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Bandwidth Enhancement Of Stacked Microstrip Patch Antenna Using Multidielectric Substrate

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Abstract—A stacked mirostrip patch antenna using two substrate is presented in this paper. This paper proposes the bandwidth enhancement of a stacked wideband antenna by varying the size and position of the parasitic patches on a FR4 substrate. The proposed antenna uses two patches one driven patch on a FR4 dielectric substrate and the other one is parasitic patch on a same substrate. Between two patches there is an air gap of 13.4 mm. The antenna resonates at 3.1 GHz frequency. With adjusted parameters, the antenna exhibits a broad impedance of about 81.8% (2.73 GHz-5.35GHz) and VSWR of 1.02 (VSWR≤2).The bandwidth, gain, efficiency obtained in the design antenna make it suitable as potential radiator for various application.

I. INTRODUCTION

The rapid development of wireless communication systems has increased the demand for compact microstrip antennas with high gain and wideband operating frequencies.Microstrip patch antenna has advantages such as low profile, conformal, light weight, simple realization process and lowmanufacturing cost. However, the general microstrip patch antennas have some disadvantages such as narrow bandwidth etc. Enhancement of the performance to cover the demanding bandwidth is necessary [13]. There are numerous and well-known methods to increase the bandwidth of antennas, including increase of the substrate thickness, the use of a low dielectric substrate, the use of various impedance matching and feeding techniques, and the use of multiple resonators [13].

To overcome the above problem, a multi-layer microstrip antenna structure with partial ground structure on the rectangular patch which results a wider bandwidth. In this paper a printed wide-band stacked patch antenna for enhancing the bandwidth is presented. The antenna is simulated using Ansoft HFSSv13.

The dielectric constant of the substrate is closely related to the size and the bandwidth of the microstrip antenna. Low dielectric constant of the substrate produces larger bandwidth, while the high dielectric constant of the substrate results in smaller size of antenna. A trade-off relationship exists between antenna size and bandwidth [14]. The resonant frequency of microstrip antenna and the size of the radiate patch can be similar to the following formulas.The width of the patch is calculated first, given by the formula

$$W = \frac{c}{2f\sqrt{\frac{\varepsilon_r+1}{2}}}$$

Where is the substrate dielectric constant, W is the width of the patch and h is the height of the substrate. An effective dielectric constant ε_{reff} is used. The effective dielectric constant is defined as the dielectric constant of the uniform dielectric material so that

For $\frac{W}{h} \geq 1$

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1 + 12\frac{h}{W}\right]^{-\frac{1}{2}}$$

For $\frac{W}{h} \leq 1$

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1 + 12\frac{h}{W}\right]^{-\frac{1}{2}} + 0.041\left[1 - \sqrt{\frac{W}{h}}\right]$$

The dimensions of the patch are extended to account the fringing effect; the extension is given by

$$\Delta L = 0.412h\frac{(\varepsilon_{reff}+0.3)(\frac{W}{h}+0.264)}{(\varepsilon_{reff}-0.258)(\frac{W}{h}+0.8)}$$

Since the length has been extended by on each side of the patch, the effective length is given by

$$L_{eff} = \frac{C}{2f\sqrt{\varepsilon_{reff}}}$$

Patch resonant length L is given by,

$$L = L_{eff} - 2\Delta L$$

The proposed antenna comprises two patches: Lower rectangular patch element and upper rectangular patch element as a parasitic element which are stacked by separating by air gap.Figure 1(a) shows the geometrical structure of the driven and parasitic rectangular patches of the proposed antenna.The geometrical dimensions of the lower that is driven rectangular microstrip patch are length L_d=21 mm and width W_d=18 mm.The lower patch and the upper patch is designed by using FR4 substrate of thickness=1.6mm, dielectric constant ε_r=4.4. The length and width of upper parasitic patch is L_p=10 mm and W_p=12.5 mm respectively. Both the patches are separated by an air gap of g=13.4 mm. In the proposed design ,the lower rectangular patch is inset- feed having length and width of 12mm and 3mm respectively. The proposed antenna used Ansoft HFSSv13 to design and simulate the antenna.

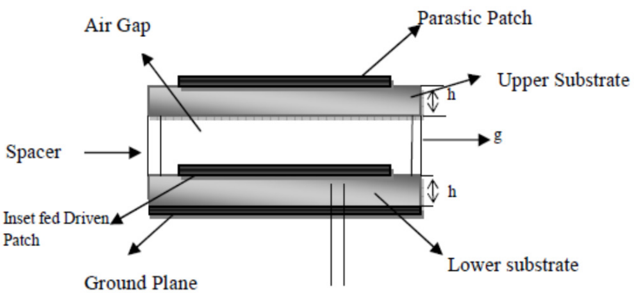

Figure1 (a)

The antenna dimensions (in mm)

Layer Geometry	Parameter	Value
Width of the substrate	W_1	25
Length of substrate	L_1	38
Width of partial ground	W_g	25
Length of partial ground	L_g	9
Width of driven patch	W_d	18
Length of the driven patch	L_d	21
Height of the substrates	h	1.6
Spcacing between substrates	g	13.3
Width of the upper substrate	W_2	25
Length of upper substrate	L_2	20
Width of parasitic patch	W_P	12.5
Length of parasitic patch	L_P	10

III. RESULTS AND DISCUSSIONS

Figure depicts the return loss(S_{11}) characteristics of the proposed antenna. This antenna resonates at 3.1 GHz with the bandwidth(Ref -10 dB) of 2.26 GHZ which is 81.8%.In the proposed antenna. air gap is introduced between two substrates to increase the effective thickness and to decrease the effective permittivity .As seen from the figure the proposed antenna maintains good performance centered around the design frequency. Figure shows the return loss and VSWR characteristic of the antenna with and without parasitic patch.

(a) WITH OUT PARASITIC ELEMENT

Figure 2(a) shows a HFSS design of microstrip patch antenna without parasitic patch.

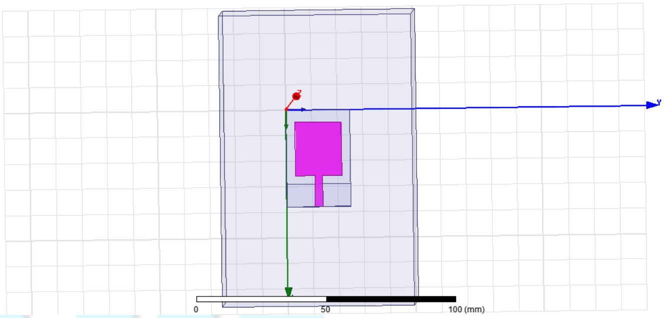

Figure 2(a) Patch (HFSS)

The Return Loss observed for the structure shows at return loss of -23 dB at 3.1GHz.

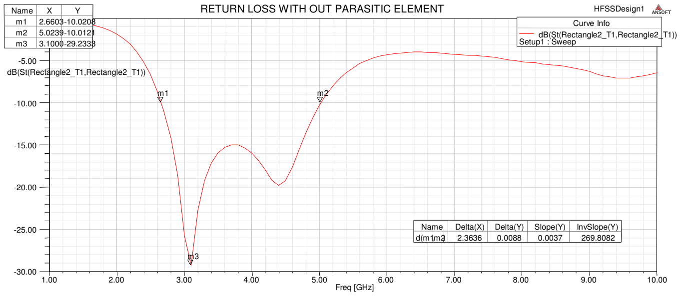

Figure 2(b) Return loss(Theoretical)

The VSWR observed in the structure shows 1.07 at 3.1GHz

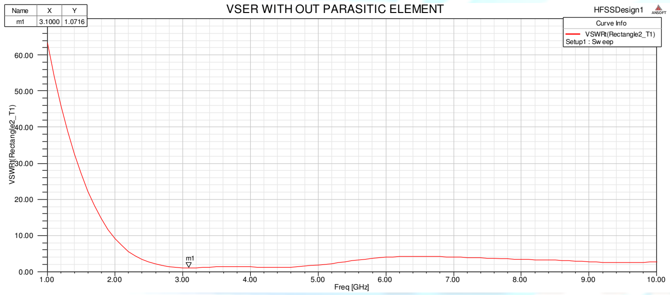

Figure 2(c) VSWR (Theoretical)

(b) WITH PARASITIC ELEMENT

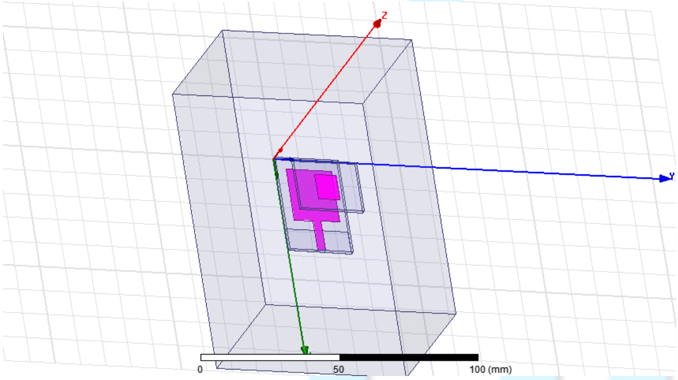

Figure 3(a) Patch (HFSS)

The Return Loss observed for the structure shows at return loss of -40 dB at 3.1GHz.

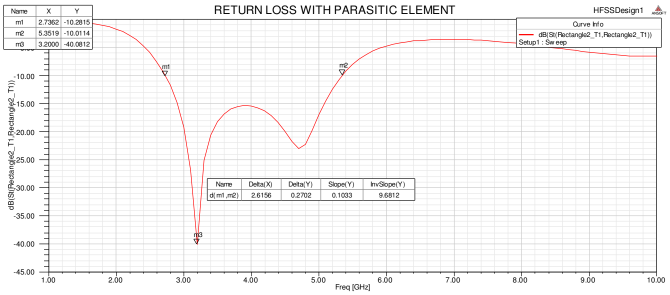

Figure 3(b) Return loss(Theoretical)

The VSWR observed in the structure shows 1.02 at 3.1GHz,

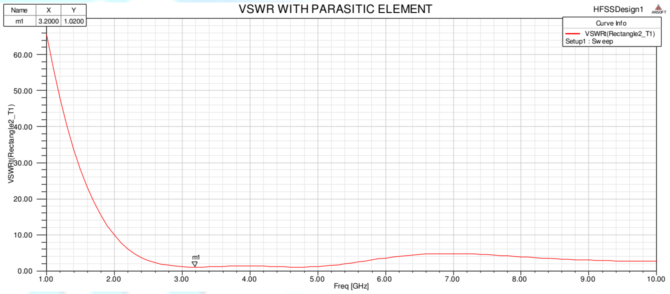

Figure 3(c) VSWR(Theoretical)

IV.CONCLUSION

The proposed structure shows that bandwidth enhancement is achieved using parasitic patch antenna. The high return loss and low VSWR is also achieved through this structure. The percentage bandwidth of 81.8% is observed in the structure at 3.1GHz which can be used for WLAN applications. So it can be used for broadband application.

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