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LINE FEED STACKED SQUARE MICROSTRIP ANTENNA WITH ENHANCED BANDWIDTH

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ABSTRACT— *A Stacked Square Microstrip antenna (SMA) using feed line has been proposed. The Proposed Structure enhances bandwidth by14.82 % while normal antenna 2.05%. Increase Radiation efficiency100 % and antenna efficiency 95% while normal antenna 32%. This paper is only based on computational analysis, we first analyze the characteristics of microstrip antenna and design methods of size structure, taking dielectric constant 4.2, thickness of substrate 1.6 mm and working frequency is 2.44 GHz.*

Keywords **-** *Microstrip antenna, Stacked SMA, Efficiency.*

I. INTRODUCTION

Microstrip patch antennas (MPAs) have attracted widespread interest due to their some advantages[3].However, their further use in specific systems is limited because of their relatively narrow bandwidth. In several investigation found some efficient approches to enhances theire bandwidth[4]. Due to some study in simple square microstrip and one stacking with slot[1-2], the bandwidth of simple antenna is 2-5% but in proposed antenna improved bandwidth upto 14.82%. In this paper, line feed techniques are applied to the stacked square microstrip patch antenna and compare result with simple square microstip antenna.

II. ANTENNA ANALYSIS

Square patch antennas can be designed by using a cavity model suitable for moderate bandwidth antennas. The lowest-order mode, TM_{10}, resonates when the effective length across the patch is a half-wavelength [2].

1) *Resonance frequency*

The resonance frequency f_{mn} depends on the patch size, cavity dimension, and the filling dielectric constant, as follows:

$$f_{mn} = \frac{k_{mn} c}{2\pi\sqrt{\varepsilon_r}} \qquad (1)$$

Where m, n=0, 1, 2… k_{mn} = wave number at m, n mode, **c** is the velocity of light, ε_r is the dielectric constant of substrate, and

$$k_{mn} = \sqrt{\left(\frac{m\pi}{W}\right)^2 + \left(\frac{n\pi}{L}\right)^2} \qquad (2)$$

For TM_{01} mode, the length of non-radiating rectangular patch's edge at a certain resonance frequency and dielectric constant according to equation (1) becomes

$$L = \frac{c}{2 f_r \sqrt{\varepsilon_r}} \qquad (3)$$

$$W = \frac{c}{f_r}\sqrt{\frac{2}{\varepsilon_r + 1}} \qquad (4)$$

Where f_r = resonance frequency at which the rectangular, by using above equation we can find the value of actual length of patch as:

$$L = \frac{c}{2 f_r \sqrt{\varepsilon_{eff}}} - 2\Delta l \qquad (5)$$

Where ε_{eff} =effective dielectric constant and Δl =line extension which is given as:

$$\varepsilon_{eff} = \frac{(\varepsilon_r + 1)}{2} + \frac{(\varepsilon_r + 1)}{2}\left[1 + 12\frac{h}{W}\right]^{-\frac{1}{2}} \qquad (6)$$

$$\frac{\Delta l}{h} = 0.412\frac{(\varepsilon_{eff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{eff} - 0.258)\left(\frac{W}{h} + 0.8\right)} \qquad (7)$$

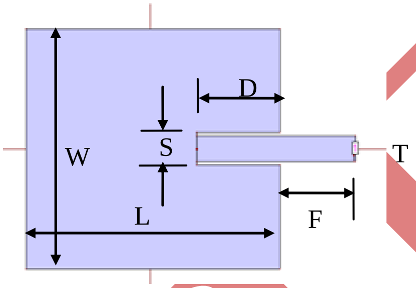


Figure 1: Upper patch SMA

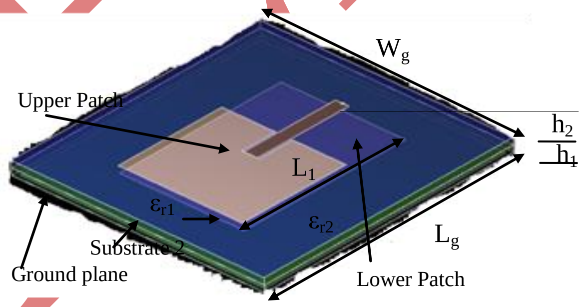


Figure 2: 3D View of Stacked MSA

A combination of parallel-plate radiation conductance and capacitive susceptance loads both radiating edges of the patch.

$$G_1 = \frac{W}{120\lambda_0}\left[1 - \frac{(k_0 h)^2}{24}\right], \frac{h}{\lambda_0} < \frac{1}{10} \qquad (8)$$

Where λ_0 is the free-space wavelength and wave number $k_0 = \frac{2\pi f_r}{c}$. The input conductance of the patch fed on the edge will be twice the conductance of one of the edge slots

$$R_{in} = \frac{1}{2G_1} \qquad (9)$$

The patch can be fed by a coax line from underneath "Fig.1". The impedance varies from zero in the center to the edge resistance approximately as

$$R_{in} = \frac{1}{2G_1}\cos^2\frac{\pi}{L}x_0 \qquad 0 \leq x_0 \leq L/2 \qquad (10)$$

Where R_i is the input resistance, R_e the input resistance at the edge, and x_0 the distance from the patch center.

III. ANTENNA DESIGN

The proposed antenna consists of two square patch antennas stacked on separation by substrate 1 and substrate 2(Fig.2). h_1 and h_2 are the thickness of the patches are1.6 mm and having dielectric constant same for simple designing 4.2(glass epoxy) and loss tangent 0.02. The designing frequency 2.44 GHz of both patches. The width W and the length L of upper patch (Fig.2) is 29.6 mm x 29.6 mm obtained by equations (1-7) and coded by [5]. The Lower patch (Fig.2) dimension is 46.78 mm x 29.6 mm due to adjusted similar of upper patch. The upper patch of the antenna is shown in Fig. 2. On the bottom side of the lower patch a 58.28 mm x 58.28 mm square metallic ground plane has been constructed and ground plane dimension calculated as $W+6h = W_g$ and $L+6h= L_g$ .The excitation for the antenna is given by a line feed at on the upper patch which dimension on 50 Ω is 17.18 mm x 3.16 mm (Fig.1). The three dimensional view of the structure is shown in the Fig.1.The main advantage of using Stacked improve the bandwidth and efficiency of the antenna.

IV. SIMULATION AND RESULT ANALYSIS

Making use of the IE3D software directly [6], we first discuss the way of stacked microstrip to improve the design as bandwidth. As shown in "Fig.2", there are three layers upper patch, lower patch and ground plane. The intermediate layer between two patches and ground plane is gloss epoxy dielectric layer with relative dielectric constant as 4.2. Now Simulate the proposed antenna and a normal antenna with IE3D 3D EM simulator find out some data [11].Finally compared output of normal and stacked antenna. Reflection coefficient of square microstrip antenna without stacked and with stacked result from IE3D shown in Fig.3-4, where the normal SMA operating frequency range below 2 VSWR (VSWR< 2) 2.415 GHz - 2.465 GHz, which is 2.05% bandwidth and after introducing stacked in SMA then operating frequency range wider as 2.34375 GHz - 2.72 GHz which is bandwidth 14.82% that means bandwidth enhanced approximate to 12.8%.

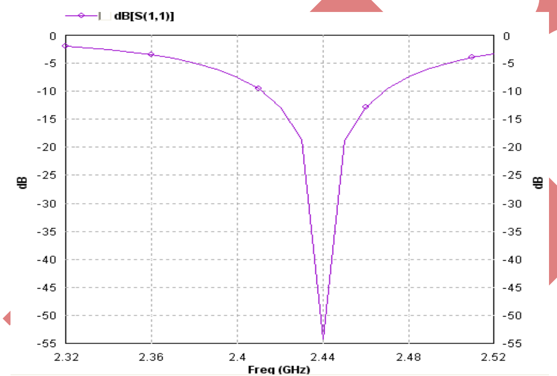


Figure: 3. Return loss Vs frequency plot without stacked

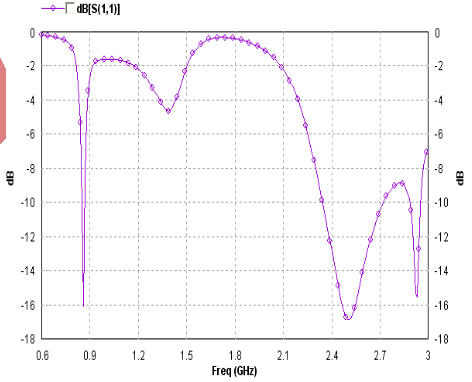


Figure: 4. Return loss Vs frequency plot with stacked

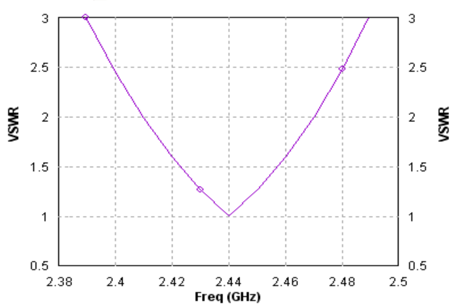


Figure: 5. VSWR Vs frequency plot without stacked

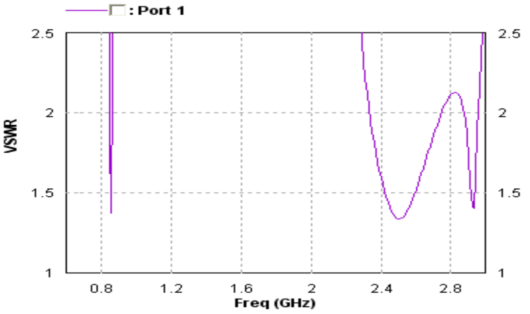


Figure: 6. VSWR Vs frequency plot of Stacked SMA

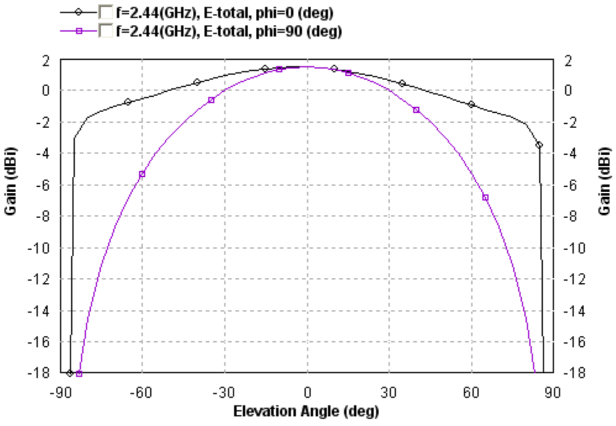


Figure: 7. Radiation Pattern plot without stacked

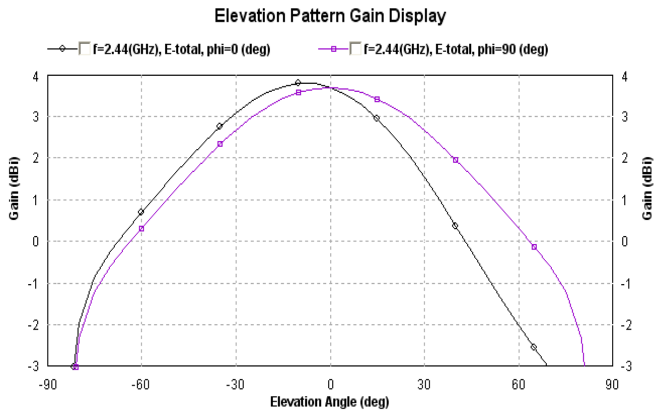


Figure: 8. Radiation Pattern of Stacked SMA

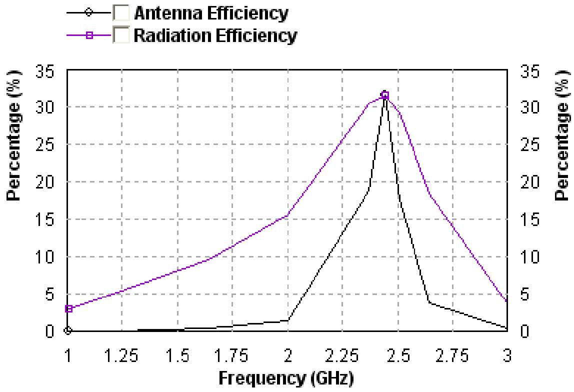


Figure: 9. Efficiency Vs Frequency plot without stacked

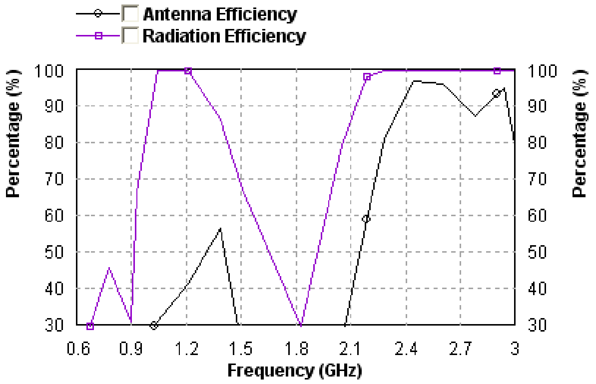
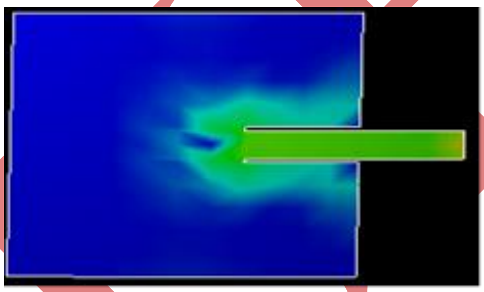


Figure: 10. Efficiency Vs Frequency plot with Stacked SMA



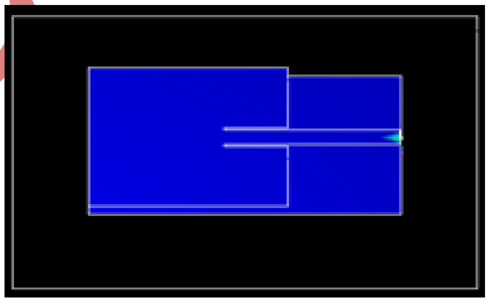
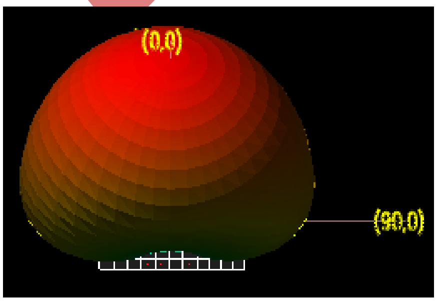


Figure: 11. Current distribution without stacked at 2.44 GHz Figure: 12. Current distribution with stacked at 2.44 GHz



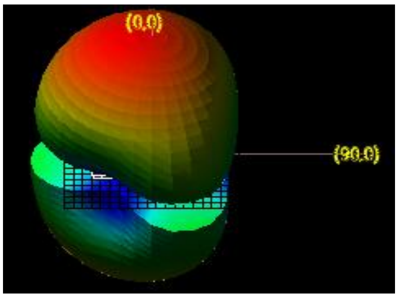


Figure: 13. Radiation pattern 3D without Stacked Figure: 14. 3D Radiation Pattern with Stacked SMA

Table I

Upper patch width	**W**	**29.6 mm**
Upper patch length	L	29.6 mm
Lower patch length	L_1	39.08 mm
Inset depth	D	7.6 mm
Inset width	S	4 mm
Feed line length	F	9.48 mm
Strip width	T	3.16 mm
Gap of depth and strip		0.42 mm
Ground plane length	L_g	58.28 mm
Ground plane width	W_g	58.28 mm

Table II

Comparison on different parameter of the antenna

Parameter	***SMA***	***Stacked MSA***		
Oprating Frequency	2.44 GHz	0.86 GHz	2.5 GHz	2.93 GHz
Return loss	-54.12 dB	-16.06 dB	-16.84 dB	-15. 51 dB
VSWR	1	1.373	1.336	1.411
Bandwidth	2.05%	14.82%		
Antenna Efficiency	32%	95%		
Radiation Efficiency	32%	100%		
Gain	1.6 dBi	3.5dBi		

V. CONCLUSION

It has been observed that by introducing the stacked structure in conventional microstrip antenna the Bandwidth, gain and the antenna efficiency can be improved. In this work focus on the bandwidth of the antenna improved 14.82% and antenna efficiency and radiation efficiency of the proposed microstrip antenna is 95% to 100% and also improved the gain about 3.5dBi.

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