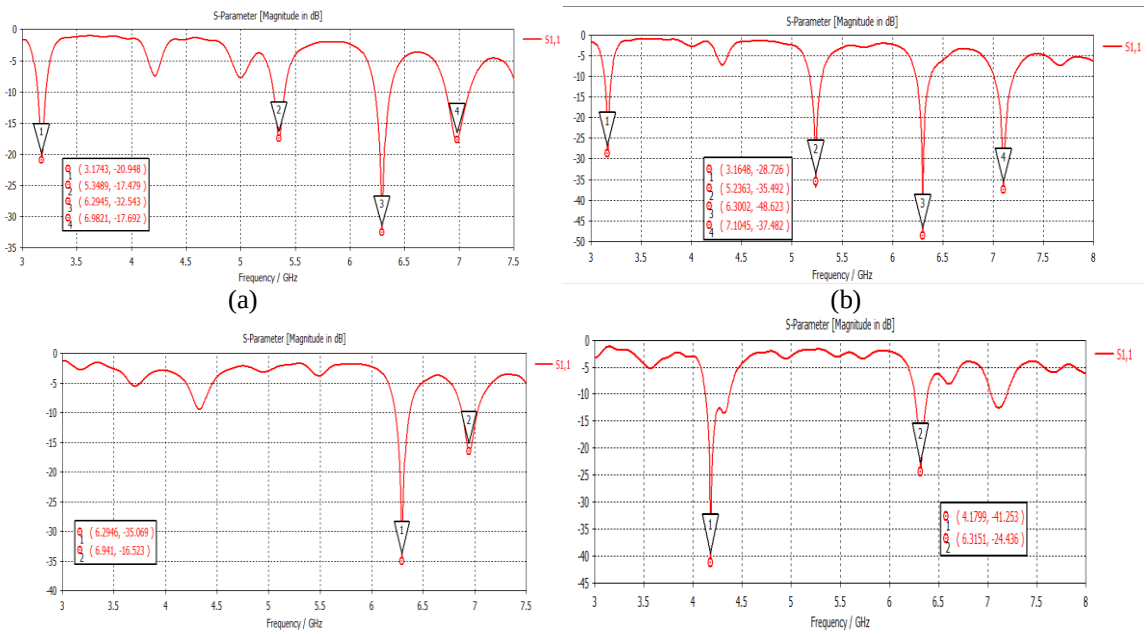


(a)



(b)

Fig. 4. Parametric S11 parameter while placing the diodes in (a) X-direction (b) Y- direction



(a) (b)

(c) (d)

Fig. 5. S11 parameters of the proposed reconfigurable antenna (a) mode 1 (b) mode 2 (c) mode 3 (d) mode 4.

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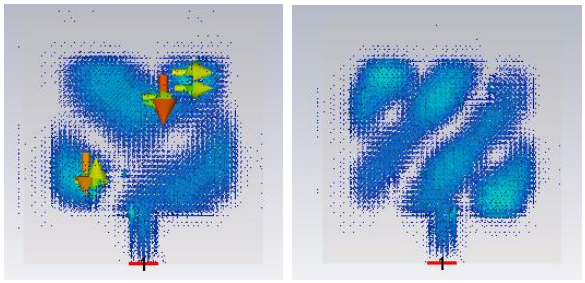
TABLE II: DIFFERENT FREQUENCY PARAMETERS AT DIFFERENT MODES

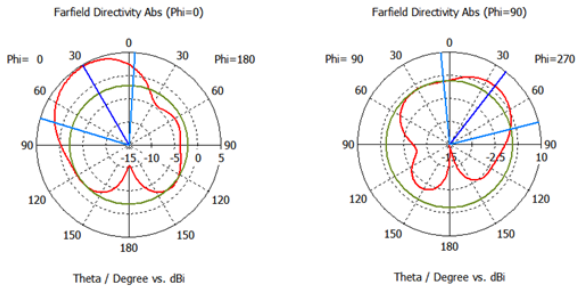
Modes	Switching sates		Frequencies occurred at different modes			
	D 1	D2	F1	F2	F3	F4
MODE1	0	0	3.08	6.29	-	-
MODE2	0	1	3.16	5.39	6.3	7.1
MODE3	1	0	6.29	-	-	-
MODE4	1	1	4.17	6.31	-	-

One of the most important features of the compact printed antenna i.e.surface current. The surface current of the proposed antenna is shown in Fig. 6 for two different frequencies4.17GHz and 6.31GHz when both diodes are ON. Radiation pattern at two frequencies are discussed as shown in Fig. 7.



(a) (b)

Fig. 6. Surface current of the proposed reconfigurable antenna when condition of the switch is in ON state at (a) 4.17GHz and (b) 6.31GHz



AT 4.17GHz- E PLANE AT 4.17GHz – H PLANE

(a)

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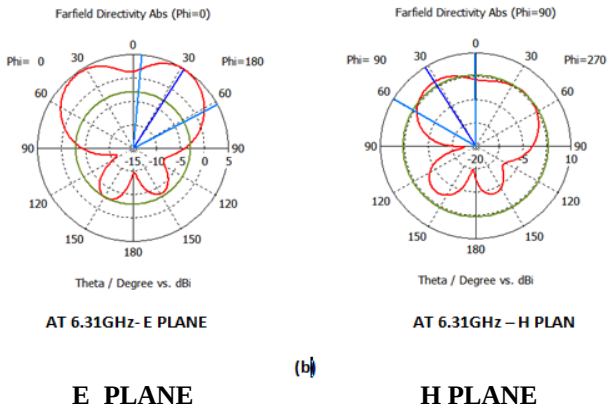

Fig. 7. Radiation patterns for the proposed antenna when switch is in ON state condition at 4.17GHz and 6.31GHz in E and H plane.

Conclusion

A compact design of slotted reconfigurable printed antenna is proposed for S-band and C-band applications. In this paper the reconfigurability of antenna is achieved by adding a PIN diodes/switches on the slots which are on the patch and then after changing the switching state (ON/OFF) of the switch, the multiple band frequencies of the proposed antenna is achieved. The proposed slotted patch antenna is analyzed in terms of various parameters like S11, radiation patterns and surface current. The proposed antenna has many applications in communication system where different frequencies are needed in different mode of operation.

References

[1]. B. R. Piper and M. E. Bialkowsky, "Electromagnetic Modeling of conformal wideband and multi-band patch antennas by bridging a solid object modeler with MoM software", *IEEE Antennas and PropagationMagazine*, Vol. 46, No. 5. October 2004. pp. 42-52.

[2]. Peroulis, D., K. Sarabandi, and P. B. K. Katehi, "Designof reconfigurable slot antennas," *IEEE Transactions onAntennas and Propagation*, Vol. 53, 645–654, 2005.

[3]. Balanis, C. A., *Antenna Theory: Analysis & Design*, 2nd edition, John Wiley & Sons, Inc., 1997.

[4]. M. T. Ali, et al., "A novel of reconfigurable planar antenna array (RPAA) with beam steering control," *Progress In Electromagnetics Research B*, pp. 125-146, 2010.

[5]. H. A. Majid, M. K. A. Rahim, M. R. Hamid, N. A. Murad and M. F. Ismail, "Frequency-Reconfigurable Microstrip Patch-Slot Antenna," *IEEE Antennas Wireless Propag. Lett.*, vol. 12, pp. 218-220, 2013.

[6]. Tariq, A., Ghafouri-Shiraz, H.:"Frequency-reconfigurable monopole antennas", *IEEE Trans. Antennas Propag.*, 2012, 60, (1), pp. 44–50

[7]. Y. F. Cao, S. W. Cheung and T. I. Yuk, "A Multiband Slot Antenna for GPS/WiMAX/WLAN Systems," *IEEE Transactions on Antennas and Propagation*, vol. 63, pp. 952-958, March. 2015.

[8]. M. Cherian and D. Das, "Triple band reconfigurable dual patch antenna with multiband and wideband operation," *International Conference on Control Communication & Computing India (ICCC)*, Trivandrum, pp. 437-441, Nov. 2015

[9]. S. Onat, L. Alatan, S. Demir, "Design of triple band reconfigurable microstrip antenna employing RF MEMS switches", *APS International Symposium*,IEEE, Vol. 2, pp. 1812 -1815, 20-25 June 2004.

[10]. Rachana Yadav, Sandeep Yadav, **Sanjeev Yadav**, " SRR and R-CSRR Loaded Reconfigurable Antenna with Multiband Notch Characteristics" *International Conference on ICT for Sustainable Development (ICT4SD-2015)*, July 03-04, 2015, Ahmedabad

[11]. R. Yadav, S. Yadav and **SanjeevYadav**, "A reconfigurable antenna with multiband characteristics for GPS and mobile communication," 2015 Communication, Control and Intelligent Systems (CCIS), Mathura, 2015, pp. 59-62, doi: 10.1109/CCIntelS.2015.7437877

[12]. Minakshi, A. Sharma, S. Yadav and R. Paliwal, "A novel reconfigurable microstrip patch antenna for triple band wireless applications," *2017 IEEE Applied Electromagnetics Conference (AEMC)*, Aurangabad, 2017, pp. 1-2. doi: 10.1109/AEMC.2017.8325695

[13]. www.cst.com