# Defected Ground Micro strip Patch Antenna For WLAN applications

**S. Suganthi, P. Thiruvalar selvan**

***Abstract*: In this paper, a microstrip rectangular patch antenna (MRPA) with defect in ground in terms of reduction in dimension has been simulated, tested and analyze for multiband wireless applications. The defect (reduction in size) has been introduced to study the grounding effect in patch antennas for four configuration namely full ground, quarter ground, half ground right and half ground left antennas. After the comparison of simulated results of all four structures, the proposed better performed antenna with 23.815mm x 41 mm x 1.6mm dimension has been fabricated and tested. It operates in wide bandwidth from 2.5 GHz to 9.2 GHz suited for S band requirements which covers many wireless applications like Wifi, WLAN and WiMax. The experiment results shows that the proposed antenna has lower group delay and loss, ideal VSWR less than 1.5, impedance nearer to ideal 50 ohm and gain of 4.3 dBi. There is very good agreement between the simulated and tested results.***

***Index Terms*: Microstrip rectangular patch antenna, grounding effect, return loss, VSWR, impedance characteristics, group delay, radiation pattern, wireless applications.**

## I. INTRODUCTION

All GPS (Global Positioning System) signals are in L-band of frequency spectrum (1–2 GHz). This band has been Antenna design is one of the important researches for present wireless technology to provide cost effective (1) and flexible communication. For the past two decades, microstrip patch antenna becomes most investigated topic due to its several advantages. Some of the (2) benefits of microstrip patch antenna over conventional antenna are:

1. These antenna are characterized by several physical parameters hence these antennas can be designed in different geometrical shapes and dimension(3)
2. Microstrip antenna can be easily integrated with other active due to its planner structure(4)
3. Recent wireless radio frequency circuits mostly uses microstrip antenna due to is low weight, low cost, fabrication conformal structure for dual or multiple wide bandwidth (5) and dual or circular desired radiation characteristics polarization(1)

To meet out the requirement of wireless communication development many techniques have been adapted for improving the performance and reducing the size of microstrip patch antenna. Defected group structure (DGS) in one of the technique in microstrip technology by introducing slot or defects in ground of planer microstrip structures (6). The defect the shape of ground plane is introduced to alter the current (1) within the structure. This disturbance will change the input impedance and antenna current (1). This technique is used to improve the bandwidth and cross polarization characteristics of microwave structures like filters, amplifiers, antennas and planar waveguides [7]. DGS can be used in microstrip antennas for higher order harmonics subversion (8) and reduction of multi coupling (9) and cross polarization (10). Increase in line capacitance and inductance (11) due to DGS in microstrip antenna reduces its size at a given resonant frequency.

A simple compact size and good gain rectangular patch antenna is presented in [12] having the limitation of poor feeding not suited for cellular application. In [13] good bandwidth antenna is presented in compact size and low gain of less than 3 dB. Different technologies have been proposed for WLAN applications and it becomes a research point [14] in the past decades.

In this paper we demonstrated DGS based microstrip rectangular patch antenna (MRPA) for eight multiband radio applications. Initially MRPA with full ground is designed and simulated for the band of 2.5GHZ to 8.8GHZ with gain of 2.5dB. Later for validation and study the effect of ground, the defect in terms of size reduction as quarter and half in ground at left has been introduced. Based on comparison the better performance and proposed half ground left (HGL) structure has been fabricated and tested at 2.5-9.2 GHZ frequency range with eight resonance and 4.3 dBi gain.

## II. DESIGN OF ANTENNA

In general there are four basic parts in microstrip antennas [15] like patch, dielectric substrate, feedline and ground plane. The MRPA with full ground is geometrically presented in figure 1(a). The patch is the radiating part in one side of antenna with other side of ground. Patch can be geometrically rectangular or circular which are simple and mostly used for microstrip antenna. The circular patch was the advantage of symmetrical radiation. Since the analysis is simple and geometrically is easily separable in nature rectangular shape in preferred for patch.

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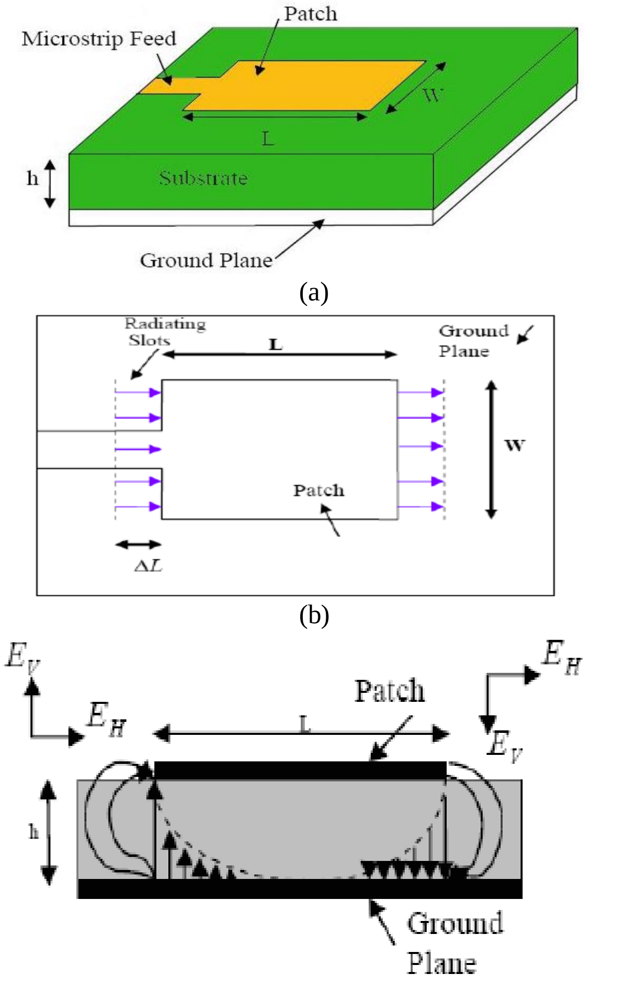
**Santhanam Suganthi**, Professor, Department of Electronics and Communication Engineering, K. Ramakrishnan College of Technology, Tiruchirappalli, Tamilnadu, India .

**Palavesanadar Thiruvalar selvan,** Professor, Department of Electronics and Communication Engineering, SRM-TRP Engineering College, Tiruchirappalli, Tamil nadu, India.

The length of patch is chosen as less than λ/2 (λ is the wavelength of dielectric medium) in order to operate the patch in $TE_{10}$ mode. In this patch the micrstrip is represented by two slots with open end and voltage is maximum and current is minimum along the width due to open circuited at both end as shown in figure .1 (b).

The excited filed at the edge of patch can be in normal or tangential to ground. The normal components ($E_V$) are in opposite direction at two edges as shown in figure 1(c) and are cancelled due to out of phase. But the tangential components ($E_H$) which are in phase give the maximum resulting filed in normal [16] to the surface of the structure.



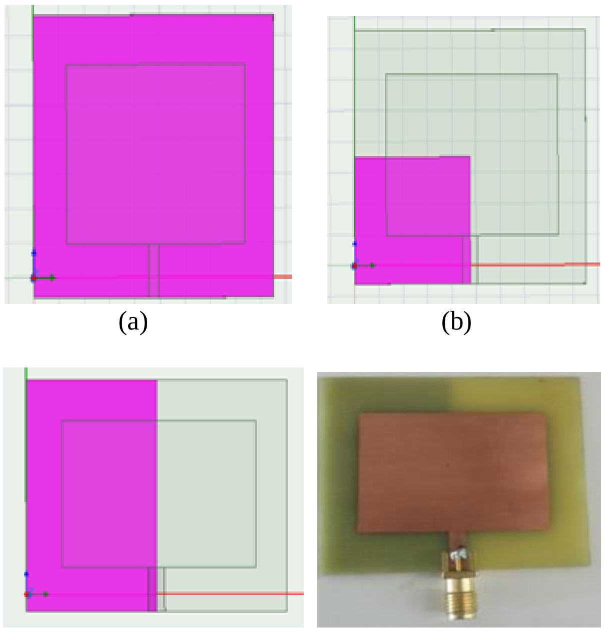
(c)

**Fig.1. Microstrip patch antenna (a) Structure (b) Top view (c) Side view**

This antenna is designed on FR4 substrate [17] with rectangular shape for patch and fed by microstrip line. The FR4 (flame retardant) used in this paper is more conventional microwave substrate with cost saving for broadband antennas. For the present wireless applications, with low cost consumer based microwave systems, FR4 is the best substrate where low and dielectric constant are critical.

Microstrip feed is one of the earlier techniques among the other for feeding of antenna. The other methods like coaxial feed having narrow bandwidth [18] and proxy coupling with difficult fabrication are rarely used for consumer applications. In microstrip feed used in his paper, impedance matching can be controlled easily by changing the feed position.

A rectangular patch on FRA substrate having a relative permittivity $\varepsilon_r$=4.4 and of thickness of 1.6mm is planned on one side. The other ground side has been taken for our analysis study. At first the full ground MRPA structure is designed with substrate and entire ground. The antenna with geometrically of 47.63mm (L) x 41mm (W) x1.6mm (h) is designed using HFSS software as shown the figure.2 (a).



(d)

**Fig.2 Simulated structures of MRPA (a) Full ground (b) Quarter Ground (c) Half Ground Left (HGL) ; d) Fabricated & Tested Photo of HGL**

**Method 1: Quarter-Ground antenna:** In this analysis, the size of ground in the antenna has been reduced as quarter as the size of full ground antenna. The dimension of 11.9mm x 41mm x 1.6mm has been chosen as shown in figure 2 (b) and the MRPA structure is simulated.

**Method2: Half ground – Right & left antenna:** The six of ground in the above MRPA structure has reduced four 47.63mm x 41mm x 1.6mm into 23.815mm x 41 mm x 1.6mm. In half ground left (HGL) as shown in figure 2 (c), the reduction on size (or the defect) in ground is introduced at right and the remaining left half portion of ground has been taken for our analysis. The mutliband low loss half ground left MRPA structure has been considered for better performance and is fabricated as shown in figure 2.(d).

## III. RESULTS & DISCUSSION

Ansoft HFSS, the electromagnetic solver was used to analyze the ground effect in the micrtstrip rectangular patch antenna. As in figure 3.(a) the simulation shows six resonant at frequencies 2.5,3.9,5,6.7, 7.7 GHz and 8.8 GHz with return loss of -15.96, -11.68, -28.20, -14.72, -26.66 and -14.31 dB respectively. The above frequency from 2.5 GHz to 8.8 GHz with allowable VSWR from 1.09 to 1.7 as shown in figure 3.(b) covers the wireless LAN industrial applications.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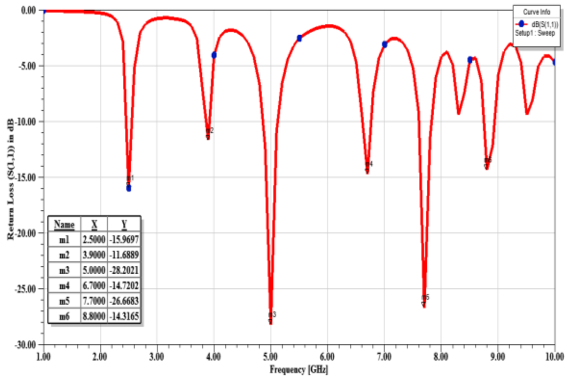
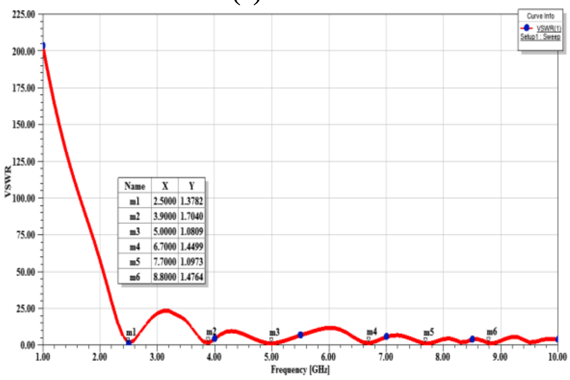
The radiation pattern obtained is omnidirectional with main lobe directed at an angle of zero degree as shown in figure 3.(c) The main lobe is 15 db and back lobe is 6 dB down from the peak. Figure 3(d) shows maximum antenna gain of 1.15 dBi with a main lobe in the direction of theta = 0 degrees and phi = 0 degrees.




(a)

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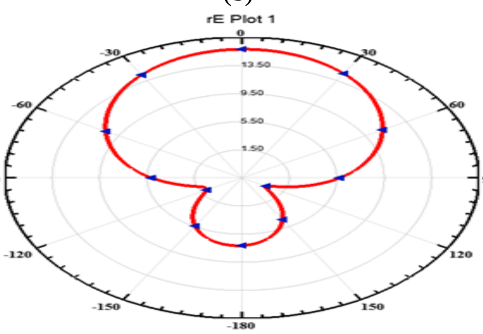
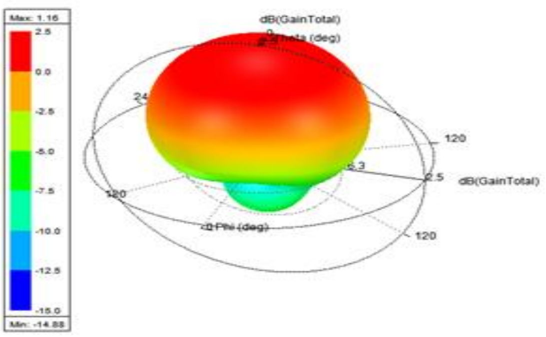


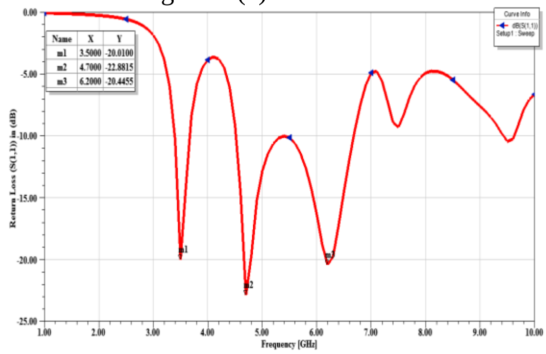

(c)



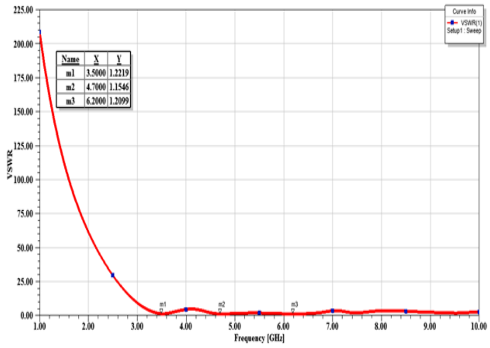

(d)

**Fig.3 (a) Characteristics of full ground microstrip Rectangular patch antenna (a) Return loss (b) VSWR (c) Radiation pattern (d) Gain**

For the MRPA with quarter ground the antennas simulation shows three resonant at frequencies 3.5, 4.7 GHz and 6.2 GHz with return loss of -20.01, -22.88 and -20.44 dB respectively as shown in figure 4.(a). The above frequency from 3.5 GHz to 6.2 GHz with allowable VSWR from 1.15 to 1.22 as shown in figure 4.(b).




(a)

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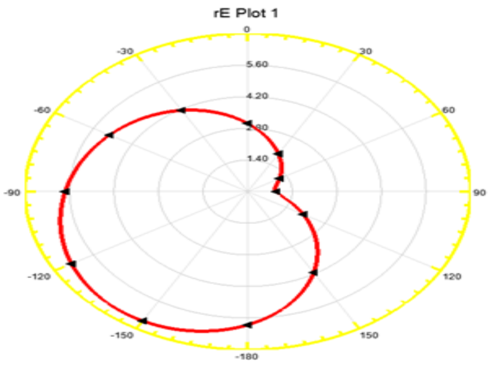


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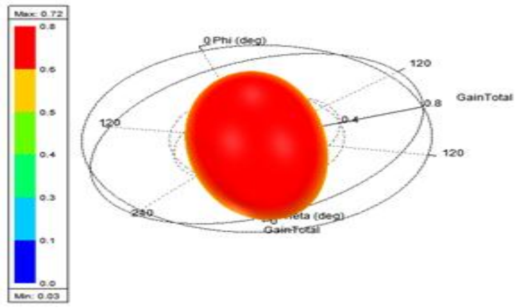


(d)

**Fig.4 (a) Characteristics of quarter ground microstrip Rectangular patch antenna (a) Return loss (b) VSWR (c) Radiation pattern (d) Gain**

Though there is no back lobe, the main lobe has been shifted from zero degree in the radiation pattern as shown in figure 4.(c). Figure 4(d) shows maximum antenna gain of 0.72 dBi which is only 62% of the antenna with full ground.



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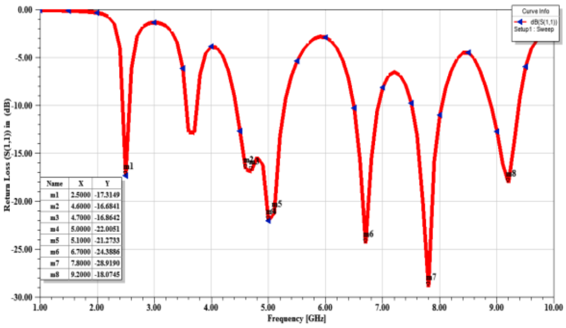
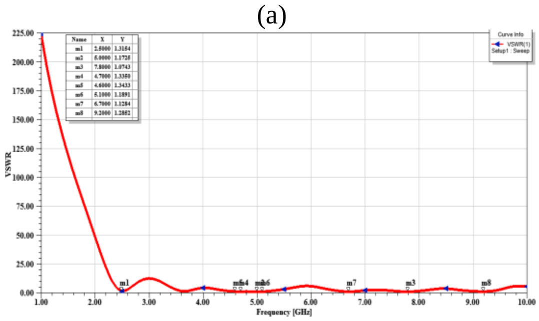
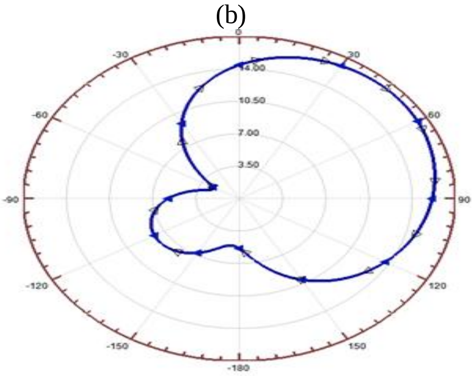
In MRPA with half ground at left (HGL), the antennas shows superior performance compared to other three structures with eight resonant at frequencies 2.5, 4.6,5.0, 5.1, 6.7, 7.8 GHz and 9.2GHz with return loss of -16.68 to -28.92 dB as shown in figure 5.(a). This configuration has higher operating frequency upto 9.2 GHz with low loss and allowable VSWR from 1.07 to 1.34 as shown in figure 5.(b). Though the radiation pattern has main lobe at 60 degree with 17 dB and back lobe at -120 degree with 8 dB and gain of 1.10 dBi as shown in figure 5.(c) & (d) respectively.




(a)




(b)



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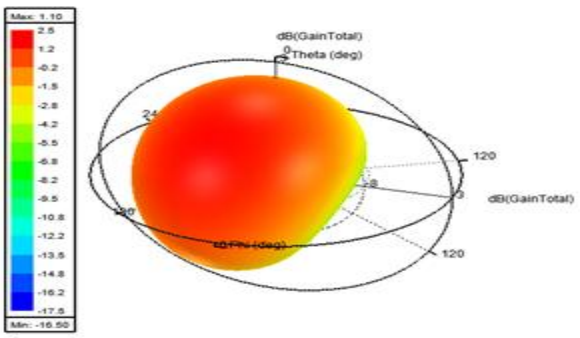
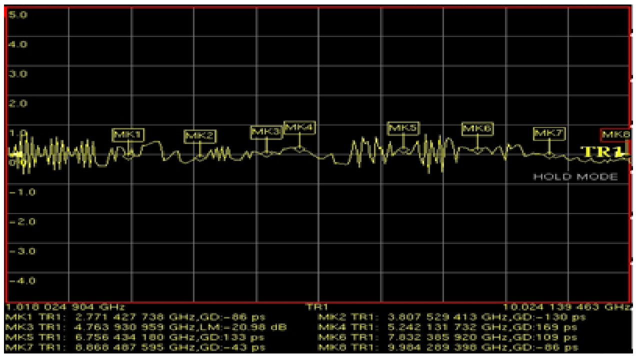


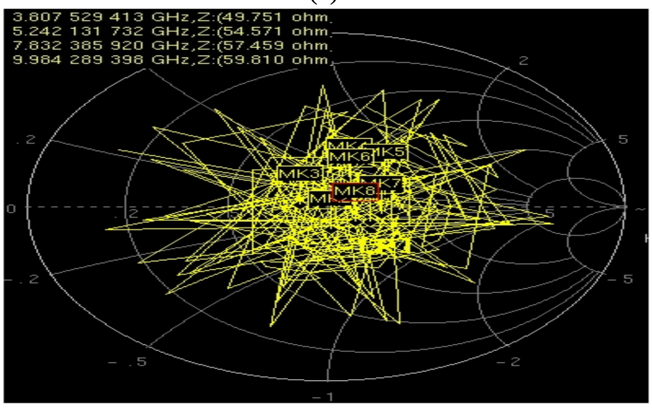

(d)

**Fig.5 (a) Characteristics of Half ground left (HGL) microstrip Rectangular patch antenna (a) Return loss (b) VSWR (c) Radiation pattern (d) Gain**

For the proposed multiband MRPA with wide bandwidth from 2 to 9 GHz the group delay has been tested to validate the distortion. Generally the group delay has been calculated as the differentiation of phase with respect to frequency and it should be less than to void serious problem in broadband applications. Our proposed MRPA with half ground left has group delay in all eight resonant in terms of picoseconds as shown in figure 6.(a) which clearly conform that our antennas is best suited for wide band applications. Figure 6 (b) shown the characteristics of out proposed antenna having impedance about 49 ohm to 59 ohm which is very closure to the characteristics impedance of ideal transmission line.




(a)




(b)

**Fig. 6. Measuremnet results of proposed MRPA with half ground left(HGL) (a) Group delay (b) Impedance charcteristics.**

To compare the grounding effect and to validate our proposal we have summarise the statictics of the transmission parameters of MRPA with full ground and our proposed half ground in left antenna with simulation and tested values in table.1. The below table clearly conclude that the microstrip rectangular patch antenna with half ground at left has multiband wide bandwidth with low loss ideal VSWR and high gain.


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**Table.1: Comparison of transmission property of proposed antenna with conventional full ground structure.**

| **Full Ground-Simulation** | | | **Half Ground Left (HGL)- Simulation** | | | **Half Ground Left (HGL)- Measurement** | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| **Frequency (GHz)** | **Return loss(dB)** | **VSWR** | **Frequency (GHz)** | **Return loss (dB)** | **VSWR** | **Frequency (GHz)** | **Return loss (dB)** | **VSWR** |
| 2.5 | -15.96 | 1.37 | 2.5 | -17.31 | 1.31 | 2.57 | -15.27 | 1.42 |
| 3.9 | -11.68 | 1.70 | 4.6 | -16.68 | 1.34 | 3.80 | -17.63 | 1.30 |
| 5.0 | -28.20 | 1.08 | 4.7 | -16.86 | 1.33 | 4.66 | **-20.98** | **1.26** |
| .7 | -14.72 | 1.44 | 5.0 | -22.0 | 1.17 | 5.20 | -14.65 | 1.45 |
| 7.7 | -26.66 | 1.09 | 5.1 | 21.27 | 1.18 | 6.75 | -12.52 | 1.62 |
| 8.8 | -14.31 | 1.47 | 6.7 | -24.38 | 1.12 | 7.83 | -17.25 | 1.32 |
| Full Ground (6 Bands) & Gain=1.15 dBi at 5 GHz | | | 7.8 | **28.91** | **1.06** | 8.86 | -14.48 | 1.47 |
| Half Ground Left (HGL) (8 Bands) & Gain-Simulation: 1.10 dBi & Test: 4.3 dBi at 5 GHz | | | **9.2** | -18.07 | 1.28 | **9.28** | -17.72 | 1.30 |

## IV. CONCLUSION

We have simulated and tested the microstrip rectangular patch antenna for multiband wide frequency wireless applications. With the skills of defect the ground in terms of size reduction, the antenna resonates at eight different frequencies within S band. On the comparison of three different structures, the prototype of better performed patch antenna with half ground left has been fabricated and tested. It has been proved that the proposed antenna have excel performance like low loss of -28.91 dB, low group delay in terms of picoseconds, high gain of 4.3 dBi, near ideal VSWR of 1.06 with good radiation characteristics. These performances have been compared with conventional full ground patch antenna for its validation.

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## AUTHORS PROFILE

**Santhanam Suganthi** was born in Tamilnadu, Indai. He received the B.E. degree in Electronic and Communication Engineering in 1998. She received M.E. degree in Computer and Communication Engineering and Ph.D in RF MEMS from Anna University Chennai, in 2006 and 2014, respectively. She is now an Professor with the private Engineering College affiliated to Anna University, Chennai from 2014 onwards. Her research interests include RF/microwave and mm-wave circuits, antennas, and ANN training.

**Palavesa Nadar Thiruvalar selvani** was born in Tamilnadu, Indai .He received M.E. degree in Computer and Communication Engineering and Ph.D in CPW in Microwave from Anna University Chennai and National Institute of Technology, Trichy, in 2004 and 2011, respectively. She is now a Professor with the private Engineering College affiliated to Anna University, Chennai from 2011 onwards. Her research interests include RF/microwave and mm-wave circuits, antennas, and ANN training.