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A HIGH GAIN DUAL BAND RECONFIGURABLE STACKED MICROSTRIP ANTENNA FOR WIRELESS APPLICATIONS

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ABSTRACT

A high gain dual band reconfigurable stacked micro strip antenna for wireless applications is proposed. In this paper the two micro strip antennas are arranged in the stacked form and in between the two antennas foam as been used as a substrate. In order to provide re configurability as the frequency of micro strip antenna changes by changing the height of the foam. Out of the two patches feed is given to the lower patch and the upper patch get the signals from the radiations of lower patch. As the two patch antennas are used and the antenna operates at dual band. It is observed that the two frequencies (lower and upper frequencies) are being varied by changing the height of the foam. It is also shown that the gains observed at the two bands are 8.11dBi at lower frequency 1.84GHz and 9.2dBi at upper frequency 2.159GHz. In order to increase the gain the upper patch is replaced by an array of four square parasitic patch elements are used and foam is used as a substrate in between the lower and upper patch and feed is given to the lower patch. Similar procedure is adopted for the second structure also, so that a high gain with frequency reconfigurability is obtained. The proposed antenna is designed and simulated using zeland IE3D electromagnetic wave simulator. The simulated results show that the antenna provides a gain of 14.5dBi at 5.93GHz lower frequency and 8.61dBi at 6.79GHz upper frequency. This type of antenna can be best suited for wireless applications.

Keywords- Reconfigurable antenna, stacked microstrip patch antenna, Antenna array,

I. INTRODUCTION

In high-performance applications such as satellite, aircraft and spacecraft we have low cost, less weight, high performance and ease of installation are the main constraints. Presently there are many other government and commercial applications such satellite and wireless communications have the similar specifications. So to meet these required specifications the Microstrip antennas can be used. Microstrip antennas have very low profile, conformable to both planar and non planar surface, inexpensive and simple to manufacture using modern printed circuit technology.

IJARSE
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Microstrip antennas are versatile in terms of polarization, resonant frequency, radiation pattern and impedance by adding the load between microstrip patch and ground plane such as pins and the adaptive elements.

In mobile communications, the antenna plays a critical role in transmitting and receiving signals from one terminal to another terminal. As the wireless devices become both smaller and more multifunctional, their antenna systems must do the same. Reconfigurable antenna offers an efficient solution to the multi functionality challenge. A single antenna can be reconfigured to operate at multiple bands can serve the function of multiple antennas.

Ideally reconfigurable antennas should be able to alter their operating frequency, impedance bandwidth, and polarization and radiation pattern to accommodate the changing operating requirements. So by making the antenna's reconfigurable, their behavior can adopt with changing system requirements or environmental conditions and provide additional levels of functionality for any system.

A reconfigurable antenna [1-5] is an attractive feature in a modern wireless communication System because of its flexibility for use in multiple applications such as multiband and point-to-multipoint. Reconfigurable antenna systems were first introduced in 1998 by Brown [6]. In the reconfigurable antenna, the structure of the antenna can be changed by integrating appropriate switches, such as PIN diode switches [7], field-effect transistors (FET), piezoelectric transducers, or electromechanical system (MEMS) [8] switches into the design. Reconfigurable antennas can be grouped into three categories: frequency, polarization and radiation pattern reconfigurable antennas.

To overcome low gain and efficiency of MSA, a gain enhancement technique based on structural resonance has been proposed and discussed. This method involves the addition of a superstrate layer over substrate. The effect of multi layered substrate and superstrate thickness, dielectric material, and patch dimensions are discussed in. By properly selecting the thickness of the substrate and the superstrate layers, a very large gain can be realized. The resonance gain method has been studied using moment method.

In this paper we are going to design two antennas in which the first antenna is designed to produce dual band frequency reconfigurability and the second antenna is used to produce frequency reconfigurability along with high gain. Both the antennas arranged in stacked form in order to get dual band reconfigurability.

In this paper we present a reconfigurable antenna with stacked structure can be used to increase the antenna bandwidth and gain with good return loss.

To get the dual band frequencies there is no need to change the antenna structure by simply changing the antenna dimensions like height of the dielectric or foam substrate we can achieve multiple frequencies.

In this paper a two layered stacked microstrip antenna is used. Two square patches are arranged in two different substrates with two different heights, dielectric constants and loss tangents. By changing the height of the second substrate the dual band operation that is frequency diversity can be achieved.

The primary advantage of the proposed reconfigurable antenna lies in its ability to support two separate applications at two different frequency bands with distinctly different radiation patterns, gain. This reconfigurable stacked microstrip antenna can be operated around 2GHz frequency range. In this a microstrip line fed is given to the first patch which should be placed at 50Ω impedance matching.

IJARSE
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In the second antenna the upper patch is replaced by 2X2 antenna arrays in order to provide high gain dual band frequency reconfigurability.

This proposed reconfigurable stacked antenna can be good application in wireless communication which can be arranged easily in a radome structure. The design of the proposed antennas can be explained in next section.

II. ANTENNA DESIGN

Two antennas are designed to provide dual band frequency reconfigurability with high gain.

2.1 Design of First Stacked Antenna

The geometry of the proposed antenna is shown in Fig. 1. It consists of two square patches, patch 1 and patch 2. Patch 1 is printed on RO4003 substrate from Rogers corporation ($h1$ = 1.5 mm, $\varepsilon r1$ = 3.38, tan δ = 0.0027). Patch 2 is located on top of a Rohacell foam substrate with thickness $h2$ and dielectric constant $\varepsilon r2$ = 1.04.

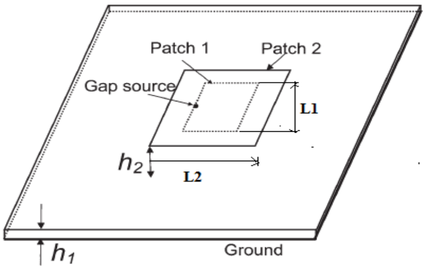

Fig 1: Schematic structure of stacked microstrip antenna

The proposed design consists of single microstrip line fed given to the patch 1 on a first dielectric substrate. The second patch should be placed on a rohacell foam substrate by varying the height of the foam substrate we can achieve dual band frequency diversity technique. The geometric view of proposed antenna should be given in fig.2.

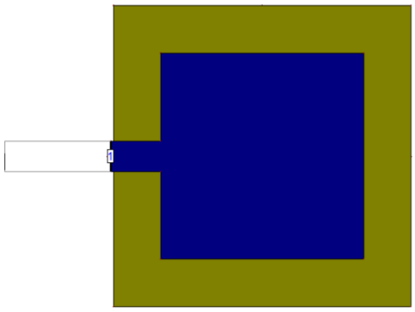

Fig 2: Geometric view of stacked microstrip antenna with microstrip line feeding

In the above figure the stacked patch antenna can be designed using IE3D simulator. The antenna having first square patch on a first dielectric substrate with the thickness h1= 1.5mm and the second square patch should be placed on a foam substrate at a thickness h2. By varying the thickness h2 of the foam substrate then we can acheive the dual band frequency diversity.

IJARSE
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2.2 Design of High Gain Stacked Array Antenna

From the above antenna design observations it is clear that the antenna should operate 1.84GHz and gain of and 8.11dBi and at another frequency 2.16GHz and gain of 9.2dBi. To improve the gain of the antenna here we are replacing the upper patch P2 with an array of square parasitic patches.

The microstrip device in its simplest form consists of a sand witch of two parallel conducting layers separated by a single thin dielectric substrate. The lower conductor functions as a ground plane and the upper conductor may be a simple resonant rectangular patch, and the associated feed network. The feed network employed may be a microstrip transmission line or coaxial fed connector. Fig 3 shows a microstrip line fed rectangular microstrip antenna and coaxial fed rectangular microstrip antenna respectively.

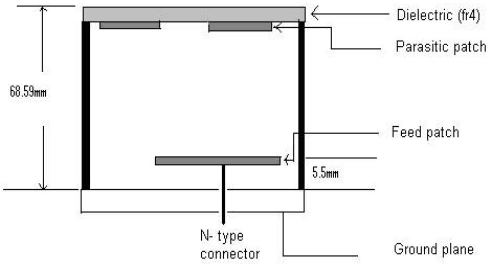

Figure 3: Geometry of multilayer antenna

The proposed antenna consist of a MSA which feeds 2X2 in to array of planar square parasitic patches (PPs) printed on a FR4 superstrate and positioned at $\lambda_0/2$ from the MSA. The antenna provides 80% efficiency and side lobe of -24 dB with an associated gain of 14.6 dB. The structure is designed, fabricated, and tested at 5.825 – 6.825 GHz band.

The geometry of the proposed antenna structure. The FP is metallic patch of 0.7-mm thickness placed at a height h=2 mm from the ground plane .The 2X2 square PPs are located at a height “hsl” from the FP and fabricated on the bottom side of FR4 superstrate of thickness 1.59 mm. Relative permittivity and loss tangent of superstrate or 4.4 and 0.02 respectively.

The superstrate also acts as a radome to the antenna. Air is used as a dielectric medium between FP and ground plane and also between superstrate and FP to achieve high efficiency. FP is fed through a coaxial probe of 50Ω . The antenna is designed to operate over 5.725-5.875 GHz ISM band. The structures are simulated using IE3D 12.0, Zeland software. All dimensions mentioned here are in mm only.

2X2 square parasitic patch array (SPPA) with inter element spacing of = 0.5λ is placed at hs1 =0.5 λ above the microstrip FP and the dimensions of MSA and SPPA element are optimized to operate over 5.725-5.875 GHz ISM band with central frequency at 5.8 GHz. The optimized structure has feed and SPPA element dimensions of 21.3X25.4 and 16X16, respectively. This structure is also a reference structure. The resonant conditions can be shifted by changing the dimensions of feed and element of SPPA. It also depends on the relative height between SPPA element and FP. The FP and SPPA resonate separately depending on their dimensions and the whole structure resonates when both patches resonate at same frequency.

IJARSE
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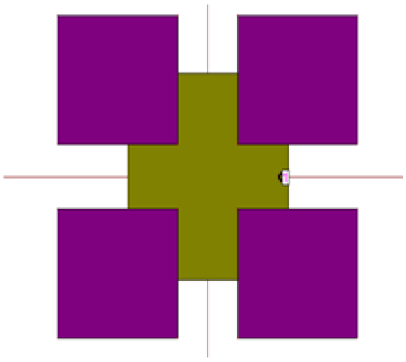

Fig 4: MGRID view of proposed high gain antenna

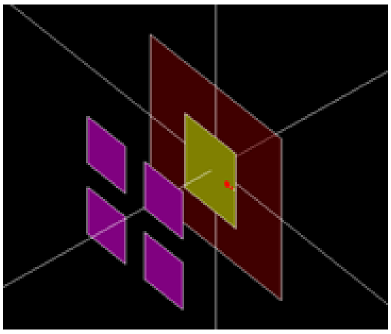

Fig 5 : 3D view of proposed high gain antenna

III. RESULTS

3.1 Stacked Patch Design at 2ghz

To design our reconfigurable stacked microstrip patch antenna at around 2 GHz, first, we conducted a study on IE3D software. The results are simulated by using IE3D eletromagnetic full wave simulator. The design was centered around 2 GHz frequency because there are several satellite apllications at that frequency which can acheive frequency diversity technique.

As, initiated in antenna design the first patch of the antenna should be designed on a R04003 dielectric substrate at thickness 1.5mm this patch is called driven patch. The second patch is designed on a Rohacell foam substrate at thickness h2.

The initial dimensions of our stacked patch antenna and the height between the two substrates is the first study. Initially the antenna parameters selected were the length of patch 1, L1=41mm, length of patch 2, L2=60mm shold be placed on afinite ground plane. Antenna parameters such as length of patch 1 and patch 2 (L1,L2) and the foam height tickness h2 can be varied according to the design. This stacked patch antenna should be operated by different feeding techniques. In this proposed work 50Ω microstrip line feeding is given to the edge of the patch1 and this fed excites between the two patches and the ground plane. To get the 50Ω impedance matching the length of the matching element should be varied according to the matching.

The reconfigurable stacked antenna is designed with the following dimensions L1= 41mm, L2=60mm, H2= 8.5mm, d= 10mm & Wo = 6mm in order to get the desired dual band frequency to achieve frequency diversity technique.

IJARSE
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The operated frequency and bandwidth can be used for wireless applications where all the wireless applications can perform. The Return loss, VSWR and Radiation patterns are shown in a below Fig. 6.

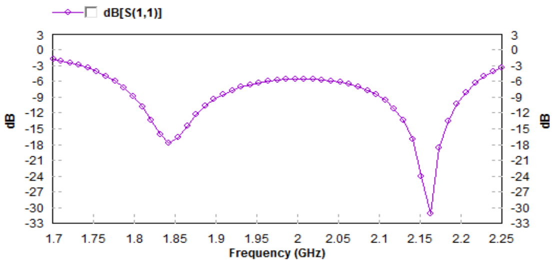

Fig 6 (a) Return loss Vs Frequency characteristics of stacked patch antenna

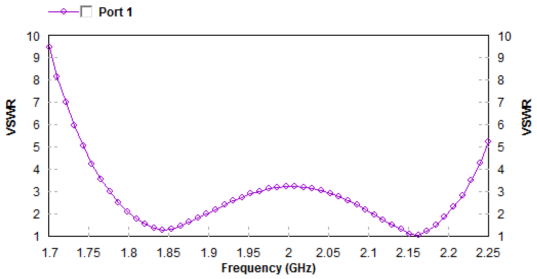

Fig 6 (b) VSWR versus frequency for the 2-GHz stacked patch (1.84–2.16 GHz).

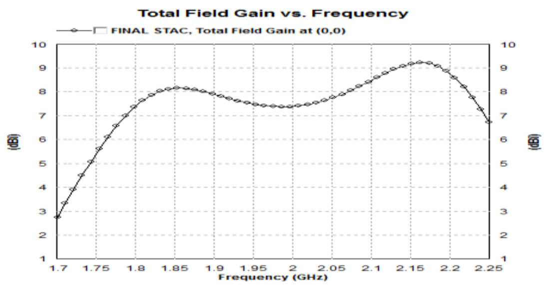

Fig 6 (c) Gain Vs Frequency characteristics of stacked patch antenna

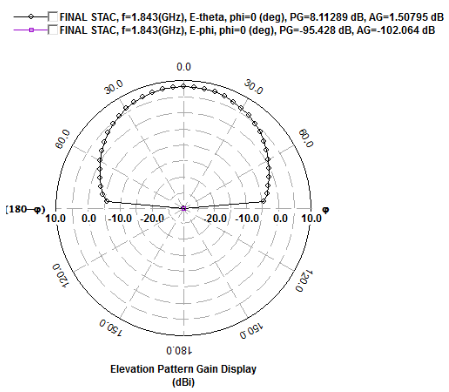

Fig. 6 (d) Radiation pattern of stacked patch antenna at 1.84 GHz

IJARSE
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ISSN (P) 2319 - 8346

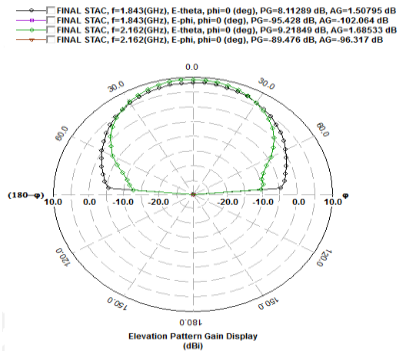

Fig. 6(e) Radiation pattern of stacked patch antenna at 2.16 GHz

1	Length of patch 1 L1	41 mm
2	Thickness of patch 1 h1	1.5 mm
3	Dielectric constant of patch 1	3.38
4	Length of patch 2 L2	60 mm
5	Thickness of patch 2 h2	8.5 mm
6	Dielectric constant of patch 2	1.04
7	Matching Element length d	10 mm
8	Matching Element length Wo	6 mm
9	Operating frequency F1	1.84 GHz
10	Operating frequency F2	2.16 GHz
11	Gain at F1	8.11 dB
12	Gain at F2	9.21 db
13	Band width at F1	856.6 MHz
14	Band width at F1	856.9 MHz

Table 1. Result of stacked patch performance at 2 GHZ (1.84 – 2.16 GHz)

3.2 High Gain Antenna Array Stacked Patch Design

Initially the feed patch having 0.7mm thickness is placed at a foam height h=2mm and SPPA elements are placed at a foam height of hs1=26.56mm and these SPPA elements are placed below the superstrate having 1.59mm thickness and dielectric constant of 4.4 is used.

The increase in SPPA element dimensions $L(L_{P=}W_p)$ at fixed inter element spacing $(S_x=S_y)$ of $0.5\lambda_0$ results in decrease in resonance frequency for a fixed FP dimensions which indicates that the SPPA resonates at different frequency and the structure resistance decreases and becomes more inductive .

The resonance frequency changes with changes with change in height of feed patch these results shows that the frequency reconfigurablity can be achieved.

1	Length of feed patch	21.3 X 25.4 mm
2	Foam height of feed patch h	2 mm
3	Length of SPPA elements	16 mm
4	Foam height of parasitic patches hs1	26.56 mm
5	Thickness of superstrate	1.59 mm
6	Dielectric constant of superstrate	4.4
7	Loss tangent	0.02
8	Inter element spacing S	8 mm
9	Operating frequency F1	5.9178GHz
10	Operating frequency F2	6.7135GHz
11	Gain at F1	14.6601dB
12	Gain at F2	9.2611dB

Table 2 : Result of final high gain stacked microstrip antenna performance

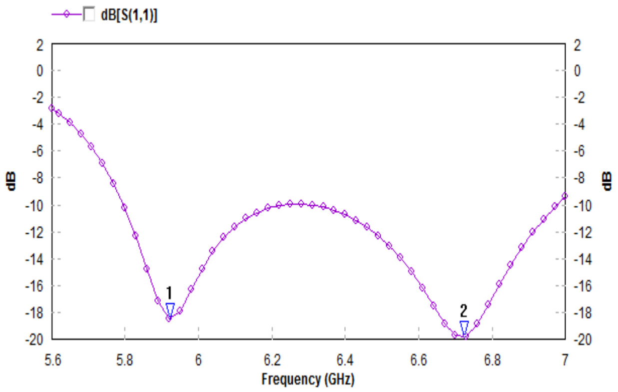

Fig 7(a) Return loss Vs Frequency characteristics of high gain stacked microstrip antenna

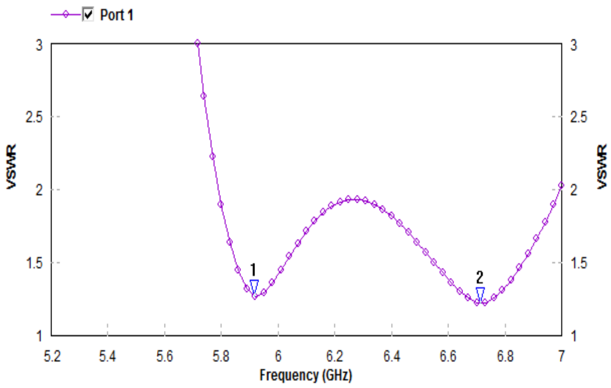

Fig 7(b) VSWR Vs Frequency characteristics of high gain stacked microstrip antenna

 IJARSE
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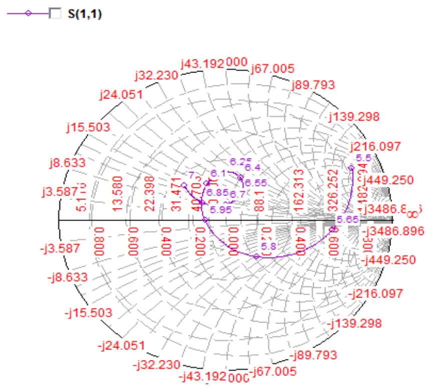

Fig 4.34 Impedance Vs Frequency characteristics of high gain stacked microstrip antenna

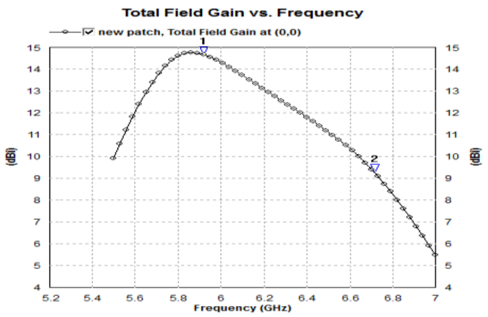

Fig 7(c) Gain Vs Frequency characteristics of high gain stacked microstrip antenna

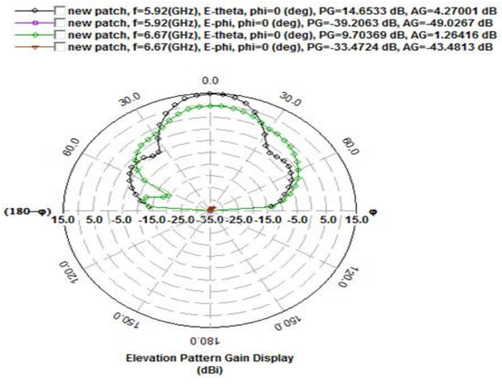

Fig 7(d) Radiation pattern characteristics of high gain Stacked antenna

From the above results it is clear that we can achieve high gain characteristics of 14.6601dB at one frequency and 9.2611dB at another frequency.

IV. CONCLUSION

The design of a High gain Dual band reconfigurable stacked microstrip antenna for wireless applications is presented. Using the stacked structure it is demonstrated that the antenna can be reconfigured to provide two

IJARSE
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different operating frequency bands varying bandwidth, gain and pattern. The proposed stacked patch antenna designed in this paper is operating at 1.84 GHz frequency having bandwidth 856.6MHz & gain 8.11 dB at one band and an another band it is operating at 2.16 GHz having Band width 856.9MHz & gain 9.21 dB which achieves frequency diversity technique. Further it is also shown the gain can be increased by replacing top patch antenna by 2 X 2 square parasitic patches. The second high gain stacked array antenna can achieve high gain characteristics of 14.6601dB at one frequency 5.9 GHz and 9.2611dB at another frequency 6.7 GHz. This antenna can be used for satellite and wireless communication applications.

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