A Multilayer Multiresonator Aperture Coupled Microstrip Antenna for Ultra Wideband Operation

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***Abstract*-This paper presents a dual stacked rectangular aperture coupled microstrip antenna for ultra wideband applications in the frequency range of 10 – 15 GHz. The antenna structure includes two rectangular patches on two different layers which are separated by two air gaps and substrates with low dielectric constants. This paper shows the resonant frequency of the patches will change by changing slots' length and position, and the substrate position on top later. By setting resonant frequencies, an antenna with 4.5 GHz (36.7%) impedance bandwidth (VSWR<2) and 4.1 GHZ (32.4%) gain bandwidth (above 8 dB) can be achieved.**

I. Introduction

Microstrip Antennas (MSAs) have been used widely because of their advantages such as low cost, light weight and easy fabrication using printed-circuit technology. However, they suffer from some disadvantages; i.e. narrow bandwidth and low gain [1,2,5,6]. Techniques, such as using multilayer structures, low dielectric constant and air gap between layers are reported resulting in high gain and increased impedance bandwidth [1,4].

This paper presents an antenna structure with two rectangular patches, with the same dimensions, placed on different layers above the slots which is excited by a 50 Ω feed line. The effect of the substrate on top layer, slots' lengths and positions are numerically investigated based on Method of Moment (MoM). Finally an antenna with 4.5 GHz (36.7%) impedance bandwidth (VSWR<2) and 4.1 GHZ (32.4%) gain bandwidth (above 8 dB) is obtained.

II. Antenna Model

In the antenna structure shown in Fig. 1 two rectangular patches are placed on top of the slot and are separated by materials with low dielectric constant and air gaps. In this structure there are two air gaps (D2, D4) for increasing gain of the antenna and three substrates (D1, D3, D5) made of the same material with relative permittivities of 2.2 and thicknesses of 0.5 mm. There is a 50 Ω feed line under the first dielectric (D1) while a 0.5 mm thickness slot is located above it.

The separation between patches and slots are then optimized using a Method of Moment based software [7]. All dimensions of the antenna are shown in Table 1.

(a)

(b)

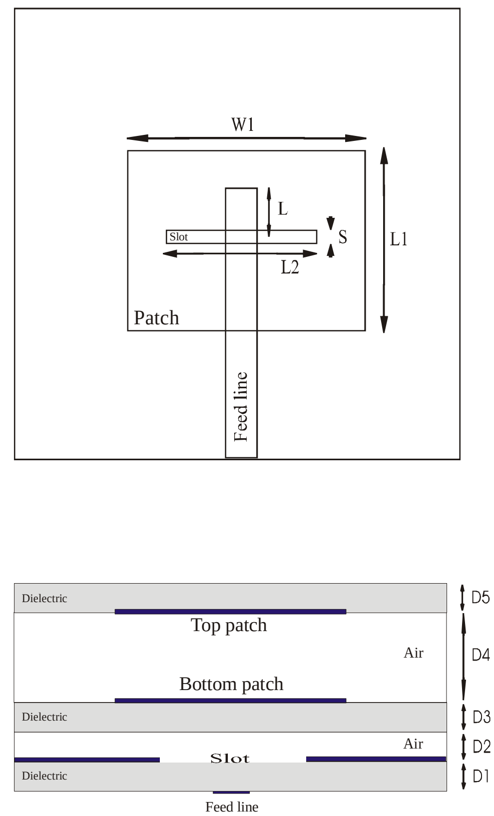

Figure 1: Antenna structure: (a) Top view, (b) Side view

TABLE I: Dimensions of the Antenna structure in Figure 1

D1,D2,D3,D5	D4	S	ε_r
0.5 mm	1.5 mm	0.5 mm	2.2

W1	L	L1	L2
10 mm	3 mm	8 mm	7 mm

III. Parameter Study

The antenna has three resonant frequencies. By changing these resonant frequencies one can achieve a better matching with more impedance and gain bandwidth.

Fig. 3 shows how the resonant frequencies will change by changing the position of the dielectric in top layer. The separation between two patches is fixed to 1.5 mm. Plot 1 is VSWR when D4 is 1 mm and D5 is under the top patch. If the structure changes by eliminating D5 and increasing D4 to 1.5 mm, VSWR will change to plot 2 and finally plot 3 is VSWR of the structure which is shown in Fig. 1. It is observed that by adding D5 on top of the upper patch all resonant frequencies are decreased and the bandwidth increases.

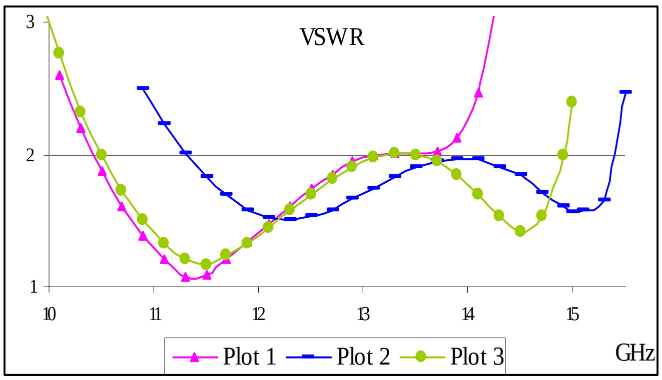

Figure 2: Effect of dielectric on the top layer

Effects of slots' lengths are shown in Fig. 3. Plots one, two and three are for lengths 7, 7.5 and 8 mm respectively. Although increasing the slots' length will result in better impedance matching, but the bandwidth will decrease. Decreasing the slots' length to less than 7 mm will yield a dual frequency antenna. In this step 7mm is a good choice for the slots' length.

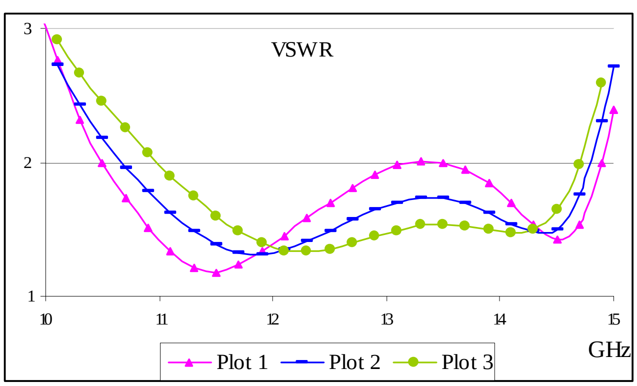

Figure 3: Effect of the slots' length

Effect of slots' position (L) on VSWR and gain of the antenna is shown in Fig. 4. Plots one, two and three are for L = 3 mm, L = 2.5 mm and L = 2 mm respectively. In plot 1 the first resonant frequency of the antenna is the main resonant frequency but in plot 3, the third resonant frequency is the main resonant frequency of the antenna. Although impedance bandwidth for L = 2 mm is 4.6 (38%) GHz and it is 4.5GHz (36.7%) for L = 2.5 mm but plot 2 has a better matching over the entire impedance bandwidth and the gain of the antenna is more then 8 dB from 10.6 GHz to 15 GHz. It is clear from Fig. 4 that L = 2.5 mm is a good choice. The final antenna has the maximum gain of 8.88 dB at the frequency of 14.7 GHz. Smith chart plots of the final antenna is shown in Fig. 5.

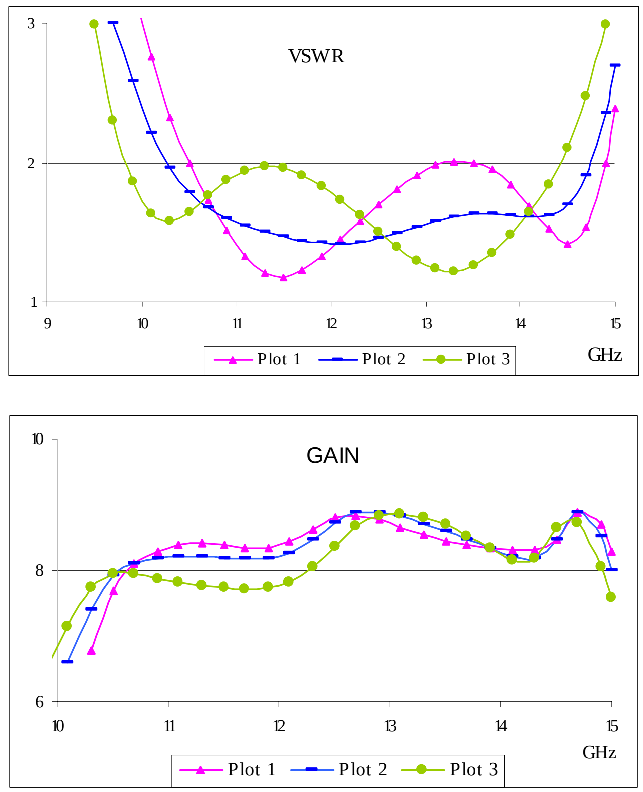

Figure 4: Effect of slots' position on VSWR and Gain of the antenna

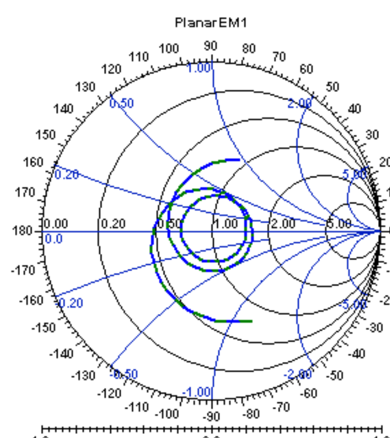

Figure 5: Smith chart plots of the antenna

IV. CONCLUSION

In this paper various methods have been used and numerically investigated to set the resonant frequencies in order to increase the bandwidth and gain of a dual stacked rectangular aperture coupled microstrip patch antenna in the frequency range of 10 – 15 GHz. Results demonstrate that the whole structure presents an impedance bandwidth of 4.5 GHz (36.7%) with a gain of about 8.37 dB which is quite useful for ultra wideband applications. However an optimization procedure is needed to consider other characteristics of the structure such as radiation pattern of the antenna.

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