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Dual Stacked Wideband Microstrip Antenna Array for Ku-Band Applications

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ABSTRACT—This paper presents design of dual stacked microstrip patch antenna for operating frequency of 12.5 GHz. Investigations show that the proposed antenna has wide bandwidth and for the overall improvement of the gain two element array has been designed. This makes the proposed antenna working in Ku-band with satisfactory bandwidth, gain and radiation characteristics.
Keywords —MSA, Stacked, Bandwidth and Ku- band.

I. INTRODUCTION

A microstrip antenna possesses many advantages such as low profile, light weight, small volume, conformal and mass production in addition to low Cost [1][2]. It has attracted increasing attention of many researchers to investigate this type of antenna or arrays of various configurations to meet various practical applications. The analysis and design of various –shapes microstrip antenna mounted on different structures have been extensively reviewed [3]. However, one of the restrictions of these antennas that limit their wide applications is the narrow bandwidth.

There have been a lot of developments in the field of antenna design in recent years. The researchers are focusing on Increasing gain and impedance, bandwidth and decreasing dimensions of microstrip antennas while keeping the antenna at low cost and easy to fabricate.

But as far as bandwidth of these antennas is concerned, it is always a challenge to the researchers to significantly increase the bandwidth of MSAs. Different techniques have already been used for the bandwidth improvement such as using the substrate with low dielectric constant, using H-shaped patches [3], stacked patches[4], or by increasing the height of the substrate.

As far as our understanding goes much has not been reported regarding the use of staked patches for bandwidth improvement. This is due to the fact that as the antenna height increases the quality factor decreases and the bandwidth increases [5]. This becomes a multilayer antenna with more height and higher bandwidth as compared to the single patch antenna.

One effective method to increase the bandwidth is to add a second patch in front of the basic one resulting in the so called dual patch microstrip antenna. The concept of stacking patches is realized through electromagnetic coupling form which gives bandwidth enhancement [6]. The microstrip stacked square patch antenna produced higher bandwidth (about 15%) in comparison to simple patch antenna (4%).

II. ANTENNA DESIGN

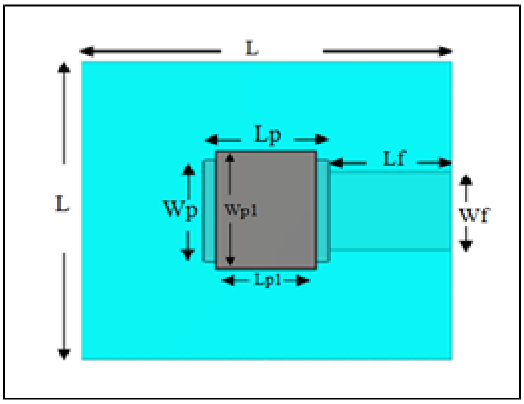
In this section, the design approach and the performance of the proposed antenna is described. At first, the single patch antenna with proximity feed was designed and simulated for the operating frequency at 12.5 GHz in Ku band using the CST Microwave studio [7]. Simple transmission line mode was used for the antenna size calculation. For which formulas are given below.

$W = c/2f\,[(\varepsilon_r + 1)/2]^{-1/2}$ -----------(1)

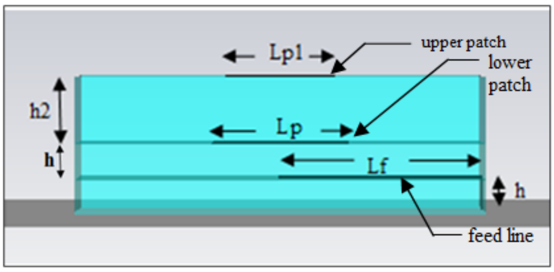
$L = c / 2f \sqrt{\varepsilon_{re}} - 2\Delta L$ -------------(2)

Where ε_{re} and ΔL can be calculated from [5].

Then for the bandwidth enhancement stacking of the patches has been proposed. In this geometry, a substrate of height h_2 along with a radiating patch is introduced over the initial proximity feed MSA. The top view and cross-sectional view of the proposed design is shown in figure 1(a-b).



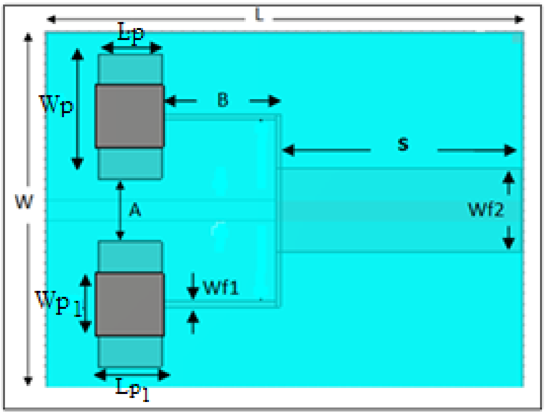
(a)



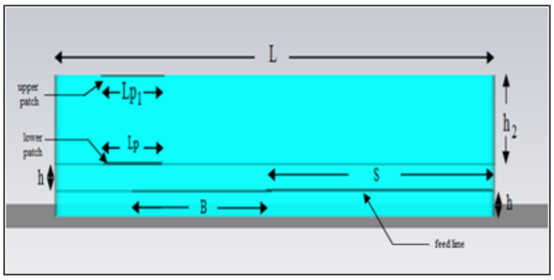
(b)

Fig. 1: Dual staked antenna (a) Top view (b) Side view

Then for the overall gain enhancement a two element array is designed and shown in figure 2(a-b)



(a)



(b)

Fig. 2: Dual staked antenna array (a) Top view (b) Side view

After that antenna array design work is carried out. The configuration of the array contains two radiating element (1x2) separated by the substrates. Then simulated using the same CST microwave studio[6]. The main feed line impedance (Z_1) selected initially is 50Ω which is further divided into two 100Ω impedance (Z_2) lines.

All the optimised parameters for the proposed designed and array feeding network is given in table 1 and table 2 respectively..

Table 1: Design parameters of array of stacked MSA.

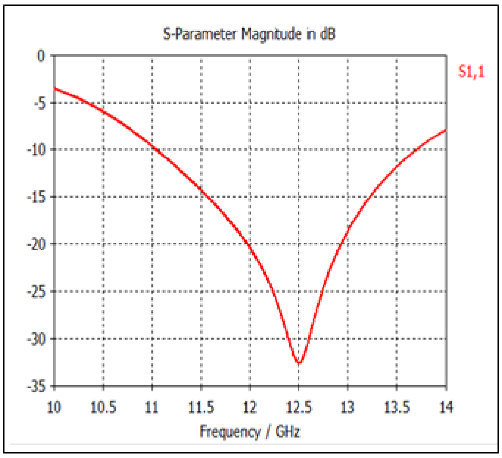
S. no	Parameter description	Notation	Experimental value
1	Size of substrates	L×W×h	45.5×8×1.524 mm^3
2	Dielectric constant of substrates top and bottom	ε_r ε_{r1}	1.5 2.33
3	Size of lower patch(Lp,Wp), size of upper patch, (Lp_1,wp_1)	Lp×Wp×t Lp_1×Wp_1×t	6×12×0.0015 mm^3 6.5×6×0.0015 mm^3
4	Size of feed line	L_f×W_f	13.9×0.5 mm^2
5	Resonant frequency	f_r	12.5 GHz

Table 2: Design parameters of the feeding network

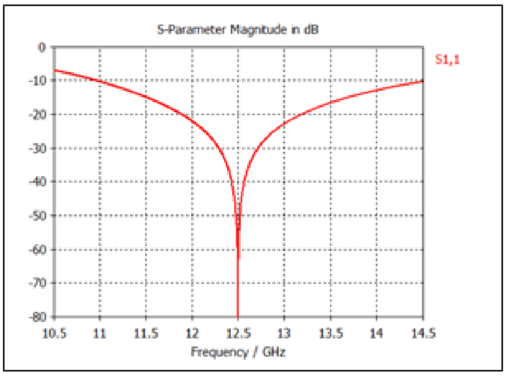
S.n.	Parameter (mm)	1x2 Element Array
1	L_1, W_1	45.5,34
2	Wf_1, Wf_2	0.5, 8
4	S	23.6

III. RESULTS AND DISCUSSIONS

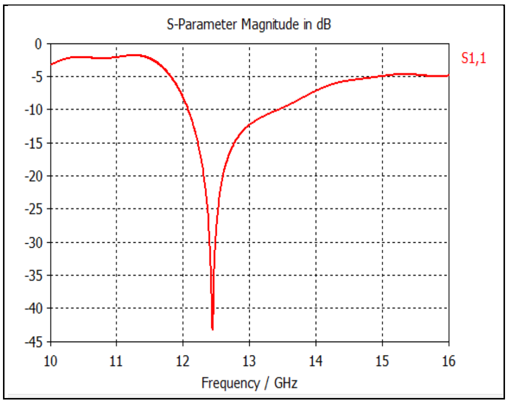
The proximity feed antenna is designed and simulated in CST microwave studio. Optimized S|11| parameter is found to be -34 dB with the bandwidth is 2.68 GHz as shown in fig. 3 (a)



(a)



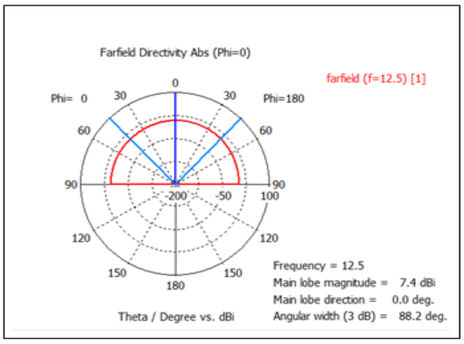
(b)



(c)

Fig. 3: S-Parameter (a) Initial proximity fed (b) Proposed dual stacked (c) Proposed dual stacked array.

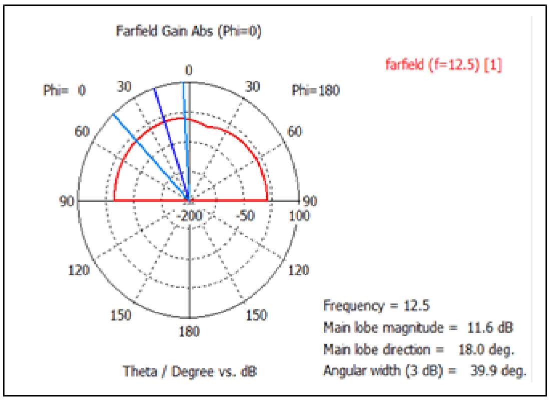
Then a stacked proximity is designed and simulated in CST microwave studio. Optimized S|11| parameter is -80 dB with the bandwidth is 3.5 GHz and gain obtained is 8.24 dB. The results are shown in fig 3(b),and fig 4(a) and fig 5(a)



(a)

Fig. 4: Radiation pattern dual stacked MSA (a) at Ø=0

Then for the further improvement of the gain, array has been designed and simulated in CST microwave studio. The S|11| parameter is -43dB and the gain is improved to 11.57 dB, shown in fig 3(c) and fig 5(a) .



(a)

Fig. 5: Radiation pattern dual stacked array (a) at Ø=0

IV. CONCLUSION

At first a proximity feed antenna is designed and then stacking of the patches is done to enhance the bandwidth of the antenna and leads to the bandwidth improvement from 2.88 GHz to 3.5 GHz. Further enhancement of the gain, array has been designed and a gain improvement from 6.9 dB to 11.6 dB is achieved shown in table 3. It is found that all the designs are working in Ku-band for operating frequency 12.5 GHz and making the MSAs suitable for satellite and radar communications.

Table 3: Comparison of results.

Parameters	Proximity feed	Stacked antenna	Stacked antenna array
Bandwidth	2.68 GHz	3.5 GHz	~ 3.5 GHz
Gain	4.6 dB	6.9 db	11.6 db
Operating frequency	12.5 GHz	12.5 GHz	12.5 GHz

V. REFFERENCE

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