International Journal of Psychosocial Rehabilitation, Vol. 24, Issue 05, 2020
ISSN: 1475-7192

A Survey on Frequency Reconfigurable Antenna for Wireless Applications

K. Jayamani, Rahulkrishnan, S. Aishwarya Nachiya, R. Arjun Raj
and C. Atchaya

Abstract--- *Wireless communication technology has experienced exponential growth over the past years. The growth of technologies has led to increased demand for the antenna, which could serve for different wireless applications. Reconfigurable antennas are the subject of study in many researches as they play an important role in smart and adaptive systems in wireless networks. Reconfigurable antenna provides an advantage of combining multiple functions in a single antenna. Reconfigurable antennas are able to dynamically modify its frequency and radiation properties. Different reconfiguration techniques are used to modify the properties of an antenna. There are popular due to its low cost, compact size, and light weight. Various papers on frequency reconfigurable antenna are studied, and a comparative study is presented.*

Keywords--- *Reconfigurable Antenna, Reconfiguration Techniques, Switches, Microstrip Patch, Wireless Networks.*

I. INTRODUCTION

In microwave engineering, the antenna acts as a current- carrying conductor that can convert electrical energy to electromagnetic waves and vice versa. Antenna is considered an important component in all radio equipment. Microstrip antenna, otherwise known as printed antenna, catches application in various wireless communication systems such as radar, mobile, and satellite communications systems. An antenna that takes the capability to adjust its radiation pattern, polarization, or even the operating frequency in consonance with the condition of the neighboring is named as a Reconfigurable antenna. The use of reconfigurable antenna is extensively seen in multiband system because of its dynamic spectrum restructuring.

Reconfigurable antenna is extremely adorable since it is beneficial for a wireless communication system which has diverse principles and multi-frequency solicitations. Over the last two decades, wireless communication technology and its usage like Bluetooth, Wi-Fi, GPS, WLAN, and many others have validated extraordinary growth [5]. The reconfigurable antenna obtains an ample bandwidth via various ON and OFF switching conditions. Generally PIN diode, RF MEMS switch, and varactor diode are used to realize the switching condition. However varactor diode and RF MEMS switch have benefit like low insertion loss and Q-factor, the fabrication is challenging and extravagant[7].

The demand for frequency reconfigurable antenna has been increased due to its ability to adjust for different antenna parameters like return loss, VSWR, gain, directivity, polarization, radiation characteristics and also for

K. Jayamani, Rajalakshmi Institute of Technology, Chennai.
Rahulkrishnan, Rajalakshmi Institute of Technology, Chennai.
S. Aishwarya Nachiya, Rajalakshmi Institute of Technology, Chennai.
R. Arjun Raj, Rajalakshmi Institute of Technology, Chennai.
C. Atchaya, Rajalakshmi Institute of Technology, Chennai.

DOI: 10.37200/IJPR/V24I5/PR2020281
Received: 18 Mar 2020 | Revised: 30 Mar 2020 | Accepted: 08 Apr 2020

operating frequencies reconfigurability, which can be achieved by using pin diode as a switch (ON-OFF) mode [6]. The principal benefits of the suggested reconfigurable antenna are that it is resonant at eleven divergent resonant frequencies. Rather applying two or three antenna, only one antenna is used to emanate at eleven distinct frequency bands, and the antenna profile is low [7].

II. MICROSTRIP PATCH ANTENNA

Heinrich Hertz demonstrated the microstrip antenna in 1886. Microstrip antennas are further known as "Printed Antennas." In recent days, Microstrip antennas catch usage in various wireless criterions. It has noticeable characteristics like small figure, tiny weight, and less volume, economical, regularity to planar and non-planar surfaces, arduous and rapidly incorporated on printed circuit board.

The microstrip antenna comprises of three layers. The undermost layer is the ground plane, and the upmost layer is the patch with a dielectric substrate is employed in the middle of these layers. The range of dielectric coefficients of the substrate used in the proposal is 2.2 < < 12. Copper is mostly used as a radiating material for patch and ground plane [9].

The patch antenna has different form and size like rectangular, square, dipole, circular, triangular, circular ring, elliptical [15]. Excitation to antenna is provided using numerous kinds of feeding techniques. The predominant methods are proximity coupled feeding, co-axial feeding, aperture coupled feeding and microstrip line feeding. Since Microstrip line feeding is easy to fabricate, it is the utmost frequently selected feeding technique. [4,9].

III. DESIGN OF RECONFIGURABLE ANTENNA

The delineation of reconfigurable antennas is adopted using different methods established on the reconfiguration techniques in addition to the behavior of each reconfiguration [3]. There are 4 main categories under which reconfigurable antenna are assorted on the basis their reconfigurability function [1]

A. Frequency Reconfigurable Antenna

Antennas in this batch can transform their frequency of operation formulated on the user's demand. They change their process to function in various frequency bands. This antennas are generally valuable in wireless communication solicitations which require an alteration in working frequencies also to shift from one channel into another. Cognitive radio is an illustration for this antenna set..

B. Radiation Pattern Reconfigurable Antenna

Antennas in this category can modify their radiation pattern while keeping a fixed frequency of operation. These antennas reform their radiation patterns to block a signal or to permit radiation in an assured prearranged direction [11]. Mobile antenna systems can be suggested as examples of this antenna group.

C. Polarization Reconfigurable Antenna

Antennas in this category can modify their polarization method at the same time retaining their fixed frequency and radiation pattern [16]. These antennas remodel their radiation characteristics to reveal numerous polarization patterns. Multiple input multiple-output (MIMO) channels are solicitation models of this antenna group [2,12].

DOI: 10.37200/IJPR/V24I5/PR2020281
Received: 18 Mar 2020 | Revised: 30 Mar 2020 | Accepted: 08 Apr 2020

D. Hybrid Reconfiguration Antenna

Antennas in this set can concurrently alter several characteristics in their activity. These antennas can, for instance, alter their operating frequency along with their polarization scheme for every single frequency of attention. They can furthermore remodel their radiation pattern although varying their operating frequencies or polarizations [12].

IV. RECONFIGURATION TECHNIQUES

Several reconfiguration techniques are proposed ever since the conspicuous rise of reconfiguration antenna. Reconfiguration techniques are selected depending on the characteristics of reconfigurable antenna. Considering the constraints, a suitable reconfiguration technique is selected by the antenna designer. The four main reconfiguration techniques proposed are [13].

a) Electrical reconfiguration technique

b) Optical reconfiguration technique

c) Mechanical reconfiguration technique

d) Material change reconfiguration technique

A. Electrical Reconfiguration Technique

Electrical reconfiguration techniques achieve reconfiguration with the help of switches. The switches are used for the redistribution the antenna currents. Antenna parts are connected and disconnection using these switches. Radiofrequency micro-electromechanical system (RF-MEMS)have been proposed for integration into reconfigurable antennas. Alternative to RF-MEMS, PIN diodes and varactors seems to be a faster and more compact. PIN diode switching speed lies between 1–100 nsec. PIN diodes provide better dynamic reconfiguration ability in reconfigurable antenna [13].

B. Optical Reconfiguration Technique

When the laser light comes in contact with the surface of semiconductor material (silicon, gallium arsenide), an optical switch is formed.

This results in excitation of electrons to the conduction band from the valence and thus creating a conductive connection. Integrating such a switch into an antenna structure and using it to reconfigure the behavior of antenna is called an optically reconfigurable antenna.

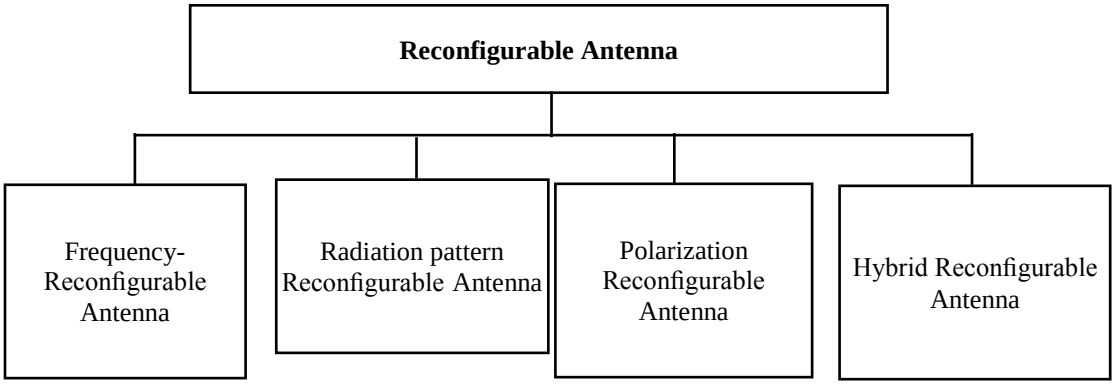
C. Mechanical Reconfiguration Technique

Mechanical reconfiguration technique alters the physical composition of the antenna by which antennas are physically reconfigured

D. Material Change Reconfiguration Technique

Smart materials for instance liquid crystals and ferrites are used to achieve reconfiguration in antennas [14].

DOI: 10.37200/IJPR/V24I5/PR2020281
Received: 18 Mar 2020 | Revised: 30 Mar 2020 | Accepted: 08 Apr 2020



V. ANTENNA DESIGN EQUATION

Designing a microstrip patch antenna requires selection of resonant frequency and dielectric medium. After the creation of patch antenna slots are introduced and corresponding length and width are chosen based on the antenna design equations. To design a micro strip patch antenna, one has to select the operating frequency along with a dielectric medium for which antenna is to be designed. The length and width of the antenna can calculate using the mathematical equations.

Width (W): Calculated using the following equation

$$W = C_o / f_r \sqrt{\frac{2}{\in_r + 1}} \quad (1)$$

W = Width of the patch,

C_0= Speed of light,

$\in_r$ = dielectric substrate

The effective dielectric constant ($\mathbf{\varepsilon_{eff}}$): Calculated using the following equation.

$$\in_{reff} = \frac{\in_r + 1}{2} + \frac{\in_r - 1}{2}[1 + \frac{12h}{W}]^{\wedge\frac{-1}{2}}, \frac{W}{h} > 1 \quad (2)$$

Length: The size of the antenna is increased by an amount of (ΔL) due to fringing, electrically Therefore, the actual increase in length (ΔL) of the patch is to be calculated using the following equation

$$\frac{\Delta L}{h} = \frac{0.412(\in_{reff} + 3)(\frac{W}{h} + 0.264)}{(\in_{reff} - 0.259)(\frac{W}{h} + 0.8)} \quad (3)$$

h= height of the substrate.

Length (L) of the patch : Calculated using the equation

$$L = \frac{C_0}{2 f_r \sqrt{\in_{reff}}} - 2\Delta L \quad (4)$$

DOI: 10.37200/IJPR/V24I5/PR2020281
Received: 18 Mar 2020 | Revised: 30 Mar 2020 | Accepted: 08 Apr 2020

Length and width of substrate: Determined using the following equations.

$$L_g = 6h + L$$
$$W_g = 6h + W \quad (5)$$

VI. LITERATURE SURVEY

In this section, papers related to frequency reconfigurable antenna is discussed.

Venkateswara Rao Tumati and Jaya Cheruku [4] proposed an antenna that can achieve dual-frequency and triple frequency reconfiguration. Microstrip line feeding technique is applied for the excitation of antenna. At the centre of the patch a staircase slot is made. The position of the slot is adjusted to obtain the obligatory frequency of operation. BAR6402 PIN diode (D) is employed in the slot at the augmented position. In forward bias the PIN diode will performances as (closed switch) a lesser resistance in series with minor inductance (L). In reverse bias it performances as (open switch) a bulky resistance in parallel with lesser capacitance and series with minor inductance (L). To acquire threefold frequency reconfiguration, two steps slots were prepared, which are mirror images of each other, and the slot locations are adjusted to acquire the needed frequencies. Two PIN diodes D1, D2 were positioned in two slots at the augmented locations. HFSS (High-Frequency Structural Simulator) V.15 used for design and simulation.

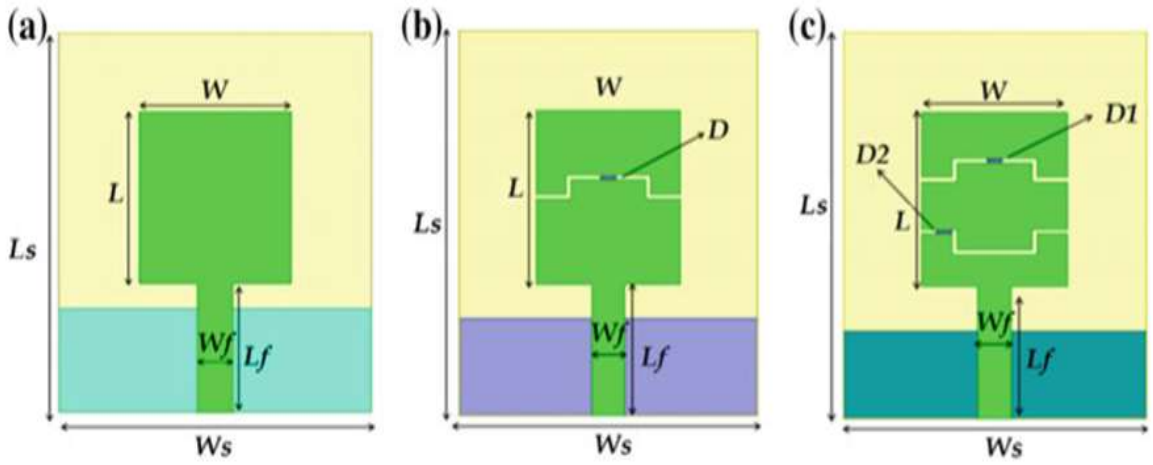


Figure 1: Geometry of a Dual Band Antenna, b Dual and c Triple Frequency Reconfigurable Antenna[4]

Frequency reconfigurable microstrip patch antenna with three slots on the ground is suggested by Babu Lal Sharma, Girish Parmar, Mithilesh Kumar [5]. In this design two switches (copper strip) are positioned on the slot at the ground plane to create three different frequency bands at 3.06, 3.26 for (S-Band) and 4.27 GHz(C-Band) correspondingly. Instead of copper strips, PIN diodes are used in fabrication. The recommended antenna simulated using the FR-4 substrate with permittivity 4.1 and substrate thickness 1.5mm. CST used for design and simulation.

DOI: 10.37200/IJPR/V24I5/PR2020281
Received: 18 Mar 2020 | Revised: 30 Mar 2020 | Accepted: 08 Apr 2020

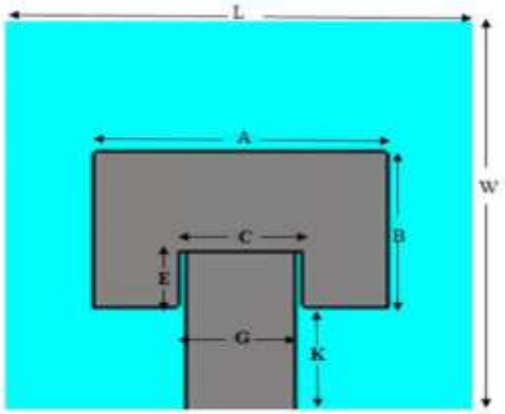


Figure 2: Schematic Diagram of t Microstrip Patch Antenna [5]

H The proposal of frequency- reconfigurable microstrip patch antenna is suggested in H. A. Majid, M. K. A. Rahim, M. R. Hamid, N.A. Murad and M. F. Ismail [8]. The plan of antenna system is completed by employing a rectangular shape patch antenna with rectangular slots etched in the ground level to be responsible for swapping band of frequency. The suggested antenna reveals its switching characteristics of its frequency by placing five PIN diodes in the slots and function at nine distinct frequencies. The planned antenna is simulated and determined outcomes like return loss, radiation pattern improve the enactment of suggested system with the diminished size.

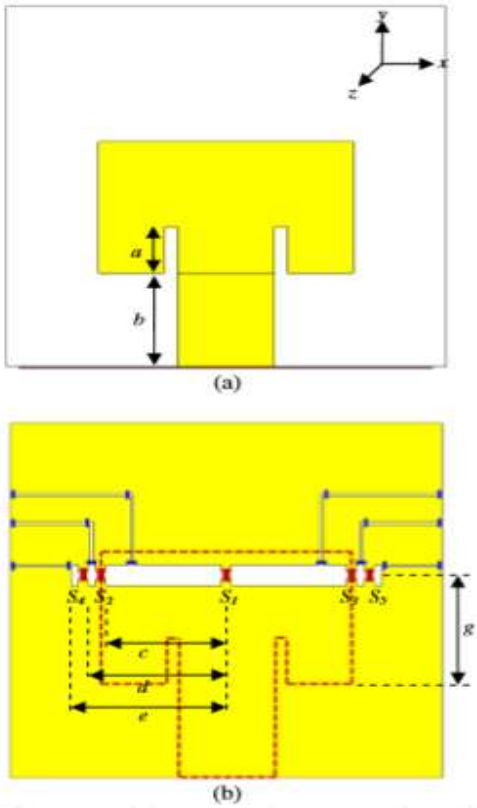
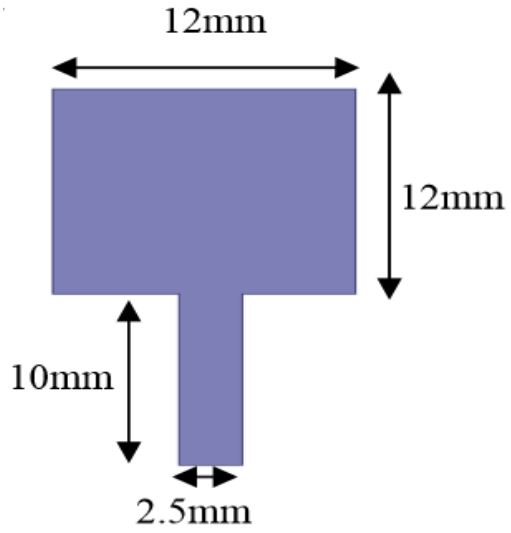


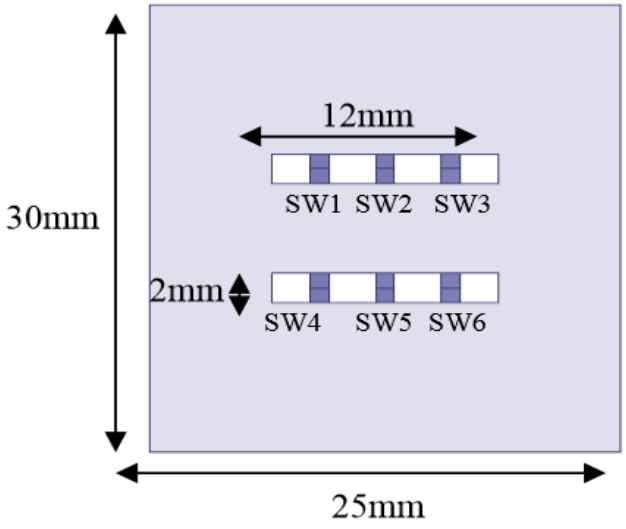
Figure 3: Basic Structure of Patch -Slot Antenna (a) Inset Fed Patch Antenna In Front View and (b) Slots with RF PIN Diode in Back View [8]

DOI: 10.37200/IJPR/V24I5/PR2020281
Received: 18 Mar 2020 | Revised: 30 Mar 2020 | Accepted: 08 Apr 2020

R. Jothi Chitra, V. Nagarajan [7], proposed a miniature frequency reconfigurable dual slot microstrip patch antenna for wireless communication. The antenna comprises dual slot with six RF PIN diodes inserted at distinct locations on the ground. Based on the switching state of the PIN diode, the antenna is able to work at eleven different frequency ranges. The antenna functions in both single band mode and dual-band mode depending on the switching states of PIN diodes. This is achieved without modifying the antenna size. The investigations are performed using the Ansoft HFSS v13.0 software.



(a)



(b)

Figure 4: Front View of Antenna and (b) Back View of Antenna [7]

DOI: 10.37200/IJPR/V24I5/PR2020281
Received: 18 Mar 2020 | Revised: 30 Mar 2020 | Accepted: 08 Apr 2020

Mubashir Ul HASSAN, Farzana ARSHAD, Syeda Iffat NAQVI, Yasar AMIN1, Hannu TENHUNEN [17] proposed coplanar waveguide-fed adaptable antenna. The design uses adaptable Rogers RT/duroid as a substrate. Dual switches are incorporated on the seeming of the antenna to vary the frequency in various switching condition. The proposed antenna is simulated using CST software. The antenna has VSWR less than 2 and the radiation patterns achieved exhibit positive gain in preferred frequency bands. Based on the results, the suggested antenna is planned to be used for solicitations such as aeronautical radio navigation AMT fixed services, WLAN, Unlicensed WiMAX and X-band.

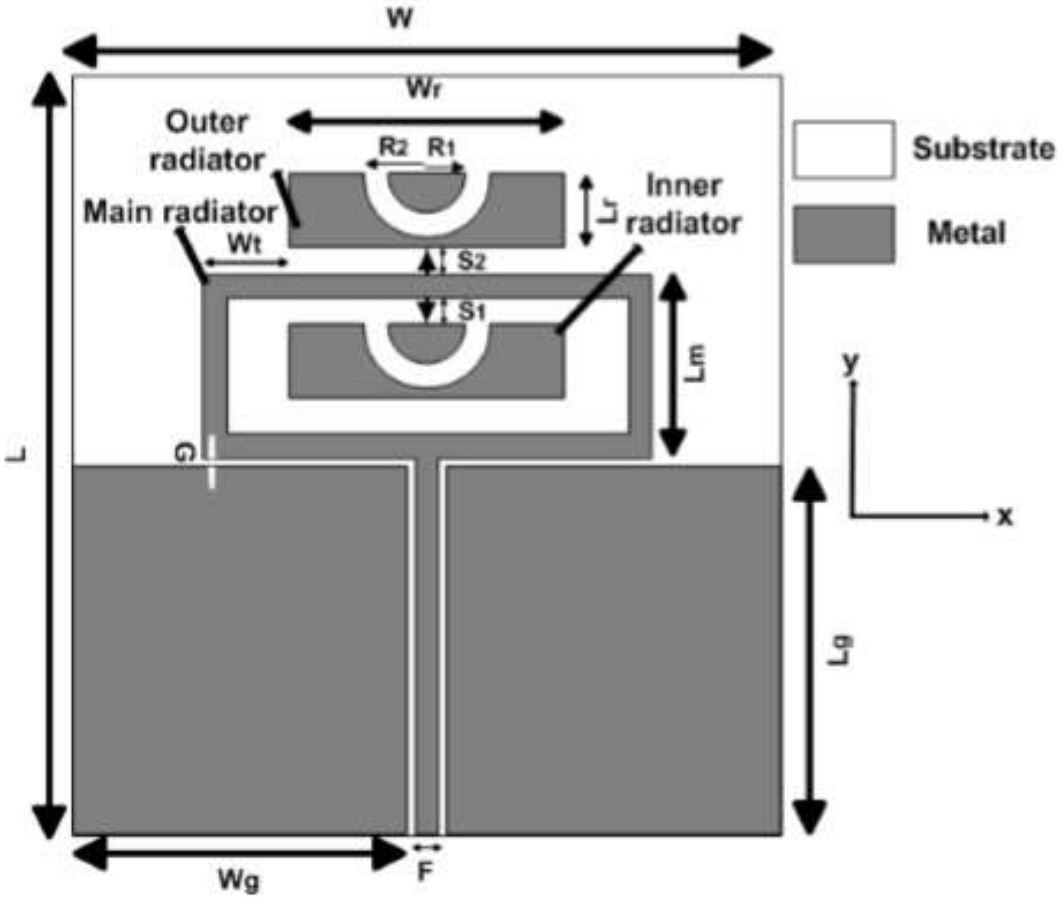


Figure 5: Antenna Configuration (top view). [17]

Liping Han et.al [10] legitimated a paper on reconfigurable antenna. By using this proposal, Dual-band of action is attained. Etching the ground plane thru the U shape and L shape slots through switching diode is used to achieve this result. The antenna is compact when related with the prevalent reconfigurable slot antenna. The final result of simulation signifies that the antenna functions at different frequency bands. The radiation pattern obtained for aimed antenna is stable.

DOI: 10.37200/IJPR/V24I5/PR2020281
Received: 18 Mar 2020 | Revised: 30 Mar 2020 | Accepted: 08 Apr 2020

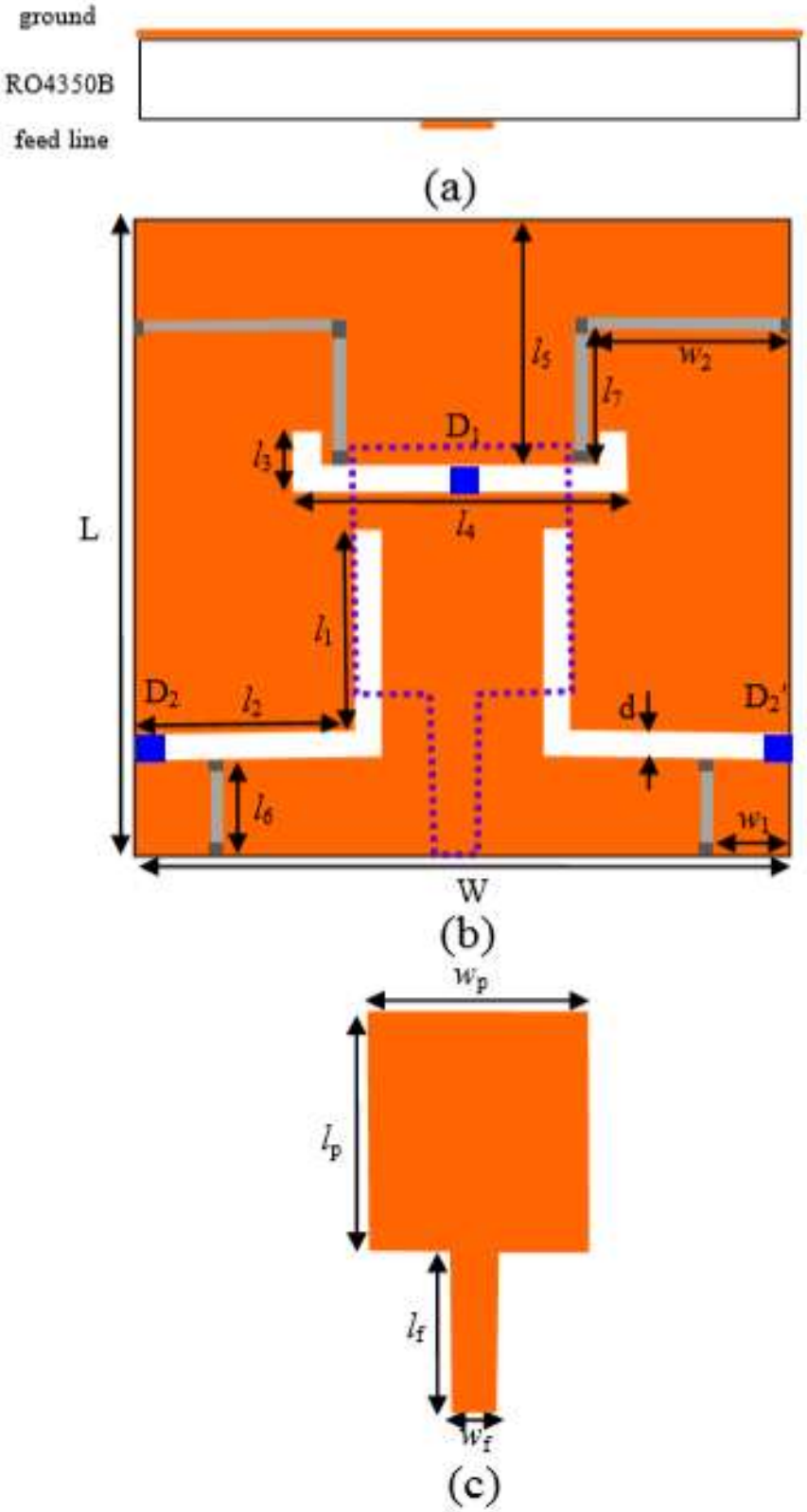


Figure 6: Configuration of Antenna. (a) Side View. (b) Front View. (c) Back View.[10]

DOI: 10.37200/IJPR/V24I5/PR2020281
Received: 18 Mar 2020 | Revised: 30 Mar 2020 | Accepted: 08 Apr 2020

Comparison of the studied papers is summarized in Table 1.

Table 1: Literature survey Analysis

S.No	*Antenna Type*	*Antenna Size*	*No of switches*	*Frequency*
I	Rectangular microstrip Patch with dual slots	40 mm× 30 mm	2	2.35/4.6/3.61/ 4.51 GHz
II	Microstrip patch antenna with three slots	48 mm × 48 mm^2 mm	2	4.27/3.06/3.06 GHz
III	Microstrip patch antenna with rectangular slots	50 mm × 50 mm	5	1.98-3.59 GHz
IV	Frequency reconfigurable dual slot microstrip patch antenna	30 mm x 25 mm	6	3.7/3.9/7.6/ 7.9/4.4/4.9/ 9.1GHz.
V	coplanar waveguide-fed flexible antenna	30 mm × 28.4 mm	2	4.2/ 4.3/ 5.1/ 5.5/ 7.5 GHz
VI	compact frequency reconfigurable slot antenna	27 mm × 25 mm	2	2.3/4.5/5.8GHz

VII. CONCLUSION

Reconfigurable antennas ensure their applicability in diverse areas such as space communication, radar, satellite communication, and cognitive radio systems. In this paper, various types of reconfigurable antennas adopted for wireless applications is deliberated. Also, the switching element, materials and different types of reconfiguration techniques used to achieve reconfiguration are also analyzed. The use of Microstrip antennas in different wireless standards application and the suitable feeding techniques are examined.

REFERENCES

[1] Haydar M. Al-Tamimi, Salah Mahdi "A Study of Reconfigurable Multiband Antenna for Wireless Application" *International Journal of New Technology and Research (IJNTR)* ISSN: 2454-4116, Volume-2, Issue-5, May 2016 Pages 125-134.

[2] Sowmyadevi A, Phalguni Mathur, Anupam R Chandran, Nick Timmons, Jim Morrison and Sujith Raman "2.45 GHz Pattern Reconfigurable Antenna for Wireless Sensor Network applications" *URSI AP-RASC 2019*, New Delhi, India, 09 - 15 March 2019.

[3] Naser Ojaroudi Parchin, Haleh Jahanbakhsh Basherlou, Yasir I. A. Al-Yasir, Raed A. Abd-Alhameed, Ahmed M. Abdulkhaleq and James M. Noras "Recent Developments of Reconfigurable Antennas for Current and Future Wireless Communication Systems" *Electronics* 2019, 8, 128.

DOI: 10.37200/IJPR/V24I5/PR2020281
Received: 18 Mar 2020 | Revised: 30 Mar 2020 | Accepted: 08 Apr 2020

[4] Venkateswara Rao Tumati and Jaya Cheruku "Design and Study of Frequency Reconfigurable Antenna for Wireless Application" *Proceedings of 2nd International Conference on Micro-Electronics, Electromagnetics and Telecommunications, Springer Nature Singapore Pte Ltd.* 2018

[5] Babu lal Sharma, Girish Parmar, Mithilesh Kumar "Design of frequency reconfigurable Mictrostrip patch antenna for S-band and C-band Applications" 2015 *IEEE, 4th International Conference on Reliability, Infocom Technologies and Optimization (ICRITO).*

[6] Monika Priyadarshani, Santosh Kumar Gupta, Anil Kumar, Mayur Kumar, A. K. Jaiswal, Ekta Singh Chauhan "Dual Band Re-Configurable Pin Diode Based Microstrip Patch Antenna with and without Slot" *International Journal of Engineering Trends and Technology (IJETT)* – Volume 59 Issue 2 - May 2018.

[7] R. Jothi Chitra, V. Nagarajan "Frequency Reconfigurable Antenna Using PIN Diodes" *2014 IEEE Twentieth National Conference on Communications (NCC).*

[8] 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 and Wireless Propagation Letters* (Volume: 12)-2013.

[9] Cheruku Jaya, Tumati Venkateswara Rao "Frequency Reconfigurable Patch Antenna for Bluetooth, WLAN and Radar Applications" *International Journal of Innovative Research in Science, Engineering and Technology* Vol. 5, Issue 4, April 2016.

[10] Mr.M. Paranthaman, P. Kaviya, R. Kaviyavarshini, M. Nagapriya, K. Nandhini "Frequency reconfigurable patch antenna design using HFSS" *International Journal of Pure and Applied Mathematics* Volume 118 No. 20 2018.

[11] Meraline Selvaraj, B. S. Sreeja, "Pattern Reconfigurable Antenna for Wireless Applications using Parasitic Ring" *2nd Extending Industrial Applications of Information, Communications and Computations conference.*

[12] Joseph Costantinea, Youssef Tawkb and Christos G. Christodoulouc "Reconfigurable Antennas and Their Applications" *Handbook of Antenna Technologies, Springer Science+Business Media Singapore* 2015.

[13] Joseph Costantine, Youssef Tawk, Silvio E. Barbin and Christos G. Christodoulou "Reconfigurable Antennas: Design and Applications" *Proceedings of the IEEE,* Vol. 103, No. 3, March 2015.

[14] Christos G. Christodoulou, Youssef Tawk, Steven A. Lane, and Scott R. Erwin "Reconfigurable Antennas for Wireless and Space Applications" *Proceedings of the IEEE* | Vol. 100, No. 7, July 2012.

[15] M. Jenath and V.Nagaraja "Review on Frequency Reconfigurable Antenna for Wireless Applications" *International Conference on Communication and Signal Processing,* April 6-8, 2017.

[16] Mustafa Murat Bilgiç and Korkut Ye Lin "Polarization Reconfigurable Patch Antenna for Wireless Sensor Network Applications" Hindawi Publishing Corporation International Journal of Distributed Sensor Networks Volume 2013.

[17] Mubashir Ul HASSAN, Farzana ARSHAD, Syeda Iffat NAQVI, Yasar AMIN1, Hannu TENHUNEN "A Compact Flexible and Frequency Reconfigurable Antenna for Quintuple Applications" *RADIOENGINEERING,* VOL. 26, NO. 3, SEPTEMBER 2017.

[18] Liping Han, Caixia Wang, Xinwei Chen and Wenmei Zhang, "Compact Frequency Reconfigurable Slot Antenna for Wireless Applications", *IEEE Antennas and Wireless Propagation Letters*, Vol: 15, Page No. 1795 – 1798, March 2016.

DOI: 10.37200/IJPR/V24I5/PR2020281
Received: 18 Mar 2020 | Revised: 30 Mar 2020 | Accepted: 08 Apr 2020