Bandwidth Enhancement by Slotted Stacked Arrangement and its Comparative Analysis with Conventional Single and Stacked Patch Antenna

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***Abstract*- This paper presents proposed stacked arrangement of square patch antenna with slot and comparative analysis of single, conventional stacked arrangement and proposed stacked arrangement. An antenna is designed by using glass epoxy-FR4 substrate. In the proposed stackedarrangement there are two patches: driven(lower) patch&parasitic (upper) patch, both patches having the same dimension. Lower patch is modified by having two slots. There is an air gap of 0.5 mm between these two patches. The driven patch is fed through probe feed with sub miniature version A (SMA) connector and the upper structure is parasitically coupled to the driven patch. Simulation process is done by using IE3D simulator. Simulation results: return loss, input impedance, voltage standing wave ratio (VSWR) and 2-D radiation pattern of all three antenna geometries are compared.It is analyzed in this paper that the proposed stacked arrangement has relatively broad impedance bandwidth (40.15%).**

Keywords- Reflection coefficient, parasitic upling,impedance bandwidth, input impedance, VSWR,radiation pattern

I. INTRODUCTION

In rapidly expanding market for wireless communication and applications, microstrip antenna has become widely popular as it is low profile, conformable to the hosting surfaces, light weight and can be easily integrated with the electronic system[1-2].But it has some disadvantages too. The bandwidth of the microstrip patch antenna is very narrow [3-5]. Therefore, a lot of work has been done for improving the operating bandwidth of the microstrip patch antenna[5-6].
Stacking and slotting are the techniques to improve the performance of antenna by enhancing the bandwidth [6-7].
In this paper, the radiation performance of modified stacked arrangement of patches is analyzed. The lower patch is modified by making two slots. It is fed through probe feed with SMA connector and the upper structure is parasitically coupled to the lower patch. The size of the upper patch and lower patch are kept same. The propose structure has been initially optimized using the Method of Moments based CAD tool IE3D [8].
This paper has V sections, Brief introduction is given in section I. Section II describes about single patch, section III about stacked arrangement and section IV describes about modified proposed stacked arrangement. Discussion and conclusion is presented in section V.

II. SINGLE CONVENTIONAL PATCH

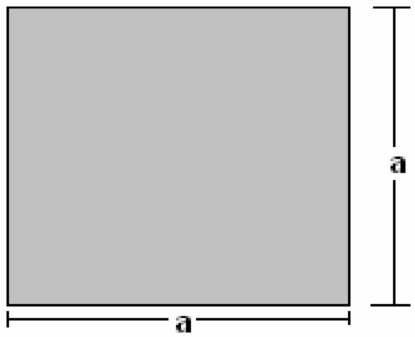


Fig 1.1: Conventional single square patch

A conventional square patchhaving dimension of 20mm*20mm designed on glass epoxy FR-4 substrate (ϵ_r= 4.4, tanδ= 0.025, substrate thickness 'h' = 1.59 mm). The square patch is fed through SMA connector with associated 50 ohm feed line. This arrangement is simulated with method of moment based IE3D simulationsoftware.
Simulation results for this geometry are as follows:

1. *Reflection Coefficientv/s Frequency*:
Reflection coefficient plot determines the return loss of antenna. Return loss is a logarithmic ratio measured in dB that compares the power reflected by the antenna to the power that is fed into the antenna from the transmission line.The centre frequency or resonant frequency is selected as the one at which the return loss is minimum.

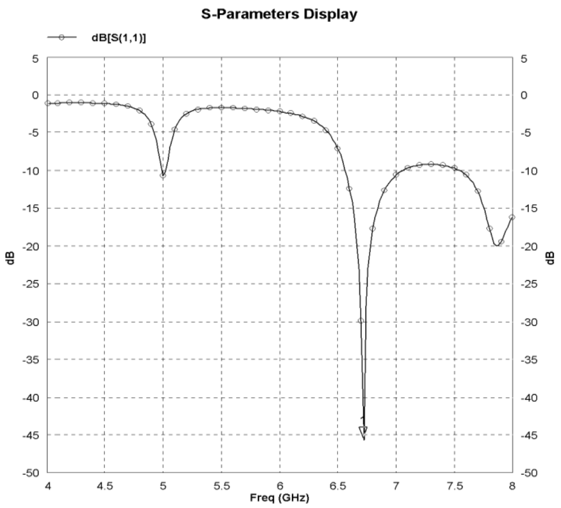


Fig 1.2: Simulated reflection coefficient (S11) of single square patch with frequency

Fig 1.2 shows return loss for single patch antenna. At resonant frequency 6.71 GHz, return loss is -45.38 dB. It is observed from the plot that single patch operates at only one frequency. Bandwidth can be calculated from return loss plot. For single patch impedance bandwidth is 7.23 %.

2. *Input impedance v/s Frequency*:

Smith chart represents the input impedance v/s frequency plot.

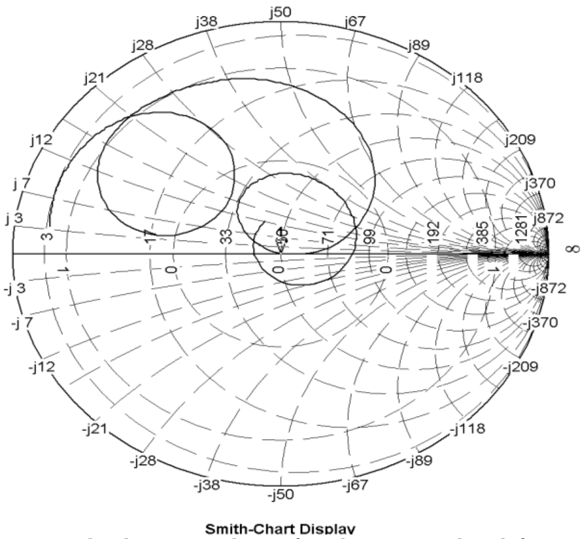


Fig 1.3: Simulated input impedance of single square patch with frequency

The simulated input impedance of single patch antenna at resonance frequency is(49.92+j 0.20) ohmwhich suggests excellent matching between antenna and feedarrangement.

3. *VSWR v/s Frequency:*

The parameter VSWR is numerically describes how well the impedance of antenna is matched to the transmission line.

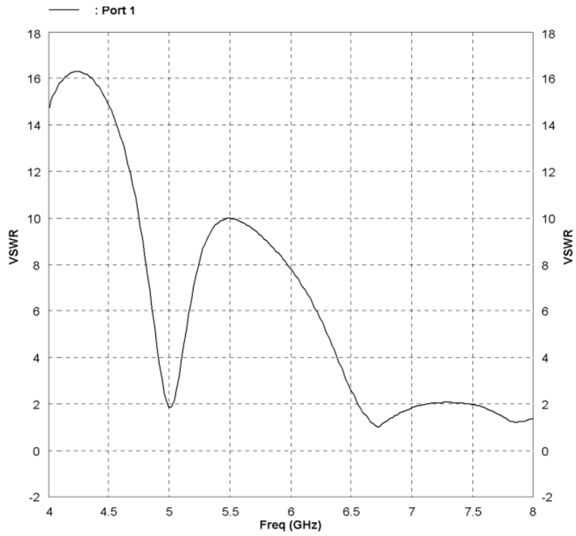


Fig 1.4: Simulated VSWR variation with frequency of single square patch

Fig 1.4shows VSWR variations with frequency. It is observed from the plot that VSWR values at resonant frequencies are very near to the ideal value of VSWR (1), which indicates very good matching between antenna and feed arrangement.

4. *Radiation pattern*:

Since a Microstrip patch antenna radiates normal to its patch surface, the elevation pattern for φ = 0 and φ = 90 degrees would be important. So the elevation radiation pattern for φ = 0 and φ = 90 degrees are presented here.

In fig 1.5 elevation pattern plot is shown for single patch antenna. This plot shows E-plane and H-plane elevation patterns at resonant frequency.

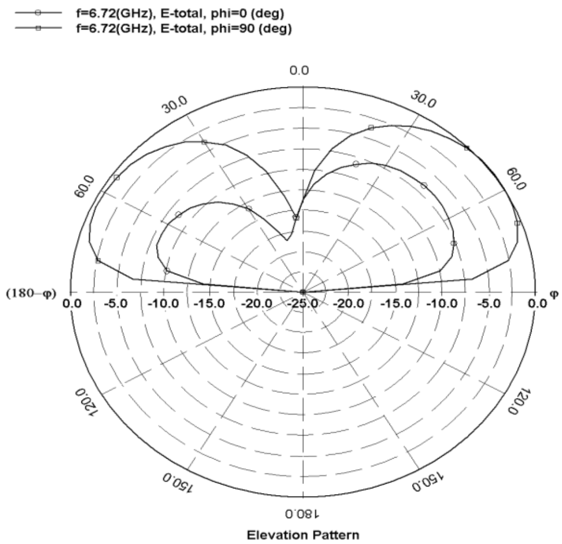


Fig 1.5: Elevation pattern for single patch

III. STACKED ARRANGEMENT

The proposed stacked antenna design is made up of two patches, one layer of air and a probe connected to the lower patch. The antenna structure is simulated with substrate parameter available for glass epoxy FR-4(ϵ_r=4.4,tanδ= 0.025).The substrate thickness is 1.59 mm. The lower patch having the dimension 20mm*20mm, an air-gap layer with dielectric permittivity 1and thickness 'd' =1 mm is between the lower and upper patches. The upper patch has the same dimension as lower patch. The lower patch named as driven element is feed through SMA connector and the upper patch is parasitically coupled to lower patch.

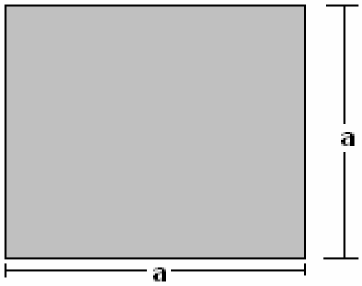


Fig 2.1(a): Conventional stacked lower(driven) patch

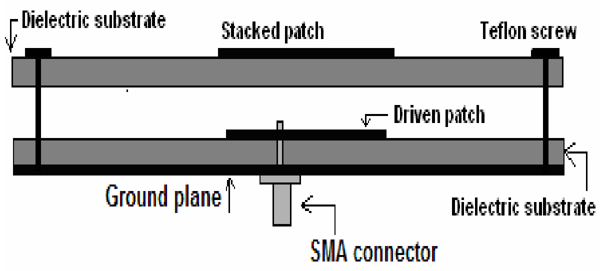


Fig 2.1(b): Side view of stacked arrangement

Simulation results for stacked arrangement are as follows:

1. *Reflection Coefficient v/s Frequency*:

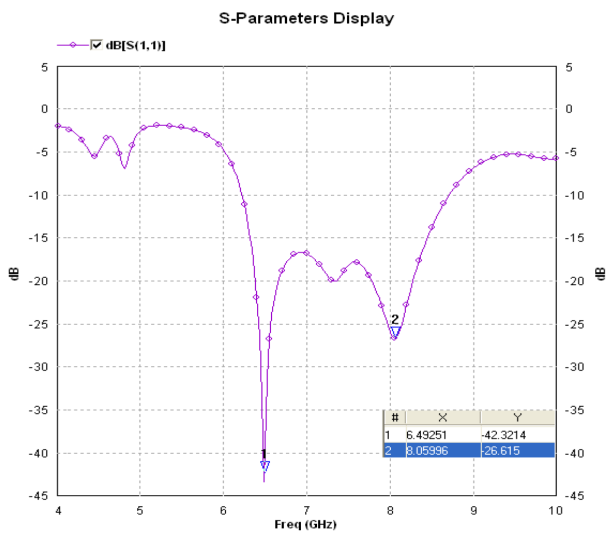


Fig 2.2: Simulated reflection coefficient (S11) of stacked arrangementwith frequency

As shown in fig 2.2, return loss is -42.32 dB at resonant frequency 6.49 GHz and -26.61 dB at resonant frequency 8.05 GHz. This stack arrangement operates at these two frequencies 6.49 and 8.05 GHz.

2. *Input impedance v/s Frequency*:

The simulated input impedances of stack arrangement at two resonance frequencies are (49.69 +j 0.62) ohm and (50.30 + j 4.64) ohm which suggests excellent matching between antenna and feedarrangement at both resonance frequencies.

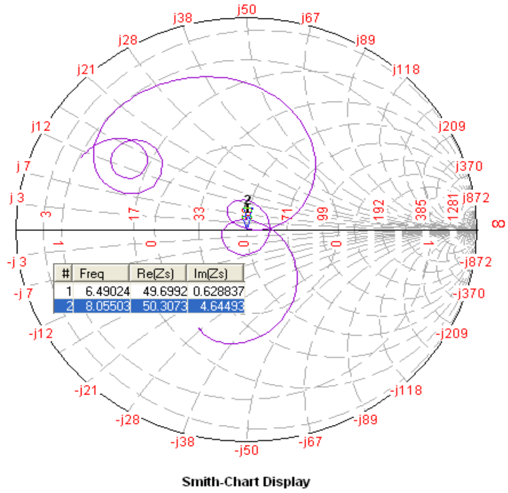


Fig 2.3: Simulated input impedance of stacked arrangement with frequency

3. *VSWR v/s Frequency:*

It is observed from the figure 2.4 that VSWR values at resonant frequencies are very near to the ideal value of VSWR (1), which indicates very good matching between antenna and feed arrangement.

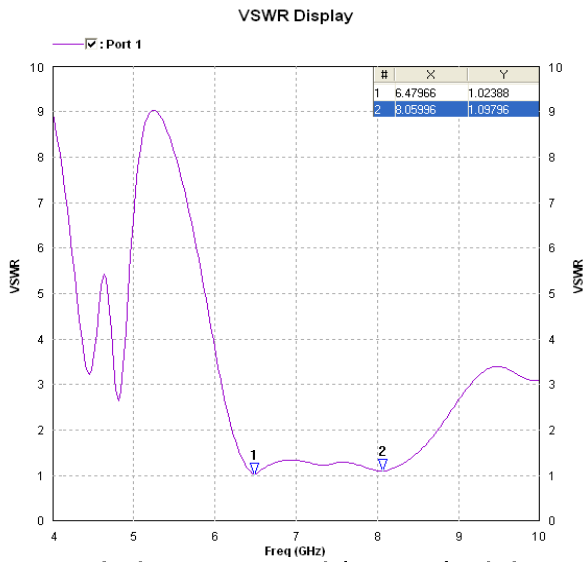


Fig 2.4: Simulated VSWR variation with frequency of stacked arrangement

4. *Radiation pattern*:

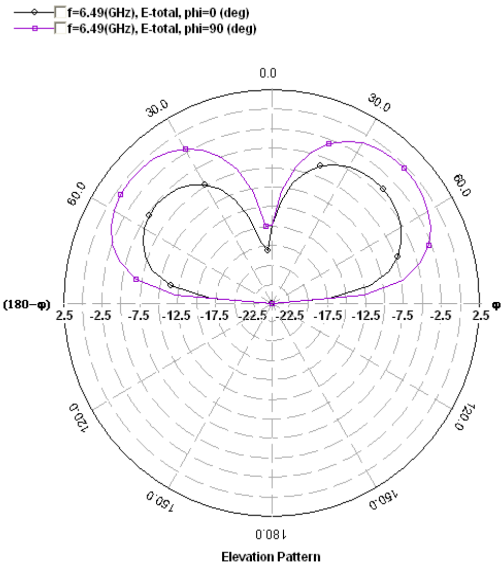


Fig 2.5: Elevation pattern for stacked arrangement

In fig 2.5 elevation pattern plot is shown for stacked arrangement. The radiation pattern of stacked arrangement in entire bandwidth is almost identical in shape and nature as compared to single patch.

IV. PROPOSED STACKED ARRANGEMENT WITH SLOT

The proposed stacked antenna design is made up of two patches: the lower patch having the dimension 20mm*20mm and having two slots, while upper patch kept same as previous stacked arrangement. An air-gap layer with dielectric permittivity 1and thickness‘d’ =0.5 mm is between the lower and upper patch. The lower patch named as driven element is feed through SMA connector and the upper patch is parasitically coupled to lower patch.

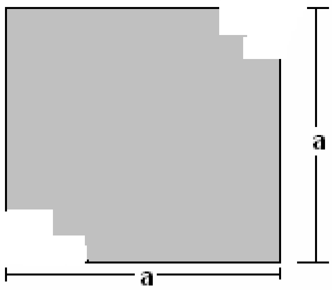


Fig: 3.1: Modified lower(driven) patch

Simulation results of this proposed modified stacked arrangement are as follows:

1. *Reflection Coefficient v/s Frequency*:

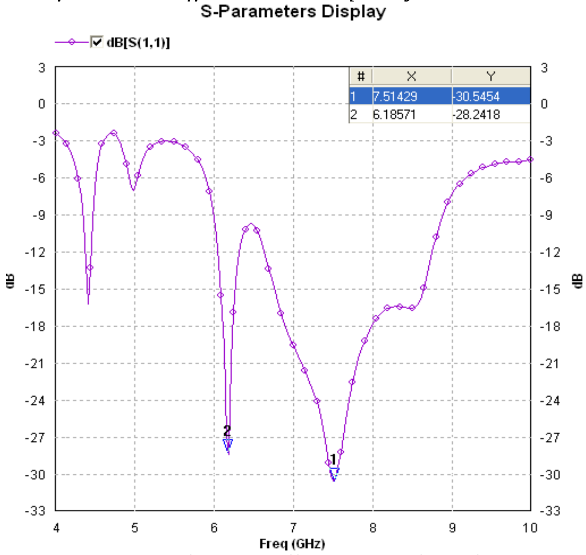


Fig 3.2: Simulated reflection coefficient (S11) of modified stacked arrangement with frequency

As shown in fig 3.2, return loss is -30.54 dB at resonant frequency 7.51 GHz and -28.24 dB at resonant frequency 6.18 GHz. This arrangement operates at these two frequencies 7.51 GHz and 6.18 GHz.

2. *Input impedance v/s Frequency*:

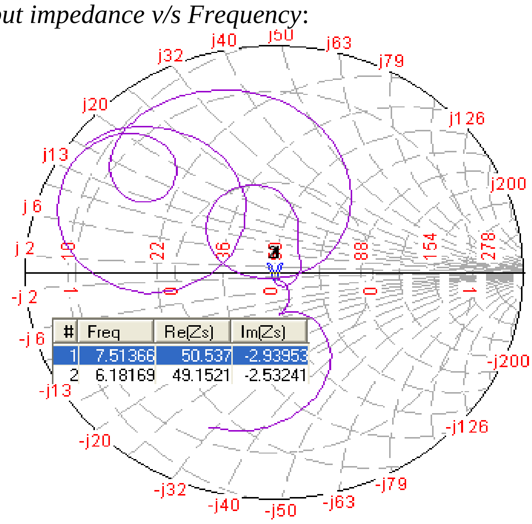


Fig 3.3: Simulated input impedance of modified stacked arrangement with frequency

The simulated input impedances of stack arrangement at two resonance frequencies are (50.53 -j 2.93) ohm and (49.15 - j 2.53) ohm which suggests excellent matching between antenna and feedarrangement at both resonance frequencies.

3. *VSWR v/s Frequency:*

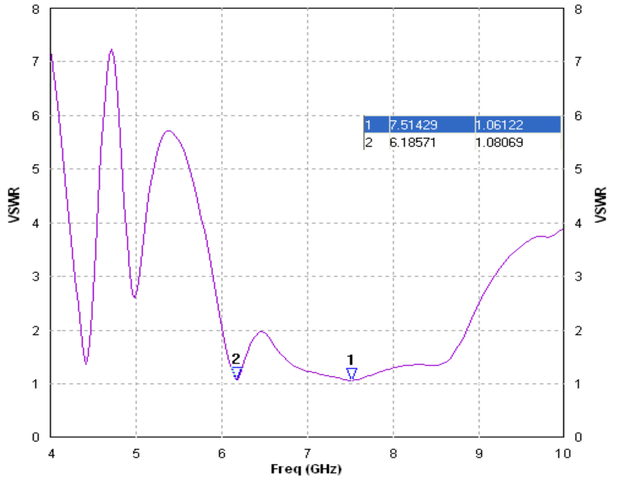
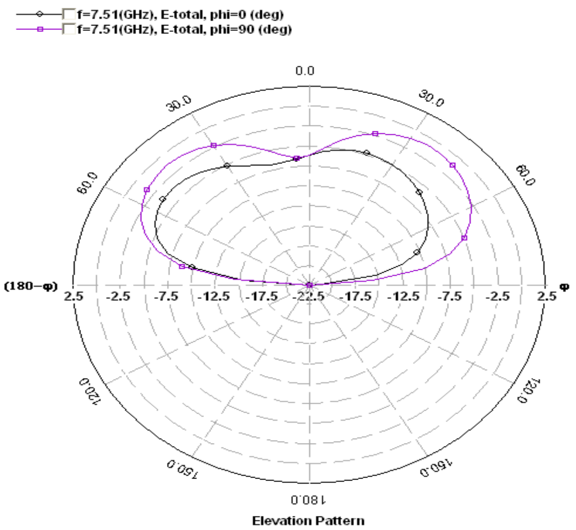


Fig 3.4: Simulated VSWR variation with frequency of modified stacked arrangement

Fig 3.4 shows VSWR variations with frequency. It is observed from the plot that VSWR values at resonant frequencies are very near to the ideal value of VSWR (1), which indicates very good matching between antenna and feed arrangement.

4. *Radiation pattern*:



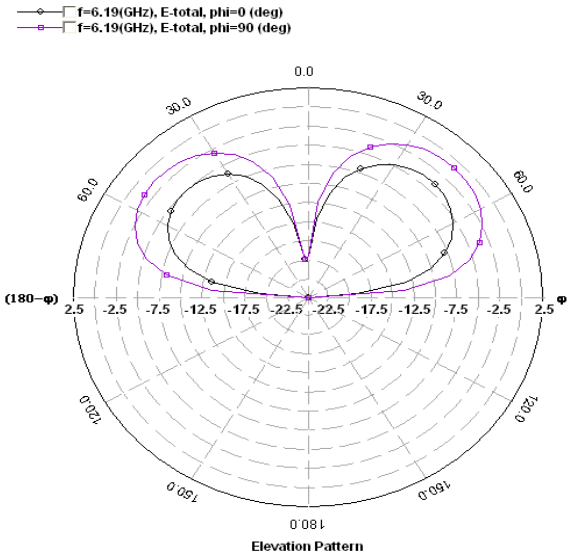


Fig 3.5(a) & (b): Elevation patterns for modified stacked arrangement

In fig 3.5(a) and 3.4(b) elevation pattern plots are shown for proposed stacked arrangement. These plots show E-plane and H-plane elevation patterns at resonant frequency.The radiation pattern of proposed stacked arrangement in entire bandwidth is almost identical in shape and nature as compared to single patch.

V. DISCUSSION AND CONCLUSION

The radiation performance of proposed arrangement of square patches is simulated by using IE3D simulation software and its performance parameters i.e. return loss, bandwidth, VSWR, radiation pattern is compared with conventional stacked arrangement and single patch antenna. After the comparison it is realized that proposed antenna operates at two resonant frequencies with much improved impedance bandwidth (40.15%) than stacked arrangement (33.74%) and conventional square patch (7.23%). It shows that the proposed arrangement enhanced the impedance bandwidth. Also the radiation patterns in entire bandwidth are almost identical in shape and nature and uniformly radiate in all directions.

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