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Design of Stacked Patch Antenna

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ABSTRACT

This study examines about microstrip patch antenna and designing of Stacked Patch Array Antenna. The proposed Stacked antenna executes the frequency range of 2 GHz to 4 GHz in S band with center frequency of 3.25 GHz. The proposed antenna is used fir a wide range of applications, such as weather radar, satellite communication, and air traffic control, and unmanned aerial vehicles that is drones due to their excellent aerodynamic performances. The parameters of the antenna are analyzed using the computer simulation technology (CST) software.

Keywords: Stacked Patch antenna, quasi-Minkowski fractal patch, dual feed Antenna

1. INTRODUCTION

Microstrip patch antenna is preferred in wireless communication system because of its small size, light weight and low profile characteristics. Now a days, communication engineers are very interested in researching the microstrip patch antenna. Due to its novelty, miniature nature, and low cost, wire less communication is rapidly maximizing. In tele communications, smart antenna techniques are used to increase the bandwidth and minimize dimensions compared to conventional ones. Research in antenna started from multiple perspectives, one of the important approaches being the research on the use in stack antenna.[1][2][4].

Microstrip patches are among the most adopted solutions in airborne applications where stringent aerodynamic constraints on the overall system layout must be fitted. Dealing with microstrip antennas, aperture stacked patches proved to be very profitable for increasing the operational bandwidth and the gain with respect to standard microstrip patch designs, while still guaranteeing compactness, radiation symmetry, and a straightforward integration into array arrangements. ASPs consist of a multi-layer structure where multiple microstrip patches and dielectric layers are stacked over an aperture-fed substrate [4][12]. Besides the advantages in terms of radiation performance, they also avoid soldered connections that would lead to undesired parasitic effects. Moreover, they enable linear/dual/circular polarization by acting on the position, orientation, and shaping of the aperture and of the patches. Furthermore, stacked structures allow the designers to integrate radio- frequency (RF) switches to yield reconfigurability.[3][8]

In the current scenario, antenna researchers focus on the wide band or multi-band antenna that performs well when it comes to characteristics like rotation, minimizing the antenna dimension and covering all the desired frequency. Microstrip patch antenna is the main focus for the theoretical and experiential role of the research [2][10]. But, narrow bandwidth is in the major drawback in the microstrip patch antenna. The problem of narrow band width is solved by the use of multilayer structure.

Multilayered planner antenna is called stack antenna which is placed at the intersection of dielectric layers with multiple resonators. These multilayer vertical patches are used to obtain multiple resonates without affecting the overall area.The main limitation of the microstrip patch antenna is narrowband; this problem can be eliminated with the stack antenna structure, using which unidirectional radiation pattern and large bandwidth could be achieved without altering the ground plane, and large bandwidth [1][2][3][9][10][11][12].

These unidirectional antennas are used for imaging systems and airborne radars such as drones. Here figure 4 shows us how the stacked patch antenna are to be designed.

2. ANTENNA DESIGN

The proposed double layer antenna is designed with two different patches this antenna utilizes a one order quasi Minkowski fractal patch on top substrate to reduce the patch size which also reduces the coupling between adjacent elements. The antenna is fed by standard SMA coaxial connectors from the bottom.

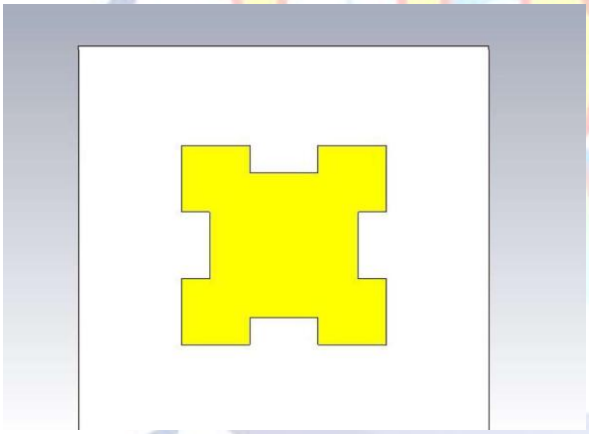

Figure 1. Diagram depicting Top view of Top layer of stacked patch antenna

This Fig.1 is the top view of the top layer in the stacked patch antenna by analyzing the patch we can confirm it as quasi Minkowski fractal patch. The quasi Minkowski fractal patch has the cut into a shape on either side. The proposed Minkowski fractal antenna design achieves wideband and continuous frequency tuning in a multiple-input and multiple-output (MIMO) antenna system[4][12]. By manipulating the fractal geometry of the unit antenna element, the resonance frequency of the antenna can be adjusted simply by changing its electrical length. The Minkowski fractal operator generates an increasing current path, resulting in a leftward frequency shift as the antenna side length increases with each iteration.

Fig.2 is the top view of bottom layer of stacked patch array antenna and fir this layer the patch is of the shape rectangle which is a rectangular patch. And for this bottom layer there will be two coaxial feeds which are present in the downward direction. A rectangular micros trip patch antenna is a form of antenna which consists of a rectangular patch. This patch is of any planar or non-planar geometry on one side of dielectric substrate and a ground plane on the other side. Micro strip patch antenna have low profile configuration, narrow bandwidth and is capable of dual and triple frequency operations [1]. Patch used is made of conducting material such as gold tin and nickel. The rectangular patch can be easily analyzed using transmission line model and cavity model. Transmission line model yields less accurate results and lacks versatility. In cavity model the interior region of dielectric substrate is modeled as cavity bounded by electric walls on top and bottom.

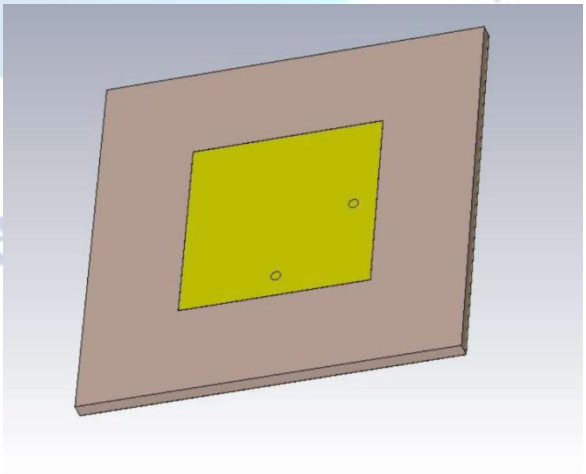

Figure 2. Diagram depicting Top view of bottom layer of stacked patch antenna

The rectangular patch antenna is a low-profile antenna composed of a patch of metal mounted onto a substrate that is backed by a metallic ground plane. It is used in applications from MHz to THz frequencies when size, weight, cost, reliability, and aerodynamic performance are constraints[7][12]. When mounted on electrically large objects, such as the hull of an aircraft, the ground plane is considered as infinitely large, and, at low enough frequencies, a perfect electric conductor (PEC). In these situations, the patch [4][6][7][10]. antenna is excited from the bottom using a coaxial pin extending out of the ground plane and terminating on the top patch.

Fig.3 is the bottom view of the bottom layer of the stacked patch array antenna. For this layer there are two coaxial feeds are given which has inner radius and outer radius. And giving the coaxial feeds we have to assign the ports for the coaxial feeds. Coaxial probe feeds are a commonly used technique for microstrip patch antennas. The microstrip patch antenna feeding technique can be broadly classified into contacting and non-contacting methods. The feeding point of the coaxial probe can be anywhere inside the patch to establish an input impedance match.

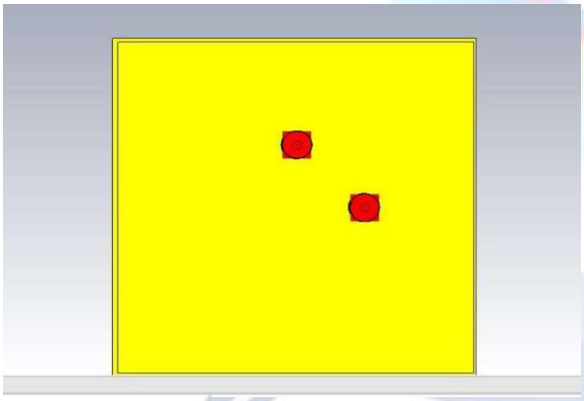

Figure 3. Bottom view of bottom layer of stacked patch antenna

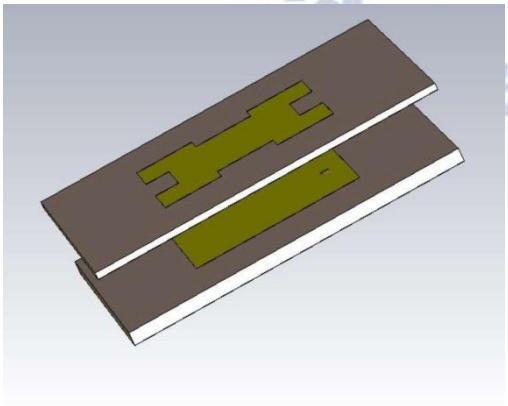

Figure 4. Stacked patch antenna

This Fig.4 is the stacked patch array antenna which is dual layer and having two fractal patches in which one is quasi Minkowski fractal patch and other one is rectangular patch and for the bottom layer there will two coaxial feeds and also two ports are inserted to the rectangular patch. And whenever we are inserting ports into the patch there will be two cylinders present in the coaxial feed we will take inner cylinder by cutting the ground plane and we will keep it into the substrate whereas the outer will be with the contact to the ground plane. For the separation of the inner layer and the outer layer of the coaxial feed we will use Teflon [1][2].

3. DESIGN PARAMETERS

For the design of the stacked patch antenna as we know that there are mainly three things firstly designing of ground plane by using copper annealed then secondly we will design substrate same length and width of ground plane then thirdly we will design patch in necessary shape. For design of patch we again use copper but for substrate we have choose from material library with required relative permittivity. The required parameters for design of Stacked antenna will be shown below in table:

Parameters	Values
Substrate width	Top layer 57 Bottom layer 55.4
Substrate length	Top layer 57 Bottom layer 55.4
Patch width	Top layer 28.5 Bottom layer 27.7
Patch length	Top layer 28.5 Bottom layer 27.7
Substrate height	Top layer 1 Bottom layer 2
Distance between each substrate	9
Coaxial feed	Inner radius 0.7 Outer radius 2.35
Dielectric constant	2.65

[All Values are in “mm”.]

The substrate with 2.65 dielectric constant is Taconic TLT-6 which has Thermal conductance of 0.19 [W/K/m] and Electric tendency of 0.0017 (Const. fit) and Mu is 1. And in general for designing a antenna we choose Substrate of lossy nature and for ground we choose copper annealed.

The substrate width and length of Top layer is the same as the ground plane and both length and width are equal

that is 57 mm. The substrate width and length of bottom layer are same as ground plane and both length and width are equal to55.4 mm. The patch length and width of the top layer which quasi Minkowski fractal patch has the same length and width which is half of substrate length and width that is 28.5mm. And for forming the quasi Minkowski fractal patch we have do cuts of four sides of the patch at ending of patch of length 9.5 mm and width of 3.9 mm then the desired quasi Minkowski fractal patch shape will be formed. The patch length and width of the bottom layer will be half of the substrate that is 27.7 mm. And the distance between the two layer of the stacked antenna will be 9 mm. Between the two layer of the stacked antenna there will be no material it will vacuum present in between two layers.

The coaxial feeds are given to the bottom layer of the antenna which are of the Cylindrical shape and has the inner radius of 0.7 mm and the outer radius of 2.35 mm and in between the inner radius and outer radius there will a non conducting material which Teflon. It is generally known as PTFE (lossy) has the dielectric 2.1 and Mu is 1 and its thermal conductance is 0.2 [W/K/m]. The inner radius cylinder will be of present from the patch to 9 mm outside of ground plane[1]. For that we have to cut the ground plane because if there is ground plane it will become short. So that we will cut the ground plane but outer radius part will not present in the patch it will start from the substrate.

4. RESULTS

The two layer antenna was designed with the 9 mm gap in the substrate gives the S parameters results by analyzing using CST software. The proposed two layer antenna is designed to show the S parameter results.

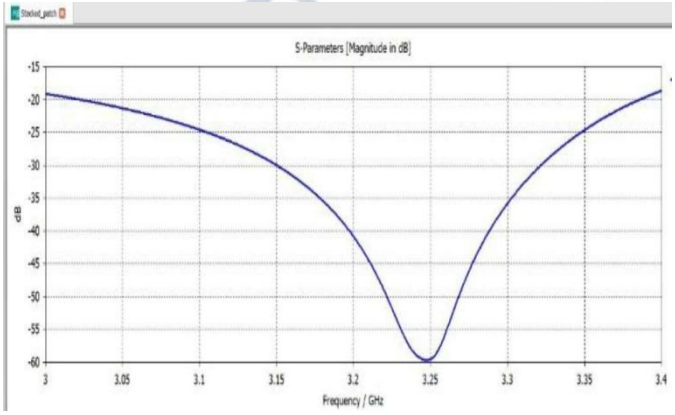

Figure 5(A).

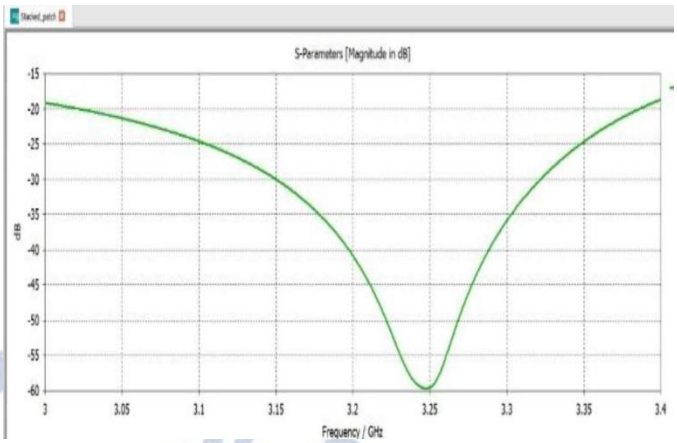

Figure 5(B).

The both Fig.5(a) and 5(b) denotes the S parametric results of two layer stacked patch antenna. The two layer antenna are achieved at the magnitude less than -10dB. The proposed Stacked dual band antenna resonates with the 3.25 GHz frequency. And the magnitude less than -10dB denotes that there will no much loss to the communication when the antenna starts sending the signal. The S parametric result is obtained at 3.25 GHz means in the range of S band so that we can use this antenna for radar and satellite and other applications. The frequency of 3.25 GHz is due to the design parameters we used for the for designing of the antenna the substrate Taconic TLT-6 which has properties as special antenna material for low cost, excellent peel strength, exceptionally low loss, low stable dielectric constant, excellent mechanical and thermal properties.

The stacked patch antenna factors as frequency and magnitude for the dual layer antenna has influence of one on another the distance between the two substrates are of 9 mm but there will mutual influence of one layer on another layer and leading towards to the less loss and at a desired frequency so that we can use that stacked two layer antenna for various applications as weather radar and air traffic control.

5. CONCLUSION

This section presents the simulation results obtained through the utilization of the Novel Particle Swarm Optimization (NPSO) technique, focusing on the minimization of both the Side Lobe Level (SLL) and

This study presents the design and performance of a dual coaxial feed stacked arrangement of one quasi Minkowski fractal patch and rectangular patchs on a Taconic TLT-6 substrate which has properties as special antenna material for low cost, excellent peel strength,

exceptionally low loss, low stable dielectric constant, excellent mechanical and thermal properties.

The designed antenna provides the results as S parameters which gives frequency of 3.25 GHz which is S band so that we can use in variety of applications as weather radar, surface ship radar, satellite communication, and air traffic control.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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