Comparative Analysis for Different Stack Shaped Microstrip Patch Antenna

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Abstract— A compact stack antenna consisting of square patch, loop couplers and inset feed line is reviewed in this work. This proposed design represents a stacked patch antenna having an arrangement of two substrates separated by an air gape and a coupling is provided using square loop structure. The structure is reviewed in two different directions firstly the feed arrangement is varied and secondly a variation in coupler structure is done to make the antenna work at multiple frequencies in UWB range. The simulation results of this work with different resonator structure and feed structures are presented and comparative analysis of these different arrangements is presented in this paper. Simulation results obtained from the proposed antenna for return loss, polar radiation and pattern voltage standing wave ratio (VSWR) shows its suitability for ultra wide band application.
Key words: Microstrip antenna, Return loss, Bandwidth, VSWR, Reflection Coefficient

I. INTRODUCTION

For decades the microstrip antenna has been intensively used due to its significant merits of small size , low profile, light weight and easy integration to circuits. However, the microstrip antennas inherently have a narrow bandwidth. To overcome its limitation of narrow impedance bandwidth, many techniques have suggested e.g., microstrip patch antennas, for probe fed stacked antenna, on electrically thick substrate, stacked shorted patches and slotted patch antenna have been proposed and investigated. In general, the impedance bandwidth of a patch antenna is proportional to the antenna volume, measured in wavelengths. However, by using two multi layered patches with the walls at the edges between these two patches, one can obtain enhanced impedance band width. A compact stack antenna consisting of square loop resonators, aperture couples and feed line [1] was reported for a dual band operation also the stacked structure was utilized for multiband structure [2] again a stacked structure had been applied to an equilateral triangular microstrip patch antennas to reduce its overall size [3], the stacked structure is utilized for bandwidth enhancement also [4-6]. There has recently been considerable interest in the two layer probe fed patch antenna consisting of a driven patch in the bottom and a parasitic patch [7-15]. This article represents a stacked square patch antenna having an arrangement of two substrates separated by an air gape and a coupling is provided using square loop structure. A variation in feed arrangements is done in different iterations to get a wide band structure in UWB range.

The task is completed using two different techniques and different results are summarized and discussed, in section II basic design is discussed; in section III the results of different designs are discussed. Further the article is concluded.

II. ANTENNA DESIGN

The proposed antenna has a simple square patch using an inset feed; the patch antenna is designed using the basic concepts of the microstrip technology.

A. Basic theory

Microstrip patch antennas consist of a metallic patch of metal that is on the top of a grounded dielectric substrate of thickness *h*, with relative permittivity ε_r as shown in Fig. 1.

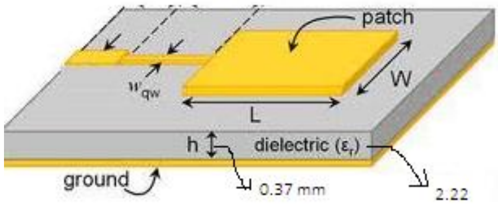

Fig. 1: Geometry of rectangular microstrip patch antenna

The metallic patch may be of various shapes, with circular and rectangular being the most common; the geometry of a Rectangular Microstrip Patch Antenna (RMPA) is shown in Figure 3. The patch of length ‘L’, width ‘W’ and thickness ‘t’ is printed on RT- Duroid (ε_r = 2.22) substrate.

B. Proposed Design

The proposed antenna is composed of a PEC (Perfect Electric Conductor) ground plane, substrate #1 which is RT-Duroid (ε_r = 2.22, h = 0.37 mm) above which a square loop structure is printed with PEC, an air gape is introduced between the first loop and second loop which is printed on the bottom of the substrate # 2 RT-Duroid (ε_r = 2.22, h = 0.37 mm) above this substrate the PEC patch is printed with inset feed line.

Fig. 2: Cross sectional view of the stacked structure patch antenna

The dimensions of the patch are calculated using the standard design equations [16] and optimized to a value of 10 x 10 mm^2 , both the substrates have dimension 25.4 x 25.4 mm^2, length of the inset feed line is optimized to 10.2 mm with a calculated width of 1.2 mm. The coupling loops #1 and #2 are squares of sides 18 mm and 15 mm respectively, the ground plane used here is defective ground structure (DGS) with dimensions 25.4 x 13 mm^2. Partial ground or defective ground structure is used here, in such a technique named defected ground structure (DGS), the ground plane metal of a microstrip (or coplanar, or stripline waveguide) circuit is intentionally modified to enhance performance [17]. The DGS helps in shifting the resonant frequency to get desired frequency [18], by combining with a defective ground plane, the resonant frequency is lowered and the bandwidth is augmented simultaneously [19]. DGS helps in convergence of field in a relatively small region shifting the high frequencies at lower dimensions, ultimately playing a significant role in size reduction.

III. SIMULATION RESULTS AND ANALYSIS

Initial simulations were carried out for the proposed design (Fig. 3) with the optimized dimensions.

The initial simulation results of Return loss (S_{11} in dB) were obtained for the optimized design which is shown in Fig. 4, we can observe from the result that there are two frequency bands on the UWB range for which the S11 is observed less than -10 dB. Initial results are quite sufficient to prove the design satisfactory for the purpose, while the stack antenna presented in reference design the bands of 2.46 GHz with bandwidth (BW) = 160MHz (6.58%) and 5.28 GHz with BW = 450MHz (8.52%) are achieved [1]. So the frequencies obtained in this case are at 3.8GHz (1.84%) and 9.4(2.23%) GHz respectively. The respective radiation patterns for the central frequencies of the two bands i.e. at 3.8 GHz and 9.4 GHz are shown in Fig. 5 and Fig. 6 and it can be observe from the radiation patterns that the far-field pattern is invariant of the frequency.

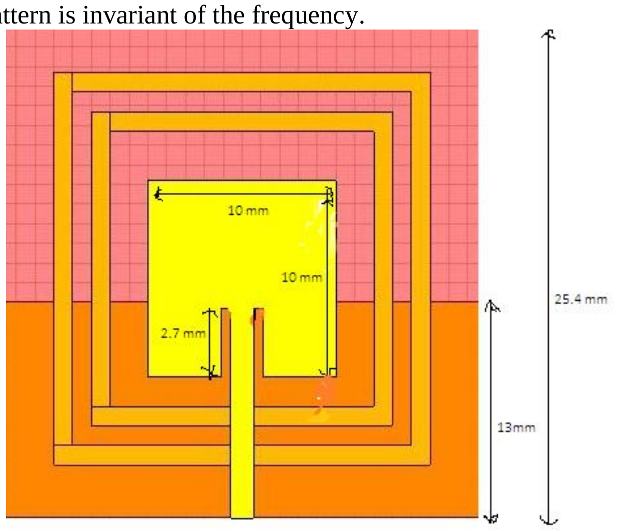

Fig. 3: Top view o the stacked structure patch antenna

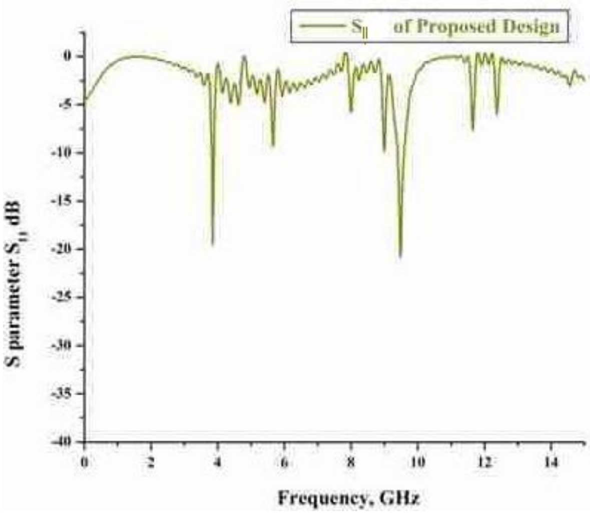

Fig. 4: S_{11} parameter of the proposed design

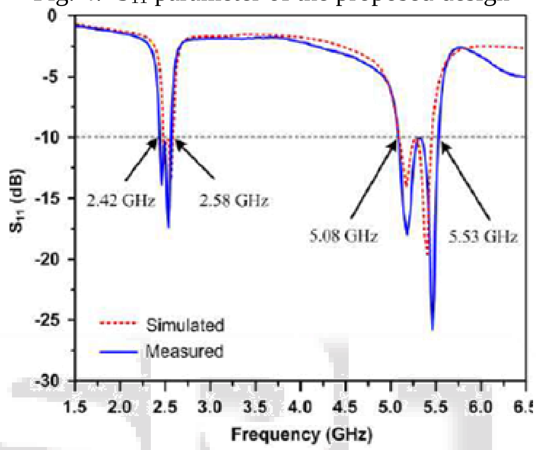

Fig. 4(a): S_{11} parameter of the reference paper design design

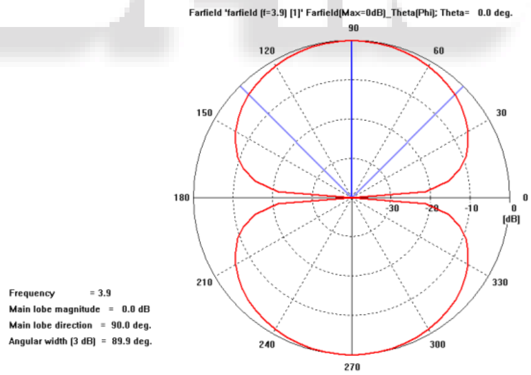

Fig. 5: Far Field E- Field of proposed antenna at 3.9GHz

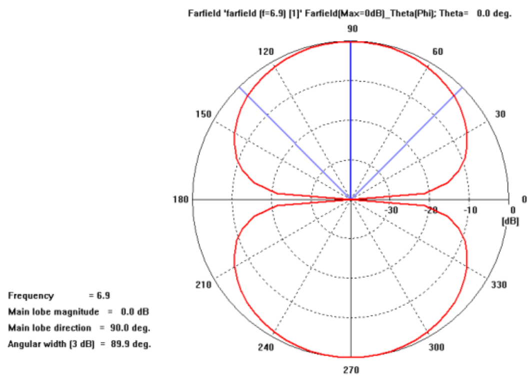

Fig. 6: Far Field E- Field of proposed antenna at 6.9 GHz

The smith chart of input impedance is as follows the input impedance comes out to be 73.21 ohms, the vswr pattern follows the next

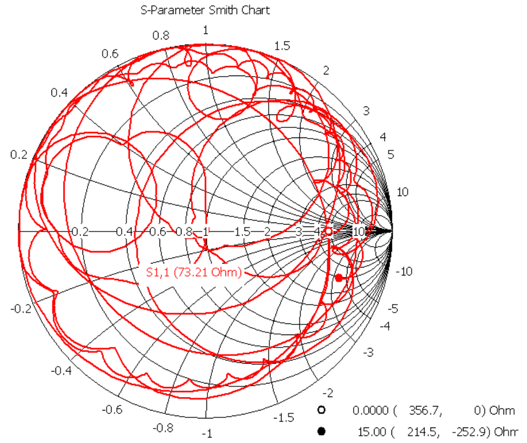

Fig. 6: Smith chart of Impedance matching of proposed antenna

Fig. 6: VSWR Graph of Proposed Design

IV. CONCLUSIONS

In this paper the proposed antenna shows the enhancement of bandwidth and simulation output gives a band of 5 GHz frequency range. Initial results obtained are useful for comparative study of different feed arrangements in single patch. Thus the antenna solves the purpose for which it is designed.

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